California State University, Northridge

AN EVALUATION OF THE CRITERIA FOR THE DESIGN
OF THE DRAIN AREA FOR SEPTIC TANKS

A thesis submitted in partial satisfaction of the
requirements for the degree of Master of Science in
Health Science

by

Roger J. B. Cole

June, 1972
The thesis of Roger J. B. Cole is approved:

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>vii</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>II. REVIEW OF LITERATURE</td>
<td>6</td>
</tr>
<tr>
<td>III. METHODS</td>
<td>26</td>
</tr>
<tr>
<td>IV. RESULTS</td>
<td>30</td>
</tr>
<tr>
<td>Sandy Loam or Sandy Clay</td>
<td>30</td>
</tr>
<tr>
<td>Clay with Considerable Sand or Gravel</td>
<td>32</td>
</tr>
<tr>
<td>Clay with Small Amount of Sand or Gravel</td>
<td>33</td>
</tr>
<tr>
<td>V. CONCLUSION AND RECOMMENDATIONS</td>
<td>35</td>
</tr>
<tr>
<td>Conclusions</td>
<td>35</td>
</tr>
<tr>
<td>Recommendations</td>
<td>37</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>39</td>
</tr>
</tbody>
</table>
## APPENDIX

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Test Procedure</td>
<td>42</td>
</tr>
<tr>
<td>II. Health Department Sketch</td>
<td>44</td>
</tr>
<tr>
<td>III. Building Department Sketch</td>
<td>45</td>
</tr>
<tr>
<td>IV. Application for Permit</td>
<td>46</td>
</tr>
</tbody>
</table>
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# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Data for Determining Field Requirements from Percolation Tests</td>
<td>14</td>
</tr>
<tr>
<td>2.</td>
<td>Data for Determining Field Requirements for Character of Soil</td>
<td>15</td>
</tr>
<tr>
<td>3.</td>
<td>Rated Absorption Capacities</td>
<td>16</td>
</tr>
<tr>
<td>4.</td>
<td>Requirements for Seepage Pit Design (Federal Housing Authority)</td>
<td>18</td>
</tr>
<tr>
<td>5.</td>
<td>Requirements for Seepage Pit Design (National Plumbing Code)</td>
<td>18</td>
</tr>
<tr>
<td>6.</td>
<td>Location of Sewage Disposal System</td>
<td>21</td>
</tr>
<tr>
<td>7.</td>
<td>Sandy Loam-Sandy Clay</td>
<td>31</td>
</tr>
<tr>
<td>8.</td>
<td>Clay with Considerable Sand or Gravel</td>
<td>32</td>
</tr>
<tr>
<td>9.</td>
<td>Clay with Small Amount of Sand or Gravel</td>
<td>33</td>
</tr>
</tbody>
</table>
ABSTRACT

AN EVALUATION OF THE CRITERIA FOR THE DESIGN OF THE DRAIN AREA FOR SEPTIC TANKS

by

Roger J. B. Cole

Master of Science in Health Science

June, 1972

Individual sewage disposal systems have taken a prominent place in the overall practice of sewage treatment. It is estimated that at present 49 million persons are served by 15 million individual disposal systems in the United States. The great majority of these systems are septic tank installations.

Over the years, efforts have been made to determine the life span of existing septic tank systems. It was felt that this type of data could be helpful to those responsible for designing and issuing construction permits for new installations.

It was determined that the most critical part of the septic tank was the leaching area. In those
geographical areas studied, the type of soil in which a leaching system was installed greatly effected the life span of the entire system.

Existing predictive methods for determining the life span of a septic tank leaching system seem to be inadequate. Methods vary from one community to another, and different criteria have been used in developing these methods. The purpose of this study was to develop new standards for determining the size of a septic tank leaching system following the study of survival rates of installations in a selected area of Los Angeles County.

Three hundred leaching systems installed between the years 1959 and 1965 were evaluated. The leaching systems had been installed following the use of percolation tests or a visual inspection of the soil as required by the Los Angeles County Plumbing Code. Survival rates were composed for systems installed according to the two sets of standards. The data revealed the following:

Sandy Loam-Sandy Clay

In this type of soil, drainfields can be installed following the use of percolation tests or the requirements of the Los Angeles County Plumbing Code. The failure rate for existing systems was approximately the same not
matter which criteria were used.

If seepage pits are to be used, the Plumbing Code requirements should be the basis for construction. Percolation testing will result in an inadequate system because the test does not seem to work well when clay layers in the soil are present. Water drains well during the testing period, but continued daily use causes the clay to swell and seal off the leaching areas.

Clay with Considerable Sand or Gravel

In this type of soil, drainfields can be installed following the use of percolation tests or the requirements of the Los Angeles County Plumbing Code. The failure rates for existing systems was approximately the same no matter which criteria were used. If seepage pits are to be used, then percolation tests should be the basis for construction. The Plumbing Code requirements will result in an adequate system because in this type of soil the requirements should be higher.

Clay with Small Amount of Sand or Gravel

In this type of soil, drainfields can be installed following the use of percolation tests or the requirements of the Los Angeles County Plumbing Code. The failure rates
for existing systems was approximately the same no matter which criteria were used. If seepage pits are to be used, then percolation tests should be the basis for construction. The Plumbing Code requirements will result in an inadequate system because in this type of soil the requirements should be higher.

As a result of this study, the following recommendations have been made:

1. The Los Angeles County Plumbing Code should be changed to take into consideration the following criteria

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Required Sq. Feet of Leaching Area/100 Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy Loam</td>
<td>10% - Clay 30% - Silt 60% - Sand</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>30% - Clay 20% - Silt 50% - Sand</td>
</tr>
<tr>
<td>Clay with Considerable Sand</td>
<td>50% - Clay 20% - Silt 30% - Sand</td>
</tr>
<tr>
<td>Clay with Small Amount of Sand</td>
<td>70% - Clay 10% - Silt 20% - Sand</td>
</tr>
<tr>
<td>Clay - Heavy tight clay, hard pan adobe, gumbo</td>
<td>90% - Clay 10% - Silt</td>
</tr>
</tbody>
</table>

2. The percolation test need not be conducted
before installing a drainfield in any of the soils studied, the examination of the soil according to the Los Angeles County Plumbing Code is adequate.

3. If seepage pits are to be used, in the sandy loam-sandy clay soil, then the Plumbing code requirements should be the basis for construction.

4. If seepage pits are to be used, in the clay with considerable sand or gravel and the clay with small amount of sand or gravel soils, then percolation tests should be the basis for construction.

5. Before the installation of either a seepage pit or a drainfield a test hole should be provided so that the structure, texture and color of the soil can be adequately studied.

6. A septic tank disposal system should not be installed in heavy tight clay, hard pan, adobe or gumbo.
CHAPTER I

INTRODUCTION

In recent years, there has been steady movement of population from the cities to the surrounding fringe areas. For economic and other reasons, the extension of public sewers has not kept pace with the relocation of the population. As a result, the individual sewage disposal system has taken a prominent place in the overall practice of sewage treatment. Accurate figures are not available, but it is estimated that at present 49 million persons are served by 15 million individual sewage disposal systems in the United States. Of even more importance, roughly one-fourth of the new homes being constructed are served by these systems. (1)

For a nation whose reputation for technological prowess is epitomized by indoor plumbing, there are an enormous number of cesspools and septic tanks. Almost everyone, in fact, who lives beyond reach of city sewers
depends on cesspools or septic tanks for disposal of human waste. The remainder of the rural population still depends on the outdoor privy. Many of the persons who move to areas where sewage is disposed of by septic tank systems are not familiar with the operation of these systems. Too, many septic tank systems have been installed without giving adequate consideration to the soil that must be used for the ultimate disposal of liquid waste.

Basically, a proper septic system consists of a large concrete tank that has been sunk into the earth and then attached to the house sewer pipe. A second pipe leads out of the septic tank to a distribution box. From here, a number of lines of drain tile are utilized to dispose of liquid in an underground leaching field. The leaching area is the most critical part of the system.

The solid waste matter which is deposited in the septic tank, is acted upon by bacteria that reduce part of this matter to gases. The sludge-like semi-solids then settle to the bottom of the tank, while the liquid residue joins other liquids flowing into the tank and forms an effluent. The gases flow up through the house soil stack and harmlessly into the atmosphere. The effluent moves through the underground piping system and into the soil
where it is acted upon by aerobic bacteria.

At several localities in the nation, the Public Health Service has made intensive surveys to determine the life spans of existing systems. This information has been related to soil types and the outcome has been compared with survival curves of septic tank systems. For example, in Fresno county, it was noted that ninety percent of the seepage pits in brown alluvial soils lasted about five years, eighty percent lasted six years, fifty-five percent lasted eight years, and about twenty-five percent lasted ten years. Studies conducted in other parts of the United States have provided similar results. A general conclusion that has been reached as a result of these studies is that existing predictive methods for determining the life span of a septic tank leaching system are inadequate. There is a need to develop new predictive criteria that will assist those responsible for the design and installation of septic tank systems.

Statement of the Problem

The purpose of this study was to develop new standards for determining the size of a septic tank leaching system.
Limitations of the Study

This study was limited to selected areas in the communities of Chatsworth Lake Manor, Twin Lakes, Hidden Hills, Calabasas, Topanga, Cornell and Agoura.

The selection of the sites depended upon the availability of records. Only single family dwellings were evaluated. New percolation tests and soil evaluations were not conducted. Instead septic tank systems that were installed during the period between 1959 and 1965 were evaluated on the basis of percolation tests and soil evaluations done at that time.

Definition of Significant Terms Used in This Study:

Septic Tank - A septic tank is a watertight receptacle which receives the discharge of a drainage system or part thereof, designed and constructed so as to retain solids, digest organic matter through a period of detention and allow the liquids to discharge into the soil outside of the tank through a system of open joint piping or a seepage pit.

Seepage Pit - A seepage pit is a lined excavation in the ground which receives the discharge of a septic-tank so designed as to permit the effluent from the septic-
tank to seep through its bottom and sides.

**Cesspool** - A cesspool is a lined excavation in the ground which receives the discharge of a drainage system or part thereof, so designed as to retain the organic matter and solids discharging therein, but permitting the liquids to seep through the bottom and sides.

**Drainfield** - A drainfield receives and distributes the effluent from the septic-tank. This is accomplished through a series of trenches that contain gravel and distribution lines. These lines are laid with spaces between them so the sewage can escape and be absorbed into the surrounding soil. Synonymous terms are: disposal lines, disposal fields, tile fields, leach field, leaching lines, drain lines, disposal trenches, absorption field and leaching beds.

**Sewage** - Sewage is any liquid waste containing animal or vegetable matter in suspension or solution and may include liquids containing chemicals in solution.

**Domestic Sewage** - Domestic sewage means the waterborne wastes derived from the ordinary living processes and of such character as to permit satisfactory disposal, without special treatment, into the public sewer or by means of a private sewage disposal system.
CHAPTER II

REVIEW OF LITERATURE

The literature was reviewed to obtain the design criteria for septic tank leaching systems, the leaching area being the most critical part of the system. The leaching system consists of either a drainfield or a seepage pit.

Development of the Percolation Test for Drainfields

According to Winneberger (3) the percolation test was developed in 1926 by Henry Ryon, Senior Sanitary Engineer of the New York State Department of Public Works. When a complaint was received about a poorly operating leaching field, Ryon went to the site. There he dug a few holes in fresh soil, each being about one foot square and eighteen inches deep. He saturated the holes with water and allowed the excess to seep away. Then he filled each hole to a depth of six inches and measured the time it took the water level to fall one inch. He called the
average time for the water to fall one inch the percolation rate. He then developed the formula \( \frac{T+6.24}{29} \), where \( T \) was the time in minutes it took water to fall one inch.

Then, as best he could, he determined the size of the poorly operating leaching field in terms of square feet of bottom surfaces and the amount of sewage it received daily. From this, he calculated the loading rate in gal/sq.ft./day. If a system was less than twenty years old, it was not included in Ryon's figures. He assumed that a system was a success if it performed well for twenty years or more. He also assumed that failures were a result of overloading; that is, too many gallons per square feet per day.

It is reported that Ryon observed that failures of septic tank systems almost always occurred where percolation rates were slow and from this originated the 60 min./in. limit as a standard for designing leaching systems.

Ryon concluded that if it took more than sixty minutes for one inch of water to percolate in the test hole, the soil was not suitable for sewage disposal. This sixty minute per inch limit has been accepted as standard procedure in all parts of the United States and in other
parts of the world.

When Ryon related his percolation test to rates of maximum soil loading, he made several assumptions. The most basic of these was that the short-term ability of soil to accept fresh water was related to its long-term ability to accept sewage.

As previously indicated Ryon's method for conducting percolation tests has become universal although some variations of the test have been recommended by many of the state health departments.

As a tool for estimating water absorption characteristics of soils for design of subsurface sewage disposal systems, it has undoubtedly been valuable in many cases.

Over the years the percolation test has become standardized throughout the country. Sanitary engineers, architects, geologists and septic tank contractors have assumed these tests to be valid. However, one problem has arisen. There have evolved so many variations of the percolation test that the original formula has become invalid.

In a report by Weibel, Straub and Thoman⁴ the following procedures for conducting percolation tests
were described:

A. Number, type and location of tests, one (or more as circumstances may warrant), in unaffected soil area using a 12-inch square hole, dug to trench bottom level.

One, in unaffected soil area, near the 12-inch square hole located above mentioned, using the 10-inch diameter tube, in a hole dug also to trench bottom level.

Three (more or less), at selected locations in the bottom of the absorption system trench, using the 10-inch tube. The number and distribution of these are left to the judgment of the field engineer, the aim being to determine the average percolation rate of the trench bottom. All tests made in this connection however should be reported individually.

B. Preparation of test hole before saturating test hole, place 2 inches of washed coarse sand, or pea gravel in bottom of test hole, or after the 10-inch cylinder is in place.

Saturate hole to at least 8 inches above top of sand or gravel. In connection with making tests by means of the tube, it was found at Cincinnati that a 2-inch penetration of tube into the soil was necessary in some cases to effect a seal.

C. Test

Refill hole, bring water up to between 6 and 8 inches above the sewage level outside the tube.

D. Observation

All vertical measurements should be reformed to a common origin, such as a reference board across the top of the unconfined hole or the top of the tube. This includes distance to the bottom of hole, top of sand, ground surface and water levels.

Water level observations should be made at approximately 2 minute intervals for the first 10 minutes, at approximately 10 minute intervals thereafter, to complete a total
run of 1 hour, or the time it takes to observe the total 6 inch subsidence, whichever is the shorter. In a very permeable soil, it would be advisable to take observations more frequently, and in a heavy soil to extend the total time of observations, if time permits.

Variations of the Percolation Test

Kiker (5) reported that the percolation test has been successfully employed as a quantitative measure of the absorptive characteristic of a soil. However, his method differed as follows:

1. Continue adding water until the soil is saturated and the water seeps away at a constant rate.

Quenelle (6) suggested that the determination of the rate of absorption be calculated by a different method involving observation of the rate at which water must be poured into an 8 inch diameter hole containing a six inch depth of one inch or two inch diameter gravel, in order to maintain a constant depth of about six inches of water in the hole.

Ehlers and Steel (7) differed and recommended the following:

1. 4 inch diameter hole.
2. 12 inches of water for 4 hours.
3. Add 6 inches of water over gravel.
4. After 30 minutes the drop in water level is recorded.
Hopkins and Schultze\(^{(14)}\) suggested a similar method of testing the soil:

1. A test hole is dug, water put in it and allowed to soak overnight.
2. 6 inches of water is put in the test hole and allowed to seep out.
3. The time required for the water to drop 1 inch is obtained by dividing the depth of water in the hole originally by the length of time in minutes required for all of the water to run out.

Bendixon, another authority,\(^{(9)}\) recommended:

1. 4 inch test of holes dug with a posthole auger.
2. Replication of test would give a more accurate estimate of soil absorption characteristics than a single measurement.
3. In analysing the percolation test data consider the later period of the test as being more representative of the true absorption rate of the soil.

Nottingham\(^{(10)}\) suggested the following:

1. Borings should be made to establish the types of soil strata.
2. After determining the stratum level to be employed for leaching, a percolation test should be made at several points in this stratum selected as being typical.

In 1953 the Federal Housing Administration recommended still another method of making a percolation test.

1. Repeat the test until the average time for two successive tests does not vary more than 20 percent.
2. Determine from Table 1 seepage area (in square feet) required per bedroom.
In an old Sanitarians Field Manual(15) from Los Angeles County some guide lines were listed for use in the design of the disposal area for septic tank systems. The general soil type classifications are the same as found in many other publications. The percolation test procedure was also similar.

Other Methods for Drainfield Design

The capacity of a soil to absorb effluent is an important criterion in the proper design of septic tank soil drainfield system. Successful operation requires that the soil completely absorb the effluent discharged from the septic tank for a comparatively long time. Individual drainfield size is based on household size and the rate at which soil at that site can be expected to absorb effluent.

The capacity of a soil to absorb effluent is determined indirectly. First the rate that a soil will absorb water is measured by a percolation test. The rate that the same soil can be expected to absorb effluent over a prolonged period is then estimated from a previously developed empirical relationship. In most cases the size of the drainfield needed is estimated directly from tables.
which take into account the percolation rate, empirical relationship and expected daily sewage flow.

Nottingham (10) stated that determining the necessary leaching area is the most difficult question in the design of a leaching system. Because of the difficulties involved in obtaining a reliable answer, it is often guessed at by sanitary engineers. The failure of a septic tank system, if properly designed, is due more to improper leaching layout than to any other single factor.

In a vicinity where enough leaching systems have been previously installed, a reliable percolation rate figure may best be determined from experience. Where there has been no appreciable experience in the immediate vicinity of the site under consideration, the only reliable means for determining percolation rates involves considerable work in digging test holes to establish the types of soil strata present.

**Drainfield Size by Bedrooms**

The Federal Housing Administration (12) has suggested that the drainfield size for single family dwellings be determined from percolation rates based upon the square feet per bedroom.
Table 1

Data for Determining Field Requirements from Percolation Tests

<table>
<thead>
<tr>
<th>Average time required for water to fall one inch in minutes (stabilized rate)</th>
<th>Effective absorption area (area in bottom of disposal trench) in sq. ft. per bedroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 or less</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
</tr>
<tr>
<td>5</td>
<td>80</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>15</td>
<td>120</td>
</tr>
<tr>
<td>30</td>
<td>180</td>
</tr>
<tr>
<td>60</td>
<td>240</td>
</tr>
<tr>
<td>Over 60 unsuitable except for special design</td>
<td></td>
</tr>
</tbody>
</table>

*Federal Housing Administration. 1953

Soil Types

In lieu of conducting percolation tests, drainfields can be determined by considering the type of soil encountered. (see Table 2)
### Table 2

**Data for Determining Field Requirement for Character of Soil**

<table>
<thead>
<tr>
<th>Character of Soil</th>
<th>Effective absorption area (area in bottom of disposal trench) in sq. ft. per bedroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sand or gravel</td>
<td>60*</td>
</tr>
<tr>
<td>Fine Sand</td>
<td>80*</td>
</tr>
<tr>
<td>Sandy loam or sandy clay</td>
<td>120*</td>
</tr>
<tr>
<td>Clay with considerable sand or gravel</td>
<td>180</td>
</tr>
<tr>
<td>Clay with small amount of sand or gravel</td>
<td>240</td>
</tr>
<tr>
<td>Heavy tight clay, hardpan, rock</td>
<td>suitable*</td>
</tr>
<tr>
<td>or other impervious formations</td>
<td>unsuitable</td>
</tr>
</tbody>
</table>

*Note: A minimum of 150 square feet of effective absorption area (100 lineal feet of 18-inch trench) shall be provided per living unit.

*Federal Housing Administration. 1953

The Los Angeles County Plumbing Code \(^{(13)}\) has stated that the septic tank size for single family dwellings should be based on the number of bedrooms. The Code further stated that the minimum effective absorption area in disposal fields in square feet of trench bottom, shall be predicated on the required septic tank capacity in gallons and shall conform to the absorption capacities of soils as indicated in Table 3.
Table 3

Rated Absorption Capacities of Five Typical Soils

<table>
<thead>
<tr>
<th>Type of Soil</th>
<th>Required Sq. ft. of leaching area/100 gallons</th>
<th>Maximum absorption capacity gals/sq. ft. of leaching area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sand and gravel</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Fine sand</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>Sandy loam or sandy clay</td>
<td>40</td>
<td>2.5</td>
</tr>
<tr>
<td>Clay with considerable sand or gravel</td>
<td>60</td>
<td>1.66</td>
</tr>
<tr>
<td>Clay with small amount of sand or gravel</td>
<td>90</td>
<td>1.11</td>
</tr>
</tbody>
</table>

*Los Angeles County Plumbing Code. 1958

An additional requirement of the Code has been that when disposal fields are installed, a minimum of one hundred and fifty square feet (150 sq. ft.) of trench bottom shall be provided for each system exclusive of any hard pan, rock, clay or other impervious formations.

Ehlers and Steel (7) have stated that in the absence of percolation tests, percolation areas provided per bedroom may vary from 50 square feet for most favorable soils to 100 square feet in average soils and 200 square feet or more in heavy soils. In any case a minimum of 150 square feet should be provided for each individual dwelling unit.
The Los Angeles County Plumbing Code (13) has required that the minimum effective absorption area in seepage pits in square feet of side wall be predicated on the required septic tank capacity in gallons and shall conform to the absorption capacities of soils as indicated in Table 3. Use of seepage pits is permitted with septic tanks when soil conditions, ground water level, or topography indicate the need and when such use is acceptable to the Health Authority having jurisdiction. Effective absorption area of a seepage pit shall be calculated as the excavated sidewall area below the inlet, exclusive of any hard pan, rock or clay formation. Each seepage pit shall have a minimum side wall, not including the arch, of 10 feet (10') below the inlet.

The Federal Housing Administration (12) has recommended that the required seepage area be determined by the requirements outlined in Table 4.
Table 4

Requirements for Seepage Pit Design

<table>
<thead>
<tr>
<th>Character of Soil</th>
<th>Effective absorption area of wall area of pit per bedroom.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sand or gravel</td>
<td>30</td>
</tr>
<tr>
<td>Fine sand</td>
<td>45</td>
</tr>
<tr>
<td>Sandy loam or sandy clay</td>
<td>75</td>
</tr>
<tr>
<td>Clay with considerable sand or gravel</td>
<td>120</td>
</tr>
<tr>
<td>Clay with small amount of gravel or sand</td>
<td>240</td>
</tr>
<tr>
<td>Heavy tight clay, hardpan, rock or other impervious formation</td>
<td>Unsuitable</td>
</tr>
</tbody>
</table>

*Federal Housing Administration. 1953

The National Plumbing Code(11) has called for seepage pits to conform the requirements listed in Table 5.

Table 5

Requirements for Seepage Pit Design

<table>
<thead>
<tr>
<th>Soil Structure</th>
<th>Effective absorption area required per bedroom (Square foot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sand and gravel</td>
<td>20</td>
</tr>
<tr>
<td>Fine sand</td>
<td>30</td>
</tr>
<tr>
<td>Sandy loam or sandy clay</td>
<td>50</td>
</tr>
<tr>
<td>Clay with considerable sand and gravel</td>
<td>80</td>
</tr>
<tr>
<td>Clay with small amount of sand and gravel</td>
<td>160</td>
</tr>
</tbody>
</table>

In calculating absorption wall area of pit, gross diameter excavation shall be used.

*National Plumbing Code. 1944
Test Requirements for Seepage Pits

When testing the absorption qualities of questionable soils (i.e., other than those soils listed in Table 3), the Los Angeles County Plumbing Code has called for percolation tests to be performed on the proposed site. No seepage pit installation shall be permitted unless it can be clearly demonstrated to the satisfaction of the administrative authority that the proposed installation will absorb a quantity of clear water in a twenty four hour period equal to at least five times the liquid capacity of the septic tank.

Nottingham (10) has indicated that leaching or seepage pits are often used rather than horizontal trenches. They are useful where the ground area available for leaching is limited. They are especially applicable where it is necessary to dig to considerable depths to reach a suitably porous stratum. Circular holes are easily drilled and the large vertical wall area (when in a porous strata), is effective for leaching purposes.

The factors influencing the design of leaching pits are essentially the same as those for horizontal trenches. That portion of the side wall area below the inlet which contacts the leaching stratum (or strata) is considered
effective together with the bottom area. The effective pit diameter is considered to extend to the outside of the masonry, or rock lining, i.e., the dug diameter.

As with trenches, the procedure in design is first to determine the leaching rate for sewage effluent in gal./sq. ft./day at the strata where the unmortared masonry or rock fill will be placed. This factor multiplied by the effective leaching area gives the volume of effluent which a single given pit can percolate away daily. The number of pits selected must provide both sufficient leaching area and sufficient storage space for the leveling off of the surge flow.

Seepage pits may be used either to supplement the sub-surface disposal field or in lieu of such field where conditions favor the operation of seepage pits, as may be determined and approved by the administrative authority.

Care must be taken to avoid extending the seepage pit into the ground water table. Where the pit is used to receive the septic tank effluent, the same limitations shall be placed on the location of the pit as on the cesspool.
Table 6

Location of Sewage Disposal System

<table>
<thead>
<tr>
<th>Minimum horizontal distance in clear required from</th>
<th>Building Sewer</th>
<th>Septic Tank</th>
<th>Disposal Field</th>
<th>Seepage Pit or Cesspool</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Buildings or structures</strong></td>
<td>2 (feet)</td>
<td>5 (feet)</td>
<td>8 (feet)</td>
<td>8 (feet)</td>
</tr>
<tr>
<td><strong>Property line adjoining private property</strong></td>
<td>clear</td>
<td>5 (feet)</td>
<td>5 (feet)</td>
<td>8 (feet)</td>
</tr>
<tr>
<td><strong>Water supply wells</strong></td>
<td>50 (feet)</td>
<td>50 (feet)</td>
<td>50 (feet)</td>
<td>100 (feet)</td>
</tr>
<tr>
<td><strong>Streams</strong></td>
<td>50 (feet)</td>
<td>50 (feet)</td>
<td>50 (feet)</td>
<td>100 (feet)</td>
</tr>
<tr>
<td><strong>Large trees</strong></td>
<td>- (feet)</td>
<td>10 (feet)</td>
<td>10 (feet)</td>
<td>10 (feet)</td>
</tr>
<tr>
<td><strong>Seepage pits or cesspools</strong></td>
<td>- (feet)</td>
<td>5 (feet)</td>
<td>5 (feet)</td>
<td>12 (feet)</td>
</tr>
<tr>
<td><strong>Disposal fields</strong></td>
<td>- (feet)</td>
<td>- (feet)</td>
<td>4 (feet)</td>
<td>5 (feet)</td>
</tr>
<tr>
<td><strong>Domestic water line</strong></td>
<td>1 (feet)</td>
<td>5 (feet)</td>
<td>5 (feet)</td>
<td>5 (feet)</td>
</tr>
<tr>
<td><strong>Distribution box</strong></td>
<td>- (feet)</td>
<td>- (feet)</td>
<td>5 (feet)</td>
<td>5 (feet)</td>
</tr>
</tbody>
</table>

Note: When disposal fields and/or seepage pits are installed in sloping ground the minimum horizontal distance between any part of the leaching system and ground surface shall be fifteen feet.

1. Including porches and steps whether covered or uncovered, breezeways, roofed porte cocheres, roofed patios, carports, covered driveways and similar structures or appurtenances.
2. All nonmetallic drainage piping shall clear domestic water supply wells by at least fifty feet. This distance may be reduced to not less than twenty-five feet when approved type metallic piping is installed. Where special hazards are involved, the distance required shall be increased, as may be directed by the Health Officer or the Administrative Authority.
3. Plus two feet for each additional foot of in excess of one foot below the bottom of the drain line.
4. See Section 1108.

*Los Angeles County Uniform Plumbing Code. 1958
Other Methods of Appraisal

Vanatta and Uhland\(^8\) have shown that percolation rates obtained by measuring the rate of water absorption from holes dug in a variety of soils at a variety of depths correlate very well with estimates of soil permeability made by different and independent methods such as visual inspection.

Although a percolation test is the only known means for obtaining a quantitative appraisal there are other means by which a rough appraisal of soil-moisture absorption potentiality can be made. Those methods generally have not been utilized in the design of sewage disposal fields.

Considerable information about relative absorption capacities of soils may be obtained by a close visual inspection of the soil. The value of such an inspection depends upon some knowledge of the pertinent soil properties. The main properties indicative of absorption capacity are soil texture, structure, and color.

Soil Texture

Soil texture, the relative proportion of sand, silt and clay, is the most common clue to water absorption
capacity. Texture can best be judged by feel. The lighter or sandier soils have a gritty feel when rubbed between the thumb and forefinger; silty type soils have a "floury" feel and, when wetted, have no cohesion; heavier clay-type soils are dense and hard when dry and have a slick, greasy feel when wetted.

Soil Structure

Soil structure is characterized by the aggregation or grouping together of textural particles, forming secondary particles of larger size. The structure can easily be recognized by the manner in which a clod or lump breaks apart. If a soil has structure, a clod will break apart with very little force along well-defined cleavage plans into uniformly sized and shaped units. If a soil has no structure, a clod will require more force to break apart and will do so along irregular surfaces with no uniformity in size and shape of particles.

Soil Color

One of the most important practical clues to water absorption is soil color. Most soils contain some iron compounds. The iron, like a piece of iron in a tool or piece of machinery, if alternately exposed to air and to
water oxidizes and takes on a reddish-brown to yellow oxidized color it indicates that there has been free alternate movement of air and water in and through the soil. Such a soil has desirable absorption characteristics. At the other extreme are soils of a dull gray or a mottled coloring, indicating lack of oxidizing conditions or very restricted movement of air and water. These soils have poor absorption characteristics.

Soil Structural Types

In general, there are four fundamental structural types, named according to the shape of the aggregated particles: platy, prism-like, block-like, and spheroidal. A soil without structure is generally referred to as massive. Spheroidal structure tends to provide the most favorable absorption properties, and platy structure, the least.

Although other factors, such as size and stability of aggregates to water, also influence the absorption capacity, the recognition of the type of structure is probably sufficient for general appraisal.

Transpiration

Nottingham (10) has suggested that plants will grow prolifically near and over the leaching area. Plants with
deep roots such as shrubs and trees may clog the trench zone if adequate rock fill is not used and should not be used unless plant transpiration is being depended upon for disposing of an appreciable portion of the flow. Grass planted over the lines is usually not harmful and assists leaching by transpiration. This disposes of an appreciable amount of water. For tight clay soils where leaching is very limited, plant transpiration may be employed to dispose of appreciable amounts of effluent. Such installations are especially adapted to summer camps and other installations operating only during the dry season of the year. The feeder or distribution pipe of the leaching system should be placed near the top of the trench where it is not likely to become clogged with roots. The roots usually become established at the trench bottom. With this precaution, clogging and attendant repair work will be delayed for many years.
CHAPTER III

METHODS

The purpose of this study was to develop new standards for determining the size of a septic tank leaching system.

The capacity of a septic tank system is determined by (1) plumbing code guidelines and (2) percolation tests. The plumbing code guidelines are based on soil types while the percolation tests are based on the soil's capacity to accept water. (See Appendix for the detailed procedure for conducting percolation tests.)

The area studied had three soil types: sandy clay, sandy loam; clay with considerable sand and gravel; and clay with small amount of sand and gravel.

Study Units

The study included all single family dwellings built in the years 1959 to 1965, depending upon the availability
of records. This time period was chosen for the following reasons: all of the field tests were conducted by the author; in this six year period, over 450 single family dwellings were constructed; the time period chosen would give six to twelve years of use to test the results of the design of the private sewage disposal system, and the plan of the original design for each installation had been drawn by the author and was filed with the Los Angeles County Health and Building Departments.

Steps in the Study: Sources of Data

Since the Los Angeles County Health Department issues an approval for the design of a septic tank system, the first step was to review the files that contained the appropriate information about septic tank installations. From this, 450 records were selected that conformed to the criteria that was described previously. (See Appendix for a copy of the form in which information was recorded.)

The second step was to review the records of the Los Angeles County Building Department because this office issues permits for the installation of the septic tank systems. The Building Department had only 400 records of the septic tank systems as many of the systems that had
been approved by the Health Department were not built. The third step in selecting the septic tank system for review was to make home visits and interview the owners of homes with septic tank systems. In many cases it was not possible to gather appropriate information because there were new owners, new tenants or no one home. After this survey was made, it was found that the records of 300 homes could be used.

Survey Form

The following survey form was used while visiting homes in order to assess the "functioning" of the septic tank system.

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Have you had any trouble with your septic tank?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Have you ever had your septic tank pumped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Have you ever repaired or added to the system?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Have you ever had the seepage pit pumped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Is there any evidence of overflowing sewage and any other related problems at the time of the home visit?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Recording of Data

The results of the performance of the originally designed septic tank system were tabulated. The data was divided into (a) soil evaluation according to the Los Angeles County Plumbing Code and (b) percolation tests. These categories were further divided into (a) drainfields and (b) seepage pits.
CHAPTER IV

RESULTS

When septic tank systems installed according to the Los Angeles County Plumbing Code requirements were compared to septic tank systems installed following percolation tests, differences in performance were noted.

The data were examined according to three types of soil and two types of leaching systems. Each soil type was evaluated by means of soil appearance and percolation tests.

Sandy Loam-Sandy Clay Soil

The failure rate of the drainfield leaching system was the same for facilities installed under the Plumbing Code requirements and those installed following percolation tests (see Table 7). The four percent failure rate is considered to be quite low. The one failure in the group tested was due to a cement driveway being constructed over
the drainfield, thus preventing evaporation.

Table 7

Sandy Loam-Sandy Clay

<table>
<thead>
<tr>
<th>Test</th>
<th>% Failure Drainfield</th>
<th>% Failure Age/ Pits Yrs.</th>
<th>% Failure Drainfield</th>
<th>% Failure Age/ Pits Yrs.</th>
<th>% Code Failure Drainfield</th>
<th>% Code Failure Age/ Pits Yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy Loam-Sandy Clay</td>
<td>4</td>
<td>6</td>
<td>24</td>
<td>6.1</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

Drainfields installed following a percolation test lasted six years before they failed. On the other hand, drainfields installed according to Plumbing Code requirements lasted seven years before they failed. The difference in years between the two categories was not significance.

Twenty-four percent of the seepage pits installed as a result of percolation tests failed in 6.1 years. This contrasted with a twelve percent failure in 8.1 years for seepage pits installed as a result of using the Plumbing Code requirements. The results would seem to indicate that the Plumbing Code Requirements were preferable to the percolation tests when seepage pits were to be considered as part of a leaching system.
Clay with Considerable Sand or Gravel

This type of soil had the least number of failures (see Table 8). There was enough sand in the soil to permit percolation of effluent and enough clay to require that an extensive leaching system be constructed.

Table 8

Clay with Considerable Sand or Gravel

<table>
<thead>
<tr>
<th>Test</th>
<th>Failure</th>
<th>%</th>
<th>Failure</th>
<th>%</th>
<th>Failure</th>
<th>%</th>
<th>Failure</th>
<th>%</th>
<th>Age/Drainfield</th>
<th>yrs.</th>
<th>Age/Pits</th>
<th>yrs.</th>
<th>Age/Pits</th>
<th>yrs.</th>
<th>Failure</th>
<th>yrs.</th>
<th>Failure</th>
<th>yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure Drainfield</td>
<td>8</td>
<td>8.5</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td>20</td>
<td>6.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Eight percent of the drainfields installed as a result of percolation tests failed in 8.5 years. On the other hand drainfields installed according to the Plumbing Code requirements failed in seven years. The difference in years between the two categories was not significant. Four percent of the seepage pits installed following percolation tests failed in eight years. This contrasted with a twenty percent failure in 6.8 years for seepage pits installed as a result of using the Plumbing Code requirements. The difference in years between the two categories was not significant. The failure rate of the drainfield leaching.
system seemed to coincide with the amount of clay in the soil. The greater the amount of clay the greater chance of failure. The results indicated the need to use percolation tests as a means of determining the leaching system for seepage pits in soil of this type.

**Clay with Small Amount of Sand or Gravel**

This category proved to be the poorest type soil for both drainfields and seepage pits (see Table 9).

**Table 9**

<table>
<thead>
<tr>
<th>Test</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Failure</td>
<td></td>
</tr>
<tr>
<td>Drainfield</td>
<td>%</td>
</tr>
<tr>
<td>Age/ Failure</td>
<td>%</td>
</tr>
<tr>
<td>Pits</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>

Sixteen percent of the drainfields installed following percolation tests failed in five years. On the other hand sixteen percent of the drainfields installed according to Plumbing Code requirements failed in five years. Twenty percent of the seepage pits installed following percolation tests failed in 4.2 years. This contrasted with a forty-eight percent failure in 4.6 years for seepage pits.
The failure rate of the drainfield leaching system seemed to coincide with the amount of clay in the soil. The greater the amount of clay the greater chance of failure. The high failure rate indicated that seepage pits should not be installed in heavy clay soil.

**Summary**

In general, the failure rates for drainfields ranged from four percent in sandy loam-sandy clay soil to sixteen percent in clay with small amount of sand or gravel soil. The failure rates for seepage pits ranged from four percent in clay with considerable sand or gravel to forty-eight percent in clay with small amount of sand or gravel soil.
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Most septic tank systems are designed with the expectancy that they will last for twenty years. Since the leaching system is the most important component of a septic tank system, careful consideration must be given to the criteria that will be used to determine the type and magnitude of the leaching system to be installed.

Sandy Loam-Sandy Clay

In this type of soil, drainfields can be installed following the use of percolation tests or the requirements of the Los Angeles County Plumbing Code. The failure rate for existing systems was approximately the same no matter which criteria were used.

If seepage pits are to be used, then the Plumbing Code requirements should be the basis for construction. Percolation testing will result in an inadequate system
because the test does not seem to work well when clay layers in the soil are present. Water drains well during the testing period, but continued daily use causes the clay to swell and seal off the leaching areas.

Clay with Considerable Sand or Gravel

In this type of soil, drainfields can be installed following the use of percolation tests or the requirements of the Los Angeles County Plumbing Code. The failure rates for existing systems were approximately the same no matter which criteria were used. If seepage pits are to be used, then percolation tests should be the basis for construction. The Plumbing Code requirements will result in an inadequate system because in this type of soil the requirements should be higher.

Clay with Small Amount of Sand or Gravel

In this type of soil, drainfields can be installed following the use of percolation tests or the requirements of the Los Angeles County Plumbing Code. The failure rates for existing systems were approximately the same no matter which criteria were used. If seepage pits are to be used, then percolation tests should be the basis for construction. The Plumbing Code requirements will result in an
inadequate system because in this type of soil the requirements should be higher.

Recommendations

As a result of this investigation, the following recommendations have been made:

1. The Los Angeles County Plumbing Code should be changed to take into consideration the following criteria:

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Required Sq. Ft. of Leaching Area/100 Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy Loam</td>
<td>10% Clay 30% Silt 60% Sand</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30% Clay 20% Silt 50% Sand</td>
</tr>
<tr>
<td>Clay with Considerable</td>
<td></td>
</tr>
<tr>
<td>Clay with Small Amount</td>
<td></td>
</tr>
<tr>
<td>Clay - Heavy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>90% Clay 10% Silt Not suitable for leaching</td>
</tr>
<tr>
<td></td>
<td>tight clay, hard pan, adobe, gumbo</td>
</tr>
</tbody>
</table>
2. The percolation test need not be conducted before installing a drainfield in any of the soils studied, the examination of the soil according to the Los Angeles County Plumbing Code is adequate.

3. If seepage pits are to be used, in the sandy loam-sandy clay soil, then the Plumbing Code requirements should be the basis for construction.

4. If seepage pits are to be used, in the clay with considerable sand or gravel and the clay with small amount of sand or gravel soils, then percolation tests should be the basis for construction.

5. Before the installation of either a seepage pit or a drainfield, a test hole should be provided so that the structure, texture and color of the soil can be adequately studied.

6. A septic tank disposal system should not be installed in heavy tight clay, hard pan, adobe or gumbo.
BIBLIOGRAPHY


APPENDIX I

Test Procedure

Drainfields

The theory behind the percolation test assumes that the short term water absorption capacity of a given soil can be a predictor of the long term absorption capacity. In practice drainfields are designed after testing the water absorption capacity of soil for a few minutes. Many other factors need to be considered before the drainfields are designed. Another important factor in designing a septic tank disposal system is the soil differential.

For the best results a percolation test must be designed properly. A three foot square hole is excavated to a depth of three feet. A one cubic foot hole is dug in the bottom of the large hole, this being the depth of the drainfield. This one cubic foot hole can be tested for percolation. The procedure used was to fill the one cubic foot hole, allow it to drain, then refill again. After the second filling allow the water to drain the first five inches. Then measure the time in minutes it takes for the next inch (sixth inch) to drop. This time is inserted into the Ryon formulae: \( \text{Time} + \frac{6.24}{\text{size of}} \)
drainfield.

Seepage Pits

The requirements for percolation testing of a seepage pit are as follows:

1. Excavate a five foot diameter hole approximately thirty feet deep.

2. Fill it with water to within five feet of the top of the ground. Allow it to soak twenty four hours.

3. Refill the hole and record the time. Allow it to drain twenty four hours.

4. At the same time on the following day measure the depth to water. The Plumbing Code requires that one or more seepage pits be installed that can seep five (5) times the size (gallons) of the septic tank in twenty four hours.
SEWAGE DISPOSAL MUST BE REvised.
ENCOUNTERED THE LOCATION OF THE
Remarks: IF ANY DOMESTIC WATER LINES ARE

CALABASAS RD.

APPENDIX III

Box

DISP.

50

50

3

3

5

5

4

3

100 CALABASAS RD.

NAME Joe Doaks

DATE 5-10-60

From-Los Angeles County Health Departement

To-Los Angeles County Building Department
APPENDIX IV

APPLICATION FOR PLUMBING PERMIT

<table>
<thead>
<tr>
<th>CITY OF LOS ANGELES</th>
<th>DEPARTMENT OF BUILDING AND SAFETY</th>
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<tbody>
<tr>
<td>TOILETS</td>
<td>SHOWERS</td>
</tr>
<tr>
<td>CLOTHES WASHERS</td>
<td>TRAYS</td>
</tr>
<tr>
<td>LAWN SPRINKLERS</td>
<td>SWIMMING POOLS</td>
</tr>
<tr>
<td>NO. OF VALVES:</td>
<td>SURVEY</td>
</tr>
<tr>
<td>CRITICAL SOIL</td>
<td>SEWER TO:</td>
</tr>
<tr>
<td>WATER HEATERS</td>
<td>W.H. VENTS</td>
</tr>
<tr>
<td>FIRE SPRINKLERS</td>
<td>UNDERGROUND SERVICE</td>
</tr>
</tbody>
</table>

Qualified Installer—

NAME: Joe Doaks

ADDRESS: 100 Calabasas Rd., Calabasas, CA.

CITY: Calabasas, STATE: Ca.

PHONE NO.: 110110

CITY REGIST.: OWN OR LESSEE: Joe Doaks

STATE LIC.: PHONE NO.: none

USE OF BLDG.: INVESTIGATION FEE: $220

CHECK: OLD | NEW

APPLICATION APPROVED

PLUMBING OUTLETS INSTALLED

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<th>TOILETS</th>
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<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

SEPTEC TANK | SEWER | CESSPOOL-SEEPAGE PIT | MISCELLANEOUS

GAS WATER HEATER | SUPPLEMENTARY PERMIT NOS.

WATER METER | RELIEF VALVE

H. S. | CESSPOOL-SEEPAGE PIT

G. W. HEATER VENT | GAS WATER HEATER

FIRST PLUMBING | FINAL PLUMBING

FIRST GAS | FINAL GAS

WATER | SEWER

TOTAL

WHEN PROPERLY VALIDATED THIS IS YOUR PERMIT

Applicant certifies that the information given is correct, and certifies that in the performance of the work for which this permit is issued no person shall be employed in violation of the Workmen's Compensation laws of California.

Cashier's Use Only

Permit expires if work is not commenced within 90 days after fee is paid or if work is suspended for a period of more than 90 days.