DESIGN MANUAL

SUBSURFACE SEWAGE DISPOSAL SYSTEMS

FOR HOUSEHOLDS AND

SMALL COMMERCIAL BUILDINGS

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC HEALTH

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TABLE OF CONTENTS

PAGE

Scope and Purpose. iv

PART I - GENERAL DESIGN PRINCIPLES

CHAPTER

1. Domestic Sewage. 1
2. Determining Design Sewage Flows. 6
3. Site Investigation. 10
4. Soil Identification. 14
5. Percolation Testing 18
6. Determining Maximum Ground Water Levels 22
7. Ground Water Control Drains. 27
8. House Sewers. 33
9. Septic Tanks and Grease Traps. 35
10. Dosing the Leaching System. 38

TABLE OF CONTENTS (Continued)

11. How Leaching Systems Function. 47

12. How Products are Assigned an Effective Leaching Factor. 54

13. Leaching Systems in Soils with Slow Seepage. 57

14. Leaching Systems in Highly Permeable Soils. 61

15. Leaching Systems in Areas of Shallow Ledge. 64

16. Leaching Systems in Hardpan Soils. 68

17. Leaching Systems in Select Fill Material. 73

18. Submission of Engineering Plans. 82

19. Check List - Design Plans. 87

20. Repair Procedures. 86

21. Model Guideline for Limited System Repairs. 92

22. Home Buyer's Guide 95

PART II **SPECIFIC DESIGN CONSIDERATIONS**

23. Hydraulic Analysis - General Principles. 101

24. Methods of Estimating Soil Permeability. 111

25. Hydraulic Analysis - MLSS Examples. 123

26. Field Examination of Soils. 138

27. Identifying Sewage Pollution in Ground and Surface Waters. 139

28. Non-conventional Toilet Systems. 144

TABLE OF CONTENTS (Continued)

29. Holding Tanks. 150

30. Sewage Pumping Systems. 152

31. Distribution Boxes. 155

32. Siphons and Dosing Chambers. 157

33. Subsurface Sand Filters. 160

PART I

1. DOMESTIC SEWAGE

Subsurface sewage disposal systems designed in accordance with the requirements of Section 19-13-B103 of the Public Health Code, the Technical Standards and the engineering practices described in this manual are intended for the treatment and disposal of domestic sewage only. Domestic sewage consists of wastes incidental to the occupancy of a residence or small commercial building. It contains toilet wastes, laundry wastes, wash water, kitchen wastes and possibly wastes from garbage grinders. It may also contain small amounts of potentially dangerous chemicals such as paints and solvents which may be used in the home and which cannot practically be excluded from the disposal system. Wastes from small restaurants and commercial laundries are also considered as domestic sewage, although the composition is not typical, and therefore special design may be required for a subsurface sewage disposal system which receives them.

Table 2-1 lists the pollutants of concern in domestic sewage, the per capita contribution and the concentration range.

Table 2-1 - Pollutants in Domestic Sewage

Pollutant	Per Capita Contribution (grams/day)	Concentration in Domestic Sewage (mg/l)
Suspended Solids	35-50	200-290
Bio-chemical Oxygen Demand (BOD_5)	35-50	200-290
Total Nitrogen	6-17	35-100
Total Phosphorus	1-4	6-24
Grease & Oils	4-25	25-150
Coliform Bacteria	-	10^6-10^8 /100ml

A sewage containing chemical or biological pollutants and concentrations significantly outside this range, or which may contain non-biodegradable synthetic organics, carcinogens or biotoxins should not be considered domestic sewage, since it may not be properly treated or disposed of by subsurface sewage disposal systems designed to receive domestic sewage. These wastes must be disposed of in accordance with standards established by the State Department of Environmental Protection under permits issued by that agency. Following is a partial list of such wastes.

- Industrial process wastes
- Liquid agricultural manure
- Food processing wastes
- Car wash wastes
- Dry cleaning wastes
- Photographic wastes
- Slaughter house wastes
- Waste oils
- Waste from furniture stripping
- Milk Wastes

In designing and constructing a subsurface sewage disposal system, even one intended only for domestic sewage, it is necessary to know the various pollutants of concern in order to have an understanding of the possible effects on ground and surface waters. Following is a brief discussion of the various pollutants.

BIO-CHEMICAL OXYGEN DEMAND (BOD)

Bio-chemical oxygen demand, commonly referred to as BOD, is a measure of the amount of bio-degradable organic chemicals in the wastes. Sewage effluent contains a vast array of organic chemicals which are biodegradable to varying degrees under various conditions. It is not practical to measure them directly. Organic compounds are bio-degradable when common soil or water bacteria can utilize them as a source of energy or “food”. When these chemicals are discharged into ground or surface water, the bacteria will bio-chemically combine them with oxygen dissolved in the water to produce bacterial cells. This reduces the amount of dissolved oxygen in the water. The amount of dissolved oxygen removed from the water is in direct proportion to the amount of biodegradable organic chemicals present, and this is the way they are measured. The BOD_5 test is a measurement of how much dissolved oxygen is removed from aerated water inoculated with bacteria, mixed with a sample of the sewage and held under standard conditions for a period of five days. This measure is of great environmental significance because of the undesirable effects which it can cause.

Ground water is said to be polluted when it contains potentially harmfully bacteria or bacteria producing undesirable physical characteristics such as taste or odor. Removal or depletion of the dissolved oxygen in the ground water also can produce undesirable chemical changes. Certain minerals normally present in soils, such as iron and manganese, are chemically reduced to more soluble forms and readily dissolved by oxygen deficient ground water. Rust colored deposits occasionally are found in streams draining built-up areas containing many subsurface sewage disposal systems crowded together in a small area. These deposits do not result directly from bio-degradable organic chemicals in the water itself, but rather are due to the leaching of inorganic iron caused by oxygen deficient ground water. The soluble iron in the water is oxidized upon contact with the air producing the undesirable deposits.

A properly functioning septic tank will reduce the BOD in the effluent by about 25 to 30 percent. Greater reductions occur when the septic tank is compartmentalized. Further reduction occurs as the effluent comes in contact with bacterial growth in the leaching system and the aerated soil zone above the ground water table. The amount of reduction depends on the volume of bacterial growth in the leaching system, the manner in which the effluent is distributed throughout the system, the availability of oxygen and the contact time. A large leaching system constructed in moderately permeable soils and effectively dosed is quite efficient in reducing BOD, and is unlikely to cause any significant ground water pollution. On the other hand, leaching systems constructed in highly permeable soils, particularly where the ground water is shallow, may have an adverse affect on ground water, since in this case the amount of bacterial growth in the leaching system would be relatively small, distribution through the system might be quite irregular and movement of the effluent through the soil would be rapid.

NITROGEN

Nitrogen in domestic sewage and sewage effluent exists in different chemical forms depending on the degree of oxidation. Fresh sewage is high in organic nitrogen. This will first break down into ammonia nitrogen. In the presence of oxygen, ammonia nitrogen is quite rapidly oxidized, first into nitrite nitrogen (NO_2) and subsequently into nitrate nitrogen (NO_3). This oxidation process primarily takes place near the infiltrative surface of the leaching system. Nitrate nitrogen is an essential nutrient for the growth of plants and algae, and is an end product of any properly functioning leaching system. Nitrates are not readily removed by filtration through soil, so that ground water underlying a leaching system would receive a certain amount of nitrate "fertilization". Typically, septic systems remove approximately 30% of total nitrogen with the remaining 70% being discharged to the ground water.

There are many other nitrogen sources in the environment which also will contribute nitrates to the ground water, such as fertilizers, rotting vegetation and the atmosphere itself. For this reason, it is usually not practical or necessary to try to design small subsurface sewage disposal systems for nitrate removal. An exception to this might be in heavy developed lakeside property where nitrates from subsurface sewage disposal systems could be a significant source of nitrate fertilization of the lake water, which would cause undesirable algae blooms. Excessive nitrate levels in drinking water wells could be a hazard to the health of infant children who consume the water regularly. However, it is extremely unlikely that domestic subsurface sewage disposal systems could ever produce hazardous nitrate levels in wells as long as the separating distances required by the Public Health Code are provided.

PHOSPHATE

Phosphate in another nutrient which is essential for plant growth, but unlike nitrate, only a small amount may be required to stimulate a considerable algae growth in surface water. Domestic sewage contains small, but significant amounts of phosphates. Fortunately, research has shown that phosphates in sewage combine readily with certain minerals normally present in soils, such as iron and aluminum, to form insoluble deposits which are readily removed by filtration through only a foot or two of soil. Since these minerals are generally abundant in Connecticut soils, it is unlikely that properly designed subsurface sewage disposal systems would be a significant source of phosphate pollution.

COLIFORM BACTERIA

Coliform bacteria are a type of bacteria which are indigenous to the intestinal tract of humans and warm-blooded animals. Therefore, they are always present in sewage. While they are not necessarily harmful themselves, the presence of coliform bacteria indicates that disease causing pathogenic organisms might also be present. High concentrations of coliforms are found in the septic tank effluent and throughout the leaching system. They are removed by filtration through the soil and are rarely found to pass through more than three to five feet of unsaturated soil, or ten to fifteen feet of saturated, naturally occurring soil. It has also been shown that the survival of this bacteria seldom exceeds 10 days if confined to unsaturated soils. The principle factor determining the survival of bacteria in soil is moisture. In view of this, the minimum separating distances required by the Public Health Code between sewage disposal systems and wells or surface waters may seem to be very conservative. However, these separating distances are mainly based on the possibility of disease transmission by viruses in contaminated ground water.

Viruses are smaller than bacteria and are not as readily removed by filtration. Also, viruses are better able to survive in harsh environments than coliform bacteria, and therefore require a much longer time for natural die-off in ground water. Presently a 21 day minimum travel time is desired for proper viral renovation.

The presence of even one coliform organism in ground water may be taken as an indicator of possible sewage pollution. However, coliforms in surface waters do not necessarily indicate sewage pollution, since sewage is not the only source of coliforms in the environment. A more detailed discussion of coliform levels in surface waters may be found in Chapter 27 of this manual.

HAZARDOUS CHEMICALS

Domestic sewage must be considered to possibly contain some of the more hazardous chemicals such as paints, solvents and chlorinated hydrocarbons. These chemicals are considered to be hazardous because they will readily pass through a subsurface sewage disposal system and enter the ground water. Many of them are known to be cancer producing agents, and even small amounts of such chemicals in a water supply well could present a health hazard. Presumably, the amount of such chemicals in domestic sewage would be extremely small on the average, but some home activities as photographic development, furniture refinishing, metal working, arts and crafts could result in significant amounts of hazardous chemicals being discharged carelessly into the subsurface sewage disposal system. It is probably neither practical nor necessary to attempt to exclude such chemicals from all sewage disposal systems. However, special consideration should be given where domestic sewage systems are located within the drawdown area of a public water supply well. It may be necessary to limit the number of subsurface sewage disposal systems in such a location, in order to be assured that there will be sufficient dilution of these hazardous chemicals before they enter the water supply. Homeowners within public water supply aquifer areas should be educated about careless dumping of paints, solvents, etc., on the ground or into the subsurface sewage disposal system, and commercial or home businesses which generate such wastes may have to be restricted in these areas.

NON-TYPICAL DOMESTIC SEWAGE

Most domestic subsurface sewage disposal systems receive wastes from kitchens and laundries. The kitchen waste may sometimes include garbage grinders. However, there are occasions when a separate subsurface sewage disposal system is provided for this waste, or where the amount of such wastes received is disproportionate to the overall sewage volume. An understanding of the particular characteristics of each waste is necessary in order to properly design a modified subsurface sewage disposal system.

Kitchen wastes are relatively high in grease, containing approximately five times the concentration of domestic sewage. The wastes may also be quite warm due to the amount of hot water used in machine dishwashing. This, together with the high detergent level in the waste, tends to keep the grease in an emulsified condition so that it is not easily removed by floatation or settlement in the septic tank. Grease removal is enhanced by mixing the kitchen wastes with cooler sewage such as toilet wastes. For this reason, it is not advisable to construct separate systems for kitchen wastes.

Wastes from garbage grinders are extremely high in settleable solids, as would be expected. However, they are also very high in grease, due to ground-up foods, and BOD resulting from organic decomposition in the septic tank. Garbage grinders are not recommended for residential systems served by subsurface sewage disposal systems. Increasing the size of the septic tank will provide more storage volume for settleable solids, but it will not necessarily reduce the BOD of the effluent unless the tank is pumped frequently. Experience has shown that pumping the septic tank more frequently is more effective in preventing problems resulting from garbage grinders than by increasing the tanks size itself.

Laundry wastes are normally low in nitrogen and high in phosphates. This has a tendency to retard bacterial action in a septic tank which receives only this type of waste, but should have no adverse affect when discharged to a septic tank which also receives toilet wastes. Laundry wastes also contain cloth fibers called lint which bio-degrade very slowly. It also contains a surprisingly high amounts of oils and coliform bacteria, presumably shed from the body on soiled clothes. Laundry wastes can cause excessive clogging of soil by the formation of a mat formed from strained lint and emulsified oils, and by inorganic phosphates. Some type of filtration system for lint removal ahead of the septic tank is beneficial for commercial laundry systems**.** Outlet filters can also be utilized to prevent lint and other fibrous material from entering the leaching field.

The backwash from swimming pool filters is quite high in settleable solids, but the solids themselves are relatively stable. Pool filter backwash shall be directed to a dedicated leaching system or on to the surface of the ground as provided by DEP's General Permit for this type of discharge. It is not advisable to discharge the backwash into the septic tank serving the building since the hydraulic load created would have a tendency to wash solids from the tank into the leaching fields..

2. DETERMINING DESIGN SEWAGE FLOW

The Public Health Code specifies design requirements for subsurface sewage disposal systems serving residential buildings which are different from those serving non-residential buildings. There are two practical reasons for this. Firstly, it is logical to relate the size of the sewage disposal system to architectural features of the building served, wherever possible, since the system is a permanent attachment to the building. This can conveniently be done by basing the size of the sewage disposal system of a residential building on the number of bedrooms it contains. Secondly, subsurface sewage disposal systems serving owner-occupied dwellings must be designed on a much more conservative basis than those serving other buildings since it is almost impossible to condemn such a dwelling because of a failing sewage disposal system which cannot be corrected. The economic and social hardships presented by putting a family out of a home in which they have invested their life savings are such that regulatory officials usually must resort to less satisfactory abatement methods, such as holding tanks and reduced water use, which are objectionable to the residents and difficult to enforce. Non-residential buildings present a different situation, of course. A restaurant or other high water use facility may be converted to a retail store or low water use facility, without any undue economic hardship. Also, there is more latitude for the use of water reducing fixtures and water conservation. It probably also would be possible to condemn a non-residential building within the legal and political structure if abatement is impossible by any other means.

RESIDENTIAL BUILDINGS

The size of the septic tank and leaching system serving a residential building is related to the number of bedrooms, without consideration of the number of occupants or the water consumption. The requirements in the Technical Standards may appear to be extremely conservative, considering that the size of the average family has been decreasing and now consists of less than three persons, and considering that studies have shown per capita water consumption to average approximately 50 gallons per day. On the other hand, it must be realized that sewage disposal requirements cannot be based on average figures, since if this were done, one-half of all the systems would be substandard and in danger of failing. A factor of safety of 1.5 is required to bring the confidence level to over 90 percent, for the reasons previously described. Therefore, in water usage terms, the design flow for each bedroom has been set at 150 gallons per day. This is based on two occupants. each averaging 50 gallons per day, with a 1.5 safety factor applied. The 150 GPD per bedroom usage factor would be utilized whenever performing hydraulic analysis calculations for residential buildings. The leaching system sizing tables in the Technical Standards utilized this flow rate to determine the effective leaching area per bedroom. No new residential building should be constructed except on this basis of design.

REVIEWING THE HOUSE PLANS: The design of sewage disposal systems in repair situations is relatively simple due to the fact that the number of bedrooms in an existing house can be provided by the licensed installer, the design engineer or the property owner during the application phase of the repair process. If there is a question, the sanitarian could request the property owner to allow access to the dwelling in order to confirm the basis of design. This process becomes much more complex with respect to proposed new home construction, particularly when permits are requested and approved prior to the final determination of what the house may look like. For that reason, it is essential that the basis of design be based on very detailed house plans and those plans be incorporated as part of the sewage disposal review
process. In order to reduce the risk of any miscommunication, a copy of the house plans should be signed off by the health department and forwarded to the town building official prior to issuance of a building permit.

DEFINITION OF A BEDROOM: Within today's custom homes it is not uncommon to see exercise rooms , sewing rooms, studies, offices, dens, family rooms and other similarly labeled non-bedroom spaces shown on residential house plans. However, these same rooms can and are used as bedrooms when a family grows or the house is sold to another family which has different needs. To make sure the home is served by a sewage disposal system which is sized properly, the system must be based on the potential number of bedrooms in the house.

There are certain standards by which a room can be deemed a potential bedroom. They provide:

1. A defined habitable space per Building Code requirements. The exception to this statement would pertain to obvious future habitable space (such as the unfinished second floor in a "cape" style home) which has the appropriate structural shell but has not been "finished" to meet Building Code standards for habitable space.
2. Privacy to the occupants.
3. Full bathroom facilities (containing either a bathtub or shower) which are conveniently located to the bedroom served.
4. Entry from a common area, not through a room already deemed a bedroom.

Consideration should be given to the number of rooms in a new dwelling which may be used as bedrooms, even though the builder may not intend to use them as such. This is particularly true for homes built on speculation, since the builder has no control over who purchases the dwelling. Generally, all rooms on the second floor of a two story house, except for the bathroom and hallway, are considered bedrooms. Two bedrooms houses are allowed by the Public Health Code. However, such buildings would be expected to be relatively small in total floor area.

A significant number of homes are being constructed with habitable space above a two or three car garage. This space may be accessible from either the first or second floors or both. They are typically labeled as second floor playrooms or bonus rooms, may be quite large in area and have the potential to be a bedroom. Using the above criteria, this space should be deemed a bedroom when access is from the second floor and a full bathroom is readily available. The same designation would apply if access were provided from both the second and first floor. It would not be designated a bedroom if the only way to gain access to this area above the garage were perhaps from a first floor stairway when the first floor does not have a full bathroom facility, or access is from the garage.

Some latitude can be applied to the above when dealing with large homes, consisting of more than 5 bedrooms. It would not be unusual for this type of home to have a truly functional library, an exercise room, or a home office. However, before a bedroom designation can be made there should be some architectural feature which would typically exclude it from being used as a bedroom (such as, bookshelves around perimeter of library, sauna built into exercise room, etc.).

Rooms on the first floor of two story homes are generally easier to deal with. If rooms do not have access to full bathroom facilities on the first floor or are constructed with large archways, or, where entrance is through another room, they would not be deemed bedrooms.

Basement areas can be utilized for bedrooms in certain circumstances. Walk-out basements with large windows, sliding glass or conventional doors could allow the area to be converted to a bedroom in the future. The key to this situation is the availability of plumbing fixtures on this level of the house. Plumbing plans should be examined at the time of initial construction to determine if plumbing will be "roughed in" which would provide access for future bathroom facilities. If a full bathroom (with a tub or shower) is shown on the plans then all rooms in the basement area shall be considered bedrooms when they meet the aforementioned "potential bedroom" standards.

It is also a phenomenon of the 90's that large homes are being built for "small" families. The two person occupancy per bedroom used for design purposes is not realistic for many single family homes that exceed four (4) bedrooms (there are just not a lot of families which consist of 10 or more people). It is for that reason that a reduction in the sizing tables for leaching systems serving single family homes is being considered for homes which exceed four (4) bedrooms.

WASTE DISTRIBUTION: There may be a situation where a residence will be served by more than one subsurface sewage disposal system and the total sewage flow divided between the two systems, in accordance with the sanitary fixtures which they serve. This is not very desirable from the design standpoint since the characteristics of the wastes and the functioning of the sewage disposal systems may be altered. The Public Health Code requires that the subsurface sewage disposal system receiving the toilet wastes be large enough to meet the requirements for the entire house, and the other system to be at least one-half the size required for the full house. This requirement is based on the following normal distribution of sewage flow from a residence, with a factor of safety.

Usage	Per Cent of Total Flow
Toilets	40
Bath and Shower	30
Laundry	20
Kitchen	10

In most split systems, the toilet and bath water goes to one system and the kitchen and laundry to the other, although occasionally only the laundry system is separated.

The volume of sewage flow from a residence will fluctuate considerably during the course of a day, and from day to day. However, the peak discharge rate is not a critical factor in the design of a residential sewage disposal system. Peak flows are unlikely to exceed 100 gallons per hour or 20 gallons a minute, and these should not interfere with the functioning of a properly designed septic tank.

NON-RESIDENTIAL BUILDINGS

Non-residential buildings are designed on the basis of the estimated 24 hour sewage flow. A list of estimated flows for certain non-residential buildings is included in the Technical Standards. These figures include a factor of safety. Non-residential buildings also may be designed on specific flow figures obtained for the particular type of facility to be constructed. However, the design engineer must include a factor of safety in this figure. For instance, water consumption figures may be available for a chain of fast food restaurants or supermarkets which would be acceptable as a design basis for similar facilities in Connecticut. In such a situation, an average flow figure for 3 to 5 such establishments maybe used with a factor of safety of 1.5 to 2.0. Lacking any specific information, the flow figures in the Technical Standards should be used.

Unlike residential buildings, the peak flow for certain non-residential buildings may be a critical design consideration. Buildings such as churches and athletic stadiums have extremely high one day flows, but relatively low weekly average flows. In such a situation, the septic tank is normally designed for the peak day flow, but the leaching system could be designed for an average flow over a few days to a week providing there is sufficient storage volume in the leaching system to hold the peak flows. Sewage would fill up the leaching system during the peak day and leach away into the soil before the next peak. Leaching galleries or pits are usually used in order to provide sufficient storage of peak flows. Some facilities such as parks and recreational camp grounds have very high three day flow on certain week-ends, but lower flows during other times. The subsurface sewage disposal system should be designed for these peak flow periods.

SEWAGE FLOW REDUCTION BY USE OF SPECIAL SANITARY FIXTURES

Subsurface sewage disposal systems serving new buildings normally should not be based on a low design flow due to the use of sanitary fixtures which reduce the amount of water used. Such sanitary fixtures do not always prove to be acceptable to the users, and they may subsequently be replaced by conventional fixtures. This is difficult to prevent, particularly in residential buildings. However, there are situations where the use of low flow sanitary fixtures is desirable in order to abate an existing sewage overflow. The only reliable way to produce a significant volume reduction is by the use of special toilets or toilet appurtenances. Tank inserts may be used which reduce the volume of flushing water in the tank. Some toilets have adjustable flush controls which allow either a large volume or a limited volume flush. Other types have a specially designed bowl for a reduced flush volume. Connecticut has passed legislation which requires that all new toilets discharge a maximum 1.6 gallons per flush. In general, these types of low water flush toilets will reduce the volume of toilet wastes by 25 to 50 per cent and reduce the total sewage flow by 5 to 15 per cent produced from fixtures used in older homes. There are also available special toilets which provide only a minimum bowl rinse, or which use vacuum or compressed air assisted flushing water. In general, these toilets will use only about one gallon per flush and will reduce total sewage volume by 20 to 30 per cent. There are also non discharging toilets which would reduce the volume of sewage generated in a household by about 40 per cent. A more detailed discussion of the various types of low water use toilets may be found in Part II of the manual.

Pressure reducing attachments on shower heads and sink faucets also will tend to reduce water consumption. However, it is doubtful that it will produce much over 5 to 10 per cent reduction in total sewage volume. The amount of water used for sanitary fixtures other than toilets is controlled mainly by the habits of the users, not by the sanitary fixture itself. When the desire is strong enough, it is possible to make extreme reductions in water consumption. This has occurred in some cases, such as where a holding tank is used which must be pumped periodically at a considerable expense. However, it is not advisable to rely on reducing sewage volume in this manner.

3. SITE INVESTIGATION

The importance of the site investigation cannot be over-emphasized. A careless or incomplete site investigation which fails to identify soil limitations, such as seasonal high ground water or underlying ledge, is the cause of a high percentage of sewage disposal system failures. Certain planning must be done even before going to the site, and the investigation itself must be sufficiently thorough as to identify all the soil conditions which could affect sewage disposal. Reinvestigation is expensive and time consuming, and therefore is unlikely to be done simply to obtain information which was overlooked initially. If the investigation is done properly, immediately afterwards it should be possible to make a general conclusion as to the suitability of the site for sewage disposal purposes and specific recommendations for the design of the sewage disposal system. In certain cases, additional investigation for maximum ground water levels may be necessary, but it should be possible to develop a procedure and schedule for obtaining this information on the basis of the original site investigation.

PREPARING FOR THE SITE INVESTIGATION

There is a considerable amount of information relative to land use and development which sanitarians and engineers should review and be familiar with before making any site investigation. First of all, the investigator should know the type and size of the building which is proposed for the site. Obviously, large commercial buildings or apartments would require larger sewer disposal systems than single family homes, and therefore the area of the site to be tested must be larger. The investigator should also be familiar with local planning and zoning requirements. For instance, if 100 foot setbacks are required from watercourses, it would be foolish to test any area located within 100 feet of a stream. If the property to be tested is located within an approved subdivision, it is probable that the site has been tested previously. These tests results should be reviewed, if available, prior to the investigation, since they might be helpful in indicating the type of soil conditions to look for. The availability of public water supply mains and public sewers should also be checked prior to the investigation because these would have considerable bearing on determining the suitability of the site and the location of the sewage disposal system. A water supply well would not be necessary if the public water supply were available, and more of the lot area could be used for sewage disposal purposes. If public water supply is not available, it would mean that there may be wells on adjacent lots which must be located, either from review of health department records prior to the investigation, or from inquiries made during the investigation. Reserve area for enlargement of the leaching system will not be required if public sewers were scheduled within five years, so that the area to be tested could be reduced. Also, it would be likely that the sewage disposal system would be located between the proposed building and the street to facilitate the future sewer connection. It also may be necessary to check information regarding the location of high volume public water supply wells and public water supply reservoirs and watersheds. Special design considerations may apply in these locations, and the investigator should be aware of it before he goes on to the site.

Certain types of soil and geological information may be available on maps published by the U.S. Government. Review of these maps will be helpful in indicating the type of soil conditions to expect, but should not be used in place of a site investigation. The U.S. Geological Survey publishes a series of topographic maps on a scale of 1:24,000 showing ground contours, hydrographic features, such as streams, swamps, etc., streets and buildings. An effort should be made to locate the site to be tested on these maps before making the investigation. If this is not possible, the appropriate map should be taken along and the site located on the map in the field. An experienced investigator can tell much about a site from its location in the general topography of the area. The U.S.G.S. also publishes surficial geology maps which classify the soils overlying bedrock on the basis of their geological formation. The classification is not detailed, but can be helpful in identifying such features as flood plains, alluvial terraces and drumlins, which exhibit certain characteristic soil conditions. The National Cooperative Soil Survey published by the Soil Conservation Service, uses a more detailed soil mapping system. Soils are classified on the basis of certain characteristics, such as texture, structure, color consistency and drainage. The maps reflect soil profiles to a depth of about 5 feet. Therefore, they may be generally useful for evaluating soils for subsurface sewage disposal purposes. However, they are not sufficiently accurate to be used in place of a site investigation. Their main value is in indicating wetlands or soils with a seasonally high ground water table, which must be carefully evaluated before any sewage disposal system is designed. See the Chapter on “Soil Identification” for a more detailed discussion of the use of the soil survey maps.

Certain arrangements should be made by the applicant or his representative for the scheduled time of the investigation. Normally, a back hoe and operator, another person with a hand shovel and about 40 gallons of water are required. It also would be desirable to have on hand several 10 foot lengths of rigid plastic pipe which could be placed in the deep pits as monitoring wells for ground water before backfilling. A plot plan must be provided. As a minimum, the plan must show property lines accurately and indicate some landmarks which can be located easily in the field, such as stone walls, fences, survey markers or numbered utility poles. Property lines should be flagged or staked where suitable landmarks are lacking or are difficult to find, such as in proposed subdivision lots located away from existing roads. It may be necessary to do some clearing of trees and brush on the site to make it accessible to digging equipment. The owner, builder or engineer must be available on the site at the time of the investigation, in order to answer any questions which the investigator may have.

Engineers and developers should carefully consider testing needs prior to hiring a backhoe for site testing. If deep leaching structures are contemplated, such as galleries or pits, conventional rubber tired backhoes may have great difficulty in digging a deep enough test hole for evaluation. In such cases, it may be economical to rent a large, track-mounted backhoe for rapid, definitive exploration. Terrain and weather conditions may also dictate tracked equipment for efficient testing.

DETERMINING WHEN TO MAKE THE SITE INVESTIGATION

In general, site investigations may be made at any time of the year. However, on some sites it may not be possible to determine the maximum ground water level accurately unless the investigation is made during the season when the ground water is high. The Public Health Code gives the director of health the authority to require that the maximum ground water levels in areas of special concern be determined by investigation made between February 1 and May 31, or at such other times as the ground water is determined to be near its maximum level by the State Department of Public Health. This does not mean that all testing for ground water must be done at this time, even for areas of special concern. This frequently is unnecessary, and can present a hardship, both for the property owner and for the local health department. There are many sites where the maximum ground water level can be determined quite accurately by other methods, such as soil mottling. If there is general agreement between the engineer and the sanitarian as to the maximum ground water level and the design of the sewage disposal system, additional ground water investigation during the wet season may not be required. This is more fully discussed in the chapter on "Determining the Maximum Ground Water Level".

While the maximum ground water level almost always occurs sometime between February 1 and May 31, there may be other times when the level is sufficiently high to allow a reasonably accurate determination to be made of the maximum level. The State Department of Public Health utilizes monitoring information supplied by the U.S. Geological Survey which documents monthly ground water levels in various locations throughout the state. When levels are found to be at or above mean springtime elevations, the allowable testing period may be extended by the State Department of Public Health. Variations in water levels in the U.S.G.S. wells are used as an indicator of the general ground water levels within a town or region. The range of such variations may be quite different from well to well, however, depending on the construction of the well and its geological and topographic location. Water level readings in observation wells cannot be used to adjust ground water level readings taken at other locations. For instance, the water level in an observation well which seasonally rises and falls about three feet may be observed to be one foot below its normal maximum. This does not mean that the maximum ground water level at another location can be determined by adding one foot to the observed level at that location, since the ground water level at that particular location may rise and fall seven feet during the year.

The real danger in making site investigations during a dry season is not the inability to determine the maximum ground water level accurately, since this also can be done by additional investigation or monitoring during a wetter season. Rather, it is the possibility that a seasonal ground water condition may be completely overlooked. This probably is more likely to occur where the soils are fairly well drained, than where the soils are poor and evidence of seasonal ground water is obvious. For this reason, some town health departments do not allow site investigations to be made during certain months of the year. Fortunately, experience has shown that 80 to 90 percent of the time that an investigator had failed to identify a seasonal ground water condition was when the investigation was made during the months of July, August or September. Therefore, there probably is some basis for restricting site investigations during those months. However, there is little justification for requiring all site investigation to be made only during the wet season, since a trained and careful investigator should be able to make a valid assessment of ground water conditions at most times of the year. A technique sometimes used in dry soil conditions in order to enhance coloration and improve identification of mottles is to moisten the side of the test hole with water from a spray bottle.

MAKING THE SITE INVESTIGATION

Before any test holes are dug, the investigator must determine the location of the property lines, the probable building location and the location of existing wells on adjacent property. It should be kept in mind that the sewage disposal system normally is located down slope from the building served, in order to allow gravity flow without placing the leaching system too deep in the ground. Some investigators make the mistake of testing the highest part of the property because it appears to have the best soil. In fact, this would be the least likely area to be used for sewage disposal purposes. The well, if required, should be located on the higher portion of the lot, uphill from the sewage disposal system. However, the location of both well and sewage disposal system may depend on the location of wells and sewage disposal systems on adjacent lots.

Once a likely location has been selected, the probable depth of the leaching system must be decided. Leaching systems on a level lots are usually somewhat deeper than on sloping lots, and if it is necessary to locate the sewage disposal system upgrade from the building, it could be quite deep. If leaching pits or deep leaching galleries are used, the bottom of the leaching system could be up to eight or ten feet deep. It also should be determined from the builder whether or not basement fixtures will be used. Split level houses and raised ranch houses usually require deeper sewers, since sanitary fixtures are on the lower floor. The builder should be questioned about this. It should also be determined whether or not there will be any regrading done in the area of the building and sewage disposal system, since this will affect the depth to which the soil must be tested.

MINIMUM NUMBER OF DEEP TEST AND PERCOLATION HOLES

A minimum of two or three deep test holes should be dug in the area of the proposed leaching system to a depth of four feet below the probable bottom of the deepest leaching unit. Such holes are normally at least seven feet deep and may be considerably deeper. At least one percolation test should be conducted at the probable depth of the bottom of the primary and reserve leaching system areas. A much greater number of deep pits and percolation tests should be made if there are any significant variations in the soil characteristics, either in depth or from location to location, or if shallow ledge rock is found. An effort should be made to lay out a series of test holes in a grid arrangement where the sewage disposal system is large and will cover a considerable area, since this would provide more meaningful information than randomly located holes. At each test hole, the soil should be identified and the depth to ledge and ground water noted. When determining the percolation rate for sizing purposes, the Technical Standards require that it be based on representative test results. The number of percolation tests performed should be a function of the consistency of the results. If the soil conditions throughout the primary system area (and the reserve area if located directly downgrade of the proposed primary area) are consistent and the two initial percolation tests resulted in rates that are within the same sizing category than there would not be a need for further testing. However if the initial test results are not consistent then multiple percolation tests would be required. Tests would be concluded when 3 out of 4 percolation tests (75% or greater) resulted in rates which are within one sizing category.

The location of each deep test and percolation hole must be measured from a landmark and recorded on the plot plan or in the field notes. To avoid confusion, a north orientation should be determined or assumed in the field, and marked on the plot plan. The U.S.G.S. maps are helpful for this purpose. This should be the responsibility of the engineer or surveyor, if one is involved in the investigation. If the test holes indicate a probable seasonal high ground water condition, an. effort should be made to obtain as much information as possible relative to existing and proposed drainage improvements. Existing and proposed storm drains in the street should be noted because they may be necessary if foundation or curtain drains are required. Note also should be made of potential surface water drainage problems which might be caused by building or regrading, both on the property being investigated and on the adjacent property. These should be addressed on the sewage disposal plan before it is approved.

4. SOIL IDENTIFICATION

There are many ways that soils can be identified or classified. Geologists generally classify soils according to how they were formed, using such terms as "alluvium" or "terrace deposits". Soil scientists from the U.S. Conservation Service classify soils on the basis of the profile of the upper few feet of soil. Soils that have profiles nearly the same are given series names, such as "Paxton" or "Woodbridge". Civil engineers identify soils by describing their physical appearance, such as "light brown medium sand with a trace of silt". It may be difficult to understand how the same soil can be identified in three different ways. The fact is that soils do not exist in a limited number of distinct, uniform and consistent types. Rather, the variability of soils is infinite. They have been identified and classified by scientists or engineers in different ways for different purposes. Geological maps are used mainly to identify soil deposits for mining, aquifer development or large scale construction. The SCS soil survey maps were developed for agricultural or land use planning purposes, and the soil designations used by civil engineers are related to their use for construction purposes.

The civil engineering method of describing soils is the most useful one for subsurface sewage disposal purposes, since this is basically a construction activity. However, leaching systems normally are constructed in naturally occurring soils, and therefore information obtained from other sources, such as the soil survey maps, may also be quite pertinent. Satisfactory identification of a soil depends mostly on the experience and thoroughness of the investigator. The system of identification serves to record and transmit soil information in a clear and consistent manner so that it may be used for certain purposes, in this case the design of subsurface sewage disposal systems.

EXAMINING SOILS

Soils in a test pit must be examined at close range and felt with the hand. Examining the soil after it has been excavated can be misleading. For instance, hardpan often will have the appearance of a sandy or silty loam when broken up. The degree of compaction of a soil layer is difficult to determine unless the investigator enters the test pit and probes the sides of the pit with a stick or shovel. This also is necessary in order to determine the exact level at which changes in soil characteristics occur. These must be measured from a fixed reference point, normally the ground surface, so that the elevation of the various soil layers can be calculated and the leaching system elevation set properly relative to these layers. This cannot be over-emphasized, since a mistake of six or twelve inches in the elevation of a leaching system relative to hardpan or groundwater could cause the system to fail.

Coarse grained soils, such as sand and gravel, are readily identified by rubbing the soil between the fingers. However, some care should be taken to note the size and shape of the grains. Flat grained soils will compact easily and may cause trouble with leaching systems, particularly when used as fill material. Sand and gravels to be used as fill should be examined as to the uniformity of the particle sizes. If all of the particles are approximately the same size, it would be good for leaching purposes, but if there is wide range of particle sizes, it would be poor for this purpose. It should be noted that the term "well graded" is used to refer to a soil which has a wide range of particle sizes. The term originated because this type of fill material was best suited to road construction. It certainly would not be "well graded" for the purposes of sewage disposal.

Fine grained soils, such as silt, clay and even very fine sand, are difficult to differentiate either by sight or feel. Almost all Connecticut soils contain silt, and determination of the approximate amount of the silt in the soil is a critical consideration, since even small percentages of silt will greatly reduce the ability of a soil to transmit water. The amount of silt in a sand or gravel may be determined by placing a spoonful of the soil in a glass of water. The sand and gravel grains will settle almost immediately, while the silt particles will still be in suspension after five or ten minutes. Determination of the amount of silt in a loamy soil is more difficult. One way this can be done is by observing how easily the soil surface is smeared by digging equipment or in the hand, when moist. Soils with high silt content can be formed into a clod which can be handled without breaking, and when dried and pulverized on the hand, will have a feeling like flour or talcum powder. Some purer silts, lacking binders such as clay, will become elastic when saturated, and water may be squeezed from them. Soils with high clay content are rare in Connecticut and there normally is no need to differentiate them from silty soils. Where clays do occur, they usually are prevalent throughout a general area. Experienced investigators normally are aware of this and may take special care to identify and avoid these soils. A more detailed description of methods for field identification of soils is included in Section II.

The soil color should be noted, since it is a good indicator of how well drained it is. Light brownish, yellowish or reddish colors indicate that the soil is well drained and aerated. Bands or mottles of brighter color should be noted, particularly if they are interspersed or underlain by layers of grayish soil. This may indicate a seasonal or perched water table. Grayish or dark colors indicate poorly drained soils.

The firmness of each soil layers should be noted. Some generally firm soil layers may have narrow bands of looser, sandy soils which should not be overlooked. Similarly, some coarse grained soils are extremely stratified, with thin layers of silt which may not be readily apparent. Ground water seepage and soil dampness must also noted, and the level measured. Such seepage does not always occur immediately, so that the test pits should be left open and reinspected after an hour or so. The observed ground water table is normally recorded as the highest level at which seepage is noted. The depth to the bottom of the pit must also be measured so that it is understood that there is no information available on soil characteristics below that level. The presence of ledge rock or refusal should be noted. Occasionally, it is difficult to determine whether refusal is caused by ledge or by a large bolder. In such a case, another pit should be dug about ten to fifteen feet away. If refusal is found in this pit also, it can be assumed that ledge is present. The ground will vibrate when a boulder is struck or scraped by a backhoe. An experienced investigator or backhoe operator is unlikely to mistake a boulder for ledge.

DESCRIBING SOILS

Each layer of soil with different physical characteristics, such as particle size, color or compactness, should be described separately, and its boundary levels noted. Soils usually are described as gravel, sands, silts or clays, depending on their dominant particle size, in accordance with the following table:

Soil Type	Particle Size		Example#	Sieve Size
	(inches)	(mm)		
Gravel	3.0 - 0.19	76 - 4.75	Lemons to peas	3” - #4
Coarse Sand	0.19 -0.08	4.75 - 2.0	rock salt	#4 - #10
Medium Sand	0.08 - 0.02	2.0 - 0.425	sugar	#10 - #40
Fine Sand	0.02 - 0.003	0.425 - 0.075	powdered sugar	#40 -#200
Silt	.less than 0.003	0.075-0.002	talcum powder	pass #200
Clay		Smaller than 0.002	-	pass #200

Most soils are a mixture of particle sizes, and therefore are described as a mixture of soil types, such as "silty sand" or "fine sandy clay". A "silty sand" has the predominant characteristics of sand, but contains a significant amount of silt. A "fine sandy clay" is essentially a clay, but contains an identifiable amount of fine sand. A more sophisticated system for describing mixed soils sometimes is used, as follows, although the accuracy of such a description must be suspect unless a sieve analysis is made.

Descriptive Term	Percentage Range
"And"	More than 40%
"With"	30 to 40%
"Some"	20 to 30%
"Little"	10 to 20%
"Trace"	Less than 10%

There are other terms used to describe soil which are more general but which can be useful if properly used. "Loam" is frequently used to describe a mixture of loose sand, silt and clay. This term is usually modified by describing the predominant soil type in the mixture, such as a "sandy loam" or "silt loam". Another descriptive term commonly used is "hardpan". This refers to a soil layer which is significantly more compact than the overlying soils layers. While the physical characteristics of "hardpan" may vary somewhat, the term is useful in describing a silty, compact soil layer commonly formed in glacial till soil. The term "top soil" needs no explanation, and is meaningful when used in connection of leaching systems.

A soil identification may be as follows:

0 - 6	inches - top soil
6 - 30	inches - light brown medium sandy loam, some stones
30 - 48	inches - clean, medium sand. Mottling at 36 inches to 48 inches.
48 - 86+	inches - firm, silty sand. Groundwater at 54 inches.

USING THE SOIL SURVEY MAPS

Some mention should be made of the S.C.S. soil survey maps and their use in identifying soils for subsurface sewage disposal purposes. These maps are useful, but are not sufficiently detailed to eliminate the need to dig test pits. The soil maps indicate the predominant soil type within a particular area, but that does not necessarily mean that all of the soil within that area is of the designated type. There generally are small areas of other related soil types within any delineated area. The amount varies, depending on the complexity of the soil pattern on the landscape and the skill of the soil scientist who mapped the area. Soil scientists know this, and usually are willing to gather more detailed information on a particular piece of property, if it would be helpful. Information shown on soil maps generally is not precise enough for design purposes since it is necessary to have a range of physical characteristics within each soil type. Soil maps are most reliable in identifying seasonal ground water conditions, and find their greatest use for this purpose. They are also quite reliable in identifying the existence of underlying layers of compact soil. However, the depth to these layers and the degree of compaction may show some variation within the same soil type. This could be critical in the design of a leaching system. It is generally acknowledged that the maps are less reliable in identifying underlying ledge rock because of the wide topographic variations of this material.

5. PERCOLATION TESTING

The percolation rate is not a measure of any one physical property of a soil, but is generally related to the rate at which a soil will disperse liquid by capillary uptake. When properly performed, the percolation test provides a valid basis for determining the necessary amount of leaching area in a subsurface sewage disposal system. Although there is a general relationship between the percolation rate and the soil permeability, this relationship is not sufficient to indicate possible hydraulic restraints in the surrounding soil layers. This can only be done by considering site-related conditions, such as soil permeability, ground slope, size and configuration of the leaching system, and depth to ground water, ledge or hardpan.

PERFORMING THE TEST

The Technical Standards state that when calculating the required leaching area, only representative tests results in the area and at the depth of the proposed system be used. Care must be taken to insure that only one soil layer is being tested at a time. Since the test is made in only the bottom 12 inches of the hole, frequently the top 1« to 2 feet of soil is stripped away by a back hoe to make the test hole easier to observe and measure. The hole itself is hand dug with a shovel or post hole digger. There should be no large stones or boulders on the bottom or side of the hole which could give misleading results. A fixed reference point is established, usually consisting of a stick or nail on the side of the hole or across the top. From this point, the depth to the top of the water in the hole is measured at regular intervals and recorded. The time that the reading was made is also recorded. The depth of the bottom of the test hole below ground surface must be recorded in order to relate the percolation rate to the various layers of soil. Table 5-1 shows the way that the data is tabulated from a typical percolation test.

TABLE 5-1 Calculation of Minimum Percolation Rate

Field Data		Calculations		
Time	Reading (Inches)	Elapsed Time (Minutes)	Drop (Inches)	Percolation Rate (Minutes/Inch)
9:45 AM	7			
9:50 AM	10 1/2	5	3 1/2 = 3.5	5/3.5 = 1.4
9:55 AM	13 1/4	5	2 3/4 = 2.75	5/2.75 = 1.8
10:00 AM	15 1/4	5	2	5/2 = 2.5
10:05 AM	16 1/4	5	1	5/1 = 5.0
10:10 AM	16 3/4	5	1/2 = 0.5	5/0.5 = 10.0
10:15 AM	17 1/8	5	3/8 = 0.375	5/0.375 = 13.3
10:25 AM	17 3/4	10	5/8 = 0.63	10/0.63 = 15.7
10:35 AM	18 1/4	10	1/2 = 0.5	10/0.5 = <u>20.0</u>
10:50 AM	19	15	3/4 = 0.75	15/0.75 = <u>20.0</u>

The data to the left two columns must be recorded in the field, while the remainder of the data may be calculated later. However, it is desirable to calculate the percolation rate while the tests are being done in order to determine how long the readings should be made and whether additional tests should be made at different locations or depths. The percolation rate is calculated as follows:

1. The drop in water level is found by subtracting the previous readings of the depth to water from the current reading.

2. The elapsed time is found by subtracting the previous time reading from the current reading.

3. The percolation rate is found by dividing the elapsed time by the drop in water level.

Figure 5-1 shows graphically how the percolation rate in a typical test hole will decline as the test proceeds, reaching a relatively uniform rate after 30 to 60 minutes. This relatively uniform rate is taken to represent the minimum percolation rate referred to in the Public Health Code.

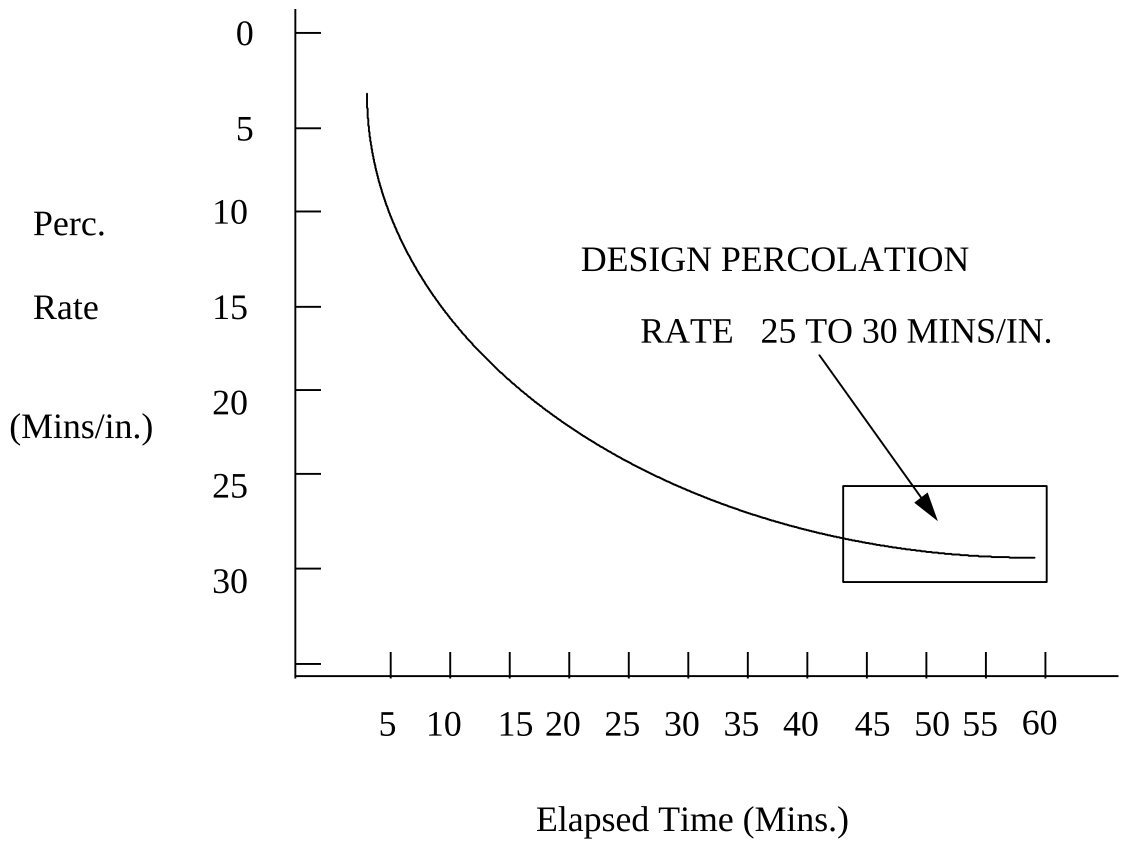


Figure 5-1 - Percolation Test

TESTING INTERVALS: Due to the nature of the testing procedure, erratic fluctuations sometimes occur when calculating percolation rates between timing intervals. This is mainly due to errors in reading a ruler when the drop in water in the hole is relatively small because of the combined effect of slow soils and a short time frame between readings. To reduce this effect it is recommended that the time intervals between readings increase in proportion with the slowness of the percolation rate. It is suggested the following table be utilized when performing a percolation test:

TABLE 9-2 SUGGESTED TIME INTERVALS BETWEEN READINGS

INTERVAL PERCOLATION RATE	SUGGESTED TIME INTERVAL

Faster than 1.0 minute/inch	Less than every 2 minutes
1.0 to 5.0 minutes/inch	Every 2 to 5 minutes
5.1 to 10.0 minutes/inch	Every 5 to 10 minutes
10.1 to 20.0 minutes/inch	Every 10 to 15 minutes
20.1 to 30.0 minutes/inch	Every 15 to 20 minutes
30.1 to 45.1 minutes/inch	Every 20 to 30 minutes*
45.1 to 60.0 minutes /inch	Every 30 minutes**

* Test expanded to approximately 1.5 hours   ** Test expanded to approximately 2.0 hours

EFFECT OF FIELD CONDITIONS ON TEST RESULTS

As with most tests which are performed in place, the results of the percolation tests may be affected by certain field conditions prevailing at the time of testing. The sanitarian or engineer must be careful to look for conditions which might affect test results, and use judgment in performing the test and evaluating the results. Of principal concern is the ground water level relative to the test hole and the soil moisture content at the time of testing.

The percolation test must be done in unsaturated soil above the ground water table, since it is greatly affected by capillary dispersal into the soil. Furthermore, when the bottom of the test hole is close to the ground water table, the capillary water zone above the ground water table may interfere with capillary dispersal from the test hole. Percolation tests may be misleadingly slow if the test hole is located only a few inches above the water table, and it may show no percolation if located partly below the ground water table. It is surprising how many times investigators fail to look for ground water before making a percolation test, particularly in relatively tight soils or during the spring of the year. Wherever possible, the bottom of the percolation test hole should be located at least 18 inches above the observed ground water table. Where this is not practical, the ground water level should be noted with the test results so that a proper evaluation of the test results can be made when designing the leaching system.

Seasonal variations in soil moisture also will affect percolation test results. Percolation tests made during the early spring, when soil moisture is high, will be somewhat slower than those made during the late spring or fall, when the soil moisture is lower. However, the requirements for leaching area in the Public Health Code are based on percolation tests made when the soil is only slightly moist, and therefore there is no need to require that all percolation tests be done during the early spring. Such a requirement could present a hardship to both builders and sanitarians. Percolation tests made during the months of July, August and September, when the soils may be very dry, can give erratic results. In some soils, the percolation rate results are somewhat faster than normal, while in other soils the results are somewhat slower than would be expected. The faster than normal results probably are due to silt shrinkage and cracking, and the relatively short presoaking period specified in the Code. The slower than normal results may be due to entrapment of air bubbles in dusty soils, which are not adequately purged by a short presoak period. The elimination of percolation testing during the driest time would eliminate misleading results, but this may create some hardship and additional expense. Most investigators have found it more practical, and just as safe, to oversize leaching systems which are designed on the basis of percolation tests made during the dry months of July, August and September. Experience has shown that the variation in percolation test results obtained in dry and moist soils will not exceed one category in the range of percolation rates shown in the tables for required leaching system capacity in the

Technical Standards. Therefore, most investigators and health departments have adopted the policy of using a leaching system that is one category larger than required when the percolation tests were done during an unusually dry period. For instance, if a minimum percolation rate of 1 inch in 7 minutes were obtained in August, the designer would use 675 square feet of leaching area for a three bedroom house, rather than 495 square feet, to compensate for possible variation in percolation test results due to soil dryness.

OTHER FACTORS AFFECTING TEST RESULTS

The condition of the soil interface in the percolation test hole can affect the results. Washing silt into the hole when pouring the water or smearing the soil surface during digging may cause artificially slow percolation test results. On the other hand, lining the hole with burlap or filling it with stone may give an artificially fast percolation rate. In general, the percolation test holes should be tested no differently than the excavation for a leaching system would be treated. The depth of water in the test hole can have some effect on the readings. This effect is not significant, however, as long as the water depth during the test is not over 12 inches or less than 4 inches. The width of the test hole also has an effect, and it is important to follow the Code requirement that the percolation test be made in a 6 to 12 inch diameter hole. Placing 100 gallons of water in the bottom of a pit excavated by a back hoe and observing how quickly it seeps into the soil, is not a meaningful test of any kind.

Percolation tests should be conducted at least 18” above actual groundwater levels. However, there are circumstances whereby this may not be possible (water table is less than 30” below the surface of the ground on the day the test is conducted). Under these conditions a percolation test can be run knowing full well that the results will be somewhat slower than if the water table was the proper distance below the percolation hole. The intent of the code is to prevent deeming a soil impervious based on a percolation test which has been performed too close to the water table. In such a case the area would have to be dewatered by installing a curtain drain or the test would have to be postponed to a drier time of the year.

6. DETERMINING THE MAXIMUM GROUND WATER LEVEL

"Maximum ground water level" as used in the Public Health Code refers to a relatively static ground water table which exists for one month or more during the wettest season of the year. It does not refer to a short term "perched" water table, a capillary water zone, or a temporary subsurface flooding condition which may occur following a heavy rainfall or snow melt. All of these ground water conditions are significant, however, and must be recorded and taken into account in designing the leaching system.

There are several reasons why it is not necessary to attempt to determine the absolute maximum ground water level. Experience has shown that short periods of moderately high ground water are unlikely to cause a leaching system to fail, as long as the system itself does not fill with water. Furthermore, high ground water levels of short duration are difficult to detect, since they do not last long enough to leave indications of high ground water, such as soil mottling or wetland vegetation. Most importantly, a high ground water table which lasts for a month or more is very likely to be caused by hydraulic limitations of the soil or topography, not by temporary conditions of rainfall or flooding. Logically, leaching systems should be designed on these hydraulic limitations rather than on something as unreliable as weather conditions prior to the time of the site investigation.

The ground water table is the upper boundary of a continuous zone of saturated soil. The water level in a pit or observation well will rise to the level of the ground water table over a period of time. The ground water generally rises and falls with the ground surface, but normally is deepest near the top of the slopes and shallowest near the bottom. Ground water flows from higher elevation to lower elevation. Therefore, the direction of ground water flow can be determined by the relative elevation of the ground water table at various locations. This can be important in determining the location of water supply wells and ground water drains in relation to leaching systems, particularly on relatively flat lots where the slope of the ground surface may not indicate the direction of ground water flow. Changes in ground water depths at various locations or over a period of time can also be used in calculating the soil permeability and the capability of the site to disperse sewage effluent. Therefore, it is always advisable to record water levels at several locations.

VARIATIONS IN GROUND WATER LEVELS

The level of the ground water table fluctuates seasonally, with the greatest fluctuation occurring in the less permeable soils. Silts, clays and hardpan with minimum percolation rates poorer than 1 inch in 60 minutes will show no evidence of a ground water table during the driest months, but will be completely saturated for a month of more during the wet season. For this reason, such soils are considered unsuitable for leaching purposes. Year to year variations in rainfall will affect the duration of the maximum ground water level, but appears to have little effect on the maximum level, itself. In an extremely dry spring, the ground water may be at its maximum level for only a week or two, while it may be at its maximum level for three months or more during an extremely wet year.

In addition to seasonal fluctuations in the ground water table, heavy rainfall or snow melt can cause short term subsurface flooding conditions which will raise the ground water table above its normal maximum level. Such short term flooding should not last more than a few days to a week, and will not adversely affect the functioning of a properly designed leaching system. Of course, the ability of the leaching system to disperse liquid into the surrounding soil is reduced as the ground water level in the soil rises. When the dispersal rate is less than the rate at which sewage is discharged, effluent will accumulate in the leaching system. However, leaching systems designed in accordance with Code requirements contain a relatively large volume of hollow spaces, either in the stone or the hollow leaching structure, which normally would be sufficient to store any excess volume of sewage accumulated during a period of high ground water not exceeding one month in duration.

Flooding conditions become more serious when the ground water level rises above the level of the bottom of the leaching system, since not only is the dispersal rate severely restricted, but the storage capacity of the leaching system also is reduced. Sewer backup will occur when the ground water level rises to the level of the distribution pipe in the leaching system. For this reason, the

Public Health Code requires that all leaching systems must be protected from flooding. Leaching systems located in low areas are more subject to flooding by both ground and surface water than those located on slopes. Such systems routinely should be kept higher above the probable maximum ground water level. Leaching systems on flood plains must be elevated above normal spring flooding levels. It is neither practical or necessary from the public health standpoint to elevate such systems above any flood level occurring less frequently than every five or ten years. Flooded leaching systems do not pollute ground or surface waters, since they are not functional when flooded. They are an inconvenience to the property owner who cannot flush his toilet during this time, but there is a question as to how much importance regulatory officials should assign such a condition when it may occur for only a day or two, every five to ten years.

PERCHED GROUND WATER

Ground water is said to be "perched" when there is an underlying layer of slowly permeable soil which restricts its downward movement. Water will accumulate on top of this layer and move laterally in a downhill direction. Perched water tables are seasonal in nature, developing when the rainfall exceeds the ability of the underlying soil to disperse it. The duration and severity of the condition is quite variable, depending on the tributary drainage area, the ground slope, and the relative permeability's of the upper and underlying soil layers. Most hardpan soils in Connecticut would be expected to develop a perched water table under certain conditions. This may last only a few hours following a heavy rainfall, or it could last for three months or more during the wet season. With proper design, most perched ground water conditions can be controlled, and it may not be necessary to keep leaching systems 18 inches above a perched water level. See the chapters on "Ground Water Control Drains" and "Leaching Systems in Hardpan Soils". Perched ground water, as indicated by high level seepage from the side of an observation pit, must not be disregarded or overlooked during the site investigation. Unless controlled, perched water flowing down from higher elevations usually will flood leaching systems constructed below the perched water level, causing them to fail.

Soil dampness occasionally is noted above the static water table. This results from capillary action, and is most apparent where the soil consists of a fairly uniform fine sand or silt. It is not necessary to keep the bottom of the leaching system 18 inches above this capillary water zone. However, leaching systems constructed close to or within the capillary zone will disperse liquid more slowly than those constructed in dry soil. This can be compensated for if the design of the leaching system is based on percolation tests made completely within the capillary zone, not in the dry soil above it.

INDICATORS OF SEASONAL HIGH GROUND WATER

The best way to determine the maximum ground water level is to make the site investigation during the spring of the year when ground water is high. This is not always practical, and it may be unreasonable to require that all soils be tested during this time period. Whenever the site investigation is made, the investigator must look for certain characteristics of soil and topography which may indicate a seasonal high ground water level, or give an indication of the maximum level to which ground water may rise during the wet season. On some sites, these indicators might be conclusive enough to serve as a basis for designing the leaching system, while on other sites they may be inconclusive, but would serve to indicate the need for reinvestigation or monitoring ground water levels during the spring.

Soil mottling is one of the best indicators of seasonal ground water. Mottling consists of contrasting patches of color in the soil, and may be either gray, orange or reddish. The variations in color is caused by a chemical oxidation of certain minerals containing iron. Orange or reddish mottles indicate oxidized iron and a relatively well aerated zone of soil. Gray mottling indicates that poor soil aeration has kept the iron minerals in a chemically reduced state. Orange and reddish mottling frequently is found in the capillary water zone just above the seasonal high ground water level. Much of the ground water evaporation takes place in this zone, and it is probable that over a period of years a certain amount of soluble iron is deposited at this point as the ground water evaporates. A layers of relatively bright orange or reddish mottles separating an upper layer of tan or brownish soil from an underlying grayish soil is a reliable indicator of the seasonal maximum ground water level. However, investigators should not rely too heavily on indistinct or non-typical soil mottling, or on the absence of soil mottling. Such indications are best interpreted by an experienced soil scientist.

There are several situations where soil mottling or its absence can be misleading. Frequently, stratified deposits of sand and gravel will show distinct orange or reddish mottling well above the maximum ground water table. This appears to be caused by capillary retention and evaporation of rainfall runoff in layers of fine grained soil, causing deposition of iron in these layers. Perched water tables may also cause some mottling above the normal maximum ground water level. A careful examination usually will reveal both reddish and grayish mottles where seasonal perching is significant. Certain deposits of light colored silica or "beach" sand do not contain enough iron bearing minerals to cause mottles. The absence of mottling in these deposits does not indicate that there is no seasonal high ground water. Some Connecticut soils, particularly in the Central Valley, are highly colored throughout, and mottles are extremely difficult to detect. Examination of these soils for mottling is best left to experts.

Surface slopes and elevations, soil type, underlying ledge rock or hardpan, and general topography also are indicators of possible high seasonal ground water. Wetland vegetation and shallow tree roots indicate seasonally wet soil and a need to monitor ground water levels during the wet season. Publications on wetland plants may be obtained from the State Department of Environmental Protection.

MONITORING GROUND WATER LEVELS

Where the site investigation indicates a seasonal high ground water, but the probable maximum level cannot be determined, an observation well should be constructed so that the ground water level can be measured periodically during the wet season. Such monitoring should reveal the normal maximum ground water level referred to in the Public Health Code, as well as any short term subsurface flooding condition which may occur. Care should be taken to record the date as well as the ground water level at each reading so that the duration of the high ground water level and its relationship to season and rainfall can be established. This is extremely valuable information when designing a leaching system in an area where seasonal ground water is severe. Monitoring wells are also used in questionable areas to establish the effectiveness of ground water intercepting drains.

DURATION OF MONITORING: Section 19-13-B103d.(e)(2) of the Public Health Code states that the investigation for maximum ground water levels be made between February 1 and May 31 (designated wet season), or such other times when ground water is determined by the Commissioner of Public Health to be near its maximum level. The interval was set over that long a time frame because in Connecticut each year the median maximum peak for ground water is usually reached within that particular period of time. Since no one can predict when ground water will reach peak conditions within any one year, monitoring should be conducted throughout the designated wet season interval. If while monitoring maximum peak ground water levels are observed (documented by the U.S. Geological Survey for the region of the state being observed) monitoring may be discontinued prior to the end of the defined wet season. However if monitoring commences following the start of the designated wet season (February 1) it will be at the applicants risk. Monitoring during a partial wet season will only be valid if a median peak ground water level is reached in the region during the actual monitoring period.

MONITORING WELL CONSTRUCTION: Monitoring wells are easily constructed by placing a length of 4 inch diameter plastic sewer pipe upright in the deep observation pit before it is backfilled. Solid pipe should be used rather than perforated pipe to prevent loose soil and silt from collecting in the pipe. In particularly silty soils, it may also be necessary to place some stone or filter fabric around the open end of the pipe before it is buried. It is not necessary to place stone or gravel completely around the pipe, since the back fill is loosely compacted and readily transmits water. However this technique may lead to erroneous results since the entire pit serves as the groundwater collector, so that both perched and static groundwater are measured. Surface water may also collect around the well, giving misleading results. The ground should be mounded up in this area so that surface water does not puddle around the pipe.

A preferred method of installation would consist of digging a relatively small diameter hole (8-12 inches) down to a depth which would be at least two (2) feet below the proposed leaching system. Place stone or sharp sand on the bottom 3” of the hole; then place a solid or slotted 4” PVC pipe upright in the hole. Once placed, the pipe should be surrounded by stone or sharp sand to within 6” of the surface of the ground. Soil should then be packed around the pipe making sure that it is “mounded” above grade level to prevent surface water from entering the monitoring well. The extension of the pipe above grade should not be such that it will hinder the actual monitoring procedure (See Figure 6.1)

ANALYSIS OF THE RESULTS: In many cases it is not necessary to determine the exact maximum ground water level in order to make a conclusion as to the suitability of the site for building purposes. For instance, there are many sites which may have a moderately high seasonal ground water table, but which are not severely limited by ground water conditions. In such a case, the builder or engineer may agree to keep the elevation of the proposed building and sewer high so that it would be possible to construct a shallow leaching system, using some fill if necessary, which would be sufficiently above any likely maximum ground water level. The sewage disposal system itself would not be installed until an accurate determination has been made of the maximum ground water level by subsequent observations during the wet season. In the meantime, it might be possible to approve preliminary plans for the sewage disposal system and issue the building permit so that construction can start on the foundation or building. There also may be situations where there is an underlying hardpan layer which could cause a seasonal perched water table. It may not be possible to make an assessment of the severity of the perched water condition or the necessity of a curtain drain to control it until additional investigation can be made during the wet season. However, if the engineer or builder agrees to design the sewage disposal system with a curtain drain, it may be possible to issue the necessary approvals and permits so that construction can start. A final decision on whether or not to install the curtain drain could be delayed until further investigation can be made during the wet season, as long as the building will not be occupied in the meantime.

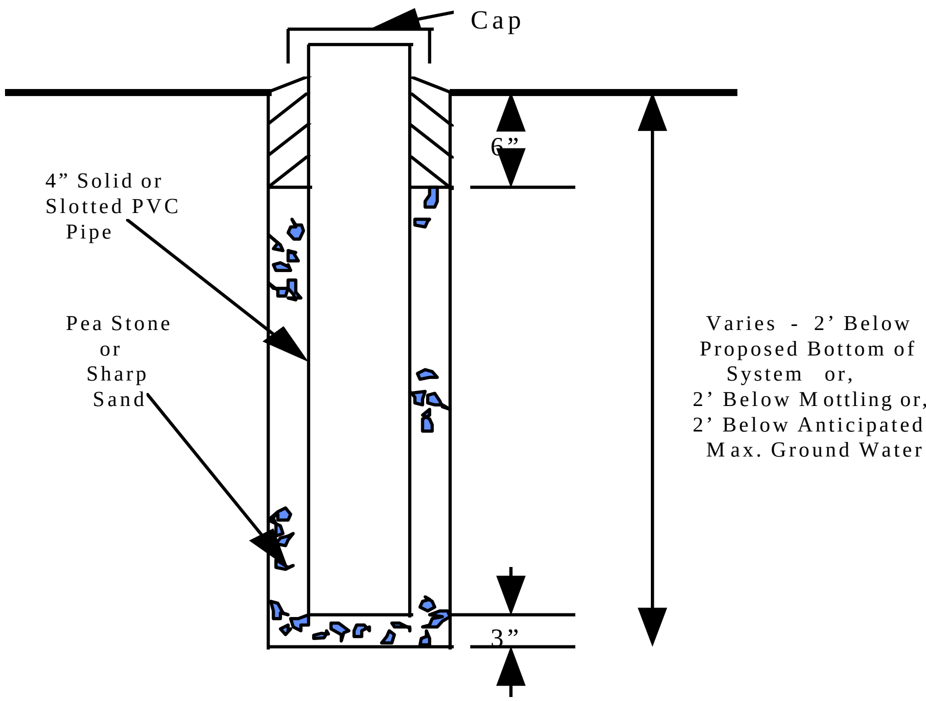


Figure 6.1 Ground Water Monitoring Well

7. GROUND WATER CONTROL DRAINS

In certain situations, ground water drains can be used to control a seasonal high ground water condition. However, in other situations such drains may not be effective, and cannot be relied upon. Therefore, when ground water is found, it is essential that a careful evaluation is made of the soil and site conditions in an effort to determine the nature or cause of the ground water, the type of control drain to use, and it s probable effectiveness, before designing any sewage disposal system.

GROUND WATER INTERCEPTING DRAINS

Intercepting or "curtain" drains are reliable only for the control of perched water tables which seasonally develop where there is a layer of relatively permeable soil underlain by a layer of relatively impermeable soil or ledge. During wet periods, the ground water will be retained upon the relatively impermeable layer, saturating the looser soil above it. This is particularly severe on hillsides or low areas where there will be an accumulation of ground water flowing down from higher elevations. Where there is sufficient slope, the perched ground water can be intercepted by drains on the uphill side of the leaching system. In order to be effective, the drain must be constructed deep enough to penetrate into the relatively impermeable underlying layer of soil and completely intercept the ground water moving on top of it. Generally, the bottom of the intercepting drain should penetrate a minimum 24 inches into this underlying soil layer to assure that the perched ground water condition will be encountered. The stone or gravel in the drain should extend at least 18 to 24 inches above the top of the relatively impermeable soil layer to effectively collect the water moving on top of that layer. Figure 7-1 shows how a typical intercepting drain functions.

GROUND WATER DRAINS IN PERMEABLE SOILS

Ground water control drains constructed in permeable soils function differently from intercepting drains, and are far less reliable. In this situation, the ground water table is continuous since ground water easily can move under the drain. The construction of the drain produces a drawdown in the level of the ground water table at the drain location, as shown in Figure 7-2. In permeable soil, the drain must be quite deep in order to draw the ground water table down sufficiently over a wide enough area to allow the construction of a conventional leaching system. This is even more of a problem on slopes because the distance of the drawdown area in the downslope direction is relatively small. For this reason, intercepting drains on slopes are generally ineffective when the underlying soil is permeable. See Figure 7-3.

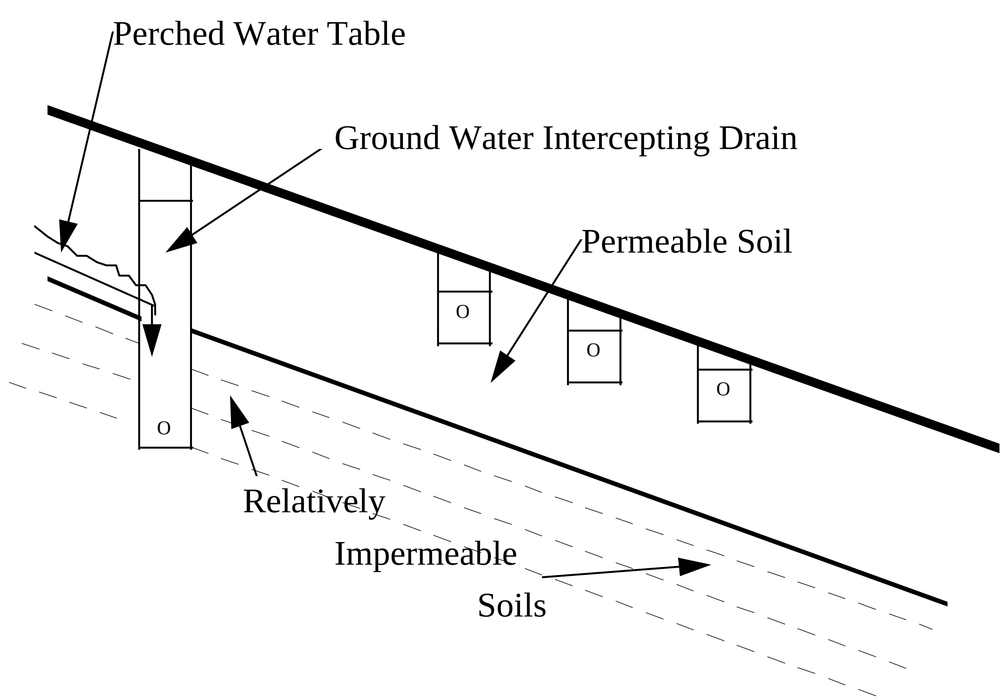


Figure 7-1 - Ground Water Intercepting Drain

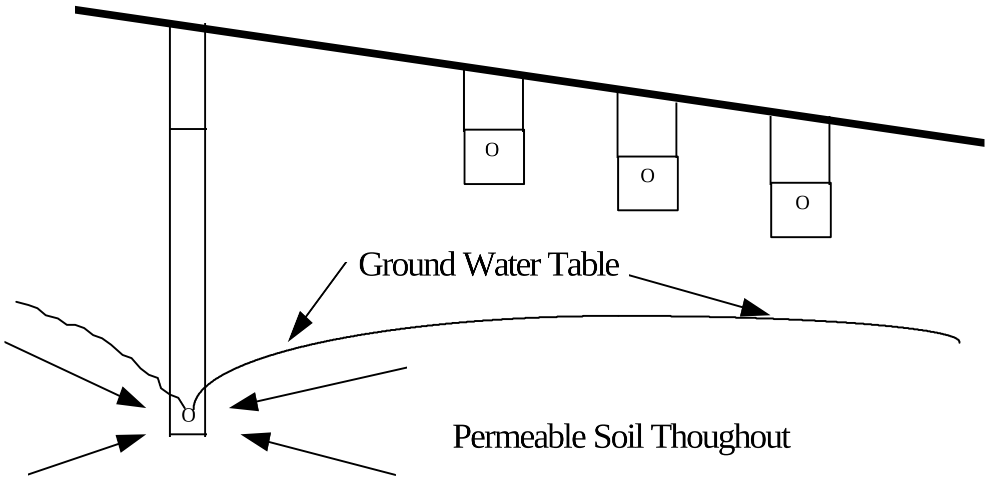


Figure 7-2 - Ground Water Drain In Permeable Soil

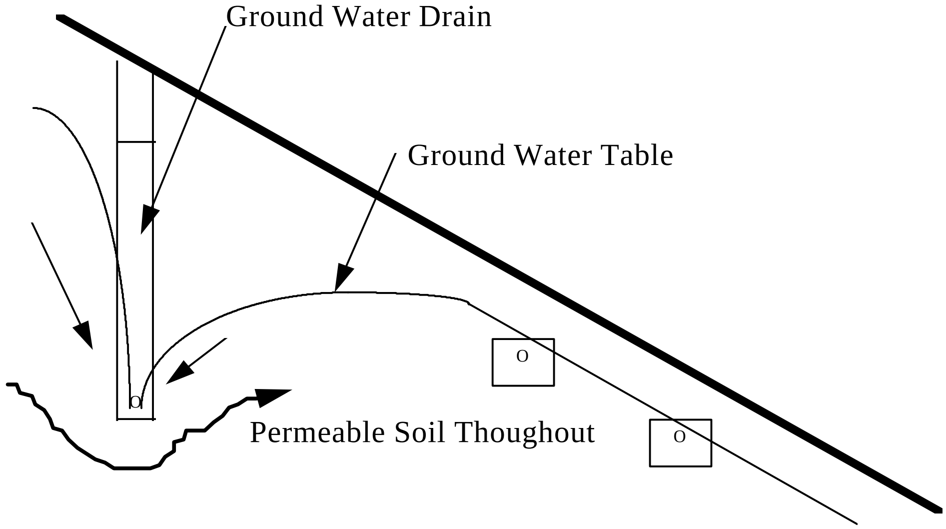
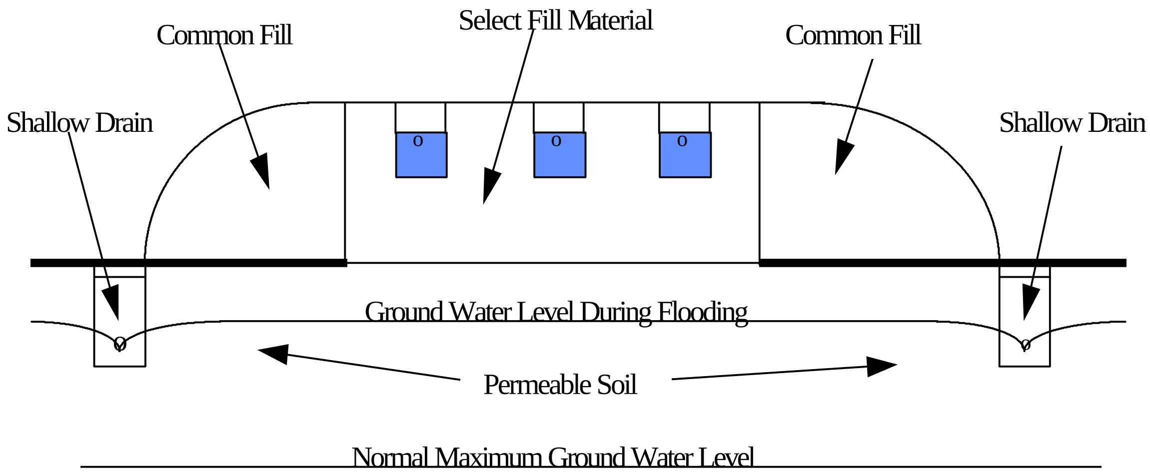


Figure 7-3 - Ground Water Drain on Permeable Slope

Ground water control drains usually are effective where the ground is relatively level and the soil is highly permeable, because the area of the drawdown is quite large. However, there is a danger of collecting insufficiently treated sewage effluent, since the ground water movement is from the area of the leaching system toward the drain, and sewage may not be adequately filtered by the highly permeable soil. In this situation, leaching systems usually are elevated in fill above the observed ground water level, but occasionally shallow ground water drains also are installed for the purpose of controlling subsurface flooding conditions. Figure 7-4 shows an elevated leaching system protected from flooding by shallow ground water drains.



<u>Figure 7-4</u> - Shallow Drains To Control Flooding

<u>LOCATION OF GROUND WATER DRAINS</u>

The Public Health Code requires a minimum separating distance of 25 feet between a subsurface sewage disposal system and a ground water drain located up-gradient of the system, and a minimum separating distance of 50 feet when the drain is located down-gradient. The term "gradient" refers to the hydraulic movement of the ground water table <u>before</u> the drain and leaching system are installed. In most cases, the ground water gradient may be assumed to be consistent with the slope of the ground surface, but in questionable cases the ground water gradient should be determined by observation pits. Evidently, the ground water gradient may change after installation of the drain and leaching system. Experience has shown that ground water intercepting drains which are properly designed for controlling perched ground water are unlikely to collect sewage effluent as long as they are located 25 feet from the leaching system. However, ground water drains in relatively level areas of permeable soil may act as collection drains for sewage effluent, and should be carefully evaluated. In such cases, a hydraulic analysis should be made of the direction and rate of ground water movement after construction of the drain and leaching system, or the separating distance should be increased to 50 feet. Ground water intercepting drains should be located no farther than 25 feet away from leaching systems wherever possible, since experience has shown that such drains often are unreliable in controlling severe seasonal ground water or short term ground water flooding if located much greater than 25 feet from the leaching system. Any part of a ground water drain which must pass within 25 feet of a leaching system, or within 50 feet in a down gradient direction, must be constructed of tight pipe with no stone or gravel backfill.

<u>DRAIN CONSTRUCTION</u>

The construction detail of the drain itself may vary depending on soil and ground water conditions. Collection pipe must be surrounded by carefully specified stone or gravel in order to effectively collect water without becoming clogged with silt. A fairly uniform « inch stone or screen gravel has been found effective. Larger stones may become clogged. Stone clogging can be eliminated by wrapping the stone with filter fabric of an appropriate mesh size. Unspecified bank run sand and gravel should not be used, since this often will not have the required permeability. Stone or gravel graded to engineer's specifications for drainage purposes would be satisfactory. Slotted or porous wall collection pipe with washed sand or gravel backfill have been used successfully where the flow of intercepting groundwater is not great. In any case, the collection pipe should be raised 6 to 12 inches above the bottom of the trench to prevent silt from settling in the pipe. The collection pipe should be set with perforations downward, so that any silt settling in the pipe will be washed out.

In areas where separation distances are critical, an “egg crate” plastic fin and corrugated plastic pipe enveloped in a non-woven filter fabric (Eljen Drainage System) can be used to produce a ground water collection system which is relatively narrow in cross-section. However, this type of system should not be installed without a technical analysis of filter fabric pore sizes relative to the grain sizes of the soils the drain is being installed into, the iron content of the ground water and bacteriological slime which may buildup on the fabric’s surface.

Where there is relatively little difference in elevation between the ground water intercepting drain and the leaching system, it may be advisable to line the downslope face of the intercepting drain trench with an impervious polyethylene plastic sheet, such as is used for agricultural purposes. This reduces the possibility of sewage effluent flowing toward the drain and increases the drains effectiveness. Such impervious barriers also are used when a footing, foundation or other collection drain is located somewhat less than 25 feet from a leaching system, or less than 50 feet in a downhill direction.

The depth of stone or gravel in a ground water drain should be sufficient to intercept all of the layers of soil which carry ground water, and in some cases should extend to near ground surface. The top of the stone should be covered with a filter fabric to prevent silt or mud from entering. No impervious soil should be used for backfill purposes.

MONITORING GROUND WATER CONTROL DRAINS

Normally, it can be assumed that a properly designed and constructed intercepting drain will correct a seasonal perched ground water condition, and it would not be necessary to evaluate the effectiveness of the drain before installing the leaching system. However, there are some situations where the underlying soil layer is somewhat permeable, and the seasonal ground water is due to both perched ground water and the rising ground water table itself. There may be other situations where the seasonal ground water is extremely severe due to topographic location, or where it is necessary to install a leaching system below the seasonal ground water table. In all of these situations, a properly designed ground water drain probably will lower the seasonal ground water level, but it is difficult to know exactly how much. There are methods of calculating how much a ground water drain will lower the water table, but such methods are frequently unreliable since they depend on limited testing and certain assumptions. Unlike similar calculations made relative to leaching systems, there is no margin of safety in most of these methods of analysis. A more reliable and practical method of evaluating the effectiveness of a ground water drain is to construct a drain at the proper location and depth, and monitor the ground water level in the area of the leaching system through the wet season (See Chapter 6 on Determining Maximum Ground Water Levels). Although this may cause some delay in construction schedules, it is a relatively simple procedure, and gives extremely reliable results. Normally it is not necessary to complete the ground water drain, since an open ditch will function just as effectively. Monitoring wells are usually placed in a grid 25 and 50 feet below the drain (at least to a distance which will be at the lowest extension of the proposed leaching system) and approximately 25 feet above the drain. The results from monitoring a grid arrangement of wells in the above configuration will determine the effectiveness of the installed drain. The wells above the drain will monitor preconditions, while the lower wells will establish how much the water table <u>rebounds</u> as the distance increases from the drain.

PROTECTING THE SEWAGE DISPOSAL SYSTEM FROM GROUND WATER INFILTRATION

Excessive amounts of ground water can be collected in house sewers, manholes, septic tanks and sewage pumping chambers which are installed in areas where the maximum ground water table is high. This collected water can hydraulically overload the leaching system and cause it to fail, even when the leaching system itself is located in an area where the ground water table is not high. This potential is frequently overlooked, particularly in the design of large systems where the leaching system is located some distance from the septic tank and collection system. Pumping chambers usually are located in low areas or are quite deep in the ground, and frequently are below the water table. Leakage of ground water into these chambers is likely to occur in this situation because the liquid level inside the pumping chamber is frequently low. Leakage into septic tanks is less likely because it will occur only when the ground water level is higher than the tank outlet. Both septic tanks and pumping chambers are generally precast units which are made up of several sections assembled in the field. It is important that the joints between the sections are made water tight with bituminous seal. Knock-out holes where sewers enter must be tightly sealed. Many precast tanks are constructed with small drain holes located in the bottom so that rain water will not collect in them while they are stored outside. These holes must be sealed when the tanks are installed. All such units must be sealed and tested for leakage after installation according to engineers and manufacturers specifications if they are to be located in high ground water areas. Sewers should be air tested for leakage when they are constructed in high ground water areas, or if the total sewer length exceeds 200 or 300 feet. Manholes on sewers, septic tanks and pumping chambers should be raised to prevent surface water from entering. If they are located under a road or parking lot and cannot be raised, bolted manhole covers with rubber gaskets should be used.

It should be noted that sealing tanks against ground water infiltration is done differently than sealing tanks against leakage of sewage from the tank. Generally, the tanks must be sealed from the outside, rather than the inside, so that this must be done before the tanks are backfilled. It is not easily accomplished, and sometimes a clay backfill is used to reduce the water pressure on the tank. As a last resort in repair situations, a curtain drain can be used to lower the water table around the tank.

8. HOUSE SEWERS

The term “house sewer” refers to sewers located between the building served and the septic tank.. These sewers carry raw sewage and require special design to prevent settling of solids and clogging of the pipe. These sewers must be particularly tight and strong to assure that there will be no leakage of sewage which could enter the basement of the dwelling or the foundation drain and present a health hazard. The section of sewer extending from the foundation wall to the septic tank may be subjected to greater stresses than a public sewer buried in the street, and for this reason must be constructed of extra heavy cast iron pipe or a pipe with equal structural strength. This sewer is rigidly supported at the foundation wall and at the septic tank, but frequently is laid in poorly compacted backfill between these points. Excavations around the building foundation and septic tank frequently become a disposal pit for scrap lumber, stone and other construction debris. Little care and no inspection generally is given to the backfilling of these excavations, so that subsequent settlement may be great, causing the sewer to bend and separate. Even if the pipe does not leak, a low point in the line can allow sewage to collect and freeze in the winter, or cause blocking and sewage backups.

Table 2 in the Technical Standards lists types of sewer pipe which have adequate structural strength and tightness to be accepted for house sewers within 25 feet of the building served. All of these pipes are relatively expensive, but since only 15 to 25 feet of pipe would be required, the savings which would result from using a lighter weight pipe would not be worth the risk involved. The State Building Code does allow lighter weight pipe to be used in the building, however, some difficulty can be encountered where it is necessary to make a transition from one type of pipe to another immediately outside the foundation wall. Special transition fittings with rubber compression gaskets should be used in these instances. However, in some cases it may be necessary to use rubber sleeves with steel straps to make the transition joint. If a tight joint (see Table 2 in the Technical Standards) is not provided, additional sleeving with heavy duty pipe should be provided whenever such a joint is encountered. In some older homes, the house sewer may pass through the foundation wall within 25 feet of the well. Special construction is required when it is necessary to replace such a line. Generally, all pipe joints within 25 feet of the well should also be sleeved in heavy duty pipe to provide extra protection, or the pipe should be laid in a vault which is accessible for inspection, so that any leakage can be detected and the sewer repaired before the well becomes polluted.

House sewers are designed for open channel flow, both to assure adequate velocity for carrying settleable solids and to allow positive venting of gases. It should be noted that in an properly installed subsurface sewage disposal system, gases are vented from the leaching system and septic tank through the house sewer and out the roof vent on the uppermost end of the waste line. All sanitary fixtures attached to the line must be trapped to prevent gases and odors from escaping within the building. Such an arrangement increases air circulation in the soil around the leaching system and promotes BOD reduction. However, occasionally there are odor problems resulting from a poorly located roof vent, usually connected to a large disposal system which receives a strong waste. In such a case, the odor problem usually can be eliminated relatively easily by placing an elbow on the inlet to the septic tank or by capping the top of the inlet “T”, so as to trap the gases before they go out the roof vent. In these cases a separate vent pipe should be installed at the tank or from the leaching system. The vent piping then could be directed up a tree or similar structure which is located away from the building served.

House sewers should be kept as high as possible in order to allow a shallow leaching system to be constructed, if necessary. The house sewer drains dry in use, so that there is no need to provide a minimum cover of soil over the pipe to prevent freezing. Sanitary fixtures located in the basement should be avoided, particularly on relatively level lots. Some towns have gone as far as prohibiting the construction of split level houses or raised ranch houses in certain subdivisions where the ground water is high, because these type of houses generally have the sanitary fixtures located on the lower level. Washing machines have discharges capable of lifting wastes about 5 to 7 feet above the washer level, so that it is not necessary to keep the sewer low to serve such equipment. However, the connection to the sewer should have a check valve or manual shut-off on the washer discharge line where the machine is located below sewer level. Toilet systems are available which will grind and lift waste discharges, and these should be considered for basement usage.

House sewers carry raw sewage containing solids which will readily settle and may cause blockages at changes in direction and slope. Changes in direction exceeding 45° particularly should be avoided since sewer routing equipment may not go around such sharp bends. It is also recommended that whenever there are more than one change of direction on a house sewer line that cleanouts extending to grade be provided at every second bend. Occasionally, distribution boxes are installed on the house sewer for the purposes of dividing sewage between two sewage disposal systems, or to reduce flow velocity ahead of the septic tank. Invariably, these cause settling of solids and clogging. Special non-clogging design is required for all structures or manholes on the sewer ahead of the septic tank. In general, a continuous pipe or channel must be provided with smooth changes of direction and no corners or projections. The best way to divide raw sewage is by means of a “T” with a relatively high approach velocity or slope. “Y’s” or “D-boxes” will clog or partly clog, creating an unequal division of flow. Reduction of flow velocity is best accomplished by flattening the slope of the sewer ahead of the septic tank, rather than by constructing a special structure or manhole.

9. SEPTIC TANKS AND GREASE TRAPS

A properly functioning septic tank serves three main purposes.

1. It removes most of the settleable solids.

2. It produces an effluent of relatively uniform physical, chemical and biological quality from a raw sewage with widely fluctuating characteristics.

3. It produces some reduction in pollutant levels in the effluent.

The removal of settleable solids is important in protecting the leaching system from excessive sludge and slime build-up and possible clogging. A relatively uniform effluent promotes the development of a stable biological slime in the leaching system which is important in protecting against groundwater pollution. The septic tank will reduce influent BOD levels by about 25 to 30 percent. Most of this reduction is due to the venting of certain gases, such as methane. Solid organic particles are removed by settlement, and a certain amount of soluble organic chemicals are removed by the formation of bacterial cells within the tank. However, no significant BOD reduction results from this without regular removal of the accumulated sludge. A relatively stable biological system soon is established in a septic tank in which most of the organic solids are converted to soluble organic chemicals and gases. This chemical decomposition results in a relatively slow build-up of sludge in the tank, most of which is biologically stable in the absence of oxygen. The septic tank will produce about 10 percent reduction in nitrogen and 30 percent reduction of phosphate in the effluent, mostly by combining these chemicals in the relatively stable biological sludge. The proper venting of gases is very important in the efficient functioning of a septic tank. An excessive buildup of scum or grease may interfere with this, and it is important that large volumes of grease not be discharged into the septic tank. There must always be space between the scum layer and the top of the tank. The inlet baffle should be open at the top to allow venting. Where a two compartment tank is used, the baffle wall between the first and second compartments must be open at the top, for the same reason.

The efficiency of the septic tank as a settling unit is reduced when the velocity of the liquid moving through the tank is increased. This may be caused by a tank which is too small or too shallow due to an excessive depth of sludge in the bottom. The lack of a proper inlet baffle will tend to allow liquid entering the tank to short-circuit across the surface of the tank, particularly if the liquid is warm and consequently less dense than the liquid in the tank. The settling efficiency of a septic tank can be greatly improved by constructing the tank with two compartments. This results from both further reduction of velocity currents within the tank and from reduction in gas information in the second compartment. Gas bubbles formed within decomposing sludge layer will cause solids to float and possibly go out the outlet. In a two compartment tank, practically all of the sludge digestion and gas formation takes place in the first compartment.

SEPTIC TANK CONSTRUCTION

All concrete septic tanks utilized in the State of Connecticut shall conform to ASTM C-1227-95 standards by July 1, 2000.

Presently**,** most septic tanks are constructed of precast concrete sections which are assembled in the field. Such precast tanks come in sizes up to 30,000 gallons. Larger capacities also may be obtained by installing two tanks in series. The outlet of the first tank is joined to the inlet of the second tank. Normally this is done with pipe baffles extending to approximately mid-depth of each tank. In this way, the tanks may be considered equivalent to one large two compartment tank. The first tank in series should be twice the capacity of the second tank in order to be consistent with the requirement that 2/3 of the total volume of a two compartment tank be in the first compartment. It should be noted that many precast tanks with a capacity of 2,000 gallons or greater are not fabricated as two compartment tanks. In this case, it will be necessary to specify that a baffle wall be constructed in the field. This is relatively easy to do with concrete block. The normal precast concrete tank is not designed to withstand heavy loads on top of it. For this reason, it should be specified that the tank be reinforced for H-20 wheel loading if located under a driveway or parking lot.

Metal, fiberglass or polyethylene plastic septic tanks are also acceptable, providing they are equivalent to a two compartment concrete tank in size, dimensional requirements and strength. Such tanks are relatively expensive. They normally are used in locations which are inaccessible to the heavy truck which is necessary to carry the concrete tank. Plastic tanks can be hand-carried to inaccessible locations. However, such tanks should not be used in areas of high ground water because they are light weight and tend to float, particularly when the liquid level is low during cleaning.

Septic tanks are constructed with the inlet three inches higher than the outlet in order to assure that the liquid level will not rise up into the house sewer. If this occurs, solids could be deposited in the sewer, causing clogging. Installers must take care that precast tanks are not reversed during installation, and that all tanks are set as level as possible.

SEPTIC TANK MAINTENANCE

Septic tanks should be inspected at intervals of no more than every two years to determine the rate of scum and sludge accumulation. If inspection programs are not carried out, a pumpout frequently of once every three to five years is reasonable. Once the characteristic sludge accumulation rate is known, inspection frequently can be adjusted accordingly. The tank should be cleaned whenever the thickness of the scum layer is two inches or more, or the sludge level is within 12 inches of the bottom of the outlet baffle.

Scum can be measured with a stick to which a weighted flap has been hinged or with any device that can be used to feel the bottom of the scum mat. The stick is forced through the mat, the hinged flap falls into a horizontal position, and the stick is raised until the resistance from the bottom of the scum is felt. A long stick rapped with rough, white toweling and lowered to the bottom of the tank will show the depth of sludge and the liquid level of the tank. After several minutes, the sludge layer can be distinguished by sludge particles clinging to the toweling.

Following is a list of considerations pertaining to septic tank operation and maintenance.

1. Climbing into septic tanks can be dangerous, as the tanks are full of toxic gases, such as, hydrogen sulfide. Do not enter a septic tank without a proper air supply or safety rope tied around the chest or waist.

2. The manhole, not the inspection opening, should be used for pumping so as to minimize the risk of harm to the inlet and outlet baffles. Inlet and outlet baffles should be inspected for damage or clogging whenever the septic tank is cleaned. It is particularly important that missing or damaged outlet baffles are replaced promptly, since floating solids can be carried into the leaching system, clogging it and requiring expensive repairs.

3. It is not necessary to leave solids in the septic tank as an aid in starting digestion.

4. When pumped, the septic tank need not be disinfected, washed or scrubbed.

5. Chemical or biological additives should not be added to a septic tank. They are unnecessary and probably ineffective. Furthermore, certain chemical additives such as chlorinated hydrocarbons may be carcinogenic and cause groundwater or well pollution if added to the septic tank. Ordinary amounts of bleaches, lye, caustics, soaps, detergents and approved drain cleaners will not harm the operation of the septic tank.

6. Materials not readily decomposed, such as sanitary napkins, coffee grounds, cooking fats, bones, wet-strength towels, disposable diapers, facial tissues, cigarette butts, etc., should not be flushed into a septic tank. They will not degrade in the tank and can clog the inlet or outlet.

GREASE TRAPS

Grease traps, although similar in appearance to septic tanks, are intended as pretreatment units for kitchen wastes only, before discharge to conventional septic tanks. In a large restaurant or cafeteria, the sewer serving the dishwasher, pot sink, floor drains and food preparation sinks and equipment should be separated from the toilet wastes inside the building and connected to a grease trap located outside the building. The grease trap is deeply baffled and is sized to allow food particles to settle and floating grease to rise to the top of the unit. Some studies suggest that grease traps are capable of removing up to 60% of oil and grease and 50-80% of the BOD and TSS. Grease traps are not intended for decomposition of the accumulated solids, and should therefore be cleaned frequently, about every one or two months. To facilitate this, cleanout manholes on grease traps should be extended to grade. Grease traps will not remove emulsified grease from the kitchen wastes. Kitchen waste may contain considerable amounts of emulsified grease where dishwashers are connected to the system discharging large amounts of hot water and detergent. Some removal of emulsified grease may be produced in the septic tank where the kitchen waste is cooled by mixing with toilet waste and comes in contact with solid particles and gas bubbles produced by biological decomposition.

It may not be practical to use outside grease traps in large office buildings or schools where the cafeteria is connected into the main sewer system. Also, it may not be feasible to install an outside grease trap on an existing restaurant. In such cases, small, inside grease traps located in the kitchen may be used. These units should be cleaned once or twice a week. This frequently is not done, since the traps would have to be cleaned by kitchen workers, who find the job objectionable.

10. DOSING THE LEACHING SYSTEM

Incomplete utilization of the leaching system is an important but often overlooked factor in subsurface sewage disposal system failure. The most common example is sloping leaching trenches constructed on a hillside, where all the sewage effluent collects at the lowest point in the system and breaks out on the ground surface, while the higher portions of the system receive little or no effluent and are still completely functional. The primary objective in laying out the dosing arrangement of any leaching system is to assure that all portions of the leaching system are utilized before failure can occur. An equal or uniform application of sewage effluent throughout the leaching system is also considered to be desirable, but it is questionable how important the distribution arrangement is in achieving this. The growth of slime layers on the infiltrative surfaces appear to be the most important factor in producing a relatively uniform usage of the leaching area. Perforated distribution pipe in trenches, and hollow chambers in pits and galleries mainly serve to assure that excessive slime growth will not clog portions of the leaching system and prevent effluent from reaching other portions.

There are three techniques which can be used to assure that all portions of the leaching area are utilized before failure can occur. These are:

1. Intermittent dosing or flooding of the leaching system,
2. Keeping the leaching units level and interconnecting them, and
3. Serial distribution with high level overflow connections from higher leaching units to lower leaching units.

These techniques may be used separately or in combination. The decision as to which type of dosing arrangement to use depends on the type of leaching unit, the size of the leaching system and the slope of the ground surface in the area where the system is located.

INTERMITTENT DOSING

Intermittent dosing is necessary where there is a system of leaching trenches containing a large amount of perforated or open-joint distribution pipe. Intermittent dosing causes sewage effluent to be carried farther along the perforated pipe, preventing excessive loading on the inlet ends of the leaching system which could cause heavy slime growth and premature soil clogging. It allows an increase in the length of leaching trench which can be effectively used. There is also some advantage in using intermittent dosing where it is necessary to divide effluent equally to a number of separate leaching units, either trenches, pits, or galleries. Intermittent dosing will flood, or at least raise the liquid level in the distribution box sufficiently to assure that the volume of effluent discharged through each outlet in the box will be more or less equal. If intermittent dosing is not used, the liquid level in the distribution box in a small sewage disposal system will rarely rise more than 1/4 inches above the outlet inverts, and there could be extreme variations in the volume of effluent discharged through the various outlets if the inverts are not set exactly at the same elevation (see Table 10-1).

Table 10-1 Discharge Rate and Theoretical Head Developed in Distribution Box for Various Household Plumbing Fixtures.

Fixture	Discharge Rate (gpm)	Head Developed in Dist. Box (inches)	
		3-Outlet D-box	Single Outlet Serial D-box
Wash basin-water running	0.75	1/8	1/4
Kitchen sink-dishwasher rinse	1.50	3/16	3/8
Shower	3.50	1/4	1/2
Washing Machine	10.0	1/2	7/8
Bathtub Draining	15.0	5/8	1 1/8

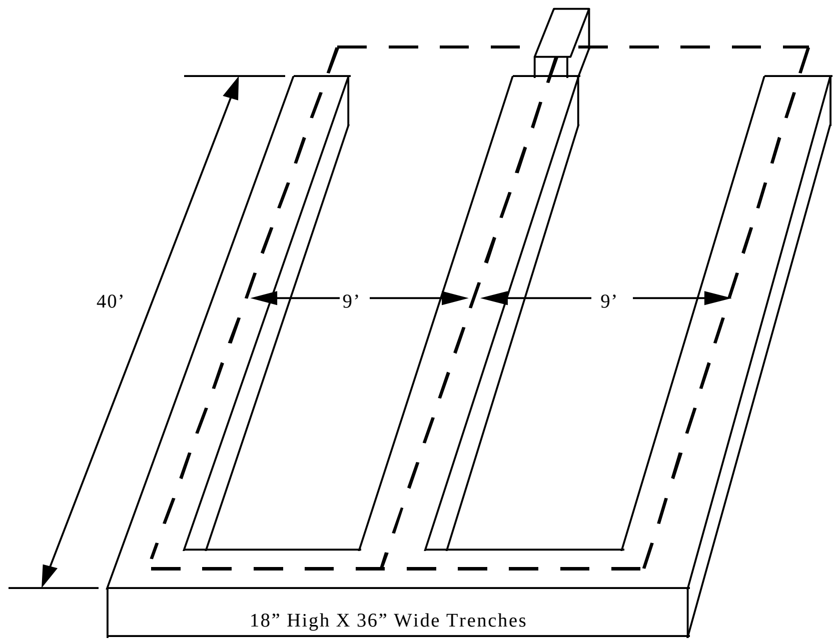
In deciding whether or not to use intermittent dosing, some consideration also must be given to the difference in elevation which could be prudently provided between the septic tank and the leaching system. The most inexpensive and reliable method of dosing is by means of a siphon chamber or the Rissy Floating Outlet Distribution Chamber. However, these devices require a hydraulic head in order to function, so that a minimum elevation difference of 21 to 24 inches must be provided between the chamber inlet and outlet, depending on the diameter of the siphon. Where the ground is relatively flat, this might result in the leaching system being constructed too deep. Problems which could result from high ground water and underlying ledge or hardpan may outweigh any advantages produced by intermittent dosing in this situation. Sewage pumps can be used for intermittent dosing where siphons are not feasible. However, they are relatively expensive to install and operate, and some provision must be made to eliminate inconvenience and possible health hazards which could result from pump or power failure. For these reasons, intermittent dosing of smaller leaching systems normally is considered only where siphons can be used.

Another perceived advantage of intermittent dosing is the "rest period" which a leaching system receives between doses. There may be some marginal benefit where the period between doses is long enough for the leaching system to drain completely and allow air to reach the slime layers. But in most cases, this is of questionable value, since variation in water usage throughout the day and night provides a substantial rest period for a properly designed leaching system to drain completely. Past design practice occasionally had called for separate leaching systems dosed by alternating siphons, in order to provide a longer rest period between doses. This is no longer an acceptable design practice since it reduced the assurance that all portions of the leaching system would be utilized before failure occurred. When one siphon became inoperative due to clogging or leakage, all of the effluent was directed to the leaching system served by the functional siphon, resulting in overload and premature failure. The design of siphons and sewage pumping systems is more fully discussed in Section II of this manual.

LEVEL LEACHING SYSTEMS

The type of leaching system which provides the greatest assurance that all portions of the system will be utilized before failure occurs is a system in which all of the leaching units are of the same type, are constructed at the same elevation, and are interconnected as fully as possible. The leaching units in such systems may consist of trenches, pits or galleries. All level leaching systems have two features in common. (1) Each leaching unit has appropriately the same effective leaching area and is dosed with approximately the same volume of effluent from a central distribution box. (2) The leaching units also are connected to one another by a separate pipe or trench with acts as a relief line, allowing effluent from overloaded leaching units to flow to underloaded ones before failure occurs.

In trench and gallery systems, the relief line is normally located at the end of the trench or gallery farthest from the inlet. Trench systems are usually connected by an equalizing trench consisting of perforated pipe laid in a stone filled trench, rather than a solid pipe relief line (Figure 10-1). The equalizing trench is counted as part of the required leaching area. An equalizing trench is much more effective in preventing overloading than a solid pipe, since effluent can flow through the stone to other trenches before severe overloading occurs.



EFFECTIVE LEACHING AREA

40 FT X 3 X 3 = 360 SF
6 FT X 3 X 2 = 36 SF
396 SF

Figure 10-1 Level Leaching Trenches

Leaching pits are normally interconnected to one or more other pits on the same elevation by solid pipe connections at mid-depth (Figure 10-2). Connections near the pit bottom are difficult to construct and may become clogged with sludge or dirt. High level connections are not desirable for pits on the same elevation because a pit must be full and near the point of failure before relief occurs. In level leaching systems, it is also desirable that the central distribution box be located near the leaching units and sufficiently deep so that it is below the elevation of the ground surface over the leaching unit. This would allow the distribution box itself to act as a relief line, since effluent would backup into the box and be redistributed between the functioning leaching units before breaking out on the ground surface.

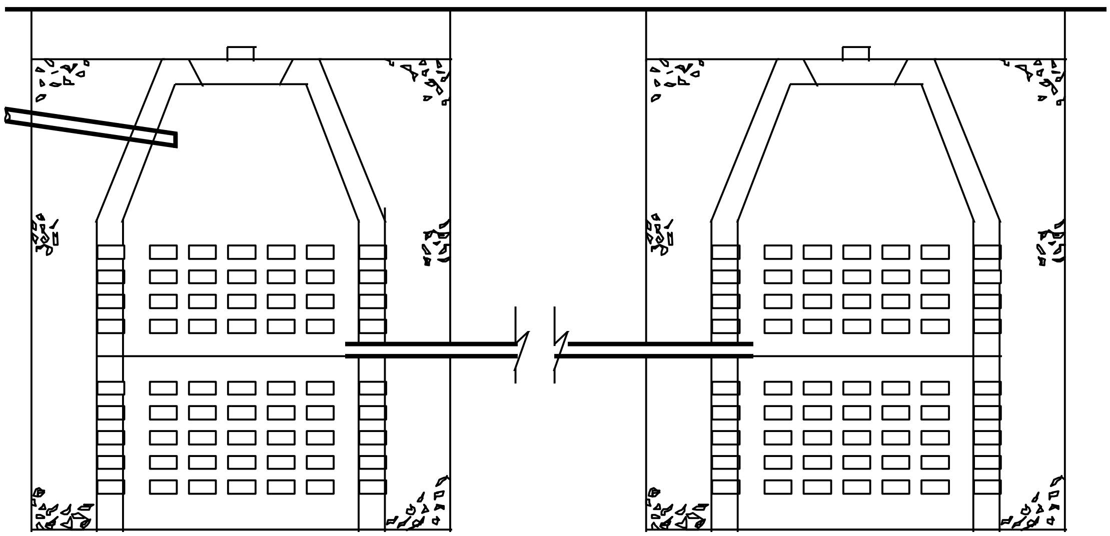


Figure 10 -2 - Pits at Same Elevation - Connection at Mid-Depth
Effective Area = Pit Depth **Utilized** X Pit Diameter X π

Level leaching systems should be used where the ground surface in the area of the leaching system is generally flat. They may also be used on sloping areas where there is a sufficiently deep strata of good soil to allow the bottom of the deepest leaching unit to be kept the required elevation above underlying ledge, hardpan and groundwater. As a rule of thumb, level leaching systems should be considered wherever the slope of the ground surface across the area of the leaching system is less than two feet. If leaching trenches were used in such a situation, the deepest trench on the upslope side could be three to four feet below grade, which would not be excessive. The shallowest trench on the downslope side would then be one to three feet deep, and could be constructed partially in fill, if necessary.

SERIAL LEACHING SYSTEMS

In a serial leaching system, the individual leaching units are set on different elevations, and each unit is connected by a high level overflow pipe to the next lower unit. Effluent is directed to the highest leaching unit. When this unit becomes filled and is functioning at its maximum capacity, any additional effluent will overflow to the next lower unit, and subsequently to others in series. No failure will occur until all leaching units are fully utilized (Figure 10-3). This is the only practical design for small leaching systems constructed on sloping ground where it is necessary to have the leaching units on different elevations. Experience has shown that many leaching systems installed on slopes fail because sewage effluent is not equally divided between the various leaching units. Some units receive an excessive amount which causes overload and failure. This is usually due to a carelessly installed distribution box, in which the outlets are not level. Serial systems are not likely to fail even if installed in somewhat careless fashion since effluent will overflow to lower leaching units before breaking out on the ground surface.

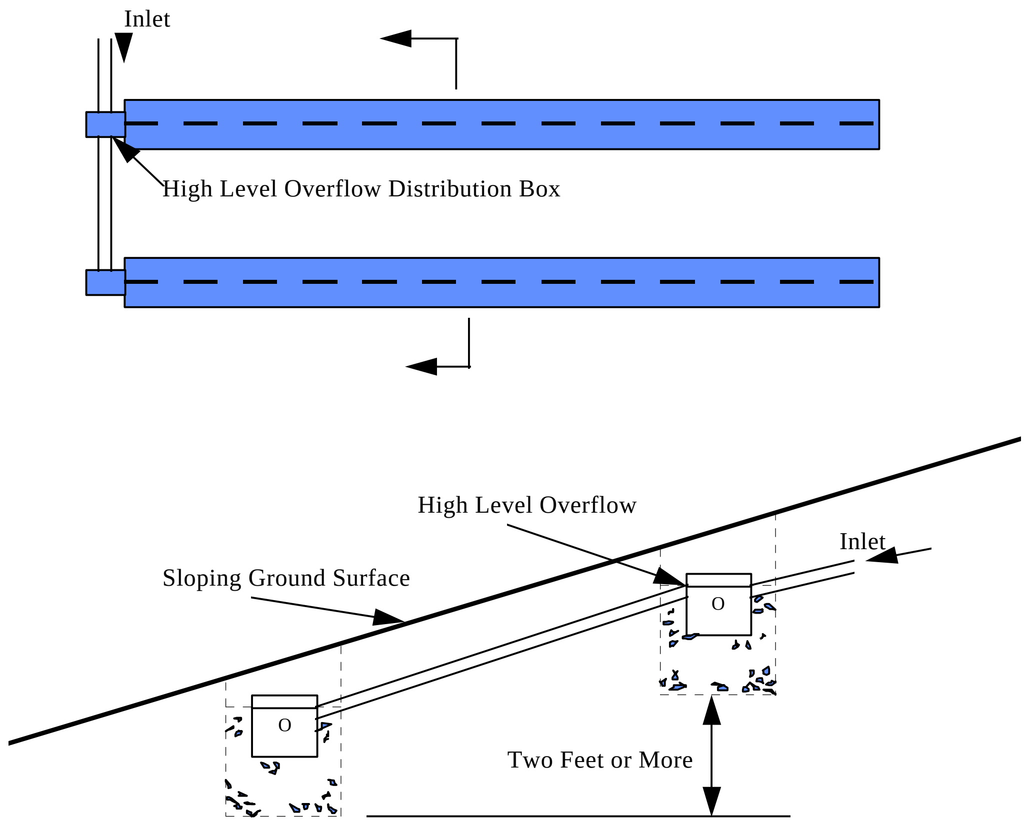
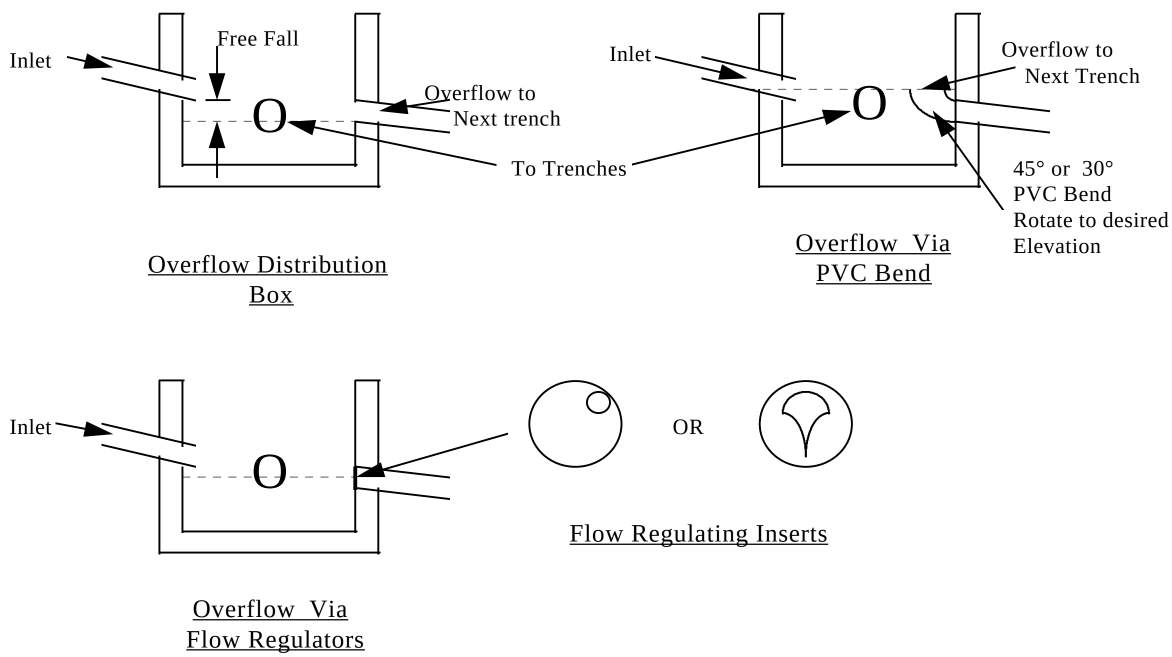


Figure 10-3 - Serial Leaching Trenches

In serial leaching trenches, the upper trenches are flooded above the flow line of their distribution pipes. This is commonly done by means of a distribution box which has been configured so that the outlet opening of the overflow pipe is set one to two inches above the trench piping. Another method is the use a normal distribution box where all the outlets are set at the same elevation, but the overflow outlet is raised by means of a weir which is constructed and set in the field at the desired overflow level. Often, an elbow or perforated plastic cap is used for the overflow weir because the overflow level can be easily adjusted by rotating it on the outlet pipe. Figure 10-4 shows typical overflows for serial distribution trenches. The higher the overflow level is set above the trench distribution pipe, the more fully the trench is utilized before overflow occurs. However, care must be taken that the trench is not filled so high that break-out occurs at a low point on the ground surface over the trench. Normally, serial distribution trenches are constructed with at least twelve inches of cover to guard against this possibility. The overflow can be located at any point in the trench, since the trench is constructed level. It is usually at one end or the other so that it can be more easily located. There is no particular limit on the length of serial trenches, since there is no attempt to equalize trench loading. Excessively long trenches become more difficult to construct level, and overflows should be provided at least every seventy-five feet in order to prevent possible effluent break-out at low points along the trench. Intermittent dosing normally is not used with serial trenches because the upper trenches are usually filled with effluent, and a sudden surge of additional effluent could cause break-out. The excavation between trenches containing the overflow pipes must be backfilled with compacted soil, not stone, so that effluent does not pass through the stone to the lower trenches before the upper ones are full.



HIGH LEVEL OVERFLOW DISTRIBUTION BOXES

Figure 10-4

Leaching pits and galleries also may be arranged for serial distribution, as shown in Figure 10-5. In such systems, the overflow is through an outlet pipe placed near the top of the hollow structure. Overflow of effluent from the upper pits or galleries occurs less frequently than in trenches because of the relatively large storage volume in these units. For this reason, no more than two such units normally are arranged in series.

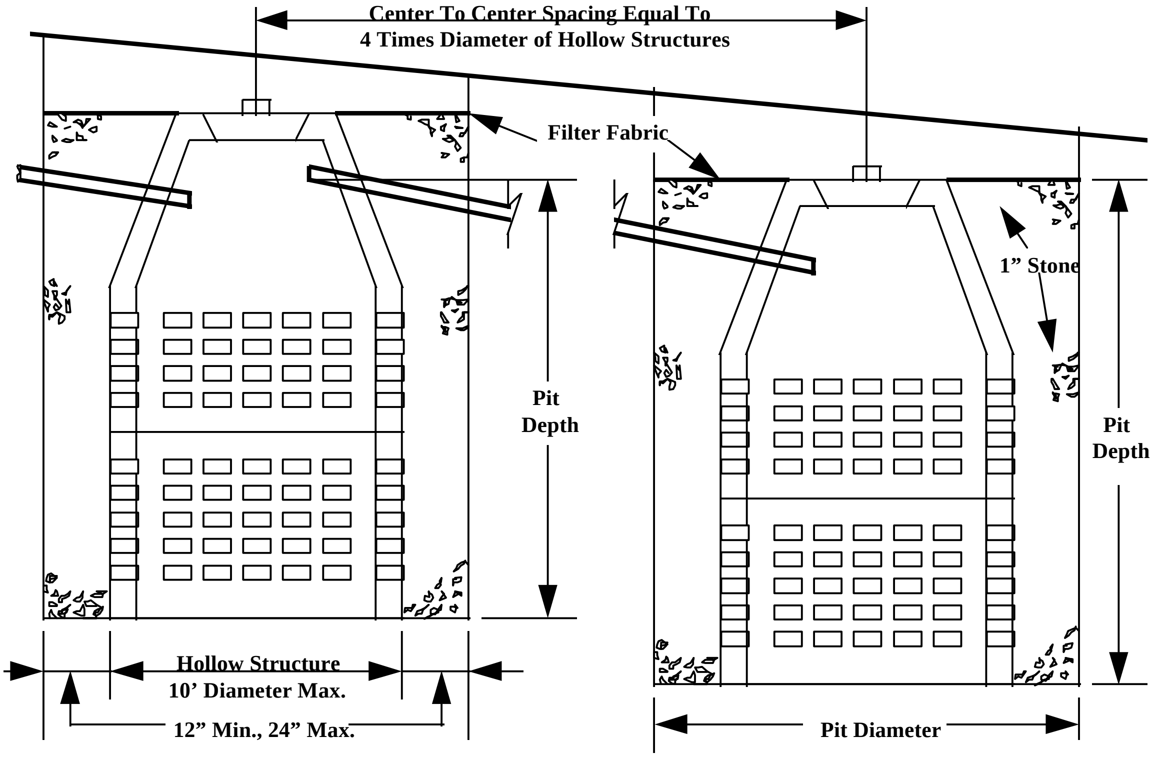
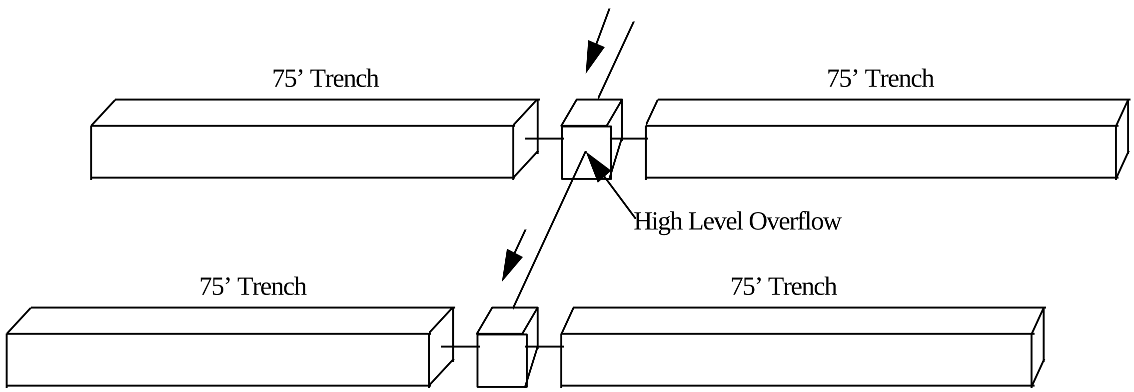


Figure 10-5 Pits at Different Elevations - High Level Overflow
No More Than Two Pits in Series

COMBINATIONS OF LEVEL AND SERIAL LEACHING SYSTEMS

The difference in the loading rate on the various leaching units in a serial leaching system is quite large, the higher units receiving much more effluent than the lower ones in series. This has caused some concern about the functional life expectancy of such systems. For this reason, most serial leaching systems are arranged in such a manner as to avoid placing more than three or four leaching units in series. As long as this design practice is followed, there appears to be no detectable reduction in the functional life expectancy of a serial leaching system. Of course, there are many leaching systems which require more than three leaching units in order to provide the necessary leaching area. In such a case, it will still be possible to avoid having more than three units in series if several leaching units can be constructed on the same elevation and can be interconnected as a single level leaching system. One way of doing this is to spread out a number of leaching units on the same elevation along the slope. Figure 10-6 shows how this may be done using trenches or pits. Other arrangements can be used where it is not possible to spread along the hillside due to space limitations.



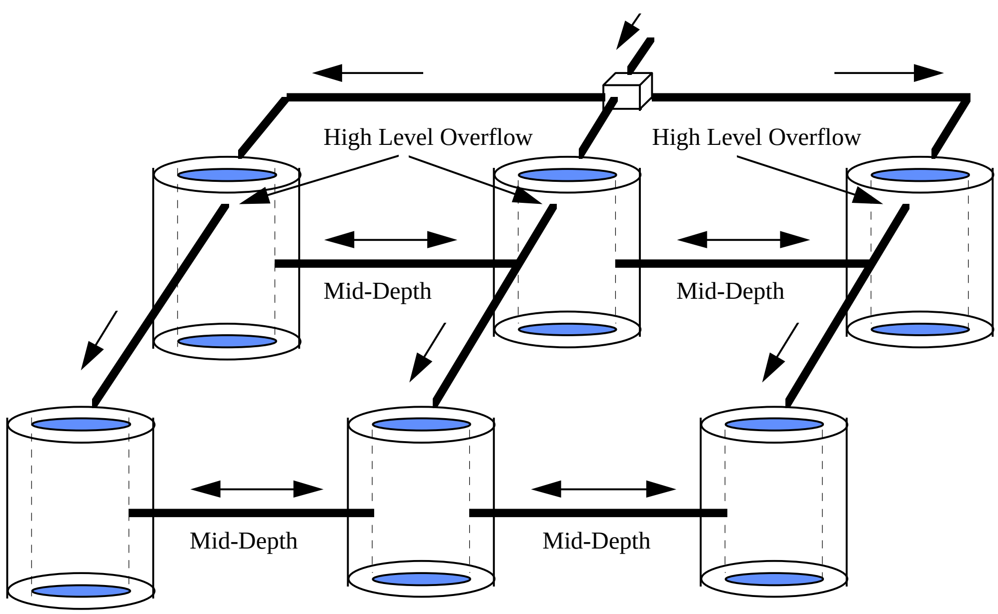


Figure 10-6 - Combination Level and Serial Distribution

If the slope is moderate, and there is no shallow underlying ledge, hardpan or ground water, it may be possible to keep one or more rows of leaching units on the same elevation, even though they may be located in a downhill direction from one another. Figure 10-7 shows such an arrangement of trenches. Note that trenches on the same elevation are connected with equalizing trenches. Such an arrangement has only one high level overflow, and constitutes an arrangement of two level leaching systems in series. Where the slope is relatively steep, or where it is underlying shallow ledge, hardpan or ground water which prevents a leaching system from being constructed too deeply below grade, an opposite arrangement may be used. That is, two separate serial distribution systems may be constructed down hill from one another, each feed from a dosing distribution box which splits the effluent volume approximately equally among the two systems. In such an arrangement, the dosing distribution box is able to perform that function by storing sewage in a tray which flips over when approximately 1.5 gallons of sewage is collected.. Once empty, the tray's counterweight returns it to the horizontal position for the next cycle. The box should be set on a firm base but it is not critical that each outlet pipe be set at the exact elevation of the other since the rush of the sewage leaving the storage tray will negate any small difference in outlet elevations. See Section II for a discussion on D-box design and construction.

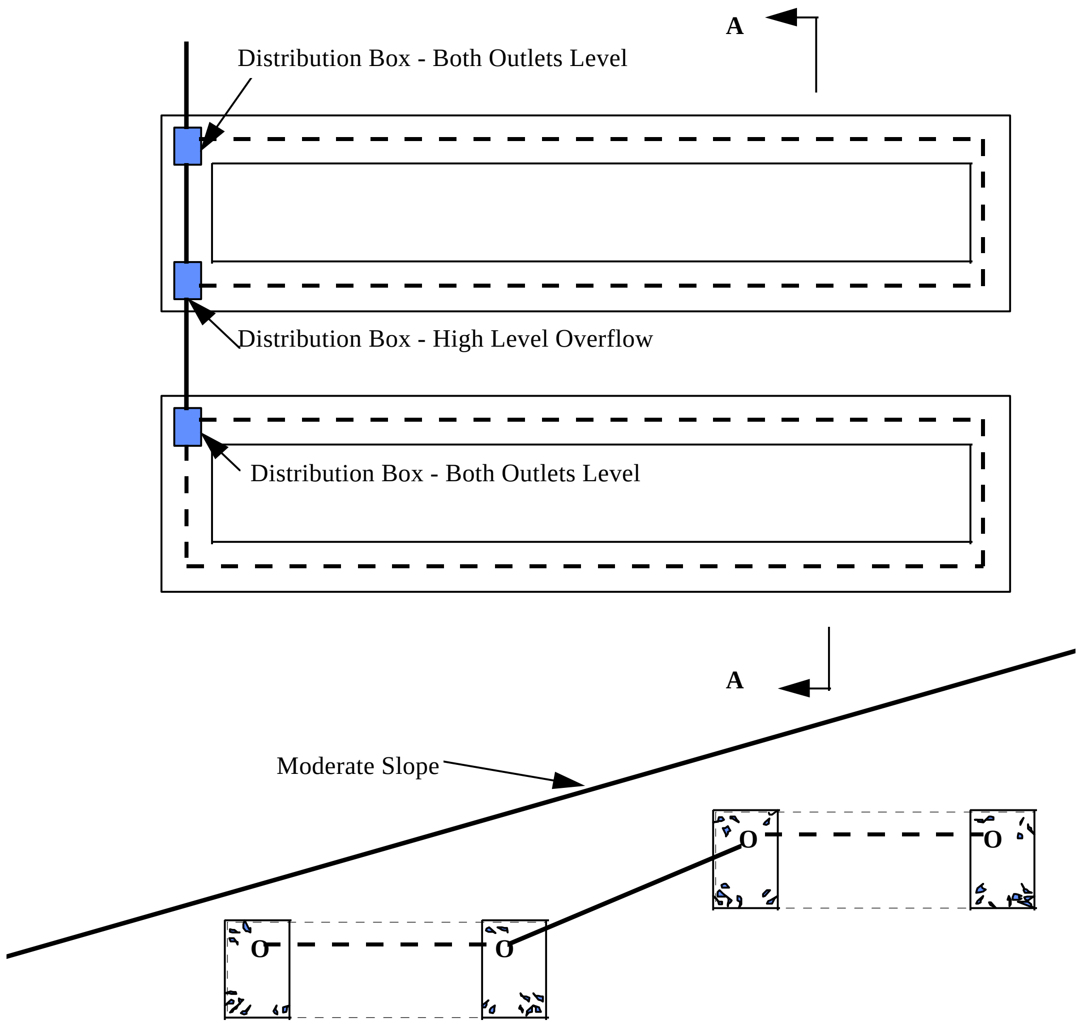


Figure 10-7 - Two Level Trench Systems in Series

11. HOW LEACHING SYSTEMS FUNCTION

A properly functioning leaching system should disperse sewage effluent into the surrounding naturally occurring soil without breaking out on the ground surface or backing up during periods of heavy use or under adverse weather conditions. Such a system also should not cause an unacceptable level of ground water pollution. In order to accomplish these objectives, a leaching system must be designed with three separate functions in mind.

1. The system must provide sufficient infiltrative surface to prevent excessive clogging by the biological slime which forms on the soil interface.

2. The system must be surrounded by an area of soil with sufficient hydraulic capacity to disperse the liquid volume without becoming saturated.

3. The system must contain sufficient hollow spaces within the stone or leaching structure to allow sewage to be stored during periods of heavy use, or when rainfall or subsurface flooding reduces the ability of the system to disperse liquid.

Enlarging a leaching system will enhance all of these functions, assuming it is not constructed in saturated or impermeable soil. However, it is more proper to consider the effect of the soil, site conditions and system design on each of these functions separately when designing the leaching system.

PREVENTING CLOGGING OF THE SOIL INFILTRATIVE SURFACE

A layer of biological slime is formed on the interface between the soil and the leaching surface of the particular type of leaching unit being utilized (such as the stone in a leaching trench or gallery; filter fabric used in products like the Contactor, etc.; or the soil itself utilized in stoneless plastic leaching trenches). This soil infiltrative surface results from bacterial and biological particles being collected on the soil surface, and from the growth of certain organisms within the slime layer itself. The thickness of the slime layer mainly is related to the sewage application rate, being thicker for more heavily loaded systems. The growth of the slime layer reduces the rate at which sewage passes into the soil. In so doing, it causes sewage effluent to be distributed over more infiltrative surface, thereby equalizing the distribution of sewage effluent throughout the leaching system. This, together with the reduction of BOD which occurs when the sewage effluent is filtered through the slime layer, is extremely important in preventing ground water pollution. Eventually, most of the active infiltrative surface will be covered by a slime layer of more or less uniform thickness, and the rate of which the sewage effluent passes through the layer will stabilize. This stabilized infiltration rate is sometimes called the “long term acceptance rate” of the soil.

The minimum leaching area requirements of the Public Health Code are related to the expected long term acceptance rate of the infiltrative surface within the leaching system, as indicated by percolation testing. The relationship between the percolation test results and the expected long term acceptance rate has been established empirically through observation and experience by many agencies over a long period of years. The effective leaching credits assigned to each type of leaching product in the Technical Standards of the Code have taken this relationship into account (a more detailed discussion of effective leaching credits is presented in Chapter 12). Therefore, in theory, no matter what type of leaching product is utilized, in order to provide the minimum square footage of effective leaching area required for any system, the daily discharge volume should be the same. The only exception to the above statement pertains to leaching pits, where only the side area is counted as effective, not the bottom. This discrepancy is due more to the variability of pit construction and an attempt to ease the mathematical calculation process then to any scientific reason. In fact, both the bottom and sides of leaching pits constitute active infiltrative surfaces the same as all other leaching products. The decision as to what type of product to use should be based on the soil conditions present in and around the proposed leaching area (deep pits should not be used in areas of high ground water, etc.) and economic factors. In general, the adequacy of the Code requirements for leaching area are well proven. Engineers, Sanitarians and Installers can be assured that leaching systems for household and small commercial subsurface sewage disposal systems based on the Public Health Code requirements will not fail due to excessive clogging of the leaching systems.

Periodically, the slime layer on the infiltrative surface will become unstable and a "breakthrough" of sewage effluent will occur. Such breakthroughs are more frequent in the more permeable soils where the biological particles are more easily detached and washed into the larger voids in the soil. Fluctuating liquid levels and loading rates accelerate slime deterioration and breakthrough. In fact, many leaching systems in highly permeable sand and gravel have functioned satisfactory for many years at loading rates well in excess of the theoretical long term acceptance rate. This is probably because instability of the slime layer allows frequent breakthroughs of sewage effluent. Engineers sometimes take advantage of this by using deep leaching systems in permeable fill where the area available for leaching purposes is severely limited.

DISPERSING LIQUID INTO THE SURROUNDING SOIL

After sewage effluent passes through the slime-covered soil infiltrative surface, it must be dispersed into the surrounding soil. In a properly functioning leaching system, this is accomplished in two ways: (a) by hydraulic flow through the voids in the soil, and (b) by capillary dispersal and evaporation. Hydraulic flow is the predominant mechanism of dispersal in the coarser grained soils, while capillary dispersal is important for the finer grained soils. Most leaching systems are constructed in moderately permeable, well graded soils where hydraulic flow and capillary dispersal occur simultaneously. An understanding of the mechanisms of dispersal can help engineers, sanitarians and installers in designing and constructing leaching systems for maximum dispersal into the surrounding soil.

In a properly functioning sewage disposal system, liquid flowing from the leaching system to the ground water table will not saturate the soil under the system because the liquid will pass through the slime-covered soil infiltrative surface at a slower rate than it will pass through the soil behind it. However, it will cause a slight elevation of the ground water table under the system as the liquid is added to the ground water in this area, or will cause a "mounding" of liquid on underlying impermeable layers of ledge or hardpan. (See Figure 11-1) In the worst case, the mound of saturated soil could rise to the level of the leaching system, causing it to fail. Therefore, a conservative estimate of a hydraulic capacity of this soil surrounding a leaching system can be obtained by assuming a certain saturated flow pattern from the leaching system, and calculating the rate at which liquid would flow through the saturated soil. This sometimes is called the "hydraulic conductivity" of the surrounding soil. It depends on the soil permeability, the cross-sectional area of saturated flow, and the slope of the hydraulic gradient. Increasing any one of these factors will increase the hydraulic conductivity. On the other hand, if any one of these factors is severely limited, the hydraulic conductivity is also severely limited. Therefore, leaching systems can fail because of hydraulic limitations of the surrounding soil, such as flat slope or shallow underlying hardpan or ledge. This type of failure has nothing to do with clogging of the leaching area, and enlargement of the leaching system may not prevent such failure. This subject will be discussed in more detail in Chapter 13 - Hydraulic Capacity of Underlying Soils and Minimum Leaching System Spread.

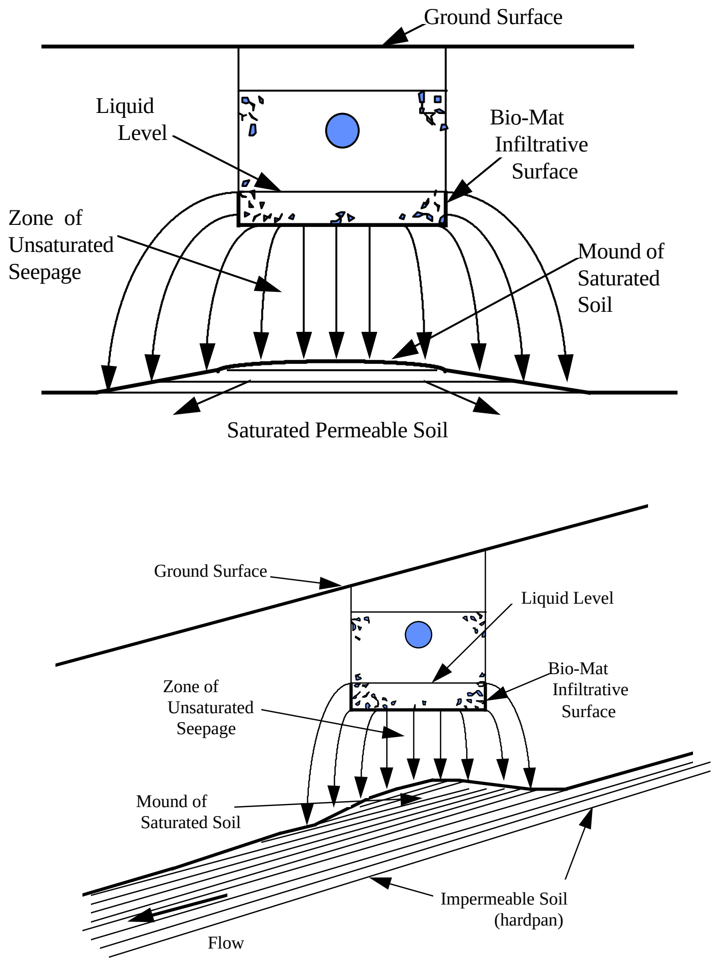


Figure 11-1 - Effluent Mounding

Where site conditions are particularly severe, the Public Health Code states that a study may be required of the capacity of the surrounding natural soil to absorb or disperse the expected volume of sewage effluent without overflow or breakout. The method of making such hydraulic analyses are discussed in Part II. The key to proper analysis depends on a correct determination of the type of flow pattern by which the sewage effluent is dispersed into the surrounding soil. This depends on whether or not there are impermeable “boundaries” which restrict downward flow. Where there is an underlying boundary layer of hardpan or ledge, the cross-sectional area of saturated flow can be increased by spreading the leaching system as much as possible along the hillside, perpendicular to the slope of the hydraulic grade. Figure 11-2 shows how this can be done. The slope of the hydraulic grade can be increased by elevating the leaching system as shown in Figure 11-3. Engineers, sanitarians and installers should take this into account when repairing systems which are located in areas where there may be hydraulic limitations.

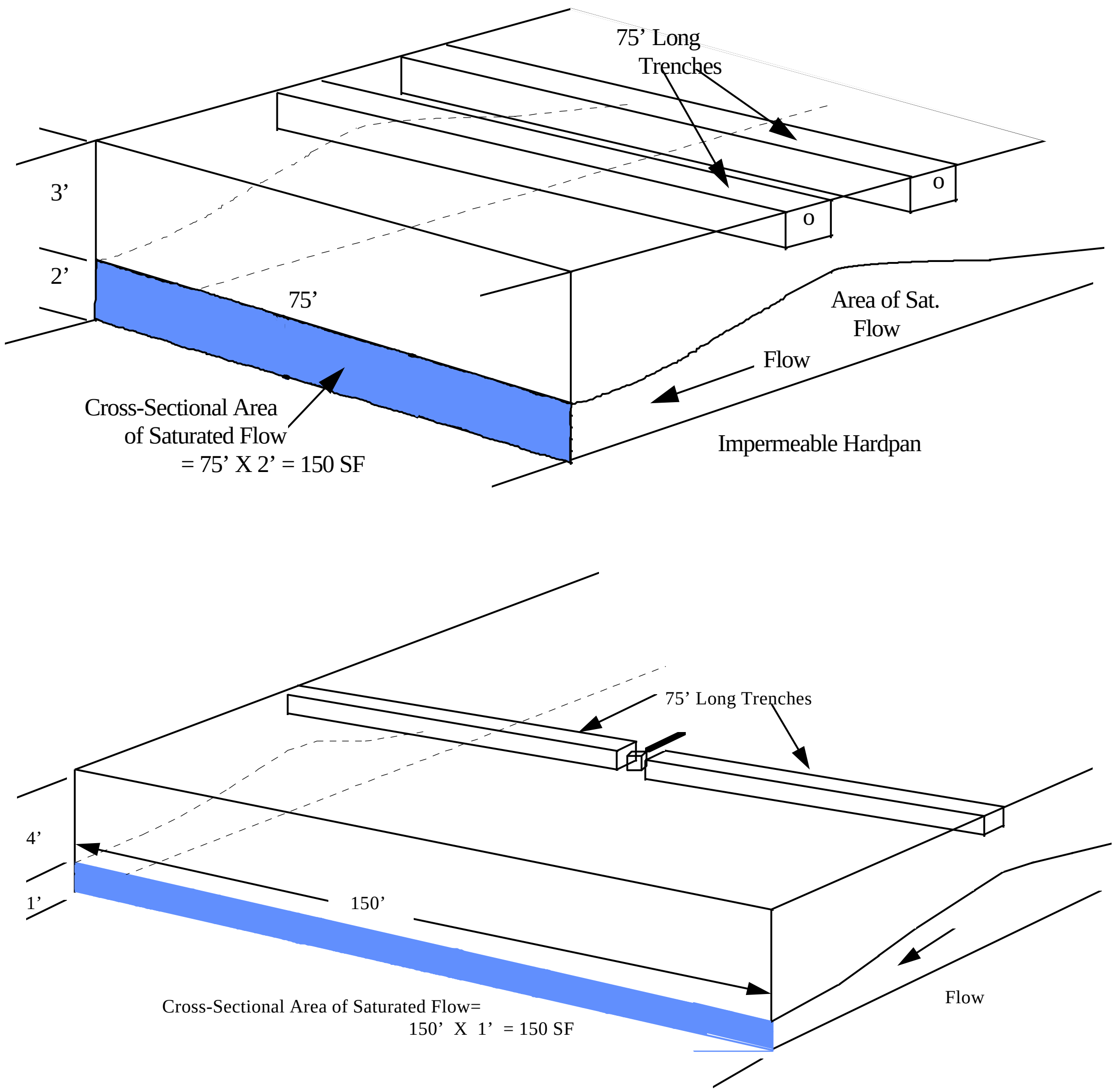


Figure 11-2 Spreading Trenches to Reduce Effluent Mounding

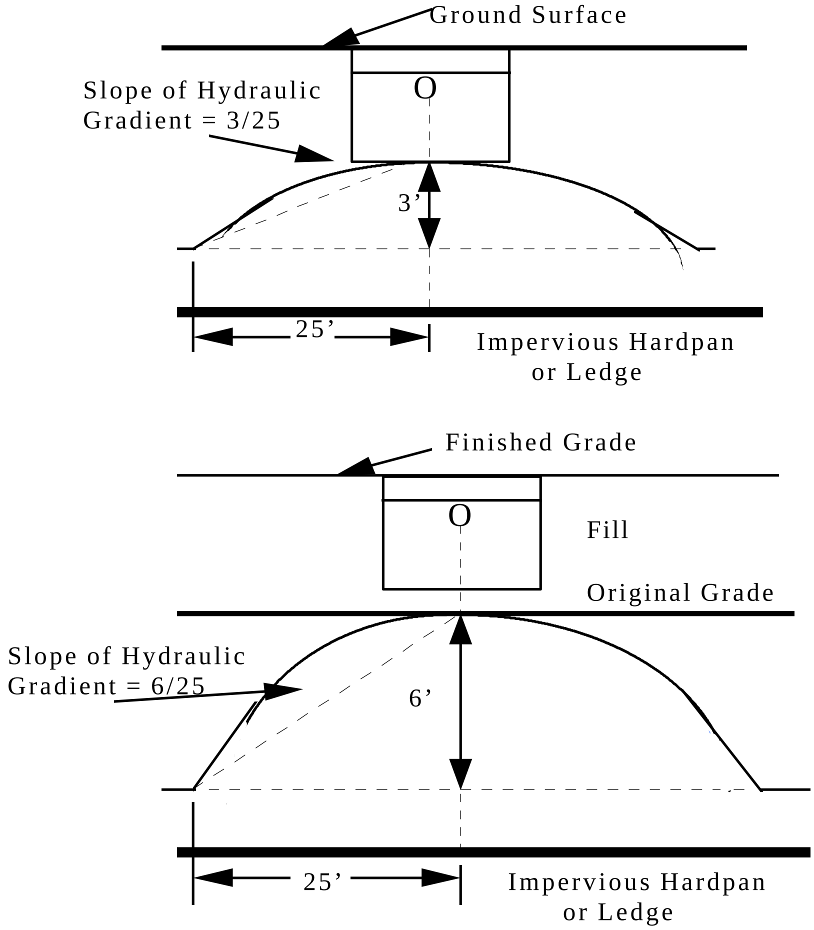


Figure 11-3- Elevating Trenches to Increase Hydraulic Gradient

Water readily adheres to the surface of most naturally occurring minerals. In moderately permeable soils, capillary attraction tends to hold water in the smaller void spaces, preventing them from draining. This creates a zone of moist, unsaturated soil around a leaching system in which air circulating through the larger voids will evaporate water from the smaller voids and disperse it to the atmosphere as water vapor. See Figure 11-4. This process is continuous as long as the soil is unsaturated, and results in a significant dispersal of liquid from leaching systems constructed in moderately permeable soils. The amount of liquid dispersed depends primarily on the size and uniformity of the soil particles, their mineral composition, and the atmospheric evaporation rate. Most leaching systems constructed in fine grained soils function primarily by capillary dispersal and evaporation during the drier months. Capillary dispersal will slow or stop when rainfall, frost or snow cover prevents atmospheric evaporation. However, such periods rarely exceed a few weeks or a month in Connecticut, even during the winter and spring seasons. Capillary dispersal and evaporation becomes less important as soils become saturated because the capillary area under and around the leaching system is reduced and air circulation is impeded. While some evaporation occurs when capillary dispersal moves liquid upward toward the more permeable shallow soil layers, this is relatively minor compared to the hydraulic flow under saturated conditions. For this reason, it is inadvisable to depend on capillary dispersal and evaporation in slowly permeable soils which tend to become seasonally saturated. Capillary dispersal and evaporation is maximized in leaching systems consisting of shallow, narrow leaching trenches. Leaching systems constructed in a relatively uniform very fine sand or silt loam have the greatest capillary dispersal and evaporation. Engineers sometimes specify this material for covering leaching systems in marginal locations.

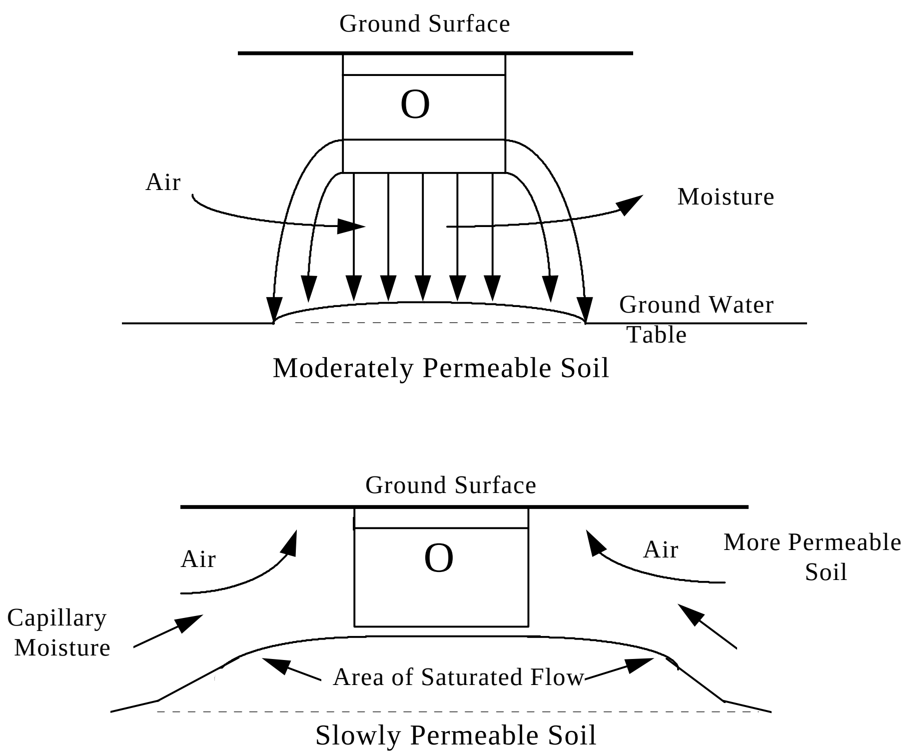


Figure 11-4 - Capillary Dispersal and Evaporation

STORING LIQUID WITHIN THE LEACHING SYSTEM

There are times when rainfall or poor soil evaporation will reduce capillary dispersal into the surrounding soil. Seasonally high ground water levels reduce the hydraulic gradient and the hydraulic conductivity of the surrounding soil. Excess sewage effluent will accumulate in the leaching system when the rate of dispersal is reduced below the rate at which sewage is discharged to the system. Accumulation can also result from unusually high sewage discharge from the building served. All leaching systems must have sufficient void space within the stone or leaching structure to store excess sewage effluent during this time, until it can be satisfactorily dispersed into the surrounding soil. Leaching systems designed in accordance with the Public Health Code requirements should have sufficient storage within the system to provide for all normally occurring variations in soil dispersal rate or sewage flow. Hollow structured plastic leaching products, leaching galleries or pits provide considerable storage under the above adverse conditions, but are normally only suitable for relatively permeable soils.

12. HOW PRODUCTS ARE ASSIGNED AN EFFECTIVE LEACHING FACTOR

For many years the only types of leaching systems installed in Connecticut consisted of trenches, galleries, pits and beds (beds are now prohibited by Code). Over the past few years many new products have been introduced utilizing different materials and configurations in order to apply sewage into the soil. In order to provide a fair and consistent means of assigning effective leaching credits to these various products an empirical formula was developed by the State Department of Public Health (in conjunction with their Code Advisory Committee).

DEVELOPING THE FORMULA

In developing the formula, basic assumptions were made based on the performance characteristics of the most widely used leaching system in Connecticut at the time, the three (3) foot wide leaching trench. Over the years this type of system has been installed using "sizing tables" which have been modified (upward) as experience and data accumulated. To a point were today a leaching trench system, installed per Code requirements, will perform satisfactorily for a substantial period of time. Due to the vast amount of historical information available, it was decided that the three (3) foot leaching trench would be the standard by which all other leaching products would be judged.

As stated in the previous chapter, a leaching system must provide sufficient infiltrative surface to prevent excessive clogging by the biological slime which forms on the soil interface. Studies have been performed which actually determined the long-term acceptance rates (LTAR) of sewage passing through this biological mat. Typically, they range from 0.3 to 0.8 gallons per square foot per day. The rate is at the low end of the scale when the permeability of the soil is slow and at the high end when the permeability of the soil is fast.

An analysis of the present sizing tables in the Technical Standards will illustrate that the typical stone/soil leaching trench corresponds to the following LTAR values:

STONE/SOIL INTERFACE				LTAR RATE
Percolation Rate	0-10.0	Min./Inch	=	0.55 GAL/SF/DAY
	10.1-20		=	0.40
	20.1-30		=	0.36
	30.1-45		=	0.30
	45.1-60		=	0.27

The basis of the above Table is predicated on the leaching system being fully utilized at the design rate for the system (150 gallons/bedroom/day) and sized per the representative percolation rate of the soils in which it will be installed. It therefore can be concluded that if the water usage from the building does not exceed its daily design rate and the LTAR is not slower than the above levels (caused by slower than anticipated percolation rates or a stronger quality septage inadvertently leaves the septic tank), the leaching system should be able to release the daily discharge indefinitely.

Also working in the system's favor is the fact that water usage on average should be lower than these "peak" design rates and that the LTARs being utilized are somewhat slower than typically found in the above cited studies (if the actual LTARs are faster then the system would be able to discharge a greater volume than the design rate).

All of the above analysis is based on standard stone/soil interfaces. However the "new technology" products are made of different materials and are configured in numerous ways in order to "maximize" infiltrative surfaces. In discussing these variables with the Code Advisory Committee, it was decided that each type of infiltrative surface would be assigned its own Interface Factor (IF). These factors would be based on our judgment on how the LTAR would be affected by the different means of sewage application. The highest rating was assigned to "direct soil" application (open bottom area beneath galleries and plastic leaching products); a reduced rating was given to "filter fabric/direct soil" application: followed by the standard "stone/soil" application; ending with the lowest rating given to systems which are backfilled with "native material" or when "stone is wrapped with filter fabric".

In developing a formula to determine an Effective Leaching Unit (ELU) credit for each indivual product approved for leaching system use, the three (3) foot wide leaching trench, at 3.0 SF/LF, was used as the standard, knowing full well that the actual "wetted area" of sewage application was five (5) SF/LF (three SF/LF of bottom and one SF/LF for each side of the trench). To assign ELUs to any other type of product the total wetted area provided by the product for each type of interface would have to be determined. This is due to the fact that some leaching products consist of more than one type of interface (example: galleries consist of both "direct soil" and "stone/soil" interfaces). Once each interface's wetted area (per linear foot) is determined it is a straight mathematical procedure to apply the interface factor to each and then multiply the total by a constant to determine the product's ELU**.**

ADVANTAGES AND CONCERNS

The advantages of utilizing the ELU method for crediting new products are as follows:

1. The speed in which a new product can be assigned an ELU factor.

2. The consistency in which each product is reviewed and credited. This eliminates all appearance of unfairness relative to crediting different leaching products.

3. The product manufacturers, knowing the basis of the formula, can design products which maximize their products infiltrative surfaces and hence increase their product's ELU factor.

4. If in the future it is determined that a "Interface Factor " is not representative of its actual LTAR, the factor can be adjusted and the ELUs of all of the products utilizing that type of infiltrative surface can be recalculated.

It is important to keep in mind that the ELU of any particular product was and is based on the configuration of the product at the time of review by the Department of Public Health. Any physical change to the product must be reviewed by the Department and reassigned a new ELU. At that time a new name or model number would have to be designated by the manufacturer to distinguish the new product from the old. Any misuse of product ELUs could lead to premature failure of the leaching system.

13. LEACHING SYSTEMS IN SOILS WITH SLOW SEEPAGE

Leaching systems in soils with a minimum percolation rate slower than 1 inch in 30 minutes require special design in order to avoid possible problems. Both the investigation and the detailed plan of the system must be made by a qualified professional engineer. Experience has shown that with proper design and construction, subsurface sewage disposal is possible in soils with minimum percolation rates of 1 inch in 30 to 60 minutes, assuming that there is no ground or surface water draining into the area from a higher elevation. Such drainage must be excluded from the area of the leaching system by ground water intercepting drains and surface swales. Soils with minimum percolation rates slower than 1 inch in 60 minutes are considered impervious and unsuitable for leaching purposes because they are likely to become saturated for a month or longer during the wettest season of the year.

NARROW LEACHING TRENCH SYSTEMS

Shallow leaching trenches, 18 to 24 inches wide, are the preferred type of leaching system in soils with slow seepage. Such systems take maximum advantage of lateral seepage into the more permeable layers in the upper few feet of soil, and promote capillary dispersal and evaporation. Four (4) foot wide trenches should not be used since the majority of their effective leaching is through the bottom. When systems are located in slow soils, it is important that the loamy subsoil not be stripped from the area of the leaching system because this usually is more permeable than the underlying soil. Care should be taken to only remove the vegetative growth on the top surface and not compact the loamy subsoil with heavy equipment during construction in order to maintain the larger soil voids through which air may circulate and evaporate moisture. Rainfall will tend to saturate soils with slow seepage. Therefore, it is important that the ground surface over the leaching system is sloped to drain rapidly.

ALTERNATELY USED LEACHING SYSTEMS

In some cases on existing lots it is necessary to repair leaching systems in soils which will become saturated by a continuous application of sewage effluent during the wet season. Where space is available, this may be done successfully by constructing two separate leaching systems, each large enough to dispose of the entire sewage flow under favorable seasonal conditions. During the wet season, the leaching systems are alternated in use, with one system “resting” while the other receives the entire effluent flow. The systems are watched closely and switched over manually by means of a gate or valve in a diversion box when the system in use appears to be almost saturated. Alternation intervals are usually 1 to 3 weeks during the wetter season and 3 to 4 months during the drier season. The relatively frequent alternation during the wetter season makes maximum use of the storage capacity in both the leaching system and in the surrounding soil. The relatively longer rest periods during the drier season allow the slime layer in the leaching system to dry and shrink, partially restoring the infiltrative capacity which had been reduced by clogging while the system was saturated. Figure 13-1 shows a typical alternately used leaching system.

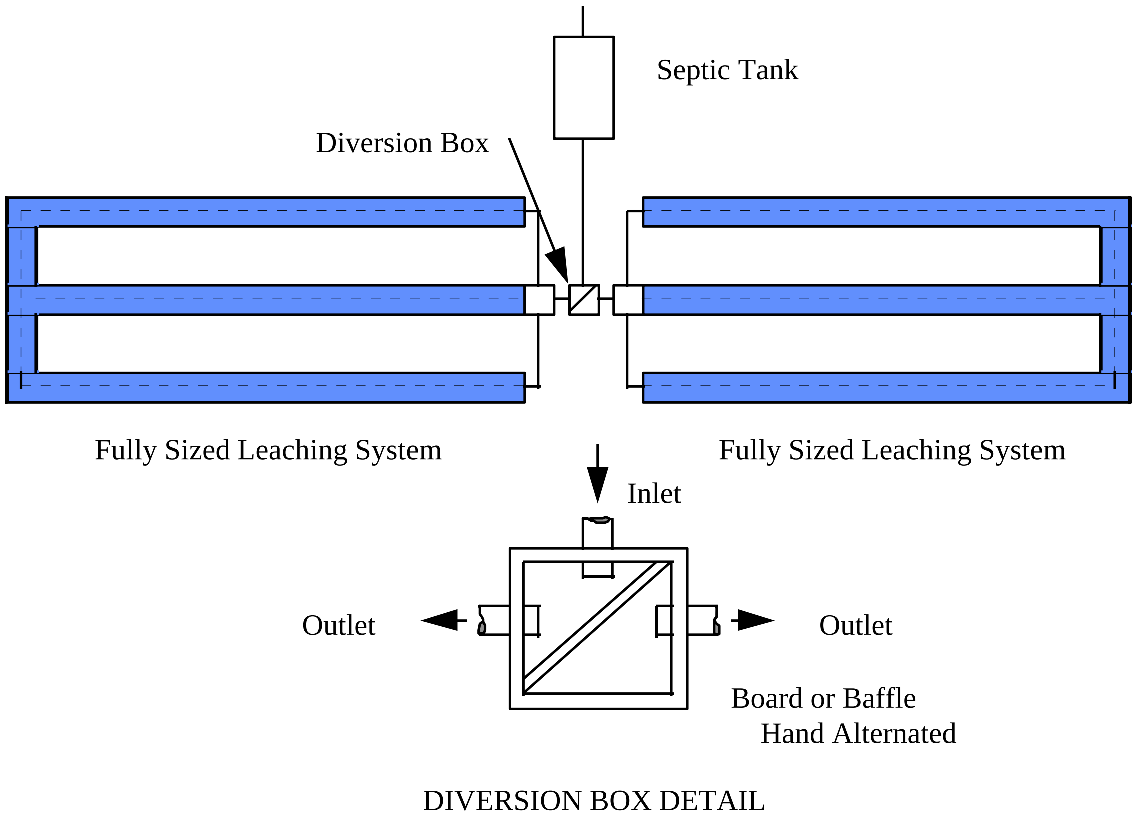


Figure 13-1 - Alternating Leaching System

SUBSURFACE IRRIGATION SYSTEMS

Subsurface irrigation systems are systems of distribution pipe buried just below ground surface for the disposal of partially stabilized sewage effluent. Such systems are not included in the Technical Standards of the Public Health Code, and require special approval of state and local health departments. Trench construction details vary, but they are normally very shallow and narrow, frequently only 12 inches wide and 12 to 18 inches deep. A relatively long length of distribution pipe is necessary to produce maximum liquid dispersal and to provide the storage volume which is lacking in the trench. Application rates are normally less than 1.0 gallons per lineal foot per day. Slotted or filter fabric wrapped plastic pipe laid in a washed sand or gravel backfill may be used, or perforated plastic pipe laid in pea stone. In any case, the sewage effluent must be partially stabilized before being applied to the leaching system in order to reduce clogging around the distribution pipe. Normally a subsurface sand filter is used for this purpose. Subsurface irrigation systems generally are constructed in high, well-drained areas which are not subject to seasonally high ground water, or are surrounded by shallow swales or ditches which prevent ground and surface water from saturating the upper soil layer. Figure 13-2 shows a typical subsurface irrigation system.

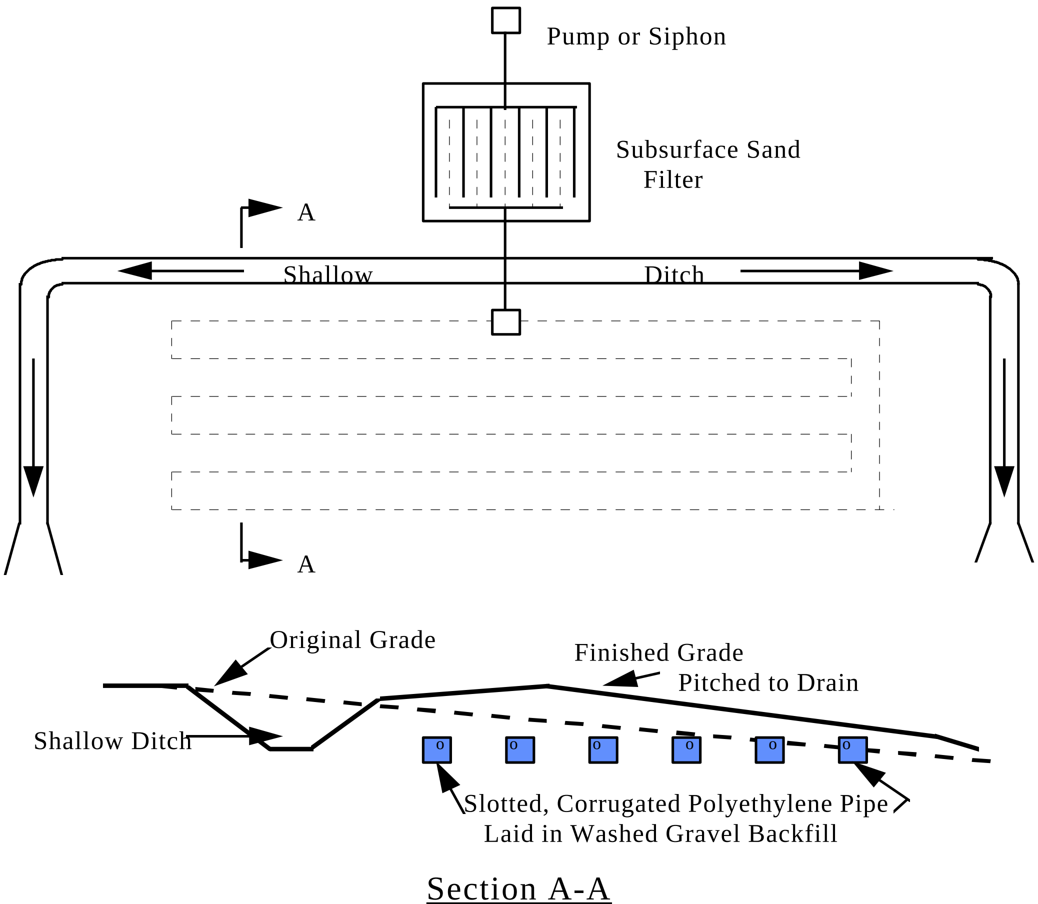


Figure 13-2 - Subsurface Irrigation System

SUPPLEMENTING OR REPLACING IMPERVIOUS SOIL

Occasionally it is necessary to repair or enlarge a leaching system in a location where the available area is limited and the existing soil has a minimum percolation rate slower than 1 inch in 60 minutes. In such a case, it is not advisable to attempt to construct a leaching system directly in the existing impervious soil. Instead, the leaching system should be constructed in an area of fill placed on top of or within the existing soil in such a manner as to allow liquid to pass through the fill into the surrounding soil with a minimum of seepage to ground surface. The most important considerations in the design of such systems is to provide the greatest possible interface area between the fill and the surrounding impervious soil, and to distribute the sewage effluent throughout the fill in such a manner as to prevent it from collecting at one point and breaking out to the surface. The amount of interface area between the stone in the leaching system and the fill is less critical because failure is unlikely to occur due to clogging at that point. Where grades permit, the leaching system should be constructed in a low mound of fill over a generally level area of existing soil. The base of the mound should be as large as possible to provide for extremely slow seepage of sewage effluent into the underlying soil, and to allow development of a mound of saturation within the fill. Generally a minimum lateral separating distance of 25 feet is provided between the leaching system and the toe of the fill to reduce the possibility of breakout. In critical cases, the basal area of the mound may be designed on the results of hydraulic analysis of the underlying soil. See the section on “Leaching Systems In Fill” for further discussion.

EFFLUENT DISTRIBUTION IN SOILS WITH SLOW SEEPAGE

Leaching systems in soils with slow seepage have a tendency to become seasonally saturated, so that special care must be taken in design and construction to assure that no part of the leaching system is overloaded to the extent that effluent comes to ground surface during the wet season. In level areas, all leaching units should be level and interconnected as much as possible. Serial distribution or a combination of serial and level leaching systems should be used on slopes. Leaching systems of narrow trenches require proportionately greater trench length, and intermittent dosing may be necessary even for household and small commercial systems under 2000 gallons per day in size. The discharge volume usually is limited by the available storage within the leaching system during adverse seasonal conditions, and frequently it must be adjusted after installation. Pumps are often used for dosing because the discharge volume can be easily adjusted by changing the pump control level switches. Pressure dosing through small diameter pipe is sometimes used because effective distribution can be produced with a relatively small discharge volume.

14. LEACHING SYSTEMS IN HIGHLY PERMEABLE SOILS

Soils with a minimum percolation rate faster than 1 inch a minute are considered to be highly permeable. Leaching systems in such soils require special design consideration in order to assure that they will not pollute wells, and ground and surface waters. In general, a determination should be made of the direction and rate of ground water movement, and a review should be made of the adequacy of the lateral separating distances between the leaching system and down-gradient wells or watercourses. If necessary, separating distances should be increased, or the design of the leaching system modified to reduce possible pollution. It is not advisable to attempt to alter the permeability of the soil by excavating and replacing it with less permeable fill or by mixing silt or loam with the existing soil. Attempts to do this in the past have been consistently unsuccessful due to poor construction techniques and lack of proper control.

<u>PREVENTING WELL POLLUTION</u>

The Public Health Code requires that the minimum separating distance between a subsurface sewage disposal system and a water supply well be doubled where the soil percolation rate is faster than 1 inch per minute and ledge is located less than eight (8) feet from the bottom of the proposed leaching system. Most wells serving households and small commercial buildings have a withdrawal rate of less than 10 gallons per minute, therefore a minimum separating distance of 150 feet would be required only where the soil is highly permeable and ledge is less than eight feet from the bottom of the leaching system.. The intent is to discourage the use of individual wells and sewage disposal systems in areas of highly permeable soil and shallow ledge rock. If such areas are to be developed, the public water supply or a community well should be used. See the section on “Leaching Systems In Areas of Shallow Ledge Rock” for further discussion on this subject. Wells in highly permeable soils have rapid recharge rates which result in relatively shallow drawdown and quick recovery. For this reason, movement toward such wells is not as rapid as might be expected. Time of travel from the leaching system to the well is related mainly to the amount of water withdrawn from the well over a period of time, rather than to the pumping rate. As long as the well does not receive heavy use, there is ample time for bacterial die-off. The rate of movement increases where the aquifer is shallow and underlain by impervious soil or bedrock. Fortunately, shallow, high yield wells are rare in Connecticut, and are usually only used for public water supplies which are regulated by the State Department of Health Services. The Public Health Code classifies the drawdown area of a public water supply well with a withdrawal rate in excess of 50 gallons per minute as an area of special concern. A special study of possible detrimental affect of the sewage disposal system on ground water quality may be required in such areas. The Code also requires that all wells drilled into rock be cased and sealed where overlying soil is less than 20 feet deep.

Both experience and hydraulic calculations have shown that leaching systems serving household and small commercial buildings with a sewage flow of 5000 gallons per day or less will not cause well pollution even in the most permeable soil as long as three precautions are observed.

1. The volume of water removed from the adjacent well should not exceed 5000 gallons per day.

2. The adjacent well should be properly cased and sealed into consolidated rock where ledge rock is less than 20 feet below ground surface.

3. The domestic sewage should contain no unusual amount of hazardous chemicals.

Improperly cased and sealed wells located in areas of shallow ledge rock can become polluted even by small sewage disposal systems, however. The potential for pollution is greater if the overlying soil is highly permeable, of course, although the basic problem is poor well construction.

PREVENTING GROUND WATER POLLUTION

Ground water may become polluted by biodegradable organic chemicals where the soil is highly permeable, the ground water is relatively high, and the volume of sewage discharged is large. However, experience has shown that an unacceptable level of pollution is unlikely to occur unless the volume of sewage discharged exceeds 2000 gallons per acre over an area of about 5 acres or more. Where this situation does occur, design engineers should consider pretreatment of the sewage by aeration systems or subsurface sand filters before discharge to the ground by conventional or modified leaching systems. Elevating leaching systems as much as possible above the ground water will reduce the potential for pollution where the soil is highly permeable. Deep leaching pits or galleries should not be used in such soils unless the ground water is very deep. Providing larger leaching systems is of questionable value, since distribution of sewage effluent throughout the leaching system is extremely difficult where the soil is highly permeable. Intermittent dosing would be beneficial, however, to distribute effluent more evenly through the leaching system. Pressure distribution leaching systems built up in fill have been effective in preventing pollution in areas of highly permeable soil and high ground water

PREVENTING SURFACE WATER POLLUTION

Pollution of surface waters by bacteria, oxygen-depleting organic chemicals or phosphates from household or small commercial subsurface sewage disposal systems is extremely unlikely even in the most permeable soils, as long as the minimum separating distances in the Public Health Code are observed. However, nitrate enrichment of surface waters from such leaching systems could be a problem since the nitrate level in the sewage effluent would not be reduced significantly by percolation though highly permeable soil. Generally, nitrate levels in surface waters must be controlled by limiting the volume of sewage effluent discharged into a given area of soil, thereby assuring adequate dilution by rainfall and mixing with groundwater. The nitrate level in sewage effluent discharged to the groundwater from a single family home located on a 1 acre building lot in Connecticut should be about 3 milligrams per liter when diluted by the average annual rainfall infiltrating into the soil on the lot. This is well below the drinking water standard of 10 milligrams per liter. Therefore, no adverse affect would be anticipated on surface water quality from housing developments with 1 acre or even ½ acre building lot requirements.

A possible exception might be lake front developments, where even low levels of nitrates could contribute to accelerated eutrophication. Such situations must be studied on a watershed basis, and is clearly beyond the control of an engineer designing a single subsurface sewage disposal system. There are certain things that a design engineer can do in such a situation, however. Leaching systems on lakefront lots could be located as far from the lake as possible, even if pumping is required. The increased distance from the lake would assure adequate mixing of sewage effluent with the groundwater before entering the lake. The ground surface could be graded or terraced to promote infiltration of rainfall rather than runoff, thereby enhancing dilution. In particularly critical situations, non-discharging toilet systems could be used. These could reduce the nitrate contribution from a dwelling by as much as 80%. Garbage grinders should not be used since they significantly increase nitrate levels in the sewage effluent. Where necessary, special subsurface sewage disposal systems can be designed for nitrogen removal. These are described in Section II of the manual, “Denitrification Systems”.

RECOMMENDED SIZING WHEN SYSTEM IS PLACED IN UNIFORM VERY FINE SANDS

Across the country, there have been a disturbing number of leaching systems which have experienced overloading, where the only common link as to the cause was the type of soil the systems were installed. All of the systems were installed in a highly permeable uniform very fine sand (a soil where the majority by percentage of the particle size is smaller than 0.15 mm - passing the #100 sieve). The theory is that the bio-mat which develops on the soil interface is thicker and less permeable than coarser soils. Therefore more wetted surface should be provided by a leaching system when installed in this type of soil condition (whether as a fill material or naturally occurring). Hence, it is recommended that a percolation rate no faster than 10.1-20 minutes/inch be utilized for sizing purposes.

15. LEACHING SYSTEMS IN AREAS OF SHALLOW LEDGE ROCK

As commonly used, “ledge rock” refers to the continuous bedrock underlying the soil layers. In Connecticut, ledge rock is quite variable in elevation and slope, and it generally forms an impervious barrier to the movement of ground water and sewage effluent. The upper surface of the ledge rock frequently is deeply contoured, forming hollows and ravines which collect percolating ground water and direct it into a channeled flow over the surface of the ledge rock. This can cause a rapid rise in the ground water level following a heavy rainfall which will interfere with the functioning of a leaching system. Sewage overflow can occur if the leaching system is not sufficiently above the underlying ledge rock.

Drainage channels on the ledge rock surface often contain granular soil or broken rock fragments which are considerably more permeable than the overlying soil. Sewage effluent “streamlining” through these drainage channels on top of ledge can move for a considerable distance before being adequately treated by filtration or dilution. This can cause well pollution where wells are not properly cased and sealed into the rock, or where the rock is fissured, allowing pollutants to enter the aquifer.

DETERMINING LEDGE ROCK ELEVATIONS

The design of the leaching system in an area of shallow ledge rock depends on the contour and slope of the underlying ledge, the size of the upslope drainage area, and the depth of the soil overlying the ledge, both under the leaching system and in a downslope direction. For this reason, it is extremely important that a sufficient number of observation pits or probes for ledge rock be made where ledge rock is found at a depth of 7 feet or less. For a household system, the depth to ledge rock should be determined at three or four locations within the area of the proposed leaching system, and at one or more locations downslope from the system. A greater number of pits would be required for larger systems or where ledge outcroppings are noted adjacent to the proposed system. It may also be advisable to dig an observation pit at the proposed location of the septic tank, in order to avoid possible installation problems. The location of ledge outcroppings should be noted.

Ledge rock depth normally is measured from ground surface. Such depth readings are often quite variable, however, since both the ground surface and the underlying ledge rock usually slope. In order to avoid confusion in designing the leaching system, the ground surface elevation should be determined at each test pit location by measuring from a bench mark. The ledge rock elevation and slope can then be calculated, and the location and elevation of the leaching system determined. Using this approach, it will frequently be found that ledge rock shows a relatively consistent profile, even when the depth readings are erratic.

REQUIRED DEPTH OF SOIL ABOVE LEDGE ROCK

Technical Standard VIII requires that the bottoms of leaching systems be kept a minimum of 4 feet above ledge rock, but some judgment is necessary in using this standard. The basic consideration should be the likelihood of the underlying ledge rock interfering with dispersal of ground water and sewage effluent. Experience has shown that underlying ledge rock is unlikely to interfere with the functioning of a leaching system as long as the bottom of the leaching system is elevated 4 feet above the ledge rock surface. However, a small projection of ledge rock under a leaching system is unlikely to cause failure if it rises closer than 4 feet from the bottom of the system, particularly if the ledge is sloped so that ground water and sewage effluent will move out of the area. On the other hand, an elevation greater than 4 feet may be required if the ledge forms a basin or ravine which causes a buildup of ground or surface water during wet periods.

Where there is less than 6 to 7 feet of existing soil over ledge rock, the placement of fill would be necessary in order to construct a leaching trench system with the trench bottoms 4 feet above ledge. Such a method of construction would present no unusual difficulty as long as there is at least 4 to 5 feet of soil above ledge rock, since the bottom of the leaching trenches essentially would be constructed in existing soil. However, construction becomes more critical if there is less than 4 feet of existing soil above underlying ledge. In this situation, the entire leaching system must be constructed in fill, and the nature and compaction of the fill must be carefully evaluated before the leaching system can be designed. For this reason, Section 19-13-B103e(a) of the Public Health Code prohibits the issuance of sewage disposal approvals or permits where there is less than 4 feet of existing soil over ledge rock. It should be understood, however, that this does not mean that no sewage disposal system could ever be built at this location. It only means that the necessary fill must be placed, compacted and tested before the final sewage disposal plan is approved and a building permit issued. This puts the responsibility for making the site improvements entirely on the property owner or builder, and tends to discourage the installation of sewage disposal systems in areas with less than 4 feet of naturally occurring soil over ledge rock. It also encourages owners and builders to test their properties more thoroughly in order to find a location for the sewage disposal system where ledge rock is sufficiently deep to avoid the need for filling before a permit can be obtained. Many planning and zoning commissions use the requirement of 4 feet of existing soil over ledge rock as a standard for approving building lots. All of this is beneficial in avoiding potential sewage disposal problems in shallow ledge rock areas.

The depth of soil overlying the ledge rock <u>downslope</u> from the leaching system also must be considered. In general, a more or less continuous layer of at least 2 feet of soil would be necessary on top of the ledge rock to assure adequate dispersal of sewage effluent. A greater depth of soil would be necessary if significant amounts of ground or surface water drain through the area, or if the ledge rock is relatively level. Where there is less than 2 feet of soil over ledge down grade of a proposed leaching area, it may be necessary to make a hydraulic analysis to determine whether or not sewage effluent will break out prematurely. See Section II for further information on hydraulic analysis. There should be no ledge outcroppings within 50 feet downslope of the leaching system, and no springs within 75 feet downslope.

PREVENTING WELL POLLUTION

Well pollution is frequently a problem in areas of shallow ledge rock, particularly where there are a number of building lots involved, each served by an on-site sewage disposal system and water supply well. In larger subdivisions, some lots normally are located downhill from others, and the wells on these lots may be downhill from the sewage disposal systems. Sewage effluent moving through permeable channels on top of ledge may travel quite a distance and enter wells which have been improperly cased or sealed into consolidated rock. Some ledge rock is fissured, and sealing of the wells may be difficult. Proper well construction should prevent pollution, but unfortunately experience has shown that where there are large number of wells involved, some are always likely to be improperly sealed and subject to pollution. The surest way to prevent well pollution in areas of shallow ledge rock is to extend public water supply mains to the area, or to construct a community well to serve the subdivision. Such a well could be kept at a high elevation and remote from on-site sewage disposal systems. In general, all subdivisions containing 25 or more lots located in an area with underlying ledge rock less than 7 feet deep should be served by a public or community water supply.

Well pollution also has occurred when shallow ledge rock is excavated by blasting to construct roads, sewer lines or subsurface sewage disposal systems. Blasting can open fissures in the ledge and rupture the well casing or seal. Public water supply systems are essential if any rock blasting is to be done in an area of shallow ledge rock and on-site sewage disposal systems.

OTHER DESIGN CONSIDERATIONS

The construction of ground water intercepting drains in areas of shallow ledge rock is difficult and in many cases they are not effective in controlling subsurface flooding. On top of ledge rock, ground water tends to "streamline" through depressions or channels in the rock surface, or through fissures in the ledge rock itself. It is extremely difficult to intercept this flow of water effectively without excavating into the rock. Even if the ground water were intercepted, it may not be possible to discharge the drain by gravity without rock excavation (see Figure 15-1). For these reasons, ground water intercepting drains must be considered unreliable on shallow ledge rock, and generally should not be used. Ground water flow usually is found only in certain locations on top of ledge, and it is better to avoid using those areas for leaching systems.

In some shallow ledge rock areas there may be only limited areas, or "pockets", where the overlying soil is sufficiently deep to be considered for leaching purposes. In such a situation, it may be advisable to divide the leaching system into two or more separate systems, rather than to attempt to put all of the sewage effluent into an area of soil with a limited dispersal capacity. This is particularly important for larger leaching systems, which generally should not be constructed over shallow ledge rock unless the leaching system can be spread over a large area.

NON-TYPICAL LEDGE ROCK

Occasionally a soft, partly decomposed rock layer will be found which easily can be excavated by a backhoe, but which appears to be part of the continuous bedrock. This material is considered to be non-typical ledge rock, inasmuch as it does not present a barrier to the movement of water. In fact, a percolation test made in this material would probably show a moderately good percolation rate. However, in this case, the water moves through small, continuous pores in a solid matrix, rather than through larger, non-continuous voids, as in a soil. While water moves rapidly, sewage effluent will tend to clog the small pores. Because of this, leaching systems should not be constructed directly in decomposed rock. Recommended design practice calls for the bottoms of leaching systems to be constructed at least 2 feet above such non-typical rock, or if necessary, a portion of the decomposed rock may be removed and replaced with 2 feet of sand for filtration purposes. The decomposed rock is usually underlain with consolidated rock, and the leaching system must be at least 4 feet above this layer.

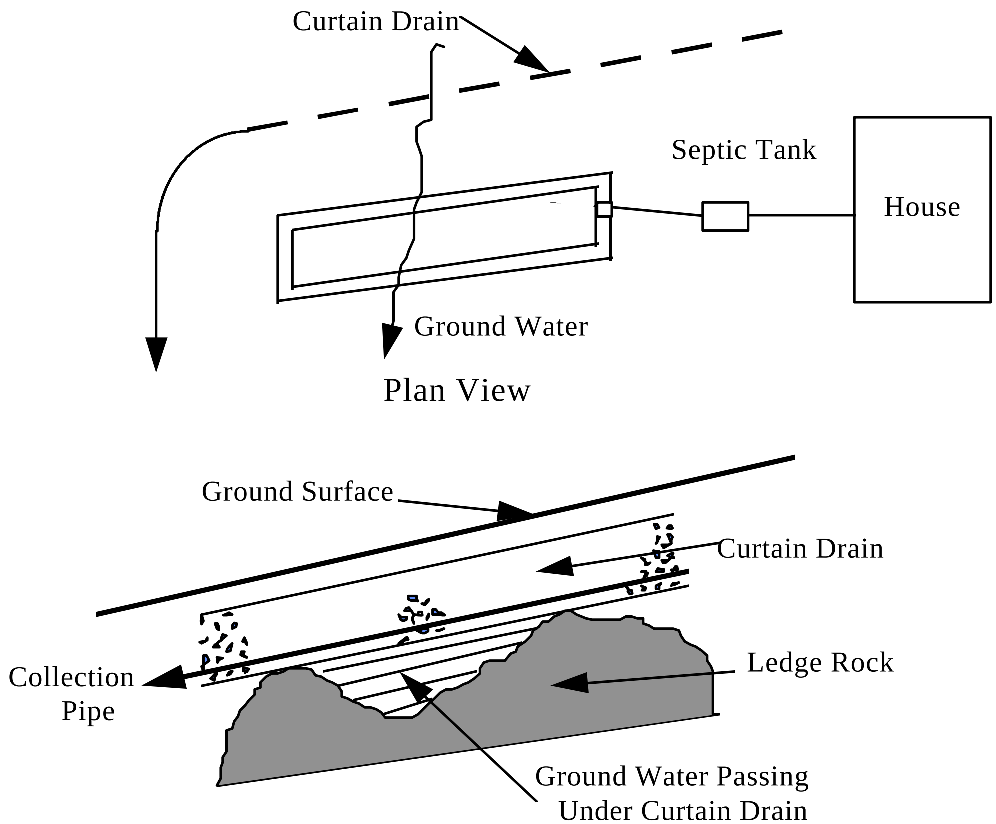


Figure 15-1 - Profile Through Curtain Drain

Sometimes, layers of loose, fractured rock will be found on top of consolidated ledge. Unlike the decomposed rock, the fissures are large and do not provide filtration of sewage effluent. Leaching system normally should be kept 4 feet above the top of the fractured layers, and no attempt should be made to remove the loose rock. This is particularly important when there are water supply wells in the area which would be difficult to seal into fractured rock.

16. LEACHING SYSTEMS IN HARDPAN SOILS

"Hardpan", as commonly used, refers to any naturally occurring layer of hard, densely compacted soil. In Connecticut, such hardpans generally are formed on glacial tills and are located on upland areas where they frequently are found at a depth of 4 feet or less. Hardpans vary in composition, but they always have relatively little void space, low permeability, and slow percolation rates. The minimum percolation rate will vary from 20 minutes per inch to virtual imperviousness, depending on the particle gradation and the degree of compaction. Hardpan in Connecticut normally contains a high percentage of silt which tends to fill the voids between the larger soil particles. This is why even a hardpan with a large amount of sand or gravel will be quite compact and have relatively low permeability.

Sewage system failures are common in hardpan soil areas. In most cases, these are related to failure to properly evaluate the minimum percolation rate, the restrictive effect of underlying hardpan, or seasonal perched water. Often the percolation test hole penetrates only a few inches into the hardpan layer. When tested with a 12 inch depth of water, a fairly good percolation rate may be obtained due to lateral seepage into layers of good soil on top of the hardpan. The leaching system subsequently may be constructed deeper into the underlying hardpan and may fail due to poor seepage or groundwater flowing on top of the hardpan layer.

Failure also can occur because of the inability of the leaching system to adequately disperse sewage effluent into the surrounding soil due to the restriction presented by the underlying hardpan layer. This can occur even with proper testing and construction and effective control of perched groundwater. Possible dispersal limitations in hardpan soils can be evaluated by permeability testing and hydraulic analysis. However, it probably is not practical or necessary to require this procedure for all sewage disposal systems in such soils. The design guidelines in this section have been developed through many years of experience with small residential sewage disposal systems installed in hardpan soils. It is based on selective percolation testing of both the underlying hardpan and the looser upper soil layers, and on careful placement of the leaching system relative to the restrictive hardpan layer. It should be cautioned that while these design principles are well proven for small sewage disposal systems, they may not be adequate for effluent discharges exceeding 1,000 gallons per day, or for areas where the soil layers overlying the hardpan has a minimum percolation rate poorer than 20 minutes per inch. In these situations, permeability testing and hydraulic analysis is advisable. It also should be noted that hardpan layers at depths greater than **5** feet below ground surface normally need not be considered for small sewage disposal systems, since experience has shown that they are unlikely to significantly restrict dispersal of small volumes of effluent.

TESTING HARDPAN SOILS

The key to proper design of small leaching systems in hardpan soils is making a proper evaluation of the minimum percolation rate of the underlying hardpan layer and the overlying looser soil, and accurately measuring the depth to the top of the hardpan layer. It is important that the percolation tests be made entirely within the hardpan layer wherever hardpan is found at a depth of less than 5 feet, in order to determine the characteristics of the hardpan only. This would mean that the bottom of the test hole must penetrate at least 12 inches into hardpan, so that the water will contact only the hardpan soil itself. If the hardpan layer is found to have a minimum percolation rate slower than 30 minutes per inch, another percolation test should be made in the looser soil layers above the hardpan.

Extended presoaking normally is not necessary in order to obtain the minimum percolation rate of a hardpan, since most hardpans in Connecticut contain very little swelling clay.

MODERATELY RESTRICTIVE HARDPAN

Hardpan with a minimum percolation rate of 20 to 30 minutes per inch is considered to be moderately restrictive. A leaching system constructed with all or part of the stone-soil interface within the hardpan layer itself should function properly provided:

a) The size of the leaching system is based on percolation tests made completely within the hardpan layer, not partially in the looser upper soils, and

b) A ground water control drain is provided which will control both perched water on top of the hardpan layer and the seasonal high groundwater table in the hardpan layer itself.

Figure 16-1 shows the cross section of a typical leaching trench system constructed partly in moderately restrictive hardpan. Note that the percolation test was made at a sufficient depth to properly measure the minimum percolation rate in the hardpan, and this was used to determine the required amount of leaching area. Also note that the ground water control drain penetrates deeply into the hardpan layer in order to draw down the seasonal high ground water table in that layers, and that the stone in the drain is extended to near ground surface to intercept ground water perched on top of the hardpan.

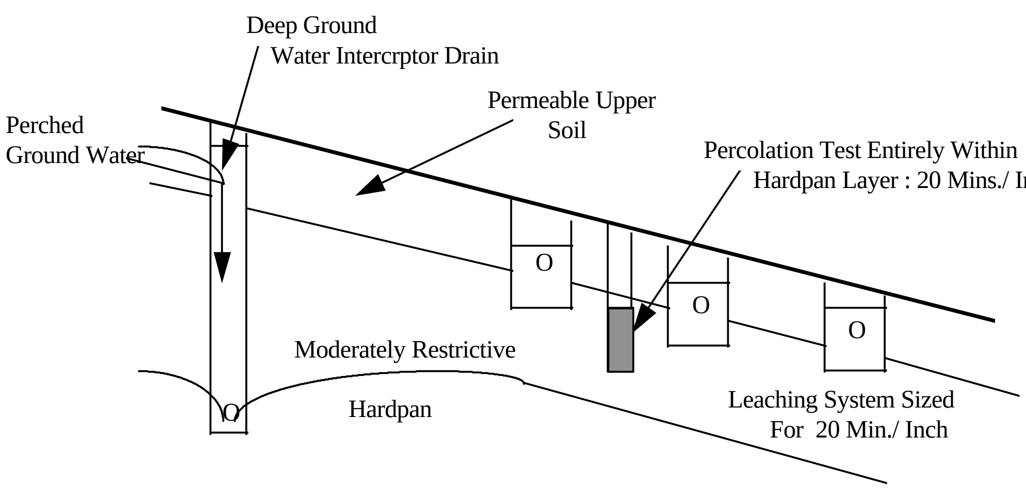


Figure 16-1 - Moderately Restrictive Hardpan

SEVERELY RESTRICTIVE HARDPAN

Hardpan with a minimum percolation rate of 30 to 60 minutes per inch is considered to be severely restrictive. Because of its low capacity to transmit water, the hardpan probably will become saturated during the wet season, even though a ground water control drain is used. For this reason, no part of the stone-soil interface in a leaching system should be constructed directly in the hardpan layer. Instead, the bottom of the leaching system should be raised above the top of the hardpan. It may not be necessary to keep the leaching system 18 inches above the hardpan layer (as long as a curtain drain is provided) because the hardpan would be saturated only for short periods of time, and it is unlikely that there would be significant effluent mounding on top it. Normally, the bottoms of leaching systems should be kept 12 inches above the top surface of severely restrictive hardpan, with a greater elevations being used where the hardpan surface is more level. Of course, an intercepting drain would be necessary to control perched ground water which would collect on top of the hardpan layer, but in this case, the drain would not have to penetrate deeply into the hardpan because no attempt is made to lower the ground water level in the hardpan itself.

Determining the required size and configuration of the leaching system in this case shall be based on the percolation rate of the upper permeable subsoil above the hardpan and the minimum spread of the system determined by MLSS criteria.

Figure 16-2 shows the cross section of a typical leaching trench system constructed above severely restrictive hardpan. Note that separate percolation test were made in both the hardpan and in the more permeable upper soil layer. The size of the leaching system is based on a minimum percolation rate of 10 minutes per inch. In order to keep the underlying soils from becoming saturated due to the daily discharge from the leaching system, the system must be spread to meet MLSS criteria. Also note that the placement of some fill is necessary in order to construct a leaching system sufficiently above the hardpan layer. Refer to the section on "Leaching System In Fill" for information on how this should be done.

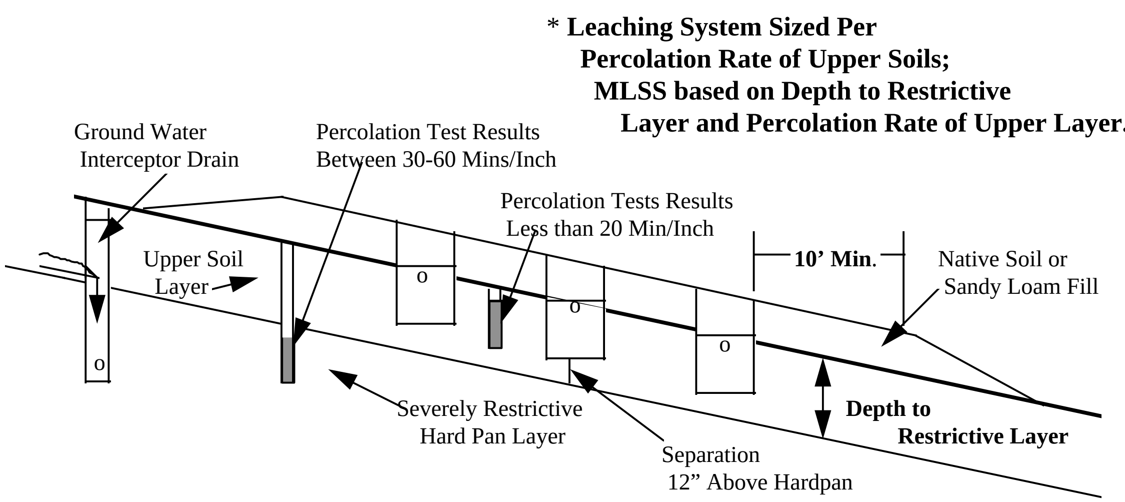


Figure 16-2 - Severely Restrictive Hardpan

IMPERVIOUS HARDPAN

Hardpan with a minimum percolation rate poorer than 60 minutes per inch is considered to be impervious. Leaching systems must be raised well above such an impervious layer since it is likely that a mound of saturated soil will develop on top of this barrier when sewage effluent is applied. Where possible, the bottom of the leaching system should be kept 18 inches above impervious hardpan to allow a zone of unsaturated soil between the leaching system and the effluent mound for effluent renovation. While the leaching system can be constructed in fill, if necessary, to keep it sufficiently above the impervious hardpan, the depth and permeability of the surrounding soil overlying the hardpan is critical since all of the effluent must be dispersed laterally through these soil layers. If the depth or permeability of the overlying soil is insufficient, or if the hardpan is too flat to allow adequate hydraulic gradient, sewage effluent may surface. It may be necessary to make a hydraulic analysis of the capacity of the surrounding soil to disperse the expected volume of sewage effluent in marginal situations or where the volume of effluent is large. (See section II for information on hydraulic analysis.) However, experience has shown that small leaching systems, such as for single family residences, can be installed successfully over imperious hardpan as long as there is at least a 24 inch depth of overlying surrounding soil with a minimum percolation rate of 20 minutes per inch or better. Perched ground water on top of the hardpan must be controlled, of course, and this may be difficult in extremely level areas.

In general, the leaching system shall be sized, as with Severely Restrictive Hardpan mentioned above, based on the percolation rate of the upper permeable soils. Hydraulic concerns shall be addressed by applying MLSS criteria and spreading the system out enough to avoid saturating the underlying soils from the system's daily discharge.

Figure 16-3 shows the cross section of a typical leaching trench system constructed above impervious hardpan. It is evident that construction becomes critical when the hardpan layer is less

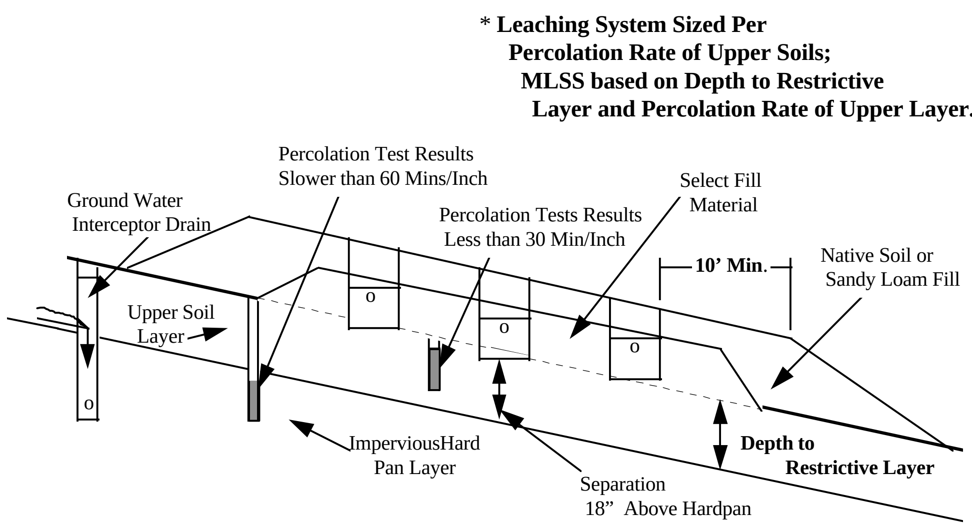


Figure 16-3 - Impervious Hardpan

than 30 inches below ground surface because part of the leaching system must be constructed in fill. Special care must be taken to follow the recommended design and construction practice in this manual to avoid possible problems.

A question frequently asked as to why leaching system must be kept 4 feet above ledge rock, but only 18 inches above impervious hardpan. The reason for this is that channeled flow seldom occurs on top of hardpan layers. The surface of the hardpan normally is smooth, without depressions to collect and transmit effluent. Also, there rarely are layers of highly permeable soil on top of the hardpan, as there frequently are on top of ledge, so that movement over the hardpan in relatively slow, allowing effluent renovation.

CONTROL OF PERCHED GROUND WATER

There is almost always perched ground water flowing on top of hardpan during the wet season or after periods of heavy rainfalls. This ground water will collect in leaching systems which penetrate into the hardpan layer, particularly on hillsides where the ground water will flow down from higher elevations. Particularly severe ground water conditions can be expected on top of hardpan with a minimum percolation rate slower than 30 minutes per inch, or where there is an extensive uphill drainage area. Uphill curtain drains should be used wherever possible to alleviate this condition. Such drains normally are effective when they are constructed deep enough to penetrate 24 inches into the hardpan layer and are backfilled with stone extending 18 to 24 inches above the top of the hardpan layer to intercept perched ground water.