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Basic Subsurface Sewage Disposal Design

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1. DOMESTIC SEWAGE

Subsurface sewage disposal systems are intended and designed for the treatment and disposal of domestic sewage. 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 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 domestic sewage, although the composition at those types of facilities is not typical, and may require special design considerations for a subsurface sewage disposal system.

Subsurface sewage disposal systems are also governed by local and state codes. Such codes must be reviewed when designing a system.

A sewage containing chemical or biological pollutants and concentrations significantly outside governed ranges, or which may contain non-biodegradable synthetic organics, carcinogens or bio-toxins 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 the specific standard established by state and federal code.

Following is a partial list of such wastes.

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

In designing and constructing a subsurface sewage disposal system it is necessary to know the various pollutants in order to have an understanding of the possible effects on ground and surface waters. Brief discussions of the various pollutants are provided as follows:

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

Table 1-1 - Pollutants in Domestic Sewage

Pollutant (mg/l)	Per Capita Contribution (grams/day)	Concentration in Domestic Sewage
Suspended Solids	35-50	200-290
Bio-chemical Oxygen (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

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, this is the way they are measured. The BOD 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 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 biodegradable organic chemicals in the water itself, but 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 designed and 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. 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 (NO2) and subsequently into nitrate nitrogen (NO3). 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 code are maintained.

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 in soils, it is unlikely that properly designed subsurface sewage disposal systems would be a significant source of phosphate pollution.

COLIFORM BACTERIA

Coliform bacteria is a bacteria which is indigenous to the intestinal tract of humans and warm-blooded animals. 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.

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. 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. Coliforms in surface waters do not necessarily indicate sewage pollution, since sewage is not the only source of coliforms in the environment.

HAZARDOUS CHEMICALS

Domestic sewage may also 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. 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 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 amount 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

Design requirements for subsurface sewage disposal systems serving residential buildings are different from those serving non-residential buildings. There are two practical reasons for this. First, 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.

RESIDENTIAL BUILDINGS

The size of the septic tank and leaching system serving a residential building should be related to the number of bedrooms, without consideration of the number of occupants or the water consumption. This requirement is 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. However, sewage disposal requirements cannot be based on average figures, since if this were done, one-half of all the systems would, most likely, be substandard and in danger of failing. A factor of safety of 1.5 should be used to bring the confidence level to over 90 percent. Therefore, in water usage terms, the design flow for each bedroom should be considered as 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 is utilized whenever performing hydraulic analysis calculations for residential buildings.

DEFINITION OF A BEDROOM

With today's custom homes it is common to see exercise rooms , sewing rooms, studies, offices, dens, family rooms and other similarly labeled non-bedroom spaces. 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 should be based on the potential number of bedrooms in the house.

There are standards by which a room can be considered as potential bedroom and are listed below:

- 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.
- Privacy to the occupants.
- Full bathroom facilities (containing either a bathtub or shower) which are conveniently located to the bedroom served.
- 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 intend is not 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.

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.

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 should be 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. MostCode 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 is based on the following normal distribution of sewage flow from a residence, with a factor of safety.

Usage	% 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 shall be designed on the basis of the estimated 24 hour sewage flow. Non-residential buildings should 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 such a situation, an average flow figure of 3 to 5 gallons per minute may be used with a factor of safety of 1.5 to 2.0.

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. 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

It is importance to perform a proper site investigation. An 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 site investigation is done properly it should be possible to make a general conclusion immediately afterwards 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.

SITE INVESTIGATION PREPARATION

There is a considerable amount of information relative to land use and development which design engineers should review and be familiar with before making any site investigation. First of all, the engineer 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 engineer 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 was 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 engineer 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 engineer can tell much about a site from its location in the general topography of the area. The U.S.G.S. also publishes 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 (SCS), 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.

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. 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 a question to the maximum ground water level, additional ground water investigation during the wet season may be required.

The U.S. Geological Survey (USGS) documents monthly ground water levels in various locations throughout the country. U.S.G.S. wells are used as an indicator of the general ground water levels within a town or region. The range may be quite different from well to well 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. A trained and careful engineer 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 test holes are dug, the engineer 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 engineers 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 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 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 engineer. 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 engineer 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. 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 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. Where clays do occur, they usually are prevalent throughout a general area. Experienced engineers normally are aware of this and may take special care to identify and avoid these soils.

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.

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	Partical Size (inches)	(MM)	Example #	Sieve Size
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
Find Sand	0.02-0.003	0.425-0.075	powdered sugar	#40 - #200
Silt	<0.003	0.075-0.002	talcum powder	pass #200
Clay		<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.

Soil identification may be written 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 (see sample technical standard)

A technical Standard may 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	5/3.5=1.4
9:55 AM	13 1/4	5	2 3/4	5/2.25=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	5/0.5=10.0
10:15 AM	17 1/8	5	3/8	5/0.375=13.3
10:25 AM	17 3/4	10	5/8	10/0.63=15.7
10:35 AM	18 1/4	10	1/2	10/0.5=20.0
10:50 AM	19	15	3/4	15/0.75=20.0

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:

- The drop in water level is found by subtracting the previous readings of the depth to water from the current reading.
- 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 uniform rate represents the areas minimum percolation rate.

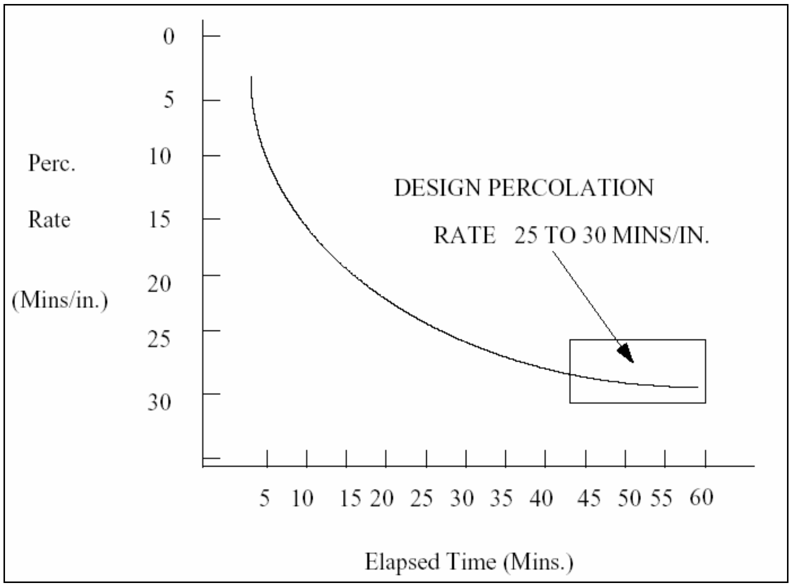


Figure 5-1
Percolation Test

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 5-2 RECOMMENDED TIME INTERVALS BETWEEN READINGS

Interval Percolation Rate	Recommended 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 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 engineers 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 when soil moisture is high will be somewhat slower than those made during times when the soil moisture level is lower. However, the requirements for leaching area should be based on percolation tests made when the soil is only slightly moist, and therefore percolation tests should be done during periods when the soil is slightly moist. Percolation tests made 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 slower than normal results may be due to entrapment of air bubbles in dusty soils. The elimination of percolation testing during the driest time would eliminate misleading results, but this may create some hardship and additional expense. Most engineers 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. 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. Most designers 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 during a dry period, 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.

Table 5-3 Typical Leaching Sizing Chart

PERCOLATION RATE	SQUARE FEET OF REQUIRED EFFECTIVE LEACHING AREA				
MINUTES TO DROP ONE INCH	2 BEDROOM BUILDING	3 BEDROOM BUILDING	4 BEDROOM BUILDING	FOR EACH BEDROOM ABOVE FOUR Single Family	FOR EACH BEDROOM ABOVE FOUR Multi-family
LESS THAN 10.1	375	495	660	100	165
10.1-20.0	500	675	900	150	225
20.1-30.0	565	750	1000	175	250
30.1-45.0	675	900	1200	225	300
45.1-60.0	745	990	1320	250	330
LESS THAN 5.0*	300	375	500	100	125
GREATER THAN 60.0	UNSUITABLE FOR LEACHING SYSTEMS				

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 therefore, it is important to follow Code requirements for percolation test. 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" 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. It is always wise 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 that does not exceed one month 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, 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 a code 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 toilets during this time.

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. 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 engineer 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. 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, engineers 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. Soil color charts are found in Munsells soil color chart manual (published by Macbeth).

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 soils 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 each States 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, 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: It is hard to 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 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.

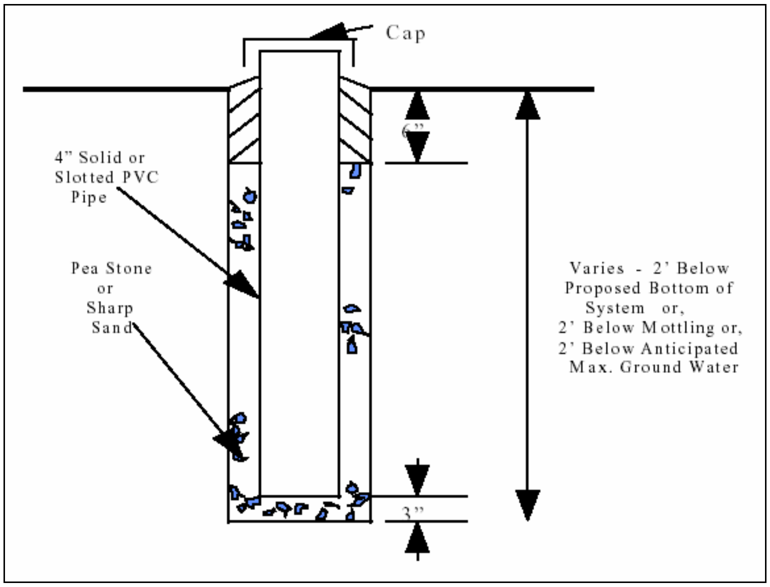


Figure 6.1
Ground Water Monitoring Well

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 engineer may 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.

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.

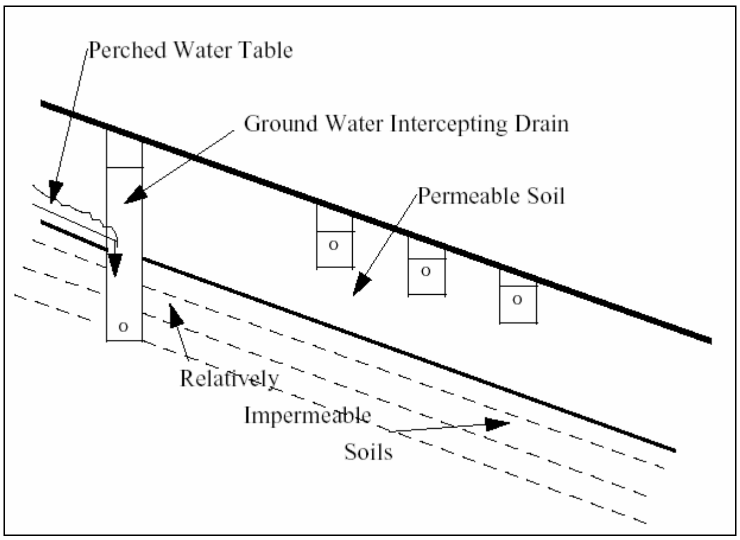


Figure 7-1
Ground Water Intercepting Train

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.

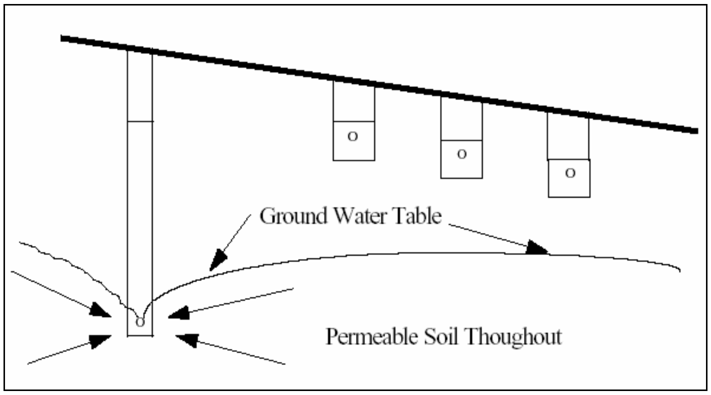


Figure 7-2
Ground Water Drain In permeable Soil

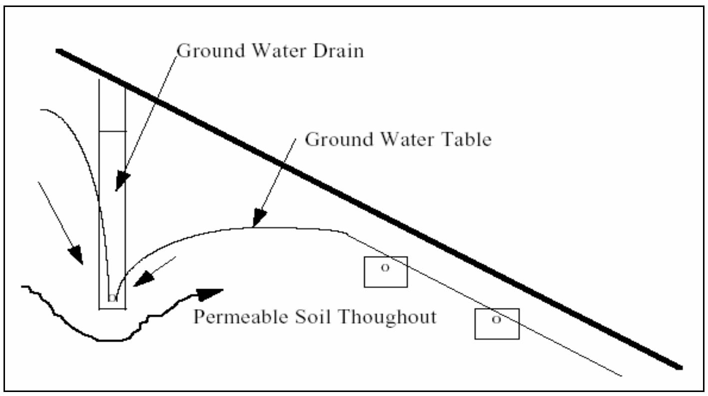


Figure 7-3
Ground Water Drain on Permeable Slope

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.

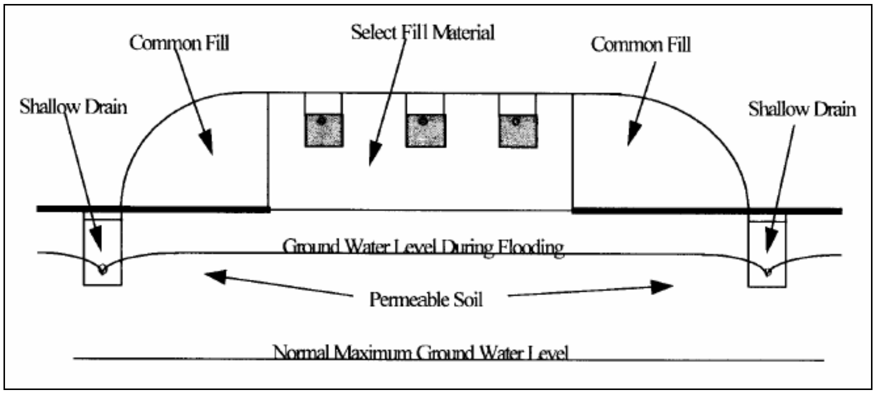


Figure 7-4
Shallow Drains to Control Flooding

LOCATION OF GROUND WATER DRAINS

Most Codes require 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 before 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.

DRAIN CONSTRUCTION

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 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 down-slope 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 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. 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 rebounds 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 therefore, 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 could be subject to freezing in the northern states, or may cause blocking and sewage backups.

Most state and local Codes list 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. State Building Codes 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 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.

Table 7-1 Typical List of Acceptable Sewer Piping (Refer to Specific State and local Code)

USE	PIPE DESCRIPTION	ACCEPTABLE JOINT	REMARKS
Building sewer from foundation wall to septic tank or grease interceptor tank, within 25 feet of building served Building sewer line within 75 feet of a private water supply well, spring or water suction pipe <u>but no closer than 25 feet</u> for wells with withdrawal rates less than 10 gpm. Greater separation distances required for wells with withdrawal rates 10 gpm or greater (see PHC 19-13-B51d) NOTE: Building sewer may cross potable water lines under pressure. To reduce separation distances for the <u>following other items listed in Table No. 1:</u> -Human habitation on adjacent property -Building served -Top of embankment -Property line -Pressure water lines -Swimming pools -Accessory structures -Utility service trench	Cast iron hubless ASTM A-888	Cast iron split sleeve bolted joint with rubber gasket, MG coupling or equal OR 3"-wide, heavy -duty, stainless steel banded coupling with rubber gasket; clamp-all, ANACO SD 4000, or equal	Roll-on "donut type" gaskets not acceptable if connection is within 25 feet of foundation wall. Pipe must be properly bedded, laid in straight line on uniform grade FERNCO - stainless steel 3" wide shear band allowed for connection of dissimilar piping materials
	Cast iron bell and spigot ASTM A-74	Rubber compression gaskets	
	PVC ASTM D 1785 /ASTM D 2665, Schedule 40	Rubber compression gasket couplings, Harco Mfg., ASTM D 3139 or equal* OR Solvent weld couplings/ fittings using proper two step PVC solvent solution procedure	*Use of 3"-wide approved stainless steel banded couplings on PVC Schedule 40 ASTM D 1785 is acceptable UL (gray) Piping - Schedule 40- 36" radius- may be utilized as 90º sweep without the need for cleanouts. ABS Schedule 40 is not acceptable
	Ductile iron ANSI A 21.51	Rubber compression gaskets	Connection to cast iron building sewer must be made with compression gaskets.
	PVC AWWA C-900 (PC 100 psi min.)	Rubber compression gaskets	"O"-ring gasket is not acceptable
	PVC ASTM F 1760, Schedule 40	Rubber compression gaskets	Only 4" pipe approved Minimum 1' cover in vehicular loaded traffic areas

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

A properly functioning septic tank :

- Removes most of the settleable solids.
- Produces an effluent of relatively uniform physical, chemical and biological quality from a raw sewage with widely fluctuating characteristics.
- 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

Most septic tanks conform to ASTM C-1227-95 standards and 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 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.

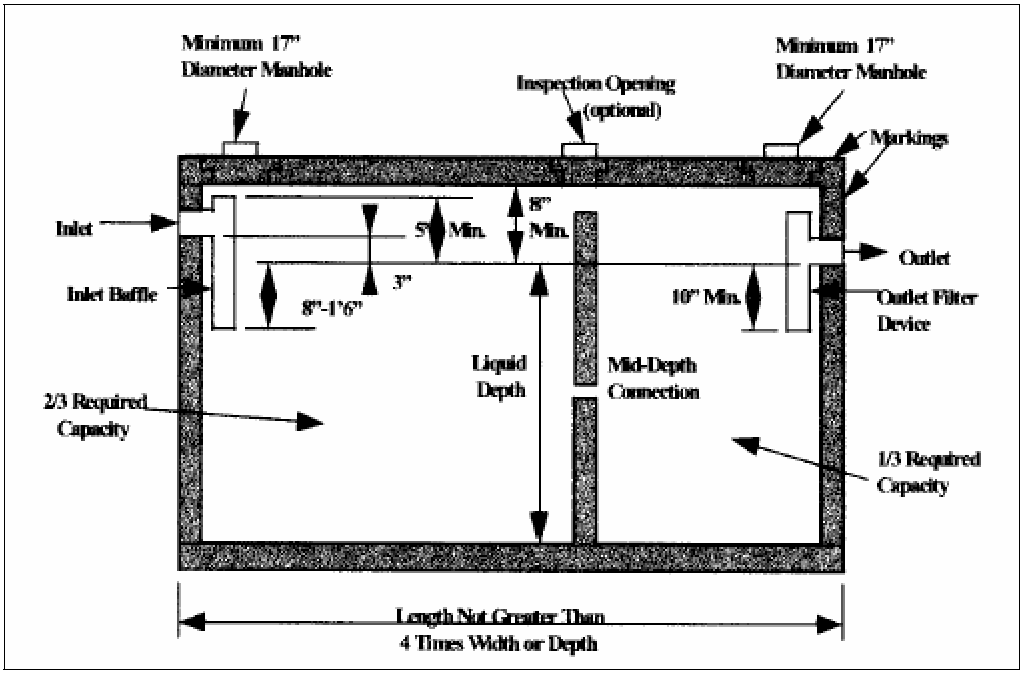


Figure 9-1
Typical Concrete Septic Tank

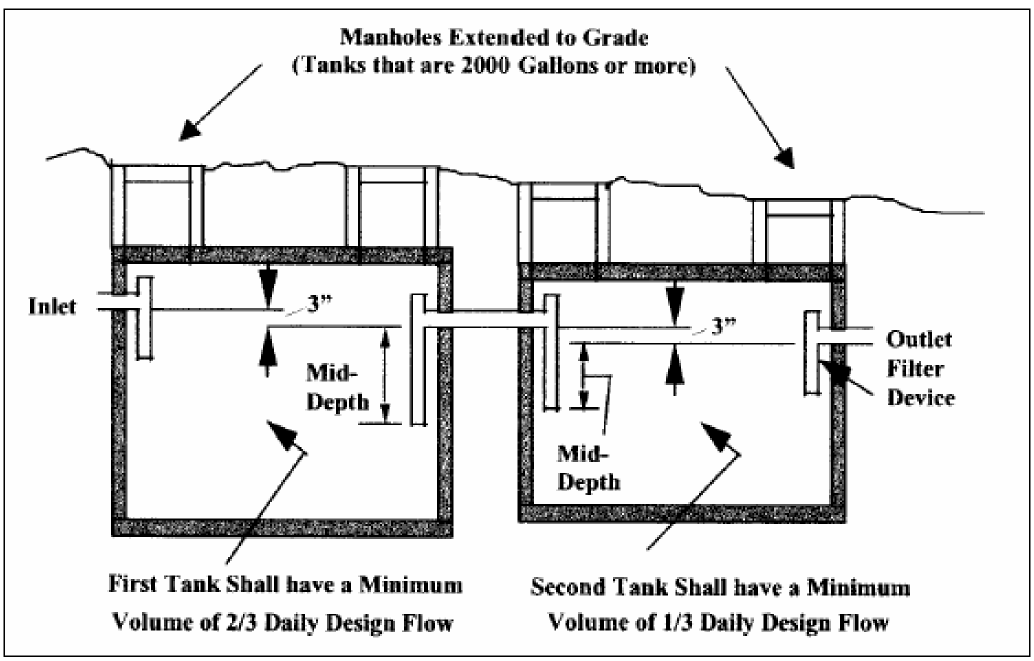


Figure 9-2
Typical Concrete Septic Tanks In Series

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:

- Intermittent dosing or flooding of the leaching system,
- Keeping the leaching units level and interconnecting them, and
- 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 Distribution 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. However, this device requires 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.

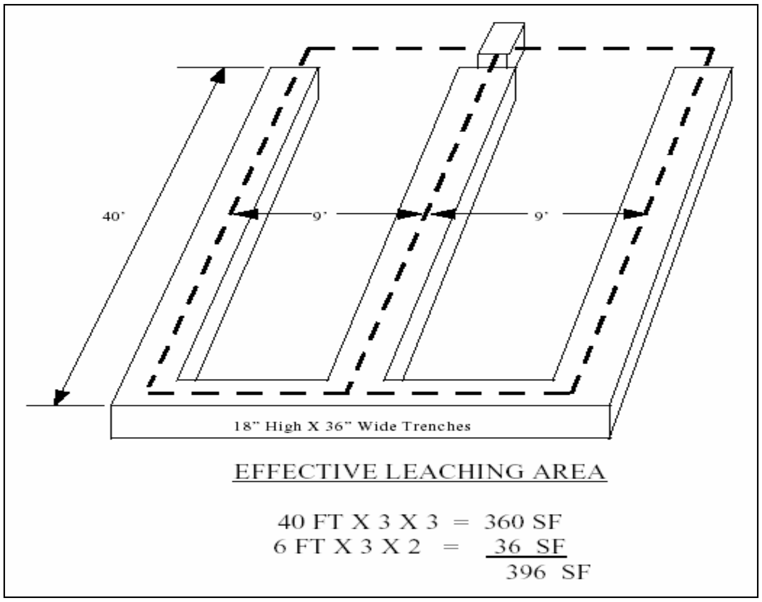
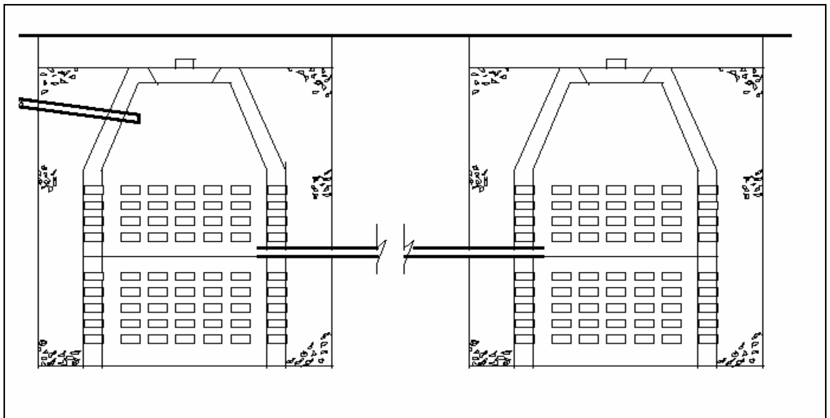


Figure 10-1
Level Leaching Tranches

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 occur. 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.



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

Figure 10-2
Pits at Same Elevation

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.

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.

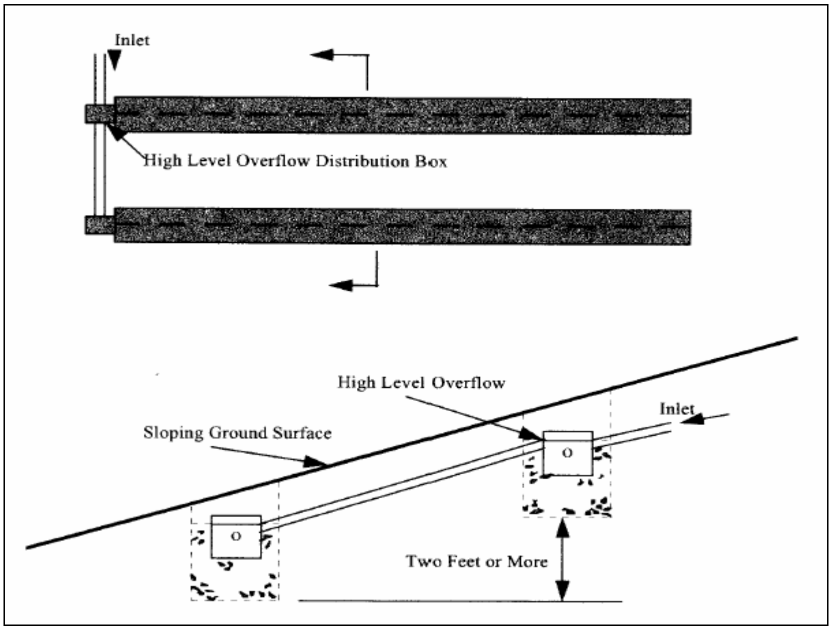


Figure 10-3
Serial Leaching Trenches

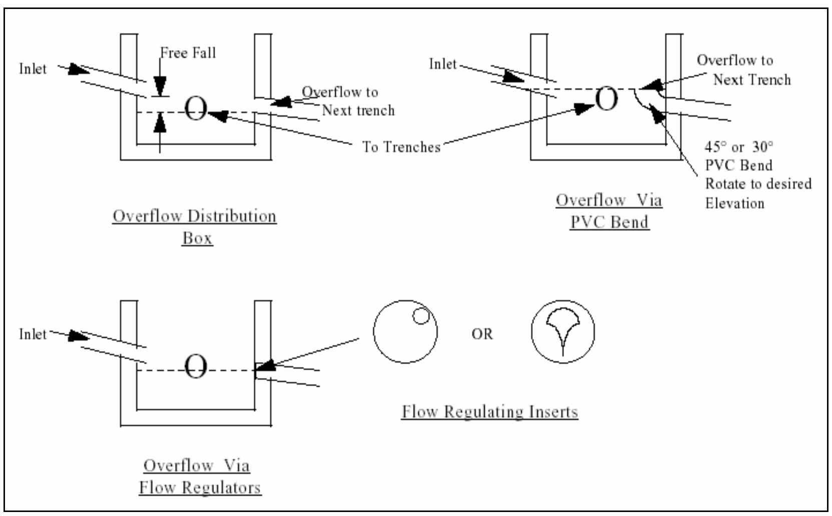


Figure 10-4
High Level Overflow Distribution Boxes

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.

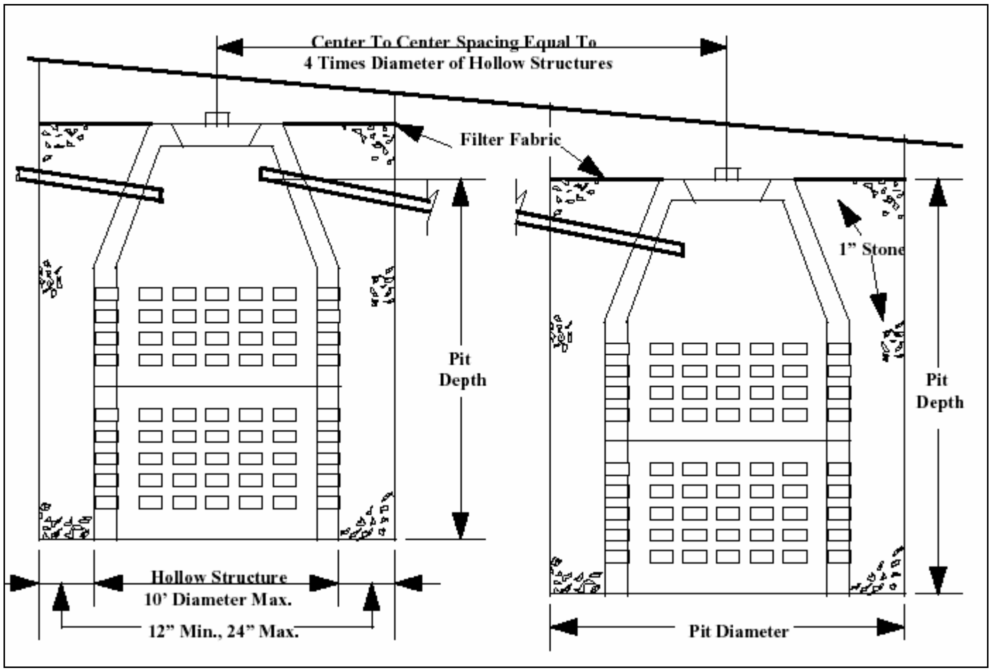


Figure 10-5
Pits at Different Elevations - High Level Overflow No More Than Two Pits in Series

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.

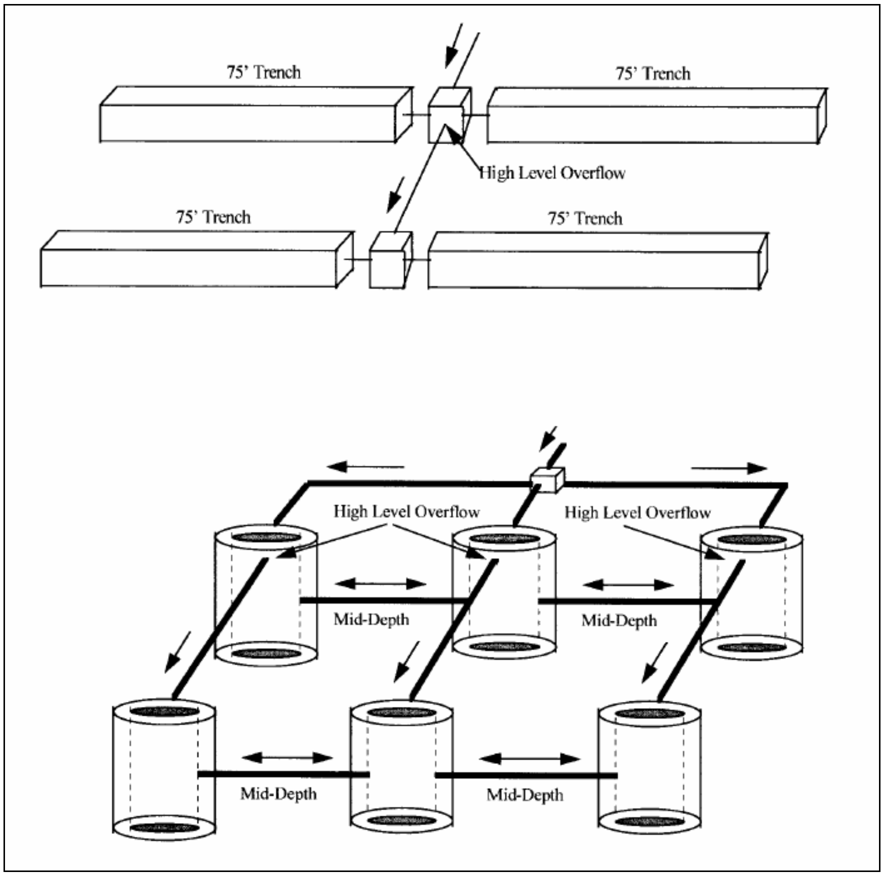


Figure 10-6
Combination Level and Serial Distribution

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.

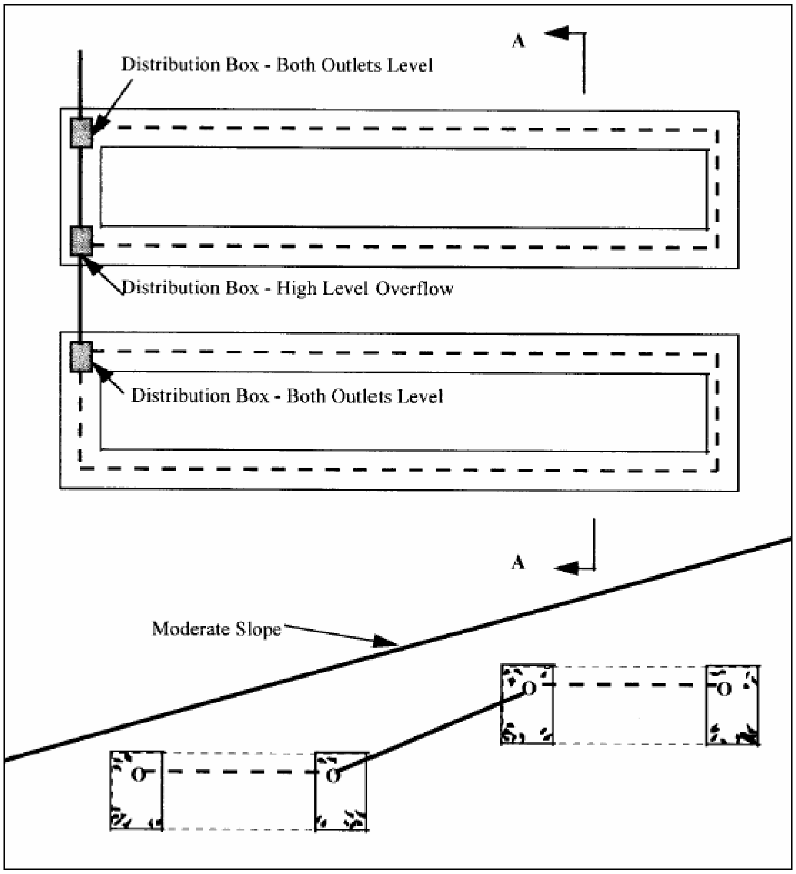


Figure 10-7
Two Level Trench Systems in Series

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.

- The system must provide sufficient infiltrative surface to prevent excessive clogging by the biological slime which forms on the soil interface.
- The system must be surrounded by an area of soil with sufficient hydraulic capacity to disperse the liquid volume without becoming saturated.
- 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; 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 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. 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 adequacies of Code requirements for leaching areas are well proven. Engineers can be assured that leaching systems for household and small commercial subsurface sewage disposal systems based on 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.

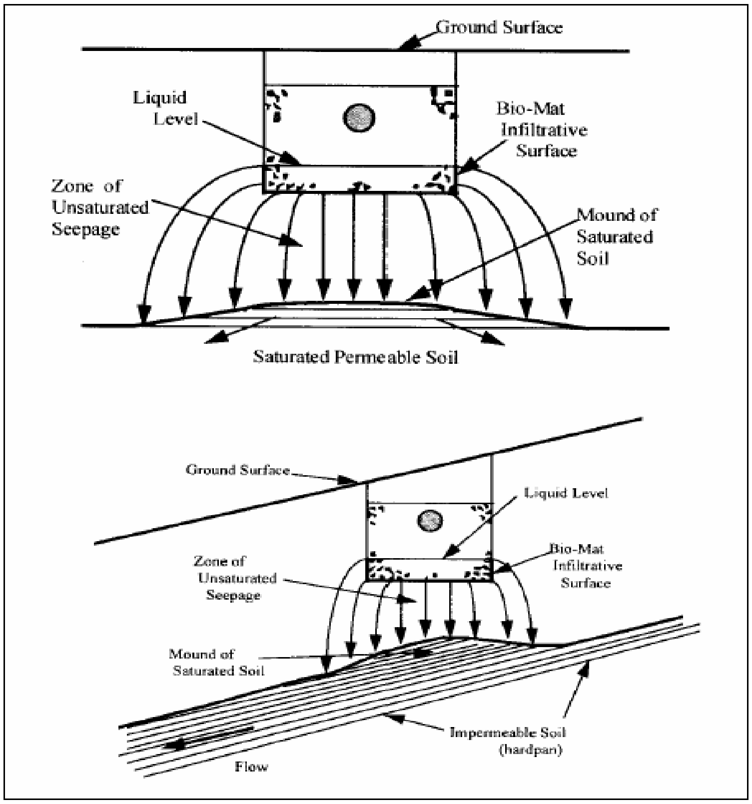


Figure 11-1
Effluent Mounding

Where site conditions are particularly severe 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 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 (also call a raised bed) as shown in Figure 11-3.

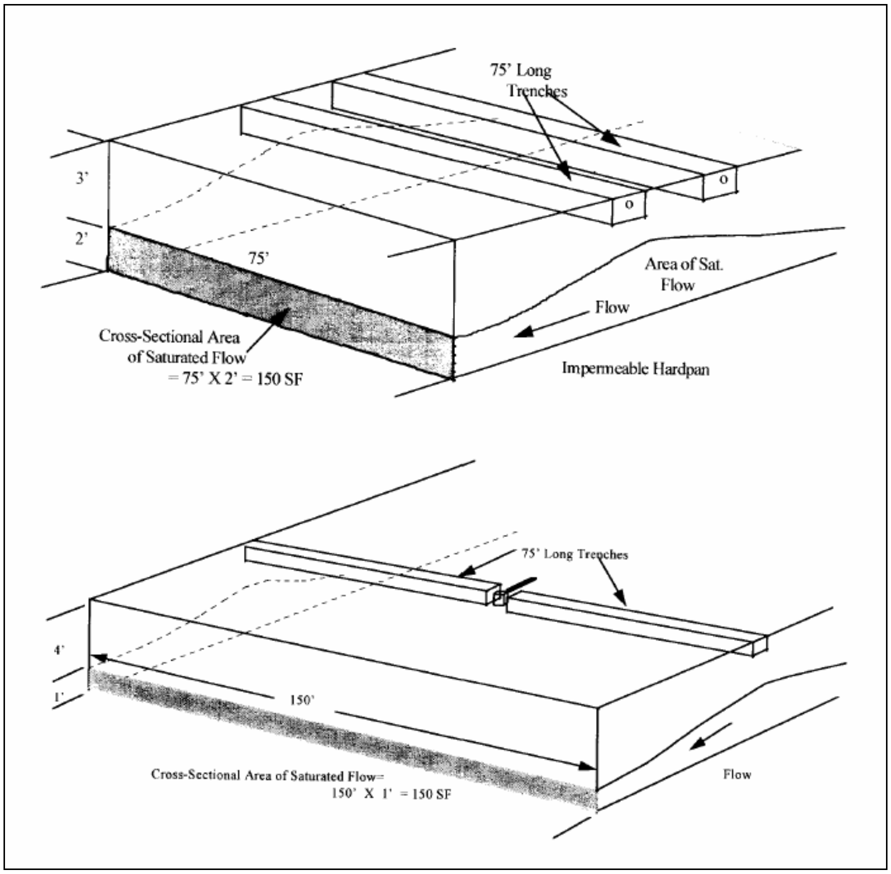


Figure 11-2
Spreading Trenches to Reduce Effluent Mounding

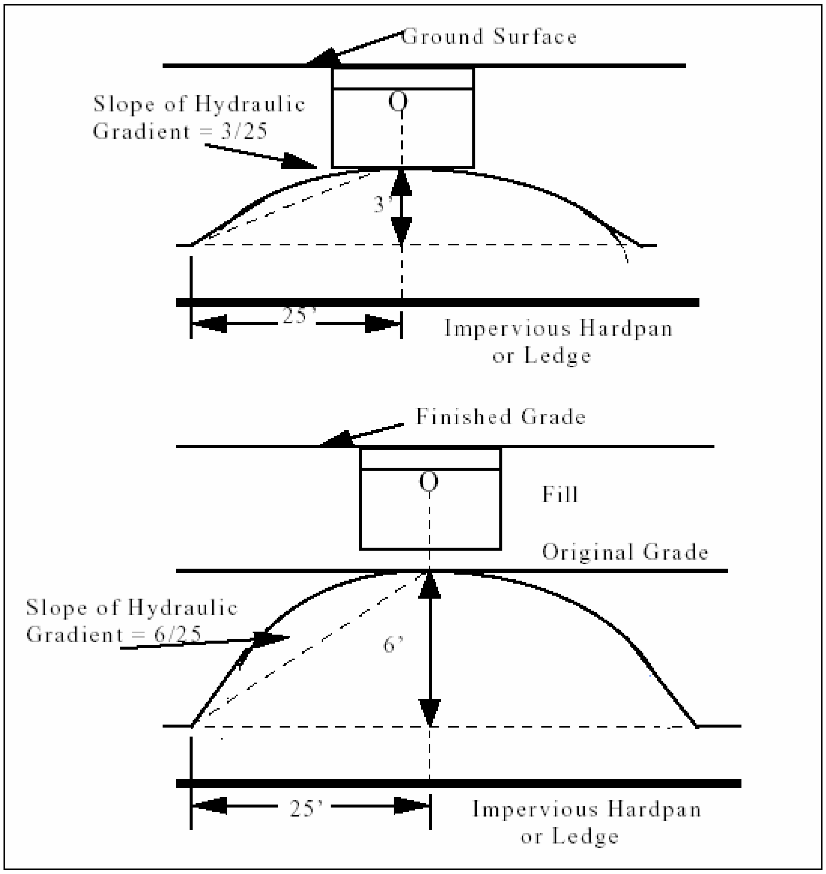


Figure 11-3
Elevating Trenches to Increase Hydraulic Gradient

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. 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.

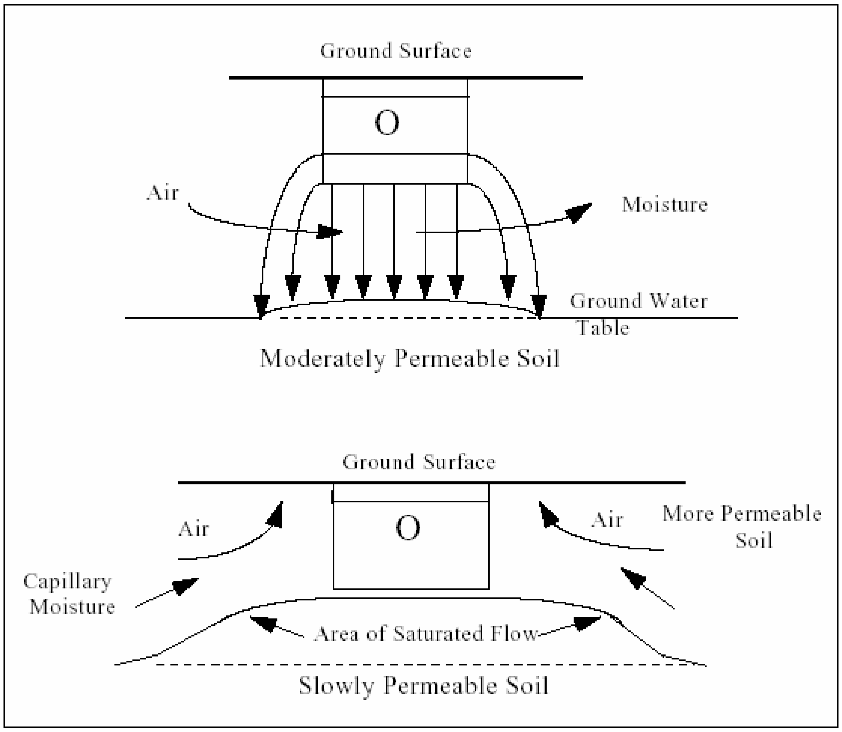


Figure 11-4
Capillary Dispersal and Evaporation

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 Code requirements will 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. 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 12-1 shows a typical alternately used leaching system.

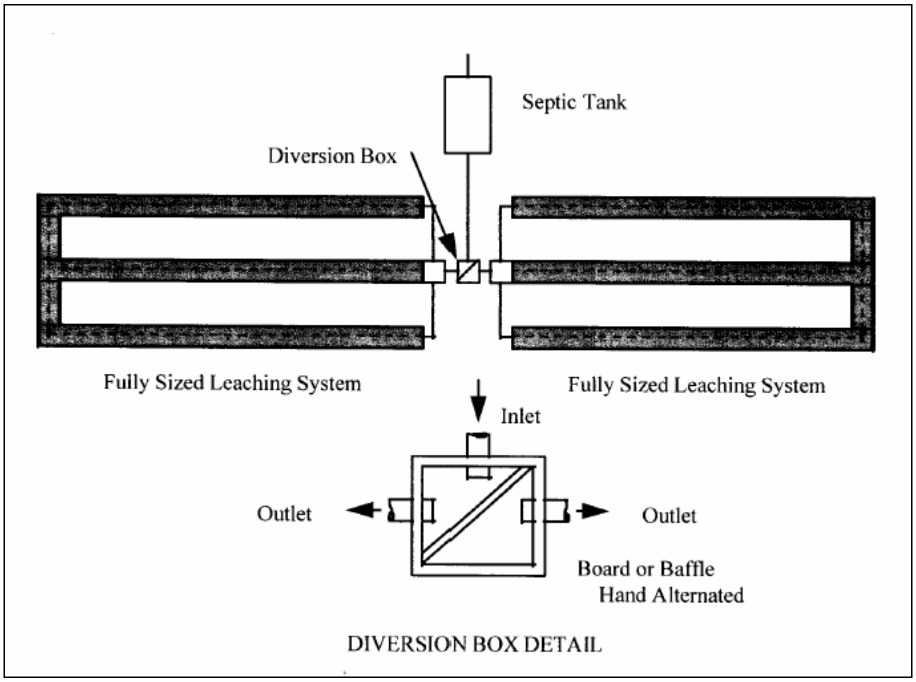


Figure 12-1
Alternating Leaching System

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 mostCode, 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 12-2 shows a typical subsurface irrigation system.

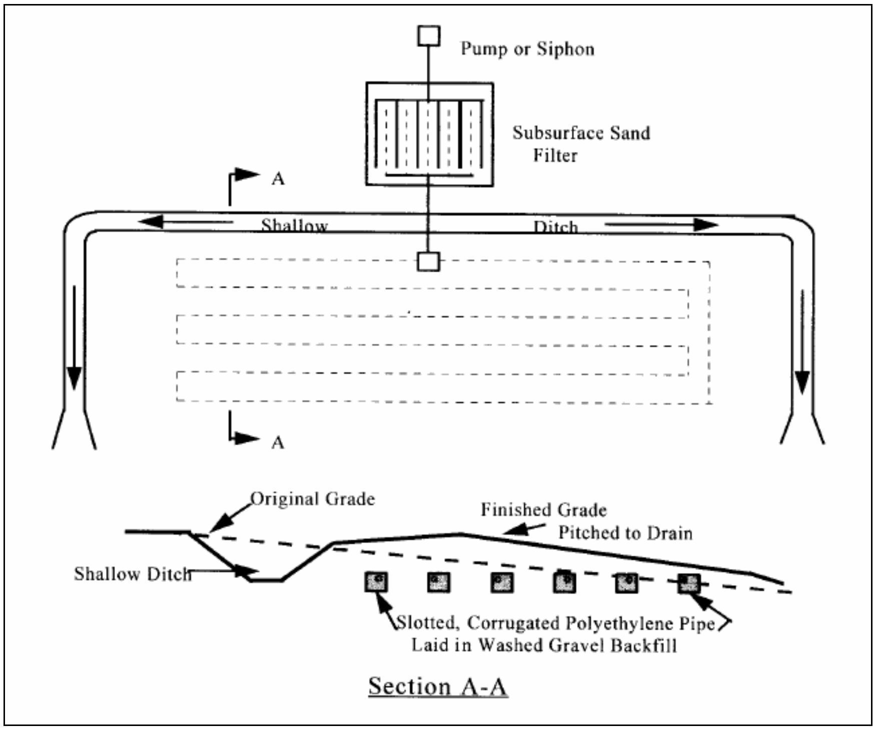


Figure 12-2
Subsurface Irrigation System

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.

13. 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.

PREVENTING WELL POLLUTION

It is recommended 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.

Hydraulic calculations show 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.

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

- The adjacent well should be properly cased and sealed into consolidated rock where ledge rock is less than 20 feet below ground surface.
- 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 mostCode 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 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 1/2 acre building lot requirements.

An exception is 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. Leaching systems on lakefront lots should 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".

SIZING WHEN SYSTEM IS PLACED IN UNIFORM VERY FINE SANDS

All across the country, there have been a large 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 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). Therefore a percolation rate no faster than 10.1-20 minutes/inch should be utilized for sizing purposes.

14. LEACHING SYSTEMS IN AREAS OF SHALLOW LEDGE ROCK

As commonly used, "ledge rock" refers to the continuous bedrock underlying the soil layers. In some areas of the country 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

The bottoms of leaching systems should be kept a minimum of 4 feet above ledge rock. 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.

The depth of soil overlying the ledge rock downslope 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. 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 numbers 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 14-1). 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

Soft, partly decomposed rock layer easily excavated by a backhoe, but which appears to be part of the continuous bedrock 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 may 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.

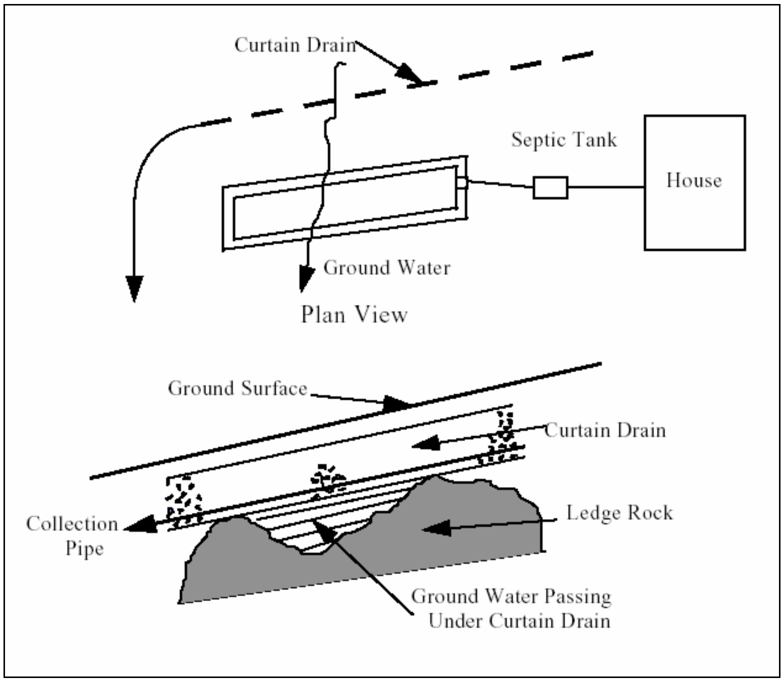


Figure 14-1
Profile Through Curtain Drain

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.

15. LEACHING SYSTEMS IN HARDPAN SOILS

"Hardpan", as commonly used, refers to any naturally occurring layer of hard, densely compacted soil. 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 can contain a high percentage of silt which tends to fill the voids between the larger soil particles. Hardpan with a large amount of sand or gravel will be quite compact and could 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.

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.

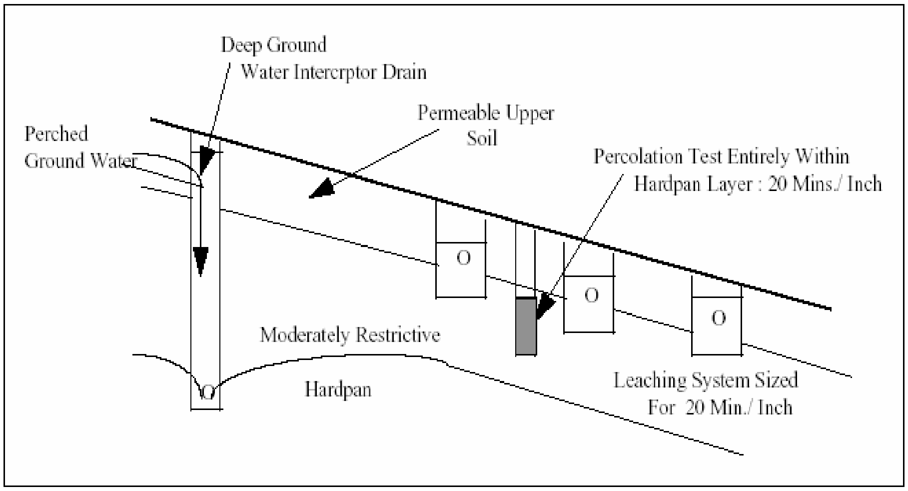


Figure 15-1
Moderately Restrictive Hardpan

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 15-2 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.

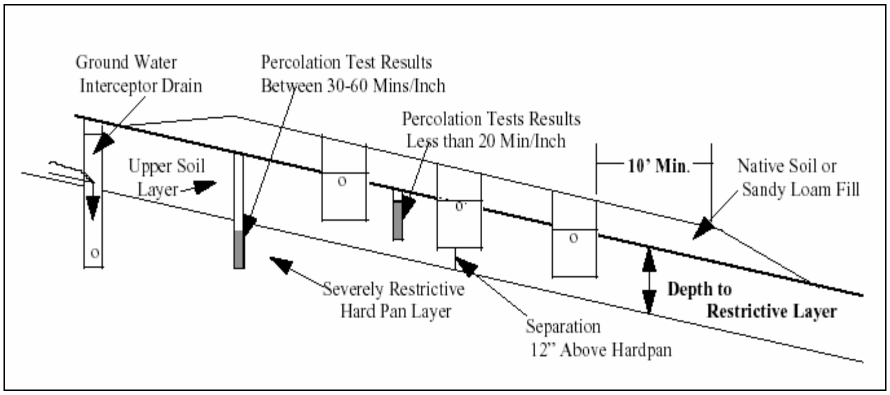


Figure 15-2
Severely Restrictive Hardpan

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. 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 15-3 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 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.

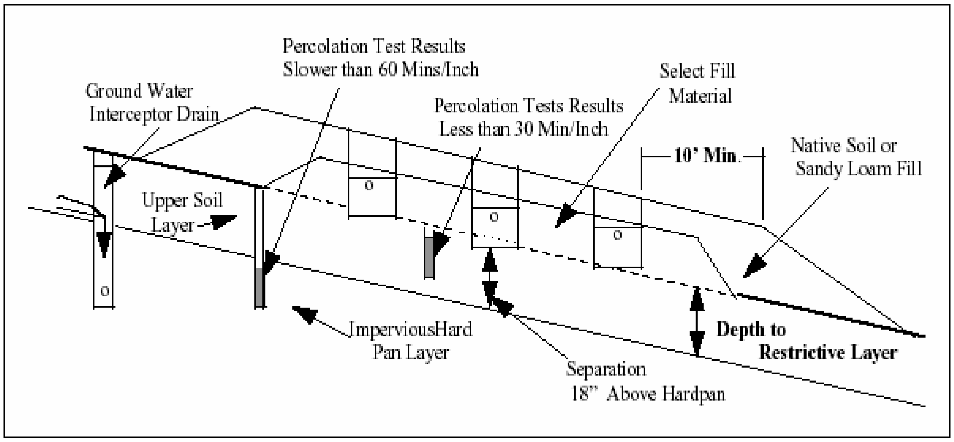


Figure 15-3
Impervious Hardpan

One may wonder 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.

16. LEACHING SYSTEMS IN SELECT FILL MATERIAL

Codes allow the use of leaching systems in fill providing the following two conditions are met:

- The soil conditions in the area of the proposed leaching system are not unsuitable for sewage disposal purposes.
- The surrounding naturally occurring soil can adequately absorb or disperse the expected volume of sewage effluent without overflow, breakout, or detrimental effect on ground or surface water.

Certain sites with soil conditions which are unsuitable for sewage disposal may be made suitable by filling. However, other sites, such as those consisting of exposed ledge rock, cannot be made suitable by filling because sewage effluent eventually would pass through the fill and seep to ground surface. Therefore, any filling done where soil conditions are unsuitable is done entirely at the risk of the owner or builder. Ultimately, the acceptability of the site will depend on the results of tests made after the fill has been placed and compacted. In some cases, a special study will be required of the capacity of the surrounding naturally occurring soil to absorb or disperse sewage effluent before any approval is given. Because of these uncertainties, owners and builders are strongly urged to have a qualified professional engineer study the feasibility and cost of the necessary site improvements before placing any fill where soil conditions are classified as unsuitable for sewage disposal.

There are several situations where the placement of fill in the area of the leaching system is necessary or desirable to assure that it will function properly. One such situation is where the soil is permeable, but has a high ground water table which cannot be lowered by an intercepting drain because the area is low or flat. Filling allows the system to be raised sufficiently above the observed maximum ground water level. In other cases, there may be a layer of suitable soil underlain by shallow hardpan or ledge rock. Placement of fill would allow the leaching system to be constructed sufficiently above this material so that it will not interfere with the proper functioning of the system.

TYPE OF FILL MATERIAL, PLACEMENT AND INSPECTION

A clean, granular sand and gravel fill should be used in the area of leaching systems. The fill should contain no more than 5% fines, and preferably no more than 2%. Fines are clay and silt sized particles which pass the #200 sieve. Even a small amount of these particles will severely reduce the ability of the fill to transmit water, particularly when compacted. It has been determined that a significant number of leaching systems installed in select fill fail because the material brought to the site did not meet the above standard.

In order to reduce the risk of fill related failures it is recommended that the following guidelines be followed:

- “Select fill” shall be comprised of clean sand and gravel, free from organic matter and deleterious substances. Mixtures and layers of different classes of soil should not be used. The fill material should not contain any material larger than three (3) inches. A sieve analysis should be performed on a representative sample of the fill. Up to 45% by weight of the fill sample may be retained on the#4 sieve. The material that passes the #4 sieve is then dried and reweighed and the sieve analysis started. The sieve analysis must demonstrate that the material meets each of the following specifications:

	SIEVE SIZE	EFFECTIVE PARTICLE SIZE	% THAT MUST PASS SIEVE
Coarse Sands	#4-#10	± 4.75 mm - 2.0 mm	#4 100%
Medium Sands	#10-#40	± 2.0 mm - 0.425 mm	#10 0% - 100%
Fine Sands	#40-#100	± 0.425 mm - 0.15 mm	#40 0% - 50%
Very Find Sands	#100-#200	± 0.15 mm - 0.075 mm	#100 0% - 20%
Silts and Clays	#200	< 0.075 mm	#200 0% - 5%

- Inspection and testing of the fill material may be necessary unless an approved commercial sand or gravel bank is to be used which can supply material which will meet the above criteria. The location of the area to be filled should be marked by the engineer at this time and approved by the sanitarian.

- The area should be cleared and rough graded. All stumps and large boulders should be removed. If necessary, top soil should be stripped and the area plowed or scarified. Prior to placement of the fill, the bottom surface of the excavation shall be scarified. Fill material should be stockpiled at the edge of the excavation until a suitable base of select material has been spread over the entire exposed area. Fill should not be placed during periods of heavy rains, snow storms or freezing temperatures. If water is present at the bottom of the excavation following a period of rain, the excavation shall be dewatered as necessary and rescarified. The excavation for and placement of "select fill" shall extend a minimum of five (5) feet laterally in all directions beyond the outer perimeter of the leaching system and to a depth to make contact with naturally occurring pervious material.

- The engineer should inspect the prepared site and set grade stakes before "select fill" is placed.

- "Select fill" should be placed on the edge of the site and spread over the prepared area with a bulldozer. No trucks should run over the fill until 12 inches of fill has been placed. The remainder of the fill should be placed in layers 8 to 12 inches deep and compacted by normal bulldozing or other construction equipment. Filling and compaction should be discontinued during rain storms and for 24 hours thereafter. All fill should be placed and compacted before any of the leaching system is installed.

- If there is any question as to the characteristics of the fill material being placed, a minimum of one representative sample (made up of a composite taken from numerous locations in the fill section) may be taken from the in-place fill for a system serving a single family residence. The sample should be tested for compliance with the grain size distribution noted in Item 1, above. For larger systems, one sample may be taken for each day the filling operation is conducted.

- The engineer should inspect any fill over 30 inches in depth. Observation pits should be dug when there is any question as to the nature or depth of the fill, and percolation tests shall be conducted whenever the entire leaching structure (bottom and sides) will be situated within the fill package or when it appears that the fill may not be suitable. If it appears that the fill may not be sufficiently compacted, an engineering compaction test may be required. Inspection of the upper surface of fill can be misleading, particularly if the fill is clean and has not recently been compacted. The top few inches of a clean and or gravel fill, lacking binding material, may appear loose and insufficiently compacted. However, digging a few inches into the fill will usually show adequate density in the underlying material.

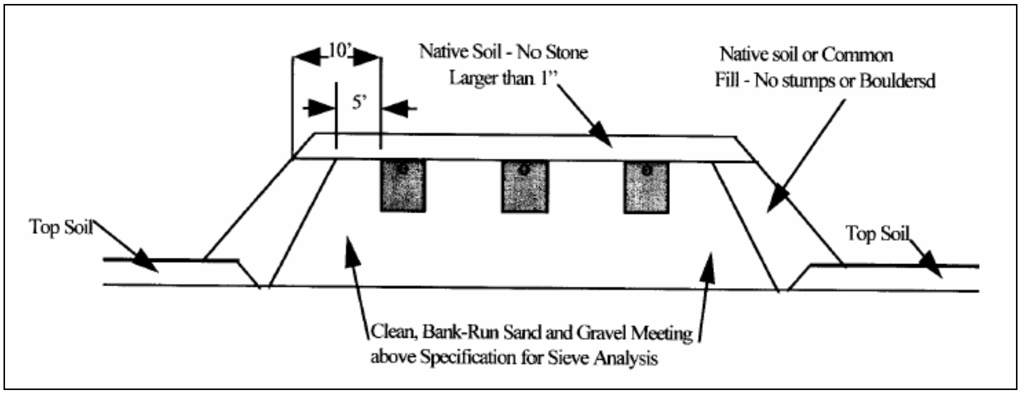


Figure 16-1
Filling on Flat Lots

The reason clean bank-run sand or gravel makes the best fill for leaching systems is because its permeability is not greatly reduced by compaction. This is not true for most soils. Loamy soils, containing a well graded mixture of sand, silt and clay, may have a permeability in the desired range when found in their naturally compacted state. However, they can be easily compacted by standard construction equipment, and their permeability can be reduced to an unacceptable level. On the other hand, it is relatively difficult to compact a clean mixture of sand and gravel by more than 5% to 10%, and even when compacted to over 90% of optimum density, it has a sufficient permeability for leaching purposes. Native soil normally should not be used for fill in the area of the leaching system itself. However, a reasonably workable native soil could be used for cover over a leaching system or for forming the fill embankment outside the leaching area, as shown in Figure 16-1.

SIZE OF THE LEACHING SYSTEM

The required size of a leaching system constructed totally in fill in the past was determined by the percolation rate of the underlying soil, not that of the fill. In most cases, select fill is more permeable than the underlying soil, even when adequately compacted. Therefore basing the size of the leaching system on percolation tests conducted in the fill would theoretically be adequate to disperse the expected sewage from the leaching system. However, predicting the quality and resulting percolation rates of select fill prior to its placement is very difficult due to the number of variables associated with the filling operation. Therefore sanitarians are very skeptical of basing the size of a proposed leaching system on fill material that has not been placed and tested. It is for that reason that the Technical Standards allows a maximum size reduction based on a percolation rate of 30 minutes per inch when the underlying naturally occurring soils are slower than 30 minutes per inch. For example, a four bedroom house is proposed on a lot which has percolation rates in the naturally occurring soils which are slower than 30 minutes per inch. If the design engineer proposes a leaching system which will be installed totally in "select fill", he may size the system utilizing a 21-30 minute percolation rate. This would result in a minimum 200 sq. ft. reduction (1,200 sq.ft. requirement down to 1,000 sq. ft.) in system size.

It should be noted, however, that the use of select fill and the ability to downsize the leaching system does not change the hydraulic conditions below the system and the need for adequate dispersal of the sewage discharge. Minimum Leaching System Spread shall be applied using the percolation rate of the underlying slow naturally occurring soil when determining the Percolation Factor (PF) when calculating the required spread of the system.

Compacted fill may not always be as permeable as expected, and in some cases it may be less permeable than the underlying soil. Therefore, a percolation test may be required in the fill wherever the active infiltration surface of the leaching system is entirely within the fill. Occasionally, on existing lots under repair conditions, it is found that the minimum percolation rate in the fill does not meet design requirements, and there is insufficient area of fill to enlarge the leaching system. It may be too costly or impractical to replace the entire fill section. In such a situation, deep leaching trenches penetrating into the better underlying soil could be used. If necessary, select sand fill could be placed in the bottom of the deep trenches so that the stone in the leaching system would be sufficiently above ground water. The additional storage and infiltrative surface provided by the side area of the deep trenches should adequately compensate for the poor percolation of the fill (See Figure 16-2).

Another possible way of circumventing the poor fill situation would be to provide “Tee-Wicks” of select fill material in which to place new leaching units. This configuration has the dual advantage of providing access to the more permeable suitable soils below the leaching system and a sidewall interface with absorptive capabilities. See Figure 16-3 for an illustration of a “Tee-Wick” installation. NOTE: Access should be into soil conditions where groundwater will not interfere with the downward movement of effluent into the natural soils.

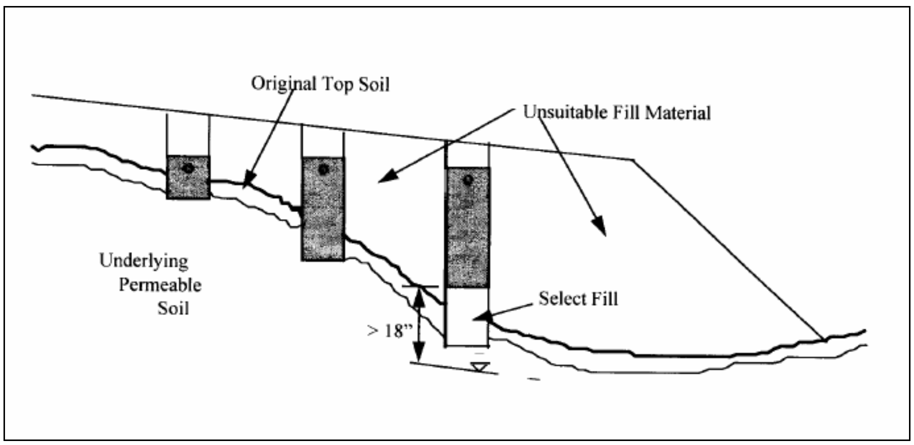


Figure 16-2
Leaching System In Unsuitable Fill

FILLING ON HILLSIDES

There are many situations where placement of a shallow depth of fill on a hillside can be used to raise the area of the leaching system to utilize a layer of good soil overlying relatively poor hardpan or shallow ledge rock. In such a case, the bottom of the leaching system should be located in the original soil wherever possible, not in the fill, otherwise sewage effluent may flow through poorly compacted fill on top of the original soil, and break out below the filled area.
The selection of fill to be used on hillsides also is important. Extremely permeable materials should be avoided, since this would facilitate downhill seepage, and is unnecessary as long as the size of the leaching system is based on tests made in the underlying soil. Native soil, taken from the site, frequently is used where the depth of fill is 18 inches or less, since the active part of the leaching system is mostly in the underlying, original soil, and the leaching characteristics of the fill is less important. A clean bank-run sand and gravel fill also may be used on slopes providing it is carefully

compacted before the trenches are dug. The fill should extend 15 to 20 feet downhill beyond the lowest trench and should be smoothly sloped to the original grade.

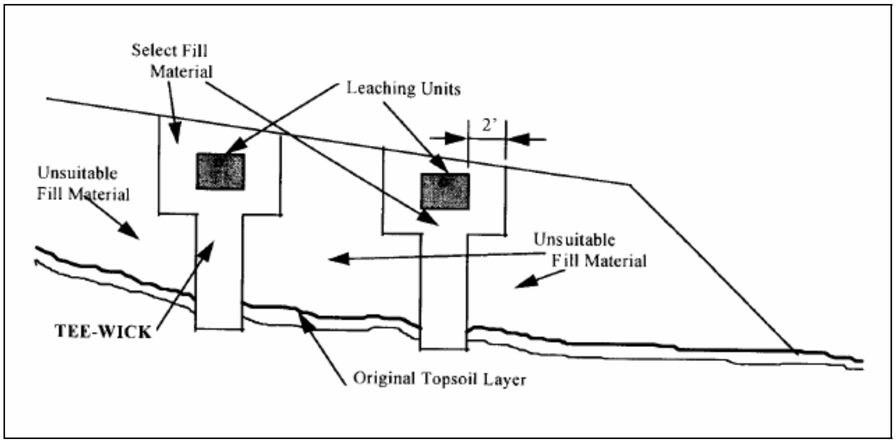


Figure 16-3
Tee-Wick Installation

Special precautions are required where a leaching system on a slope must be constructed entirely in fill due to unusual soil conditions, such as very shallow ledge rock or hardpan. Clean, bank-run sand and gravel must be used to allow thorough compaction and to assure proper permeability. The fill should be mechanically compacted and carefully inspected. The original soil should be contour plowed or scarified to form a rough interface between the fill and underlying soil, which will retard downhill movement of effluent. A denser soil usually is used for the fill embankment downhill from the leaching system. Clay or hardpan are difficult to work with, however, and should not be used for this purpose. A loamy, easily compacted native soil is recommended. It is extremely important that the downslope fill be free of large boulders, stumps and other debris which could create channels through which sewage effluent might surface.

The construction of level leaching trenches on terraces made by cutting and filling on slopes should be avoided. Cuts on slopes frequently intercept ground water which will flood leaching systems constructed in these areas. Even if a ground water intercepting drain is used, the soil in cut areas may be dense hardpan, unsuitable for leaching purposes. Figure 16-4 shows an unsatisfactory construction practice which often lead to sewage problems.

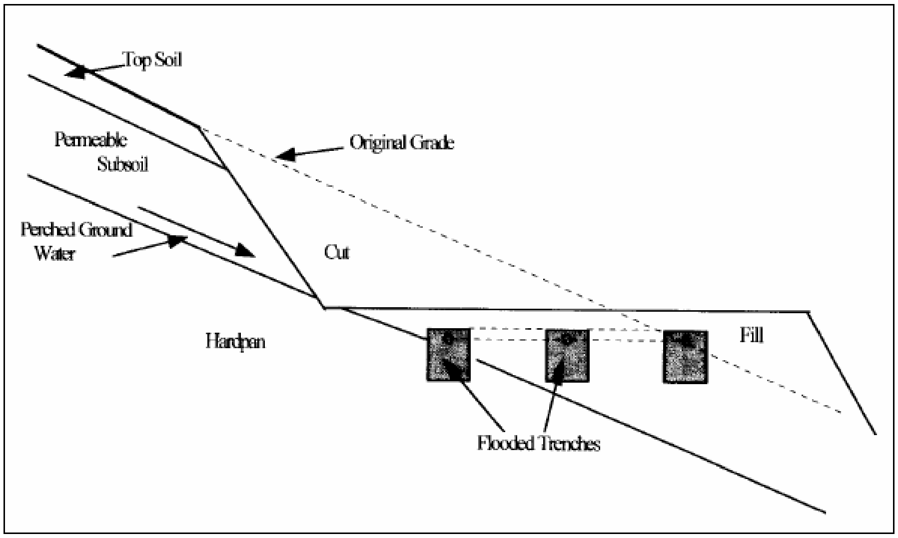


Figure 16-4
Cut and Fill on Slope

FILL SYSTEMS IN LEVEL AREAS

Frequently low, level areas having a high ground water level are underlain with permeable soil. Generally, it is not possible to lower the ground water level by ground water control drains. In such a situation, leaching systems may be installed in fill raised sufficiently above the anticipated maximum water level. In some areas, leaching systems in permeable, alluvial soil may be subject to seasonal flooding if they are not raised in fill.

When a leaching system is constructed in fill placed over a level area of permeable soil, there is little tendency for sewage effluent to move laterally. Therefore, there is no particular limitation on the depth of fill, and leaching systems have been installed successfully in mounds of fill up to 5 feet deep. However, whenever the bottom of the leaching area will not be in original soil, clean, bank-run sand or gravel fill should be used. Methods of placement and compaction also are critical for fill over 3 feet deep. Relatively impermeable sites or organic layers may be found overlying permeable alluvial soils. These must be stripped before filling. However, stripping of silt layers over 4 feet deep to reach permeable underlying soil may not be practical because of construction difficulty. Such excavations often fill with water and washed-in silt which clogs the soil. The excavations must be pumped continuously while digging to remove silt before it can settle. The water level may rise when the silt layer is removed. Therefore, it is very important to make an accurate determination of the maximum ground water level by the use of monitoring pipes where there is permeable soil overlain with a thick layer of silt.

Often it is difficult to determine whether or not a saturated soil layer is suitable for leaching purposes. It is not possible to make a percolation test in this situation, but other tests may be used. The soil permeability may be determined by a bailing test or a tube sample. A sieve analysis also may be used to obtain a rough idea of soil suitability in a questionable case. No leaching system should be constructed in fill unless it can be determined by some method that the underlying soil is suitable.

The top of the fill embankment should have a slight slope to shed surface water. When the bottom of the leaching system is above the surrounding ground surface, the fill should be extended 10 feet beyond any part of the leaching system. Beyond that point, the fill may be sloped on a one on two slope to existing grade. Figure 16-5 shows a typical leaching system in fill over level, permeable soil. Note that topsoil and silt have been removed to expose the permeable underlying soil before filling. The fill is pitched to shed water, and surface runoff from uphill areas has been diverted around the fill by a berm or swale.

FILL COMPACTION

Generally, all sand or gravel fill should be mechanically compacted at the time that it is placed. Clean sand and gravel is readily compacted by the methods described above, and is unlikely to become over-compacted. Compaction tests seldom are necessary as long as this material is spread in layers during placement. Where there is a question, a modified optimum density test (ASTM D1557, Method C) may be required. A compaction of 90 to 95% of optimum usually is used as a standard for clean sand and gravel since it can be readily obtained and such material still is sufficiently permeable for leaching purposes at this density. Another important reason for mechanically compacting sand and gravel fill when it is placed is to prevent the possibility of silt migration, which can occur when this material is loosely placed and subjected to rainfall during or after placement. In its natural state, silt particles have been retained in the smaller void spaces in the sand and gravel and do not move. However, they become loosened when the soil is disturbed during excavation and handling. If the fill is loosely placed, rainfall will cause the small silt particles to migrate, possibly forming layers within the fill or clogging the leaching system itself.

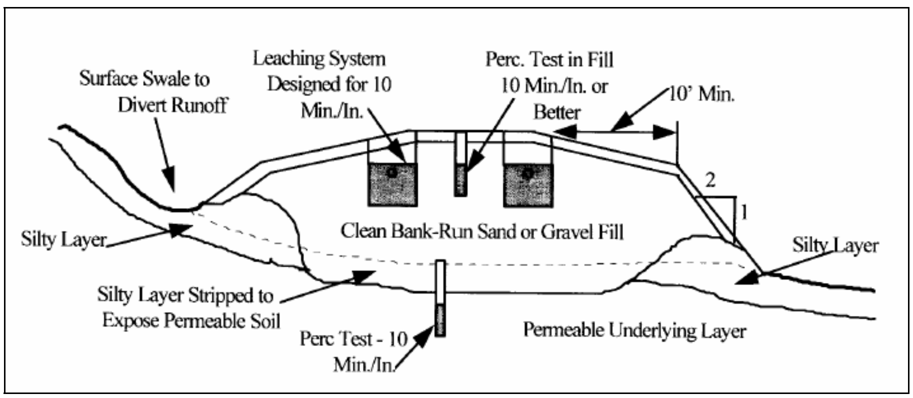


Figure 16-5
Soil Replacement Filling

Uneven mechanical compaction and subsequent settling can be a problem in deep fills. This frequently occurs when trucks or earth moving equipment heavily compact the embankment slope on a deep fill, but neglect the center portion of the fill. When sewage is applied to the leaching system, the center of the filled area may settle forming a "dish" or basin which retains rainfall. This can flood the leaching system and cause failure. The problem can be prevented by over filling the center portion, forming a crown which compensates for possible settlement.

Loamy soils may not have sufficient permeability if mechanically compacted to 90% of optimum density. Therefore, native soils or loamy fill should not be compacted in the same manner as sand and gravel, unless they are to be used only for covering the leaching system. Instead, they should be allowed to compact naturally over a period of 3 to 6 months, preferably during a wet season. Rainfall and settlement will compact these soils to about 85% of optimum density, which is about the same as the density of the root zone in most naturally occurring soils. Depending on the composition of the fill, the permeability should remain within the acceptable range.

OTHER DESIGN CONSIDERATIONS

Freshly placed fill is easily eroded. Therefore, erosion control measures should be taken as soon as final grading is completed. Uphill drainage should be intercepted and diverted by means of a berm or swale. The fill should be protected with mulch or tobacco netting if it is too late in the season to establish a grass cover before winter.

Placement and compaction of clean sand and gravel fill on steep slopes is difficult because of the looseness of this material. In such a situation, some contractors will first form an embankment on the downhill side, either by cutting into the existing soil or by placing large boulders, top soil and stumps in the area. This is said to hold the fill in place. Such practices are extremely dangerous, since a channel of loosely compacted or permeable material can be formed which allows sewage effluent to break out at the lower end of the fill. See Figure 16-6. Sanitarians and engineers should make sure that this is not done.

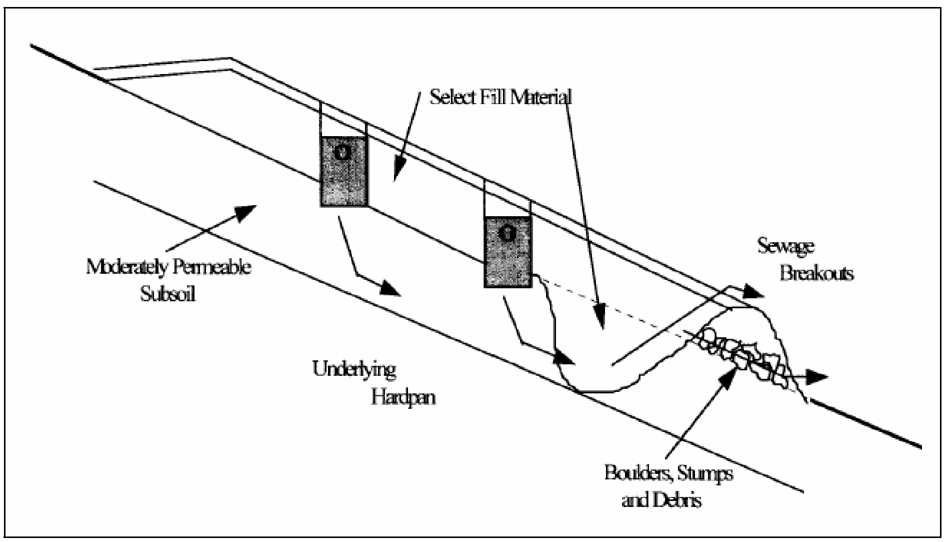


Figure 16-6
Cut In Downslope Subsoil

Sometimes a leaching system is constructed in a filled area at the base of a hillside because the fill is less obtrusive is such a location. Unfortunately, such areas are the location of seasonal springs. Ground water may rise into the fill and cause the leaching system to fail. Ground water levels should be carefully monitored during the wet season before any fill is placed at the base of a hillside. If ground water is found at ground surface during this time, there is the possibility that it may rise up into any fill placed at this location and the area should be avoided.

17. HYDRAULIC ANALYSIS – GENERAL PRINCIPLES

Hydraulic analysis is simply applying basic hydraulic laws to the flow of sewage effluent through soil. However, there are certain differences between the way that leaching systems are assumed to function by hydraulic analysis and the way that they actually do function. For instance, hydraulic analysis assumes a constant and continuous flow of sewage effluent through saturated soil. It is known that, under normal conditions, sewage effluent is dispersed into the soil surrounding leaching systems in an unsaturated and discontinuous flow. Depending on seasonal conditions, effluent may be dispersed by atmospheric evaporation or may accumulate within the leaching system or surrounding soil. However, the continuous, saturated flow conditions assumed for hydraulic analysis probably will occur before a leaching system fails. A mound of saturated soil will form under the leaching system where the hydraulic capacity of the surrounding soil is limited. This will rise to surround the leaching system as failure approaches. In this situation, the leaching system itself will be continuously filled with sewage effluent causing fluctuating sewage discharges from the building served to be equalized into a steady flow into the soil. Where the soil surrounding a leaching system is poor or where there is high ground water, flat slopes or underlying ledge or hardpan, hydraulic analysis is a useful tool for estimating the maximum capacity of the leaching system to disperse effluent into the surrounding soil without breakout.

Using Hydraulic Analysis For Small Leaching Systems

In general, hydraulic analysis should not be used for the design of household or other small sewage disposal systems with a capacity of 1,000 gallons or less where the site is generally favorable for leaching purposes. Conformance to the requirements of local Code and the general design principles outlined in this course should assure a satisfactory system. Hydraulic analysis becomes important where the capacity of the surrounding soil is limited.

The most common purpose of hydraulic analysis is to indicate the nature and probable magnitude of the hydraulic limitations on a particular site so that the leaching system can be designed to overcome those limitations. When hydraulic analysis is used for design purposes, the accepted practice is to make an analysis based on existing site conditions, maximum ground water levels and conservative sewage flow estimates. This results in a conservative leaching system design, which is what is desired.

Darcy's Law

The flow of sewage effluent and ground water through soils may be analyzed by using a basic hydraulic formula referred to as "Darcy's Law". This formula assumes a constant and continuous gravity flow through unconfined "channels" or areas of saturated soil. In its simplest form, Darcy's Law states that the velocity of a liquid moving through an unconfined channel under gravity conditions is proportional to the loss of hydraulic head per unit length of flow path, or:

$$V = K \times (H_1 - H_2 / L)$$

Where:
V = Velocity of flow
K = Coefficient of permeability
H_1= Hydraulic head at start of test
H_2= Hydraulic head at end of test
H_1-H_2 = Loss of hydraulic head
L = Length of flow channel

Darcy's Law generally is used in a modified form for hydraulic analysis of sewage and shallow ground water flow. In this analysis, the main concern is the volume of water which will flow through an area of saturated soil in a given period of time. This sometimes is called the hydraulic conductivity of the soil.

The equation is usually written:

$Q = K\ i\ A$

Where:

Q = The hydraulic conductivity or saturated flow rate, usually expressed in cubic feet per day.
K = The coefficient of permeability of the soil through which the saturated flow takes place. This is usually expressed in feet per day.
i = The slope of the hydraulic grade. When used in hydraulic analysis of sewage or shallow ground water flow, only the horizontal length of the flow channel normally is considered since the flow channel usually follows the ground surface and is relatively flat.

Therefore,

i normally is expressed as a dimensionless fraction or decimal representing a vertical drop divided by a horizontal distance.

A = The cross sectional area of saturated flow, usually expressed in square feet.

It is evident from the form of this equation that if either the permeability, the slope of the hydraulic grade or the cross sectional area of saturated flow is limited, the hydraulic conductivity of the soil is likewise limited.

Determining Soil Permeability

The coefficient of permeability, or simply the permeability of the soil, is a measure of how easily liquid passes through a particular soil. This depends on such things as the distribution of the particle sizes in the soil and their shape and geometrical arrangement. The permeability of naturally occurring soils can be quite variable due to stratification of different particle sizes, varying degrees of compaction and the existence of naturally occurring drainage channels formed by percolating ground water. It is not unusual for the permeability to vary by a factor of 1,000 in small samples taken from various soil layers at different locations or depths on the same site. There also may be considerable difference between the horizontal and vertical permeability in the same soil at the same location and depth. Horizontal permeabilities usually are much greater than ertical permeabilities due to the effect of layering, particle orientation and natural drainage channels. Because of this variability, considerable judgment must be used in determining the permeability of naturally occurring soils.

While the permeability is a definite physical property of a soil, it should be understood that the overall permeability of any site or any portion of the naturally occurring soil on the site can only be estimated. It cannot be measured directly. Estimates of site permeability can be based on four general types of measurements or observations.

- Estimates based on ground water observations made on the site.
- Estimates based on in-place testing on the site.
- Estimates based on testing of soil samples.
- Estimates based on soil identification and reference to available data.

The most appropriate method for estimating the permeability depends mainly on the soil and site conditions. The season or time of year also is an important consideration since most field tests or observations depend on ground water being present. In many cases, the most reliable method of estimating the overall site permeability for sewage disposal purposes is by observations of ground water levels on the site. This is particularly true where shallow or stratified soil layers are involved. In-place pit bailing tests are quite reliable and may be used for estimating the permeability of deep soil layers. Estimating overall site permeability on the basis of sample testing or soil identification requires considerable experience and judgment on the part of the engineer. However, this may be done in the absence of seasonal ground water and the field procedures are quite simple.

Wherever possible, the permeability should be estimated by more than one method. If the estimates are fairly close, it can be assumed that no errors of judgment have been made in selecting or performing the test and that the estimated permeability is valid for hydraulic analysis. Refer to the "Methods of Estimating Soil Permeability" for a detailed discussion of the various procedures for estimating soil permeability. Only procedures for the particular conditions existing on the site should be used. Particular attention should be given to the special precautions which should be taken when using each method.

Determining the Hydraulic Grade

The slope of the hydraulic grade depends on the direction and slope of the flow channel. Where layers of compact hardpan or ledge underlie a leaching system, sewage effluent flows in a generally horizontal direction following the ground surface. In this case, the slope of the hydraulic grade is equal to the difference in elevation of the underlying impervious layer at two observation pits, divided by the distance between the pits. If only horizontal distances are considered and minor variations in depth of underlying impervious layer are disregarded, the slope of the hydraulic grade may be taken to be equal to the slope of the ground surface (refer to Figure 17-1).

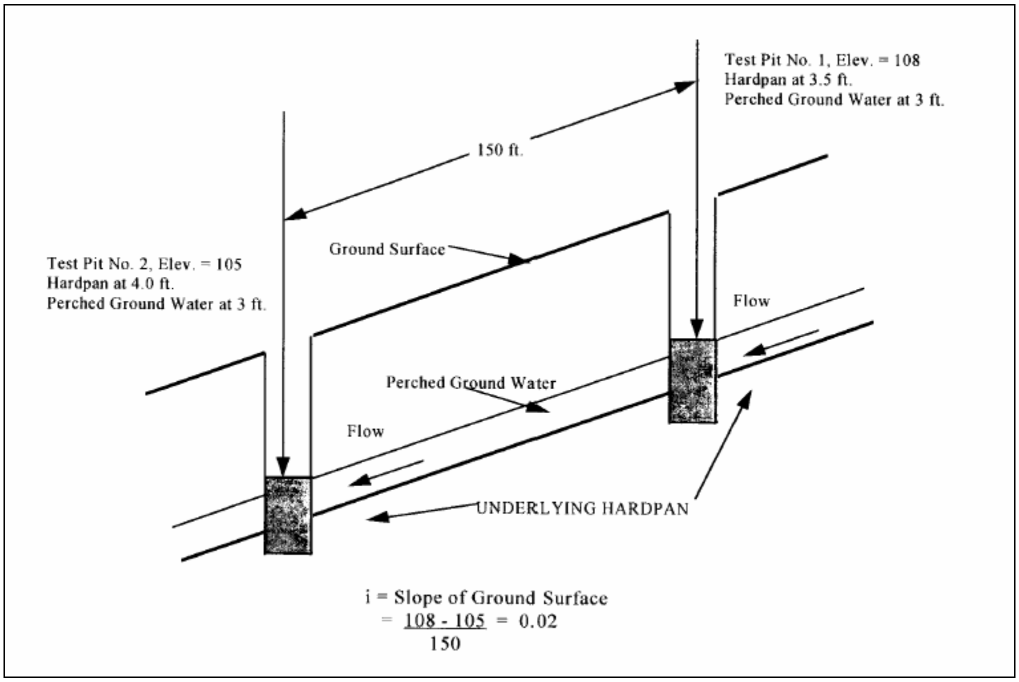


Figure 17-1

Horizontal flow also may be assumed to exist in slowly permeable soils even though underlying impervious boundary layers are not apparent. In this case, the slope of the hydraulic grade may be taken to be equal to the difference in the ground water elevation at two observation pits divided by the distance between the pits (refer to Figure 17-2). If variations in depth to the ground water table are minor, the slope of the hydraulic grade also may be taken to be equal to the slope of the ground's surface.

A mound of saturated soil will form under the leaching system where there are hydraulic constraints in the surrounding soil. This mound of saturated soil constitutes part of the effluent flow channel and its formation increases the slope of the hydraulic grade of the flow channel. Therefore, it is evident that constructing a leaching system in fill above the surrounding ground surface will increase the slope of the hydraulic grade and enhance the ability of the system to disperse effluent into the surrounding soil. Increasing the slope of the hydraulic grade in this manner normally is not considered when using hydraulic analysis to design a leaching system because such systems should be designed on conservative assumptions. However, when hydraulic analysis is used for regulatory purposes, it is reasonable to allow certain minor adjustments to be made in the hydraulic grade of the leaching system by elevating it in fill. Where leaching systems are located over underlying impervious layers, it may be assumed that the upper end of the hydraulic grade is at the bottom of the proposed leaching system but not higher than the original grade. The lower end can be assumed to be the elevation of the impervious layer at a distance 50 feet downslope. The 50 foot distance represents the normal maximum horizontal extent of the saturation mound, as indicated by field experience (refer to Figure 17-3). Similarly, where there is no underlying boundary layer, the lower end of the hydraulic grade may be assumed to be at the elevation of the ground water table 50 feet downslope from the leaching system.

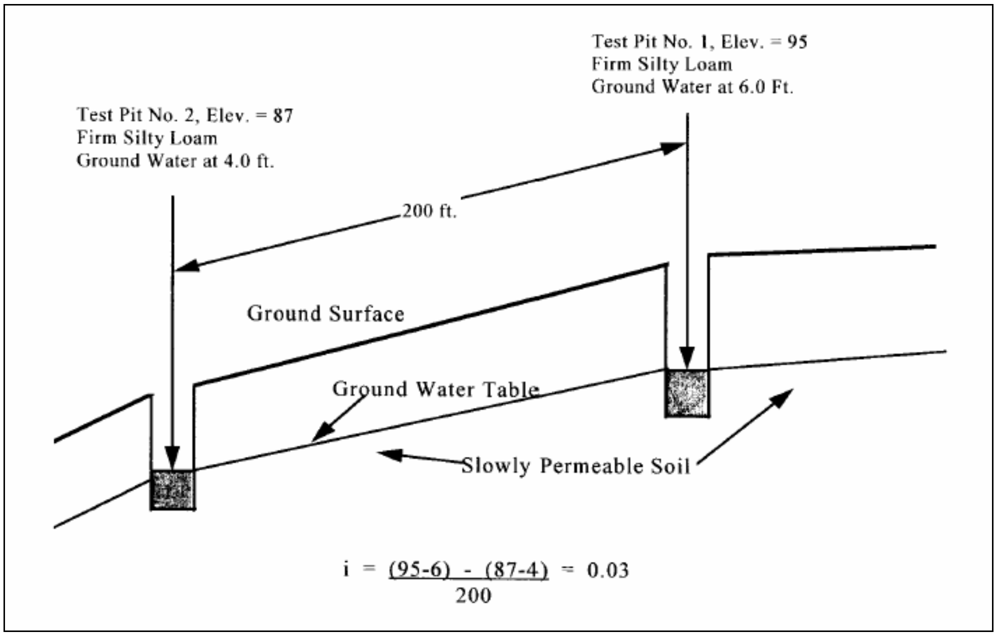


Figure 17-2

The exact horizontal extent of the saturation mound depends on the rate at which potential energy (system elevation) is converted into kinetic energy (flow velocity). This in turn depends on the soil permeability, with the more permeable soils having less extensive mounding.

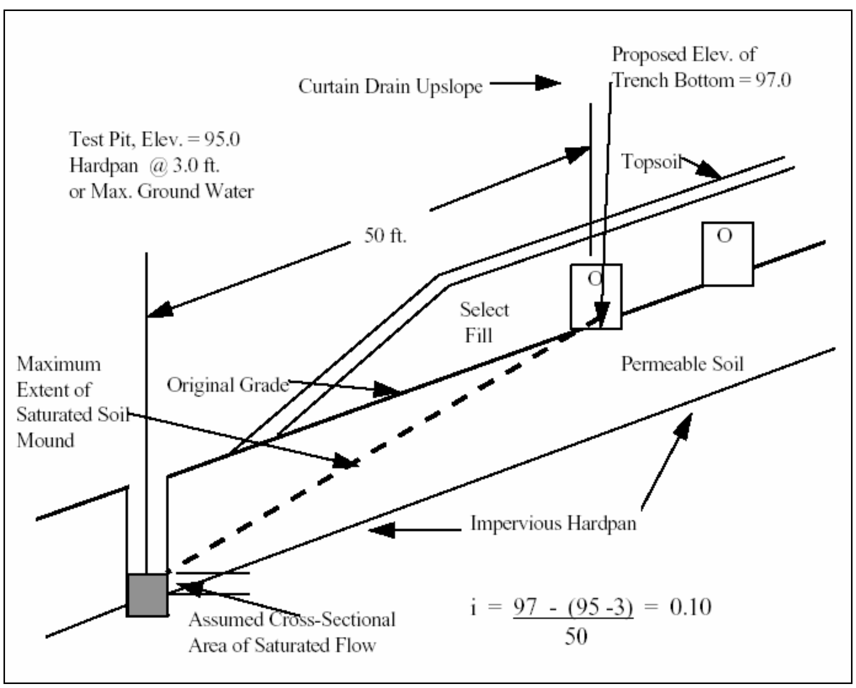


Figure 17-3

In level areas, the saturation mound extends out in all directions from the leaching system and the lower end of the hydraulic grade may be assumed to be at the elevation of the ground water table

25 feet from the leaching system (refer to Figure 17-4).

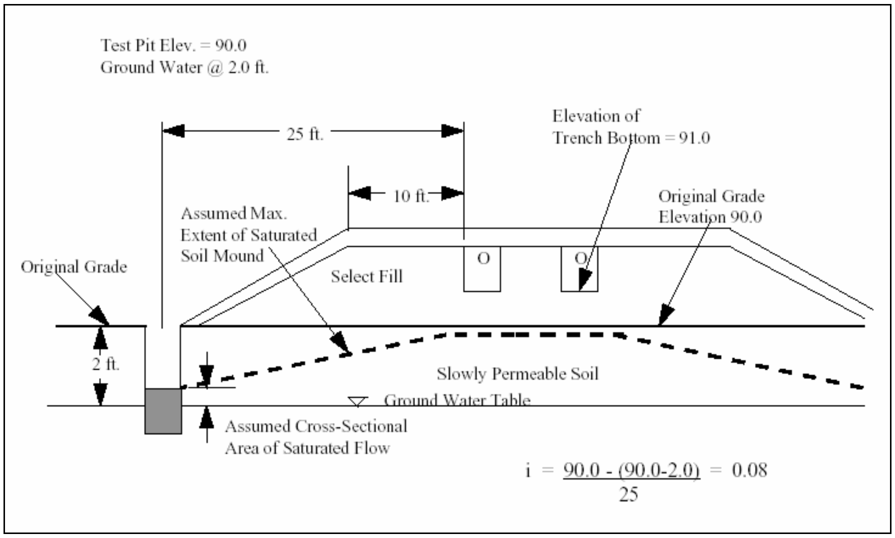


Figure 17-4

Determining the Cross-Sectional Area Of Saturated Flow

Where flow is in a generally horizontal direction due to underlying impervious layers, slowly permeable soil or high ground water, the cross-sectional area of saturated flow is measured in a vertical direction. The maximum cross-sectional area available to disperse sewage effluent on a hillside is equal to the depth of unsaturated soil downslope from the leaching system. Saturated flow will occur in all directions where the ground is level.

The cross-sectional area of unsaturated soil downslope from a leaching system can be increased by spreading the system perpendicular to the direction of the slope. Assuming that the volume of effluent to be dispersed remains constant, the depth of the area of saturated flow is reduced (Refer back to Figure 11-2).

It is evident that where horizontal flow occurs, the depth of unsaturated soil available for effluent dispersal may be increased by spreading fill over the naturally occurring soil surrounding the leaching system. This would enhance effluent dispersal and prevent breakout within the filled area. This concept is routinely employed in the repair of sewage disposal systems which failed due to hydraulic overloading. However, breakout still may occur from the naturally occurring soil at the toe of the fill, particularly when located on a slope For this reason, leaching systems normally should not be designed in this manner. Even though it is possible to calculate the combined permeability of both original soils and fill placed on the lot, it is extremely important to realize that wherever the fill material ends, the underlying original soil has to have sufficient capacity to absorb and disperse projected flows. Bleed out of partially treated effluent is unacceptable. Sewage disposal systems which depend upon filtration and detention in fill material prior to discharging at the surface of the ground, water course or subsurface drain cannot be approved by local health departments (refer to Figure 17-5).

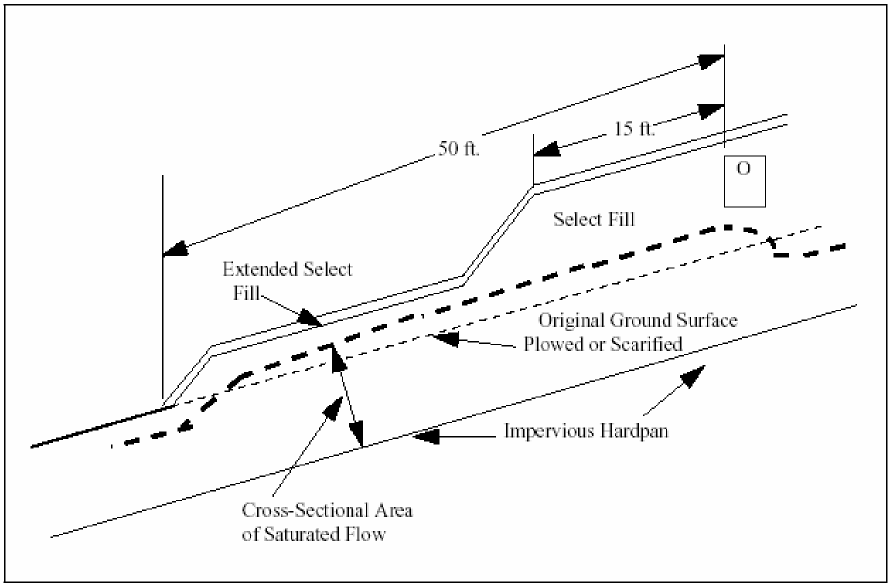


Figure 17-5

Where there is a deep layer of permeable soil underlying a leaching system, sewage effluent will flow downward. Such downward flow is impeded where the underlying permeable soil is saturated and horizontal flow may be assumed where the saturated underlying soil is only moderately permeable. However, where the underlying soil is quite permeable (percolation rate of 5 minutes per inch or faster), downward flow still will occur. This is particularly true for small sewage disposal systems where the effluent flow volume is small relative to the storage volume of the permeable soil underlying the system. Such soils may be considered to be unconfined aquifers and downward flow into the aquifer may be assumed. It would be a mistake to assume that no flow occurs simply because the ground water table is level. Hydraulic limitations are slight where these soil conditions exist and hydraulic analysis normally is not necessary (refer to Figure 17-6).

Determining the Required Hydraulic Conductivity

The naturally occurring soil surrounding leaching systems should be capable of hydraulically dispersing the entire volume of sewage effluent discharged into it on a continuous basis. Ideally, it also should be capable of dispersing any ground water flowing into the area of the leaching system from higher elevation, as well as any rain falling in the immediate area of the system. In theory, any hydraulic analysis of the surrounding soil should take into count all of these sources of flow. However, for small leaching systems, it has been found to be much more realistic to design the systems with such site improvements as ground water intercepting drains or fill which will eliminate or mitigate the effects of seasonal ground water or rainfall accumulations.

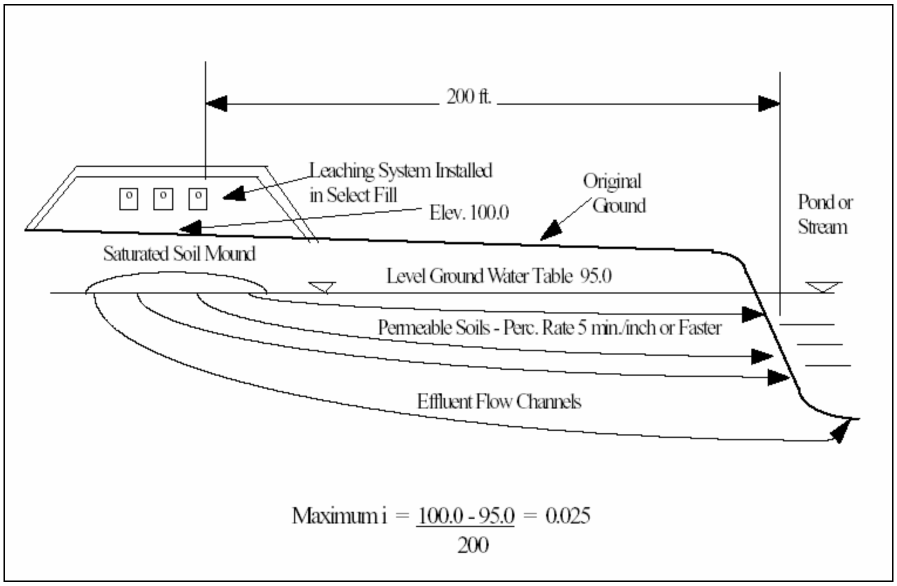


Figure 17-6

In practice, hydraulic analyses made for the design of small leaching systems consider only the hydraulic conductivity in the surrounding soil necessary to disperse the expected daily volume of sewage effluent discharged to the system. For single family dwellings, a figure of 150 gallons per bedroom per day should be used. Other daily usages from non-residential type buildings should be based on figures contained in the following table or on more detailed flow estimates calculated by the engineer.

Table 17-1
Typical Non-Resident Daily Water Usage

SCHOOLS, PER PUPIL	GALLONS PER DAY
BASE FLOW (EXCLUDES KITCHEN & SHOWERS)	
HIGH SCHOOL	12
JR. HIGH/MIDDLE SCHOOL	9
KINDERGARTEN/ELEMENTARY SCHOOL	8
KITCHEN	3
SHOWERS	3 to 5
RESIDENTIAL	100
DAY CARE CENTER (NO MEALS PREPARED)	10
COMMERCIAL/INDUSTRIAL BUILDINGS, PER EMPLOYEE	
FACTORY (NO SHOWERS)	25
FACTORY (WITH SHOWERS)	35
OFFICE (AVERAGE 200 SQ.FT./PERSON-GROSS AREA)	20
SMALL RETAIL BUILDING-LESS THAN 2,000 SQ.FT.-GROSS AREA	20
LARGE RETAIL/COMMERCIAL BUILDING-SEE MISCELLANEOUS	
CAMPS	
RESIDENTIAL CAMPS (SEMI PERMANENT), PER PERSON	50
CAMPGROUND WITH CENTRAL SANITARY FACILITIES, PER PERSON	35
CAMPGROUND WITH FLUSH TOILETS (NO SHOWERS), PER PERSON	25
CAMPGROUNDS PER CAMP SPACE (WATER AND SEWER HOOK-UPS)	75
DAY CAMPS, PER PERSON	15
LUXURY CAMPS, PER PERSON	75
PICNIC PARKS (TOILET WASTES ONLY), PER PERSON	5
PICNIC PARKS WITH BATHHOUSES, SHOWERS, FLUSH TOILETS, PER PERSON	10
HEALTH CARE FACILITIES	
HOSPITALS, PER BED	250
REST HOMES, PER BED	150
CONVALESCENT HOMES, PER BED	150
INSTITUTIONS, PER RESIDENT	100
GROUP HOME, PER CLIENT (LARGE TUB/ON-SITE LAUNDRYING USE HIGHER FLOW)	100-150
RESTAURANTS	
RESTAURANTS (PUBLIC TOILETS PROVIDED), PER MEAL SERVED	10
TAKE OUT FOOD SERVICE/RESTAURANTS WITH NO PUBLIC TOILETS, PER MEAL SERVED	5
BARS AND COCKTAIL LOUNGES (NO MEALS) PER PATRON	5
RECREATIONAL FACILITIES	
SWIMMING POOLS, PER BATHER	10
INDOOR TENNIS COURTS, PER COURT	400
OUTDOOR TENNIS COURTS, PER COURT	150
THEATERS, SPORTING EVENTS, PER SEAT	3.5
CHURCHES	
WORSHIP SERVICE ONLY, PER SEAT	1
SUNDAY SCHOOL, PER PUPIL	2
SOCIAL EVENTS (MEALS SERVED) PER PERSON	5
MISCELLANEOUS	
AUTO SERVICE STATIONS, PER CARS SERVICED	5
BEAUTY SALON, PER CHAIR	200
BARBER SHOPS, PER CHAIR	50
DENTAL/MEDICAL OFFICES WITH EXAMINATION ROOMS, PER SQ. FT. OF GR. AREA	0.2
KENNEL DOG RUNS, PER RUN, ROOF MUST BE PROVIDED	25
LARGE RETAIL/COMMERCIAL BLDG., PER SQ. FT. OF GROSS AREA	0.1
LAUNDROMATS, PER MACHINE	400
MOTELS, PER ROOM, (NO FOOD SERVICE, KITCHENETTE OR LAUNDRY FACILITIES)	75
MOTELS, PER ROOM, (WITH KINCHENETTE BUT NO LAUNDRY FACILITIES)	100
MARINAS (BATHHOUSE-SHOWERS PROVIDED), PER BOAT SLIP	20

Designing For Seasonal Rainfall Accumulation and Ground Water Movement

The primary goal is designing a system so that it will not be adversely affected by temporary or seasonal rainfall accumulation. The bottom of the leaching system should be kept at least 18 inches above the maximum ground water level and at least 18 inches above any impervious soil layer. This assures a depth of at least 30 inches of unsaturated soil surrounding the leaching system (not counting the topsoil layer). Typically, a substantial portion of this soil consists of fill. Assuming a drainable porosity of 0.2, this surrounding soil would contain about 0.5 cubic feet of available storage per square foot of ground surface. This would be sufficient to store all rainfall received during the wet season. Actually, the percentage of rainfall runoff during this season can be quite substantial. Runoff can be further enhanced by proper leaching system design. Normally, the finished ground surface over the system is sloped 5 to 10% and is loamed, grassed and kept mowed to promote runoff. The width of small leaching systems usually does not exceed 25 feet, allowing surface runoff to be effectively diverted from the area of the system. Because of these considerations, seasonal accumulation of rainfall may be disregarded in hydraulic analysis of a small leaching systems on sloped lots where curtain drains can be installed up gradient from the system.

Ground water movement from higher elevation into the area of the leaching system can hydraulically overload the surrounding soil causing the system to fail. However, experience has shown that this is unlikely to be a significant problem for a small leaching system except where there is a shallow underlying layer of impervious soil or ledge. In this situation, most of the seasonal rainfall accumulation moves from higher elevation on top of the impervious layer. Such perched ground water can be effectively intercepted by a properly designed and constructed curtain drain and diverted from the area of the leaching system. Ground water movement through the underlying impervious layer is minimal. In most such cases, the intercepting drain can be assumed to be 100% effective and perched ground water moving into the area from higher elevation can be disregarded in the hydraulic analysis.

Where there is no underlying impervious layer or where the slope of the ground surface is relatively flat, curtain drains may be ineffective. Leaching systems usually are constructed in fill in such situations and curtain drains may not be used or may be used only as an extra safeguard. In these situations, the maximum ground water in the area of the leaching system must be carefully determined by field observation during the wet season. Once the maximum ground water level has been determined, an analysis may be made to determine the hydraulic conductivity of the unsaturated soil layers above this maximum level since only this soil would be available for dispersal of sewage effluent. If such design procedures are followed, it should not be necessary to provide for dispersal of seasonal ground water in most hydraulic analyses made for small leaching systems.

18. METHODS OF ESTIMATING SOIL PERMEABILITY

The following methods of estimating soil permeability are use in connection with hydraulic analysis of small subsurface sewage disposal systems receiving less than 2,000 gallons of sewage per day. Other methods may be used but are not recommended. For instance, disturbed, recompacted tube samples are widely used for permeability tests in connection with construction of dams, etc. However, they could produce questionable results for naturally occurring soil other than clean sand or gravel because the permeability in naturally occurring soils depends to a large extent on particle orientation and arrangement and on naturally formed drainage channels which are disturbed by recompaction. Block samples are of little value since normally they can only be collected from layers of compact soil which should be avoided for sewage disposal purposes. Observations of falling ground water levels following rainfall can be used to estimate the permeability of saturated soil layers. However, this is practical only where the soil is quite permeable. Hydraulic analysis should not be necessary for the design of small sewage disposal systems in such soils. Wherever possible, soil permeability should be estimated by two or more methods for confirmation purposes. Site conditions should be considered when selecting the methods to be used.

In all of the following methods of determining the soil permeability (K), it is that you are evaluating a one foot slice of soil to determine the area of saturated flow (A), Therefore,

$$A = 1 \text{ ft.} \times d$$

Method 1 - Observation of Perched Ground Water During the Spring

This method is most reliable for estimating the permeability of a sloping layer of relatively loose, well draining soil (minimum percolation rate of 10 minutes per inch or better) underlain by compact hardpan or ledge. In this situation there is a relatively large seasonal flow of ground water through a relatively small flow channel formed by the looser upper soil layer. The cross-sectional area of the flow channel is proportional to the depth of the perched watertable above the underlying impervious boundary layer and the slope of the hydraulic grade is approximately the same as the ground slope. Therefore, if the volume of ground water flowing through the upper soil layer can be estimated, the permeability of the layer can be calculated using Darcy's Law.

Field procedures are extremely quick and simple, but judgment must be used in deciding when and where to make ground water observations. Observations should only be made during the early spring after all frost is out of the ground. April probably is the most favorable month since, at this time of the year, the upper soil layers are damp, atmospheric evaporation is at a minimum and rainfall runoff is usually low. The observation pits should be dug in an area where the slope is smoothly contoured. Swales, gullies or depressions should be avoided since these will cause a concentration of ground water flow which will result in inaccurate permeability calculations.

Several observation pits should be dug in the area and, at each location, the depth of the perched water on top of the underlying impervious layer should be carefully measured. The average slope of the ground surface in the area also should be measured using a tripod or hand-held level. The drainage area must be determined either by measurements in the field or from a USGS topographic map. If the observation pits have been properly located on a smoothly contoured slope, the drainage area may be measured in profile from the pits upslope to the high point of land perpendicular to the ground contours.

During this time of year the amount of perched ground water flowing through the looser upper soil layers is roughly equal to the average rate at which rainfall is collected on the upslope drainage area minus a factor of 50% to account for surface runoff. Therefore, a rate of 0.005 cubic feet per day for each square foot of upslope drainage area will be utilized.

$$K = \frac{Q}{iA} = \frac{0.005 \times w}{S \times d}$$

Where:

K = Soil permeability, in feet per day.
w = Upslope drainage area, in square feet. (Length x 1 foot wide slice)
S = Average ground slope (drop, in feet/horizontal distance, in feet)
d = Depth of perched water table, in feet.

<u>Example:</u> (refer to Figure 18-1) - It is found that a perched water table averaging about 2 feet in depth exists in the loose soil on top of an underlying layer of impervious hardpan (percolation rate poorer than 60 minutes per inch). The ground in this area slopes about 5 feet in 100 feet, and the

drainage area extends about 500 feet upslope from the location of the observation pits.

Therefore:

$$K = \frac{0.005 \text{ X } 500}{0.05 \text{ X } 2} = 25 \text{ ft./day}$$

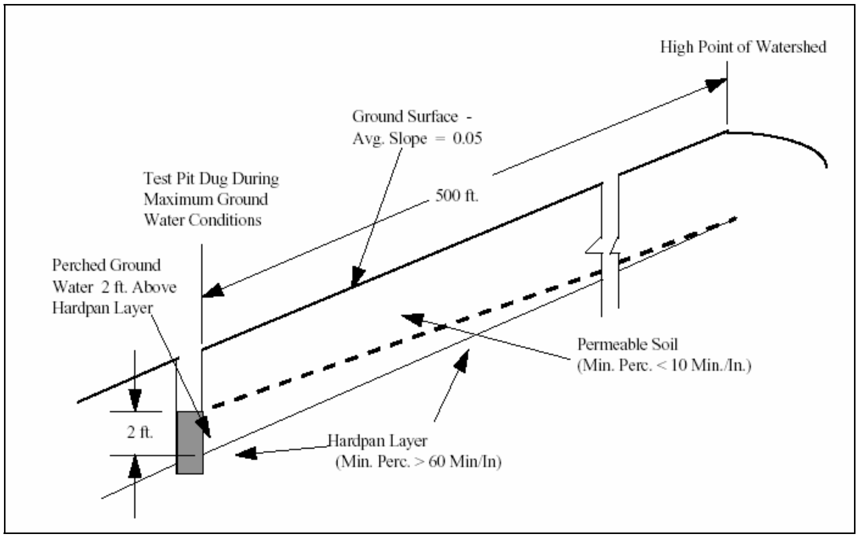


Figure 18-1

This method of estimating the permeability should not be used for soils with percolation rates poorer than 20 minutes per inch. Such soils drain slowly and the ground water level will be more closely related to rainfall occurrences than to perched ground water flow. In any case, observations should not be made for 3 to 5 days following a rainfall. The effect of rainfall can be eliminated by making a series of ground water observations over a period of time in an observation well or standpipe and determining the normal minimum perched ground water depth during this period.

This method should not be used in level areas or where the upslope drainage area cannot be defined. It should not be used in deep, uniform soil where perched water tables do not occur.

Method 2 - Observation Of Differences In Ground Water Level

This method is most reliable for moderate to slowly permeable soils (minimum percolation rate of 10 to 60 minutes per inch) on sloping areas underlain by impervious ledge or hardpan. This method also may be used where no underlying impervious layer is apparent, as long as the soil is slowly permeable (percolation rate slower than 20 miniinch) to the bottom of the observation pit. In these situations, the movement of ground water through the upper soil is slow and during the wet season, accumulating rainfall will cause a measurable rise in the water table in the downslope direction. The rise in the water table and the slope of the hydraulic grade can be determined by making ground water observations at two locations, one downslope from the other. The accumulation of rainfall during the spring of the year is proportional to the increased drainage area between the observation pits. Therefore, the soil permeability may be calculated from Darcy's Law:

Ground water observations should be made during the spring when atmospheric evaporation is minimal. Rainfall during this period will greatly affect the ground water level but both observation pits will be affected equally. The permeability calculation results should be unchanged.

Two observation pits should be dug on a smoothly contoured slope, one about 100 to 200 feet directly downslope from the other. The depth to ground water and any underlying impervious layer should be carefully measured. The difference in ground water elevation between the observation pits should be determined, preferably by use of a tripod level. The distance between the pits should be measured.

Rainfall accumulates in slowly draining soil at a rate roughly equal to 0.005 cubic feet for every square foot of upslope drainage area. Therefore, from Darcy's Law:

$$K = \frac{Q}{iA} = \frac{0.005 \text{ X } D}{i \text{ X } d}$$

Where:

D = Distance between observation pits, in feet.
i = Slope of hydraulic grade (difference in elevation/D)
d = Difference in depth of saturated flow, in feet.

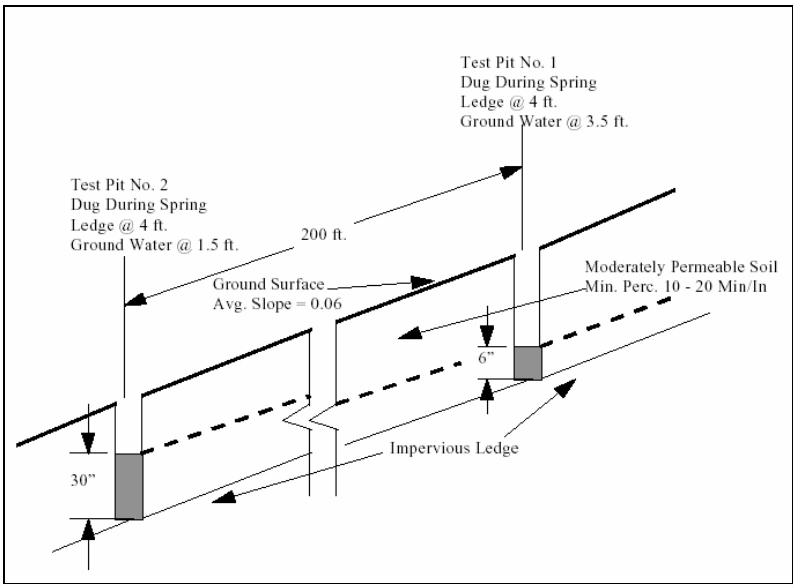


Figure 18-2

Example 1: (refer to Figure 18-2) - An observation pit is dug 100 feet upslope from a proposed leaching system, and another is dug 100 feet downslope from the system. At both locations, ledge is noted at a depth of 4 feet during the spring, a 6 inch depth of ground water is noted on top of ledge in the upper pit, and a 30 inch depth of ground water is noted on top of ledge in the lower pit. The slope of the ground and ledge surface averages about 6%.

Therefore:

$$K = \frac{0.005 \text{ X } D}{i \text{ X } d} = \frac{0.005 \text{ X } 200}{0.06 \text{ X } 2} = 8.33 \text{ ft./day}$$

This method of estimating soil permeability should not be used in level areas or where the depth to the impervious layer is inconsistent.

Example 2: (refer to Figure 18-3) - A slope is underlain with firm, silty loam having a minimum percolation rate of about 30 minutes per inch. During the spring of the year, ground water was found at a depth of 6 feet below ground surface in an observation pit near the top of the slope and at a depth of 2 feet below ground surface at another pit located 150 feet downslope. The difference in ground elevation between the pits was 15 feet.

In this case, the increase in the depth of ground water may be assumed to be equal to the decrease in the depth to the ground water surface.

Therefore:

$$K = \frac{0.005 \text{ X } D}{i \text{ X } d} = \frac{0.005 \text{ X } 150}{(15\text{-}4/150) \text{ X } 4} = 2.6 \text{ ft./day}$$

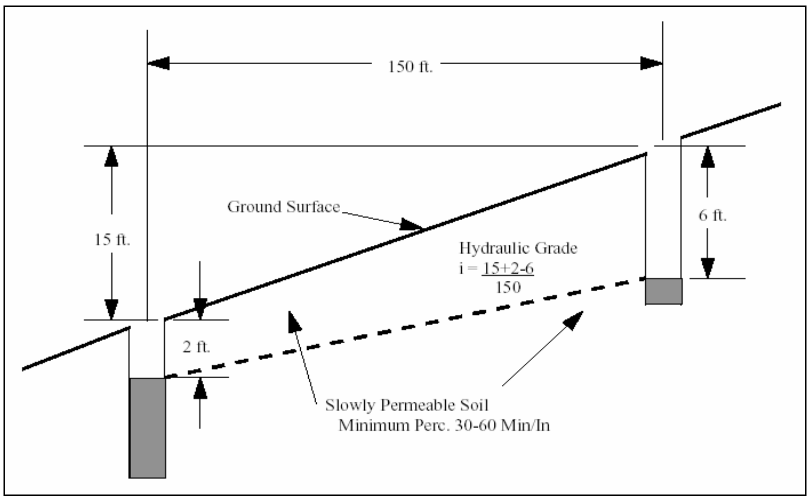


Figure 18-3

This method of estimating soil permeability should not be used in level areas or where the direction of ground water flow is not apparent.

Method 3 - Pit Bailing Tests

This method is reliable for estimating the permeability of relatively level layers of loose to firm soil (percolation rates of 60 minutes per inch or better) underlain with compact hardpan or ledge. This method also may be used where no underlying impervious layer is apparent as long as the soil is slowly permeable (percolation rate slower than 20 minutes per inch) to the bottom of the observation pit and basically uniform throughout. This in-place test is the most reliable method for estimating soil permeability where the ground water table is level and the direction of ground water flow is not apparent.

The test can be performed at any time of the year. However, the ground water table must be within 8 to 10 feet of ground surface. A deep observation pit should be dug and the depth to any impervious underlying layer measured. Where the soil is slowly permeable and no impervious layer is noted, a boundary layer may be assumed at the bottom of the pit. The permeability will be slightly overestimated by this procedure. There are two ways to perform the test. The first involves measuring the rate of water level rise in the pit when it is first dug. This is best suited to relatively firm soil which allows the pit to fill slowly without collapsing. Where the soil is loose, the pit may be dug and allowed to fill. When the water level in the pit has stabilized, normally after 24 hours, it is lowered by pumping and the rate at which it refills is measured. In either case, the static ground water level in the surrounding soil must be measured before or after performing the test.

The rate at which the water rises in the pit should be recorded in a manner similar to that used in recording percolation test results, except that in this case water is entering the pit rather than leaving. Unlike percolation test holes, the sides of the pit may slope. Therefore, the volume of water entering during any interval may not be directly proportional to the difference in liquid level. For this reason, the area of the water surface in the pit also should be measured at the same time that its depth from a reference point is measured so that the change in volume can be calculated.

The permeability of the saturated soil layer may be computed from the following equation which is derived from Darcy's Law:

$$K = \frac{\ln R / r \; Q}{H^2 - h^2} = \frac{642 \; Q}{H^2 - h^2}$$

Where:

K = Soil permeability, in feet per day.
Q = Rate of water in flow, in cubic feet per minute.
H = Static depth of water in the surrounding soil above the underlying impervious layer, in feet. Where there is no impervious layer, H may be taken as equal to the static depth of water in the pit before or after testing.

h = Average depth of water in the test pit above the underlying impervious layer during the bailing test, in feet, or above the bottom of the pit if there is no impervious layer.

$$642 = \ln R/r \times 1440 \frac{\text{Min}}{\text{Day}} = \frac{1.4}{3.14} \times 1440 = 642\text{, an assumed constant}$$

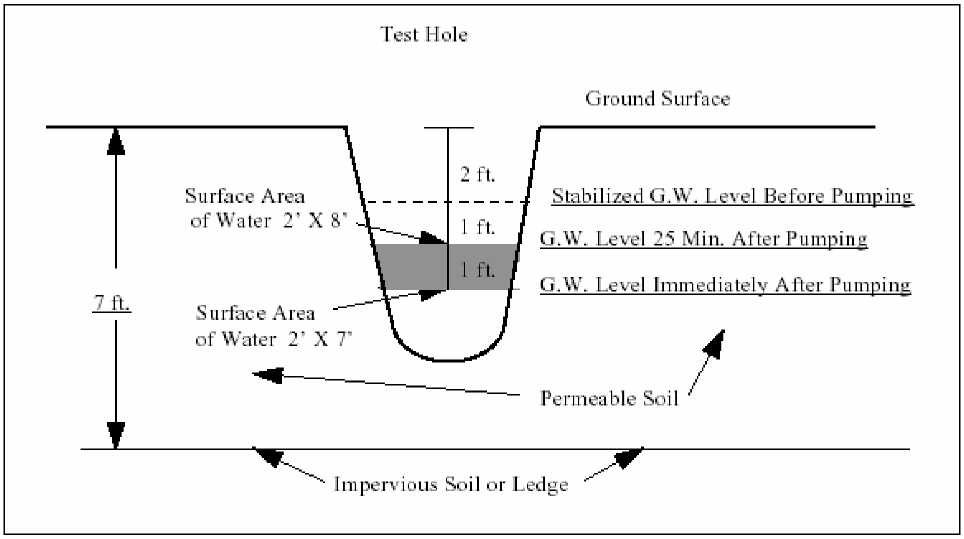


Figure 18-4

Example 1: (refer to Figure 18-4) - A 5 foot deep bailing test pit is dug in a level layer of moderately loose soil underlain with ledge at a depth of 7 feet. The static water table in the surrounding soil is observed to be at a depth of 2 feet. The test pit is allowed to fill with ground water. The next day, the water level in the pit is lowered 2 feet by pumping, and the water surface in the pit is measured. The water surface rises 1 foot in 25 minutes. The water surface area is measured again, and the following data recorded.

Time (min.) (cu.ft/min)	Depth to Water Surface (ft.)	Area of water Surface (sq.ft.)	Volume (cu.ft.)	Q
0	4	2 X 7 = 14	-	-
25	3	2 X 8 = 16	(14+16)/2 = 15	15/25 = 0.6

$$H = 7 - 2 = 5 \text{ ft.}$$

$$h = 7 - \frac{4+3}{2} = 3.5 \text{ ft.}$$

$$K = \frac{642\ Q}{H^2 - h^2} = \frac{642 \times 0.6}{(5)^2 - (3.5)^2} = 30 \text{ ft./day}$$

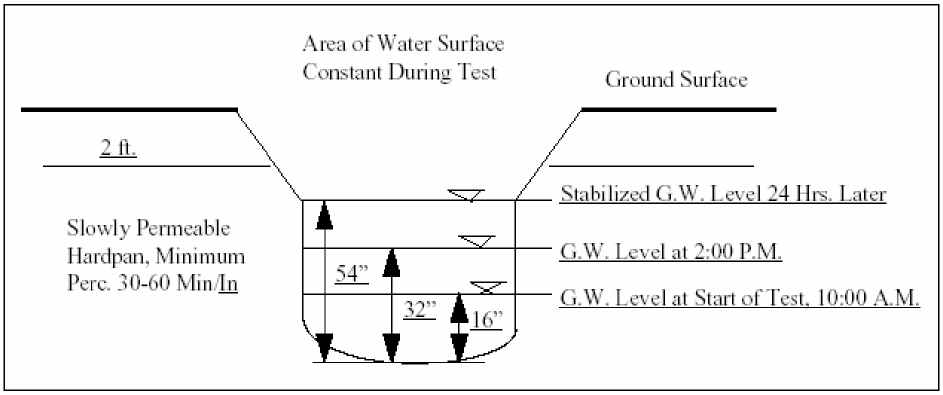


Figure 18-5

Example 2: (refer to Figure 18-5) - An 8 foot deep observation pit is dug in a level area. The soil is observed to consist of hardpan below a depth of 2 feet. Ground water starts to seep into the bottom of the pit. The sides of the pit are then made vertical above the water surface by the backhoe. The water surface is measured to be 2 feet wide and 10 feet long.

At 10:00 am, the pit is measured to contain 16-inch depth of water. At 2:00 pm, the depth of water in the pit is inches. The following day, the water level in the pit stabilizes at a depth of 54 inches.

Therefore:

$$\text{Volume} = \frac{32-16}{12} \text{ X } (10 \text{ x } 2) = 26.7 \text{ cu.ft.}$$

$$Q = \frac{26.7}{4 \text{ x } 60} = 0.1 \text{ cu.ft./min.}$$

$$H = 54/12 = 4.5 \text{ ft.}$$

$$h = 16 + 32 \text{ X } 1/2 = 2 \text{ ft.}$$

$$K = \frac{642\ Q}{H^2 - h^2} = \frac{642 \text{ x } 0.1}{(4.5)^2 - (2)^2} = 3.9 \text{ ft./day}$$

Pit bailing tests may give misleading results where there are several layers of soil carrying ground water, particularly if the permeabilities are quite different. Often, there is perched ground water moving through relatively permeable soil on top of firm underlying soil. The intercepted perched water fills the test pit relatively quickly and the overall permeability as calculated from the test will be relatively high. A careless engineer may attribute this permeability to the firm underlying soil layer. Any hydraulic analysis based on this assumption would be very misleading. The permeability of soil layers carrying perched ground water should be evaluated separately by shallower pit bailing tests. The permeability of the firm underlying soil should be determined by a pit bailing test made at a time when there is no perched water.

Method 4 - Undisturbed Tube Samples

This method is most reliable for estimating the permeability of uncemented loamy soils containing little gravel. Such soils generally are relatively soft and cohesive, and undisturbed soil samples may be collected by forcing a sharpedged, thin-walled tube into the soil. However, such a sampling technique is not suitable for loose sands or gravels which will not stay in the tube or for most hardpan soils which will crack or crumble from the excessive force required to insert the tube. The permeability of undisturbed tube samples may be determined quite accurately by measuring the amount of water which will pass through the sample in a measured period of time under known hydraulic conditions.

Field procedures are quite simple. Sharp-edged, thin-walled tubes about 6 to 12 inches long and 1 to 3 inches in diameter should be used. In practice, 1 and 1/4 to 1 and 1/5 inch diameter, plated sink drain tubes usually are used. The inside of the tube should be greased to assure that the soil sample will be sealed to the sampling tube. The tube should be pushed smoothly into the soil. It should not be driven, since this is likely to cause cracking. A 3 to 6 inch long sample should be taken. The depth and orientation (horizontal or vertical) of the sample should be carefully recorded. This could greatly affect the permeability because such samples are so small. The samples could be tested in the field if appropriate apparatus is available. However, in most cases, they are taken to an office or shop for testing. The tubes containing the soil sample should be placed upright on a bed of sand for transporting.

Undisturbed soil samples must be tested in the same tube in which they are collected. They are placed upright in a shallow pan on a bed of clean, uniform sand. A standardized material, called Ottawa Testing Sand, is available for this purpose. A 1/2 inch depth of testing sand also should be placed on the surface of the sample. The sample and testing sand should be saturated with water until the shallow pan overflows and the water level remains above the surface of the sample. De-aerated water must be used. This is water which has been heated and then cooled to remove dissolved air. Water should continue to be applied until it appears that all entrapped air bubbles have been removed and there is a constant flow rate through the tube.

The permeability may be calculated by either of two methods.

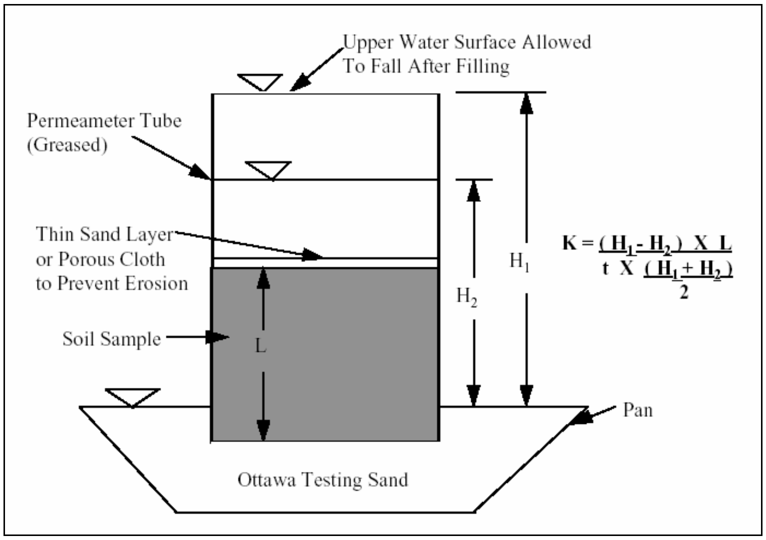


Figure 18-6
Falling Head Permeability Test

In the failing-head method, the permeability is calculated by measuring the rate at which the water level above the sample surface falls (refer to Figure 18-6). The following equation is used:

$$K = \frac{(H_1 - H_2)}{t \times \frac{H_1 + H_2}{2}}$$

Where:

H_1 = Hydraulic head at start of test, in inches.
H_2 = Hydraulic head at end of test, in inches.
L = Length of sample, in inches.
T = Elapsed time, in minutes.
K = Sample permeability, in inches/min. This can be converted to feet per day by multiplying the result by 120.

conversion: $\frac{\text{in.}}{\text{min.}} \times \frac{1 \text{ ft.}}{12 \text{ in.}} \times \frac{1440 \text{ min.}}{\text{day}} = 120$

Example 1: A 6 inch long undisturbed soil sample is collected in a 11/2 inch diameter tube. After thorough saturation, the water level above the surface of the sample is measured to fall 3 inches in 12 minutes.

Therefore:

H_1 = 11 in L = 6 in

H_2 = 8 in t = 12 min

$$K = \frac{(H_1 - H_2) L}{t \times \frac{H_1 + H_2}{2}} = \frac{(11-8) \times 6}{12 \times \frac{11 + 8}{2}} = 0.16 \text{ in/min}$$

$$K = 120 \times 0.16 = 19 \text{ ft./day}$$

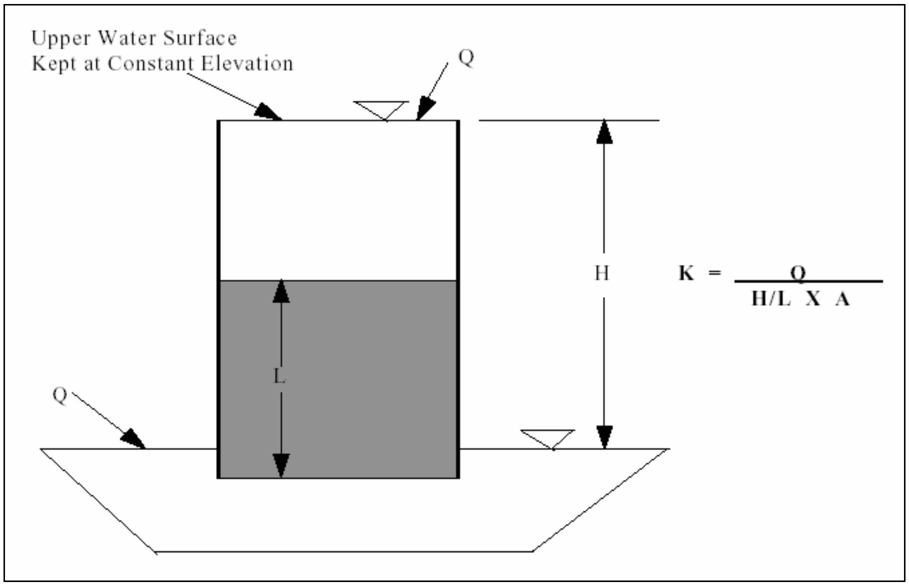


Figure 18-7
Constant Head Permeability Test

In the constant head method, the water surface is kept constant by adding water from a reservoir with an adjustable discharge. The permeability is calculated by measuring the amount of water which overflows from the receiving pan during a given time (refer to Figure 18-7). The following equation is used:

Where:

- Q = Rate of flow, in cubic inches/min.
- H = Hydraulic head, in inches.
- L = Length of sample, in inches.
- A = Cross section area of sample in square inches.
- K = Sample permeability, in inches/min. This can be converted to feet per day by multiplying by 120.

Example 2: (refer to Figure 18-7) - A 4 inch long undisturbed soil sample is collected in a 1 1/2 inch diameter tube. After saturation in a permeameter with a constant head of 12 inches, water is found to flow through the sample at a rate of 0.75 cubic inches in 10 minutes.

Therefore:

H = 12 in. $Q = 0.75/10 = 0.075$ cu. in./min.

$A = \pi r^2 = (3.14)(1.5/2)^2 = 1.77$ sq. in.

$$K = \frac{Q}{\frac{H}{L} \times A} = \frac{0.075}{\frac{12}{4}(1.77)} = 0.0\,14 \text{ in./min.}$$

$K = 0.014 \times 120 = 1.7$ ft./day

Method 5 - Soil Identification

This method should only be used for confirming estimates of soil permeability which have been made using other methods. A thorough knowledge of soils and techniques of examining them is required. This method is best applied to soil layers which are relatively uniform and typical.
An effort should be made to identify the particle sizes, their distribution and the degree of compaction. This may be done subjectively since available references for permeability values are not sufficiently exact to justify a more sophisticated examination. The soil should be examined closely at several depths and locations to obtain a true identification.

Once the soil has been identified, a number of technical references may be used to select an approximate permeability value. However, the most valid reference should be ones own experience in obtaining permeability values in similar soils by pit bailing tests or tests on undisturbed tube samples. A careful and experienced engineer should be able to estimate soil permeability within an order of magnitude (factor of 10).

The following tables may be used for relating identified soil types to their permeability values. It should be clearly understood that these relationships are approximate and may be subject to identification error.

Other references, such as the US Soil Conservation Service soil surveys, also may be used. The permeability ranges have been determined by testing typical block samples of each identified soil type at various depths. While not exact, these permeabilities must be considered quite reliable. It would be advisable to identify the soil type by field examination rather than by map reference.

TABLE 18-1 Uniform Soils

SOIL IDENTIFICATION	HORIZONAL PERMEABILITY FEET PER DAY
Coarse Sand	100 - 1,000+
Medium Sand	50 - 500
Fine Sand	20 - 100
Very Fine Sand	0.1 - 10
Silt	0.0001- 0.1

TABLE 18-2 Mixed Soils

SOIL IDENTIFICATION	HORIZONAL PERMEABILITY FEET PER DAY	
	LOOSE	FIRM
Mixed Sand and Gravel	100 - 1,000+	10 - 100
Silty Sand and Gravel	10 - 1,000	0.1 - 10
Mixed (medium) Loam	1 - 10	0.1 - 1
Sandy Loam	10 - 100	1 - 10
Silty Loam	1 - 10	0.01 - 1
Weathered Clay Loam	0.1	10
Mixtures of Sand and Silt	0.1	100
Sandy or Gravelly Clay	0.001	0.1
Hardpan	0.01	5
Weathered or Sandy Hardpan	1	20
Swamp Muck (Organic Loam and Silt	0.1	10

19. HYDRAULIC ANALYSIS - MINIMUM LEACHING SYSTEM SPREAD

Minimum Leaching System Spread (MLSS) criteria should be applied to all leaching system designs in order to address the hydraulic concerns associated with the particular site. A more in-depth analysis would be required if MLSS is not satisfied. MLSS calculations are applied where site limitations will likely impact the ability of the surrounding naturally occurring soils from absorbing and dispersing the expected daily discharge from a septic system. Leaching systems shall be configured in such a manner that the total expected daily discharge will be applied fairly uniformly over the entire length of the system so that overloading does not occur in “multi-stacked” areas. Whenever a leaching system contains more than one trench or row on a sloping lot it is recommended that each such trench or row be the required length per MLSS criteria. However when unequal length “stacking” is necessary due to site limitations, there are ways to analyze the impact of such “stacking”.

MLSS Formula

MLSS (in feet) = HF x FF x PF

HYDRAULIC FACTOR (HF) = Factor based on hydraulic gradient and depth of restrictive layer within and down gradient of the leaching area.

FLOW FACTOR (FF) = Factor based on the design flow.

PERCOLATION FACTOR (PF) = Factor based on the percolation rate of the receiving naturally occurring soil.

DEFINITIONS

Hydraulic Gradient: Is the percent of slope of the naturally occurring soil in the area of the leaching system (from uppermost leaching trench or gallery row to 25-50 feet down grade of system). Actual slope of restrictive layer may be utilized if field verification can be made.

Restrictive Layer: Is the layer which impedes downward movement of flow within the proposed leaching area. This boundary will likely be the lesser of such conditions as: ledge; severely restrictive hardpan (slower than 30 minutes/inch) which is beneath a more permeable soil layer; or seasonal maximum groundwater levels. If clear determination of maximum groundwater levels cannot be made during site testing then this level shall be determined by groundwater monitoring. The average of at least four (4) consecutive weekly readings taken in the most restrictive 30-day period of the wet season shall be used as a basis.

Depth to Restrictive Layer: Is the depth in inches from the top of naturally occurring grade to the restrictive layer. The average depth of natural soil above the restrictive layer in the area of the leaching system and between 25-50 feet down gradient shall be used to calculate MLSS.

Leaching System Spread: Is the length in feet of sewage application parallel to the contours of the naturally occurring soils in the leaching area. Sewage shall be applied fairly uniformly over the entire length to be valid. If not, each section of the leaching system shall be analyzed independently in proportion to its daily discharge volume.

FACTOR TABLES

HYDRAULIC FACTOR (HF)

HYDRAULIC GRADIENT (% OF SLOPE)

DEPTH TO RESTRICTIVE LAYER IN INCHES	<1.0	1.0-2.0	2.1-3.0	3.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-15.0	>15.0
<18.0	SEE NOTE #1								
18.0-22.0	72	62	54	48	42	34	30	28	26
22.1-26.0	66	56	48	42	34	30	28	26	24
26.1-30.0	56	49	42	34	30	28	26	24	20
30.1-36.0	48	42	34	30	28	26	24	20	18
36.1-42.0	42	36	30	28	26	24	20	18	16
42.1-48.0	36	32	28	26	24	20	18	16	14
48.1-60.0	30	28	24	22	20	18	16	14	10
>60.0	MLSS NEED NOT BE CONSIDERED								

FACTOR TABLES

FLOW FACTOR (FF)

Flow Factor = Design Flow/300	
Typical Uses	Flow Factor (FF)
Residential: Each Bedroom Has a Design Flow of 150 Gallons Per Day (GPD)	
2 Bedroom Home = 300/300	1.0
3 Bedroom Home = 450/300	1.5
4 Bedroom Home = 600/300	2.0, etc.
Non-Residential: Design Flow (GPD) / 300	(F F)

PERCOLATION FACTOR (PF)

Percolation Rate	Percolation Factor (PF)
Up To 5.0 Minutes/Inch	1.0
5.1 To 10.0 Minutes/Inch	1.2
10.1 To 20.0 Minutes/Inch	1.5
20.1 To 30.0 Minutes/Inch	2.0
30.1 To 45.0 Minutes/Inch	3.0
45.1 To 60.0 Minutes/Inch	5.0

MLSS ANALYSIS OF UNIFORMLY STACKED SYSTEMS

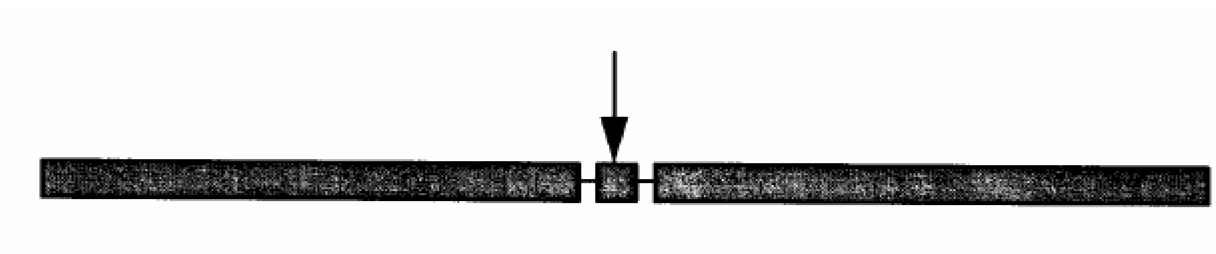
As an example, if a four bedroom house is being built on a site with maximum ground water at 24 inches, a slope of 5 percent and a percolation rate of 25 minutes per inch, the required minimums would be:

Size of Leaching System per local Code: 1,000 sq. ft.

MLSS = (HF - 34 X FF -2.0 X PF -2.0) = 136 feet

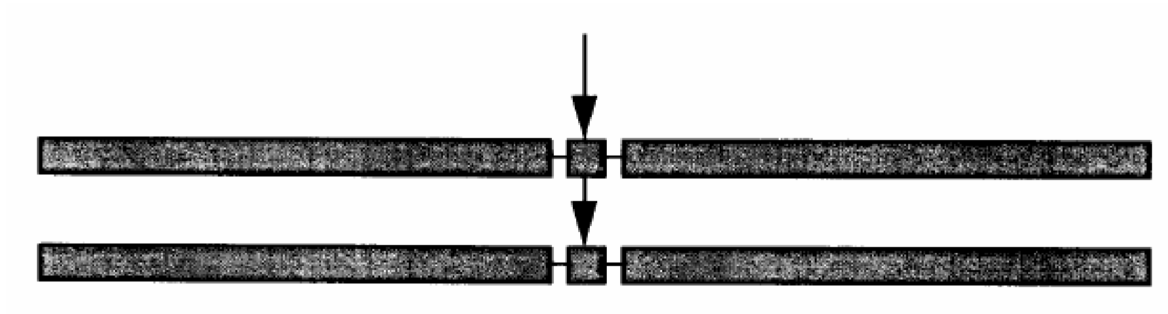
DESIGN OPTIONS

Single Row: In order to provide 1,000 sq. ft. of leaching area and 136 feet of system spread a leaching product would have to provide a minimum 7.35 sq.ft. (1,000/136) of effective area per lineal foot. Utilizing a 30 inch high gallery at 7.4 sf/lf would result in the following system configuration:



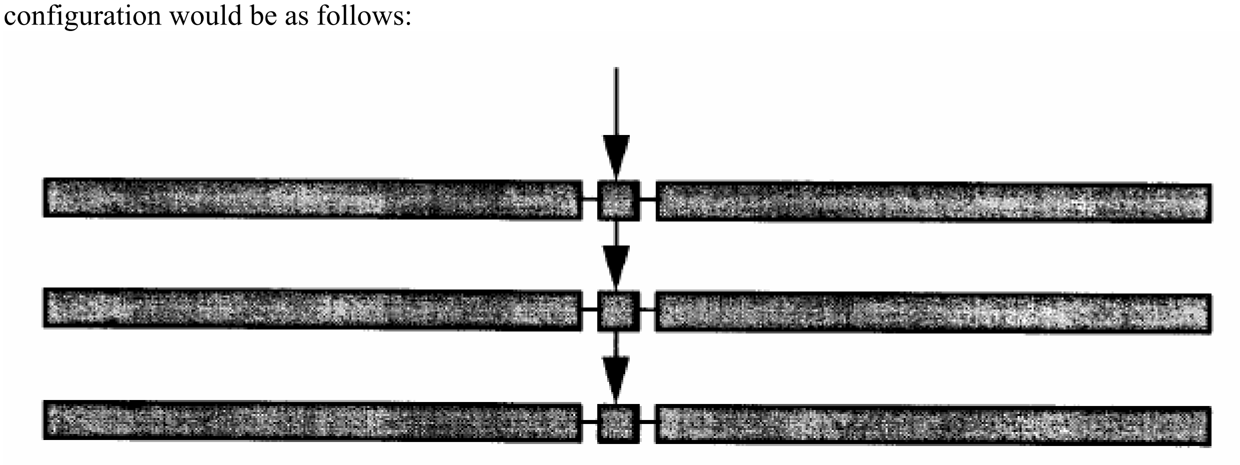
2 trenches X 68’ long X 7.4 SF/LF = 1,006 SF
(NOTE: one trench would be 72’ and the other 64’ due to concrete gallies being 8’ long)

Two Rows: If two rows are utilized a product would have to provide a minimum 3.68 sq. ft. (1,000 sq. ft. / 2 rows / 136 ft.) of effective area per lineal foot. Fourteen (14) inch BioDiffusers or twelve (12) inch Standard Sidewinders provide 3.7 sf/lf of effective area. Utilizing these products would result in the following system configuration:



4 trenches X 68’ long X 3.7 SF/LF = 1,006 SF

Three Rows: A three row system would require a product which would provide a minimum of 2.45 sq. ft. (1,000 sq. ft. / 3 rows / 136 ft.) of effective area per lineal foot. Standard 30 inch wide trenches providing 2.7 sf/lf or 12 inch Contactor 75’s providing 2.6 sf/lf could be used. The system configuration would be as follows:

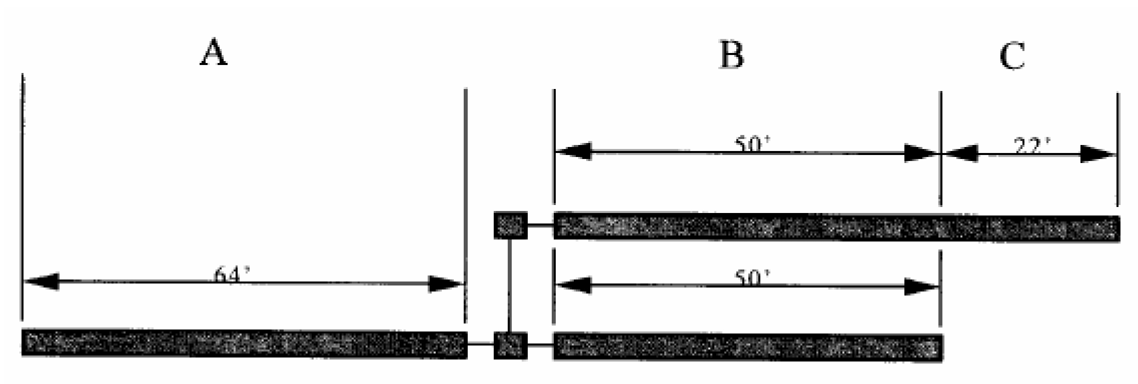


6 trenches X 68’ long X 2.6 SF/LF = 1,060 SF MLSS

ANALYSIS OF NON-UNIFORMLY STACKED SYSTEMS

Occasionally, site conditions make it necessary for engineers to configure systems which are not all the same length meeting MLSS criteria. Whenever unequal "stacking" occurs an analysis of the impact such a configuration will have on the underlying naturally occurring soils will be necessary to assure that hydraulic overloading does not occur. An example of how to perform such an analysis follows:

Unequal Stacked Rows: From the previous example, a plan is designed/submitted utilizing 12" high leaching galleries (5.9 sf/lf) in the following configuration:



Hydraulic overloading is not critical in Sections "A" and "C" of this design. Section "B" has stacking of two segments each 50 feet long. A simple mathematical analysis can be performed to determine if the percentage of leaching system which is stacked exceeds the required hydraulic window for that section. In other words, will the underlying soils beneath that section of the system be able to accept the percentage of daily flow which will be generated by the amount of leaching system within the section?

To determine if hydraulic overloading will occur in a particular hydraulic window the following analysis should be performed:

- Draw section line (perpendicular to natural contour lines) at the end of the leaching rows wherever the number of rows change within a hydraulic window (see example at bottom of page 127).
- Determine the minimum spread required for the design using MLSS criteria.

  In this case MLSS = 34 X 2.0 X 2.0 = 136 ft.

- Divide the cumulative length of system within the section which has the most "stacked" elements (Section B: 50 + 50 = 100 ft.) by the total length of system provided (Total: 64 + 50 + 50 + 22 = 186 ft.)

Section Utilization = 100/186 = 54% Utilization

This indicates that 54% of the anticipated sewage flow will be within Section "B" hydraulic window when the discharge from the home is at daily design rates (full utilization).

- Divide the length of spread provided in the hydraulic section of concern (Section "B" = 50 ft) by the minimum spread required for the entire system using MLSS criteria (Item #2, above - MLSS = 136 ft).

Hydraulic Capacity = 50/136 = 37% Capacity

Note: Only use MLSS criteria, not actual length of system if length provided exceeds MLSS criteria.

- If the percentage of Section Utilization exceeds the percentage of Hydraulic Capacity then hydraulic overloading will likely occur within this section of the system and, therefore, the design does not meet code requirements for hydraulic reasons.

Section Utilization = 54% Hydraulic Capacity = 37% Design should be rejected

This type of analysis should be performed whenever a "stacked" system configuration is of concern. The risk of hydraulic overloading will be greatest where unequal "stacking" occurs, therefore, it is important to understand the benefit of uniform application.

OTHER MLSS ISSUES

PIGGY-BACK SYSTEMS: The relative placement of adjacent leaching systems is important since hydraulic overloading can occur when too much effluent from multiple systems discharge into the same hydraulic window. This is especially relevant when subdivisions are being created. Before individual lot line are established an analysis of the impact a proposed leaching system would have on an adjacent property's leaching area most be conducted. To determine the impact of the two systems, MLSS criteria should be utilized based on the total number of bedrooms for both houses. Where soil characteristics or percolation rates differ system to system, the down gradient system's conditions should take precedence.

There comes a point when the distance between "piggy-back" systems are far enough that the upper system will not adversely affect the performance of the downslope system. Although there is no definitive way of calculating this distance in exact terms, a separation distance of fifty (50) feet has been recommended a standard practice. Due to the natural tendency for sewage to dissipate once it leaves a leaching system, the impact on a downgrade leaching system located at least 50 feet from an upgrade system will be minimal. Under these conditions each system can be analyzed independently.

HYDRAULIC RESERVE: It is desirable to provide additional hydraulic relief to facilitate future expansion of a residence, commercial or industrial building. If additional hydraulic capacity is provided either by installing the primary system wider than the required MLSS spread or if this capacity is clearly shown in the reserve area on design plans, approval of future building use changes or enlargements are more likely. If no additional hydraulic reserve is provided, property owners may not be allowed an addition which includes increasing the total number of bedrooms to the house, unless site specific hydraulic analysis is performed by a professional engineer to demonstrate suitability.

HYDRAULIC GRADIENT: When calculating MLSS, the determination of the hydraulic gradient can be influenced by the boundary conditions the reviewer uses when establishing the percentage of grade in the leaching area. A more uniform standard for determining the hydraulic gradient, measurements should begin near the upper most primary leaching trench and extend a distance of 25 to 50 feet below the lowest proposed leaching trench.

DEPTH TO RESTRICTIVE LAYER: The soil conditions near the lowest leaching trench are most critical when analyzing hydraulic capacity. Therefore, in most cases use the depths to restrictive layer in this area when calculating MLSS. Even though soil depths within the leaching area may be somewhat different, the down gradient receiving soil layer actually governs the total quantity of sewage that will be absorbed and dispersed.

HYDRAULIC ANALYSIS IN-DEPTH METHODS

Whenever conditions are unusually severe or where the volume of sewage effluent to be dispersed is large and MLSS criteria is exceeded a more formal investigation of hydraulic capacities would be required. The methods used for hydraulic analysis depend on the nature of the site limitations and the intended purpose of the analysis. The effects of site modifications (placement of fill material) normally are not considered when designing new subsurface sewage disposal systems.
Special notice should be made of the recommended applications for each particular method of hydraulic analysis outlined in the following sections. Hydraulic analysis should not be required for subsurface sewage disposal systems with a design flow of 1000 gallons per day or less except in the specific situations described.

DETERMINING LENGTH OF LEACHING SYSTEM APPLICATION ON SLOPES UNDERLAIN BY SHALLOW LAYERS OF IMPERVIOUS SOIL OR LEDGE.

In this situation, the cross-sectional area of the surrounding soil is severely restricted by the shallow, underlying boundary layer. The object of the hydraulic analysis is to determine to what extent the leaching system must be spread out parallel with the contours in order to provide sufficient cross-sectional area of soil downslope for effluent dispersal.

This method of hydraulic analysis is recommended for the design of leaching systems located on slopes where:

- The surrounding naturally occurring soil is underlain by an impervious layer at a depth of less than 2 feet or

- The area has been filled and the underlying naturally occurring soils have less than 18” of unsaturated peameable conditions.

- The capacity of the leaching system is over 1000 gallons per day and the surrounding naturally occurring soil is underlain by impervious soil or ledge at a depth of 4 feet or less.

Procedure

- Estimate the permeability of the upper naturally occurring soil by two or more of the methods described in Section 24.

- Determine the average depth of the underlying impervious layer by digging observation pits at several locations in the area of the proposed leaching system and in an downslope direction.

- Determine the slope of the underlying impervious layer. If the depth to the impervious layer varies by no more than a foot, the slope of the impervious layer may be taken to be equal to the ground slope.

- Calculate the distance that the leaching system must be spread out perpendicular to the direction of the slope in order to provide sufficient cross-sectional area of soil downslope for effluent dispersal. Use Darcy's Law, as follows:

  Q = KiA Where A is the cross sectional area of the original soil down gradient from the system. A (area) = depth (d) X Length

  $$Q = Ki\,(d \times L)$$

  $$L = \frac{Q}{Kid}$$

Where:

L = Length that the leaching system must be spread out perpendicular to the slope, in feet.

Q = Volume of sewage effluent to be dispersed, in cubic feet per day.

K = Soil permeability, in feet per day.

i = Slope of the ground surface or underlying impervious layer.

d = Average depth of subsoil above the impervious layer, in feet.

After the permeability of the soil, the slope of ground surface (or hydraulic gradient) and the depth of permeable soil available has been determined, the only variables left are the length of system spread and the volume of sewage to be discharged. Examples 1-3 address typical situations which can be used to determine minimum length (L) of system applications on critical properties.
Examples 4-6 cover situations which will help determine the total amount of water (Q) a particular parcel can safely handle and the limited options available.

Example 1: The leaching system for a two-bedroom single family house is to be located on a large lot underlain with hardpan at a depth of 18 to 22 inches. A 20-inch deep percolation test produced a rate of 15 minutes per inch. The hardpan has a minimum percolation rate poorer than 60 minutes per inch. The permeability of the upper soil layer is estimated to be about 4 feet per day, and the slope of the ground surface is about 5%.

Therefore:

System design based upon 15 min/inch perc rate, 500 sq.ft. effective area required;

Q = 150 gal/bedroom X 2 bedrooms = 300 G.P.D.;

convert to cubic feet $\frac{300}{7.5} = 40\ ft^3/day$

Q = 40 cu. ft./day K = 4 ft./day i = 0.05

d = $\frac{(18 + 22)}{2}$ = 20 in. = 1.67 ft.

$L = \frac{40}{4 \times 0.05 \times 1.67} = 120$ feet

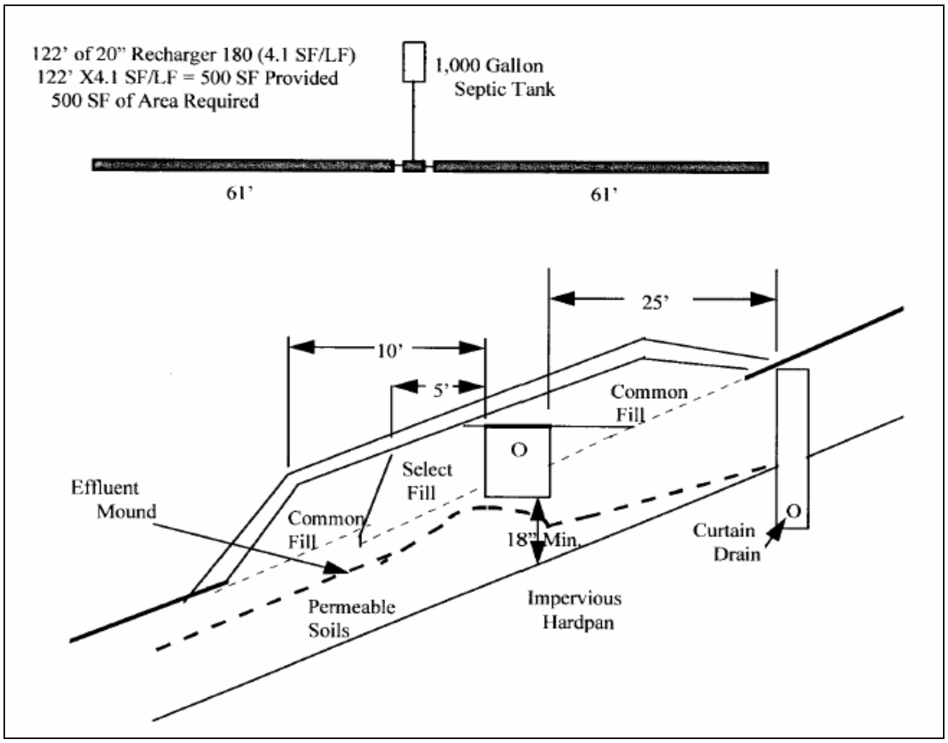


Figure 19-1
Trenches Spread On Slope Over Impervious Hardpan

See Figure 19-1 is an acceptable leaching system design for this location. Note that the leaching trenches should be constructed in fill so that the trench bottoms will be at least 18 inches above the hardpan layer. 504 square feet of leaching area will be provided, with a curtain drain to intercept perched ground water will be installed.

Example 2: The leaching system for a two-bedroom single-family home will be constructed on a large, sloping lot underlain with impervious hardpan at a depth of 3 feet. The overlying soil consists of silty loam with a minimum percolation rate of 30 minutes per inch. The permeability of the overlying soil is estimated to be about 2 foot per day, and the ground slope is about 8%.

Therefore:

$$L = \frac{Q}{Kid} = \frac{40}{1 \text{ X } 0.08 \text{ X } 3.0} = 167 \text{ feet}$$

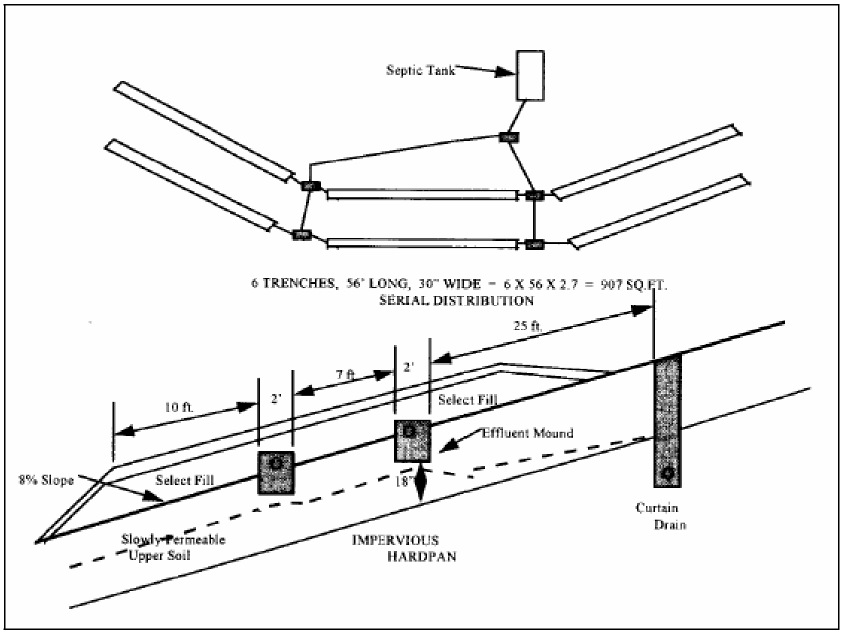


Figure 19-2
Trenches In Slowly Permeable Soil Spread On Slope

Figure 19-2 is an acceptable leaching system design for this situation. Note that **565 square feet** of leaching trenches should be used, constructed with the invert elevations approximately at original ground surface. A curtain drain will be installed.

Example 3: The leaching system for a small restaurant with a design flow of 1,500 gallons per day will be installed in a sloping area underlain by ledge at a depth of 4 to 5 feet. The soil on top of the ledge consists of sandy loam with a minimum percolation rate of 5 minutes per inch, and an estimated permeability of about 10 feet per day The ledge drops about 4 feet in a distance of 100 feet. No ground water was noted on top of the ledge even during the wet season.

Therefore:

$$Q = 1{,}500/7.5 = 200 \text{ cu. ft./day}$$

$$L = \frac{Q}{Kid} = \frac{200}{10 \text{ X } 0.04 \text{ X } 4} = 125 \text{ feet}$$

Code requires $\frac{1{,}500 \text{ GPD}}{0.8 \text{ (application rate)}} = 1{,}875$ sq. ft. of area

Design Proposal: 4 rows of 30 inch galleries, each row is 64 feet long. Total effective

leaching area provided: 4 rows X 64' long X 7.4 sf/lf = 1,894 sq.ft.
which exceeds the 1,875 sq. ft. required.

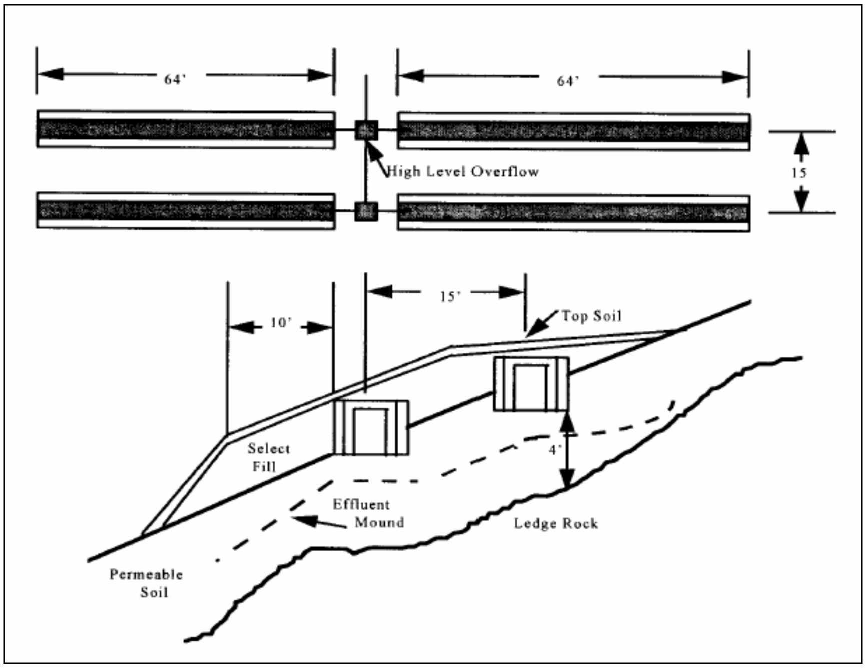


Figure 19-3
Galleries Spread On Slope Over Ledge Rock

Figure 19-3 is an acceptable design for this location. Leaching galleries are used, constructed in fill over the original soil. The size of the leaching system should be based on the requirements of state and local Codes. No curtain drain is installed. However, the relatively substantial depth of surrounding soil and fill should be sufficient to store and disperse any seasonal rainfall accumulation.

DETERMINING THE MAXIMUM HYDRAULIC CAPACITY SOILS

Quite frequently, engineers must be able to calculate or estimate the hydraulic capacity of any given site to determine if proposed development is feasible for particular soil conditions. This is particularly important for construction of large sewage disposal system or on sites where the soils are marginal for leaching purposes. Central sewage disposal systems which concentrate discharges in one or more limited areas may also warrant close evaluation. Proper use of Darcy's Law can be a useful tool in determining whether proposed development exceeds the soils ability to disperse projected sewage flows or whether the scope of development should be scaled down within a safe range to assure health and environmental protection.

The following is a few examples of situations which local health departments have typically had to analyze:

Example 4: Feasibility of Proposed Subdivision

A local developer wishes to subdivide a 10.5-acre parcel into 7 lots in accordance with existing zoning requirements. The property has 1,300 foot frontage along an existing town road and slopes gently away from the road toward a wetland near the rear property line. The developer would like approval for 6 lots, each approximately 180 ft. in width by 340 ft. in depth. Considering minimum zoning setback of 50 ft., average house width of 30 feet and the required 25 feet set back from building footing drains, a series of deep test pits were excavated approximately 125 feet from the front property lines to evaluate soil, water and ledge conditions.

Evaluation of the soils confirms the presence of a coarse loamy mix with approximately 8% slope. Subdivision plans show a series of 4-bedroom homes, all with wells located in the front yards and rear yard leaching areas spread out 100 feet parallel to the contours. Due to the compact till observed 32 inches below grade, it is reasonable to assume each system will be placed in select fill (once top soil is removed) and a curtain drain installed upgrade to intercept ground water. Percolation rates were found to be between 31 to 45 minutes per inch. The local Planning and Zoning Commission wants to know if this subdivision subservice disposal system meets code. Without requiring extensive permeability testing or ground water monitoring, how can Darcy's Law and available sources of information be used to assist you in preparing a response?

MLSS calculations can be very useful in the initial configuration of the subdivision lots. The spread required by MLSS can be “blocked” out on each lot to indicate the necessary size and spread of a typical leaching system. In this example the spread required for the system would equal:

MLSS = HF X FF X PF = 26 X 2.0 X 3.0 = 156 feet

Therefore, if each of the proposed lots provided the required amount of primary and reserve leaching areas and were spread a minimum of 156 feet along ground contours the lots could be approved.
A further analysis to confirm the above results would employee direct use of Darcy’s Law:

GIVEN:

(1) 4 bedroom houses x 150 gal/room = 600 GPD/7.5 = 80 cubic feet/day

(2) Soils have permeability’s which range as follows
0-8” - 0.6-2.0 inches/hr = 1.2-4.0 ft/day
8"-32" - 0.6-2.0 inches/hr = 1.2-4.0 ft/day
32"-60" - 0.06-0.2 inches/hr = .12-0.4 ft/day

(3) Width of system application 180’ lot - 10' each property line - +160 ft

(4) Gradient = 8% or .08

(5) Depth of permeable soil = 32"

ASSUME:

(1) K = average range 1.2 + 4.0 = 5.2/2 = 2.6 ft/day

(2) Curtain drain will cut off all inflow from up slope watershed

(3) L = 160’ parallel to contours

Solve for Q, the quantity of water each lot can handle:

$$Q = KiA = Ki(L \times d)$$
$$Q = 2.6 \times 0.08 \times (160 \times 32/12)$$

Q = 88.8 cubic feet

With the potential for generation of 80 cubic feet of sewage and capacity to handle over 88 cubic feet, it is evident that the lot can support a system for a 4 bedroom home, both in terms of MLSS criteria and Darcy's Law.

However, if the developer wanted to increase the number of lots on the subdivision by reducing the width of the property (relative to the contours), hydraulic constraints would quickly become evident. If the width of the lots were reduced to 150 feet across (meaning the maximum amount of system spread would be reduced to 130 feet) then the required spread of 156 feet determined by MLSS would not be available. The developer would than have to reduce the number of bedrooms allowed for each home to three (3) in order to meet MLSS requirements:

MLSS = HF X FF PF = 26 X 1.5 X 3.0 = 117 feet

Under Darcy's Law:

A three (3) bedroom home will generate:

Q = 150 GPD X 3 Bedrooms / 7.5 gallons per cu.ft. = 60 cu.ft.

The proposed lot will support:

Q = KiA = Ki (L X d) = 2.6 X 0.08 X (130 X 2.66) = 71.9 cu ft.

Therefore, a three (3) bedroom home would be acceptable.

Example 5: The Motel/Restaurant Proposal

A local business man owns a 1.8 acre parcel at the intersection of two busy state highways. He would like to construct a two story 30 room motel and a 50 seat restaurant on this parcel which is 280' wide by 280 feet in depth. The view from the highway shows the land sloping from the left to the right at approximately 12% grade. In order to meet all zoning requirements, preliminary site plans designate a leaching area in the rear right corner approximately 190 feet wide (parallel with contours) by 70 feet in depth. Soil tests reveal the presence of sandy loam with a restrictive compact soil noted 4.5 feet below existing grade. Can this site handle the proposed development?

GIVEN: (1) 30 room motel @ 100 gal/room = 3000 GPD
50 seat restaurant x 3 turnovers x 10 gal = 1500 GPD
Total 4500 GPD/7.5 = 600 cubic ft.

(2) Soils have permeabilities which range as follows:

0-6"	-	0.6-6.0 inches/hr = 1.2-12 ft/day
6-26"	-	0.6-6.0 inches/hr = 1.2-12 ft/day
26-60"	-	0.6-6.0 inches/hr = 1.2-12 ft/day

(3) Percolation Rate = 4 minutes/inch

(4) Width of application area 190 feet

(5) Gradient s 12% = .12

(6) Depth of permeable soil = 4.5 ft. to restrictive layer, no groundwater observed or anticipated

(7) Tube samples (minimum of 6 tubes) confirm average K values of 6.2 ft/day.

Determine whether this site can handle projected flows:

Utilizing MLSS Criteria:

MLSS = HF X FF X PF = 14 X 4500/300 X 1.0 = 210 feet of spread required.

Utilizing Darcy's Law:

This analysis will be based on the actual permeabilities from the tube samples and the actual length of application (190') available on this site.

Q = KiA = Ki (LXd)
Q = 6.2 x .12 x 190 x 4.5
Q = 636 cubic feet/day
Q = 636 cu.ft./day X 7.48 gal./cu.ft. = 4,757 gallons per day can be discharged into the naturally occurring soils without becoming completely saturated.

As this example illustrates, the MLSS calculations may be more restrictive in some cases, especially when dealing with fast soils, than Darcy's Law. MLSS indicated that 210 feet of spread would be required in order to adequately disperse the 4,500 gallons of daily discharge. Since the site can provide only 190 feet of spread, MLSS would deem it unacceptable for the proposed usage. However, when a more in-depth hydraulic analysis was performed, utilizing actual permeabilities and Darcy's Law, it was found that the 190 feet of actual spread available would be sufficient for the proposed usage.

The placement of the system in terms of elevation should be of concern in the above example, since the hydraulic mound created beneath a fully utilized system will likely saturate almost all of the underlying naturally occurring soils. Therefore it would be detrimental to the performance of the system if the system was placed into the natural soils and become flooded whenever the system is used at peak flow. Therefore, designing a leaching system 18" above maximum ground water (the minimum separation required by code) may not be appropriate when the system does not have extra hydraulic relief built in (significantly more spread than what is required by MLSS or Darcy's Law).

Consideration for "reserve hydraulic capacity" must also be considered when designing a leaching system. For the primary system adding "spread" to a system increases the safety factor for proper performance of the system by providing additional hydraulic window (access to additional unsaturated soils beneath the system) to accept those "above peak" discharges which may occur from time to time (during house parties or temporary increases in house occupancy). Another reason for providing extra hydraulic capacity, especially for the reserve area, is to allow the owners of the home or building to increase usages in the future. Under present health codes, house additions can be approved when the lot the building is located on can support a septic system, based on the ultimate configuration of the building, which will meet all health code requirements (including MLSS). If the total number of bedrooms or design flow increases, no approval may be given for a building addition, unless hydraulic capacity (MLSS/Darcy's Law) is established.

Example 6: The Flat Wet Lot

A local developer wishes to build a 4 bedroom home on the last remaining lot in an old residential subdivision. Soil testing during the wet spring months confirms the presence of ground water 18 inches below grade during the wet season monitoring. The lot is essentially level and the soil profile agrees with local mapping as silt loam. There is no slope available to allow curtain drain installation and, even if possible, there is the concern for back flow of ground water from the system area to the drain. The builder's engineer is recommending installation of a large trench system constructed in fill with trench bottoms set at existing grade. The percolation rate determined during testing in produced a rate of 35 min/inch in a hole that was 18 inches deep. Can this lot handle the projected sewage flows?

GIVEN: (1) 4-bedroom house x 150-gal/bedroom = 600 GPD = 80 cubic feet

(2) Soils have permeabilities which range as follows
0-8" - 0 .6-2.0 inches/hr = 1.2-4.0 ft/day
8-30" - 0.6-2.0 inches/hr = 1.2-4.0 ft/day
30-60" - 0.2 inches/hr = 0.4 ft/day

(3) System design is a level mound, 2.0 ft of select sand and gravel fill with 4 rows, 75' long, 3' wide standard trench, 6 end connecting trenches. The fill extends 15 feet beyond the entire trench system prior to sloping 2 ft vertical/1 ft horizontal back to original grade. Plans specify placement of select sandy fill only 5 feet beyond the proposed leaching trenches. Dimensions of the select fill mound are 85' long x 40' wide.

(4) The gradient is assumed to be the difference between the trench bottom set at grade and the ground water level (18") divided by 25 feet (assumed extension of saturated mound) i = 1.5/25 = .06

(5) Depth of permeable naturally occurring soil at base of select fill = 1.5 ft

ASSUME: (1) K = average of SCS range 1.2 + 4.0/2 = 2.6 ft/day
(2) A (application area) = length of application to both sides of system plus connected ends = (75' + 75' + 30' + 30') X 1.5' depth = 315 sq.ft.

Utilizing MLSS Criteria

MLSS = HF X FF X PF = 42 X 2.0 X 3.0 = 252 feet required

Provided = 75' + 75' + 30' + 30' = 210 feet provided sewage flow away from system

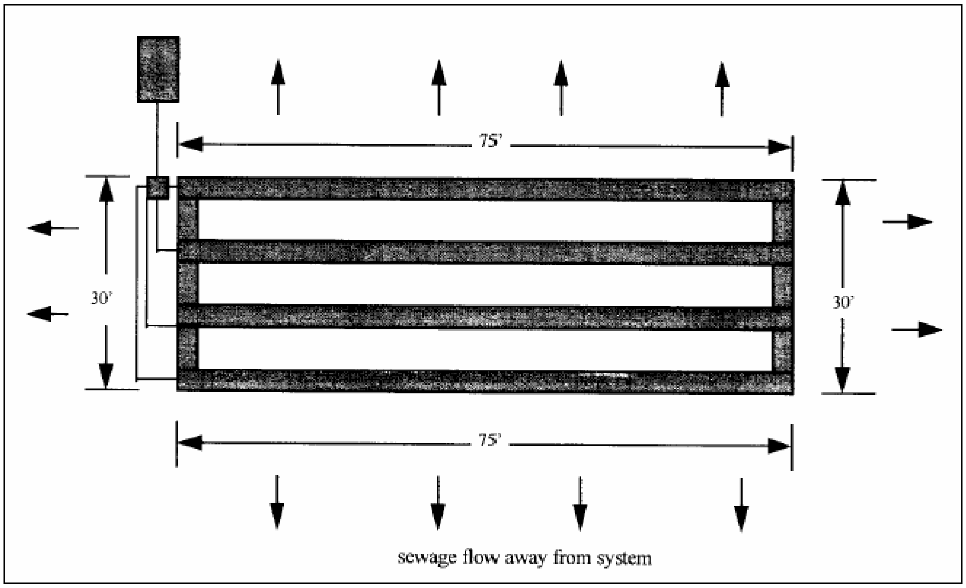


Figure 19-4
Flat Lot System with Radial Flow

Utilizing Darcy's Law

Q = KiA
Q = 2.6 x .06 x 315 Q = 49.1
cubic ft/day

The calculations indicate a 4 bedroom home could not be approved if the assumptions made above were shown to be correct. Field testing to accurately determine permeability would be warranted if the builder wanted to pursue the 4 bedroom home approval. Further analysis of the above example brings out a key element of MLSS versus Darcy's Law, namely there are going to be situations where MLSS criteria will be met when a Darcy's Law analysis fails. If the above builder decides to reduce the number of bedrooms in the proposed house to three (3) the MLSS equation will change to:

MLSS = 42 X 1.5 X 3.0 = 189 feet required < 210 feet provided
(This assumes the size of the system will not be reduced to a 3 bedroom)

Therefore, acceptable by MLSS

However, Darcy's Law indicates only 49.1 cu. ft. (368 gallons) of flow can be absorbed daily, which is below the design rate for a three (3) bedroom home of 60 cu. ft. (450 gallons).

The three (3) bedroom home would be acceptable for the above example even though Darcy's Law did not confirm result. The factor tables used for MLSS have this anomaly built in since the empirical data of years of existing leaching systems performing adequately does not warrant spreading the systems out any further.

It should be noted that if the ends of the above level leaching system where not tied in then the 60 feet of "side" lengths (30 feet to each side) could not be used.

20. FIELD EXAMINATION and IDENFICATION OF SOILS

Feel an Appearance		
Soil Class	Dry Soil	Moist Soil
Sand	Loose, single grains which feel gritty. Squeezed in the hand, the soil mass falls apart when the pressure is released.	Squeezed in the hand, it forms a cast which crumbles when touched. Does not form a rib- bon between thumb and forefinger.
Sandy Loam	Aggregates easily crushed; very faint velvety feeling initially but with continued rubbing the gritty feeling of sand soon dominates.	Forms a cast which bears careful handling without breaking. Does not form a ribbon between thumb and forefinger.
Loam	Aggregates are crushed under moderate pressure; colds can be quite firm. When pulverized, loam has velvety feel that becomes gritty with continued rubbing. Casts bear careful handling.	Cast can be handled quite freely without breaking. Very slight tendency to ribbon between thumb and forefinger. Rubbed surface in rough.
Silt Loam	Aggregates are firm but may be crushed under moderate pressure. Clods are firm to hard. Smooth, hard, flour-like feel dominates when soil is pulverized.	Cast can be freely handled without breaking. Slight tendency to ribbon between thumb and forefinger. Rubbed surface has a broken or rippled appearance.
Clay Loam	Very firm aggregates and hard clods that strongly resist crushing by hand. When pulverized, the soil takes on a somewhat gritty feeling due to the harshness of the very small aggregates which persist.	Cast can bear much handling without breaking. Pinched between the thumb and forefinger, it forms a ribbon whose surface tends to feel slightly gritty when dampened and ribbed. Soil is plastic, sticky and puddles easily.
Clay	Aggregates are hard; clods are extremely hard and strongly resist crushing by hand. When pulverized, it	Casts can bear considerable handling without breaking. Forms a

	has a grit-like texture due to the harshness of numerous very small aggregates which persist.	flexible ribbon between thumb and forefinger and retains its plasticity when elongated. Rubbed surface has a very smooth, satin feeling. Sticky when wet and easily puddle.

21. HOLDING TANKS

A holding tank is a large, watertight tank which receives and stores liquid wastes from a building. The tank is pumped periodically and the waste removed for disposal off the site by a licensed septage hauler. Pumping such a tank can be quite expensive and for this reason, holding tanks normally should be considered only as an interim measure until a permanent method of disposal is available. This is particularly true for residential buildings where per capita water consumption and related pumping costs are high. Holding tanks may be used as an interim measure while public sewers are under construction or where a building is scheduled to be abandoned in the near future. Interim holding tanks for residential buildings probably are not cost effective if the period of use exceeds twelve months, although non residential holding tanks may be used for longer periods.

There are also situations where the long term use of a holding tank may be considered. A holding tank may be used to abate an existing sewage problem at a private residence where there is no other alternative. However, it is extremely important that water usage be reduced as much as possible by the installation of non-discharging toilet systems, removal of laundry facilities and use of water saving sanitary fixtures. Failure to do this will result in high pumping costs and may cause the owner to install an illegal overflow or discharge. Water usage is more easily reduced at a seasonal cottage and holding tanks are more practical for abatement situations. There are certain commercial and industrial buildings such as warehouses, garages and equipment buildings for which installation and operation of a holding tank would represent a relatively small part of the overall operational cost of such a facility and therefore may be a feasible alternative. Holding tanks are not normally approved for new construction projects.

The holding tank should have sufficient liquid storage capacity to hold the volume of sewage expected to be discharged from the building over the period of a week or more. Holding tanks should never be designed to be pumped when full. Instead, the schedule of pumping should be such that the tanks are pumped when about half full. For instance, if a holding tank is large enough to store one weeks sewage flow, the tank should be pumped about every three days on a regular schedule. Such an arrangement anticipates that there will be occasions when the scheduled pumping will be delayed due to reasons beyond the control of the pumper such as equipment breakdown, illness or adverse weather. There should be a liquid level indicator or alarm which would readily indicate when the holding tank has reached the level at which it should be pumped. This would tell the owner of the building that there is a potential for overflow and allow him to contact the pumper before this occurs. Sometimes two holding tanks are used in series with a high level alarm sounding when the first tank is full.

Holding tanks should be located in secure areas which are not available to the general public.

Holding tanks must have easily removal manholes extended to grade, which could represent a safety hazard. Holding tanks should be considered potential sources of pollution and should be located so as to provide the minimum required separating distances for subsurface sewage disposal systems. In some situations it may be necessary to reduce the required minimum separating distance in order to abate a sewage problem. If this is done, particular care must be given to sealing and testing the holding tank for leakage and the ground surface around the tank should be paved and graded to carry possible overflow away from wells, watercourses and residences.

22. DISTRIBUTION BOXES

The use of distribution boxes has many advantages in assuring proper utilization of leaching systems of all sizes and design. Foremost of these is the precision with which effluent flow volume can be regulated to the various leaching units. Experience has shown that "T's" or 'Y's" are difficult to set and adjust to proper elevation during construction, and cannot be relied upon to regulate the flow of sewage throughout the network of effluent distribution pipe in the leaching system. On the other hand, distribution boxes can be set easily and firmly to exact elevation and provide central locations from which the effluent flow to several separate leaching units can be controlled. Furthermore, distribution boxes are readily accessible and relatively easy to find with accurate as-built plans. If a sewage problem arises, it is possible to inspect the boxes and determine which of the various leaching units are functioning properly and which are not. Effluent flow can then be redirected to the functional units by adjusting the elevations of the box outlets or by plugging the outlets to the failing units. This is easily done without damage to any part of the leaching system itself.

In practice, distribution boxes should be used at all distribution system junctions where effluent is directed to any leaching unit on a different elevation, or to more than two units on the same elevation. "T's" or 'Y's" should only be used for splitting effluent to no more than two trenches on the same elevation with ends connected.

TYPES OF DISTRIBUTION BOXES

There are three separate types of distribution boxes; splitter boxes (both equal or proportional), high level overflow boxes, and adjustable outlet boxes, which can serve both purposes.

Splitter boxes normally have a single, high level opening which serves as an inlet, and several openings on a lower level which serve as outlets. Preferably, the outlets should be set somewhat above the bottom of the box to provide a "sump" which will prevent entering sewage from flowing directly above the bottom of the box towards the nearest outlet. When a splitter box is set level, approximately the same portion of the incoming flow should flow out of each outlet and subsequently to each leaching unit connected to it. Small splitter boxes normally are used only for leaching systems where all of the leaching units are on the same elevation, or where it is desired to split flow equally between separate leaching systems. Large splitter boxes normally are used in conjunction with intermittent dosing of a large number of leaching units by pumps or siphons. Sewage effluent enters the boxes at a high rate and raises the liquid level in the box well above the outlets, assuring equal distribution. The inlet to such boxes should be baffled or the flow directed downward to prevent short-circuiting through the box.

Splitter boxes also may be used to divide effluent proportionately to leaching systems of different capacity by connecting a various number of outlets to the different leaching systems. For instance, two outlets of a three outlet splitter box could be connected to a larger leaching system and one outlet to a smaller leaching system in approximate proportion to their respective capacities. The difficulties with this division of flow are centered around the extremely critical task of setting all outlets at the exact same elevation and the prevention of box movement by frost action or construction activities.

High level overflow boxes are used for serial distribution to leaching units constructed on different elevations. The simplest form of high level overflow box consists of a standard distribution box which has been reversed so that the high opening serves as the overflow to the next lower leaching unit. One of the lower openings is used as an inlet and the other low openings are outlets to the higher leaching units. One undesirable feature of using a reversed distribution box is that the inlet and trench distribution piping are always submerged when operating at the overflow level thus making system analysis and investigation more difficult. Some boxes, specifically designed for serial distribution, have openings on three levels; a high level inlet, a mid-level overflow to the next lower leaching unit and low level outlets to the leaching units. Serial distribution boxes also may be made in the field by constructing a mid-level overflow on the outlet from a standard box which is connected to the next lower leaching unit. In this process, the outlet level is raised by installing an elbow or by capping the outlet with a flow regulating insert.

Adjustable outlet boxes are constructed by extending the outlet pipes into the box and placing elbows on the pipes. The elbows can be rotated to conveniently set each outlet to the desired level. Caps with holes cut on one side can be used where the box is too small for elbows. Adjustable outlet boxes frequently are used as splitter boxes to divide effluent equally among leaching systems at different levels because of the fine adjustment which is possible after installation and during use. They also may be used as high level overflows for serial trenches because it allows adjustment of the liquid level in the trenches for maximum utilization of the surrounding soil without breakout. Another type of distribution box which provides 1.5 gallon doses to four outlets set at the same elevation has been in use throughout the state. It is referred to as a dosing distribution box and can be used for both level and serial leaching systems.

INSTALLING DISTRIBUTION BOXES

Distribution boxes should be set as level as possible, particularly splitter boxes which must have all outlets on the exact same elevation. In general, all splitter boxes should be set on 12 to 18 inches of broken stone. The stone allows the box to be adjusted easily during installation. It also assures that there will be no wet soil in contact with the bottom of the box which could freeze, expand and tilt the box. It generally is unnecessary to place splitter boxes on slabs or poured footings. Such construction could cause more problems than it would solve. High level overflow boxes normally are set right into the stone filled leaching trenches.

All splitter box outlets should be checked for level after installation. This usually is done by means of a tripod level or by filling the box with water to the outlet level. Larger distribution boxes, containing six or more outlets, should be provided with a manhole or opening to grade which would facilitate inspection and cleaning. It is important that all distribution box knockout holes be sealed with concrete around the entering pipes so that effluent will not escape.

23. SIPHONS AND DOSING CHAMBERS

Dosing siphons, installed in specially constructed siphon chambers, are one means for providing intermittent dosing where sufficient elevation (3 to 4 feet) between the septic tank and leaching system exists. The siphon unit is a non-mechanical plumbing arrangement consisting of inverted 'U" piping, bell dome and dome vent piping. The siphon, when properly installed in its chamber, provides for the storage of liquid effluent from the septic tank and automatic discharge of a preset quantity depending upon the size of siphon chamber and construction of the siphon. Discharge of large quantities of liquid effluent to a leaching system, referred to as intermittent dosing, is required in Section VI of the Technical Standards for all large subsurface sewage disposal systems with design flows of 2000 gallons per day or greater where the total length of distribution pipe is 600 feet or greater. The primary function of the dosing chamber is to fully distribute liquid throughout leaching systems containing significant lengths of distribution pipe. Typically, effluent is directed to a large distribution box with multiple outlets which may then discharge to smaller distribution boxes at various locations and elevations throughout the large leaching system. Failure to use some form of dosing mechanism with large leaching systems could easily result in disproportionate division of effluent and premature failure caused by overloading.

Figure 23-1 illustrates a cross sectional view of a dosing siphon. In order to begin operation of the siphon, the inverted 'U" piping (trap) must be filled with water. Effluent entering the chamber flows around and under the siphon dome until the water level in the chamber rises to the elevation of dome vent piping, trapping the air under the dome. Additional liquid entering the chamber begins to compress the trapped air. When the water level in the chamber reaches the prescribed height, air pressure under the dome becomes greater than the liquid head in the trap and the air forces the liquid out of the trap. With this air-lock broken, the liquid in the chamber flows by gravity through the trap until the water level is lowered to the bottom of the dome. At this time, air entering the dome vent piping breaks the siphon effect but retains sufficient liquid in the trap to create a seal. As can be seen from the diagram, liquid entering the siphon chamber is generally 2 to 3 feet below the outlet piping. For this reason, siphon chambers are only used where sufficient elevation difference between the septic tank and leaching system exist. A high level overflow pipe within the siphon chamber is required to provide emergency gravity flow.

Dosing siphons must be routinely inspected and maintained in order to assure proper function. The chamber should be inspected on an annual basis and routine pumping of the chamber is necessary to eliminate a sludge build-up, since the domes are placed only 3 inches above the floor of the precast concrete chamber. Corrosion of the dome or vent piping will cause the siphon to malfunction and revert to trickle gravity flow. Inspection of the siphon should indicate a fluctuating water level which rises above the vent piping. Access manholes extended to grade are required for all siphon chambers with design flows of 2000 gallons per day or greater. For leaching trench systems, Technical Standard VI requires chambers to be sized to discharge at least 50% of the volume of distribution pipes. For large leaching gallery systems, the siphon should be sized to discharge approximately 1/5 to 1/3 of the design flow each discharge cycle. The siphon units are typically manufactured of PVC or cast iron and steel piping and must be installed plumb in the siphon chamber. Design plans which indicate use of a dosing chamber utilizing a siphon should include the size and manufacturers identification number of the siphon unit and the detail of the siphon chamber. The internal length and width of the siphon chamber multiplied by the effective drawdown of the siphon will determine cubic feet of discharge per cycle. Conversion to gallons per cycle may be achieved by multiplying the cubic feet quantity by 7.5.

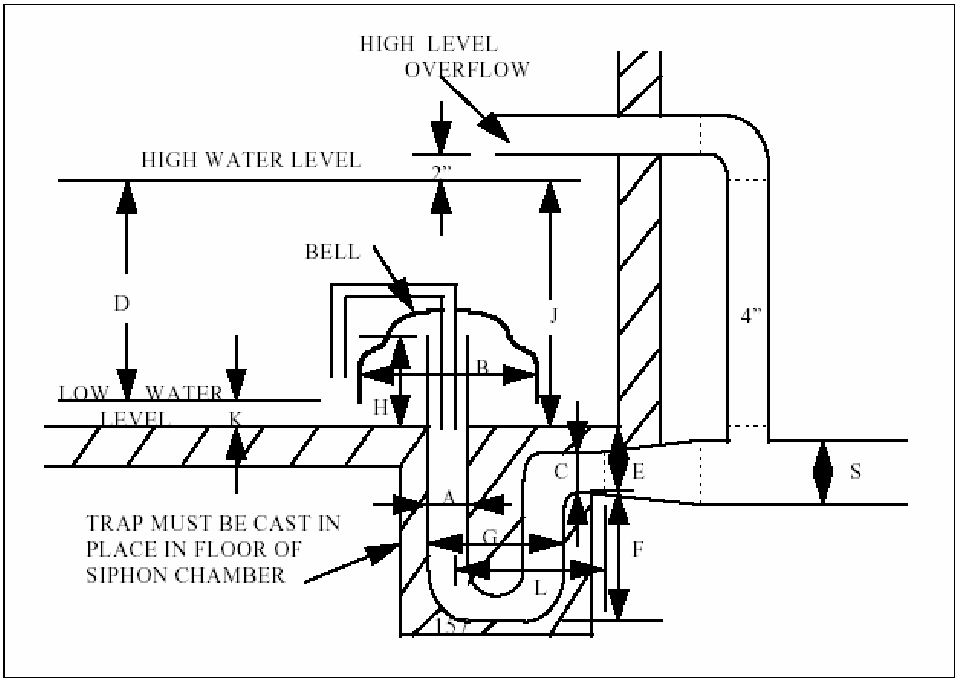


Figure 23-1
3", 4", 5", 6", 8" Standard Design Single Sewage Siphon Chamber

Approximate Dimensions in Inches and Average Weights in Pounds

Diameter of Siphon	A	3	3	4	4	5	6	8
Drawing Depth	D	13	15	14	17	23	30	35
Diameter of Discharge Head	C	4	4	4	4	6	8	10
Diameter of Bell	B	10	10	12	12	15	19	24
Invert Below Floor	E	4.25	4.25	5.5	5.5	7.5	10	12
Depth of Trap	F	13	13	14.25	14.25	23	30.25	36.5
Width of Trap	G	10	10	12	12	14	16	22.5
Height Above Floor	H	7.25	9.25	8.75	11.75	9.5	11	13.5
Invert to Discharge = D+E+K	J	20.25	22.25	22.25	25.5	33.5	44	52
Bottom of BeLl to Floor	K	3	3	3	3	3	4	5
Center of Trap to End of Discharge EU	L	8.65	8.65	11.75	11.75	15.5	17.5	23.5
Diameter of Carrier	S	4	4	4-6	4-6	6-8	8-10	12-15
Average Discharge Rate G.P.M.	-	72	76	157	165	328	474	950
Maximum Discharge Rate G.P.M.	-	96	104	213	227	422	604	1210
Minimum Discharge Rate G.P.M.	-	48	48	102	102	234	340	690
Shipping Weight in Pounds	- -	60	70	110	120	190	300	500

The use of dosing siphons is not restricted to large sewage disposal systems and are occasionally included in designs of residential sewage disposal systems. On lots where slow seeping soil requires installation of narrow trenches which may exceed over 500 lineal foot in length, a siphon may be helpful in distributing effluent uniformly. The inlet piping to the siphon chamber must be located a minimum of 3 inches above the high level overflow.

FLOUTING OUTLET (FLOUT) DOSING CHAMBER

The FLOUT dosing chamber can be used as a substitute for a conventional siphon chamber. The FLOUT consists of a waterproof PVC weighted box with one or more discharge hoses connected to discharge pipes set low in a large concrete distribution box. The flexible hose connecting the discharge pipes to the PVC box act as a tether which allows the box to pivot at the outlet pipes. As effluent enters the chamber, the plastic box begins to float and rises to a predetermined height until the liquid level reaches a large diameter hole at the top of the PVC box. As the box begins to fill with effluent and subsequently sinks, the total volume accumulated in the chamber quickly discharges to the leaching system. The flexible hoses connecting the discharge pipes to the water proof box are the only moving parts.

24. SUBSURFACE SAND FILTERS

In the design of small subsurface sewage disposal systems, buried sand filters may be used to produce a partially stabilized effluent for application to subsurface irrigation systems or evaporation-transpiration mounds. They also may be used for oxidizing septic tank effluent before it is applied to denitrification contact beds. In a conventional subsurface sand filter, septic tank effluent is distributed through a system of perforated pipe and stone over the surface of a buried sand bed. The septic sewage is filtered and oxidized as it passes through the sand bed. Effluent is collected below the sand bed and is discharged to a conventional or modified leaching system. In most subsurface sand filters, effluent is applied intermittently by pumps or siphons to produce a relatively uniform biological growth in the filter and a better stabilized effluent. Modified subsurface sand filters may be designed for higher filtration rates, sometimes with provisions for effluent recirculation. Occasionally such filters are used for final filtration of aerated sewage effluent. High rate subsurface sand filters usually are placed in buried concrete tanks or structures with access openings to the sand surface which allow cleaning if excessive clogging occurs.

CONVENTIONAL SUBSURFACE SAND FILTERS

Figure 24-1 shows the construction of a conventional subsurface sand filter, as typically designed for use with small subsurface sewage disposal systems. Septic tank effluent is discharged to the filter intermittently by means of a siphon or dosing chamber. The chamber usually is sufficiently large so that it does not discharge more than once or twice daily. The surge produced when the siphon discharges tends to surcharge the distribution pipe of small subsurface sand filters. For this reason, small filters frequently are designed with 6 inch diameter distribution pipe which will accommodate a larger liquid volume. Locating distribution boxes in the center of the filter and connecting the ends of the distribution pipe also are helpful in preventing siphon discharging. Perforated distribution pipe are laid 4 to 6 feet on centers in a continuous, 10 to 16 inch deep layer of 1/2 to 1 inch broken stone. The top of the stone layer is protected with filter fabric to prevent dirt and silt from being washed down onto the sand surface.

The filter bed itself consists of 24 to 30 inches of carefully selected sand. The sand must be relatively coarse and extremely uniform so that it will not become clogged by the buildup of fine inorganic particles which are the end product of biological decomposition. The sand should have an effective size of between 0.4 and 0.6 millimeters and a uniformity coefficient of 3.5 or less. The effective size is the sieve size which allows 10% of the grains to pass. The uniformity coefficient is the ratio of the sieve size which passes 60% of the sand to that which passes 10% of the sand. It is highly unlikely that any bank-run sand will meet this specification, no matter how good it may appear. Filter sands normally are screened and washed to meet gradation requirements. Subsurface sand filters receiving septic tank effluent usually are designed for a loading rate of about 1 gallon of effluent per day for each square foot of bed surface. Such a loading rate will allow aerobic conditions to be maintained throughout most of the filter, particularly when effluent is intermittently applied. This promotes the growth of nitrifying organisms and higher forms of protozoan which are able to reduce the BOD in the filter effluent to less than 5 milligrams per liter, and to oxidize over 80% of the nitrogen to the nitrate form. The suspended solid content of subsurface sand filter effluent normally is less than 5 milligrams per liter and the dissolved oxygen exceeds 50% of saturation.

Filter effluent is collected in a layer of 1/2 to 1-inch stone underlying the sand bed and is carried away by perforated collection type. It is important that the top of the stone layer is covered with filter fabric to prevent the filter sand from being washed away. Normally, the collection pipe is vented to ground surface to promote air circulation and help maintain aerobic conditions in the sand bed.

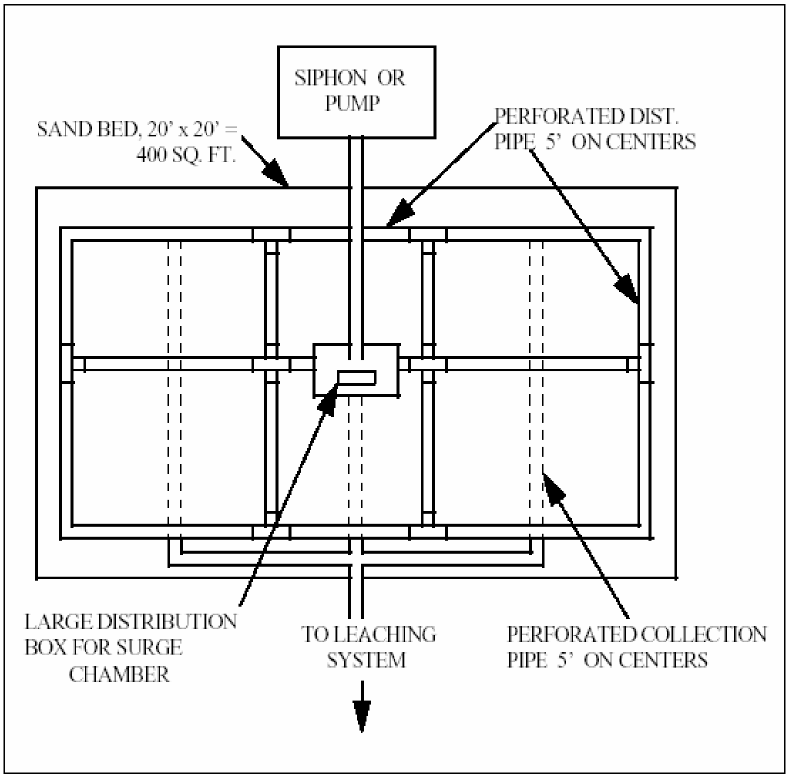


Figure 24-1
Subsurface Sand Filter (Top View)

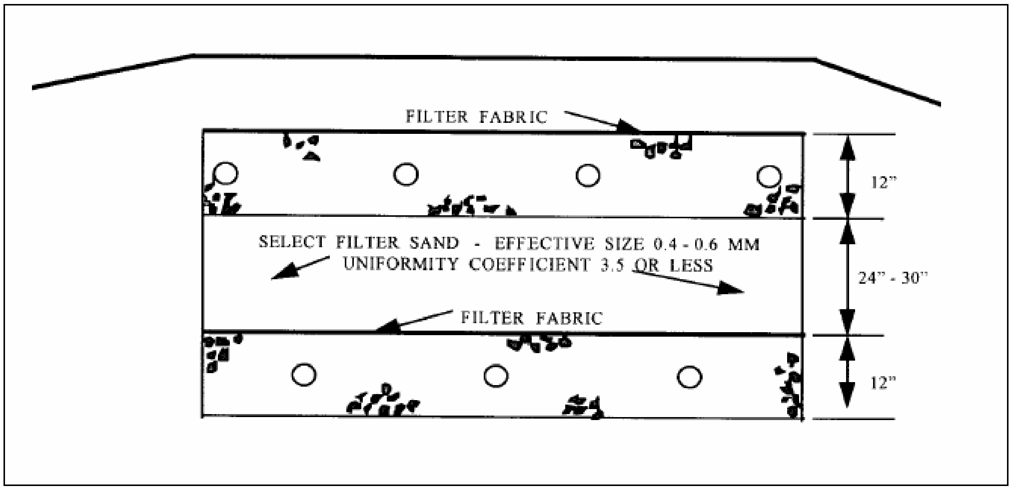


Figure 24-2
Subsurface Sand Filter (Side View)

MODIFIED SUBSURFACE SAND FILTERS

Figure 24-3 shows a modified subsurface sand filter as might be used with a small subsurface sewage disposal system. The entire sand bed is placed within a concrete structure. No system of distribution pipe is used to apply sewage to the filter. Instead, sewage is applied freely to the uncovered surface of the sand. Higher loading rates are possible because the sand surface can be cleaned through access openings in the concrete cover. This structure is vented to the atmosphere and aerobic conditions are maintained either by re-circulating filter effluent or by applying aerated sewage effluent from a small packaged aeration unit.

The gradation and depth of the sand bed is comparable to that of a conventional subsurface sand filter, but the loading rate usually is considerably higher. Loadings of 2 to 10 gallons per day per square foot of filter surface may be used. This may produce a clogging mat on the sand surface which must be periodically removed. High hydraulic loadings may produce saturated flow conditions through the filter and consequently lowered rates of BOD removal and effluent nitrification. This can be overcome by re-circulating the filter effluent by means of a pump. Recirculation rates are adjusted as required, with a recirculation ratio of about 4 volumes of re-circulated filter effluent for each volume of applied sewage being about average.

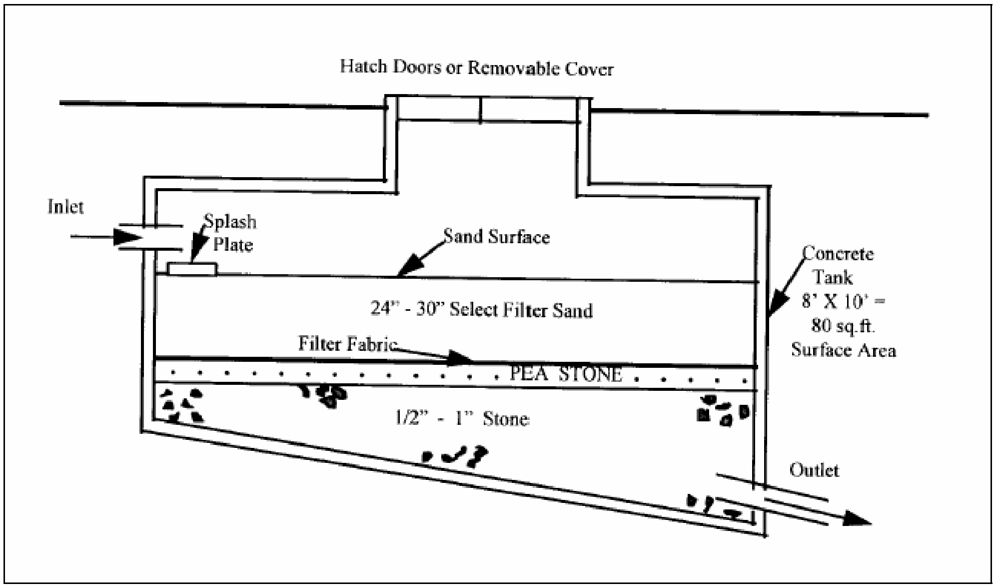


Figure 24-3
High Rate Subsurface Sand Filter

The effluent collection system in high rate sand filters must be carefully designed to handle the high flow rate without losing sand. Generally, several layers of graded stone are used, ranging from 1-inch stone to 1/4-inch pea stone. Figure 24-4 shows a re-circulating subsurface sand filter. Such a system is designed with a collection and recirculation tank containing a float controlled pump. This tank receives both incoming unfiltered sewage and re-circulated filter effluent which is mixed and intermittently pumped to the filter. An adjustable diversion box is located on the filter effluent return line. From this box, a portion of the flow is returned for recirculation and a portion is discharged to the leaching system. Re-circulating subsurface sand filters are generally unsuitable for household or small subsurface sewage disposal systems because of high installation and operating costs and maintenance requirements.

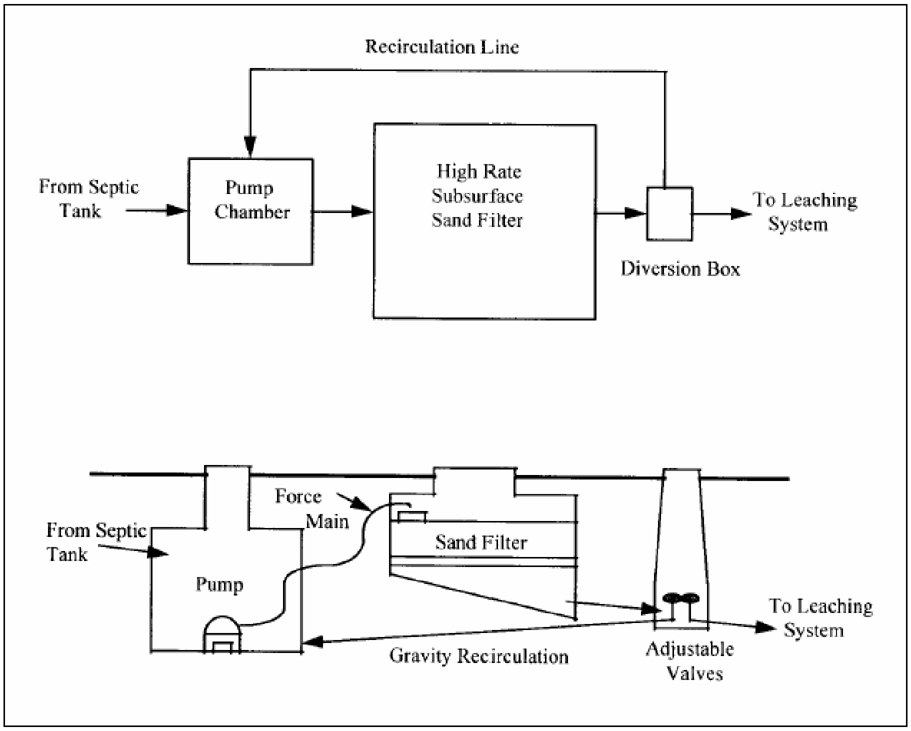


Figure 24-4
Re-circulating Sand Filter

APPENDIX A

Sample of Typical Local or State Technical Standards use for Subsurface Sewage Disposal Systems

I. DEFINITIONS

A. **Accessory structure** means a permanent non-habitable structure which is not served by a water supply and is used incidental to residential or non-residential buildings. Accessory structures include, but are not limited to, attached and detached garages, covered entryways, screened and enclosed 3-season (non-winterized) porches/sunrooms, open decks, tool and lawn equipment storage sheds, gazebos, barns, etc. Small (<200 square feet), portable structures such as sheds without permanent support foundations (concrete slab, piers, footings) are not considered permanent structures. Decks are permanent structures.

B. **Approved aggregate** means stone aggregate, two (2) inch nominal tire chip aggregate as backfill material in leaching system construction.

C. **Bedroom** means those areas within a residential building that have the potential to be utilized as a sleeping area on a consistent basis. In order to be deemed a bedroom the room must meet all of the following standards:

1. Be a habitable or planned habitable space. Planned habitable spaces would include those areas which contain the appropriate "roughed- in" mechanicals, such as, heating ducts, hot water lines, or plumbing waste lines, etc., but are not currently "finished" to meet Building Code requirements for habitable space.

2. Provide privacy to the occupants. Large (minimum 5 feet width) openings or archways can be utilized to eliminate room privacy.

3. Full bathroom facilities (containing either a bathtub or shower) are conveniently located to the bedroom served. Convenience in this case means on the same floor as the bedroom or directly accessed from a stairway.

4. Entry is from a common area, not through a room already deemed a bedroom.

D. **Building served** means the physical structure that contains the habitable/interior portion of the building connected to the subsurface sewage disposal system. The building served includes any portion of the habitable structure permanently attached to the structure including but not limited to basements and 4-season (winterized) porches/sunrooms. The building served does not include attached accessory structures.

E. **Building sewer** means a sewer pipe extending from the building served to the septic tank or grease interceptor tank. Pipes approved for use under this classification are listed in Table No. 2.

F. **Effective leaching area** means a measure, in square feet, of the relative size of a leaching system or product that takes into account the amount of infiltrative area and type of infiltrative interface. Effective leaching area criterion, product ratings, and sizing requirements are included in Section VIII.

G. **Footing or foundation drains** means those drainage systems, consisting of stone or other free draining material with or without piping, which are installed to collect and redirect groundwater in order to protect below grade portions of a building.

H. **Free draining material** (e.g., gravel, broken stone, rock fragments, etc.) means backfill that meets Department of Transportation Specification (or latest specification).

I. **Leaching gallery** means a minimum four-foot wide, level, hollow structure with perforated walls and which is surrounded by approved aggregate on the sides.

J. **Leaching pit** means a hollow, covered structure with perforated sides and which is surrounded on the sides by approved aggregate.

K. **Leaching system** means a structure, excavation or other facility designed to allow settled sewage to percolate into the underlying soil without overflow and to mix with the groundwater. Leaching systems include leaching trenches, leaching galleries, leaching pits, and proprietary leaching systems.

L. **Leaching trench** means a level excavation, not exceeding four feet in width, with vertical sides and flat bottoms filled with approved aggregate and equipped with a single effluent distribution pipe running the entire length of the excavation.

M. **Proprietary leaching system** means a manufactured product to be used as a leaching system.

N. **Select fill** means clean bank run sand, clean bank run sand and gravel, or approved manufactured fill having a gradation which conforms to the specifications.

O. **Solid pipe** means pipe that has no loose or open joints, perforations, slots or porous openings that would allow seepage to escape from, or water to enter the pipe.

P. **Stone aggregate** means broken or crushed stones, or screened gravel meeting Department of Transportation Specifications for No. 4 stone (Sieve sizes 3/8 through 2-inch as shown below or latest specification) and the sieve gradation for the #200 and #40 sieve shown below based on a wet sieve test. Stone aggregate (previously "one-inch broken stone") shall be free of silt, dirt or debris, and shall show a loss of abrasion of not more than 50% using AASHTO Method T-96, and when tested for soundness using AASHTO Method T-1 04 not have a loss of more than 15% at the end of 5 cycles.

SIEVE SIZE	PERCENT PASSING (by weight)
2-inch	100
1.5-inch	90 – 100
1-inch	20 – 55
3/4-inch	0 – 15
3/8-inch	0 – 5
#40	0 - 3
#200	0 – 1.5

Q. **Tight pipe** means solid pipe that exhibit both acceptable wall strength and watertight joints. Pipes approved for use under this classification are listed in Table No. 2-C.

R. **Two (2) inch nominal tire chip aggregate** means tire chips approved for distribution by the Department of Environmental Protection (DEP) for beneficial use in leaching systems. Two inch nominal tire chip aggregate shall be graded or sized in accordance with ASTM D 448 size number 2, 24 or 3, and shall have at least 95% by weight ranging from V2 inch to a maximum of 4 inches in any one direction. Such aggregate shall have no more than 2% by weight of fines (< #200 sieve) based on a wet sieve. Such aggregate shall also have not more than 5% by weight of tire chips containing wire protruding more than V2 inch from the sides of the tire chips.

II. LOCATION OF SUBSURFACE SEWAGE DISPOSAL SYSTEMS

A. Minimum separating distance

The minimum separating distances specified in Table No. 1 are required and shall be maintained between any part of a subsurface sewage disposal system, except certain piping, and the items listed below. Tables No. 2 through 2-D list specific applications whereby specified piping shall have reduced distances.

TABLE NO. 1

ITEM	SEPARATING DISTANCE	SPECIAL PROVISIONS
A. Well (potable, geothermal, irrigation), spring or domestic water suction pipe. Required withdrawal rate under 10 gal. per minute 10 to 50 gal. per minute over 50 gal. per minute	 75 feet 150 feet 200 feet	(1) Separation distance shall be doubled where the soil has a minimum percolation rate faster than one minute/inch and there is less than 8 feet between the bottom of the proposed leaching system and ledge rock. Doubling of the separation distance will be waived if a minimum of 4 feet of slower than one minute/inch naturally occurring soils are found between the bottom of the leaching system and ledge. (2) Separation distance shall be increased as necessary to protect the sanitary quality of a public water supply well
B. Human habitation on adjacent property	15 feet	Building shall have no footing drains
C. Building served	15 feet	Building shall have no footing drains. Distance to a septic tank septic tank/pump chamber/grease interceptor tank may be reduced to a minimum of 10 feet
D. Open watercourse	50 feet	When not located on a public water supply watershed, this distance shall be reduced as necessary to not less than 25 feet on lots in existence prior to the effective date of this regulation and thereafter recorded as required by statute
E. Public water supply reservoir	100 feet	
F. Surface or groundwater drain constructed of solid pipe	25 feet	Tight pipe with rubber gasketed joints or accepted equal (see Table 2-C) are exempted from this requirement as long as the pipe excavation is not backfilled with free draining material, however no tight pipe shall be less than 5 feet from system. Leakage tests may be required to verify water tightness.
G. Groundwater intercepting drains, footing or foundation drain located up-gradient from sewage disposal system	25 feet	
H. Any down gradient drainage system, installed to collect and redirect groundwater, such as, loose or open jointed, perforated, slotted or pervious pipe drains, or piping backfilled with free draining material, located down gradient from a sewage disposal system	50 feet	(1) No such drain shall be constructed down gradient from the leaching system on the same property for the purpose of collecting sewage effluent no matter what the separating distance (2) The location of a septic tank/pump chamber/grease interceptor tank may be reduced to a minimum of 25 feet if determined to be watertight (For concrete tanks in accordance with Sec. 9.2 of ASTM C-1227) See Standard V A 6.
I. Top of embankment	10 feet	Down gradient and all sides Cuts within 50 feet down gradient of leaching systems shall not be allowed if bleed-out conditions are possible
J. Property line	10 feet	
K. Potable water and/or irrigation lines which flow under pressure	10 feet	
L. Below ground swimming pool	25 feet	
M. Above ground swimming pool	10 feet	Includes hot tubs
N. Accessory structure	10 feet	Structure shall have no footing drains Structures without full wall, frost protected footings may be reduced to a minimum of 5 feet
O. Utility service trench (Underground electric, gas, phone services, etc.)	5 feet	Excavations between 5 – 25 feet from system shall not be backfilled with free draining material

TABLE NO. 2
ACCEPTED BUILDING SEWER PIPE FOR USE FROM FOUNDATION WALL TO SEPTIC TANK

NOTE: The local director of health or authorized agent prior to covering shall visually inspect all sewer lines and joints

USE	PIPE DESCRIPTION	ACCEPTABLE JOINT	REMARKS
Building sewer from foundation wall to septic tank or grease interceptor tank, within 25 feet of building served Building sewer line within 75 feet of a private water supply well, spring or water suction pipe but no closer than 25 feet for wells with withdrawal rates less than 10 gpm. Greater separation distances required for wells with withdrawal rates 10 gpm or greater (see PHC 19-13-B51d) NOTE: Building sewer may cross potable water lines under pressure. To reduce separation distances for the following other items listed in Table No. 1: -Human habitation on adjacent property -Building served -Top of embankment -Property line -Pressure water lines -Swimming pools -Accessory structures -Utility service trench	Cast iron hubless ASTM A-888	Cast iron split sleeve bolted joint with rubber gasket, MG coupling or equal OR 3"-wide, heavy -duty, stainless steel banded coupling with rubber gasket; clamp-all, ANACO SD 4000, or equal	Roll-on "donut type" gaskets not acceptable if connection is within 25 feet of foundation wall. Pipe must be properly bedded, laid in straight line on uniform grade
	Cast iron bell and spigot ASTM A-74	Rubber compression gaskets	FERNCO - stainless steel 3" wide shear band allowed for connection of dissimilar piping materials
	PVC ASTM D 1785 /ASTM D 2665, Schedule 40	Rubber compression gasket couplings, Harco Mfg., ASTM D 3139 or equal* OR Solvent weld couplings/ fittings using proper two step PVC solvent solution procedure	*Use of 3"-wide approved stainless steel banded couplings on PVC Schedule 40 ASTM D 1785 is acceptable UL (gray) Piping - Schedule 40- 36" radius- may be utilized as 90° sweep without the need for cleanouts. ABS Schedule 40 is not acceptable
	Ductile iron ANSI A 21.51	Rubber compression gaskets	Connection to cast iron building sewer must be made with compression gaskets.
	PVC AWWA C-900 (PC 100 psi min.)	Rubber compression gaskets	"O"-ring gasket is not acceptable
	PVC ASTM F 1760, Schedule 40	Rubber compression gaskets	Only 4" pipe approved Minimum 1' cover in vehicular loaded traffic areas

TABLE 2-A
ACCEPTED SEWER PIPE FOR INSTALLING SEWER CONNECTIONS TO PUBLIC SEWERS WITHIN 75 FEET OF PRIVATE WATER SUPPLY WELLS

NOTE: All building sewer lines installed within 75 feet but no closer than 25 feet of a private well should be inspected and approved by the local director of health or sewer inspector prior to back filling

USE	PIPE DESCRIPTION	ACCEPTABLE JOINT	REMARKS
Building sewer connection to public sewers or other sewer lines within 75 feet of a private water supply well, spring, or water suction pipe serving a single-family dwelling. No sewer line shall be located within 25 feet of a private well. Note: Greater separating distances are required for wells with withdrawal rates 10 GPM or greater (See PHC 19-13-B51d)	Cast iron hubless ASTM A-888	Cast iron split sleeve bolted connector with rubber gasket, MG coupling or equal to 3" wide, heavy-duty stainless steel banded coupling with rubber gasket; Clamp-all, ANACO SD 4000, or equal	Roll-on "donut type" gaskets not acceptable if used within 75 feet of well. Pipe must be properly bedded in accordance with pipe manufacturer's specifications, laid in a straight line on a uniform grade
	Cast iron bell and spigot ASTM A-74	Rubber compression gaskets	
	Ductile iron ANSI A21.51	Rubber compression gasket	
	Extra strength PVC pressure water pipe AWWA C-900 (PC 100 psi min.)	Rubber compression gasket	
	PVC ASTM D 1785 /ASTM D 2665, Schedule 40 PVC ASTM D 2241, SDR 21 PVC ASTM F 1760, Schedule 40 or SDR 35 PVC ASTM D 3034, SDR 35 PVC ASTM F 789 PVC ASTM F 679	Rubber compression gasketed couplings, Harco Mfg., ASTM D 3139 or equal OR Solvent weld couplings/ fittings using proper two step PVC solvent solution procedure Integral rubber compression gaskets or roll-on compression gaskets	Use of 3" wide approved stainless steel banded couplings on PVC Schedule 40 ASTM D 1785 is acceptable ABS Schedule 40 is not acceptable Joints must meet ASTM D 3212 specifications Bedding in accordance with ASTM D 2321 for PVC pipe

ACCEPTED SEWER PIPE FOR USE IN CONSTRUCTING PUBLIC SEWER LINES WITHIN 75 FEET OF PRIVATE WATER SUPPLY WELL

NOTE: All public sewer lines installed within 75 feet but no closer than 25 feet of private wells serving single-family residences should be low pressure air tested in the presence of the design engineer who should submit a report of the test results to the local director of health.

USE	PIPE DESCRIPTION	ACCEPTABLE JOINT	REMARKS
Public sewer line within 75 feet of a private water supply well, spring or water suction pipe serving single-family residences but no closer than 25 feet. Note: Greater separating distances are required for wells with withdrawal rates 10 GPM or greater (See PHC 19-13-B51d)	Cast iron hubless pipe ASTM A-888	Cast iron split sleeve bolted connector with rubber gasket MG coupling or equal or 3"-wide heavy duty stainless steel banded coupling with rubber gasket; Clamp-All ANACO SD 4000 or equal	Roll-on "donut type" gaskets not acceptable if used within 75 feet of well. Pipe must be properly bedded, in accordance with pipe manufacturer's specifications, laid in a straight line on a uniform grade
	Cast iron bell and spigot ASTM A-74	Rubber compression gaskets	
	Ductile iron ANSI A21.51	Rubber compression gaskets	
	Extra strength PVC pressure water pipe AWWA C-900 (PC 100 psi min.)	Rubber compression gaskets	
	Reinforced concrete water pipe, steel cylinder type, pre-stressed AWWA C-301	Rubber compression gaskets	
	Reinforced concrete water pipe, steel cylinder type, not pre-stressed AWWA C-300	Rubber compression gaskets	
	PVC ASTM D 1785 /ASTM D 2665, Schedule 40 PVC ASTM D 2241, SDR 21 PVC ASTM F1760, Schedule 40 or SDR 35 PVC ASTM D 3034, SDR 35 PVC ASTM F 789 PVC ASTM F 679	Rubber compression gasketed couplings, Harco Mfg., ASTM D3139 or equal* OR Solvent weld couplings/fittings using proper two step PVC solvent solution procedure	*Use 3"-wide stainless steel banded couplings on PVC Schedule 40 ASTM D 1785 is acceptable ABS Schedule 40 is not acceptable Joints must meet ASTM D 3212. Bedding in accordance with ASTM D 2321 for PVC pipe

TABLE 2-C
ACCEPTED TIGHT PIPE FOR USE WITHIN 25 FEET OF WATERCOURSE AND DRAINS OR CLEAN WATER DRAIN WITHIN 25 FEET OF SEWAGE DISPOSAL SYSTEMS

USE	PIPE DESCRIPTION	ACCEPTABLE JOINT	REMARKS
PRIVATE building sewer or effluent distribution line within 25 ft. of any open watercourse, surface or groundwater drain, cellar, footing or foundation drain. and ground and surface water drainage pipes within 25 ft of a subsurface sewage disposal system	Cast iron hubless pipe ASTM A-888	Cast iron split sleeve bolted connector with rubber gasket MG coupling or 3"-wide, heavy duty stainless steel banded coupling with rubber gasket; Clamp-All ANACO SD 4000 or equal	Roll-on "donut type" gaskets not acceptable if used within 25 ft. of watercourse. Pipe must be properly bedded in accordance with manufacturer's specifications, laid in a straight line on a uniform grade
	Cast iron bell and spigot ASTM A-74	Rubber compression gaskets	
	Ductile iron ANSI A21.51	Rubber compression gaskets	
	Extra strength PVC pressure water pipe AWWA C-900 (PC 100 psi min.)	Rubber compression gaskets	
	Reinforced Concrete Pipe ASTM C 76	Rubber compression gaskets, ASTM C 443	
	Reinforced concrete water pipe, steel cylinder type, AWWA C-300/ C-301	Rubber compression gaskets	
To reduce separation distances for the following other items listed in Table No. 1: -Human habitation on adjacent property -Building served -Top of embankment -Property line -Pressure water lines -Swimming pools -Accessory structures -Utility service trench	PVC ASTM D 1785/ ASTM D 2665, Schedule 40 PVC ASTM D 2241, SDR 21	Rubber compression gasketed couplings, Harco Mfg.,ASTM D3139 or equal* or Solvent weld couplings/fittings using proper two step PVC solvent solution procedure	* Use of 3"-wide approved stainless steel banded couplings on PVC ASTM D 1785 Schedule 40 is acceptable ABS Schedule 40 is not acceptable
	PVC ASTM F1760, SDR 35 PVC ASTM D 3034, SDR 35 PVC ASTM F 789 PVC ASTM F 679	Rubber compression gaskets or Solvent weld couplings/fittings using proper two step PVC solvent solution procedure	Joint must meet ASTM D 3212 specifications. Stone bedding is not allowed
	PE, ADS N-12, ASTM F 667, AASHTO M-294, 24-inch maximum diameter PE, Hancor Blue Seal, ASTM F 667, AASHTO M-294, 24-inch maximum diameter	Series 35 ADS coupling, o-ring gasket or WT Pipe/joint (Gasketed bell/spigot) Blue Seal coupling/rubber compression gasket	Coupling: ASTM D 3034/F 1336 Joints (Coupling and WT) meet ASTM D 3212 Joint meets ASTM D 3212

TABLE 2-D

ACCEPTED SEWER PIPE FOR USE AS SEWER FORCE MAIN FOR SPECIFIC APPLICATIONS

USE	PIPE DESCRIPTION	ACCEPTABLE JOINT	REMARKS
Sewage force main within 75 ft. of a private water supply well, spring or water suction pipe (no sewer line shall be located within 25 ft. of private well). Greater separating distances required for 10 gpm or more wells (see PHC 19-13-B51d) OR Sewage force main within 25 ft. of a open watercourse, surface or groundwater drain, footing or foundation drain.	PVC pressure pipe ASTM D 2241, SDR 21, SDR 17, or SDR 13.5	Bell and spigot with compression rubber gaskets	
	PVC pressure water pipe AWWA C-900 (PC 200 psi minimum)		
To reduce separation distances for the following other items listed in Table No. 1: - Human habitation on adjacent property -Building served -Top of embankment -Property line -Pressure water lines -Swimming pools -Accessory structures -Utility service trench	PVC ASTM D 1785 / ASTM D 2665, Schedule 40	Solvent welded, threaded joints or gasketed couplings	
	PE ASTM D 2239 PE ASTM D 2737	No joints within 75 ft. of well or 25 ft. of open watercourse, ground or surface water drains	Pipe available in 100-ft. and longer coiled lengths

B. Record Plans

Following system installation and final inspection, a record plan of the subsurface sewage disposal system, as built, must be prepared. The record plan must locate building sewer exit location at building, sewage system access points (tank cleanouts, distribution boxes, etc) and leaching system ends. Drawing can be a plan to scale or a tie plan from two or more permanent reference points. Tie plans must note distance between reference points. A licensed installer shall prepare and submit the record plan unless an engineered record drawing is required by local director of health. Record plans must be submitted in a timely manner to avoid delays in permit issuance by the local director of health.

C. Plan Adherence

The licensed installer is responsible to construct the subsurface sewage disposal system in accordance with the plan approved by the local director of health.

D. System Abandonment

Abandonment of subsurface sewage disposal system components (i.e., septic tank, hollow leaching structures) or cesspools shall be performed in such a manner as to eliminate the danger of the system components or structure inadvertently collapsing. The responsibility for abandonment lies with the property owner. Structures that are to be abandoned shall be emptied of all sewage/wastewater prior to abandonment. Structures shall be filled with sand, gravel, or crushed, and the area backfilled with clean soil.

E. Benchmarks

Plans by professional engineers shall provide benchmarks that provide for vertical and horizontal controls, or field staking by the design firm shall be required.

III. PIPING

A. Building sewers

Building sewers shall be not less than four inches in diameter. The grade shall be at least one-quarter inch per foot for four-inch sewers and shall not be less than one-eighth inch per foot for six or eight inch sewers. Building sewers shall be laid with tight joints to the septic tank or grease interceptor tank, and in a straight line and on a uniform grade wherever possible. Accessible manholes or surface cleanouts shall be provided at one or more cumulative changes of directions exceeding 45^o (see Figure No. 1), unless a 90° sweep type piping approved in Table 2 is utilized. Accessible manholes or surface cleanouts shall be provided for each 75 feet length of building sewer from foundation wall to the septic tank or grease interceptor tank. Pipe for such sewers shall be of cast iron with rubber gasketed joints or accepted equal* to a point at least twenty-five feet beyond the foundation wall of any cellar or basement. Portions of building sewers within seventy-five feet of a well shall be of cast iron with rubber gasketed joints or accepted equal*, but no portion of such sewer, however constructed, shall be within twenty-five feet of a well. No sewer shall be located within twenty-five feet of a cellar drain or ground or surface water drain unless the pipe is of cast iron with rubber gasketed joints or accepted equal*. Long sewer lines shall be avoided to reduce the danger of groundwater infiltration, and sewer blockages.

*See Tables No. 2 through 2-C

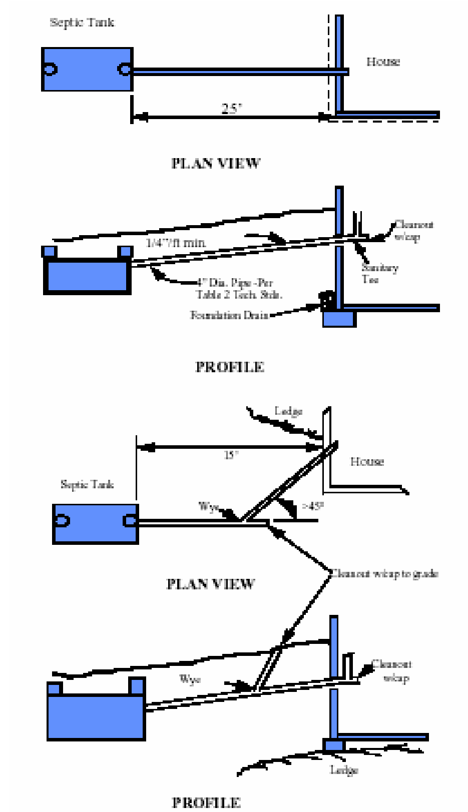


FIGURE 1 - BUILDING SEWERS

B. <u>Water pipe trenches</u>

Whenever possible, pressurized water service mains and building sewer lines shall be located in separate trenches at least ten feet apart. Where laid in the same trench, the water pipe shall be laid on a bench at least eighteen inches above the top of the sewer pipe and at least twelve inches, and preferably eighteen inches, from the side of the sewer trench (see Figure No. 2). In no case shall a building sewer pipe be located less than seventy-five feet from water suction pipe unless approved piping is used.

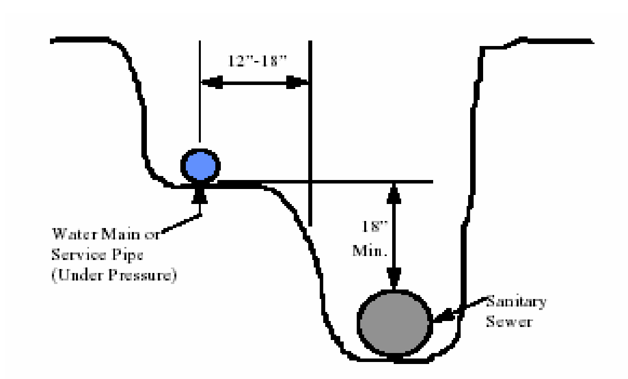


FIGURE 2 - WATER PIPE TRENCHES

When it is necessary to cross a private pressurized water service line with a pipe serving a subsurface sewage disposal system, the pipe shall be listed either in Table 2 or Table 2-C. Table 2 will apply when the water service is located below the sewer pipe. Table 2-C will apply when the water service is located above a sewer. Sewer force mains listed in Table 2-D may cross over or under pressurized water service lines.

C. <u>Procedure for Air Pressure Testing of Sewer Pipe</u>

1. Test is conducted between two (2) consecutive manholes, as directed by the engineer.

2. The test section of the sewer line is plugged at each end. One of the plugs used at the manhole must be tapped and equipped for the air inlet connection for filling the line from the air compressor.

3. All service laterals, stubs and fittings into the sewer test section should be properly capped or plugged, and carefully braced against the internal pressure to prevent air leakage by slippage and blowouts.

4. Connect air hole to tapped plug selected for the air inlet. Then connect the other end of the air hose to the portable air control equipment which consists of valves and pressure gages used to control:

   a) the air entry rate to the sewer test section, and
   b) to monitor the air pressure in the pipe line.

   More specifically, the air control equipment includes a shut-off valve, pressure regulating valve, pressure reduction valve and a monitoring pressure gate having a pressure range from 0 to 5 psi. The gage should have minimum divisions of .10 psi and an accuracy of ±.04 psi. Figure No. 3 illustrates diagrammatically a typical control equipment apparatus.

5. Connect another air hose between the air compressor (or other source of compressed air) and the air control equipment. This completes the test equipment set-up. Test operations may commence.

6. Supply air to the test section slowly, filling the pipeline until a constant pressure of 3.5 psig is maintained. The air pressure must be regulated to prevent the pressure inside the pipe from exceeding 5.0 psig.

7. When constant pressure of 3.5 psig is reached, throttle the air supply to maintain the internal pressure above 3.0 psig for at least 5 minutes. This time permits the temperature of the entering air to equalize with the temperature of the pipe wall. During this stabilization period, it is advisable to check all capped and plugged fittings with a soap solution to detect any leakage at these connections.

   If leakage is detected at any cap or plug, release the pressure in the line and tighten all leaky caps and plugs. Then start the test operation again by supplying air. When it is necessary to bleed off the air to tighten or repair a faulty plug, a new 5-minute interval must be allowed after the pipeline has been refilled.

8. After the stabilization period, adjust the air pressure to 3.5 psig and shut off or disconnect the air supply. Observe the gage until the air pressure reaches 3.0 psig. At 3.0 psig, commence timing with a stop watch which is allowed to run until the line pressure drops to 2.5 psig at which time the stop watch is stopped. The time required, as shown on the stopwatch, for a pressure loss of 0.5 psig is used to compute the air loss. Most authorities consider it unnecessary to

determine the air temperature inside the pipeline and the barometric pressure at the time of the test.

9. If the time, in minutes and seconds, for the air pressure to drop from 3.0 to 2.5 psig is greater than that shown on Table No. 3 for the designated pipe size, the section undergoing test shall have passed and shall be presumed to be free of defects. The test may be discontinued at that time.

10. If the time, in minutes and seconds, for the 0.5 psig drop is less than that shown in Table No. 3 for the designated pipe size, the section of pipe shall not have passed the test; therefore, adequate repairs must be made and the line retested.

a) Pipe sizes with their respective Recommended Minimum Times, in Minutes and Seconds, for Acceptance by the Air Test Method.

b) For eight (8) inch and smaller pipe, only: if, during the 5-minute saturation period, pressure drops less than 0.5 psig after the initial pressurization and air is not added, the pipe section undergoing tests shall have passed.

c) Multi Pipe Sizes: When the sewer line undergoing test is 8" or larger diameter pipe and includes 4" or 6" laterals, the figures in Table 3 for uniform sewer main sizes will not give reliable or accurate criteria for the test. Where multi-pipe sizes are to undergo the air test, the engineer can compute the "average" size in inches which is then multiplied by 38.2 seconds. The results will give the minimum time in seconds acceptable for a pressure drop of 0.5 psig for the "averaged" diameter pipe.

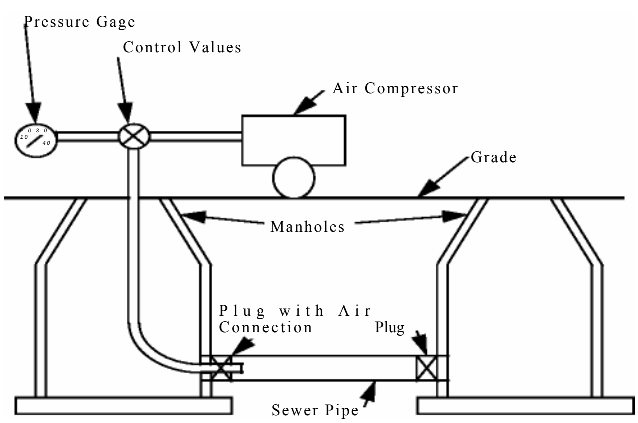


FIGURE 3 - TYPICAL AIR TEST EQUIPMENT LAYOUT

TABLE NO. 3
TIME REQUIREMENTS FOR AIR TESTING

PIPE SIZE (INCHES)	TIME	
	MINUTES	SECONDS
4	2	32
6	3	50
8	5	06
10	6	22

12	7	39
15	9	35
18	11	34

(For larger diameter pipe use the following: Minimum time in seconds = 462 X pipe diameter in ft)

IV. DESIGN FLOWS

A. Residential buildings

Design flows for residential buildings are based on the number of bedrooms in the building with a design flow of 150 gallons per day (GPD) per bedroom except for additional bedrooms beyond 4 in a single-family home which have a 75 GPD per bedroom design flow.

B. Nonresidential buildings and residential institutions

Table No. 4 shall be used for determining the daily design flow from nonresidential buildings and residential institutions unless specific water use data (minimum 1 year period) is available for the facility or similar facilities. Whenever water use data from "similar" facilities is utilized to calculate the design flow for a building, the data must be accompanied with additional supporting information (i.e., building size, plumbing fixture information, hours of operation, etc.) to establish that the comparison is appropriate. Design flow based on metered flows must use a minimum 1.5 safety factor applied to all metered average daily water use.

The required effective leaching area for subsurface sewage disposal systems serving restaurants, bakeries, food service establishments (Class 3 & 4), residential institutions, laundromats, beauty salons, and other nonresidential buildings with problematic sewage is based on the design flow and the application rates listed in Table No. 7 (See Section VIII F). Such buildings or discharges are designated in Table No. 4 with a notation that Table No. 7 application rates are to be utilized for leaching system sizing purposes. Problematic sewage is wastewater that is a concern relative to the design of the subsurface sewage disposal system due to the nature or strength of the sewage.

For nonresidential buildings that are not specifically listed in Table No. 4, the strength and nature of the wastewater must be taken into consideration in the determination as to the appropriate application rate. The strength of the wastewater can be correlated to, among other parameters, the 5-day biochemical oxygen demand (BOD5). For reference purposes, a wastewater BOD5 concentration of 110 mg/l is weak, 220 mg/l is medium, and 400 mg/l is strong per Metcalf and Eddy, Inc. *Wastewater Engineering-Treatment, Disposal, and Reuse Third Edition* (McGraw-Hill, Inc., 1991), table 3-16, p. 109. Weak strength wastewater should utilize Table No. 8 application rates whereas strong wastewater shall utilize Table No. 7 application rates. Medium strength wastewater should utilize Table 7 for a conservative design.

TABLE NO. 4

	GALLONS PER
SCHOOLS, PER PUPIL	
BASE FLOW (EXCLUDES KITCHEN & SHOWERS)	
HIGH SCHOOL	12
JR. HIGH/MIDDLE SCHOOL	9
KINDERGARTEN/ELEMENTARY SCHOOL	8
KITCHEN	3
SHOWERS	3 to 5
RESIDENTIAL	100
DAY CARE CENTER (NO MEALS PREPARED)	10
COMMERCIAL/INDUSTRIAL BUILDINGS, PER EMPLOYEE	
FACTORY (NO SHOWERS)	25
FACTORY (WITH SHOWERS)	35
OFFICE (AVERAGE 200 SQ.FT./PERSON-GROSS AREA)	20
SMALL RETAIL BUILDING-LESS THAN 2,000 SQ.FT.-GROSS AREA	20
LARGE RETAIL/COMMERCIAL BUILDING-SEE MISCELLANEOUS	
CAMPS	
RESIDENTIAL CAMPS (SEMI PERMANENT), PER PERSON	50
CAMPGROUND WITH CENTRAL SANITARY FACILITIES, PER PERSON	35
CAMPGROUND WITH FLUSH TOILETS (NO SHOWERS), PER PERSON	25
CAMPGROUNDS PER CAMP SPACE (WATER AND SEWER HOOK-UPS)	75
DAY CAMPS, PER PERSON	15
LUXURY CAMPS, PER PERSON	75
PICNIC PARKS (TOILET WASTES ONLY), PER PERSON	5
PICNIC PARKS WITH BATHHOUSES, SHOWERS, FLUSH TOILETS, PER PERSON	10
HEALTH CARE FACILITIES	
HOSPITALS, PER BED	250
REST HOMES, PER BED	150
CONVALESCENT HOMES, PER BED	150
INSTITUTIONS, PER RESIDENT	100
GROUP HOME, PER CLIENT (LARGE TUB/ON-SITE LAUNDRYING USE HIGHER FLOW)	100-150
RESTAURANTS	
RESTAURANTS (PUBLIC TOILETS PROVIDED), PER MEAL SERVED	10
TAKE OUT FOOD SERVICE/RESTAURANTS WITH NO PUBLIC TOILETS, PER MEAL SERVED	5
BARS AND COCKTAIL LOUNGES (NO MEALS) PER PATRON	5
RECREATIONAL FACILITIES	
SWIMMING POOLS, PER BATHER	10
INDOOR TENNIS COURTS, PER COURT	400
OUTDOOR TENNIS COURTS, PER COURT	150
THEATERS, SPORTING EVENTS, PER SEAT	3.5
CHURCHES	
WORSHIP SERVICE ONLY, PER SEAT	1
SUNDAY SCHOOL, PER PUPIL	2
SOCIAL EVENTS (MEALS SERVED) PER PERSON	5
MISCELLANEOUS	
AUTO SERVICE STATIONS, PER CARS SERVICED	5
BEAUTY SALON, PER CHAIR	200
BARBER SHOPS, PER CHAIR	50
DENTAL/MEDICAL OFFICES WITH EXAMINATION ROOMS, PER SQ. FT. OF GR. AREA	0.2
KENNEL DOG RUNS, PER RUN, ROOF MUST BE PROVIDED	25
LARGE RETAIL/COMMERCIAL BLDG., PER SQ. FT. OF GROSS AREA	0.1
LAUNDROMATS, PER MACHINE	400
MOTELS, PER ROOM, (NO FOOD SERVICE, KITCHENETTE OR LAUNDRY FACILITIES)	75
MOTELS, PER ROOM, (WITH KINCHENETTE BUT NO LAUNDRY FACILITIES)	100
MARINAS (BATHHOUSE-SHOWERS PROVIDED), PER BOAT SLIP	20

C. Water usage monitoring

Buildings served by large (2,000 GPD or greater) subsurface sewage disposal systems must have the ability to monitor potable water usage by metering of the source of supply.

D. Permits to discharge

Permits to discharge issued by the local director of health shall be on approved forms (Form #4 or approved equal) as required by PHC Section 19-13-B 103e (h). The discharge permits shall specify the permit volume equal to the design flow. The discharge permit should recommend the average daily discharge not exceed 2/3 of the design flow in order to allow the subsurface sewage disposal system to operate with a sufficient factor of safety.

V. SEPTIC TANKS AND GREASE INTERCEPTOR TANKS

A. General

1. Septic Tank Standards

All subsurface sewage disposal systems shall be provided with a septic tank. Such septic tank shall be made of concrete or other durable material. Septic tanks and grease interceptor tanks, including the riser and cover assemblies, located under vehicular travel areas shall be rated for H-20 wheel loadings.

a) Concrete Septic Tanks

All concrete septic tanks shall be produced with a minimum 4,000-psi concrete with 4 to 7 percent air entrainment. oncrete tanks must not be shipped until the concrete has reached the 4,000-psi compressive strength. Concrete septic tank construction shall conform to ASTM C 1227 with the following exceptions:

There shall be no maximum liquid depth.

- The air space above the liquid level shall be a minimum of eight inches.
- Inspection ports over the compartment wall shall be optional.
- The mid-depth connection can utilize a minimum 4-inch diameter pipe.

b) Non-Concrete Septic Tanks

All non-concrete septic tanks shall meet all of the applicable requirements set forth in subsections 2, 3, and 4 of Section V A regarding tank configuration, tank access, and tank cleaning. Non-concrete tanks shall be marked with the manufacturer's name and tank designation number. Non-concrete septic tanks shall be installed with strict adherence to the manufacturer's installation instructions in order to avoid tank damage or tank deformation. Proper bedding, backfill, and compaction shall be confirmed with each tank installation. Shallow groundwater conditions may prohibit installation of certain tanks due to tank designlimitations or warranty restrictions. Tank bottoms located below maximum groundwater levels must be provided with anti buoyancy/floatation provisions (check with manufacturer).

2. Tank Configuration

All septic tanks shall contain an inlet baffle submerged for a depth of eight to eighteen inches and an outlet baffle, unless tank is provided with an approved effluent filter, submerged to a depth of at least ten inches, but no lower than 40 percent, of the liquid depth. Connection of piping and baffles made out of dissimilar materials (i.e., PVC and ABS) require use of multi-purpose 2-step solvent cement meeting ASTM D 3138. The inlet baffle shall encompass not more than 48 square inches of liquid surface area. All baffles shall extend a minimum of five inches above the tank's liquid level and an air space of at least a 1/2-inch shall be provided above the baffle. Inlet and outlet piping entering and exiting the septic tank shall be as level as possible with a pitch no greater than 1/4-inch per foot. All newly installed tanks shall have an approved non-bypass effluent filter at the outlet. Effluent filters shall provide a minimum of 45 square inches of total opening area unless otherwise approved.

The outlet invert of the septic tank shall be 3 inches lower than the inlet invert. Tanks must be installed with the inlet invert between 2 and 4 inches above the outlet invert. The outlet invert of the tank shall be set at a higher elevation than the top of all leaching structures (except in pump systems), or in the case of leaching systems utilizing serial distribution, higher than the high-level overflow elevation of the upper most leaching system row. All septic tanks (except tanks in series) shall have two compartments with 2/3 of the required capacity in the first compartment (see Figure 4). The transfer port must be at mid-depth (opening in middle 25% of liquid depth). Inlet and outlet piping shall be sealed with a polyethylene gasket or rubber boot with stainless steel clamp. All septic tanks shall be manufactured with manhole covers or risers that have been placarded with notification of its two-compartment construction and a warning that “Entrance into the tank could be fatal”. The minimum liquid depth of septic tanks shall be thirty-six inches.

Additional septic tank capacity over one thousand gallons may be obtained by utilizing two tanks in series. In no case may more than two septic tanks be placed in series. When two septic tanks are placed in series, each tank shall be of single compartment design; the volume of the first tank shall be twice the volume of the second; mid-depth baffles shall be provided at the connection of the two tanks; an effluent filter shall be provided for the outlet of the second tank (see Figure 5).

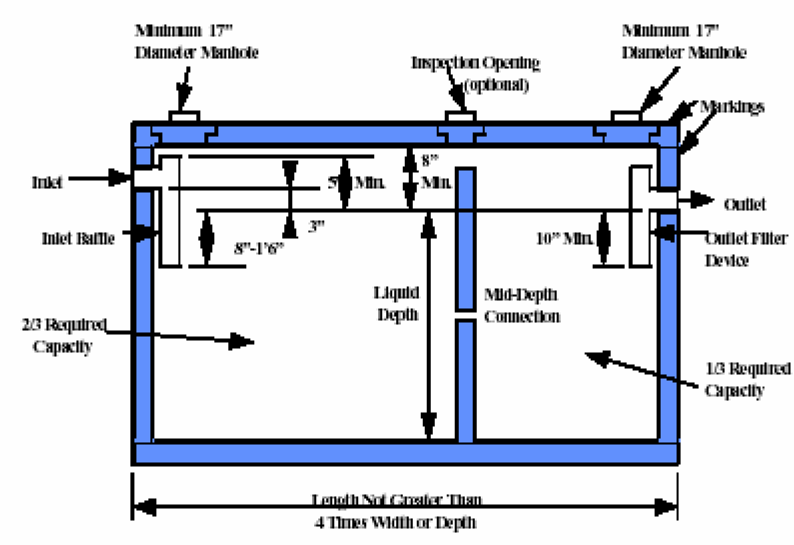


FIGURE 4 – TYPICAL SEPTIC TANK

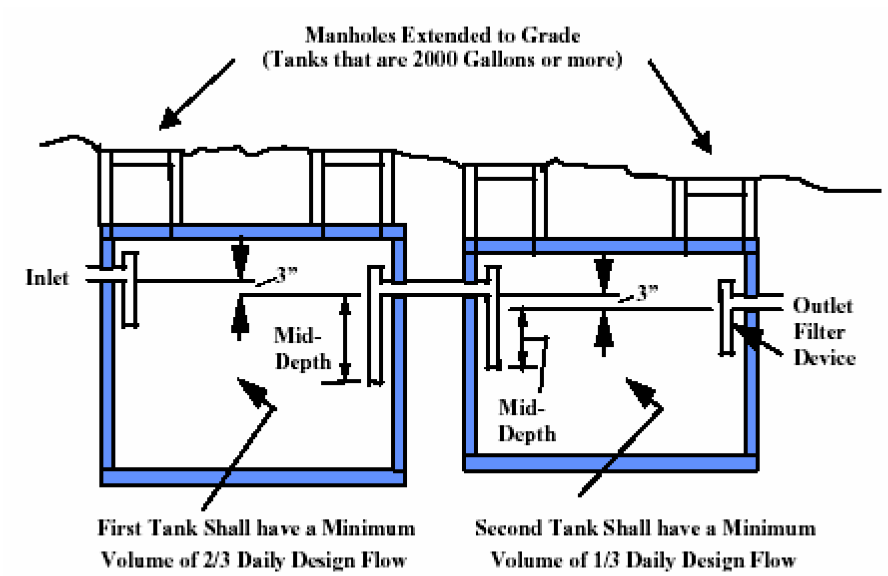
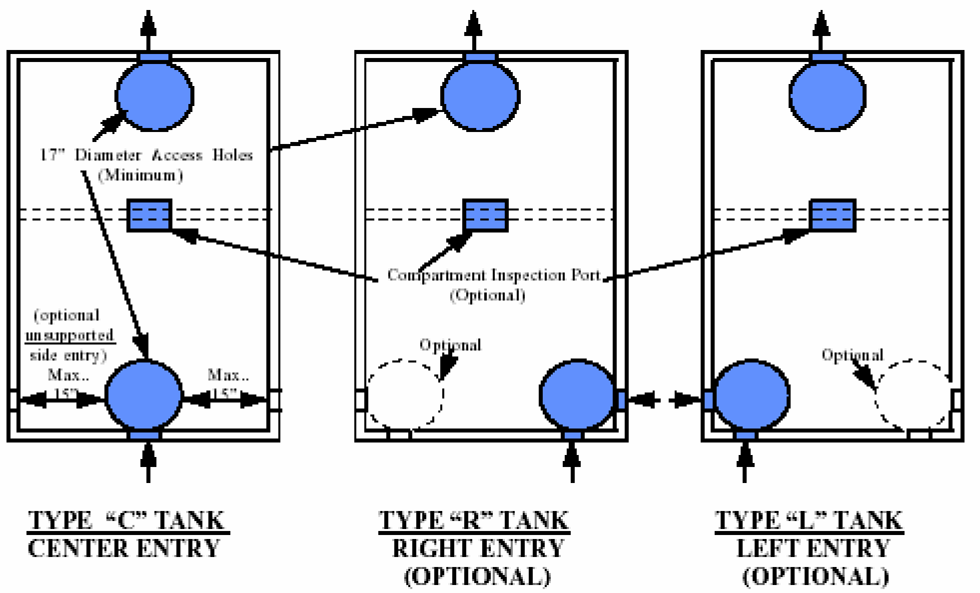


FIGURE 5 - SEPTIC TANKS IN SERIES

Septic Tank Access

Septic tanks shall have removable covers or manholes to provide access to the tank for the purposes of inspection and cleaning. Cleanout manholes shall be located at a depth not greater than twelve inches below final grade level. Existing tanks that exceed the 12-inch depth shall be retrofitted with a cleanout riser(s) at the time of tank cleaning. New tanks and existing tanks deeper than 24 inches below finish grade shall be provided with large (24-inch minimum inside diameter) access risers over each manhole opening. Cleanouts shall consist of a minimum 17-inch inside diameter opening and shall be located directly over the inlet baffle and effluent filter. If a tank provides side inlets, the maximum distance between the interior wall surface and the cleanout manhole shall be 15 inches unless the pipe extension from the tank side to the cleanout manhole opening will be supported. Baffle extensions shall not have more than a 1/4-inch per foot pitch. All tank covers shall be stepped and be provided with handles consisting of 3/8-inch coated rebar or approved plastic handles. Below ground plastic handles and plastic riser covers cannot be used unless provisions are made to allow for manhole locating with a metal detector. On septic tanks of two thousand gallons or more, manholes (watertight) shall extend to grade except for single-family residential buildings. Where covers are flush with or above grade, either the lid must weigh a minimum of 59 pounds or the cover shall be provided with a lock system to prevent unauthorized entrance. Tanks that exceed fifteen feet in length shall provide a minimum of three manholes. In any case, the overall length shall not be greater than four times either the width or the depth.



STANDARDIZED SEPTIC TANK TOP CONFIGURATIONS

4. Septic Tank Cleaning

Septic tanks shall be cleaned as often as necessary to prevent a buildup of sludge, grease and scum which will adversely affect the performance of the subsurface sewage disposal system. In a properly functioning system, wastewater should not backflow from the leaching system into the septic tank at the time of pumping under normal use conditions (not as a result of large volume flood tests). Backflow indicates the leaching system is surcharged, and unless otherwise required by the local director of health, tank pump-out reports should report the backflow conditions and note the system was "malfunctioning" at the time of the septic tank pump-out. As with other malfunctioning system signs (wastewater overflowing outlet baffle, back-up into building sewer or riser, etc.), a recommendation should be made for a more in-depth assessment of system operation by a licensed installer or professional engineer unless condition is a result of a clogged effluent filter. Subsurface sewage disposal systems that discharge sewage onto the ground surface, into an open watercourse, or otherwise cause health hazards or nuisance conditions should be identified as "failing", and the local director of health shall investigate and take necessary action to abate the conditions.

Inlet and outlet baffles shall be inspected for damage or clogging at the time of the tank pump out. When provided, effluent filters shall be properly cleaned, at the time of each tank pump out, by washing the filter waste into the septic tank or, if rinse water is not available, exchanged with a clean effluent filter. All contaminated effluent filters shall be treated as sewage and handled properly during the cleaning and/or exchange process.

5. Septic Tank Markings

Tank information (size, date manufactured, name of manufacturer and indication of limit of external loads/cover depths required by Section 13 of ASTM C 1227) shall be located on the top of the tank between the outlet access hole and outlet wall, or on the vertical outlet wall between the top of the tank and the top of the outlet opening.

6. Performance Testing

When necessary due to installation concerns, testing for leakage will be performed using either a vacuum test or water-pressure test.

Vacuum Test: Seal the empty tank and apply a vacuum to 4 in. (50 mm) of mercury. The tank is approved if 90% of vacuum is held for 2 minutes.

Water-Pressure Test: Seal the tank, fill with water, and let stand for 24 hours. Refill the tank. The tank is approved if the water level is held for 1 hour.

B. Septic tank capacities

1. The minimum liquid capacity of septic tanks serving residential buildings shall be based on the number of bedrooms in the building. For three bedrooms or less, a 1000-gallon tank is required; and another 250-gallons shall be added for each additional bedroom above three.

2. The minimum liquid capacity of septic tanks serving non-residential buildings and residential institutions shall be equal to the 24-hour design flow (see Table No. 4). In no case shall a septic tank be installed with a liquid capacity of less than one thousand gallons. In cases of non-residential buildings that are subject to high peak sewage flows, the liquid capacity of the septic tank shall provide a minimum detention time of 2 hours under peak flow conditions. The required septic tank capacity shall be increased by a minimum of 50% at food service establishments and restaurants in instances of repairs of existing subsurface sewage disposal systems where it is determined that it is not feasible to install a grease interceptor tank or internal grease recovery unit.

3. Whenever more than 25 percent of the daily design flow from a building served will be pumped into the septic tank, the size of the tank shall be increased 50 percent beyond the minimum capacity required per Section V B.

4. The liquid capacity of a septic tank shall be increased whenever a residential building contains a garbage grinder or large capacity bathtub in accordance with the following:

Garbage grinder:
Add 250 gallons to required capacity of the septic tank. Note: Garbage grinders are not recommended for use with subsurface sewage disposal systems.

Large tub
100 to 200 gallon tub: Add 250 gallons to required capacity of the septic tank Over 200 gallon tub: Add 500 gallons to required capacity of the septic tank.

C. Grease interceptor tanks

Grease interceptor tanks shall be provided for restaurants and other Class 3 & 4 food service establishments with design flows of 500 gallons per day or greater for new construction and repairs of existing subsurface sewage disposal systems where feasible. If it is not feasible to install a grease interceptor tank on a food service/restaurant system repair, a mechanical automatic grease recovery unit (AGRU) is recommended to be retrofitted on the internal wastewater piping in the kitchen. If a grease interceptor tank or an internal AGRU is not included in a food service/restaurant septic system repair, then the required septic tank capacity shall be increased by a minimum of 50% (see Section V B).

Grease interceptor tanks shall receive wastewater from the kitchen waste lines only. Effluent discharged from the grease interceptor tank shall be directed to the inlet end of the septic tank. The capacity of grease interceptor tanks shall be a minimum of 1000 gallons and shall meet or surpass the 24-hour design flow. For restaurants and food service establishments with design flows of 2,000 gallons per day or greater, two grease interceptor tanks in series shall be provided. Such grease interceptor tanks shall have a combined liquid volume meeting or surpassing the 24-hour design flow. Grease interceptor tanks shall have inlet and outlet baffles that extend to a depth of six to twelve inches above the tank bottom (see Figure No. 6) and extend at least five inches above the liquid level. All manholes over grease interceptor tank cleanouts shall be watertight and extended to grade to facilitate cleaning. Grease interceptor tanks shall be provided with manhole covers that have been placarded with notification as to the danger of entering the tank due to noxious gases.

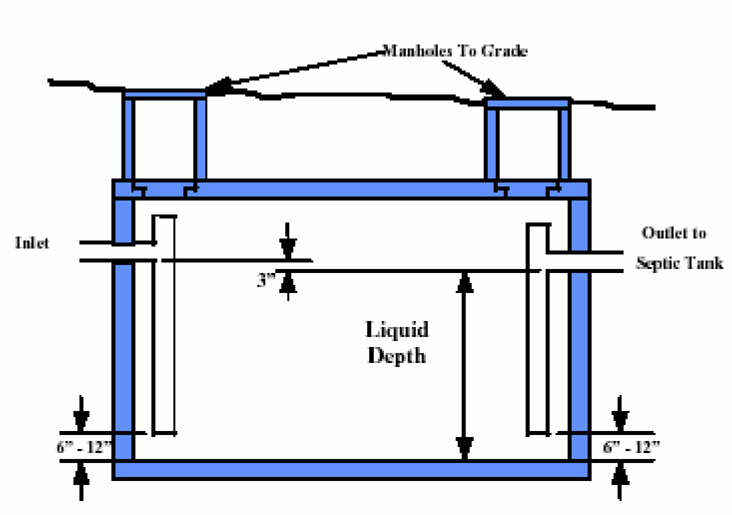


FIGURE 6 - GREASE INTERCEPTOR TANK

Grease interceptor tanks can be single or two compartment tanks and shall be constructed out of concrete or other durable material. Concrete grease interceptor tanks shall meet all structural and access requirements for concrete septic tanks. This includes applicable configuration (pipe seals, inlet/outlet differential, etc) and access (riser sizes, stepped covers, etc) requirements consistent with the requirements for concrete septic tanks. Concrete grease interceptor tanks shall be marked with tank information (size, name of manufacturer, date manufactured, loading limits), and be subject to other applicable septic tank provisions (performance testing, cleaning, tank abandonment, etc). Non-concrete grease interceptor tanks shall also meet all of the requirements for concrete grease interceptor tanks excluding the structural and marking requirements. Non-concrete grease interceptor tanks must be approved. Some manufactures of plastic (polyethylene) septic tanks do not authorize their tanks be used as grease interceptor tanks due to the high temperature of the wastewater. Non-concrete grease interceptor tanks shall be marked with the manufacturer's name and tank designation number.

VI. EFFLUENT DISTRIBUTION, PUMP SYSTEMS & AIR INJECTION PROCESSES

A. General

Septic tank effluent shall be distributed by gravity, pump, or siphon in a manner that promotes uniform distribution of effluent and full utilization of the leaching system. Leaching systems shall be designed to avoid effluent backflow into the septic tank. The outlet invert of the tank shall be set at a higher elevation than the top of all leaching structures (except in pump systems), or in the case of leaching systems utilizing serial distribution, higher than the high-level overflow elevation of the upper most leaching system row. Leaching systems designed for serial distribution shall be designed so that the high-level overflow invert elevations are within the top 3 inches (0.25 feet) of the leaching structure (trench, gallery, etc.). It is recommended that subsurface sewage disposal systems be designed to allow for gas and air transfer from the leaching system back through the septic tank and building vents. Fully flooded distribution boxes should be avoided, and it is recommended that distribution piping/boxes be designed so that there is an air space in all pipes during normal leaching system operation.

Leaching systems shall be provided with access points consisting of distribution boxes, cleanouts (galleries, pits), or capped sanitary tees extended to grade. At least one access point shall be provided for each leaching system row. A single distribution box feeding row segments at the same elevation on either side of the distribution box shall constitute access points for both row segments. Leaching systems with rows at the same elevation (level systems) shall have ends connected wherever feasible (see Figure No. 7). Non-level leaching systems may apply effluent by dosing (pump, siphon), serial distribution with high-level overflow (see Figures No. 8, 9 and 10), or by approved effluent splitting devices (i.e., Polylok Dipper D-Box or Equalizer pipe inserts, Zoeller Tru Flow D-box).

B. Mandatory Dosing

Large subsurface sewage disposal systems (2000 GPD or greater) with more than 600 linear feet of leaching system shall utilize intermittent dosing arrangements. Dosing can be accomplished by pump, siphon, or other approved methods such as the Rissy Plastics' Floating Outlet Distribution Chamber (FLOUT). Dosing systems shall be designed to dose the leaching system at a frequency of three to six cycles per day unless timed dosing is utilized. Dosing chambers shall have access manholes to grade. Large subsurface sewage disposal systems utilizing pump systems shall be designed with duplicate alternating pumps. Alternating pump and siphon systems shall be designed to provide full leaching system utilization in the event one pump or siphon fails to operate.

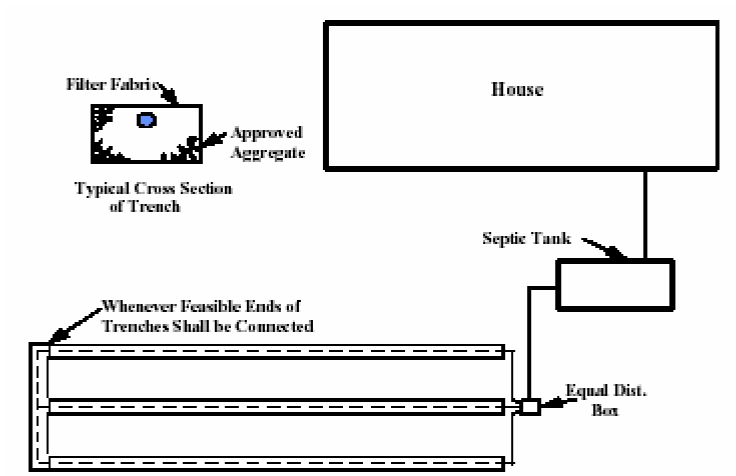


FIGURE 7 - LEVEL LEACHING SYSTEMS

Note: The high level overflow invert elevation must be set in the upper 3 inches of the leaching system row feeding the lower elevation leaching system row. Use of reversed distribution boxes are not recommended in order to insure gas transfer.

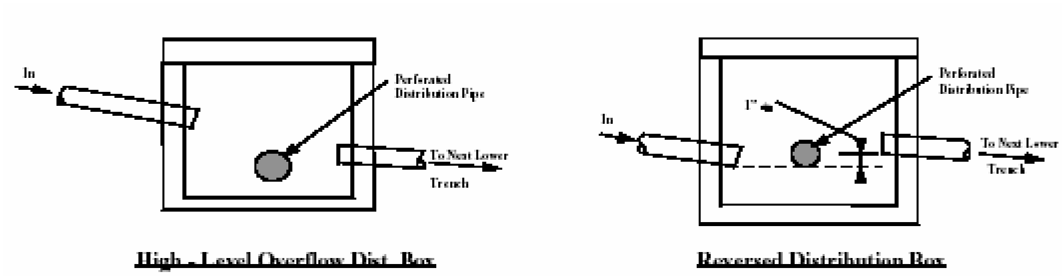


FIGURE 8 - SERIAL DISTRIBUTION BOXES

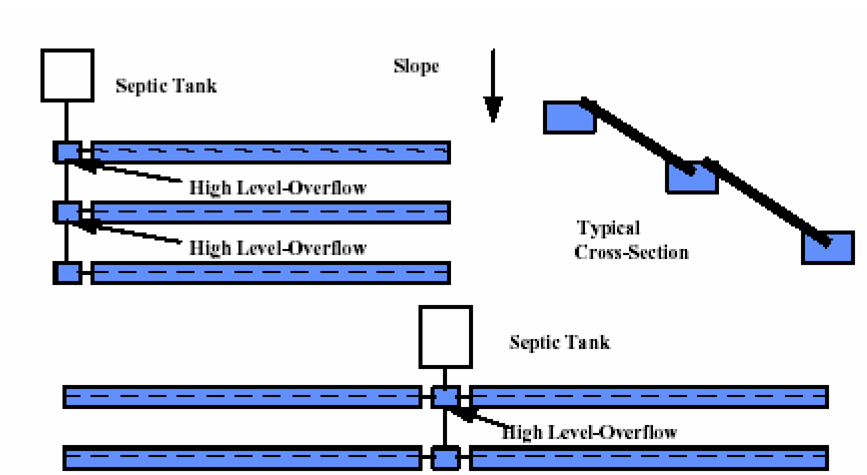


FIGURE 9 - SERIAL DISTRIBUTION SYSTEM

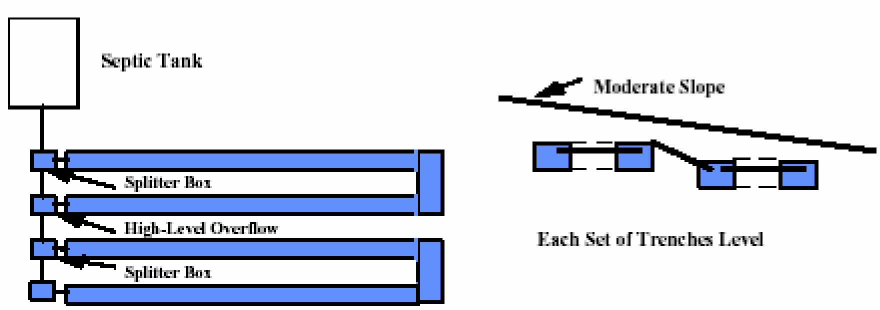


FIGURE 10 - ALTERNATIVE DISTRIBUTION SYSTEMS

C. Pump Systems

Effluent pump chambers shall be provided with watertight risers/manholes to grade and high-level alarms. Effluent pumps must be approved by the manufacturer for use in sewage disposal systems. Freeze protection must be provided for all force mains. This can be accomplished by deep burial (below frost line), back drainage into the pump chamber through a weep hole in the force main, or other method to prevent freezing. Back siphonage from the leaching system and/or excessive pump cycling must be avoided when a weep hole is provided. Pump chambers in high groundwater areas shall be tested for leakage to insure water tightness.

Pump systems less than 2000 GPD shall provide duplicate alternating pumps or a single pump with emergency storage volume (above the alarm float level) in the pump chamber equal to at least the daily design volume shall be provided. All electrical work on the pump system requires a separate permit from the local building official.

Specifications shall be provided for all the internal components of the pump chamber. This includes the pump(s), piping, floats, alarms, disconnect chain, valves, etc. On/off and alarm float levels must be specified along with the approximate dose volume and emergency storage provided. It is noted that the Department of Environmental Protection has banned the sale of mercury float switches; mechanical float switches are acceptable. The pump must be rated to handle the design flow rate at the total dynamic head for the installation. A check valve must be provided on the pump discharge line unless the pump manufacturer does not require one. Piping unions, lift chain and manhole location must allow for convenient pump removal for routine maintenance. Internal pump chamber appurtenances must be non-corrosive and suitable for the corrosive effluent environment.

Pump chambers must be made out of concrete or other durable material. Non-concrete pump chambers must be approved. Pump chambers, including the riser and cover assemblies, located under vehicular travel areas shall be rated for H-20 wheel loadings. Non-concrete pump chambers must be installed in accordance with the manufacturer's instructions. See Section V A 1 b for further restrictions/requirements for the installation of non-concrete tanks. Concrete pump chambers shall meet all structural requirements for concrete septic tanks. Concrete pump chambers shall be marked with tank marking information (size, name of manufacturer, date manufactured, loading limits) and be subject to other applicable septic tank provisions (performance testing, tank abandonment, etc.).

Combination septic tank/effluent pump systems may be utilized in instances where space constraints or other site limitations make it advantageous to install a single tank/pump unit. Combined septic tank/effluent pump systems must utilize an approved screened pump vault installed in the second compartment of an oversized two-compartment septic tank. Emergency storage must be provided for single pump systems. Draw down only in the second compartment is recommended. Use of mid-liquid depth tee baffles with a compartment connection pipe at the liquid level can be used to draw down effluent in second compartment only. Required septic tank capacity must be provided below the "pump-off" level.

Low-pressure distribution systems require a professional engineer design. The design must include access and flushing provisions for the purpose of routine maintenance and checking pressure in the lines. Provisions must also be provided for flow adjustment to the distribution lines. The design must also include pressure filters, orifice shields, manifold access and pipe information (size, specifications, hole diameter/spacing) as well as pump information. The design engineer must also specify operation and maintenance requirements (i.e., flushing of the lines, checking pressure heads).

Raw sewage pumps are not recommended for use with subsurface sewage disposal systems. Where pumping is required, and the installation of a separate effluent pump chamber is not possible, combination septic tank/effluent pump systems should be utilized. In the event raw sewage pumps are necessary, solids handling (ejector) pumps are recommended over grinder pumps. If raw sewage pumps are necessary for basement fixtures, upper level flows should be directed to the septic tank by gravity where feasible. In the event more than 25% of the daily design flow will be pumped into the septic tank, the required septic tank capacity shall be increased per Section V B 3. Raw sewage pumps outside the building served are considered part of the subsurface sewage disposal system; therefore, they must be installed in compliance with the separation distance requirements in Table No. 1. Raw sewage pumps/vaults below basement slab elevation are considered outside the building unless they are installed in a sealed pit or otherwise designed to contain potential leakage in the basement. Exterior raw sewage pump systems shall be provided with an access to grade and a system malfunction alarm.

D. Leaching System Enhancement/Rejuvenation

The patented Soil Air System provided by Geomatrix, LLC may be utilized on new leaching systems, or on existing systems that are not at risk of hydraulically overloading the naturally occurring soil and provide the required minimum separation distance above ledge rock and maximum groundwater. Utilization of the Soil Air System requires a permit from the local director of health. Site investigations will be necessary to gather soil test information if the data is not readily available.

Existing sewage disposal systems that are determined to be candidates for the Soil Air System must be evaluated to determine the extent of current code compliance. A repair plan must be prepared identifying the location of the existing system and, if feasible, a code-complying area. Sites that cannot support a code-complying area shall have a potential repair area identified. Large system sites (2,000-5,000 GPD) must have engineered plans prepared and approved. The local director of health can require engineered plans in areas of special concern on sites less than 2000 gallons per day per code provisions.

The Soil Air System shall not be utilized on cesspools, or on excessively undersized leaching systems, unless it is determined that it is not feasible to expand the leaching system. Leaching systems are considered to be excessively undersized if they provide less than 50 percent of the required effective leaching area. The local director of health may require further upgrades to existing sewage disposal systems in conjunction with implementation of the Soil Air System. Upgrades may include leaching system expansion or the installation of additional tanks (septic, grease interceptor).

Soil Air Systems must be periodically evaluated and monitored to verify satisfactory system operation. The permit to discharge must stipulate that the local director of health be notified in writing in the event the Soil Air System is no longer in use on a site. A standard tee baffle can only be utilized in place of an effluent filter on the septic tank outlet if Geomatrix, LLC and the system designer are in agreement that it is advantageous to do so. The effluent filter must be re-installed in the event the Soil Air System is removed.

E. Leaching System Clogging Break-up

The patented Terra-lift process may be utilized on existing sewage disposal systems that provide the required minimum separation distance above ledge rock and maximum groundwater, and that have historically operated satisfactorily but have experienced declining capacity due to infiltrative surface clogging. Utilization of the Terra-lift process requires a permit from the local director of health. Site investigations will be necessary to gather soil test information if the data is not readily available.

Existing sewage disposal systems that are determined to be candidates for the Terra-lift process must be evaluated to determine the extent of current code compliance. A repair plan must be prepared identifying the location of the existing system and, if feasible, a code-complying area. Sites that cannot support a code-complying area shall have a potential repair area identified. Large system sites (2,000-5,000 GPD) must have engineered plans prepared and approved. The local director of health can require engineered plans in areas of special concern on sites less than 2000 gallons per day per code provisions.

The Terra-lift process shall not be utilized on cesspools, or on excessively undersized leaching systems, unless it is determined that it is not feasible to expand the leaching system. Leaching systems are considered to be excessively undersized if they provide less than 50 percent of the required effective leaching area. The local director of health may require further upgrade of existing sewage disposal systems in conjunction with implementation of the Terra-lift process. Upgrades may include leaching system expansion or the installation of additional tanks (septic, grease interceptor).

VII. PERCOLATION TESTS

A percolation test consists of three steps: 1) presoaking the percolation hole, 2) refilling and allowing the hole to saturate under certain conditions, and 3) determining the minimum uniform percolation rate after saturation.

The purpose of the presoak is to allow sufficient soil-water contact time. During presoaking, swelling clays that may be present in the soil will expand thereby reducing the void space in the soil. Sufficient presoaking will also allow the advancing capillary wetting front, which controls the rate of water flow in unsaturated soils, to move sufficiently far away from the test hole so that an apparent equilibrium flow rate is reached.

The required presoaking time will vary depending on the soil and its moisture content. Presoaking shall be started by filling the percolation hole with 12 inches of water. If the water seeps away in less than 2 hours, the hole may be refilled to the 12-inch depth and the percolation test begun. If any water remains in the hole after 2 hours, it normally shall be refilled to the 12-inch depth and allowed to presoak for at least 2 additional hours before the percolation test is begun. However, such extended presoaking shall not be required where it is determined that the soil contains no significant amount of swelling clays. Any test hole that has continuously contained water for 4 hours or longer shall be considered adequately presoaked. Once clay particles have become swollen, they will remain so for a period of time. Therefore, it is not necessary to perform the percolation test immediately, although tests performed at the end of the presoaking period yield the most accurate results. If tests cannot be performed immediately, test holes may be presoaked in the morning and tested in the afternoon, or presoaked on one day and tested the following day. If more than 30 hours have elapsed following initial presoaking, the test hole shall be presoaked once again.

Following presoaking, the hole shall be refilled and allowed to percolate for 30 to 60 minutes, unless the hole goes dry, in order to fill the voids in the soil surrounding the test hole with water. Presoaking does not eliminate this requirement since the large voids surrounding the test hole will drain rapidly when the test hole goes dry. There is an initial rapid drop of the water level in the test hole as the water enters the voids in the soil. The rate of drop will diminish rapidly until after 30 to 60 minutes an apparent equilibrium rate will be attained. Only this minimum uniform rate following saturation shall be used in calculating the size of the leaching system. Readings taken prior to 30 to 60 minutes after refilling normally shall not be used in calculating the percolation rate. However, if after presoaking the refilled hole goes dry before 30 minutes, the readings that have been taken may be used without a second refilling.

Percolation tests shall be made in a 6 to 12 inch diameter hole dug to the depth of the proposed leaching system. At locations where there appears to be 2 or more soil strata of different texture or structure, each strata shall be tested separately with holes of comparable depths. In calculating the required leaching area (primary and reserve), only representative test results in the area and at the depth of the proposed leaching system shall be used, but all percolation tests and observation pits which were made on the site shall be reported.

Whenever a leaching system is installed entirely in select fill, the size of the system shall be based on the slower percolation rate of the natural soil or select fill except in cases where the underlying naturally occurring soil has a percolation rate slower than 20 minutes per inch. In such an instance, the leaching system can be sized based on a 10.1 – 20.0 minute per inch rate, as long as the select fill has a percolation rate of faster than 20 minutes per inch. MLSS shall be based on the percolation rate of the natural soil.

VIII. LEACHING SYSTEMS

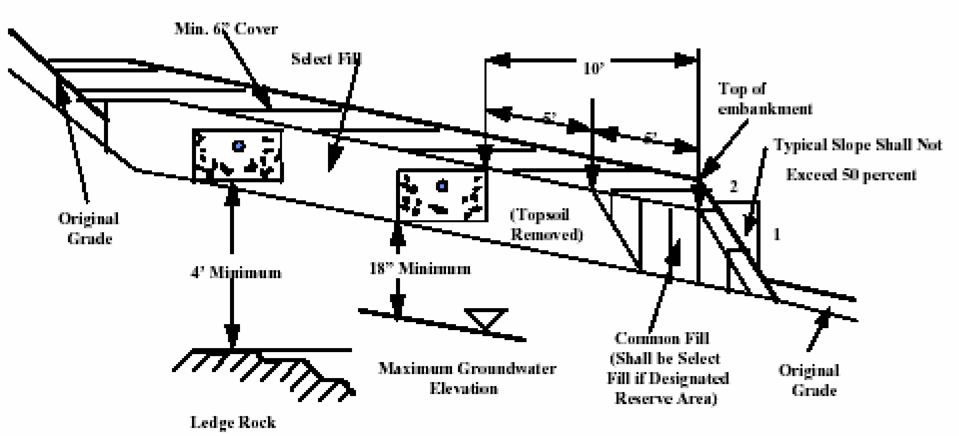
A. General

No leaching system shall be constructed in areas where high groundwater, surface flooding or ledge rock will interfere with its effective operation. Leaching systems should be installed as shallow as possible and preferably not under parking or vehicular travel areas. The maximum depth of the bottom of a leaching system below finished grade shall be eight (8) feet. The maximum width of leaching products (i.e., trenches, galleries, proprietary systems) except for leaching pits is 6.5 feet. Entering deep test pits above the waist can result in bodily harm or death in the event of cave in. Use of shallow shelves is recommended to allow for assessment of the soil in the upper profile of the pit. Refer to OSHA standards for pit safety measures and restrictions. Site investigation documentation shall be recorded on Form #2 or Form #2 Alternate. The bottom of any leaching system shall be at least eighteen (18) inches above the maximum groundwater level and at least four (4) feet above ledge rock. Additional separation must be provided if the natural soil has a percolation rate faster than one minute per inch and for large sewage disposal systems. Whenever the design percolation rate is faster than one minute per inch the minimum separation to maximum groundwater must be increased to twenty-four (24) inches, and the minimum separation above ledge rock shall be increased to eight (8) feet or the distances shall be doubled from any well in accordance with Section II, Table No. 1, Item A, Special Provisions. For large (2,000 GPD or greater) subsurface sewage disposal systems the minimum separation above maximum groundwater shall be increased to twenty-four (24) inches unless the design engineer conducts a mounding analysis that demonstrates the mounded maximum groundwater table is at least eighteen (18) inches below the bottom of the leaching system.

The applicant shall submit calculations to demonstrate compliance with the Minimum Leaching System Spread (MLSS) criteria using the procedure outlined in Appendix A of the Technical Standards. No subsurface sewage disposal system shall be denied based solely upon non-compliance with MLSS but may be denied if the applicant is unable to demonstrate compliance with PHC Section 19-13-B103e (a)(4). Local health departments should advise against the creation of new lots that have unsuitable soil conditions pursuant to PHC Section 19-13-B 103e (a) in the primary or reserve leaching system area. Unsuitable soil conditions include areas with less than eighteen (18) inches of soil above maximum groundwater, and areas with less than four (4) feet of soil above ledge rock. In the context of determining leaching area suitability where soil conditions require placement of select fill, the entire fill package shall be considered part of the leaching system area. The leaching system area shall include soil within 10 feet in all directions from the side edge of the leaching structure (trench, gallery, etc.). Note: Down-gradient receiving soil must be taken into consideration for the purposes of minimum leaching system spread (MLSS) criteria (See Appendix A).

New subsurface sewage disposal systems constructed in areas where there is no definite schedule for the extension of public sewers within five years shall be laid out in such a manner to provide an acceptable reserve leaching area of suitable soil; or in the case of existing single-family residential building lots created prior to January 1, 2007, potentially suitable soil. An area with potentially suitable soil contains less than four feet of existing soil above ledge rock but at least two feet of which is naturally occurring soil. The reserve area shall be sized based on its representative percolation rate and have the feasibility to be constructed in conformance with all aspects of mostCode and Technical Standards for the purpose of enlargement or replacement of the primary leaching system. No reserve area shall be required for repairs, alterations or extensions of existing leaching systems. No single-family residential building lot shall be required to fill a reserve area at the time of installation of the primary system. Reserve areas for multifamily dwellings and commercial buildings do not have to be prepared with necessary select fill unless the designated reserve area is located under asphalt pavement or poured concrete (parking or vehicular travel areas).

The ground surface over the entire subsurface sewage disposal system shall be graded and maintained to lead surface water away from the area. All subsurface sewage disposal systems shall be protected from siltation and erosion during and after construction. Leaching systems shall be covered with a minimum of six inches of soil and finished in a condition that will prevent erosion over and adjacent to the leaching system. Proprietary leaching systems shall be covered with additional soil in conformance with the manufacturer’s installation specifications. The licensed installer shall properly cover the leaching system within two (2) working days following the local health department's final inspection and approval.



MINIMUM SEPARATING DISTANCES ABOVE LEDGE ROCK AND GROUNDWATER

No cast iron or ductile iron piping shall be allowed following the septic tank or grease interceptor tank due to corrosive factors. Use of 3" diameter PVC, meeting ASTM D 2729 or 4" diameter PVC, meeting ASTM D 3034, SDR 35 or equal, is required for all solid effluent distribution piping. Approved effluent distribution pipes are listed in Table No. 5.

The length of individual leaching trenches, gallery or proprietary leaching system row segments shall not exceed 75 feet measured from the inlet, except that in installations where intermittent dosing exceeding 25 gallons/cycle is used, a maximum length of 100 feet may be utilized.

A layer of non-woven filter fabric shall be placed over all approved aggregate used in leaching system construction before backfilling. Minimum average roll values for fabric used for covering stone aggregate shall have a unit weight of 1.5 oz./yd^2 (per ASTM D 5261), a permittivity of 1.0 sec-^{1} (per ASTM D 4491) and a trapezoid tear strength of 15 lbs. (per ASTM D 4533). Minimum average roll values for fabric used for covering two (2) inch nominal tire chip aggregate shall have a unit weight of 3.0 oz./yd^2 (per ASTM D 5261), a permittivity of 1.0 sec-^{1} (per ASTM D 4491) and trapezoid tear strength of 35 lbs. (per ASTM D 4533). All non-woven filter fabric used for proprietary leaching systems and for covering approved aggregate shall bear the appropriate manufacturer's label specifying the product's name and identification number. Labeling shall be affixed in such a manner to be readily visible to facilitate inspection.

Whenever two different types of leaching products are utilized side-by-side, the average of the required minimum center to center spacing shall be maintained. The specified center to center spacing is also applicable for the primary system relative to the reserve system. All leaching products with effective leaching credits of 7.4 SF/LF and higher shall not be utilized where the underlying naturally occurring soil has a percolation rate slower than 30 minutes per inch.

Select fill placed within and adjacent to leaching system areas shall be comprised of clean sand, or sand and gravel, free from organic matter and foreign substances. The select fill shall meet the following requirements unless otherwise approved by the design engineer. Select fill exceeding 6% passing the #200 sieve based on a wet sieve test cannot be approved by the design engineer.

1. The select fill shall not contain any material larger than the three (3) inch sieve.
2. Up to 45% of the dry weight of the representative sample may be retained on the #4 sieve. Note: This is the gravel portion of the sample.
3. The material that passes the #4 sieve is then reweighed and the sieve analysis started.
4. The remaining sample shall meet the following gradation criteria:

SIEVE SIZE	PERCENT PASSING	
	WET SIEVE	DRY SIEVE

#4	100	100
#10	70 - 100	70 - 100
#40	10 - 50 *	10 - 75
#100	0 - 20	0 - 5
#200	0 - 5	0 - 2.5

* Percent passing the #40 sieve can be increased to no greater than 75% if the percent passing the #100 sieve does not exceed 10% and the #200 sieve does not exceed 5%.

Select fill that does not meet the dry sieve gradation criteria but meets the wet sieve gradation criteria is acceptable. Sieve testing of select fill is required for large (2,000 GPD or greater) systems whenever the leaching system is located totally in select fill. The local director of health may require sieve testing of select fill on less than 2,000 GPD sewage systems.

The licensed installer is responsible for preparing the leaching area with necessary select fill. The topsoil in the leaching system area must be removed and the subsoil scarified prior to select fill placement unless otherwise directed by the design engineer. The installer shall take the necessary steps to protect the underlying naturally occurring soil from over compaction or damage. The installer is responsible for properly compacting select fill to facilitate construction and to prevent settling. Select fill shall extend a minimum of five (5) feet laterally in all directions beyond the outer perimeter of the leaching system.

Rock used to produce manufactured fill must have a loss of abrasion of not more than 50 % using AASHTO Method T-96, and when tested for soundness using AASHTO Method T 104 not have a loss of more than 15% at the end of 5 cycles. Suppliers of manufactured fill must make application for approval. Documentation must be submitted on the quarry operation and production process. Fill specifications (gradation, permeability, etc) and a narrative of the quality control/quality assurance program must also be included for all active quarries. The manufactured fill producers must provide annual product registrations.

Individuals distributing two (2) inch nominal tire chip aggregate for leaching system construction must receive approval to do so from the Department of Environmental (DEP). Such individuals must arrange for annual testing by a Professional Engineer licensed to confirm compliance with the specifications noted in the definition of such material. Two inch nominal tire chip aggregate shall not be utilized in leaching systems under vehicular travel areas. Two inch nominal tire chip aggregate shall not be utilized as a substitute for stone aggregate unless authorized by the plan designer, and shall not be utilized for backfill with proprietary leaching systems unless so authorized by the leaching system product manufacturer.

Leaching systems utilizing two inch nominal tire chip aggregate shall be covered with heavy duty filter fabric (specifications on previous page; Cultec 410 or equal). DEP's General Permit for distribution of two inch nominal tire chip aggregate includes specific requirements related to record keeping, management of excess tire chips and system abandonment, which are included in Appendix A of the DEP General Permit. Installers utilizing tire chips must be provided with a bill of lading and a copy of Appendix A from the DEP General Permit. The local director of health must be provided a copy of the bill of lading prior to issuance of the permit to discharge. As stipulated in the appendix, on-site abandonment by burial of leaching systems containing tire chips can only be performed if approved by the local director of health, and a minimum 18-inch separation distance is provided above maximum groundwater. Two inch nominal tire chips cannot be used for groundwater drainage structures.

B. Leaching trenches (See Figure 11)

All leaching trenches shall follow ground contours. Trench widths shall be 18, 24, 30, 36, or 48 inches. No trench shall exceed 48 inches in width. The trenches shall contain a depth of at least twelve inches of approved aggregate. A distribution pipe shall be laid the entire length of the trench near the top layer of aggregate. Distribution pipes shall be of acceptable material (see Table 5) with suitable perforations or open joints laid in a downward direction. Distribution pipes shall be laid level or on a grade not exceeding two to four inches per one hundred feet. The distribution pipes shall be covered with at least two inches of approved aggregate, and there shall be at least six inches (for 48" wide trenches) or twelve inches (for 36" or less wide trenches) of this material under the distribution pipe.

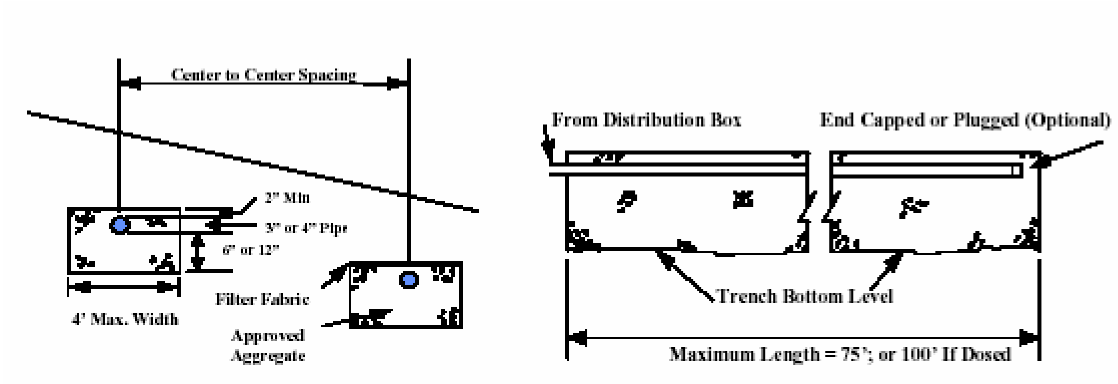


FIGURE 11 - LEACHING TRENCHES

For the purposes of Section VIII F & G, the effective leaching area of leaching trenches and corresponding minimum center to center spacing between trenches shall be as follows:

Trench Depth (inches)	Trench Width (inches)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
18	18	2.1	7
18	24	2.4	7
18	30	2.7	7
18	36	3.0	7
12	48	3.0	8

TABLE NO. 5 - DISTRIBUTION PIPE

USE	PIPE DESCRIPTION	TYPE OF JOINT	REMARKS
Solid and perforated effluent distribution pipe used after the septic tank for leaching system (Also see Table 2D for sewage force main)	PVC ASTM D 3034, SDR 35 PVC ASTM F 789, PS-46 PVC ASTM F 891, PS-50 PVC ASTM F1760 SDR35	Rubber compression gasket, or bell and spigot with no gasket	Heavy duty plastic pipe for shallow pipe installation
	PVC ASTM D 2729 - only 3" diameter pipe (see remarks for use of 4" pipe)	Bell and spigot, no gaskets	4" diameter pipes can be used but must be bedded in 6" min. of approved aggregate and covered with 2" min. of aggregate or with other special bedding requirements to protect against crushing
	PE ASTM F 810, SDR 38 PE ASTM D 3350 - only 3" diameter pipe (see remarks for use of 4" pipe)	Bell and spigot, no gaskets	
	PE corrugated rigid pipe: ASTM 1248 (coil pipe not acceptable) - only 3" diameter pipe (see remarks for use of 4" pipe)	Sleeve joints	4" diameter corrugated smooth interior wall polyethylene leaching pipe meeting ASTM D 3350 and performance specification ASTM F 405 may be used without bedding
	PE ADS N-12, ASTM F 667, AASHTO M-294	Snap on sleeve joint	Gasket couplings for watertight installation are available

C. Leaching pits (See Figure No. 12)

Leaching pits shall be hollow structures with perforated or open-joint walls and tight covers. The side walls shall be surrounded by at least twelve inches, but not more than twenty-four inches, of approved aggregate and the hollow structure shall be no less than five feet in diameter nor greater than ten feet in diameter. Pit covers shall be equipped with a cleanout manhole. Center to center spacing of leaching pits shall be at least four times the diameter of the hollow structure. No more than two leaching pits shall be connected in series. Leaching pits shall not be used where groundwater may interfere with their operation or where soil of better leaching quality is found at shallow depth. The bottom of leaching pits shall not be more than eight feet below finished grade. Leaching pits shall not be used where the percolation rate is slower than twenty minutes per inch.

For the purposes of Section VIII F & G, the effective leaching area of leaching pits shall consist of only the side area of the usable aggregate-filled excavation. The maximum utilization of a leaching pit cannot be higher than the septic tank outlet elevation or the high-level overflow elevation of the serial distribution box.

Effective Area = Excavation Diameter X π X Pit Depth
(Note: π equals approximately 3.14)

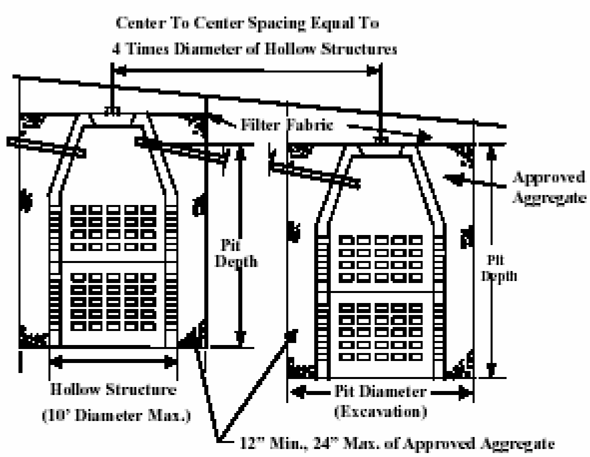


FIGURE 12 - LEACHING PITS

D. Leaching galleries (See Figures No. 13)

Leaching gallery rows shall follow ground contours. Leaching galleries shall be hollow structures with perforated or open joint sides and tight covers. Leaching galleries must provide a minimum 40 inches of open bottom width. The sidewalls shall have a minimum depth of twelve inches and a maximum depth of four feet, including up to six inches of approved aggregate above the top of the structure. Twelve inches of approved aggregate shall be placed on the sides of the galleries and on the ends of the gallery rows. The width of the rench excavation shall not be less than six feet and the width of the hollow structure(s) shall be not less than four feet. The bottom of each leaching gallery row shall be level.

For the purposes of Section VIII F & G, the effective leaching area of gallery rows and corresponding minimum center to center spacing between rows shall be as follows:

Gallery Height (inches)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
48	9.2	12
36	8.0	12
30	7.4	12
27	7.1	12
24	6.8	12
18	6.2	12
12	5.9	12

Multiple plastic units (twin, in the case of Infiltrator Sidewinders or PSA BioDiffusers; or four unit configuration, as in the case of Contactor Field Drain C-4), or single large plastic chambers (Infiltrator ISI 3050 or Cultec Recharger 330), are approved in a gallery configuration (See Figure 13). Total length of excavated row shall be utilized to calculate effective area. L-shaped, U-shaped, or box gallery row extensions shall not be credited unless the restrictive layer as defined by MLSS is greater than 60 inches, or the underlying groundwater gradient is less than 1%. A 0.3 SF/LF reduction will be assessed to all gallery rows when the gallery units are placed on a bed of approved aggregate.

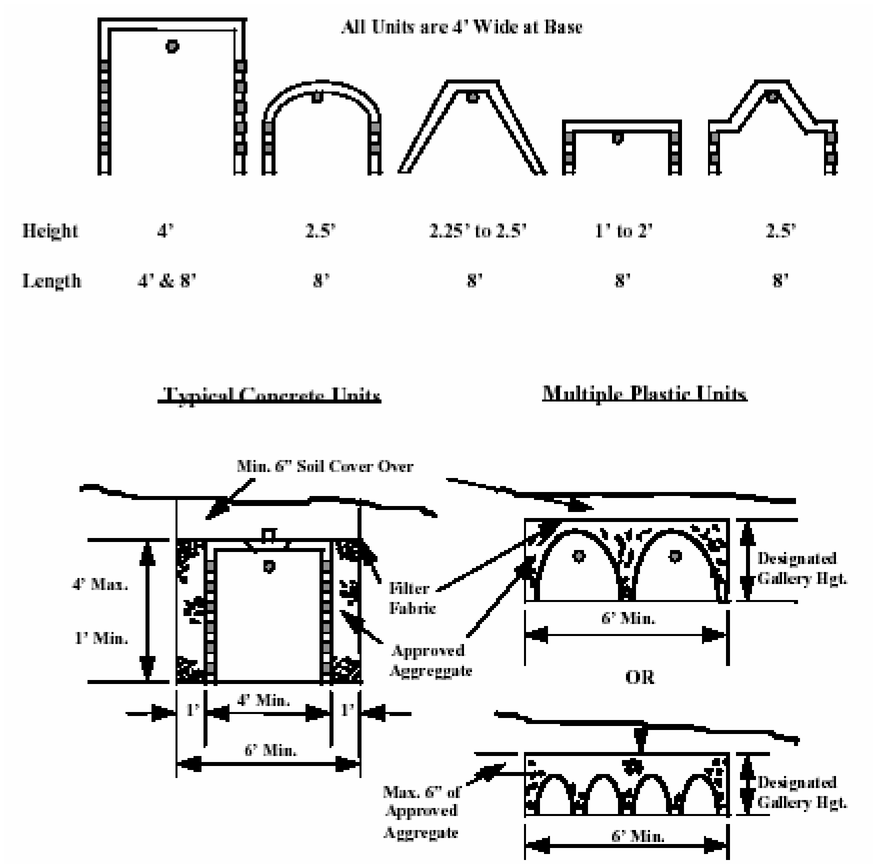


FIGURE 13 - TYPICAL LEACHING GALLERY STRUCTURES

E. Proprietary Leaching Systems

Proprietary leaching system rows shall be installed level and follow ground contours. The units must be backfilled with select fill unless otherwise noted. Several proprietary leaching products require use of

ASTM C 33 sand which includes gradation specifications for the 3/8 inch sieve (100% passing) through the #200 sieve (3% passing maximum) based on a wet sieve, or use of a washed sand meeting Department of Transportation Form 816 Specification M.03.01 for fine aggregate which has a similar gradation as ASTM C 33 sand. It should be noted that the ASTM C 33 specification and the DOT fine aggregate specifications are more stringent than the select fill specification relative to the allowable percentage of fines, and they do not allow larger gravel material to be included.

Two (2) inch nominal tire chip aggregate shall not be utilized for backfill with proprietary leaching systems unless so authorized by the leaching system product manufacturer.

Installation procedures, including the minimum depth of cover, shall be per manufacturer's specifications. **1.**

Plastic Leaching Chambers

a) Plastic Leaching Chambers Backfilled with Select Fill or Approved Aggregate

For the purpose of Section VIII F & G, the effective leaching area of the approved products listed below and corresponding minimum center to center spacing shall be as follows:

Product Name	Dimensions (W x H)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
PSA - BioDiffuser (11)	34" x 11"	3.6	7
PSA - BioDiffuser (14)	34" x 13.5"	3.7	7
PSA - BioDiffuser (High Capacity)	34" x 16"	3.6	7
PSA - BioDiffuser ARC 36	34.5" x 13"	3.6	7
PSA - BioDiffuser ARC 36HC	34.5" x 16"	3.9	7
Hancor - EnviroChamber Pro (Stand.)	34" x 11"	3.6	7
Hancor - EnviroChamber Pro (Arc 36)	34.5" x 13"	3.6	7
Hancor - EnviroChamber Pro (Arc 36 High Capacity)	34.5" x 16"	3.9	7
Infiltrator - Equalizer 24	15" x 11"	2.3	7
Infiltrator - Equalizer 36	22" x 13.5"	2.7	7
Infiltrator - Sidewinder (Stand.)	34" x 12"	3.7	7
Infiltrator - Sidewinder (High Cap.)	34" x 16"	3.9	7

The above units must be backfilled with select fill or approved aggregate to receive full credit. A 0.4 SF/LF credit reduction will be assessed if the chambers are backfilled with soil not meeting select fill gradation requirements.

b) Plastic Leaching Chambers Backfilled with Approved Aggregate

Cultec chamber products and the Infiltrator Quick 4 chamber product line are approved for use in Section VIII E 6 as approved filter fabric covered/lined products backfilled with select fill. They can also be used without being lined/covered by filter fabric in which case the chambers must be backfilled with approved aggregate. They cannot be backfilled with select fill without filter fabric covering/lining the chambers. For the purpose of Section VIII F & G, the effective leaching area of the approved products listed below and corresponding minimum center to center spacing shall be as follows:

Product Name	Dimensions (W x H)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
Cultec - Contactor EZ-24	16" x 12"	1.9	7
Cultec - Contactor EZ-24 (PDS)	16" x 12"	2.5	7
Cultec - Contactor 75	26.5" x 12.4"	2.6	7
Cultec - Contactor 100	36" x 12.5"	3.7	7
Cultec - Contactor 100 (PDS)	36" x 12.5"	4.3	7
Cultec - Contactor 125	26.5" x 18"	2.9	7
Cultec - Recharger 180	36" x 20.5"	4.4	7
Cultec - Recharger 180 (PDS)	36" x 20.5"	5.1	9
Cultec - Recharger 280	46" x 26.5 "	6.5	10
Cultec - Recharger 280 (PDS)	46" x 26.5 "	7.1	10
Cultec - Recharger 330	52" x 30"	5.6	11
Infiltrator Quick 4 Equalizer 24	16" x 11"	2.0	7
Infiltrator Quick 4 Equalizer 36	22" x 12"	2.6	7
Infiltrator Quick 4 Standard	34" x 12"	3.6	7
Infiltrator Quick 4 High Capacity	34" x 16"	4.1	7

2. **Eljen In-drains**

Eljen In-drain units must be bedded on the bottom and sides with sand fill meeting both the manufacturer's specifications and select fill specifications. For the purpose of Section VIII F & G, the effective leaching area of the approved products listed below and corresponding minimum center to center spacing shall be as follows:

Product Name	Dimensions (W x H)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
Eljen In-drain - Type "B" Unit	36" x 7"	4.7	7
Mantis 424-9, Internal Distribution Pipe	24" x 12"	5.2	9
Mantis 424-9, Top Distribution Pipe	24" x 12"	8.6	9
Mantis 430-10, Internal Distribution Pipe	30" x 12"	6.5	9
Mantis 430-10, Top Distribution Pipe	30" x 12"	11.0	12

3. **RUCK A Fins**

Ruck A Fins units must be bedded on the bottom and sides with sand fill meeting both the manufacturer's specifications and select fill specifications. For the purpose of Section VIII F & G, the effective leaching area of the approved products listed below and corresponding minimum center to center spacing shall be as follows:

Product Name	Dimensions (W x H)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
Ruck A Fins - R1032C	32" x 7"	7.0	9

4. FORM CELL Living Filter

Living Filter units must be bedded on the bottom and sides with sand fill meeting both the manufacturer's specifications and select fill specifications. For the purpose of Section VIII F & G, the effective leaching area of the approved products listed below and corresponding minimum center to center spacing shall be as follows:

Product Name	Dimensions (W x H)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
Living Filter- LF1210	29" x 18"	3.9	7
Living Filter- LF1810	29" x 24"	5.5	9
Living Filter- LF2410	29" x 30"	7.0	9
Living Filter- LF3010	29" x 36"	8.6	9
Living Filter- LF3610	29" x 42"	10.1	12
Living Filter- LF1224	60" x 18"	7.4	11
Living Filter- LF1 826	64" x 24"	11.0	12
Living Filter- LF2426	64" x 30"	14.2	14
Living Filter- LF3026	64" x 36"	17.3	14
Living Filter- LF3626	64" x 42"	20.4	14

5. GreenLeach Filter

GreenLeach Filter units must be bedded on the bottom and sides with sand fill meeting both the manufacturer's specifications and select fill specifications. For the purpose of Section VIII F & G, the effective leaching area of the approved products listed below and corresponding minimum center to center spacing shall be as follows:

Product Name	Dimensions (W x H)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
GLF 12.62	62" x 12"	7.9	12
GLF 15.62	62" x 15"	9.4	12
GLF 18.62	62" x 18"	11.0	14
GLF 21.62	62" x 21"	12.5	14
GLF 24.62	62" x 24"	14.0	14
GLF 27.62	62" x 27"	15.5	14
GLF 30.62	62" x 30"	17.0	14
GLF 33.62	62" x 33"	18.5	14
GLF 36.62	62" x 36"	20.0	14

6. Corrugated Leaching Systems Lined/Covered with Filter Fabric

Units must be lined/covered with filter fabric and backfilled with select fill. For the purpose of Section VIII F & G, the effective leaching area of the approved products listed below and corresponding minimum center to center spacing shall be as follows:

Product Name	Dimensions (Diameter / W x H)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
GEO-FLOW	12" Diam	2.3	7
Presby Env. - ENVIRO-SEPTIC	12" Diam	2.3	7
Presby Env. - SIMPLE-SEPTIC	12" Diam	1.5	7
ADS - SB2	10" Diam	0.9	7
Cultec - Contactor EZ-24	16" x 12"	1.9	7
Cultec - Contactor EZ-24 (PDS)	16" x 12"	2.5	7
Cultec - Contactor 75	26.5" x 12.4"	2.6	7
Cultec - Contactor 100	36" x 12.5"	3.7	7
Cultec - Contactor 100 (PDS)	36" x 12.5"	4.3	7
Cultec - Contactor 125	26.5" x 18"	2.9	7
Cultec - Recharger 180	36" x 20.5"	4.4	7
Cultec - Recharger 180 (PDS)	36" x 20.5"	5.1	9
Cultec - Recharger 280	46" x 26.5 "	6.5	10
Cultec - Recharger 280 (PDS)	46" x 26.5 "	7.1	10
Cultec - Recharger 330	52" x 30"	5.6	11
Infiltrator Quick 4 Equalizer 24	16" x 11"	2.0	7
Infiltrator Quick 4 Equalizer 36	22" x 12"	2.4	7
Infiltrator Quick 4 Standard	34" x 12"	3.3	7
Infiltrator Quick 4 High Capacity	34" x 16"	3.7	7

The above Cultec and Infiltrator Quick 4 fabric-lined chambers must be backfilled with select fill to receive full credit. A 0.4 SF/LF credit reduction will be assessed if the chambers are backfilled with soil not meeting select fill gradation requirements.

7. Geomatrix

For the purpose of Section VIII F & G, the effective leaching area of the Geomatrix products listed below and corresponding minimum center to center spacing shall be as follows:

Product Name	Dimensions (W x H)	Effective Leaching Credit (SF/LF)	Center to Center Spacing (feet)
GeoMat 1200	12" x 1"	1.0	7
GeoMat 3900	39" x 1"	3.0	8
GeoMat 7800	78" x 1"	5.9	13
LowPro WE 1200	72" x 1"	5.2	12
LowPro WE 3900	72" x 1"	5.6	12
GeoMat Edge ST 1200	72" x 14"	27.2	14
GeoMat Edge WE 1200	72" x 13"	27.2	14

F. Leaching System Sizing

1. **Residential Buildings:** Leaching system sizing for residential buildings is based on a design flow of 150 gallons per day (GPD) per bedroom except for additional bedrooms beyond 4 in a single-family home, which are based on a design flow of 75 GPD per bedroom (see Section IV). The required effective leaching area for subsurface sewage disposal systems serving residential buildings shall be designed on the basis of the number of bedrooms and percolation rate in accordance with Table No. 6.

TABLE NO. 6 - RESIDENTIAL BUILDINGS

PERCOLATION RATE	SQUARE FEET OF REQUIRED EFFECTIVE LEACHING AREA				
MINUTES TO DROP ONE INCH	2 BEDROOM BUILDING	3 BEDROOM BUILDING	4 BEDROOM BUILDING	FOR EACH BEDROOM ABOVE FOUR: Single Family	FOR EACH BEDROOM ABOVE FOUR: Multi-family
LESS THAN 10.1	375	495	660	82.5	165
10.1-20.0	500	675	900	112.5	225
20.1-30.0	565	750	1000	125	250
30.1-45.0	675	900	1200	150	300
45.1-60.0	745	990	1320	165	330

Restaurants, Residential Institutions, and Nonresidential Buildings with Problematic Sewage:

The required effective leaching area for subsurface sewage disposal systems serving restaurants, bakeries, food service establishments (Class 3 & 4), residential institutions, laundromats, beauty salons, and other nonresidential buildings with problematic sewage shall be designed based on the design flow and the application rates listed in Table No. 7. See Section IV for design flow and problematic sewage information.

TABLE NO. 7 - RESTAURANTS, RESIDENTIAL INSTITUTIONS, AND NONRESIDENTIAL BUILDINGS WITH PROBLEMATIC SEWAGE

PERCOLATION RATE (Minutes to Drop One Inch)	APPLICATION RATE (Gallons per day to one square foot of Effective Leaching Area)
LESS THAN 10.1	0.8
10.1 to 20.0	0.7
20.1 to 30.0	0.6
30.1 to 45.0	0.5

45.1 to 60.0	0.4

REQUIRED EFFECTIVE LEACHING AREA = $\frac{\text{DESIGN FLOW}}{\text{APPLICATION RATE}}$

3. **Nonresidential Buildings with Non-problematic Sewage:** The required effective leaching area for subsurface sewage disposal systems for nonresidential buildings other than those covered by Section VIII F 2 (Table No. 7) shall be designed based on the design flow and the application rates listed in Table No. 8. See Section IV for design flow and problematic sewage information.

TABLE NO. 8 - NONRESIDENTIAL BUILDINGS WITH NON-PROBLEMATIC SEWAGE

PERCOLATION RATE (Minutes to Drop One Inch)	APPLICATION RATE (Gallons per day to one square foot of Effective Leaching Area)
LESS THAN 10.1	1.5
10.1 to 20.0	1.2
20.1 to 30.0	0.9
30.1 to 45.0	0.7
45.1 to 60.0	0.6

REQUIRED EFFECTIVE LEACHING AREA = $\frac{\text{DESIGN FLOW}}{\text{APPLICATION RATE}}$

G. Leaching System Product Approvals, ELA Ratings, Center to Center Spacing

All approved leaching system products are assigned an effective leaching area (ELA) rating in square feet per linear foot (SF/LF) of product except leaching pits (See Section VIII C). Approved leaching systems with assigned ELA ratings are listed in the various subsections of Section VIII, or in a leaching system product approval issued by the Commissioner of Public Health. Concrete pre-casters of leaching galleries and/or leaching pits shall file product drawings. Proprietary leaching system companies shall submit new product approval requests along with product specifications, drawings, cross-sections, installation instructions, and a completed product application/measurement worksheet. Proprietary leaching system companies that have products listed in the Technical Standards.

All approved leaching systems are assigned an ELA rating that is calculated in accordance with crediting criterion that takes into account several factors including the type of leaching system interface on which the biologically active layer (bio-mat) forms upon the routine application of septic tank effluent. For the purpose of the ELA ratings, the factors noted for stone are used also for two (2) inch nominal tire chip aggregate, an approved aggregate/stone substitute. Interface Factors for different leaching system interfaces are as follows:

Open:	2.0
Filter Fabric (No Stone):	1.5
Stone:	1.0

Filter Fabric & Stone: 0.75

Three types of leaching system interfaces are credited: sidewall interfaces, bottom interfaces, and internal interfaces. Sidewall interfaces discharge wastewater that does not pass through the product footprint area. Bottom interfaces discharge wastewater from the bottom of the product. Internal interfaces are non-bottom leaching surfaces that discharge wastewater from within and through the product footprint area. Horizontal measurements are used for bottom interfaces, except for corrugated pipes. Vertical measurements are utilized for sidewall and internal leaching interfaces, except for corrugated pipes. Corrugated pipes have measurements taken along the perimeter of the pipe. Sidewall and internal interfaces are credited up to the leaching unit's pipe invert.

Leaching system center to center minimum spacing, except for leaching pits , is determined based on the following:

- Products with ELA ratings of 5.0 SF/LF or less: Seven (7) feet minimum, however at least four (4) feet side edge to side edge must be provided.
- Products with ELA ratings of 5.1 to 10.0 SF/LF: Nine (9) feet minimum, however at least six (6) feet side edge to side edge must be provided.
- Products with ELA ratings exceeding 10.0 SF/LF: Twelve (12) feet minimum, however at least eight (8) feet side edge to side edge must be provided.

Further center to center reductions will be considered at the time leaching system minimum storage requirements and leaching system crediting criterion for internal interfaces and competing bio-mats are established. Reduced spacing will only be considered if it is satisfactorily demonstrated that the particular leaching product can be reasonably installed by the licensed installer without compromising the installation.

IX. GROUNDWATER, ROOF, CELLAR, PARKING LOT AND YARD DRAINAGE

No groundwater drainage or drainage from roofs, cellars, roads, parking lots or yards shall discharge into or within twenty-five feet of any portion of a subsurface sewage disposal system. Separate facilities shall be provided for such drainage. Additional separation is required for such drainage structures when they are located down gradient of a subsurface sewage disposal system. Storm water swales shall be constructed to lead water away from the subsurface sewage disposal system. The minimum separation distance between drains and storm water infiltration systems from subsurface sewage disposal systems is designated in Table No. 1.

Groundwater control drains or curtain drains, if used, shall be located on the uphill side of leaching systems and on the sides if necessary, and shall be separated from these systems as specified in Table No. 1. The depth of these drains shall be such as to lower the groundwater at least two feet below the bottom of the entire leaching system. Each drain shall be equipped with a collection pipe located 6 to 12 inches above the bottom of the trench carrying collected groundwater around and discharging below the leaching system (see Figure No. 14). This collection pipe shall have a minimum diameter of four inches and shall consist of open-joint tile, porous or perforated pipe. Perforated collection pipes are typically installed with holes on the bottom of the pipe. The collection pipe shall be surrounded by clean stone or gravel to a depth necessary to control groundwater, or otherwise designed by a professional engineer.

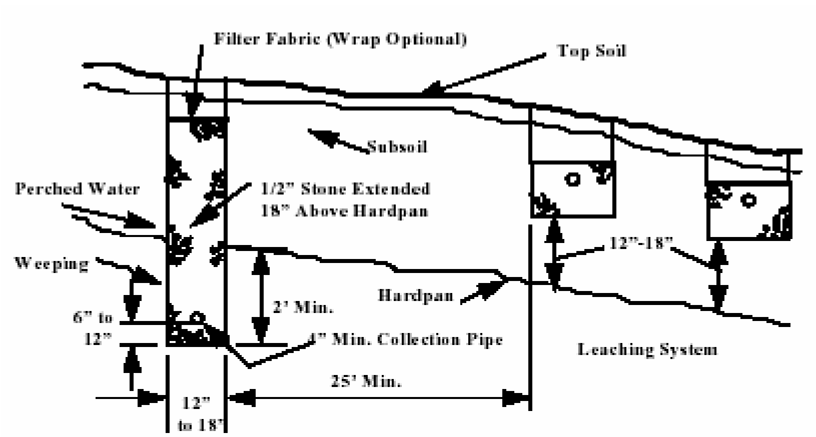


FIGURE 14 - TYPICAL CURTAIN DRAIN CONSTRUCTION

X. OTHER WASTEWATER

Oils, greases, industrial/commercial wastes, toxic chemicals and wastewater that is not sewage, shall not be discharged to a subsurface sewage disposal system. Discharges of wastewaters from water treatment systems (e.g., water softeners, iron or manganese removal filters) to surface waters, sanitary sewer systems, subsurface sewage disposal systems or to the ground surface are prohibited unless otherwise authorized by the Department of Environmental Protection (DEP). On-site disposal of water treatment system wastewater via a separate/dedicated subsurface disposal system shall be in accordance with DEP guidance or General Permit. Water treatment wastewater disposal systems shall meet the minimum separation distances specified in Table No. 1.

XI. NON-DISCHARGING SEWAGE DISPOSAL SYSTEMS

A. Large Capacity Composting Toilets

Large capacity composting toilets shall have separate receiving, composting and storage compartments, arranged so that the contents are moved from one compartment to another without spillage, or escape of odors within the dwelling. No large capacity composting toilets shall have an interior volume of less than sixty-four cubic feet. All toilet waste shall be deposited in the receiving chamber, which shall be furnished with a tight self-closing toilet lid. Food waste or other materials necessary to the composting action shall be deposited in the composting compartment through a separate opening with a tight fitting lid. The final composting material shall be removed from the storage compartment through a cleanout opening fitted with a tight door or lid. The cleanout shall not be located in a food storage or preparation area. The receiving and composting compartments shall be connected to the outside atmosphere by a screened vent. The vent shall be a minimum of six inches in diameter and shall extend at least twenty feet above the openings in the receiving and composting compartments, unless mechanical ventilation is provided. Air inlets shall be connected to the storage compartment only, and shall be screened.

B. Heat Assisted Composting Toilets

Heat assigned composting toilets shall have a single compartment furnished with a tight, self-closing toilet lid. The compartment shall be connected to the outside atmosphere by a screened vent. There shall be a mechanical ventilation fan arranged to control the humidity in the compartment and provide positive venting of odors to the outside atmosphere at all times. A heating unit shall be provided to maintain temperature in the optimum range for composting.

C. Incineration Toilets

Gas or oil fired or electrical incineration toilets shall meet applicable fire and building codes. No ignition or incineration shall occur unless the toilet lid is closed, and the blower shall operate continuously during incineration. A combustion temperature of 1,400^{o}F or higher shall be maintained during incineration.

D. Chemical Flush Toilets

Chemical flush toilets shall have toilet bowls that may be flushed when required by chemicals or chemical solutions. The liquid shall be discharged to a holding tank for removal of solids by settlement or other means prior to re-circulation. The toilet bowl shall be trapped or otherwise constructed to exclude odors, and the holding tank shall be vented to the outside atmosphere. The holding tank shall be emptied or additional chemicals added when odors or other objectionable conditions occur.

E. Dry Vault Privies

Dry vault privies shall be constructed with adequate storage space for excreta, and a fly-tight vault with a screened vent to the outside atmosphere. Self-closing, fly tight doors or self-closing seat covers shall be provided. Dry vault privies shall be constructed so as to permit ready cleaning. Separating distances shall comply with Table No. 1.

F. Chemical Privies

Chemical privies shall be constructed with a watertight vault with a screened vent to the outside atmosphere. Separating distances shall comply with Table No. 1. Chemicals shall be added to the liquid in the pit through a covered opening outside the toilet building. The vault shall be emptied, or additional chemicals added, when odors or other objectionable conditions occur.

G. Holding Tanks

Installation of non-discharging effluent holding tanks must be approved and the septage disposed by methods in accordance with local and state Code.

MINIMUM LEACHING SYSTEM SPREAD (MLSS)

In accordance with PHC Section 19-13-B103e (a) (4), no permit or approval shall be issued for any new subsurface sewage disposal system where the surrounding naturally occurring soil cannot adequately absorb or disperse the expected volume of sewage effluent without overflow, breakout or detrimental effect on ground or surface water. Naturally occurring soil is the soil material on a property that resulted from natural processes. It does not include fill deposited on a property by man, or soil that otherwise ended up on a property as a result of man's actions.

The MLSS calculation shall be utilized for all subsurface sewage disposal systems as a precursor to possible further, more in-depth, hydraulic analysis. The MLSS criteria shall be applied to the primary leaching area. Wherever feasible the reserve leaching area should provide additional hydraulic relief. Primary leaching systems located within 50 feet of one another and in the same hydraulic window shall be evaluated collectively as a common system. On sites where MLSS is applicable, single leaching system rows shall contain leaching products of a uniform ELA rating in order to avoid possible hydraulic overloading of a portion of the leaching system row.

MLSS Formula

MLSS (in feet) = HF x FF x PF

HYDRAULIC FACTOR (HF) = Factor based on hydraulic gradient and depth of restrictive layer within and down gradient of the leaching area.

FLOW FACTOR (FF) = Factor based on the design flow.

PERCOLATION FACTOR (PF) = Factor based on the percolation rate of the receiving naturally occurring soil.

DEFINITIONS

Hydraulic Gradient: Shall be deemed the percent of slope of the naturally occurring soil in the area of the leaching system (from uppermost leaching system row to 25-50 feet down gradient of system). Actual slope of restrictive layer may be utilized if field verification can be made.

Restrictive Layer: Shall be deemed the layer which impedes downward movement of flow within the proposed leaching area. This boundary will likely be the lesser of such conditions as: ledge; severely restrictive hardpan (slower than 30 minutes/inch) which is beneath a more permeable soil layer; or seasonal maximum groundwater levels. If clear determination of maximum groundwater levels cannot be made during site testing then this level shall be determined by groundwater monitoring. The average of at least five (5) consecutive weekly readings taken in the most restrictive 30-day period of the wet season shall be used as a basis.

Depth to Restrictive Layer: Shall be deemed the depth in inches from the top of naturally occurring grade to the restrictive layer. The average depth of natural soil above the restrictive layer in the area of the leaching system and between 25-50 feet down gradient shall be used to calculate MLSS.

Leaching System Spread: Shall be deemed the length in feet of sewage application parallel to the contours of the naturally occurring soils in the leaching area. Sewage shall be applied fairly uniformly over the entire length to be valid. If not, each section of the leaching system shall be analyzed independently in proportion to its daily discharge volume.

FACTOR TABLES

HYDRAULIC FACTOR (HF)

Depth to restrictive layer in inches

	HYDRAULIC GRADIENT (% OF SLOPE)								
	<1.0	1.0-2.0	2.1-3.0	3.1-4.0	4.1-6.0	6.1-8.0	8.1-10.0	10.1-15.0	>15.0
<18.0	SEE NOTE #1								
18.0-22.0	72	62	54	48	42	34	30	28	26
22.1-26.0	66	56	48	42	34	30	28	26	24
26.1-30.0	56	49	42	34	30	28	26	24	20
30.1-36.0	48	42	34	30	28	26	24	20	18
36.1-42.0	42	36	30	28	26	24	20	18	16
42.1-48.0	36	32	28	26	24	20	18	16	14
48.1-60.0	30	28	24	22	20	18	16	14	10
>60.0	MLSS NEED NOT BE CONSIDERED								

Note #1- Cannot be approved unless a formal hydraulic analysis demonstrates suitability. The hydraulic analysis must confirm compliance with PHC Section 19-13-B103e (a) (4). Sites with no unsaturated naturally occurring soil would not be a candidate for hydraulic analysis since the naturally occurring soil is already in an "overflowed" condition.

FACTOR TABLES

FLOW FACTOR (FF)

Flow Factor = Design Flow/300	
Typical Uses	**FlowFactor(FF)**
Residential: The Design Flow for each bedroom is 150 Gallons Per Day (GPD) except for additional bedrooms beyond 4 in a single-family residential building which have a 75 GPD per bedroom design flow.	
Single-family homes:	
2 Bedroom Home = 300/300	1.0
3 Bedroom Home = 450/300	1.5
4 Bedroom Home = 600/3 00	2.0
5 Bedroom Home = 675/3 00	2.25
Increase FF by 0.25 for each additional bedroom	
Multi-family buildings:	
Same as above except 5 Bedrooms = 750/300	2.5
Increase FF by 0.5 for each additional bedroom	
Non-Residential: Design Flow (GPD) / 300	(F F)

PERCOLATION FACTOR (PF)

Percolation Rate	**Percolation Factor (PF)**
Up To 5.0 Minutes/Inch	1.0
5.1 To 10.0 Minutes/Inch	1.2
10.1 To 20.0 Minutes/Inch	1.5
20.1 To 30.0 Minutes/Inch	2.0
30.1 To 45.0 Minutes/Inch	3.0
45.1 To 60.0 Minutes/Inch	5.0

USE OF MLSS FORMULA

The resulting MLSS calculation for each design plan shall be compared to the system spread proposed. If the proposed spread is less than the results of the MLSS formula than the applicant may either:

1) increase the system spread to meet MLSS;
2) relocate the leaching system to a more favorable location on the property;
3) reduce the flow factor by eliminating bedrooms or by changing the intended usage of the proposed building;
4) have an in-depth hydraulic analysis performed in order to demonstrate site suitability and code compliance.

APPROVED SEPTIC TANK EFFLUENT FILTERS

MANUFACTURER	MODEL
ORENCO SYSTEMS	FT0444-36, FT0854-36 FT1254-36, FT1554-36
PREMIER TECH	EFT-080
POLYLOK	PL-68, PL-122, PL-525, PL-625
RISSY PLASTICS	45 – CLIK N' STICK
THORSBY & BOWNE	SANITEE
TUF-TITE	EF-4, EF-6
ZABEL	A100, A300 A1800, A1801 A100-HIP, A300-HIP A1800-HIP, A1801-HIP A600-12, A600-8
ZOELLER	170-0017 170-0078 5000-0007
NORWECO	BIO-KINETIC BK2000
BIO-MICROBICS	ST 416, ST 418, ST 818, ST 838, ST 1618, ST 1638
BOWCO INDUSTRIES	EF-235
GAG-SIMTECH	STF-1 10, STF-1 10-7R STF-1 10-6W, STF-1 10-8B

APPROVED FILTER FABRICS FOR COVERING STONE AGGREGATE

MANUFACTURER	DESIGNATION NUMBER
AMERICAN ENGINEERING FABRICS	AEF-480
BRADLEY INDUSTRIAL TEXTILE	PHOENIX or LIJOMA
CARTHAGE MILLS	M35
CULTEC*	410
DUPONT	SF20
ENGINEERED SYNTHETIC PRODUCTS	TNS R020
L&M SUPPLY COMPANY	L&M 231
MIRAFI	65304 (4' WIDE) 65303 (3' WIDE)
SKAPS INDUSTRIES	SKAPS GT 120
TERRA TEX	S01.5, P01.5
TYPAR	3151, 3201
US FABRIC INC	US 1.5 CT

***Also approved to cover two (2) inch nominal tire chip aggregate**

APPROVED NON-CONCRETE SEPTIC TANKS

MANUFACTURER	DESIGNATION/ID NUMBER	GALLONS
NORWESCO Note: STD (Standard Tank) BSR. (Bruiser Tank)	STD 1000 STD 1250 STD 1500 BSR 1000 BSR 1250 BSR 1500	1000 1250 1500 1000 1250 1500
PLASTI-DRAIN (XACTICS)	X143600 X143605 X143850 X144700 X145500	1000 1000 1000 1250 1500

(Appendix D Cont'd) SNYDER INDUSTRIES	NuConSept Tanks 5060000W95302 5080000W95302 5 120000W95302 NuConSept Plus Tanks 1001000W95302 1001400W95302 1001 500W95302	 1050 1250 1500 1050 1250 1500
COON MANUFACTURING	M1000 M1500 Note: Manufacturer stipulates tank must be re-filled within 12 hours of pumping. Also inlet opening must be installed 3" above outlet.	1000 1500
ROCHESTER ROTATIONAL MOLDING	3445 3455 3465	1000 1250 1500
PREMIER TECH	PST-500 PST-660	1150 1500
DEN HARTOG INDUSTRIES (Ace Roto-Mold)	AST 1000-1* AST 1250-1* AST 1500-1 * AST 1000-2 AST 1250-2 AST 1500-2	1000 1250 1500 1000 1250 1500
FRALO PLASTECH	ST-750* ST-1000E ST-1060 ST-1250 ST-1 500	750* 1000 1060 1250 1500

*Single compartment tank can be used in series with another single compartment tank.