## Designing Septic Systems

***A SunCam online continuing education course***

### COURSE DESCRIPTION

Practically speaking, much of the new construction is taking place in urban service areas which provide a public sewer system. However, how do you provide sewer service in rural areas that is not only efficient, but sanitary, for a residential or commercial structure? In this course, we will look at common terminology, explanations of the system components, designs using gravity and pump systems, location considerations, and the regulatory codes.

We will start “at the beginning” and then progress through the sequence of components… from the septic tanks to the drainfield and the design involved in each of these components. This course is not intended to be all-inclusive in the design and installation of septic system but is intended to provide you with knowledge of how a septic system works, the components that comprise the system, the calculations, and the considerations involved in a septic system for a rural structure. Obviously, these same principles apply to all septic systems but the regulations do vary somewhat from state to state.

A residential mounded septic system


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### History of Septic Systems

The use of septic systems is nothing new and dates back to the late 1800s. Prior to that time, the outhouse was the standard bathroom. It typically consisted of a hole in ground with a wooden bench centered above the hole. And if you've ever had the "opportunity" to use one, you quickly realize they're not very appealing. The septic tank system is believed to have been invented in France in the 1860s. And it didn't take long before it was being used in the United States. The first known installation of a septic tank in the United States was in 1876. With the increasing availability of electricity and pumps to provide running water inside buildings, it much longer before the bathroom moved indoors as well.

Each state has developed its own codes to regulate the installation and use of septic systems. Florida uses Florida Administrative Code, Georgia uses the Department of Human Resources Chapter 290-5-26, Texas uses Texas Administrative Code Title 30 Part 1 Chapter 285. Regardless, always check the code requirements for the state in which the system will be constructed. There are differences, especially in system loading rates and setback requirements.

### THE COMPONENTS

A typical gravity septic system consists of a septic tank, filter, effluent lines, a header pipe or distribution box, and a drainfield. Other systems may also include a dosing tank, an effluent pump, or an Aerobic Treatment Unit (ATU). The septic system can be a gravity system or a pumped system depending on the site conditions. And it could be an in-ground or an above-ground (mounded) system regardless of it being a pumped system... as we'll see a little later in this course.


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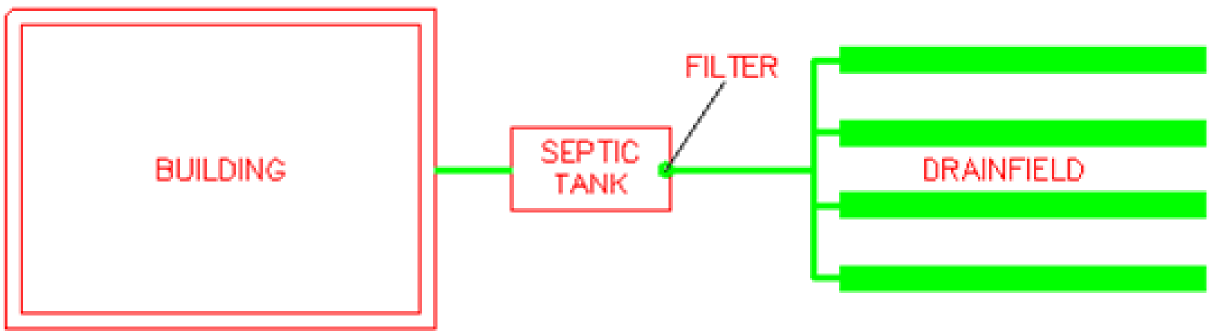


**The septic tank** is where the breakdown of the sewage occurs and it happens in an anaerobic condition (meaning without oxygen). The anaerobic conditions are referred to as being "septic," which is how the system got named. Typically a concrete or "plastic" tank is placed about five to ten feet from the building. The building's sewer lines are fed by gravity into a single pipe that then enters the septic tank.

The septic tank holds three layers of waste. The top layer is referred to as the scum layer which floats in the tank effluent until the bacteria digests it and causes it to sink to the bottom of the septic tank. The middle layer is the effluent layer consisting of the digested sewage in a liquid state. And the bottom layer is the sludge layer. It consists of the solids which are not digested and therefore will build up slowly on the septic tank bottom.

The digested liquid waste is carried into the second septic tank or the second chamber of a baffled tank for further digestion. The effluent is then discharged through the effluent filter to the drainfield or in the case of a pumped system into the dosing tank and then to the drainfield. Some states require that access into the tanks be provided with manhole covers brought to the surface. Access to the tank filter can be through a manhole cover or through a smaller access cap.


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Septic Tank Installations

Some of the advantages of concrete tanks are:

1) They are approved for use in all 50 states.
2) They have larger capacities and effluent levels than plastic septic tanks.
3) They are very heavy so there is no chance of them popping out of ground during periods of high water tables.
4) They are very durable and can have lifespans of 50 – 100 years.

Some of the disadvantages of concrete tanks are:

1) They are expensive as compared to plastic tanks.
2) They are susceptible to cracking under certain circumstances.
3) They are more susceptible to leaks from cracking.
4) They require heavy equipment to install because of their weight.

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The primary advantages of plastic tanks are:

1) They are relatively inexpensive.
2) They don't leak.
3) They are light-weight and therefore easy to install.

The primary disadvantages of plastic tanks are:

1) They're not approved for use in all states.
2) Because they're light-weight, they can pop out of the ground during periods of high water tables.

**A septic tank filter** is used in the septic tank and its primary purpose is to prevent solids from leaving the tank and entering the drainfield which could clog the system and cause problems. The cartridge filter is accessed through the last septic tank manhole cover or port cap and typically has a "T" handle for lifting. The filter is simply lifted out and rinsed off into the septic tank at the manufacturer's recommended interval. The filter is designed to become clogged early and thereby requiring action by the owner prior to the drainfield becoming damaged or failing altogether.

Zabel filter


Filter access through manhole

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Not all states require the use of septic filters but I highly recommend them because they are cheap insurance as compared to replacing a failed drainfield. Again, there is the occasional maintenance required but it only takes a few minutes to flush the filter.

**The drainfield** is typically made up of perforated plastic pipes or chambers that are buried approximately 1.5 feet below grade level. Historically, the gravity drainfield used level trenches or beds that consisted of a 12 inch thick layer of gravel or #57 stone (approx 1.5 inches in size and washed). Running through the middle of that gravel layer were perforated plastic pipes which were used to distribute the effluent. Prior to the availability of plastic pipe, clay pipe was used and can still be found in use in very old systems.

Perforated Plastic Septic Pipe

The bottom of the bed was at least 18- 24 inches above the seasonal high water table and was used to distribute the effluent in the drainfield. The gravel bed was then covered with a soil filtration fabric before adding a 6-12 inch soil cap. Once the drainfield was completed, it was sodded with grass to prevent erosion and protect the rock bed. Today, the pipes can still be placed in a gravel bed but that method is rarely being used anymore.

Typically, what is currently being used today is the newer chamber technology which uses no rock, frequently no drainfield pipe, and the chambers are quicker and easier to install. The chambers also have the advantage of providing a greater effluent storage capacity than the traditional pipe/rock bed system. Some state health departments will also allow a reduced drainfield size if chambers are used because of their increased storage capacity. Typically, the bottom of the drainfield will be set at least 24 inches above the seasonal high water table, graded level, and then the septic chambers are

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placed directly on the soil and covered with soil until a 6-12 inch cap is established and then it is sodded with grass. Many engineers will specify the placement of a soil filtration fabric over the chambers to prevent any soil from entering the chamber sides.

Septic drainfields using the septic chambers

If the septic flows are large enough or soil conditions require an even distribution of the effluent throughout the drainfield, a low pressure distribution system will be used and the pressurized pipe network is laid through the rock bed or in the center of the drainfield chambers.

Regardless of which method is used, the effluent from the septic tank will work its way through the perforated pipes or chambers and then will be absorbed in the drainfield. Microbes located in the soil will digest and remove most of the nutrients from the effluent before it can reach the groundwater.

The health department or the engineer may require the installation of inspection ports in the drainfield. These ports can then be used to monitor the performance of the drainfield. These inspection ports are typically 4 inch diameter plastic pipes with a

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threaded cap and set level or slightly above the ground elevation. They are connected to the ports located in the top of the septic drainfield chambers and are used to provide access to the bottom of the drainfield. In a rock bed, the bottom 12 inches of the pipe will be perforated to allow effluent levels within the pipe to stabilize with the drainfield levels. Then by using a flashlight or by placing a stick down the pipe to the bottom of the drainfield, it is possible to determine how much liquid is the drainfield. An inch or two of liquid is normal and is no cause for alarm. If higher levels are frequently found, it could mean there are problems that need to be addressed. Those problems could be excessive flow rates (perhaps a stuck toilet that is continuously flowing), a drainfield that was undersized when designed, or a change in the soil percolation rates. Regardless, if the problems are not resolved, there will be greater problems later.

**The dosing pump** is located in a dosing tank or pump tank and is used to pump a specific quantity of effluent to a drainfield located at an elevation that is higher than the septic tank. The dosing tank is essentially another septic tank only smaller in size. It too will have a manhole for access to the pump(s) for maintenance or repairs. It will also have an electrical conduit to provide the power necessary to run the pump.


Myers Pump

Hydromatic Pump

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A septic dosing pump installed in a tank

The dosing pumps usually require 1/4 or 1/2 h.p. pumps using 120-volt AC power on 15 or 20 amp circuits. This aspect makes them easy to install and connect for both residential and commercial applications. Only if you have large flows with extremely long distances or a drainfield located at a much higher elevation will larger pumps with 220-volts be required.

**The control panel** is typically installed within 20 feet of the pump tank and provides power to the pumps. It usually will include a disconnect breaker and a high level alarm. The high level alarm is normally a red light but may include an audible alarm as well. It should be placed in a highly visible area that is in a conspicuous location for the users to monitor for problems. If two pumps are used, it will also include controls to cycle between the pumps after each dose. Alternating the pumps ensures a longer life span for the pumps and lower maintenance costs.

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A control panel

**The elapsed time counter**, though not required, can be added to the control panel to provide an indication of the total time the pump has been running. With it, you can calculate the number of gallons of sewage that has been pumped during a single cycle or any other amount of time by multiplying the pump rate by the run time. This information can then be used to analyze a pump that may be failing and allow the user to choose the most convenient time to replace or repair the pump versus having an emergency repair at an inconvenient time (Murphy's Law). However, the counter only measures total hours of operation for the pump, not the pump rate. So if a pump is requiring 20 minutes for a designed 6 minute pump cycle, you have problems.

**The distribution box** is a box designed to accept the effluent from the septic tank and evenly distribute it to each of the lines feeding the drainfield. It is therefore critical that the distribution box be placed such that each discharge line is at the same elevation or the line with the lowest elevation will unevenly saturate a portion of drainfield.

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Tuff-Tite Distribution Box

**The header pipe** is used in lieu of a distribution box and consists of a single pipe used to feed each of the discharge lines into the drainfield. Again, it is critical that the header pipe be placed level such that each discharge line is at the same elevation to prevent unevenly saturating a portion of drainfield.

***Sample Project Design:***

*For the purposes of this course, we will assume we have a project consisting of a new doctor's office that is being constructed in a relatively rural area that needs a septic system. The office will be staffed by two doctors and six employees and will be located on a one acre parcel of land with public water available.*

**Step 1: Determining Maximum Allowable Sewage Flows**

Obviously, you can't have unlimited sewage flows on a fixed area of land. The flows would be limited by the permeability rates of the soil, water table elevations, slope, and other factors. And there are also regulatory restrictions. The state will the set maximum allowable flow allowed by a particular site... typically by lot size. However, in Florida,

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the maximum allowable flow is determined by the type of water supply being used and the total area of land. If the site is being provided potable water from a well, the maximum daily sewage flow allowance is 1,500 gallons per day (gpd) per acre. Or, for a site provided potable water from a public water supply system, the maximum daily sewage flow allowance is 2,500 gpd per acre.

### Step 2: Determining Estimated Sewage Flows

The expected septic design flow must first be determined based on acceptable values from State approved charts or through a methodology approved by the State Health Department. The state charts provide estimated flows for specific uses for commercial, institutional, and residential classifications that have been developed over a number of years. A portion of the tables from Texas and Florida are provided below:

State of Texas:

| TYPE OF FACILITY | USAGE RATE GALLONS/DAY (Without Water Saving Devices) | USAGE RATE GALLONS/DAY (With Water Saving Devices) |
|---|---|---|
| Single family dwelling (one or two bedrooms) - less than 1,500 square feet. | 225 | 180 |
| Single family dwelling (three bedrooms) - less than 2,500 square feet. | 300 | 240 |
| Single family dwelling (four bedrooms) - less than 3,500 square feet. | 375 | 300 |
| Single family dwelling (five bedrooms) - less than 4,500 square feet. | 450 | 360 |
| Single family dwelling (six bedrooms) - less than 5,500 square feet. | 525 | 420 |
| Greater than 5,500 square feet, each additional 1,500 square feet or increment thereof. | 75 | 60 |
| Condominium or Townhouse (one or two bedrooms) | 225 | 180 |
| Condominium or Townhouse (each additional bedroom) | 75 | 60 |
| Mobile home (one or two bedrooms) | 225 | 180 |
| Mobile home (each additional bedroom) | 75 | 60 |
| Country Clubs (per member) | 25 | 20 |
| Apartment houses (per bedroom) | 125 | 100 |
| Boarding schools (per room capacity) | 50 | 40 |
| Day care centers (per child with kitchen) | 25 | 20 |
| Day care centers (per child without kitchen) | 15 | 12 |
| Factories (per person per shift) | 15 | 12 |

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State of Florida:

**TABLE I**
**For System Design**
**ESTIMATED SEWAGE FLOWS**

| TYPE OF ESTABLISHMENT | GALLONS PER DAY |
|---|---|
| COMMERCIAL: | |
| Airports, bus terminals, train stations, port & dock facilities, Bathroom waste only | |
| (a) per passenger | 4 |
| (b) add per employee per 8 hour shift | 15 |
| Barber & beauty shops per service chair | 75 |
| Bowling alley bathroom waste only per lane | 50 |
| Country club | |
| (a) per resident | 100 |
| (b) add per member or patron | 25 |
| (c) add per employee per 8 hour shift | 15 |
| Doctor and Dentist offices | |
| (a) per practitioner | 250 |
| (b) add per employee per 8 hour shift | 15 |
| Factories, exclusive of industrial wastes gallons per employee per 8 hour shift | |
| (a) No showers provided | 15 |
| (b) Showers provided | 25 |
| Flea Market open 3 or less days per week | |
| (a) per non-food service vendor space | 15 |
| (b) add per food service establishment using single service articles only per 100 square feet of floor space | 50 |
| (c) per limited food service establishment | 25 |
| (d) for flea markets open more than 3 days per week, estimated flows shall be doubled | |
| Food operations | |
| (a) Restaurant operating 16 hours or less per day per seat | 40 |
| (b) Restaurant operating more than 16 hours per day per seat | 60 |
| (c) Restaurant using single service articles only and operating 16 hours or less per day per seat | 20 |
| (d) Restaurant using single service articles only and operating more than 16 hours per day per seat | 35 |
| (e) Bar and cocktail lounge per seat | 20 |
| add per pool table or video game | 15 |
| (f) Drive-in restaurant per car space | 50 |
| (g) Carry out only, including caterers | |
| 1. per 100 square feet of floor space | 50 |
| 2. add per employee per 8 hour shift | 15 |
| (h) Institutions per meal | 5 |

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For example, using the table above for a bowling alley with 6 lanes, the estimated sewage flows would be 300 gpd based on 6 lanes * 50 gpd/lane = 300 gallons per day. However, if the bowling alley also had a small restaurant included, you must add the restaurant flows to the lane flows. So for a 20-seat restaurant, we would calculate the estimated sewage flows as follows:

| | |
|---|---|
| 6 lanes * 50 gpd/lane = | 300 gpd |
| 20 seats * 40 gpd/seat = | <u>800 gpd</u> |
| | 1,100 gpd |

***Step 2: Sample Project Design - Estimated Sewage Flows:*** *Using the chart above, our doctor's office with 2 doctors and 6 employees, we would calculate the following:*

| | |
|---|---|
| *2 doctors * 250 gpd/doc =* | *500 gpd* |
| *6 empl * 15 gpd/empl =* | *<u>90 gpd</u>* |
| | *590 gpd* |

When a particular use is not listed, an estimated flow will need to be determined by obtaining the best available data and then working with the local health official. If that does not work, you will need to obtain data from 6 similar operations with at least 12 months of authenticated monthly water use data. As daunting as that may seem, most business flows can be obtained from the local water utility provider through their billing records. However, you need to be able to separate the consumed water from any irrigation water flows. This is important because you need to determine the flows that the septic system will actually see. Optionally, if the client has 24 months of authenticated monthly water use data for his own business, you may be able to use those records for your estimated flows.

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Whatever method you use to estimate your daily sewage flows, ensure they accurately reflect the maximum anticipated flows that the system will experience. If not, the results will be sickening… literally. Either the toilets won't flush or in the case of a pumped system, the drainfield will blow out and will discharge untreated waste onto the ground creating a true public health hazard. If this happens, the discharge must be reported to the local health department and dealt with immediately… meaning that you must cease operating the facility until the problem is corrected.

Once you have determined your estimated daily sewage flow, you can set the design Daily Flow by applying a safety factor to account for unusual factors that would increase the flows from the standard charts. If your system is not unique, then your design Daily Flow is your estimated Daily Flow value. For example, a service station open 16 hours or less per day has an estimated flow of 250 gpd per toilet. However, the same service station located at an interstate intersection you would apply a factor of 3. So the design Daily Flow would be 250 gpd * 3 = 750 gpd per toilet.

Note that many states have a minimum Daily Flow which cannot be less than 200 gpd regardless of the calculations or estimates.

**Step 3: Septic Tank Sizing.** Once we have the Average Sewage Flow, we can determine the required septic tank size and the pump tank size (if we have an elevated drainfield). We will discuss more on the pump tank later. Again, every state has developed their tables for use to meet the requirements of their environment.

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**TABLE II**
**SEPTIC TANK AND PUMP TANK CAPACITY**

| AVERAGE SEWAGE FLOW GALLONS/DAY | SEPTIC TANK MINIMUM EFFECTIVE CAPACITY GALLONS | PUMP TANK MINIMUM TOTAL CAPACITY GALLONS | |
|---|---|---|---|
| | | Residential | Commercial |
| 0-200 | 900 | 150 | 225 |
| 201-300 | 900 | 225 | 375 |
| 301-400 | 1050 | 300 | 450 |
| 401-500 | 1200 | 375 | 600 |
| 501-600 | 1350 | 450 | 600 |
| 601-700 | 1500 | 525 | 750 |
| 701-800 | 1650 | 600 | 900 |
| 801-1000 | 1900 | 750 | 1050 |
| 1001-1250 | 2200 | 900 | 1200 |
| 1251-1750 | 2700 | 1350 | 1900 |
| 1751-2500 | 3200 | 1650 | 2700 |
| 2501-3000 | 3700 | 1900 | 3000 |
| 3001-3500 | 4300 | 2200 | 3000 |
| 3501-4000 | 4800 | 2700 | 3000 |
| 4001-4500 | 5300 | 2700 | 3000 |
| 4501-5000 | 5800 | 3000 | 3000 |

From the chart above we find that with an 800 gpd Average Sewage Flow, the minimum septic tank size is 1,650 gallons. For a commercial application requiring a pump tank for an elevated drainfield, the pump tank size is 900 gallons. Whereas, a residential application would only need a 600 gallon pump tank. Some states do not differentiate between residential and commercial uses.

The design of the septic tank requires that the tank be baffled or consist of two tanks connected in series with two-thirds of the volume being contained in the first chamber or the first tank. Using a single 1,050 gallon tank would require an interior baffle (an interior barrier wall with an opening) creating a tank with two chambers. The first chamber would contain two-thirds of the 1,050 gallons or 700 gallons and the second chamber containing 350 gallons. Or two individual septic tanks can be used... for example, a 700 gallon tank connected to a 350 gallon tank. Either method is acceptable and will meet the code requirements. Obviously, for the really large tanks, it

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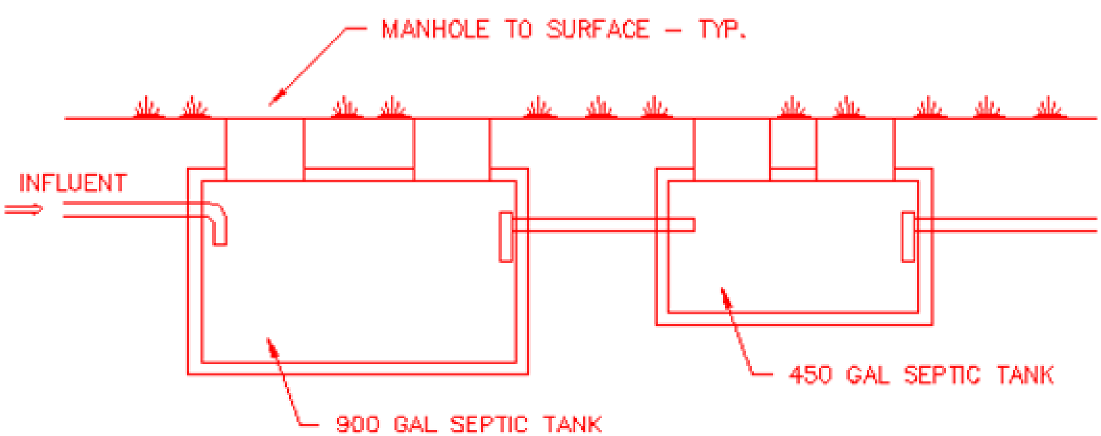
is easier to install two smaller tanks than a really large single tank. Even a 2700 gallon tank is quite large being 13 feet in length, almost 7 feet in width, and over 6 feet in height. And with concrete septic tanks, they are quite heavy requiring cranes to move and place them. So for large septic tank requirements, use two or more tanks in series and save on the installation cost.

***Step 3: Sample Project Design - Septic Tank Sizing:*** *Using our doctor's office, we know our Average Sewage Flow is 590 gpd. Then from Table II above, we find the following:*

*Average Sewage Flow = 590 gpd*

*Minimum Septic Tank size = 1,350 gal*

Since a pump tank is not needed for a gravity septic system, we don't have to worry with its selection. (This sizing will be covered later when we discuss a pumped septic system design.) The tank can be a single 1,350 gallon baffled tank or two tanks in series consisting of a 900 gallon tank and a 450 gallon tank as shown below.




Septic Tank in Series

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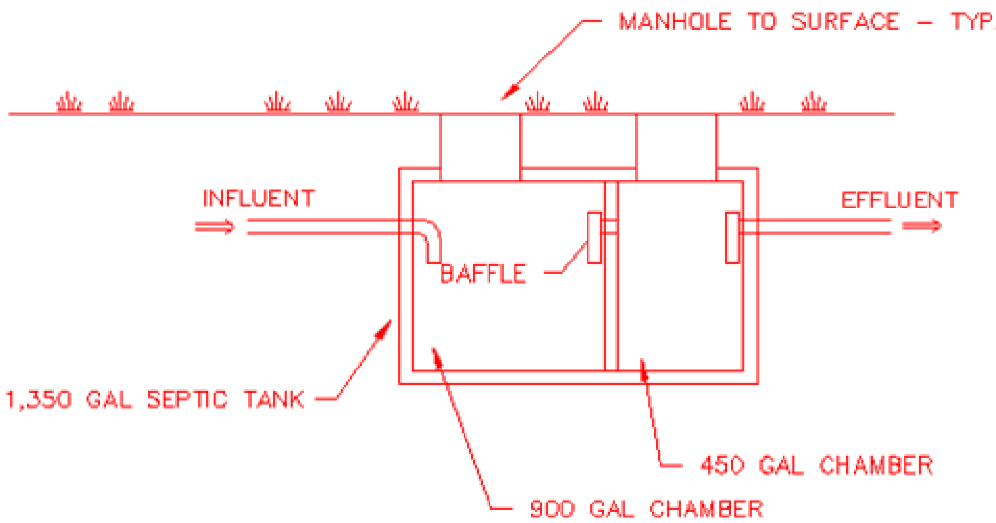


Septic Tank with Baffle

**Step 4: Determine Sewage Loading Rate.** The Sewage Loading Rate is the adjustment factor applied to the Estimated Daily Flow to determine the drainfield size. The *Sewage Loading Rate* is obtained from a chart based on the type of drainfield to be constructed and the physical properties of the type of soils being used. In some states, there are two charts. One chart is for in-ground systems and another chart is for a mounded septic drainfield. The type of drainfield will be either a trench design or a bed design. The percolation rate of the soil is the primary indicator as to the type of soil being used. The loading rates will vary from about 1.20 to 0.20 gallons per square foot per day depending on the state and soils involved. Obviously, the higher permeable soils are desired so as to minimize the drainfield size. However, highly permeable soils with a percolation rate of less than 1 minute per inch with a seasonal high water table of less than 4 feet is unacceptable for drainfield use because the percolation rates don't provide sufficient treatment times.

For highly permeable soils, a two-foot slightly-limited sand layer may be required under the drainfield. The two-foot sand layer reduces the percolation rates to an acceptable level. The imported soil prevents the sewage effluent from percolating too quickly through the native soils and entering the water table untreated. Many contractors will use ASTM C-33 concrete sand or USDA A-3 sand.

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**TABLE III**
**For Sizing of Drainfields Other Than Mounds**

| U.S. DEPARTMENT OF AGRICULTURE SOIL TEXTURAL CLASSIFICATION | SOIL TEXTURE LIMITATION (PERCOLATION RATE) | MAXIMUM SEWAGE LOADING RATE TO TRENCH & BED ABSORPTION SURFACE IN GALLONS PER SQUARE FOOT PER DAY TRENCH | BED |
|---|---|---|---|
| Sand; Coarse Sand not associated with a seasonal water table of less than 48 inches; and Loamy Coarse Sand | Slightly limited (Less than 2 min/inch) | 1.20 | 0.80 |
| Loamy Sand; Sandy Loam; Coarse Sandy Loam; Fine Sand | Slightly limited (2-4 min/inch) | 0.90 | 0.70 |
| Loam; Fine Sandy Loam; Silt Loam; Very Fine Sand; Very Fine Sandy Loam; Loamy Fine Sand; **Loamy Very Fine Sand;** Sandy clay loam | Moderately limited (5-10 min/inch) | 0.65 | 0.35 |
| Clay Loam; Silty Clay Loam; Sandy Clay; Silty Clay, Silt | Moderately limited (Greater than 15 min/inch but not exceeding 30 min/inch) | 0.35 | 0.20 |
| Clay; Organic Soils; Hardpan; Bedrock | Severely limited (Greater than 30 min/inch) | Unsatisfactory for standard subsurface system | |
| Coarse Sand with an estimated wet season high water table within 48 inches of the bottom of the proposed drainfield; Gravel or Fractured Rock or Oolitic Limestone | Severely limited (Less than 1 min/inch and a water table less than 4 feet below the drainfield) | Unsatisfactory for standard subsurface system | |

Excerpted from the State of Florida, 64E-6.008 Table III effective April 28,2010.

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***Step 4: Sample Project Design - Sewage Loading Rate:*** *Assume the site for our doctor's office has soils that are a sandy loam with a percolation rate of 3 minutes per inch. Then from Table III, we find the following:*

*Percolation rate = 3 minutes per inch*

*Sewage Loading Rate:*

*Trench Loading Rate = 0.90 gal per sq ft per day*

*Bed Loading Rate = 0.70 gal per sq ft per day*

**Step 5: Drainfield Sizing.** Now that you know the *Average Daily Flow* and the *Sewage Loading Rate*, you can begin your drainfield sizing calculations. Your drainfield size is calculated as Average Daily Flow / Sewage Loading Rate. For example, for a calculated Average Daily Flow of 400 gpd and using a trench drainfield design with soils having a percolation rate of 7 minutes per inch would look like the following:

Average Daily Flow = 400 gpd
Sewage Loading Rate = 0.65 (from chart for moderately limited soil in trench)
Drainfield Size = 400 gpd / 0.65 = 615 square feet drainfield

For the same design but using a soil with a percolation rate of less than 2 minutes per inch, the calculations change to:

Average Daily Flow = 400 gpd
Sewage Loading Rate = 1.20 (from chart for slightly limited soil in trench)
Drainfield Size = 400 gpd / 1.20 = 333 square feet drainfield

So, as we just demonstrated, the type of soils in the drainfield will have a dramatic impact on the size of the drainfield. In this case, the drainfield using slightly limited soils is almost half the size of the drainfield using moderately limited soils.


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***Step 5: Sample Project Design - Drainfield Sizing:*** *For our office's calculated Average Daily Flow of 590 gpd and using a trench drainfield design with the site soils having a percolation rate of 3 minutes per inch would look like the following:*

*Average Daily Flow = 590 gpd*

*Sewage Loading Rate = 0.90 (from chart for moderately limited soil in trench)*

*Drainfield Size = 590 gpd / 0.90 = 656 square feet*

Now that we have determined the drainfield size, we need to determine the drainfield dimensions. The drainfield dimensions are determined by site conditions and by the type of drainfield construction. So let's look at the types of drainfield construction next and then we'll address the other factors.

## DRAINFIELD TYPES

There are two types of drainfields... *trench drainfields* and *absorption beds*. Drainfield calculations only specify the size of the drainfield but not the shape or configuration. A 615 square foot drainfield could be 24.8 ft by 24.8 feet (bed) or it could be 9 feet by 68.3 feet (trench). Of the two, the 9 x 68.3 trench drainfield is preferred. Note that the shape of drainfield doesn't necessarily indicate the type of drainfield. A square drainfield could be a trench type. However, whenever possible, choose a rectangular shaped drainfield for better performance because a square drainfield has an increased chance of becoming saturated in the center of the drainfield with decreased treatment efficiency and percolation through the soil.

**Trench drainfields** are the preferred method for installation. Generally, for trenches that are 12 inches or less in width, there must be a minimum separation distance of 12 inches between the sidewalls of any adjacent trenches. For trenches widths greater than 12 inches (up to the maximum width of 36 inches), a minimum separation of 24 inches is required between the sidewalls of any adjacent trenches.

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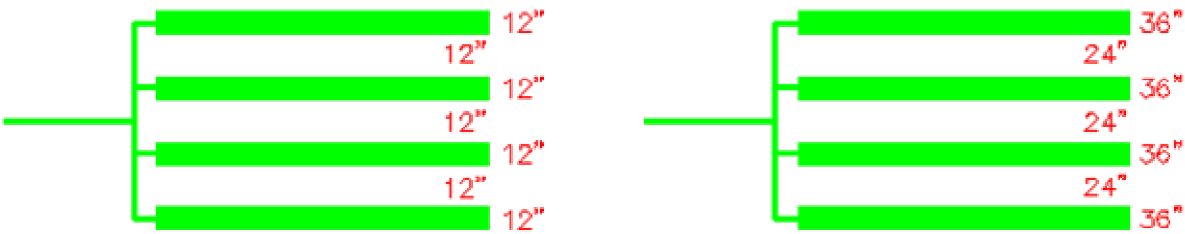


TRENCH DRAINFIELDS

**Absorption beds** are the alternative to using a trench drainfield. The absorption bed consists of an area in which the entire earth content of the required absorption area is removed and replaced**.** The distance between the centers of the effluent distribution lines are usually at a maximum of 36 inches. And the distance between the sidewall of the absorption bed and the center of the nearest drain line is between 6 to 18 inches. Another restriction is that an absorption bed cannot exceed a maximum of 1500 square feet. If more than one absorption bed is needed, many states require a minimum of 10 foot separation between the absorption beds.

Again, a drainfield should always be designed to achieve the maximum length to width ratio practical.


ABSORPTION BED DRAINFIELD


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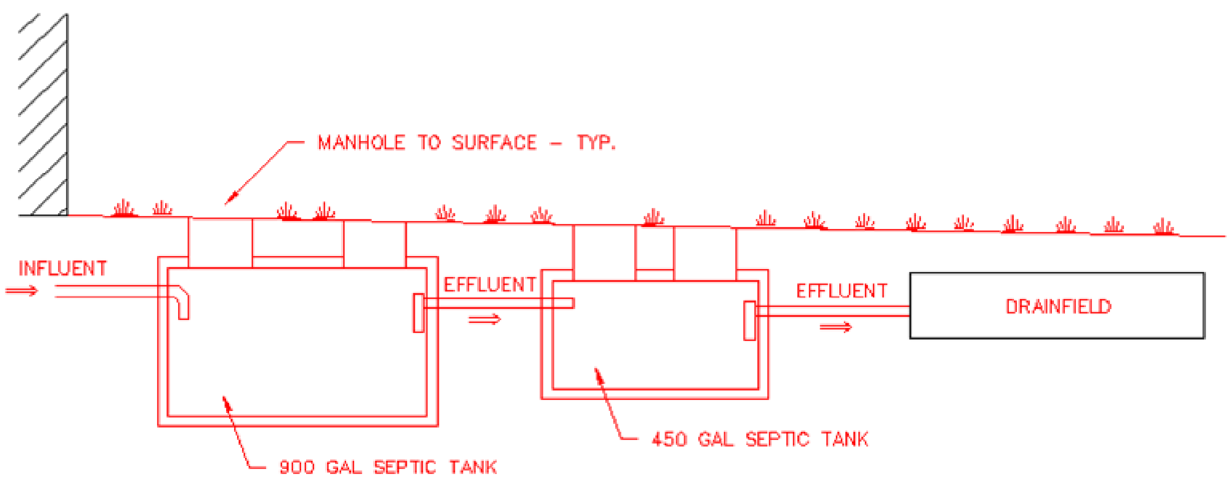
**Gravity or pumped? That is the question...**

A gravity system is the preferred septic system because of its simplicity. Water runs downhill and so does effluent. A gravity system doesn't rely on electrical pumps for it to function. There are no controls, no meters, no motors, no mechanical failures, and life is good. And gravity has been found to be very reliable. In fact, there have been no reported gravity outages to date.

However, it does have one negative aspect. A gravity system always requires the drainfield to be located "down-hill" from the building and the septic tank. If you can't place the drainfield lower than the septic tank, you will have no choice but to install a pumped system.




Gravity Septic System Layout

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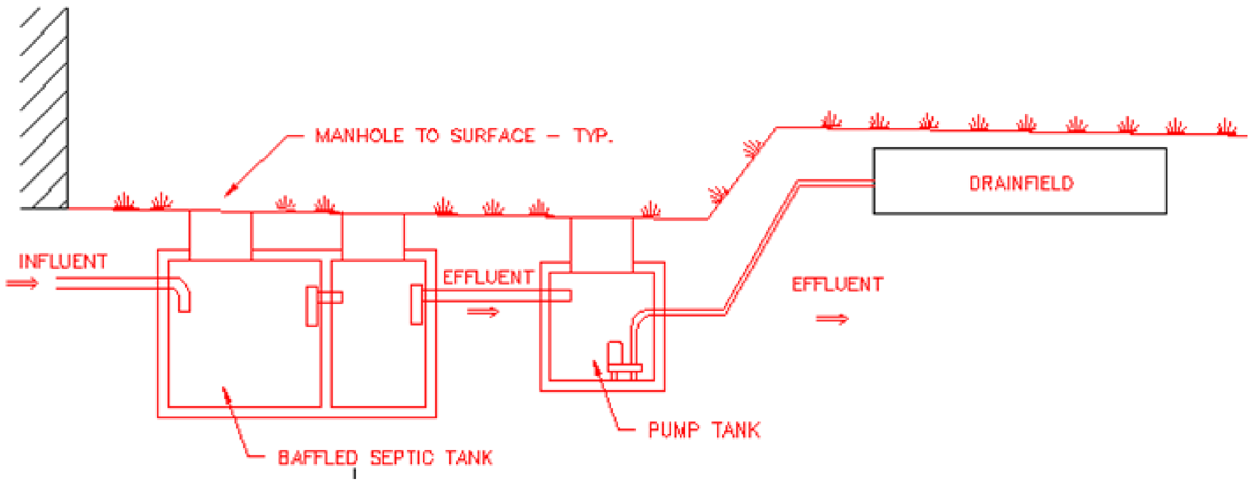
A pumped system has a tank with a submersible pump located in series following the septic tank. The effluent discharges from the septic tank, through a filter, and into the pump tank (sometimes referred to as a dosing tank) where it is pumped to the drainfield located at a higher elevation or at a great distance from the tanks. Residential systems typically have a single pump and commercial systems will have two pumps.




## SITE CONSTRAINTS

Once you have determined which type of drainfield construction you will use, you must look at the other site constraints. Let's look at some of the more common site constraints such as ground elevations, seasonal water tables, slopes, vegetation, property lines, setbacks from wells, water bodies, potable water lines, buildings, roads, driveways, etc.

**Ground elevations** are one of the first considerations for the placement of a septic system. While the building placement is generally determined by the client, the drainfield placement is generally determined by the engineer. Once the building placement is determined, you can evaluate the elevations of the possible drainfield locations. A location that is lower than the building is the preferred choice because a gravity septic system can be used. If that's not an option, you must use a pumped system.

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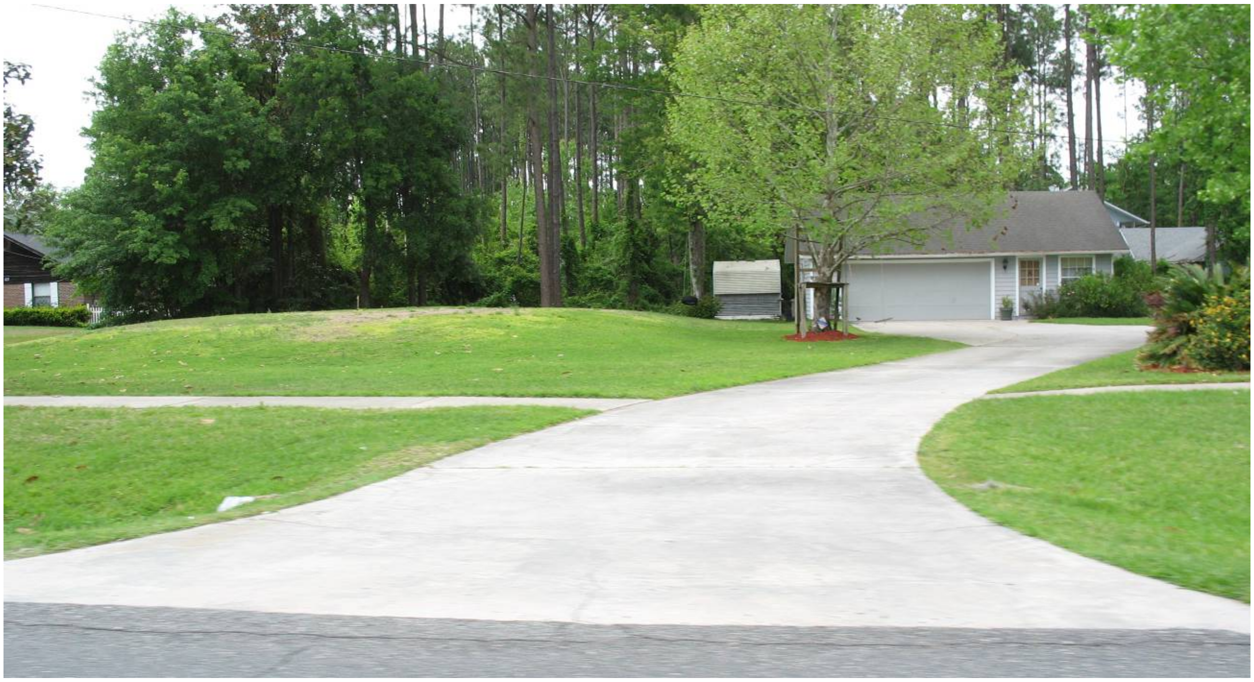
**Unsuitable soils** below a drainfield must be avoided and in many states there are minimum separations between the two that must be met. Unsuitable soils are those soils that have percolation rates that are too small or too high for use in a drainfield.

**Seasonal water tables** play a big part in the drainfield site selection. Most Health Department codes require that the bottom elevation of the drainfield be at least 24 inches above the seasonal high water table. So digging a hole to check the water table elevation isn't going to give you valid information unless the water table that day just happens to occur at the seasonal high water table elevation. For example, is the area subject to frequent flooding? If so, the site isn't viable for an in-ground drainfield. If you can't find a location that is high enough to provide the 24-inch vertical separation, you can evaluate the feasibility of a raised or mounded drainfield using a pumped system.



**Slopes** are another concern not only because of the elevation differences between the drainfield location and the septic tank but because of the stormwater runoff. You don't want to select a site that obstructs the normal stormwater runoff patterns or you risk drainfield erosion or drainfield saturation. Both can cause the drainfield problems. In

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Georgia, slopes greater than 25 percent are considered unsuitable for septic system use. Additionally, the drainfield must be level to prevent the effluent flowing to the low end of the drainfield and saturating that point to failure. In essence, if your drainfield is sloped, you have effectively reduced the size of your drainfield simply because of gravity.

**Vegetation** is another big concern for two reasons. First, the roots of the plants may be removed during the installation of the drainfield killing the plants. Secondly and more importantly, the roots may end up blocking the drainfield piping as they seek the nutrients in the effluent. If there is even a small opening anywhere in the septic system piping, vegetation roots will find it, expand it, and eventually clog the entire pipe. I've seen this many times when requested to determine the reason a septic system has failed. Do not allow any bushes or trees to be planted near a septic system.

**Property lines** are another concern due to adjacent property rights. In many states, all portions of a septic system are required to be located no closer than 5 feet to a property line.

**Adjacent water wells** are a big problem for septic systems for health reasons, obviously. Not only your client's water well but the adjacent landowner's well must be protected against any contamination from a septic system. There are different setbacks required depending on the classification of the well as non-potable, private potable, or public potable which vary from 50 to 200 feet. See some of the setbacks listed below.

**Water bodies**, like wells, must be protected against any contamination to protect people as well as animals from disease. Water bodies are generally any body of water that remains for longer than 72 hours after a storm event. It could be a pond, a lake, a ditch, a stream, a depression, anything that holds water, etc.

**Potable water lines** are also to be protected from any possibility of contamination. The typical setback requirement for potable water lines is 10 feet. As long as there is pressure in the water line, there is no possibility of contamination. However, when the pressure drops, for any reason, there is a risk of contamination.

**Buildings, building foundations, building pilings, swimming pools, and mobile homes** cannot be located within 5-10 feet of septic systems.

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**Roads and driveways** cannot be located over any portion of the drainfield. However, they can be located over a septic tank provided the lids and manhole covers rated for traffic loads are used.

While setbacks vary from state to state, some minimum setbacks are similar as can be seen below:

| | Florida | Indiana | Texas |
|---|---|---|---|
| Buildings, swimming pools | 5 ft | 10 ft | 5 ft |
| Property line | 5 ft | 5 ft | 5 ft |
| Ponds, lakes, streams | 75 ft | 50 / 25 ft | 50 ft |
| Storm sewer | 5 – 10 ft | | |
| Water lines | 10 ft | 10 ft | 10 ft |
| Wells | | | |
| Private | 75 ft | 50 ft | 50 ft |
| Public | 100 ft | 100 ft | 50 ft |

While many setbacks are similar from state to state, you must know the state's codes and comply with them in your design.

**Step 6: Drainfield Configuration.** Now that you know your required drainfield size, and have located an area on the property that will meet all of the setbacks for the system installation, you can design your system configuration.

***Step 6: Sample Project Design - Drainfield Dimensions:*** *For our calculated 656 square foot drainfield and using a gravity system with a trench drainfield design and using an Infiltrator Equalizer 36 style chamber (each chamber has a*

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*state-approved **equivalent area** of 12.0 sf in our project's state), we can make the following calculations:*

*Drainfield size = 656 square feet*

*Chambers needed = 656 sf / 12.0 sf = 54.7 => 55 chambers*

*Water Table = > 24 inches below drainfield bed*

*Trench width = 2.0 feet*

*Trench length = 76.0 feet*

*Trench separation = 2.0 feet*

*Number of Trenches = 3*

*Overall size = 10.0 ft x 76.0 ft*

*Overall area = 760 square feet*

*By using 5 trenches, we can have an alternate configuration as shown below:*

*Drainfield size = 656 square feet*

*Chambers needed = 656 sf / 12.0 sf = 54.7 => 55 chambers*

*Water Table = > 24 inches below drainfield bed*

*Trench width = 2.0 feet*

*Trench length = 44.0 feet*

*Trench separation = 2.0 feet*

*Number of Trenches = 5*

*Overall size = 18.0 ft x 44.0 ft*

*Overall area = 792 square feet*

*Either of these configurations is completely acceptable. The configuration will typically be determined by the site constraints and setbacks.*


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Some of the different septic chambers available are shown below. For more information on the Infiltrator line of products, visit www.infiltratorsystems.com. Similar products are also available from Hancor at www.hancor.com and Cultec at www.cultec.com.

**Infiltrator**

**Hancor**

**Cultec**


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**Step 7: Septic Tank Outlet Filter.** The only thing remaining to be designed in our septic system is the septic tank outlet filter. The use of an approved outlet filter device is required in most states and its purpose is to protect the drainfield. The outlet filters are installed within or immediately after the last septic tank or the last septic tank chamber. The outlet filter devices must be placed so as to allow access to the filter for routine scheduled maintenance. Typically, the routine maintenance consists of flushing the filter with fresh water to wash any solids back into the septic tank. The installation and sizing of the outlet filter must be in accordance with the manufacturers' recommendations.

> ***Step 7: Sample Project Design – Outlet Filter:*** *Our sample septic system design has an estimated flow of 590 gallons per day. We will use the specifications provided by the manufacturer to select the appropriate outlet filter for our doctor's office. For this exercise, we will use a filter manufactured by Zabel Industries. From their product catalog we find the following:*
>
> *Estimated daily flow = 590 gpd*
>
> *Selected filter = A1800-4x18-30142-68*
>
> *Product maximum daily flow = 800 gpd*

For more information on the Zabel line of products, you can visit their website at: http://zabelstore.stores.yahoo.net

Step 7 completes the design aspect of a gravity septic system. However, we often find we can't install the septic system "downhill" from the building. So what do we do then? How do we handle those instances when the drainfield elevation is higher than the building or the septic tank? The answer is a pumped system or a mounded system.

**ALTERNATIVE SYSTEMS:** Some alternative systems use sand or plastic media instead of soil to promote wastewater treatment. An alternative system is any approved

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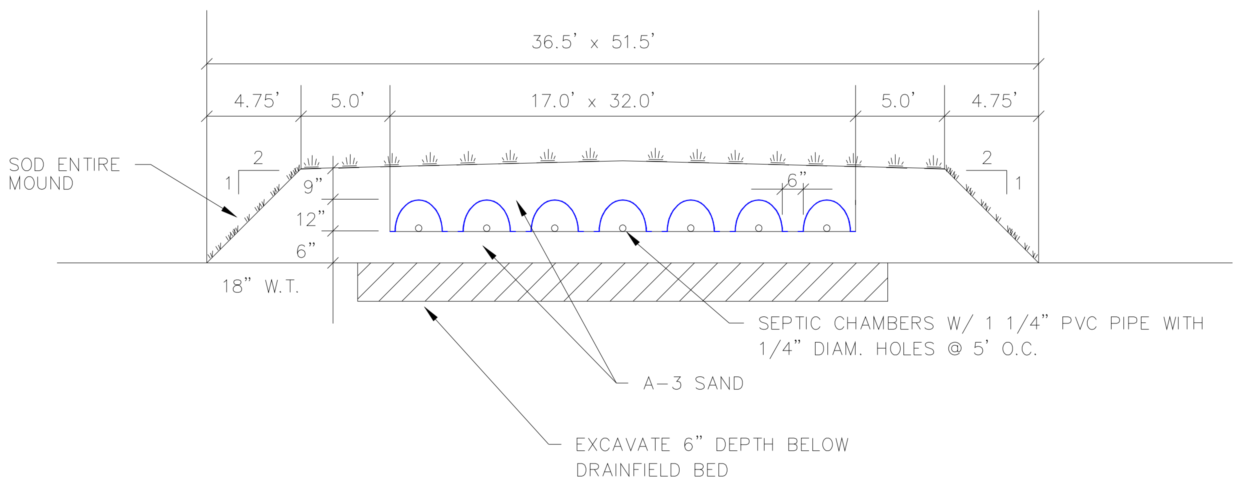
onsite sewage treatment and disposal system that is used in lieu of, including modifications to, a standard subsurface system.

A mounded system is the typical "alternative system". It is used whenever the conditions for a standard subsurface gravity system are not feasible or practical due to site specific conditions. These conditions may simply be a high seasonal ground water table such that the 24-inch separation from the bottom of the drainfield cannot be achieved. A pumped system involves using one or two small effluent pumps to force the septic effluent to a drainfield at a higher elevation or at a distance too great to reach by gravity flow from the building.




LOW PRESSURE SEPTIC SYSTEM DRAINFIELD
N.T.S.

In coastal regions, because of the low lying elevations along the coastal areas and along the many rivers and lakes, a mounded septic system is quite common. In a mounded system, the drainfield is built up from the existing ground elevation rather than placed below ground. Typically, the top six inches of the existing ground surface is excavated to remove the organics that may impede the percolation rate of the drainfield.

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Then good clean "drainfield soil" or fill is brought in and built up to the elevation that provides the minimum 24-inch separation to the seasonal high water table. The drainfield is constructed such that a minimum 4 feet separation between the shoulder of the fill and the nearest trench or absorption bed sidewall. However, a 5-foot shoulder is typically provided such that no code violation exists if portions of the shoulder are eroded during the construction and prior to the final inspection.

The drainfield system is then installed and covered with a minimum 6-inch cap up to a 12-inch soil cap. Typically, the mound will have a 12-inch cap at the center and reduce to a 6 to 9-inch cap at the outer perimeter of the shoulder. This provides good drainage flow off of the drainfield during storm events. The drainfield shoulders are sloped to the existing ground elevations at a 2:1 sideslope (2 foot horizontal to 1 foot vertical) or a 3:1 sideslope if the mound is greater than 36 inches above the existing ground elevations. The soil cap and shoulders are then sodded with grass to prevent any erosion of the drainfield cap or shoulders.

**Mounded System Design:** A mounded system is designed the same as the gravity system for Step 1 through Step 3 but with the additional step of adding a pump tank or "dosing tank" as it is sometimes called. In Step 3 above, we mentioned the sizing of the pump tank is obtained from the same Table II as is the septic tank.

***Step 3: Sample Project Design - Septic & Pump Tank Sizing:*** *Since Steps 1 and 2 are the same as for a gravity system, we begin with **Step 3**. Using our doctor's office example, we know our Average Sewage Flow is 590 gpd. Then from Table II, we find the following:*

*Average Sewage Flow = 590 gpd*

*Minimum Septic Tank size = 1,350 gal*

*Minimum Pump Tank size = 600 gal*

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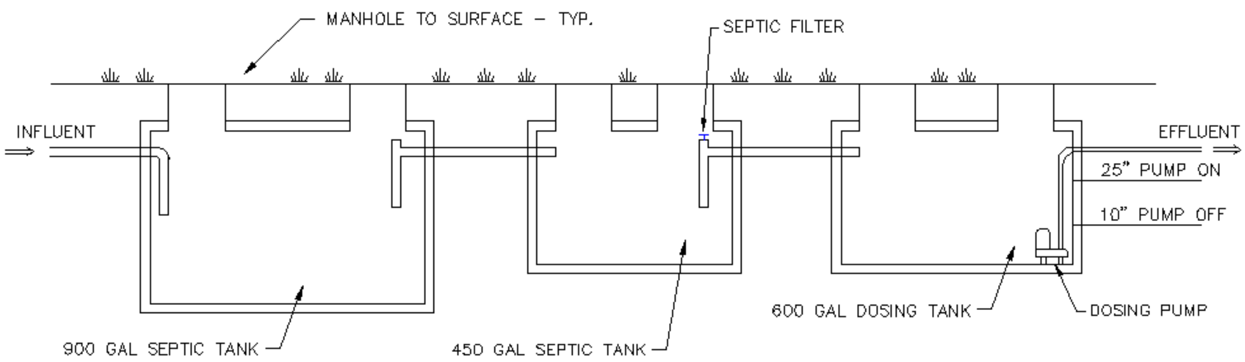
Since this is a commercial business, the larger pump tank size is required which is found under the “Commercial” column. And, if this was for a residential use, the pump tank size would be 450 gallons.




SEPTIC TANKS SECTION

**Step 4: Determine Sewage Loading Rate.** As we mentioned, the Sewage Loading Rate is different for a mounded system. For a mounded septic drainfield, Florida’s chart is shown below. Once again, the type of drainfield will be either a trench design or a bed design. The percolation rate of the soil is still the primary indicator as to the type of soil being used. The loading rates will vary from 1.00 to 0.40 gallons per square foot per day.

| Fill Material | Maximum Sewage Loading Rate to Mound Drain Trench Bottom Surface in gallons per square foot per day | Maximum Sewage Loading Rate to Mound Absorption Bed Bottom Surface in gallons per square foot per day |
|---|---|---|
| Sand; Coarse Sand; Loamy Coarse Sand | 1.00 | 0.75 |
| Fine Sand | 0.80 | 0.65 |
| Sandy Loam; Coarse Sandy Loam; Loamy Sand | 0.65 | 0.40 |

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***Step 4: Sample Project Design - Sewage Loading Rate:*** *Assume the imported fill for our septic mound has soils that are a Fine Sand. Then from the chart above, we find the following:*

*Sewage Loading Rate:*

*Trench Loading Rate = 0.80 gal per sq ft per day*

*Bed Loading Rate = 0.65 gal per sq ft per day*

***Step 5: Sample Project Design - Drainfield Sizing:*** *For our office's calculated Average Daily Flow of 590 gpd and using the Bed Loading Rate for our mounded drainfield, our calculations would look like the following:*

*Average Daily Flow = 590 gpd*

*Sewage Loading Rate = 0.65 (from chart for moderately limited soil in trench)*

*Drainfield Size = 590 gpd / 0.60 = 908 square feet minimum*

*The drainfield must be at least 908 sq.ft. in size but it can be larger depending on the engineer's design.*

**Step 6: Drainfield Configuration.** Now that you know your required *minimum* mounded drainfield size, you can begin designing your system configuration.

***Step 6: Sample Project Design - Drainfield Dimensions:*** *For our calculated 908 square foot drainfield and using a gravity system with a bed drainfield design and using an Infiltrator Equalizer 36 style chamber, we can make the following calculations:*

*Equalizer 36 specs = 22 inches W x 48 inches L x 12 inches H w/ 12.0 sq.ft. equivalent area per chamber**

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*Drainfield size = 908 square feet (calculated above)*

*Chambers needed = 908 sf / 12.0 sf = 75.6 => 76 chambers*

*Water Table = 24 inches (measured at site)*

*Lateral width = 1.83 feet**

*Lateral length = 52.0 feet (13 chambers at 4.0 feet per chamber)*

*Lateral separation = 0.50 feet*

*Number of Laterals = 6 (determined by overall size)*

*Overall size = 32.0 ft x 69.5 ft (including shoulders & sideslopes)*

*Overall area = 2,224 square feet (including shoulders & sideslopes)*

* *From manufacturer's State-approved specs*

Now that we have our drainfield bed sized, we need to set the number of effluent doses the drainfield will receive each day. Since effluent is pumped to the drainfield, we must take care to not "blow out" the drainfield. In a gravity system, the effluent drains to the drainfield where the effluent percolates through the soil. However, if the flow is greater than the percolation rate, the sewage backs up into the tanks and into the house to the point that the toilets will no longer flush. When that happens, you stop using the toilets and call a plumber. However, in a pumped system, once the drainfield reaches it maximum holding volume something bad happens. Since the pumps don't know the drainfield has reached its limits, it will continue to pump until the effluent level in the pump tank drops to the "pump shut-off level". When the pump continues to send effluent after the drainfield has reached its maximum capacity, the pressure builds until it finds a weak point in the mound and an eruption occurs spewing raw sewage onto the ground. When this happens, a public health hazard exists and the Health Department must be notified and a repair permit issued.

So, to prevent this from happening, we pump a specified amount of effluent (a dose) to the drainfield a certain number of times each day to allow time for the effluent to percolate into the soil before receiving the next dose. The number of doses per day


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must be between a minimum of two and a maximum of six. The percolation rate of the soil will determine the safe number of doses the drainfield can process daily.

**Step 7: Dosing Pump Calculations.** Since the size of the pump tank has been determined, you can begin calculating the number of doses and pump run times. As we stated, the number of doses per day must be between two and six. However, we want a pump run time of about six to 12 minutes. Too short of a run cycle is hard on the pump and too long a run time could exceed the drainfield capacity.

***Step 7: Sample Project Design – Dosing Pump Calculations:*** *For our calculated 590 gpd flow, we'll start our calculations by using 2 doses a day:*

*590 gpd / 2 doses a day (trial) = 295 gallons per dose*

*295 gallons / 6 minutes = 49.2 gallons per minute (Pump Rate needed)*

*295 gpd * 0.1337 cu.ft./gal = 39.44 cu. ft. (effluent volume)*

*39.44 cu.ft. / 31.89 s.f. (area of 600 gal tank) = 1.24 ft (tank height for volume)*

*1.24 ft * 12 in/ft = 14.8 inches (pump operating range)*

*So we need to provide an effluent pump capable of pumping 49.2 gallons per minute for 6 minutes. And the pump floats inside the pump tank need to be set at an operating range of 14.8 inches.*

*Checking our drainfield volume using the calculations for our Equalizer 36, we end up with an effluent depth of:*

*1.83 ft width * 52.0 ft length * 6 laterals = 571.0 sf*

*39.44 cu. ft. / 571 sf * 12 in/ft = 0.83 inches (depth of effluent in bed)*

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*So, our drainfield is protected with an effluent depth of approximately 1 inch over the drainfield.*

*Alternatively, running through the same calculations but using 3 doses per day will provide the following results:*

*590 gpd / 3 doses a day (assumed) = 197 gallons per dose*

*197 gallons / 6 minutes = 32.8 gallons per minute (Pump Rate needed)*

*197 gpd * 0.1337 cu.ft./gal = 26.34 cu. ft. (effluent volume)*

*26.34 cu.ft. / 31.89 s.f. (area of 600 gal tank) = 0.83 ft (height for volume)*

*0.83 ft * 12 in/ft = 9.9 inches (pump operating range)*

*So, in this design, we need to provide an effluent pump capable of pumping 32.8 gallons per minute for 6 minutes. And the pump floats inside the pump tank need to be set at an operating range of 9.9 inches. And since our drainfield area hasn't changed, we have a drainfield effluent depth of approximately one half inch each cycle.*

## LOW PRESSURE SYSTEMS

Low pressure systems provide the most efficient means of dosing a drainfield since it distributes the effluent evenly across the entire drainfield. Standard gravity flow or pumped systems tend to saturate the drainfield at the point that the effluent first enters the drainfield and the remaining areas of the drainfield may only occasionally receive doses of effluent. The system consists of a network of 2 inch or smaller diameter schedule 40 PVC pipe with 1/2 inch or smaller diameter holes drilled at a specified spacing.

As stated, the network must be designed for equal distribution of effluent which means that the flow from the least effective hole in the network must deliver no less than 75% of the flow from the most effective hole. A pipe is located in the center of each lateral or

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trench and terminates at the end of the lateral or trench and cannot be looped with the other lines regardless of whether the drainfield is a bed or a trench or in a mound.

The holes in the pipes are placed up to allow the effluent to be sprayed onto the septic chambers and then run down the sides to the bottom. This provides a means to distribute the effluent evenly and avoid erosion issues with the spray being directed into the soil.

In no case can a single drainfield exceed a total of 1500 square feet. If two or more beds are required, there must be a minimum 10 foot separation between the two beds and there must be two pumps... one pump serving a single drainfield bed. As previously stated, the drainfields should be designed to achieve the maximum length to width ratio that the site will permit.

***Sample Project Design:***

*For the purpose of designing a low pressure system, we will assume we have a project requiring 1200 gpd and needing a 1,846 sf drainfield utilizing a low pressure system. The system consists of 2 drainfields in a bed design with 16 laterals that are 20.0 feet in length and is located 60 feet from the dosing tank with a rise of 7 feet from the elevation of the low water level in the pump tank to the elevation of the drainfield.*

***Step 9: LP System Design:*** *The design becomes one of trial & error to determine the best design by changing the number of doses per day, the distribution piping size, the distribution piping hole sizes and spacing, and the force main piping size.*

*1200 gpd / 2 drainfields / 2 doses a day (assumed) = 300 gallons per dose*

*Try a 1.5 inch pipe network:*

*Computing pipe volume per foot* = $\pi d^2 / 4 * 12 / 231 = 0.092$ gallons per ft

*Computing network volume = 0.092 gpf * 16 laterals * 20.0 ft = 29.4 gal*

*Dose: Pipe Volume Ratio = 300 gal / 29.4 gal = 10.2 : 1 (ideal is 13 : 1)*


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*Our pipe network checks since we are close to the 13:1 desired ratio. So now you can determine the force main size and the pump specifications:*

*Try 1/4" holes spaced at 4 foot on center using a 3 inch force main:*

*Holes per lateral = 17.75 ft / 4 ft = 4 holes*

*Gallons per hole = 300 gal / 16 laterals / 4 holes per lateral = 3.8 gal/hole*

*A 1/4" hole with 2 ft of head = 1.04 gpm (Bernoulli's equation)*

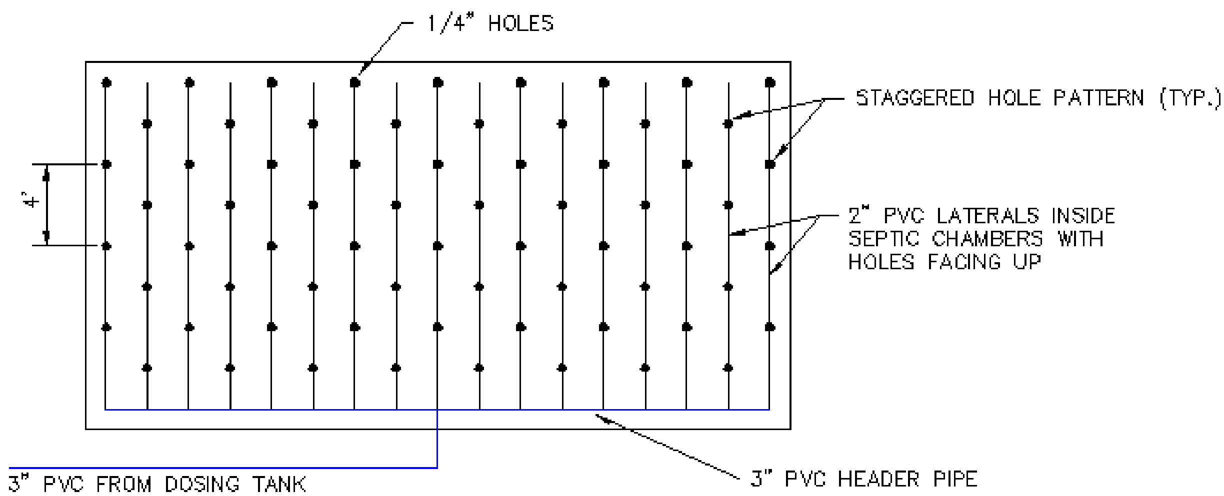
*Pump run time = 3.8 gal/hole / 1.04 gpm = 3.61 minutes*

*System pump rate = 300 gal / 3.61 min = 83.1 gpm*

*System head for 3" force main = 7' elev + 2' static + 2.95' pipe head loss*

*= 11.95 ft total head*

*So using a 3" force main, we need to supply a pump that can deliver 83.1 gpm at 11.95 ft head. Our design now looks like the following:*




LOW PRESS. DRAINFIELD PLAN

NOT TO SCALE

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*If we needed to increase the system pumping head, we could do so by changing to a 2" force main from the dosing tank and our system head would increase to 35.04 ft.*

Again, these design calculations become a series of trial and error to match up the pipe sizes, hole sizes & spacing, and number of doses to determine the most practical system that will fit on the site and function as designed.

## AEROBIC TREATMENT UNITS

**Aerobic Treatment Units (**ATUs) have a special place in on-site waste treatment because of the additional treatment provided by them. Aerobic systems use air injected into the effluent to provide aerobic biochemical stabilization within the treatment unit tank prior to it being distributed in a drainfield. Some states will allow the size of the drainfield to be reduced when the use of an aerobic system is included as part of the septic system design. This may allow for the development of a site that doesn't have the required area for a conventional septic system.

In many cases, an aerobic treatment unit is used to upgrade a failed or failing septic system. Other situations in which an ATU may be needed include sites with poor soil conditions, sites with limited useable land area, high groundwater tables, or the need for an ATU because of adjacent environmentally sensitive areas.

There are a number of manufacturers for aerobic systems, but they all have the same common features. These include pretreatment to reduce the amount of clogging solids, an aeration process, settling for suspended growth systems, and final treatment. The most common kind of aerobic system available is the suspended growth type. In this type, air is forced into an aeration compartment in which the bacteria are suspended in the effluent. Another method is the attached growth type in which an artificial surface is used for bacteria to grow. This bacteria coated surface is then sprayed or dripped with the effluent for treatment.

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There are a number of manufacturers of the aerobic treatment units. Some of them are Aqua Klear, Biomicrobic, Clearstream, Delta, Mighty Mac, and Multiflo. Simply use the design flow to find an aerobic system with that capacity in the manufacturer's specs. Then ensure the unit is approved for the state that it will be installed.

## SUMMARY

As we have seen, there are three basic septic system types. They are the gravity system, the mound system, and the low pressure system. The type of system selected will be dependent on the site characteristics, soil types, water tables, and the required flows. It is therefore, mandatory that the site be evaluated for soil, vegetation, water tables, and elevations.

The typical septic system will include one or more septic tanks (either in series or baffled), an effluent filter, and a drainfield. If the system has elevation differences to overcome, a pump tank and force main will be required. For larger systems or where it is important to have an evenly dispersed effluent over the drainfield, a low pressure system may be required.

An aerobic treatment unit may be needed if there is a limited area available for a septic drainfield or if a higher quality effluent is needed because of site environmental concerns.

Remember, this course was developed using codes and tables from various state Health Department codes, but each state has their own code which was developed for their particular environment. For that reason, you must ensure that you use the latest code for the location where the system is being installed and use approved materials and products for that state.


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