Welcome to the first of its kind self-paced course in Title 5 ! First, dispensing with the paid announcements, I would like to note that the course materials were developed under a grant from the Federal 319(b) Program, administered by the Massachusetts Department of Environmental Protection and awarded to the Barnstable County Department of Health and the Environment. The idea of the course came from you, Board of Health members and interested individuals at large who, due to busy schedules and a desire to learn the world of on-site septic systems, wanted a pace-yourself way to learn in the comfort of your own home.

As you work your way through the different course modules (there will be six in all), you will be exposed to a variety of aspects of Title 5 from basic components of a Title 5 system, to the myriad of regulations Boards of Health are charged with enforcing. Reference materials used will generally be indicated, as will their availability. The course relies heavily on materials produced by DEP including the "TRAINING MANUAL FOR THE STATE ENVIRONMENTAL CODE, TITLE 5", and what has come to be known as the "DeFeo and Wait" report, but you will also be introduced to a wide variety of resource material from different states.

The focus of this course is to teach the principles behind the code, by presenting them in an interesting, and sometimes humorous way. The primary authors of the course are George Heufelder, Environmental Program Manager for the Barnstable County Department of Health and the Environment, and Susan Rask, who has served in various positions from sanitarian to project assistant with the Department. In addition to working for "County Health" each of these individuals has served as Chair of their local Board of Health (Falmouth and Barnstable respectively) and presently still serve on their Boards. This course is dedicated to those individuals who serve on Boards of Health who in their tenure give countless hours of community service.

The course consists of informational "modules" followed by a self test. When you have completed the test module, you can take the self test at the end of each module or, in some instances test questions may be scattered throughout the module. **Very Important !** This course is still under development. The goal is to serve your needs. ***Please*** let us know your comments so that we can incorporate them into future revisions.

So, find a comfortable chair and a cup of your favorite beverage and begin. We sincerely hope that this will be a worthwhile time for you as Board of Health members.

MODULE 1
Introduction to Components of a Title 5 System and Their Function.

First Things First - What Actually *is* Wastewater?

As we begin our tour through the land of onsite wastewater treatment, it is beneficial to give some initial attention to the characteristics of the wastewater that we hope to treat with our subsurface systems. Ideally, septic systems only receive wastes that are biodegradable. By this we mean substances that are subject biological breakdown (breakdown by living organisms). The primary organisms responsible for the breakdown of our wastes are bacteria, however other organisms such as protozoa and fungi also play a vital role in some of the breakdown processes.

Some of the substances which make their way into the average septic system include toilet wastes (feces and urine), paper, hair, skin cells, soaps, greases, food, grit (inorganic inert sand and dirt), cosmetics, cleaners, plastics (hopefully not much since plastics are essentially non- biodegradable), etc. Among the biodegradable items mentioned, each has a different level of degradability. Food material and feces, for instance, degrade fairly quickly in a septic tank, while some of the constituents of paper products, such as lignin, take much longer. Presently, the majority of these solid and semi-solid wastes are carried to the septic systems by the largest constituent of wastewater - water itself.

The earliest septic system designs focused primarily upon the biological components of wastes that are responsible for the transmission of human disease. These components, collectively called ***pathogens***, are primarily made up of bacteria, viruses, and protozoa. In the mid-1800's, a British physician by the name of John Snow did a pioneering epidemiological study that linked the recurrence of a cholera epidemic with a public well that was contaminated by privy vaults. About that time, our own Lemuel Shattuck (first head of what is now the Department of Public Health), in his 1850 "report of the Sanitary Commission of Massachusetts", suggested that local Boards of Health be formed and charged with making rules and regulations for "for the construction and management of sinks, ashpits, cesspools, drains..." recognizing the connection between correct handling of human wastes and community sanitation. These and other parallel events paved the way for requiring measures that began to keep sanitary wastewater away from points of human exposure. Still, at this point, understanding of "germs" and their role in the transmission of disease was pretty crude. It would be nearly twenty five years before bacteriologist like Louis Pasteur and Robert Koch would unveil some of the mysteries behind bacteria and their role in disease transmission. Enough of that, and on to the characteristics of wastewater that we should understand.

The classes of contaminants in wastewater are summarized below. Although their concentrations or levels may vary from commercial uses such as restaurants to residential uses, the two waste streams are treated essentially the same with one exception. Restaurants, and other establishments that might be expected to generate significant quantities of grease, have additional septic system components that will be described later.

Contents of Wastewater

Pathogens - Bacteria , Viruses, Protozoa, Helminths, Nematodes, and Fungi. The occurrence of pathogens in sanitary wastes fluctuates widely and depends on the state of health of the individuals. Since this is always changing within the population as diseases go through occurrence cycles, public health officials have had to base their strategy of treatment on worst possible case scenarios. Potentially, there are over 100 types human intestinal viruses as well as a wide range of bacterial pathogens that could occur in wastewater. Bacterial pathogens found in sewage can cause food poisoning, typhoid fever, strep throat, dysentery, and other intestinal disease. Perhaps the most pervasive of the pathogens are viruses since they are the smallest and most difficult of the class of pathogens to detect and remove from wastes. The World Health Organization recommends that concentrations of viruses not exceed one per 1,000 liters at points of exposure. Accordingly, a reduction of seven orders of magnitude (to one ten millionth of the original density) are necessary to render wastewater harmless in regard to viral pathogens. The remaining classes of pathogens: protozoa, helminths, nematodes, and fungi, play relatively minor roles in disease transmission where subsurface disposal practices are reasonably prudent.

> *TRIVIA TIME*
>
> ***How many viruses can dance on the head of a pin ? -*** Over 3 million ! If you blew a virus up to the size of a bb, the equivalent "passage" size of a medium sand would be about 12 ft wide ! and 4 ft of sand passage would be the equivalent of travelling over 40 miles.

Biochemical Oxygen Demand ($BOD^{5\text{-}day}$) - Biolochemical Oxygen Demand is a general measure of sewage strength. 5-Day BOD is actually the amount of oxygen consumed by organisms that are breaking down organic wastes in a span of five days (the test was developed in England where the maximum stream flow was five days, so that was all they worried about). Although not a contaminant per se, it is a fairly good predictor of how a leaching field will perform. This is because at some point the "demand" for oxygen by septic tank effluent exceeds the ability of leaching field-soil interface to supply oxygen fast enough to allow the waste to breakdown. As the waste accumulates, it builds a biological mat to the point where water can not pass through and into the soil. Moreover, at this point, anaerobic conditions develop which further retard the organic breakdown. BODs from average households range from 150-350 mg/l, while restaurants have a wider range and typically higher BODs.

Total Suspended Solids (TSS) There is a variety of particulate matter in sewage such as bacteria, organic debris, silt and complexed metals. While much of these settle out in the septic tank, very small colloidal particles do not and thus pass through to the leaching facility. Effluent filters can be used to reduce TSS in the septic tank effluent and are a good investment, however some TSS will always get through the tank to the leachfield. Like BOD, TSS can be a good predictor of leaching facility performance. If the solids build up in the leachfield, they form an impervious layer through which the effluent will not pass.

Miscellaneous dissolved inorganic materials - Phosphates, nitrates, ammonium, chlorides, sodium, heavy metals. There are a variety of final products of septic tank effluent disposal that may vary in their level of impact on the environment. Ammonium, for instance, quickly converts to nitrate in our Cape soils and renders drinking water resources impotable relative to the Drinking Water Standards. In addition, dissolved inorganic nitrogen is a growth stimulant for marine ecosystems and may cause noxious conditions in poorly-flushed marine environments. Phosphorus, in the form of orthophosphate may cause similar problems in freshwater environs.

The Caveman and Title 5

From the time of the first cave drawings to approximately the 6th century BC., little is known about methods our ancestors used to dispose of sanitary wastes. One might guess that at the dawn of mankind, the initial concern for what today we consider "proper" sanitary waste disposal was fairly minimal. But as loose tribes formed into large nations, and centers for trade and commerce developed, methods for carrying wastes away from places where people ate and slept began to emerge if for no other reason than that of offensive odors. In the 6th Century BC, the Romans had a series of open ditches that carried water and wastes to the Tiber River. By the 3rd Century BC, these had evolved into an underground network called the "Cloaca Maxima". Systems to drain wastewater away from houses existed in India, Pakistan and on the Island of Crete during the 2nd Century BC. Some cultural and religious traditions were cautious and intelligent enough to prohibit mixing sanitary wastes with water. Unfortunately however the most common way to dispose of wastes, which emerged and continues today in many parts of the world, is to use water to carry wastes away from living areas. This water is then released back into the environment at some point, with varying degrees of understanding of its public health implication.

The modern-day onsite septic system can probably be said to have its origins during that same period of time that has given us prized literature and art - the Renaissance. It was during this period that the ***cesspool*** was developed. This was a simple pit into which sanitary waste flowed or was dumped, which allowed the solids to settle out and the clarified liquid to seep into the ground.

Starting off with the right terms

As we continue our sojourn through the land of onsite septic systems and Title 5, it is important to define some of the *basic* terms you will see used. Many of these terms you may have heard used or misused in the context of Board of Health meetings. As they are presented here, the definitions are those commonly accepted among engineers and sanitarians who design systems for handing sanitary wastes. Title 5 presently contains over 125 definitions which are presented in Section 15.002 Definitions, and you should refer to these when you are in doubt for legal purposes. The following, however are common and basic terms that are often misused.

cesspool - a pit with open-jointed linings or holes in the sides and/or bottom into which raw or untreated sewage flows. Solids remain in the pit and undergo some digestion, while the effluent leaches into the surrounding soil. Cesspools may be made of precast concrete, individual brick or block, steel, stones.[1]

[1] Legal definition for this term is included in Title 5 Section 15.002 Definitions.

leaching pit, leach field, leaching trench, leach bed, leaching gallery, leaching chamber - terms describing structures in a septic system that receive water and allow it to filter into the surrounding soil. They receive the clarified effluent from, and are always preceded by, a septic tank. The words "bed", "chamber", "field", etc.. refer to their shape and positioning and will be described in detail later.

Sewage - This term is often confused with septage, however sewage is the untreated sanitary waste discharge from a building. It contains feces, urine, washwater, laundry wastes and anything else that makes its way into a toilet, sink or bathtub in the building.

Septage - This term is often confused with sewage, however it describes the material that is in the septic system itself. I know it seems like splitting hairs, and in the case of a failed septic system that is getting pumped every other day, sewage and septage might approximate each other in composition, but septage ideally contains some stabilized wastes that have undergone some treatment in the septic system component. As you will see later, when sanitary wastes are allowed to settle, over time they begin processes of digestion and breakdown. What is left is stabilized (it can not break down any further) wastes. This stabilized waste, combined with greases that have not broken-down, water, and some freshly-introduced material is called septage. As far as Title 5 goes (refer to definitions section of Title 5) - septage is just about anything that is physically removed from any part of an on-site system (except hazardous wastes). The point we would like to make here is that, in most cases, septage has widely varying chemical characteristics from sewage. In general it is more concentrated in certain components of the waste, and contains a higher portion of stabilized material.

Septic Tank - Again, there is a legal definition, but essentially septic tanks are watertight structures that receive sewage from a building. They are designed to allow for the settling of solids, the separation of the less dense greases, anaerobic digestion of wastes, and allow for the discharge of a clarified (not to be confused with real clear or pure) effluent to the leaching facility (pit, chamber, bed, field etc.).

Title 5 System - commonly misused to describe anything from cesspools in series configuration to the real thing - an onsite system designed and installed in accordance with 310 CMR 15.00 THE STATE ENVIRONMENTAL CODE, TITLE 5: STANDARD REQUIREMENTS FOR SITING, CONSTRUCTION, INSPECTION, UPGRADE, AND EXPANSION OF ON-SITE SEWAGE TREATMENT AND DISPOSAL SYSTEMS AND FOR THE TRANSPORT AND

DISPOSAL OF SEPTAGE. Some confusion has been added to this term since the recent revisions to the Title 5. This term may also be used to describe systems installed under what is now referred to as the 1978 Code (also called Title 5), since, if there is no increase in flows from an existing building that has such a designed system, and the system is not failing by other criteria as set forth in the revised code, they are in compliance. An essential component of a complying Title 5 system is that there is an engineered plan, and proper documentation that the system has been installed in accordance with the plan and inspected prior to burial, by a Board of Health member or its agent.

Invert - By the official definition, an invert is "the lowest portion of the internal cross section of a pipe or fitting". When you look at any Title 5 plan, you will see references like "Invert El" (elevation). This simply means the lowest elevation of the pipe entering or exiting a structure. The inverts of a septic tank are labeled below, but there are inverts on all major components of a septic system.

Step 1 in the Treatment Process - The Septic Tank

Title 5 defines a septic tank as - "A watertight receptacle to receive sewage from a building sewer which is designed and constructed to permit sufficient retention of wastewater to allow for the separation of scum and sludge and the partial digestion of organic matter before discharge of the liquid portion to a soil absorption system". But what really happens inside the septic tank that makes it so important ? Why are there setback requirements for septic tanks if they are "watertight"? What should I, as a Board of Health member look for and think about as I am asked to vote on variances relative to septic tanks? These and other questions will be answered below, beginning first with some fundamentals about septic tank design and performance.

Before the Septic Tank

While the septic tank is officially the first step in the actual treatment of sanitary wastes, we would like to mention that the Board of Health should take every opportunity to encourage individuals to think about what they actually put into the septic system. When septic systems fail, it is generally either the volume or the characteristics of the solid material coming from drains and toilets that caused the problem. Although the increased size requirements for septic tanks under the new code revisions can compensate for some lack of attention to the following items, there are at least three factors, under the control of the homeowner, which can affect the performance of the septic system[2]:

> WATER FLOW - all reasonable attempts should be made to reduce flows to the septic system. Decreases in flow increase the retention time of wastewater inside the septic tank and increase the treatment level. Low flow toilets, which are now part of the plumbing code, and water-saver fixtures should be used or retrofitted where possible. Faucets and toilets should be in good repair and not leaking.
>
> VOLUME OF SOLIDS - All attempts should be made to reduce the introduction of solids that can be disposed of otherwise. No, we are not suggesting visits to the outhouse. We are merely suggesting that facial tissues, tampons, cotton swabs, cut hair, bandage material, and other bathroom vanity wastes be disposed of in a trash basket kept conveniently by the sink or toilet. Paper, with its lignin content, is particularly difficult to break down in a septic tank. In addition, kitchen wastes from plates should be scraped clean into a wastebasket prior to washing, and drain strainers should be used and emptied into the trash basket regularly. Grease is particularly difficult to break down in a septic tank and its introduction to the system should be minimized. Vegetable wastes can be composted.
>
> TOXICS - The septic tank, as we will see, is a biological digester of our wastes. If material toxic to the decomposing bacteria is introduced, the biological processes will be impeded and the septic tank will not function. Excessive bleach (household quantities necessary for laundry are generally not a problem) harsh cleaners, solvents, pesticides and the like can "kill" the septic tank. The result can be failure to retain solids, excessive sludge buildup and subsequent failed leachfields.

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[2]The Cape Cod Cooperative Extension has produced a booklet describing these measures entitled "Your Septic System" that may be obtained from them.

Septic Tanks - What Happens in There Anyway ?

Despite the popular misconception that a septic tank is merely for the settling of solids, the fact is that the septic tank is a living biological community that, if operating properly, actually treats, digests and transforms wastes. The term "Septic Tank" was coined in 1895 when Donald Cameron, a British sanitation engineer, installed a water-tight covered basin to anaerobically treat wastes. Incidentally, Cameron later unsuccessfully attempted to collect royalties for his patented design after it was shown that many such anaerobic treatment units had been constructed in the late 1800's at various locations in the United States.

The septic tank is an **anaerobic** digester of wastes. By this, we mean that, what little oxygen gets introduced in wastewater or through venting, quickly gets used up by bacteria and results in conditions lacking oxygen. The primary advantage of an anaerobic treatment of waste over treatment which actively introduces oxygen, is that anaerobic digestion of wastes produces about 10% of the sludge that aerobic conditions produce. This reduces the need for removal and disposal of sludge. Anaerobic conditions in the septic tank also produce methane, which some larger municipal treatment facilities recover to produce energy.

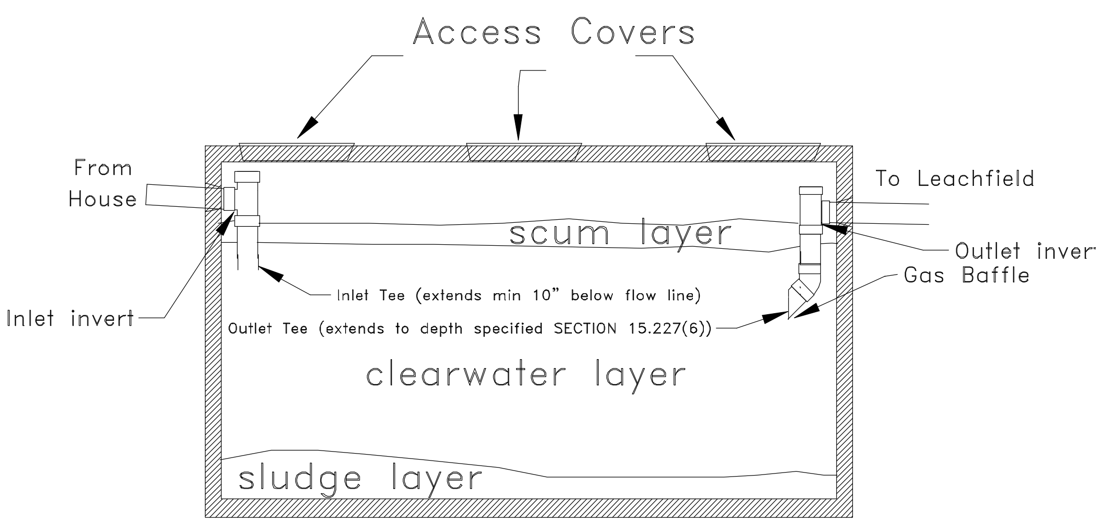
When solids are introduced to a septic tank, a three-step liquification-gasification process occurs. Initially bacteria break much of the organic matter into complex organic acids. This step is called fermentation or hydrolysis. Following another intermediate step where the complex organic acids are broken down to simpler compounds, a final step called alkaline fermentation or methanogenesis converts the simpler compounds to methane gas, carbon dioxide and hydrogen sulfide. These gases exit the system through the vent pipes in the house plumbing. Another by-product of this final process is the ammonium ion (commonly called ammonia) which exits the system with the effluent to the leachfield. Thus nitrogen enters the septic tank as solid and semisolid proteins and other nitrogen-containing waste (food, urea, feces, organic materials) and exits the septic tank primarily in the form of ammonium (NH_4^+).

Now let's look at the requirements for septic tanks in Title 5, and examine the rationale for these requirements. An understanding of these will give us information and tools by which to make decisions on variance requests that may come before our Boards of Health.

The Title 5-Conforming Septic Tank

Capacity and Shape

The revised Title 5 establishes "a minimum effective capacity of 200% of the design flow or a minimum hydraulic detention flow of 48 hours, whichever is greater". It also requires that "In no case shall the effective liquid capacity of the tank as measured below the outlet invert elevation be less than 1,500 gallons". These specifications reflect an increased requirement from the 1978 Code. These increased requirements are obviously an attempt to increase the treatment in the tank by lengthening the retention time. In addition, larger-volume tanks have larger "clearwater" middle layers that are less likely to allow solids to pass through to the field during high pulse loads. Remember that a Board of Health may locally approve smaller tanks (not less than 1,000 gallons) *in the case where a 1978 Code system is being upgraded* or for other reasons where the installation of a 1,500 gallon tank is not feasible during *upgrade (see Section 15.404 (2)(a))*. Tank sizes down to 500 gallons may be allowed in limited conditions.[3]



[3] 15.231 Construction in Velocity Zones and Floodways
(1) No septic tank or humus/composting toilet shall be constructed in a velocity zone on a coastal beach, barrier beach, or dune, or in a regulatory floodway, except a septic tank that replaces a tank in existence on the site as of March 31, 1995 that has been damaged, removed, or destroyed, where the placement of the tank outside the velocity zone or regulatory floodway, either horizontally or vertically, is not feasible. Where reconstruction of a system in existence on March 31, 1995 occurs, or reconstruction of a building or buildings is allowed in accordance with the wetlands protection act 310 CMR 10.00, it shall be presumed to be feasible to elevate the tank if the building is elevated above the velocity zone or regulatory floodway. **Author's note**: This means a 500 gallon tank could be mounted under the house- above ground as was done in Mattapoissett.

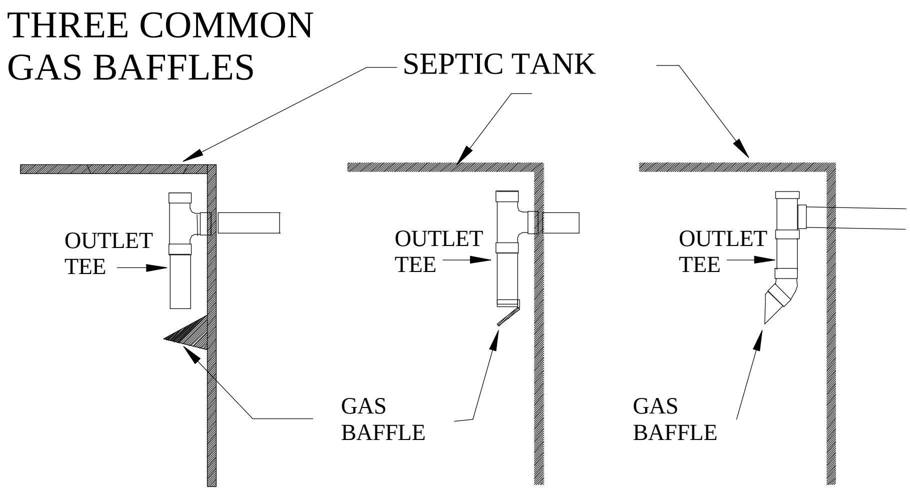
The size and shape of septic tanks and the positioning of their inlets and outlets has profound effect on their performance as anaerobic digesters. The illustration above is a typical septic tank. Outstanding features include three access covers, sanitary tees, and a gas baffle. The access covers serve the obvious purpose of allowing access to the tank for maintenance and inspection. There are two sanitary tees, one at the influent side of the tank (receiving wastewater from the building), and one at the discharge side of the tank to the leachfield. The inlet tee is designed to introduce the building sewage into the tank with minimum disruption of the bottom layer of sludge and the top scum layer in the tank. The outlet tee is designed to allow the passage of relatively clarified effluent to the leachfield, avoiding the passage of grease and scum, which would clog the soil absorption system (another generic name for a leaching field). In addition, the outlet tee prevents the short-circuiting of sewage entering the tank directly to the leachfield.

While other shapes of septic tanks are allowed (See Section 15.223 Septic Tanks), the oblong concrete box type ("tanks which are rectangular in cross section"[4]) is by far the most common. They must have a minimum length to width ratio of 1.5 to 1, an effective liquid depth of 4 feet, have an effective inside width of at least three feet, and have a minimum distance of six feet from inlet to outlet tee.

The Baffling Gas Baffle

A new addition to the code which for a while stymied many installers and engineers alike, is the gas baffle (see Section 15.227 Placement and Construction of Tees). A gas baffle is any arrangement of piping or deflection device that prevents the gasses, rising from the bottom of the septic tank, from entering into the outlet pipe or tee. Actually, it is not the gasses that are the main concern, but solids the gasses may bring with them as they bubble up from the bottom sludge layer. A gas baffle may take a number of forms, from the simple configuration shown on the septic tank drawing on the previous page, to those depicted on the next page. The essential characteristic of a gas baffle is that it prevents the direct passage of solids that are rising with the gasses from the sludge layer from entering the outlet tee. Inspection for the gas baffle is easy on a new installation. If you can see the bottom of the tank through the vertical component of the outlet tee, you don't have an effective gas baffle.

[4] 310 CMR 15.223(3)



Septic Tank - Construction Materials

Although concrete is by far the most common material used to construct septic tanks in Massachusetts, any material approved by the Department of Environmental Protection can be used. Accepted materials include precast concrete, fiberglass, polyethylene, and poured in place concrete. ***Metal septic tanks are prohibited*** (See Section 15.226 Construction of Septic Tanks).

An important aspect of the septic tank construction is a characteristic referred to as its "loading". This refers to the ability of the tank (and other components) to withstand traffic loads without breaking. Two terms are commonly used:

H-10 - standard loading where vehicular traffic is not anticipated.
H-20 - standard loading where vehicular traffic or heavy equipment might pass over.

These terms are also used for any septic system element. It is very important that septic plans identify areas such as reserve parking, driveways and other areas in which it would be reasonable to expect vehicle loads, and to make sure that H-20 loading materials are used beneath them. In case you were wondering - yes H-20 loading elements typically cost more, so there is at least one incentive to locate septic elements away from vehicle areas.

Tanks A Lot ! Special Cases

Multiple Compartment Septic Tanks
Tanks in Series
Pumping to Septic Tanks

There are a few "special cases" related to septic systems that you should at least be aware of. We will cover them in cursory manner here, but the references provided will steer you to the appropriate sections of the code.

Multiple Compartment Tanks - This is somewhat of a misnomer, since Section 15.224 Multiple Compartment Tanks states that "When multiple compartment tanks are used the following shall be required: (1) The number of compartments shall not exceed two;".

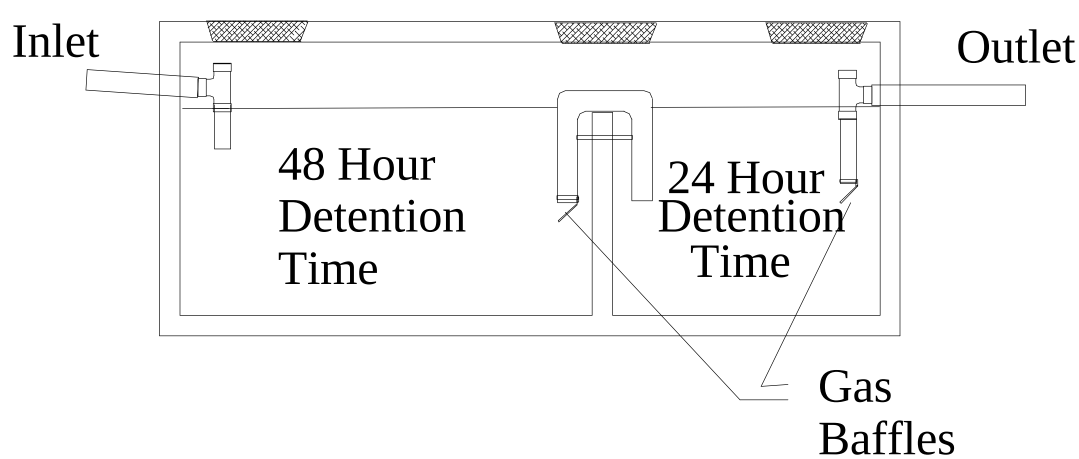
As the name implies, a multiple compartment tank is a septic tank with two or more sectioned off compartments which are interconnected with a 4-inch inverted U-shaped pipe which extends below the scum layer. The outlet tee and the interconnection are fitted with a gas baffle. Multiple compartment tanks (or tanks in series as described below) are required:

1) When garbage grinders are used;

2) When the design to serve facilities other than single family dwellings ***and*** the calculated design capacity exceeds 1000 gallons/day, and;

3) When it is necessary to pump more than 25 % of the design flow from a building *to* the septic tank (See Section 15.229(2)(b) and below)

Two Compartment Septic Tank



For the hydraulic detention times of each compartment, refer to Section 15.224 (2 and 3).

Multiple compartment tanks have the advantage of achieving better settling of solids than single compartment tanks. They do this by providing a more tortuous path for sewage on its way to the leachfield which provides more quiescence or still zones. They can compensate somewhat for surge flow (like when everybody is taking a shower in the morning and there are a few washloads), and prevent short-circuiting of sewage to the leachfield.

Tanks in Series - As the name implies, tanks in series are simply tanks arranged so that the flow of sewage passes through the first tank to the second tank (only two are allowed), prior to discharging to the leachfield. Their purpose and use is similar to multiple-compartment tanks, and their efficacy is also the same. They are similarly an option when garbage grinders are used or flows in excess of 1,000 gallons originate from facilities serving more than a single dwelling unit.

Pumping to Septic Tanks - So, you have a bathroom in the basement and your septic system is "up the hill". How do you get the waste up to the septic tank? With an ejector pump. Yes, ejector pumps can be used to pump sewage **to** a septic tank under certain conditions. Depending on whether the pump is a grinder or non-grinder pump, the receiving tank must be sized appropriately (See Section 15.229(1)(a)(b)). With what you now know about the septic tanks, and the necessity to provide a quiet place for the settling of solids, you might guess that if the ejector pump is a grinder-type (hence making a lot fine-material input to the septic tank), you would want ***more*** time and hence a ***bigger tank*** and less of a flow rate into it compared to the non-grinder-type pump. Congratulations ! you're right ! If a non-grinder pump is used, the flow rate into the septic tank:

"shall be fewer than 60 gallons per minute" and the septic tank "shall have a minimum volume of 1,000 gallons."

If it is a grinder pump, the flow rate into the septic tank:

"shall be fewer than 20 gallons per minute" and the septic tank "shall have a minimum effective volume of 1,500 gallons."

GET IT?

A Final Word About Septic Tanks

Watertight - Very few septic tanks meet the criteria of being watertight. In general, very small leaks will likely seal during the early periods of use. At minimum, an inspector should inspect the grout or seal around all pipes entering or exiting the tank and ensure that they are tight. The seal or midline seam should be installed correctly and have no breaks. If the Board of Health has granted setback approvals or variance for a septic tank, we believe that they should insist upon a clearwater tightness test. This means filling the tank with clean water and observing whether the elevation of the water drops over a reasonable period of time. Better yet, if the tank is not yet backfilled, leaks from the midline seam can be observed directly. If an alternative septic system is involved, more extreme precautions should be employed to ensure against leaks. Most alternative technologies rely on a watertight tank to achieve their performance in removing contaminants. For this, single-piece, or factory sealed tanks should be considered.

Septic tanks and pump chambers installed at elevations below the estimated high groundwater may actually be lifted out f the ground if the groundwater bouys them. Remember to make sure that buoyancy calculations and counterweight measures (if necessary) accompany all plans proposing the installation of tanks below estimated high groundwater to prevent this from happening.

The Distribution Box ("D-Box")

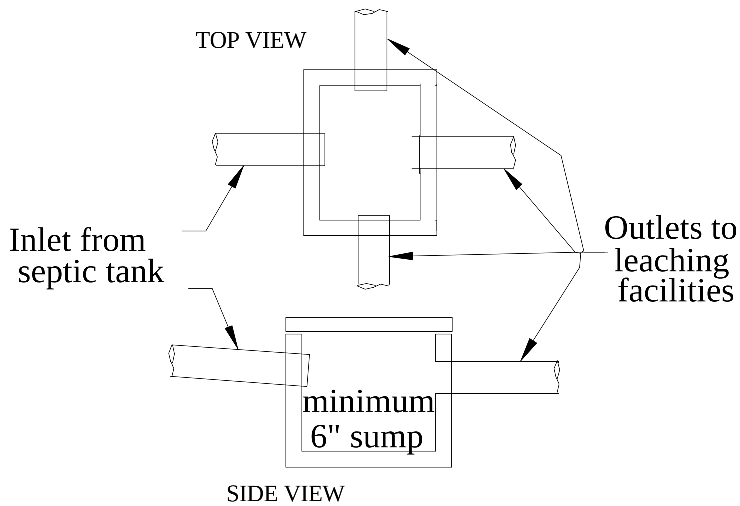
Septic tank effluent is evenly distributed to each portion of the leachfield by a device called a distribution or "D" box. They are described in detail in <u>Section 15.3232: Distribution Boxes</u>. The D-box is positioned between the septic tank and the leachfield or a pump chamber and a leachfield (pump chambers will be covered later). They are simple devices for evenly apportioning flow, but there are some things you should know about them.

Foremost, although they are among the smallest components of the system, they are one of the most important. If flow to leaching facilities (trenches or bed lines) is not apportioned evenly, the effluent begins to "load" one part of the system more than the other. This can cause premature failure of that portion that receives the excess loading, and decrease the treatment of wastes. Because of this, it is **very important that the D-box be installed on an even base and the discharge inverts are checked at the time of inspection.** This can best be achieved by pouring water into the D-box and making sure that one discharge invert does not flow longer than the others.

Realizing the difficulty in leveling a D-box exactly, some installers are using a device called a "speed leveler", "invert leveler" or "adjustable invert". In essence, these devices fit into the invert pipe and can be manually adjusted so that all of the inverts drain at the same elevation. This method obviates the need for an ***exactly*** level D-box.

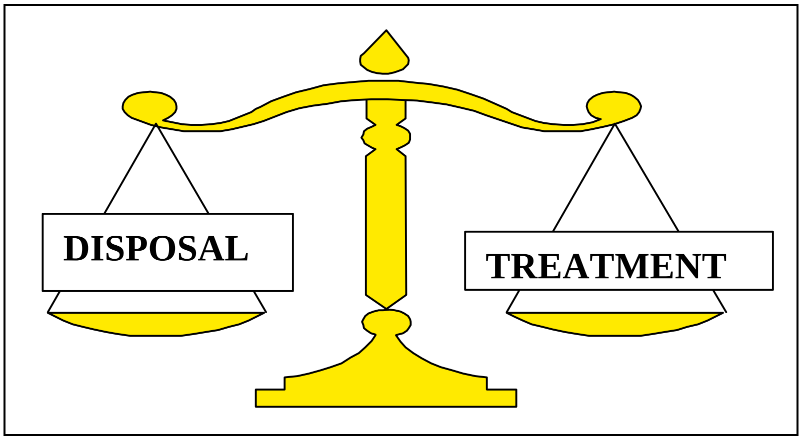
Remember that when pumping to the distribution box, or if the inlet pipe has an exessive pitch, the inlet to the distribution box must has a tee to prevent an overloading of one portion of the soil absorption system.

A Typical D-Box. Distribution boxes can have many discharge inverts. These discharge inverts must be 2" below the influent invert.



Soil Absorptions Systems (SAS)

This begins perhaps the most complicated portion of this module, the Soil Absorption System (affectionately called the SAS). Pits, Galleries, Chamber, Trenches, Beds, Fields - these are all terms that refer to the portion of septic system that functions to treat and carry away the effluent, leaching it to the surrounding soil.



Proper design of the SAS portion of the septic system is perhaps the most crucial step in achieving adequate disposal and treatment of sanitary wastes. Effluent treatment is a complex interaction of physical and biological processes that balance the goal of carrying away the effluent with the goal of actually treating it. On the one hand, the SAS must provide a means of eliminating the effluent at a rate that prevents backing up or surface breakout, but on the other hand the effluent must not pass through the soil at a rate that does not allow for actual treatment. The ideal SAS will contain an active biological community that breaks down larger organic molecules to their soluble constituents, and provides a hostile environment for enteric pathogens.

The primary treatment of effluent in a SAS occurs in the film of biological activity at the soil interface. This film is referred to as the *biological mat or biomat*. The biomat contains a variety of organisms which digest the applied effluent and derive energy to live from breaking the chemical bonds of larger molecules and digesting dead and dying bacteria. In the process of digesting the food and reproducing, the organisms use oxygen. A fresh supply of oxygen enters from the soils, and any venting that the system might have. If the soils are completely sealed and **anaerobic** conditions prevail, anaerobic organisms prevail which include primarily bacteria. Under these conditions, protozoa and other **aerobes** (aerobic microbes) die and do not digest wastes rapidly enough (remember **anaerobic** digestion may produce less sludge, but it is much slower than **aerobic** digestion). Dead bacteria in **anaerobic** conditions tend to accumulate since the oxygen-requiring protozoa are not around to remove and digest them. The biomat becomes too thick to allow effluent infiltration, and the system backs up.

Aerobic - living or occurring only in the presence of oxygen.
Aerobe - a bacterium that requires oxygen to live

Anaerobic - living or occurring in the absence of oxgyen
Anaerobe - a bacterium that lives in the absence of oxygen.

In general, changes in the code were introduced to make the SAS an aerobic (oxygen-present) component. Under these conditions the assimilation and digestion of organic matter is enhanced due to actions of protozoa in cropping the bacteria and maintaining the bacterial populations in a youthful physiological state.

In addition to the more efficient mineralization and transformation of organic matter, aerobic conditions in the leachfield are generally antagonistic to bacterial and viral pathogens. For bacterial pathogens, a "healthy" biomat contains many predator organisms which ingest and destroy them. It is generally believed that higher oxygen concentrations also reduces the persistence of viruses by destabilizing the proteins that encapsulate the nucleic acid that are necessary for virus reproduction.

The main points to remember regarding SAS is that the code revisions have emphasized those characteristics that encourage aerobic treatment in the SAS. As Boards of Health receive variance requests that would tend to limit the airflow to leaching components, they must insist that the engineer compensate for the deficiencies in the code by providing increased number of vents. This topic will be covered in detail near the end of this module.

SAS Common Ground

We will begin with those elements that are common to all systems (with few exceptions), and the common desirable characteristics of SAS in general.

Aggregate - Unless otherwise approved by DEP, aggregate is required for all SAS. Aggregate refers to the stone, of various sizes that is required to surround leaching structures. By "structure" we mean everything from perforated PVC pipe to cement structures of various shapes that have openings that allow effluent water to pass through. There are basically two types of aggregate used commonly. Base aggregate is composed of washed stone ranging in diameter from 3/4 to 1-1/2 inches and extends from an elevation just below the crown of the distribution pipe to as much as two feet below the distribution pipe holes' bottom elevation. Two to three inches of finer double-washed stone (commonly called peastone), ranging in diameter from 1/8 inch to 1/2 inch, is placed on top of the base aggregate in order to minimize the migration downward of fine material.

What does aggregate do? As you might imagine, stone aggregate has many large void spaces (space between the individual soil particles) compared with natural soil. This allows for the growth of aerobic sewage-treating bacteria on many of these surfaces. In addition, the void spaces increase the storage volume of the leaching component. The debate still goes on as to whether aggregate or "gravel" is really needed in many system designs. For years it was thought that soil clogging was an inevitable result of not using aggregate, however, there is still much research needed to determine both the treatment and hydraulic efficacy of aggregate in leaching components. A number of "gravel-less" systems discussed later claim that the treatment efficacy is either minor or compensated for by facets of their individual design.

Vents and Venting - There are two types of vents that you will see referenced when speaking about septic systems. The first type is common to all septic systems and is the vent that runs back through the house plumbing and to the roof. This vent is simply to allow the water fixtures in the house to drain, and to allow gasses from the septic system to escape.

The second type of vent is specifically designed to allow aeration of the leaching components of the system. Venting ***must*** be used to compensate for the natural movement of air to the leaching system, when the leaching area is to be located in whole or in part under "driveways, parking or turning areas or other areas of impervious material" (Section 15.241 System Venting). Venting should also be required when a Board of Health grants a variance to the requirements of Section 15.221(7), and allows more than 3 ft of soil cover on top of a leachfield. When trenches, beds or fields are used *in these situations*, the end of each distribution lateral must be connected to one or more vents. Under what other conditions should vents be used, and how many vents are enough? The code is not entirely specific in this regard and pretty much leaves it up to the engineer or designer to decide what is adequate. Certainly it makes sense to vent systems being dosed by pump in order to allow the displaced air in the distribution lines to rapidly escape. Another somewhat rare case is when distribution lines in trenches exceed 50 ft in length (Section 15.251:(11)). A curious omission of the code is that this 50-ft rule is not included for bed distribution lines.

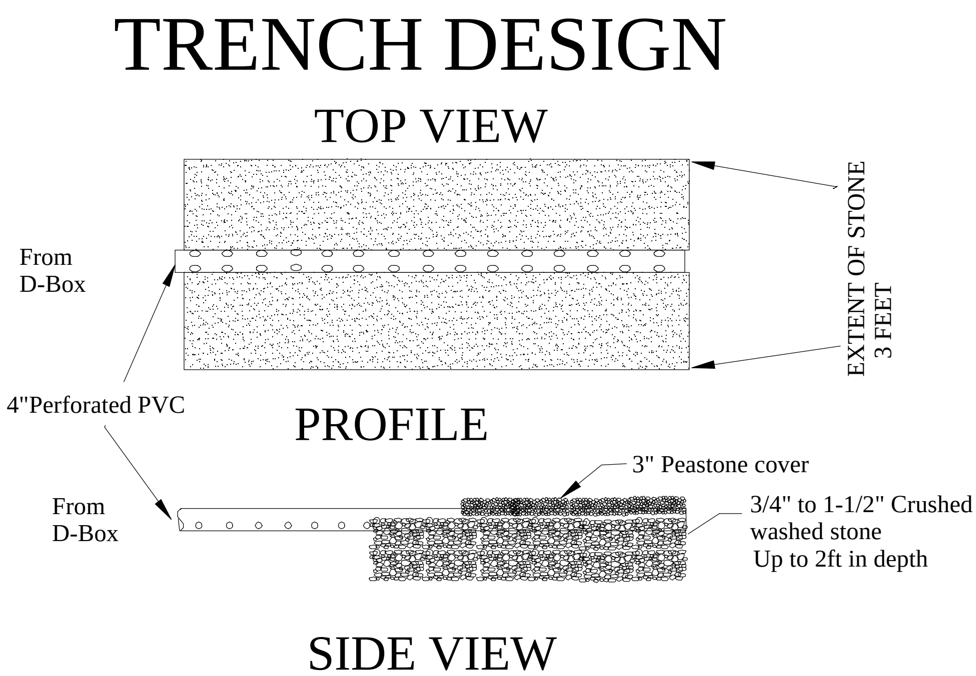
Other requirements relative to vents are common sense; make allowances to keep the animals from crawling in, make sure vents and supporting structure are made of durable resistant material, position the open ends away from traffic areas, backfill around the vents so that water doesn't drain down into the system, etc.

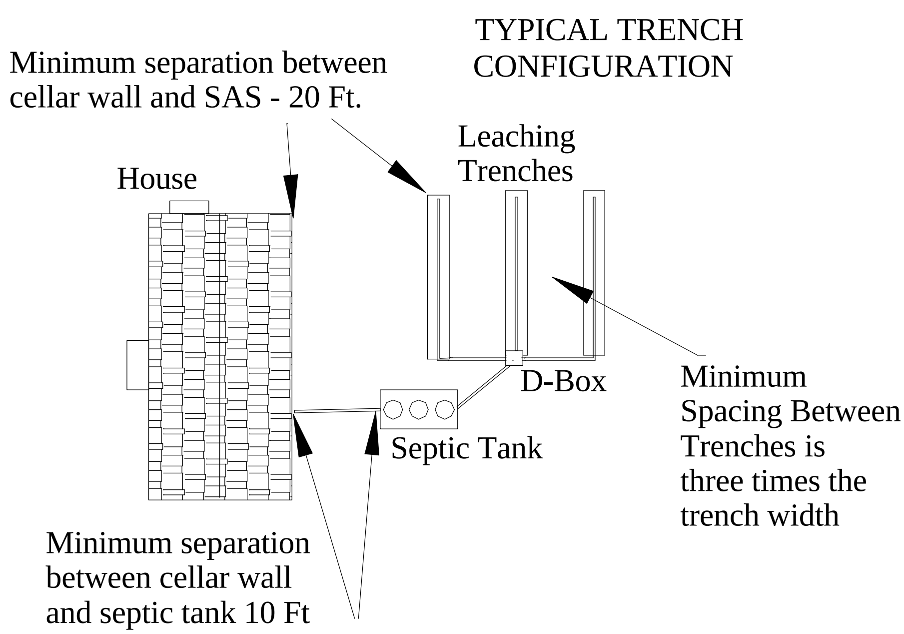
> ***Authors' Note***: If you're confused with all this terminology (bed, field, trench, etc.) - don't worry. In depth descriptions of all these are coming up.

Naturally Occurring Pervious Soil - All SAS must be located where there is at least a four foot depth of naturally occurring pervious soil beneath them. The only exception to this case is where, for purpose of repair and upgrade, the requirement is not feasible (See Section 15.415(2)). "Naturally occurring" pretty much speaks for itself, however there has been continuing controversy (which by the way we do not intend to try to resolve here) whether the intent of the Code was to require that naturally occurring pervious soil be above groundwater. One town on the Cape has clarified, through local regulation, that their intent is that the naturally occurring soil be above maximum high groundwater.

Trenches, the preferred option

Title 5 Section 15.240(6) states that "Absorption trenches shall be used whenever possible". This is a significant change from the old Title 5 which emphasized the use of pits. Trenches are essentially a perforated distribution pipe (minimum diameter of 3", but usually 4" PVC), surrounded by stone aggregate. The figure below shows a cutaway section of a trench design. To place this in context, the figure on the next page is a crude representation of a plan showing trench placement relative to other system components. As you can see, the trenches are arranged in parallel rows. Each row receives the same amount of effluent from the septic tank through the D-box. The separation between the trenches is three times the bottom dimension of the trench. In other words, if the trench is 2 feet wide, the trenches must be spaced at least six feet apart. On sloping ground, trenches should be installed along contour lines if possible, but in any event the trenches should be perpendicular to the slope.   For the full specifications of trench design and installation, refer to Section 15.251: Trenches. The important thing to remember about trenches is that, when they can be installed in accordance with the code, they are the preferred SAS.

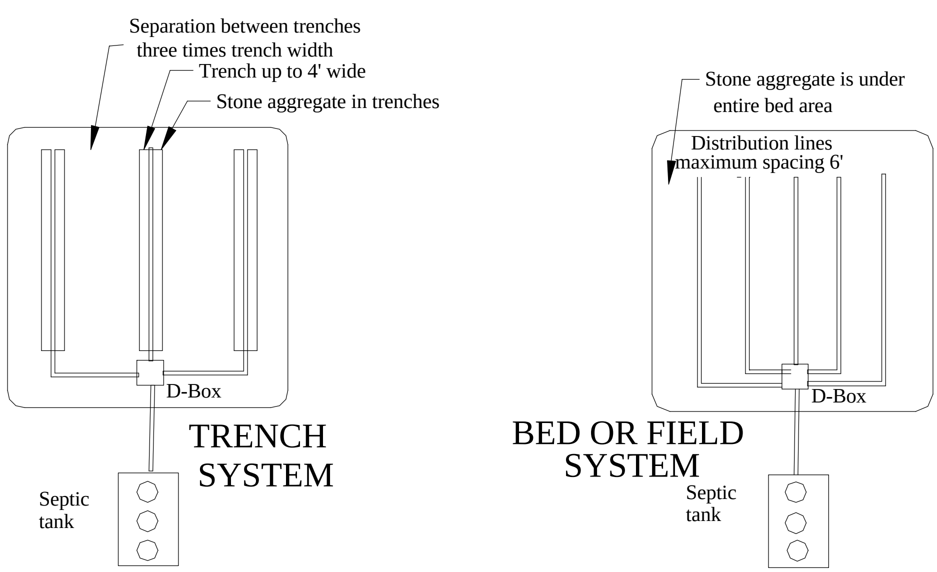




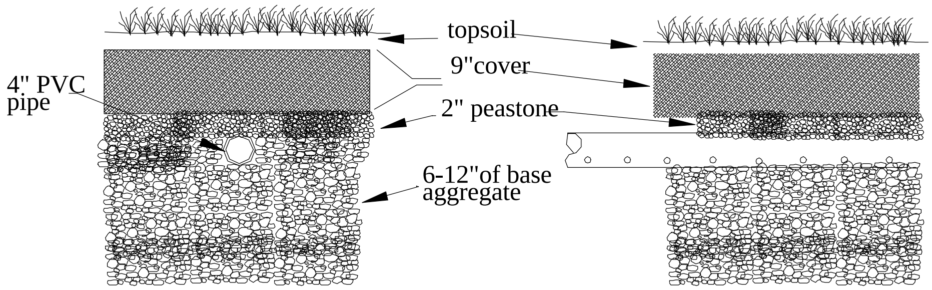
Bed = Field

The term "bed" and "field" mean essentially the same thing (especially if you're used to sleeping in fields). Leaching fields or beds are facilities consisting of at least six inches and a maximum of twelve inches (See Section 15.252) of aggregate below the invert of the distribution pipes. In essence, its a bed of stone with perforated pipe laid on top of it. In aerial view, the uncovered bed looks much like a trench system with the exception that native soils would be between the lines of parallel distribution pipe in the case of trench configuration (See next page for figure). The specifications outlined in Section 15.252 relative to distribution line spacing (maximum 6 feet between lines), number of distribution lines (minimum 2), and separation distance between the edge of the bed and the distribution lines, are all attempts to provide for the most even distribution across the bed. Fields and trenches perform the best when the effluent is dosed to them, ensuring more uniform application of effluent across the entire system.

The advantage of the bed design becomes most evident when there is a high groundwater problem. This is because the system itself is shallow in profile (See figure next page). As you can see, a bed requires 10" of base aggregate (6" below the pipe and 4" up the sides of the distribution pipe), 2" of 1/8-1/2" stone, and 12' of cover (Section 15.240(9)), assuming that this later item includes 3" of topsoil. These minimum requirements, give or take an inch or two, still make a bed design the shallowest Title 5 system in profile. Remember, however, in calculating the effective leaching area for a bed, only the bottom area can be used (as opposed to trenches in which up to 2 ft. of sidewall can be used).



Cross Section of Bed Piping



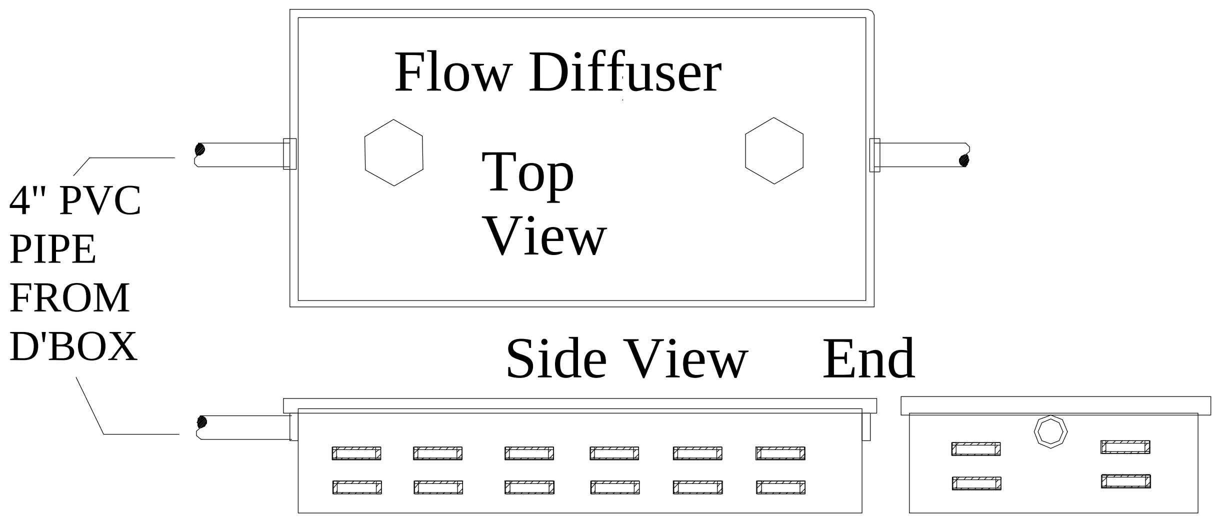
It's the Pits! (Pits, Galleries, and Chambers)

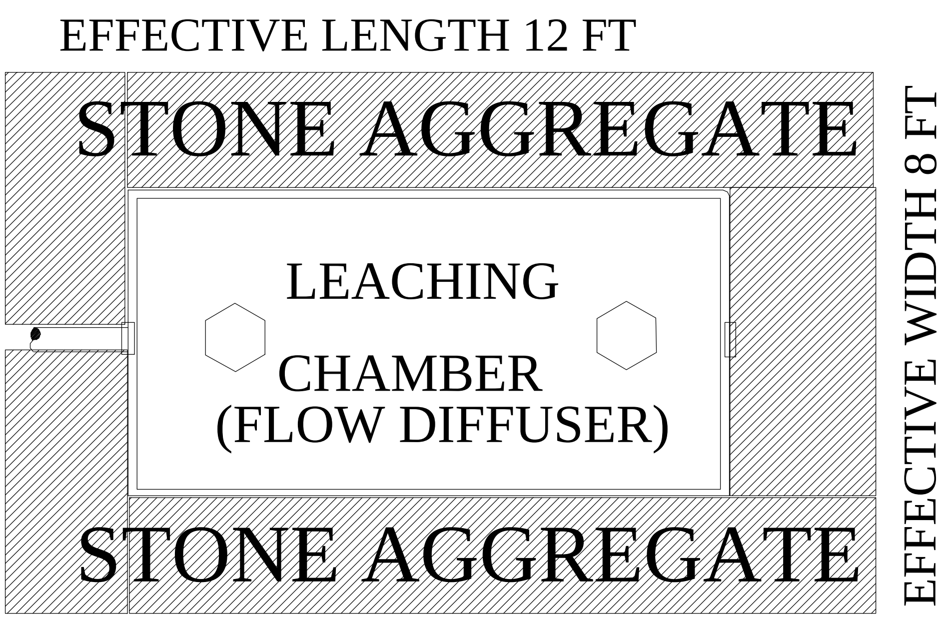
There are a variety of precast concrete structures which can serve as leaching elements for Title 5 septic systems. Many of these were more prevalent under the 1978 code because of the sidewall allowance. You may remember that, under the 1978 code, for every square foot of leaching surface on the sidewall, you were allowed to dispose of 2-1/2 gallons of waste in sandy soil.   In addition, just as in the revised code there is a stated preference for trenches, the stated preference in the old code was the pit.

Under the revised code, although pits and galleries are allowed, only two feet of the sidewall depth is allowed in calculating their allowed disposal flow. In addition, whether it is bottom area or sidewall, the maximum allowance for discharge is .74 gallons/square ft/day in sandy soil. Quite a change from the 2-1/2 gallon flow allowed under the 1978 code.

The cement structures used for leaching are basically large concrete shells with holes in them. They are variously shaped, but most of them are rectangular in cross section. A very common precast unit called a "flow diffuser" is shown below. It is 4' x 8' with an effective depth of approximately 12 inches below the invert. Remember ! Effective depth is defined by the depth below the invert, not the depth of the unit itself.

For calculation of effective leaching area of precast units, the dimensions of the unit itself plus the extent of the aggregate is used. For instance in the illustration below, although the unit itself is only 4' x 8', the bottom dimensions for calculating leaching area is 8' x 12' because there is two



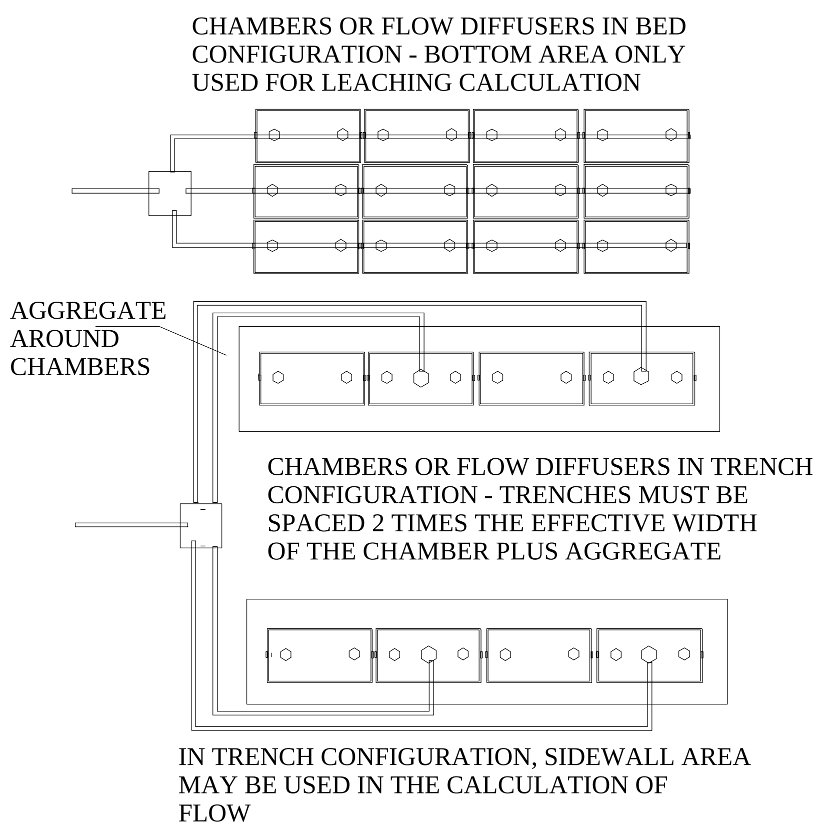


feet of stone surrounding the entire structure. In addition, the long sidewall area is 12' x 1', and the short sidewall area is 8' x 1'.

Undoubtedly, we will see a variety of shapes and sizes of leaching units emerge that have 2' effective depth. Even some of the units discussed later under "gravel-less" systems which are fiberglass or high-density plastic, when used with aggregate, fit into this category of chambers. Some of these, although dome-shaped, again are allowed the leaching area supplied by their surrounding aggregate.

One concern with plastic or fiberglass units is their weight-loading characteristics. Care must be taken to get the manufacturers' specifications to make sure that systems located under areas subject to vehicular traffic, are H-20 equivalent loading.

As if the issue of precast or plastic chambers wasn't complicated enough, there are two ways in which these types of systems can be configured; trench and bed configuration. The important thing to remember is that in bed configuration, only the bottom of the area covered by the structures and aggregate is used in calculating the allowable flow. In trench configuration, each series of structures must be situated at least two times the effective width of the structure and aggregate apart (remember for simple trenches with stone they had to be ***three*** times the effective width apart).



Gravel-Less Leaching Chambers

In addition to what has come to known as "standard" leaching chambers, several leaching systems which do not require aggregate (hence the term gravel-less systems) were approved by DEP for general use in 1995. All of these systems are constructed of molded polyethylene and represent various shapes. These chambers are most commonly connected in series and perforated PVC distribution pipe is run through the series to distribute the effluent.

The Cultec Contactor®, Hancor Envirochamber®, and Infiltrator® leaching chambers look like Quonset huts with small openings along the sides. Effluent is distributed through the chambers and leaches out through the bottom area and the side perforations. The chambers are covered with filter fabric which absorbs the effluent and distributes it over the side and top surfaces of the unit. The filter fabric is purported to provide a better interface between the chamber and soil surface than the interface between gravel and a chamber surface. After passing through the filter cloth, the effluent contacts and filters into the surrounding soil. All three systems have the advantage of having a shallow profile. The Cultec Contactor comes in two sizes: 18 inches high with an effective depth of 11.5 inches and 12 inches high with an effective depth of 6 inches. The Infiltrator and the Envirochamber are similarly sized.

The Eljen® Indrain, another leaching system, consists of a 7 inch high rectangular unit composed of convoluted plastic lined with biomat fabric. Perforated effluent pipe is laid across the top of these units. As effluent trickles through the convoluted areas, it forms a primary biomat on the biomat fabric. After filtering through the fabric, the effluent flows to the bottom of the chamber. A second biomat may form where the chamber contacts the underlying sand. The effluent passes through this layer and into the surrounding soil. Due to its convoluted shape and high surface area, the Eljen Indrain has been permitted an effective leaching area of 6.2 sq. ft.(at .74 gal/sq ft/day) per linear foot of chamber.

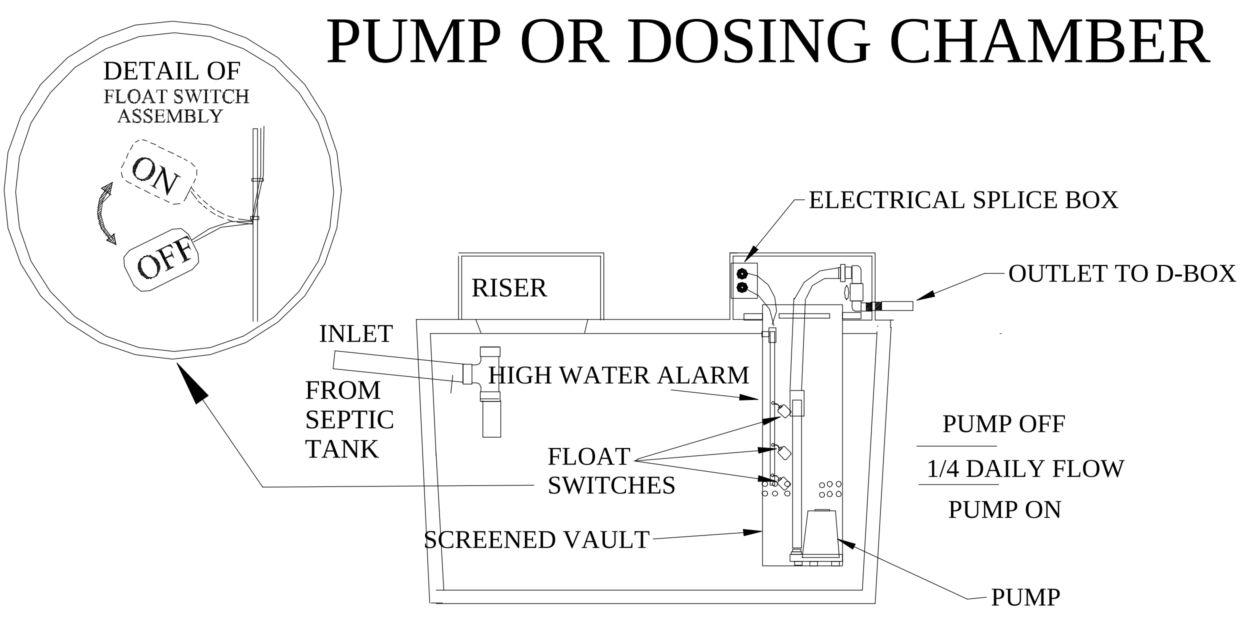
All of these systems can be configured in either leaching trench or bed configurations. They are lightweight and simple to install. A trench or bed is dug and the units are assembled and placed directly on the soil surface (the Eljen Indrain requires 6 inches of coarse sand below the unit) and backfilled. These units have an advantage over conventional trench or bed designs in that the chambers provide some storage volume for effluent. The systems also have the advantage of being shallow which makes them particularly appropriate for installation in areas where it is difficult to obtain adequate separation to groundwater.

DOSING CHAMBERS (Pump up !)

Dosing chambers (not to be confused with bedrooms or dozing chambers) are watertight structures that contain a pump for the dosing of a leaching component of the system. Dosing is simply the intermittent passing of a predetermined volume of septic tank effluent to a leaching component. Dosing is used when one of the following conditions exist:

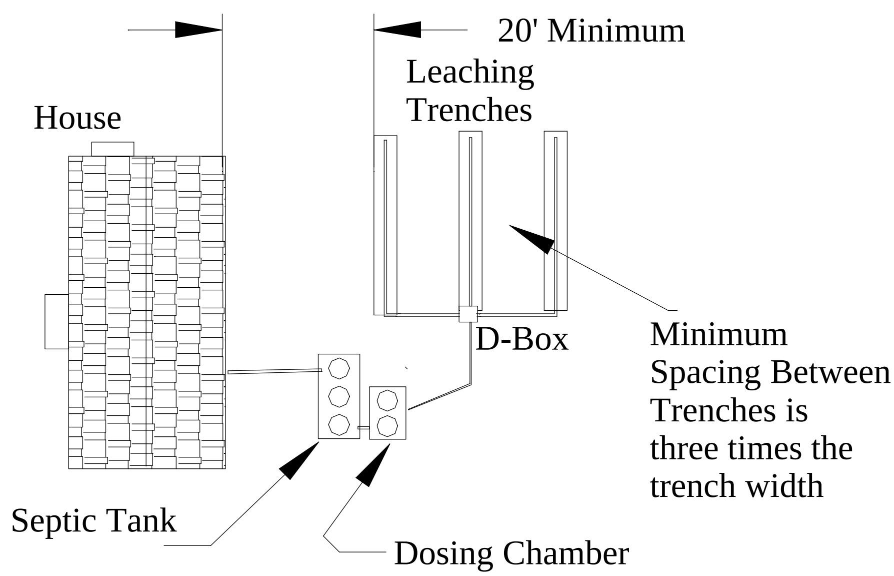
1) the septic tank effluent can not flow to the leaching components by gravity;
2) the flow from a septic tank or recirculating sand filter exceeds 2,000 gallons per day (<u>Section 15.231</u>), or;
3) there is a desire or need to load the leaching components more evenly (this achieves better treatment).

Dosing chambers are also called pump chambers because they most often achieve dosing by means of a pump. The other way dosing can be achieved (but this way is not allowed under the revised code -see <u>Section 15.233</u>) is by means of a siphon. Dosing or Pump chambers are located between the septic tank and the D-box as illustrated below.



Pump chambers are variously sized, depending on the daily flow. They are generally sized at 200% of the daily flow. The code requires that they have "emergency storage capacity above the working level equal to the design flow of the system" (Section 15.231). In order to comply with the code, the pump chamber must dose the leaching components 4 times a day in sand and loamy sand, and once per day in tighter soils (Section 15.254). The actual dosing to a leaching component is in most cases triggered by a float switch located in the pump basin like shown on the previous page. When one-fourth of the daily flow of the system enters the dosing chamber from the septic tank, the float rises causing the switch to activate the pump. The pump will continue until the falling liquid level causes the switch to shut off. The distance between the "off" and "on" position should represent a liquid height difference inside the tank that corresponds to 1/4 the daily design flow.

TYPICAL CONFIGURATION USING A PUMP OR DOSING CHAMBER



In a standard dosing or pump chamber, you might observe a variety of float switches. In all cases, you will see at least two. One switch for the off-on cycle of the pump, and one switch that is called a "highwater alarm" appropriately enough since it will signal when the tank capacity rises above the level where a one-day reserve capacity in the tank is remaining in the tank volume.
The tank illustrated has one float that turns the pump on, and one float that turns it off. While this might seem unnecessary, this setup is used where the on-off positions are so close together that a

single float system can not be adjusted to the required tolerances. Pump chambers serving more than two dwelling units, must be equipped with two pumps that alternate in their use.

Pumps used in dosing chambers must be capable of passing solids up to 1-1/4" in diameter, but as you might imagine, one hopes that they never have to since solids should not be pumped to the leaching elements. The pump chamber illustrated here encases the pump in a screened vault that prevents solids from getting pumped to the leaching components. The "standard" installation at this point is not so equipped.

When are Dosing Chambers Not Followed by a D-Box?

Most commonly, pump chambers are followed by a D-Box in what is known as a "dosed system". There is however another type of dosed system called a ***pressure dosed system*****.** In a pressure-dosed system, effluent is forced through small openings in the distribution lines. Up to three-inch lines are generally used. The effluent is disbursed through variously spaced and variously sized holes (generally ¼"), depending on the hydraulic characteristics of the pump and the demands of the system. These systems should maintain less than a 10% difference in pressure between their distribution lines. Contrast pressure distribution systems with simple "dosing" systems which simply pump effluent to a distribution box where it disperses from there via gravity.

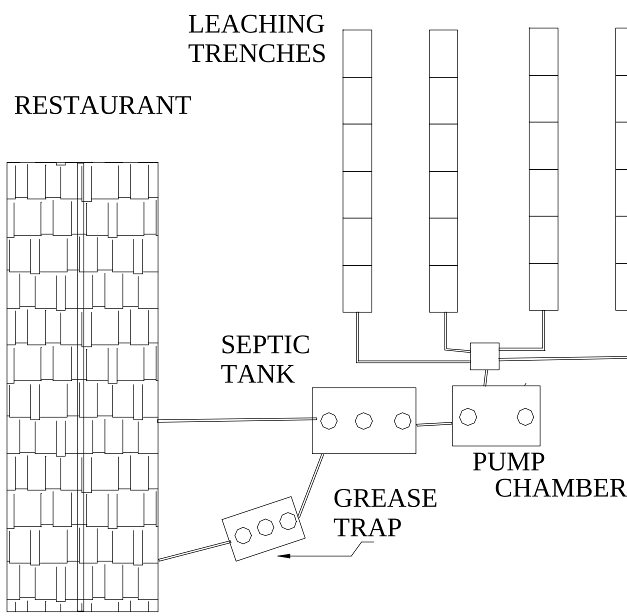
Pressure dosing is required "for all systems designs in excess of 2,000 gallons per day" (Section 15.254: Dosing (2)). In addition, there are performance monitoring requirements in these cases such that "in no instance shall inspection be performed less frequently than once every three months". So, you will likely see pressure dosing on all large systems. In addition, most alternative septic system designs that take advantage of remedial use credits (discussed later) also require pressure dosing. A small-flow system that also employs pressure dosing is the recirculating sand filter to be discussed in later learning modules. These systems employ pressure dosing when distributing the effluent on top of the filter.

Grease Traps

As previously mentioned, any facility that can be expected to generate quantities of grease must have a grease trap for pretreatment. The term "grease trap" should not be confused with the variety of grease recovery units that one might see inside a restaurant. Those units do not meet the requirement of the code unless they have been specifically approved as substitutes by DEP.

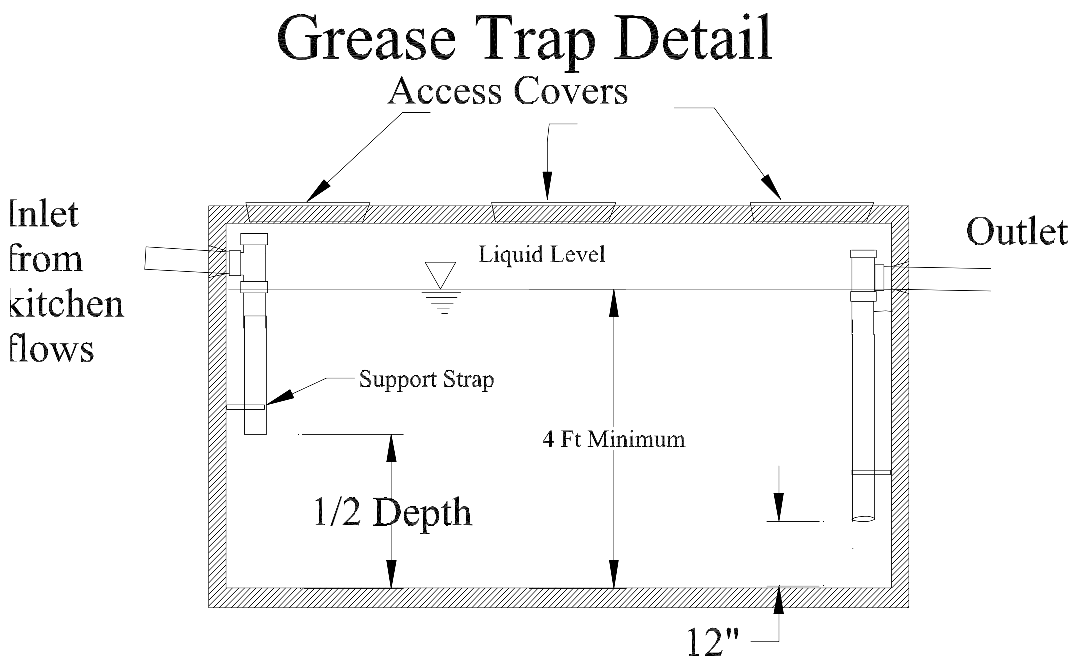
Grease traps, for purpose of Title 5, are watertight units, similar to a septic tank, that receive wastes only from the portion of the establishment that generates the grease (normally the kitchen) via a separate line from the kitchen. Their position in the overall septic system of a typical installation is illustrated below. The importance of proper grease management in facilities that generate grease can not be understated. Grease imparts a significant strength (BOD) to sewage. If it is not removed in sufficient quantities, the life of the leaching components can be significantly shortened. A recent Alternative Septic System Newsletter by our Department reviewed the problems and solutions associated with grease.

TYPICAL CONFIGURATION OF A GREASE TRAP
SERVING A RESTAURANT



The structure of a grease trap is very similar to a that of a septic tank with the exception of the sanitary tees. As can be seen in the illustration below, tees inside a grease trap penetrate

much deeper into the tank than those of a septic tank (often requiring support). This is because the primary buildup of grease wastes will be at the top of the tank. The primary requirement of a grease trap is that it provide enough residence time for the grease to cool and float to the top of the tank liquid. For the purposes of the Code, they are sized for a 24 hour retention of the ***kitchen flows***.



The chief differences between septic tanks and grease trap are:

1) the grease trap receives only kitchen wastes;
2) a grease trap may only have 2 20-inch covers (one over inlet and outlet);
3) grease traps must be pumped far more frequently than septic tanks, depending on the quantity of grease expected, and ;
4) grease traps must have a cover to grade over the inlets and outlets to facilitate the required maintenance[5]

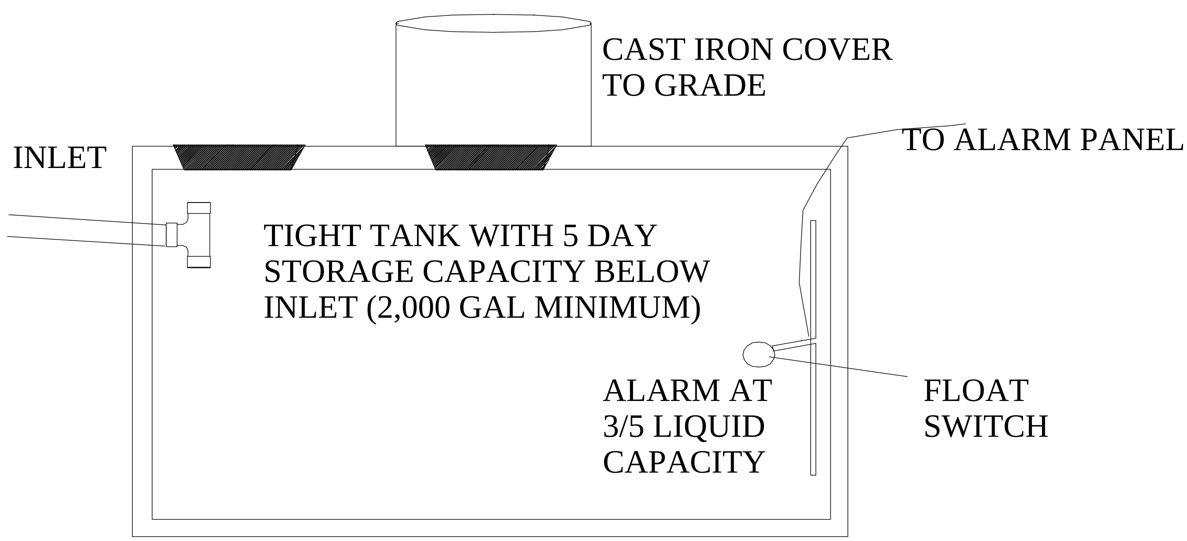
Tight Tanks

We round out our discussion of the components of Title 5 with a brief discussion of Tight Tanks. As their name implies, tight tanks are essentially watertight vaults in the ground that are used for the temporary storage of wastes. They have no outlet to a SAS. A typical tight tank is illustrated below.

[5] Section 15.351: System Pumping and Routine Maintenence (2) Grease traps shall be inspected monthly and shall be cleaned by a licensed septage hauler whenever the level of grease is 25% of the effective depth of the trap, or at least every three months, whichever is sooner.

The first major point to be made about tight tanks is their use. They are **not** approved for new construction (Section 15.260) or for increases in flow to existing systems, and they are only approved to eliminate a failed on-site system when all alternative means of disposal have been weighed and found to be not feasible. DEP has the final approval of all tight tanks, however the local Board of Health must also grant approval.

The construction requirements for tight tanks are illustrated and include; a capacity to accommodate 5 days worth of flow (2,000 gal minimum), an alarm system that activates at 60% of the tank's capacity, and a 24-inch diameter cast iron frame cover accessible for pumping at any time of the year. In some instances, aeration in a tight tank may be required in order to control odor. If any portion of a tight tank is to be installed below the high groundwater elevation, the tank should be tested for tightness.



Tight tanks should be looked upon as the last option for remediating a disposal problem. Since the expense of their operation is directly related to the volume of sewage they receive, it is prudent that a Board of Health make sure that the proponent has made all feasible attempts to decrease water use. The proponent of a tight tank must present the Board of Health and the DEP with plans outlining the system's management, including the method and frequency of removal of tight tank contents, the location of disposal, and an operation and maintenance plan (showing a monitoring of the system once every three months). Since tight tanks are a temporary solution, the Code requires that "When a sewer becomes available, any person owning a tight tank shall convert to a sewer with 30 days.."

When is a "Tight Tank" no so Tight ?

In special instances, a modified "tight" tank with a soil absorption system may be approved. Again, all these types of approvals must be obtained from DEP and the local Board of Health. These modified systems are designed with the goal of eliminating some of the clarified effluent on site. The loading rate allowed in tight soils (soils with poor drainage) is only 0.15 gallons per square foot per day (compare this to 0.74 gal/sq ft/day in sand). Systems installed under this scenario must be able to be converted back to true tight tanks, should the effluent back up into the tank. Under this scenario, where the tight tank essentially acts as a very large septic tank (recall that septic tanks are sized for 200% not 500% of the design flow), the tank must be pumped annually regardless of operation (Section 15.261 (7)), and the pumping reported to the local Board of Health.