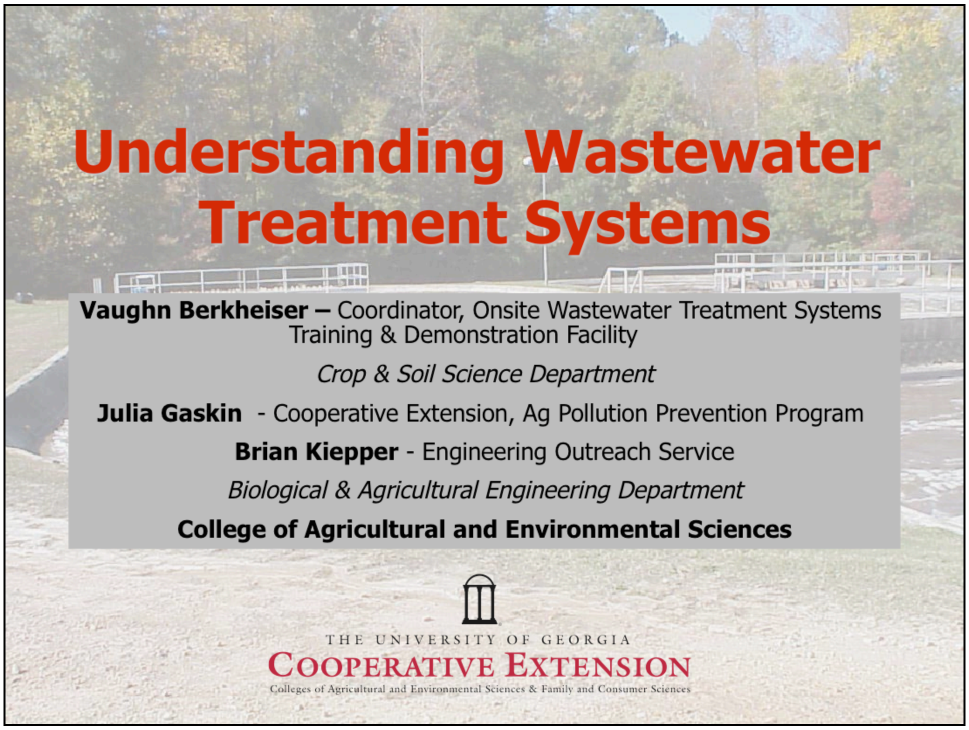
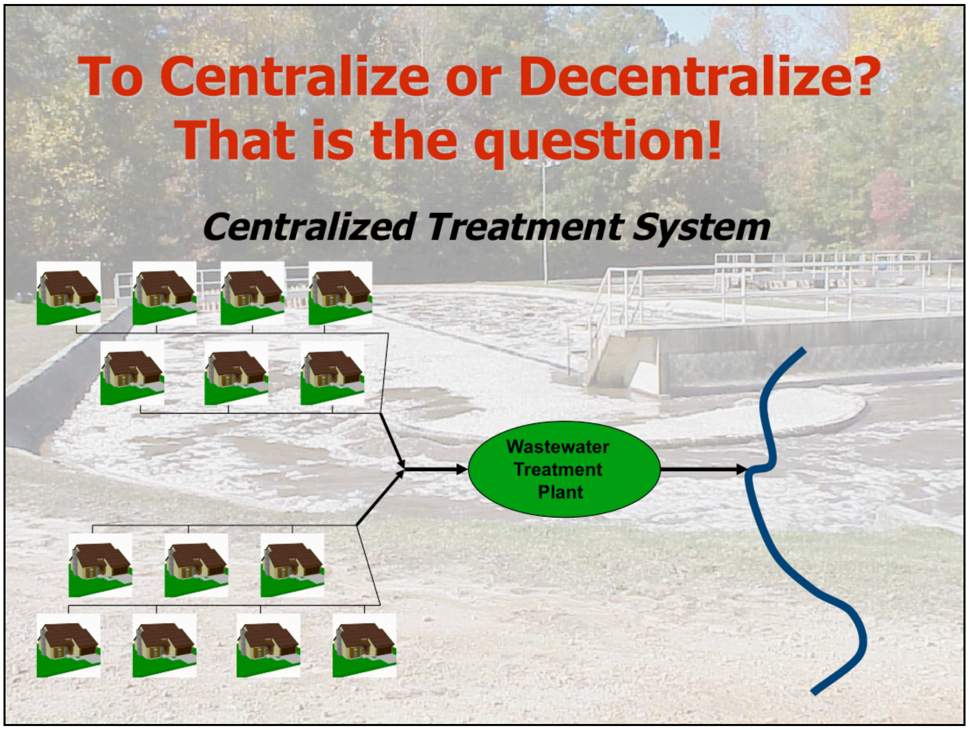
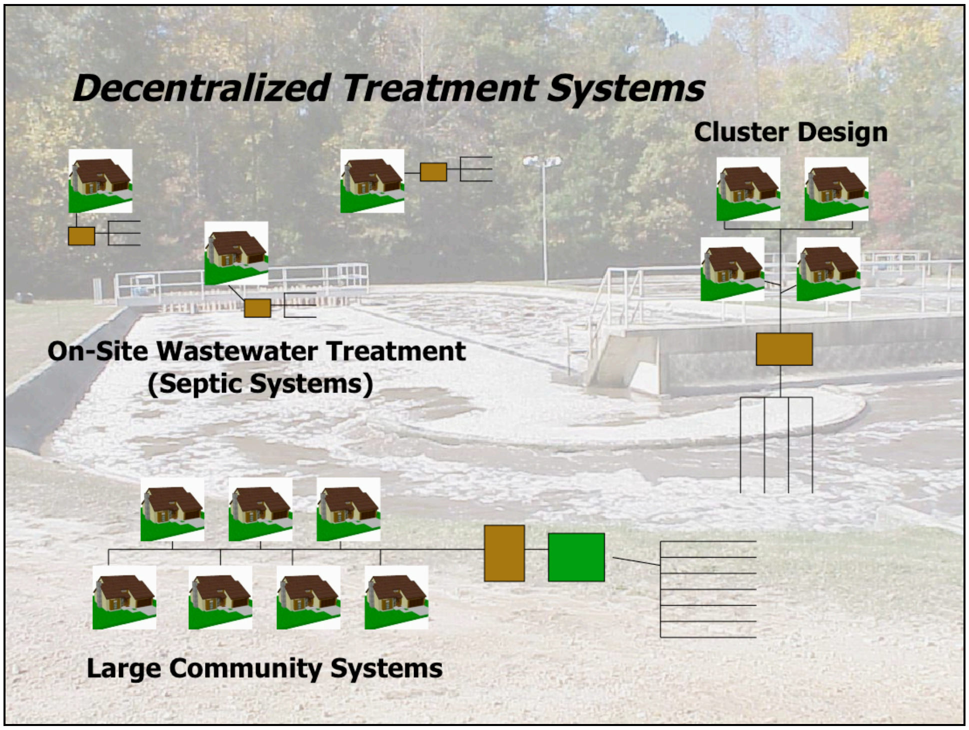



Many Georgia communities are wrestling with wastewater disposal issues. The choices a community makes may affect its growth and environmental quality. This presentation was designed to present the basics of wastewater treatment systems so *that* community leaders can make better informed choices.

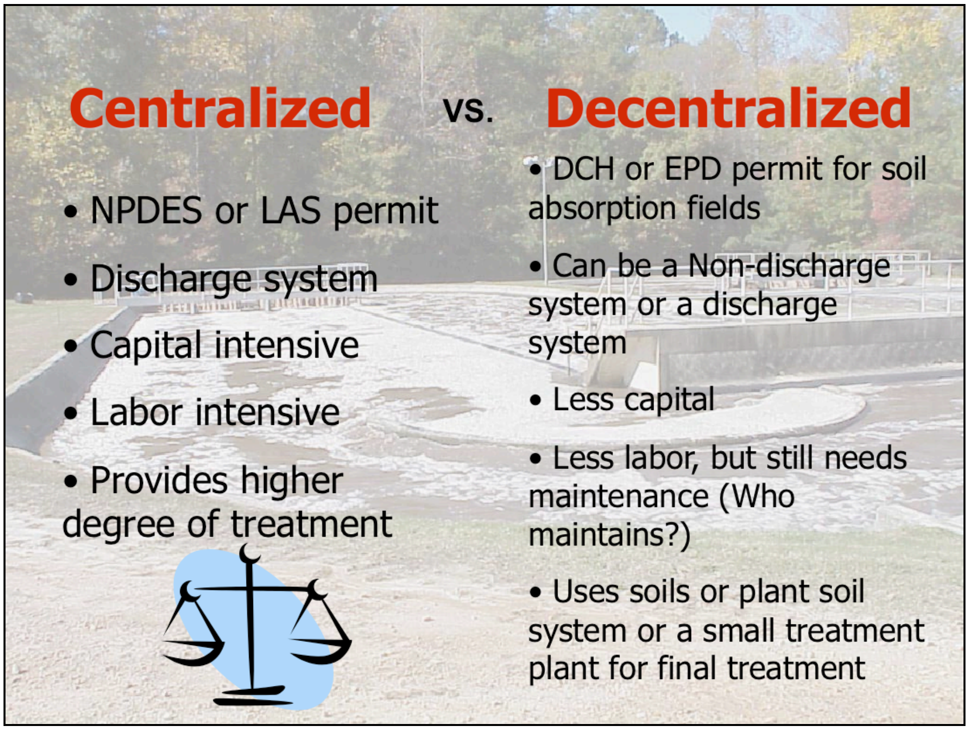

First, it's important to understand that way back in 1785 a scientist named Antoine Lavoisier discovered the "Law of Conservation of Mass", which in its simplest form states that "matter is neither created or destroyed". So when you flush it, it doesn't disappear! Most people don't know or care about what happens once a toilet is flushed, but the waste has to go somewhere. One women attending a public meeting about a local wastewater treatment plant that was having problems stood up and said "I think they should just shut that treatment plant down!" That solution might have worked the first time she flushed her toilet, but the second time she flushed there would have been a big mess to clean up. The point is that we, and all living creatures, generate waste products. When a small animal creates waste in the environment, Mother Nature can handle the treatment and disposal. But when human congregate, the waste they generate has to be treated and disposed of in man-made sewer or septic systems. Your community has a choice about how that will be done and where it will be done, but it has to be done. It doesn't *just* disappear.




There are two main types of wastewater treatment systems – CENTRALIZED and DECENTRALIZED. The CENTRALIZED system is one we're all the most familiar with – sewer pipes run from each house to a central collection point where the *raw* waste is treated and then typically discharged into some surface water like a river or lake, or spray irrigated onto land. These systems are expensive to build and require trained certified operators to run them. Many existing CENTRALIZED systems were built with subsidies by the federal government. These types of grants are no longer available. These systems require a National Pollution Discharge Elimination System (NPDES) Permits or Land Application System (LAS) Permits from the state to be able to discharge their treated effluent.




A DECENTRALIZED system collects wastewater from one or several houses in the same area. The wastewater is partially treated within the system and then *either* discharged into the soil for final treatment *or conveyed to a small wastewater treatment plant*. A septic system or on-site wastewater treatment system is an example of a DECENTRALIZED system for a single home. Larger septic systems are sometimes used for a group of homes or a small business. Another type of DECE*N*TRALIZED system is used *by* communities or larger commercial developments. These systems use a septic tank to trap large solids, then use a "package plant" (a small treatment plant that contains multiple treatment processes) to treat the wastewater. The treated wastewater or effluent is discharged below ground through *soil absorption* field, drip irrigation, or sometimes spray irrigation. There is a growing interest in these types of systems because they are typically less expensive to install or operate than large CENTRALIZED systems.




So lets summarize some key points with these types of systems. CENTRALIZED systems require NPDES or LAS permits, while most DECENTRALIZED systems do not. DECENTRALIZED systems DO require permitting from either the Health Department or Georgia Environmental Protection Division (EPD). CENTRALIZED systems are very expensive to build, while DECENTRALIZED systems are less capital intensive. CENTRALIZED systems are more labor intensive and require trained certified operators for operation and maintenance. DECENTRALIZED systems need less labor but STILL require maintenance. A critical question that has to be resolved before a DECENTRALIZED system is installed will be who will be responsible for long-term maintenance.

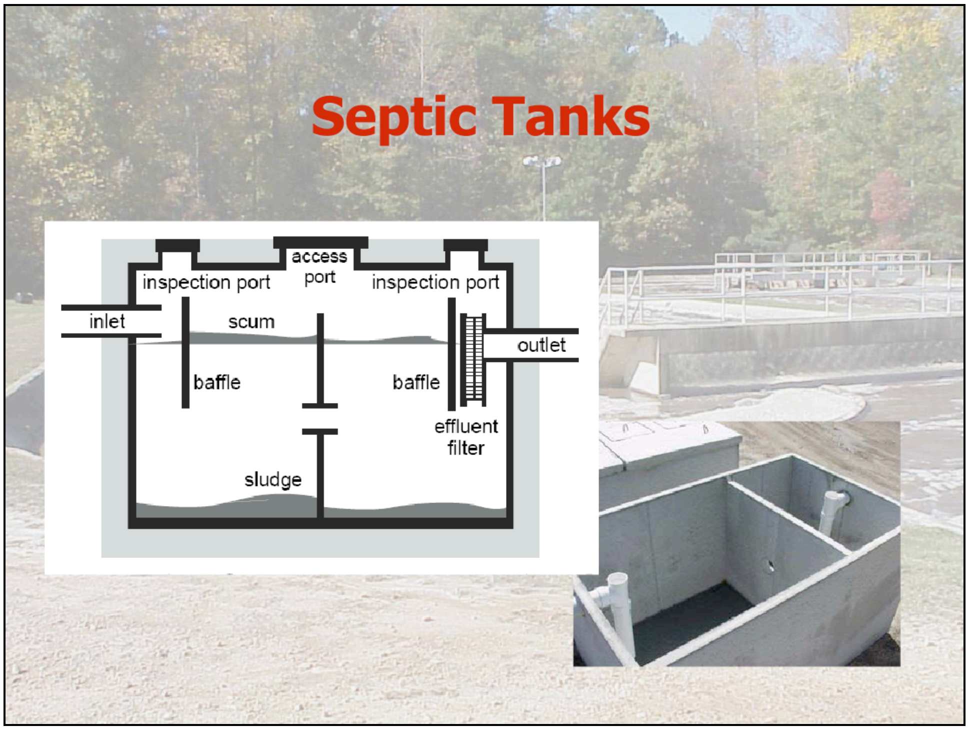
## Centralized System Treatment

- **Large Debris:** screened and sent to a landfill
- **Grit Removal:** collected and sent to a landfill
- **Biological Treatment:** microbes use organic matter to grow
- **Clarifiers:** remove floating oil & grease and biosolids
- **Biosolids:** Treated and stabilized sludge containing microbe bodies

*The w*astewater treatment *process* has several *steps*. Typically, large debris is screened out first and the screened material is collected and sent to a landfill. Heavy particles in the water or "grit" are then allowed to settle in trenches where it is conveyed to containers and typically sent to a landfill. The wastewater then undergoes biological treatment where microbes, in a controlled environment, break down the raw organic matter in the wastewater to more stable and safe forms. As these microbes use the raw organic matter to grow, multiply and then finally die, their bodies accumulate and become raw sludge *in a form called "stabilized sludge"*. The *resulting* stabilized organic matter then travels with the wastewater into clarifiers where the sludge *sinks* and other materials (like oil & grease) float to the top and are removed. The treated wastewater is disinfected and discharged. Stabilized and treated sewage sludge that meet the criteria for land application *is* known as biosolids.


As you can see, there are two waste byproducts that come from a CENTRALIZED system – the treated wastewater or effluent and the sludge or biosolids. Both of these waste byproducts have undergone significant treatment and both have to go somewhere. Remember it doesn't just disappear. As we've seen, the treated wastewater usually goes into surface water or is land applied for irrigation of crops or forests or with sufficient treatment, it is even used to irrigate golf courses. Sludge is most often landfilled, but if it is treated to certain standards, it can be used as a fertilizer for crops and trees.


Decentralized systems also have waste byproducts that have to be disposed of. In general, the *septic tank* effluent is disposed of in the soil continuously, but all these systems have solids that create sludge *in the septic tank* that also has to be disposed of periodically.




*An on-site system (septic tank) that serves a single residence is the most common* example of a DECENTRALIZED system. *The septic tank system is* designed to capture solids, let them settle to the bottom of a sealed tank and be used as a food source for bacteria that can live without oxygen (anaerobic). These solids settle in the tank liquid to the bottom of the tank and become part of the sludge. Above the sludge layer, a clearer liquid portion of the waste contains the portion of the wastewater that flows into the absorption field. A scum layer formed from oil and grease and other household products that are less dense than water, typically forms on top of the liquid layer. When a septic tank is working properly only the liquid portion between the sludge and the scum layers moves out of the tank and into the drainfield to be absorbed and treated by the soil. Once the sludge accumulates to a certain level it needs to be pumped out or solids from the sludge layer will move out into the drainfield and cause the system to fail. When the tank is pumped, all the tank contents (sludge, water, and scum) are removed. This mixture of sludge, water, and scum is known as septage. Most septage is taken to wastewater treatment plants for further treatment, but in some communities, this is getting harder to do. There are some facilities where septage is treated and applied to designated areas to supply nutrients for crops. These facilities are permitted by the state, and each permit carries important requirements for handling septage. One of the requirements is that the septage be incorporated into the soil to prevent odors and attractants for flies, rodents, and other disease carrying nuisances.

## What Are We Talking About?

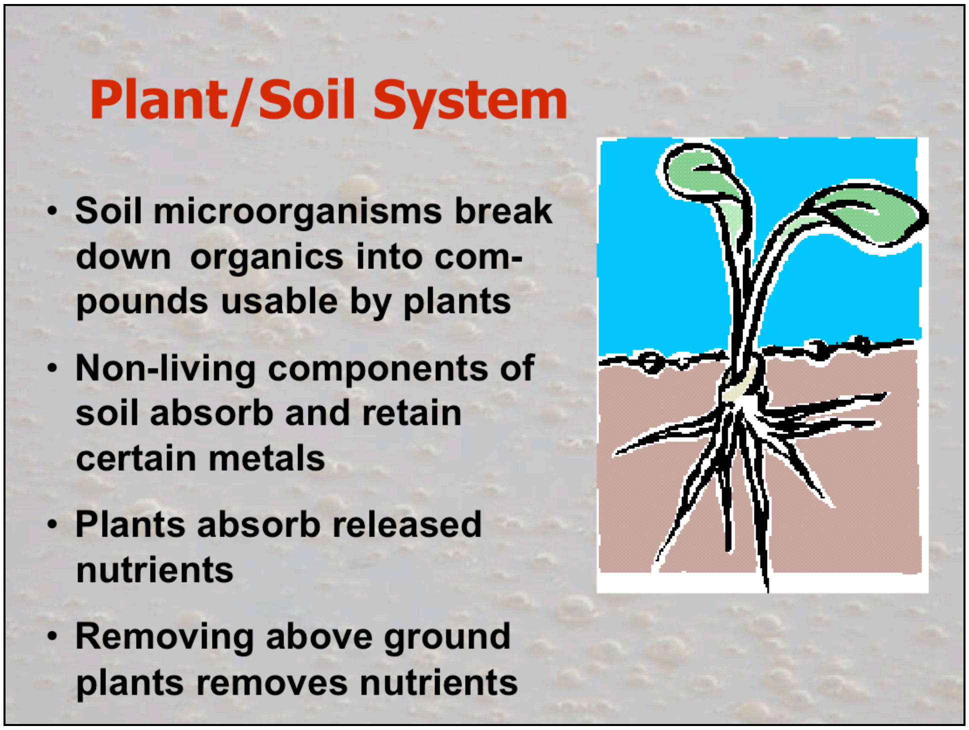
### Septic Tank Performance

| Parameter | **Concentration in Raw Sewage from the House,** (mg/L) | **Percent Reduction in the Tank** |
|---|---|---|
| $BOD_5$ | 200 - 290 | 40 – 50 % |
| TSS | 200 - 290 | 50 – 70 % |
| Nitrogen | 35 – 100 | 20 – 30 % |
| Phosphorus | 18 – 30 | 30 % |
| Fecal coliforms (#/L) | $10^8 – 10^{10}$ | ? |

$BOD_5$ – Biochemical Oxygen Demand; TSS – Total Suspended Solids

What does this mean in terms of how a septic tank treats the waste? As you can see from this table, although the waste is treated *to some degree*, the concentrations in the effluent are going to be higher than those from a CENTRALIZED wastewater treatment plant which treats wastewater to much cleaner standards. For example, total suspended solids (TSS) are reduced 70%. This means TSS concentrations in the effluent leaving the tank would range from 60 to 87 mg/L. Discharge standards for a CENTRALIZED WWTP would be in the range of 30 mg/L. Discharging the septic tank effluent to a soil absorption field will further treat the wastewater to acceptable levels before it reaches the groundwater.

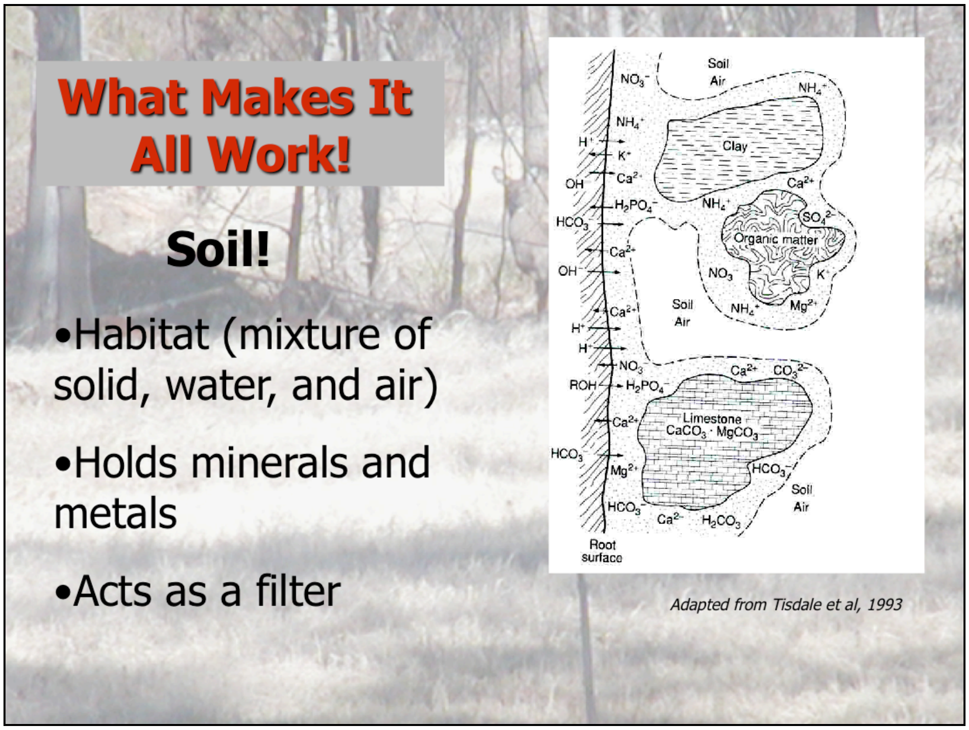

OK.  We've looked at CENTRALIZED and DECENTRALIZED treatment systems and talked about how DECENTRALIZED systems rely on the soil or the plant/soil system to further clean the wastewater.  This *method* uses natural *plant and soil processes* to recycle the nutrient and micronutrients in the waste, so let's look at some of the ways it works.



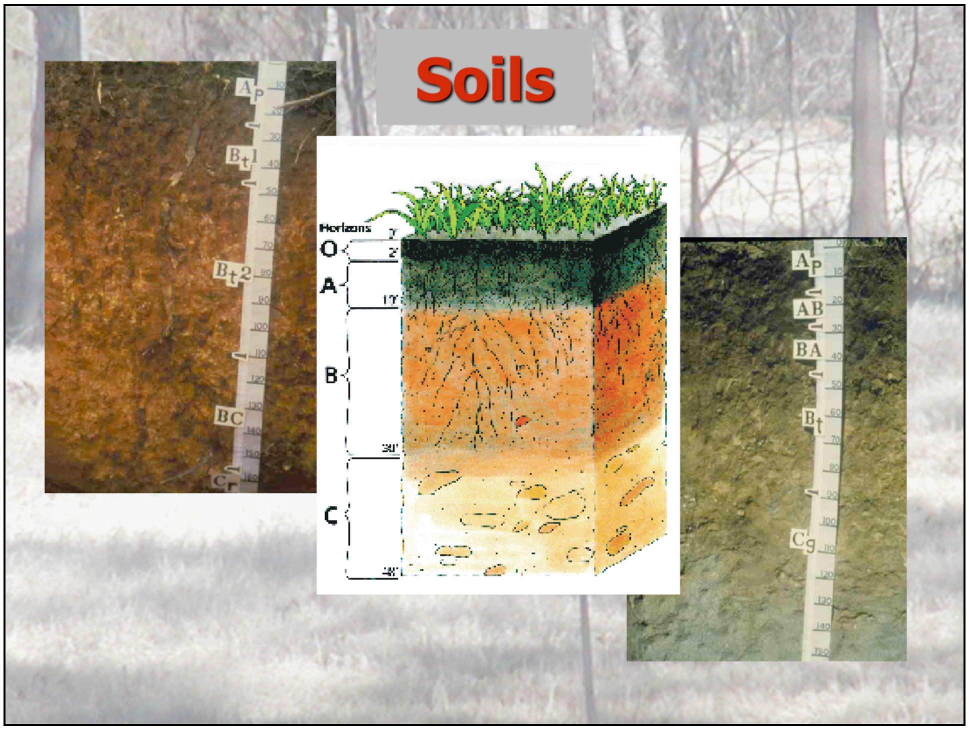

The plant/soil system works in several ways to clean the wastewater. 1) Nutrients such as nitrogen and phosphorus are taken up and used by both plants and microorganisms in the soil. 2) Some naturally occurring bacteria and fungi in the soil can breakdown and use organic compounds in the waste. 3) The soil itself can hold onto metals such as copper or zinc and keep these from moving into ground or surface water. 4) Also, in some situations, like spray irrigation systems where plants are harvested, nutrients are removed from the site and allow either regrowth or the new crop to use more nutrients released from the wastewater.


In spray irrigation systems, plants are a critical component to making things work, particularly with nutrients like nitrogen and phosphorus. Plants absorb nutrients and other compounds with their roots. These nutrients are incorporated in to their bodies. When crops are harvested, nutrients are removed from the site. This allows more nutrients to be applied to grow a new crop. Some crops use more nutrients than others. A bermuda grass hayfield uses a lot of nitrogen compared to a pine forest, but the nutrient generation principles are the same. These systems are most often used for municipalities or larger developments. Residential systems that don't harvest plants largely rely on the soil and soil micro-organisms to renovate wastewater belowground. So let's look at the soil.


Probably the most important part of the system for wastewater treatment is the soil microorganisms. Many small plants and animals thrive in the soil. One teaspoon of soil can hold 100 million bacteria, several yards of fungi, several thousand protozoa. The soil also contains tiny mites, earthworms, and other creatures. All these creatures have roles to play in releasing nutrients and other compounds form the wastewater, so that these are used and reused in the soil, leaving cleaner water to move into ground or surface water.



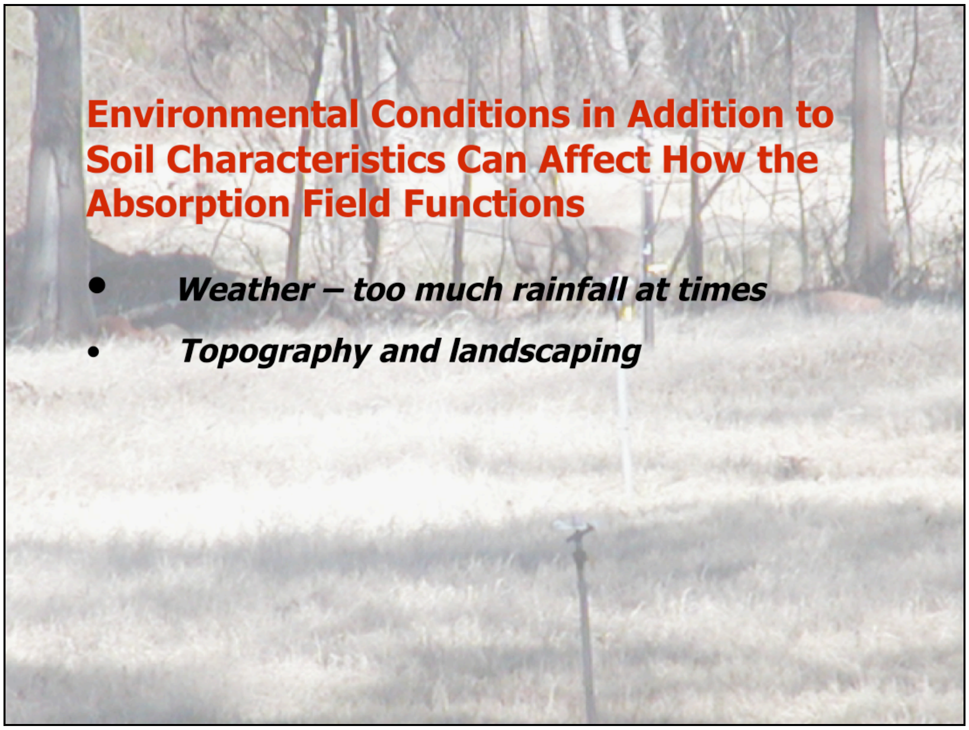

Soil provides a habitat for the microorganisms we discussed above. Many soil particles, particularly clays and organic matter, have negative charges on their surfaces. These charges hold on to metals and minerals that are positively charged such as zinc or calcium or even ammonium which is a positively charged form of nitrogen. These same soil particles also have positive charges that can hold onto things like phosphorus. Both the physical and chemical properties of the soil allow it to act as a filter.




We often think of soils as just what we can see at the surface, but soils often have different characteristics at different depths. Soils occur in layers that reflect how the soil was formed. On this diagram, you can see an O and A horizon that have dark colors. These horizons or layers usually have more organic matter (which gives them the dark color), roots, and microorganisms. Underneath these horizons there usually is a B horizon where organic matter is lower so the color of this horizon depends on the parent material. Below that is weathered parent material such as granite rock or marine sediments.

You can tell a lot about a soil by looking at its colors and other characteristics. What do you think creates the bright red colors you see in the photo on the left? Well, think of rusty nails. The red color is oxidized iron. This color tells you the soil is well drained and can accommodate wastewater effluent. In contrast, look at the soil in the photo on the right. This soil has gray colors. Gray colors are commonly found where the water table is high and the soil stays wet for long periods of time. When the soil stays wet, the oxygen in the soil is used up by microbes or plant roots. Under these conditions, iron changed to a soluble form and can be leached from the soil which leaves the gray colors of the natural minerals. This soil would not be suitable for wastewater effluent.

When used for wastewater treatment, the soils accomplishes 2 things: 1) Dispersion of the water into the environment and 2) treatment of the wastewater. The area of soil used for wastewater treatment is called a drainfield or absorption field. Current regulations require that soil, to be used as an absorption field, be evaluated by a person trained in soil science. The evaluator interprets these types of color and other characteristics in the field so that on-site wastewater treatment systems are sited and designed properly.



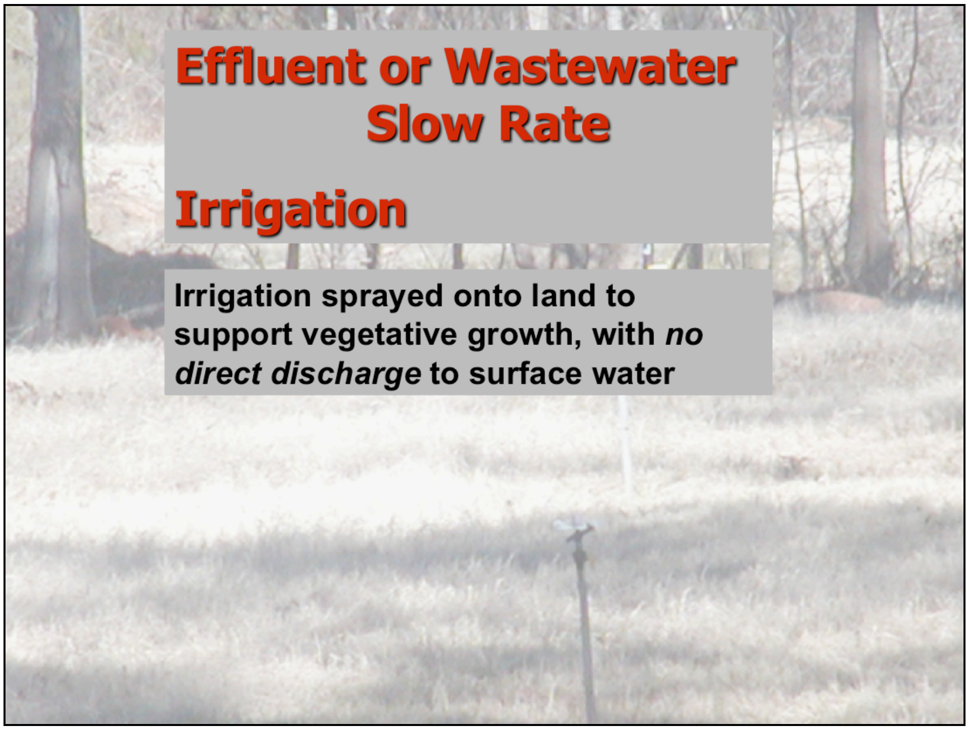

Weather parameters such as temperature and rainfall will affect the performance of the drainfield. In northern states the drainfield must be buried deep enough to prevent freezing. Even the low temperatures during the winter in Georgia will little or no effect on the performance of the drainfield. Exposed plumbing associated with a system, may, however, freeze if not properly protected.

With regard to rainfall however, rain water that enters the soil will compete with wastewater for dispersal pathways in the soil. In near-average rainfall years, a drainfield properly sited and installed in a well-drained soil will disperse water satisfactorily. In wet years or under flooded conditions, natural water may overload the absorptive (dispersal) capacity of the soil and lead to surfacing effluent. But this will be temporary and will end once the rainfall/ flooding ends.

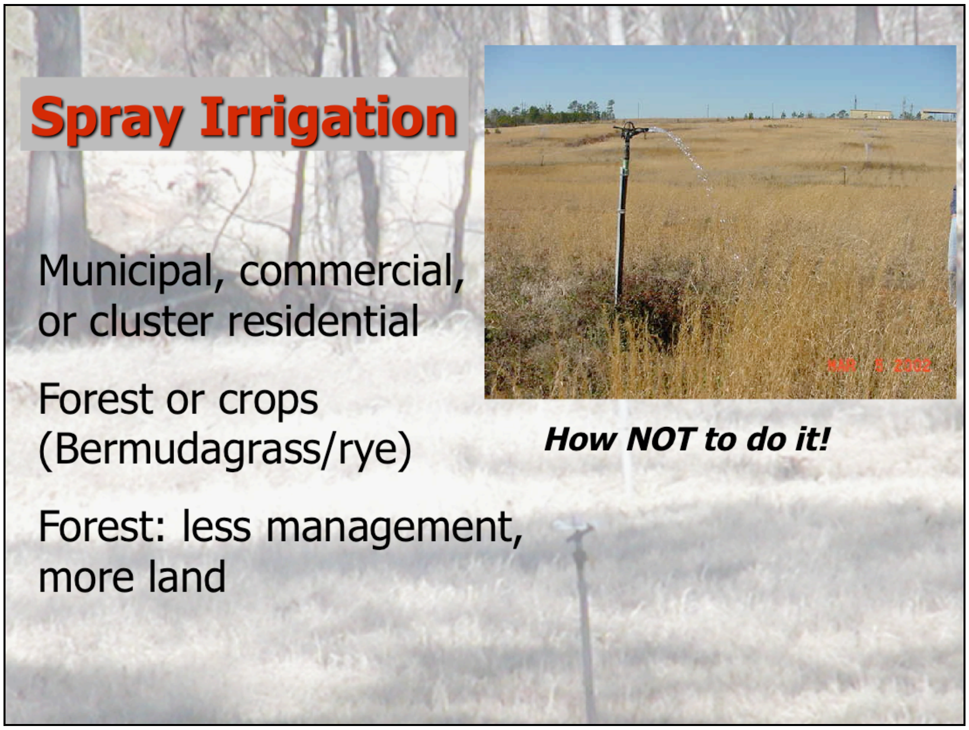
Topography can influence drainfield performance by channeling surface and/or subsurface water into the drainfield. Management of surface storm water (using landscaping and roof gutters) and subsurface flow to protect the drainfield area will allow the drainfield to function satisfactorily under Georgia weather conditions.

## Types of Systems Using Natural Treatment Media

- Slow Rate Irrigation
- Spray Irrigation
- Drip Irrigation
- Trench
- Overland Flow
- Constructed Wetlands

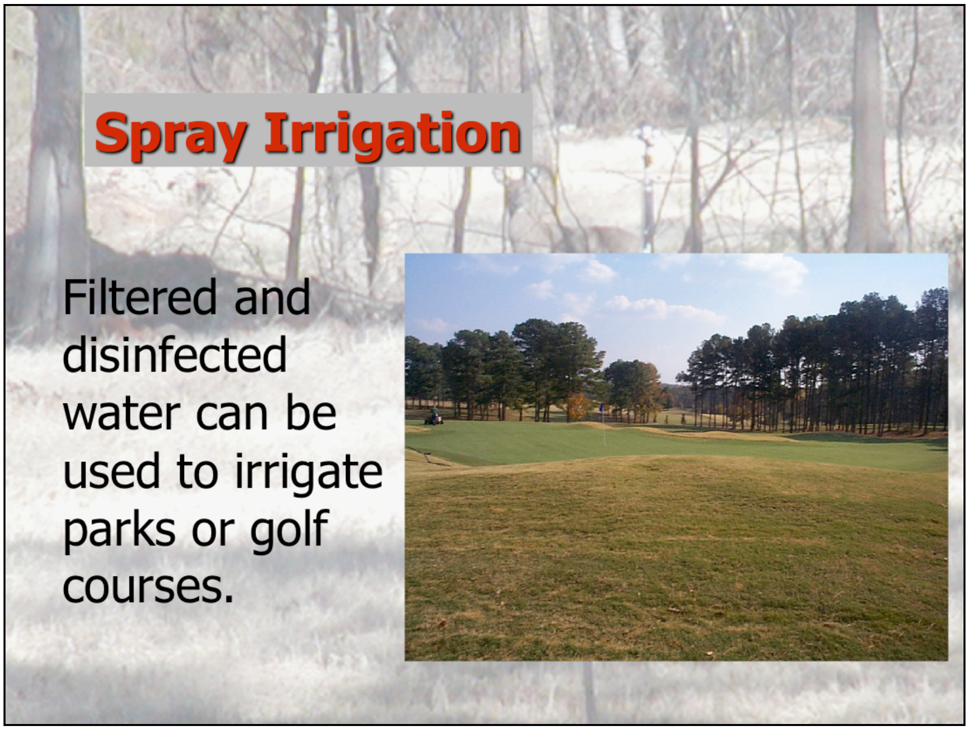



Now that we have the basics about the role of soil in wastewater treatment, lets look at the different types of natural wastewater treatment systems available. First there is slow rate irrigation. By definition, this is irrigation to support plant (read crop) growth. One important characteristic is, these systems do not have a direct discharge to river, streams, or lakes.

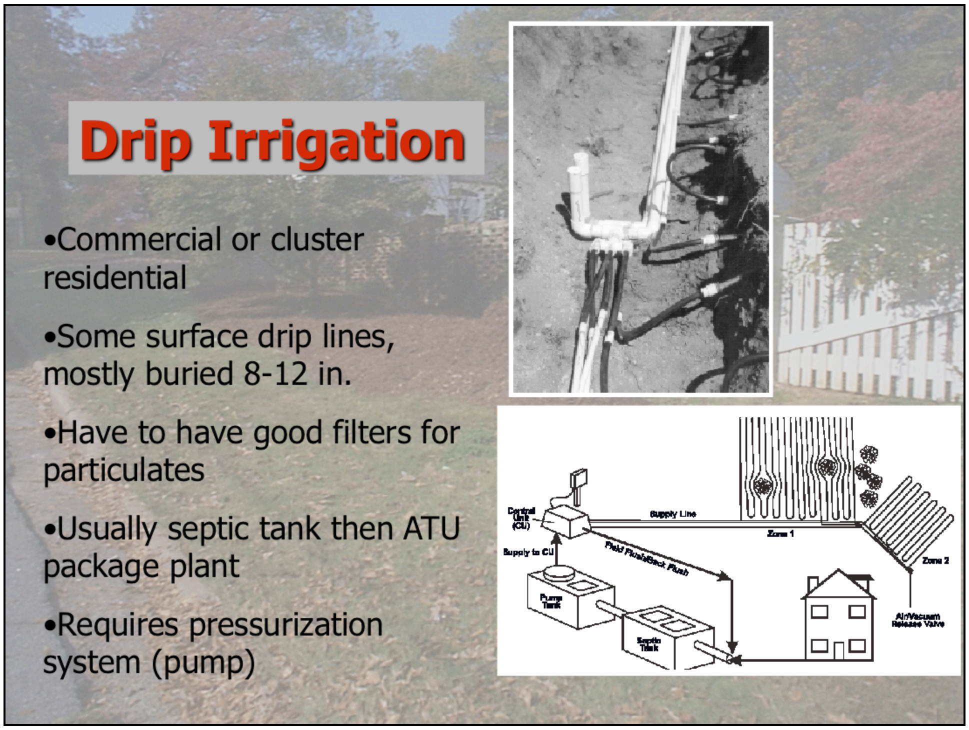



Spray irrigation systems are used mostly for treatment from municipal systems, though there are some commercial or cluster residential systems. The picture shows you a system that isn't working right. The sprinkler should distribute the wastewater evenly over a wide circle.

Most of these systems in Georgia use a bermudagrass hayfield that is overseeded in annual ryegrass in the winter months to promote nutrient uptake all year long. However, we also have a number of forest systems. A forest system requires less management, but requires more land because trees uptake fewer nutrients than most agronomic crops.



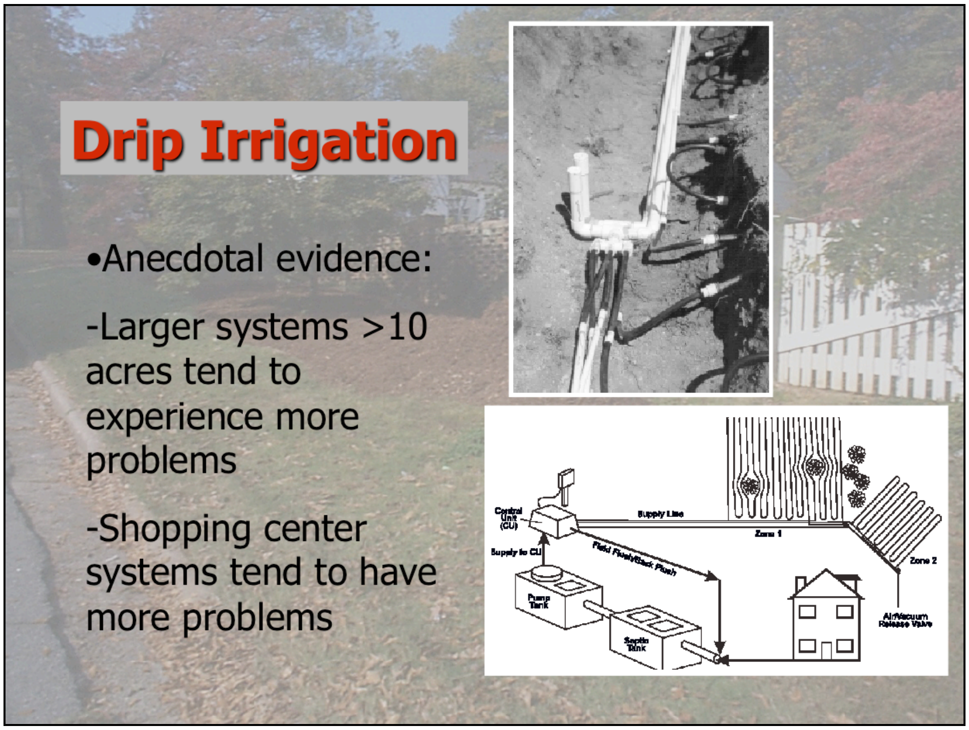

If the wastewater is filtered and disinfected, it can be used for irrigation in parks or golf courses. There are several golf courses in Georgia using highly treated wastewater for irrigation.




Drip irrigation is usually used in commercial, cluster residential developments, or individual homes. Lines are usually buried 8 to 12 inches deep about 1 to 2 feet apart. One advantage is that the lines can avoid obstacles like trees or shrubs, making it more flexible *than a trench system.* Drip irrigation is normally used only in special situations, such as steep slopes or slowly permeable soil.

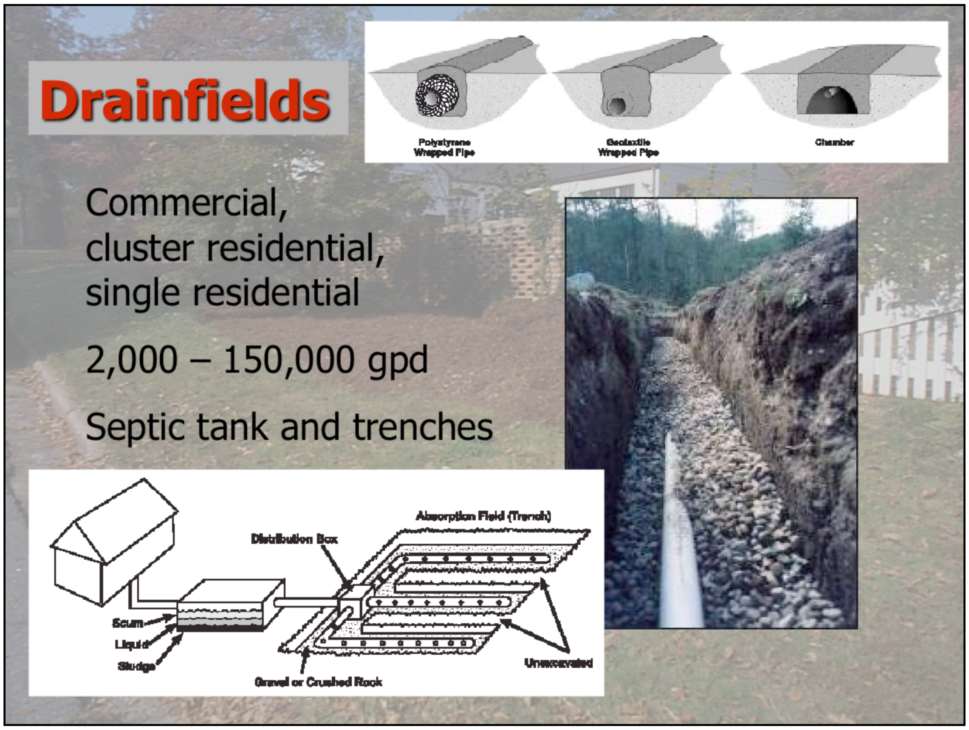
Because the lines are buried and have small holes or emitters where the wastewater comes out, it is important to have good filters for particulates. The smaller lines are generally cheaper and create less soil disturbance when being installed, but maintenance can be higher. There are sometimes problems with clogging due to particulates, biofilms, and roots.

These systems typically have a septic tank to settle out solids and begin treatment, then a package plant for further treatment. The package plants are commonly Aerobic Treatment Units (ATU). These are plants th*at* require oxygen to work. The package plants also require regular maintenance. A drip irrigation system requires more complex mechanical equipment for operation than the simpler septic tank and trench-type drainfield.




There are not a lot of published studies on drip irrigation in Georgia. These systems have been used successfully in many parts of the country. Conversations with people involved in designing and building these systems indicates that the larger systems tend to have more problems. This may be *due to* soil's variability over a site or the operational difficulties of keeping an even distribution over a larger area. Other problems have developed around commercial centers where the waste may contain more oil and grease or other constituents that make it harder for the systems to perform well.

Also these types of systems do better with continuous loadings rather than sporadic high loadings of wastewater. Nitrogen loading in these systems is usually 150 – 200 lbs/ac. In some states water loading is 50,000 – 75,000 gallons per day.




Drainfields have been traditionally used with septic tanks for residences. These systems are also used in commercial and cluster residential developments. Drainfields are usually trenches 24-36 deep on at least 7-ft centers. The top *diagram* shows several different types of drainfield *products* that are in use. Wastewater loading to these systems is ranges from 2,000 to 150,000 gallons per day.

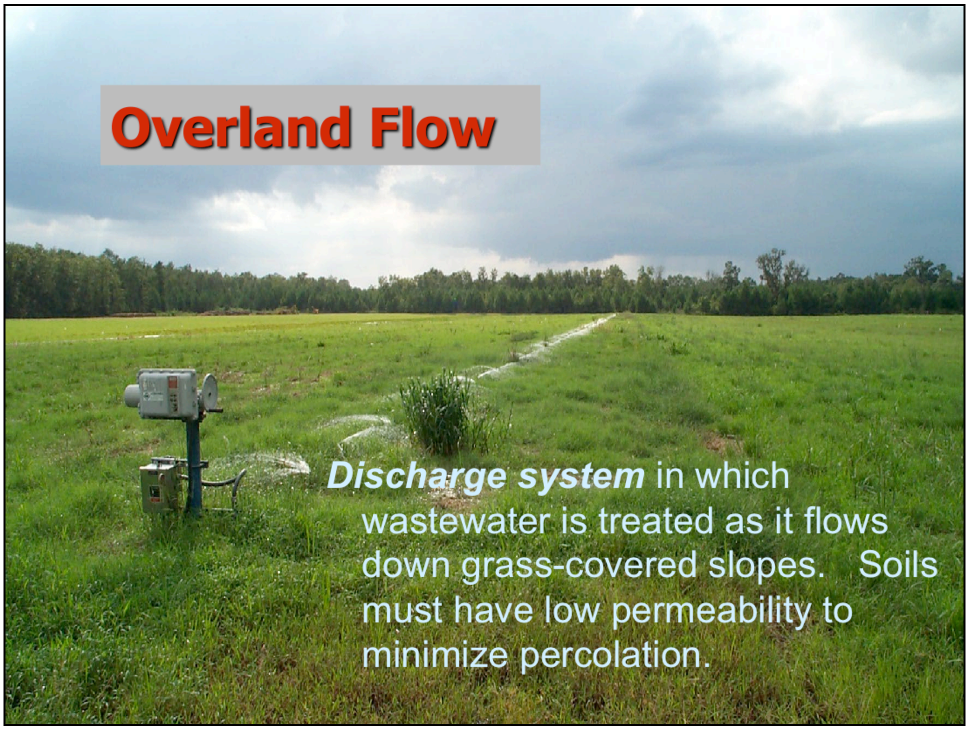
The Environmental Protection Division (EPD) of the Georgia Department of Natural Resources has defined three classes of these systems:

A community system that is >2,000 gallons per day (gpd),

A small community system between >2,000 and < 10,000 gpd, and

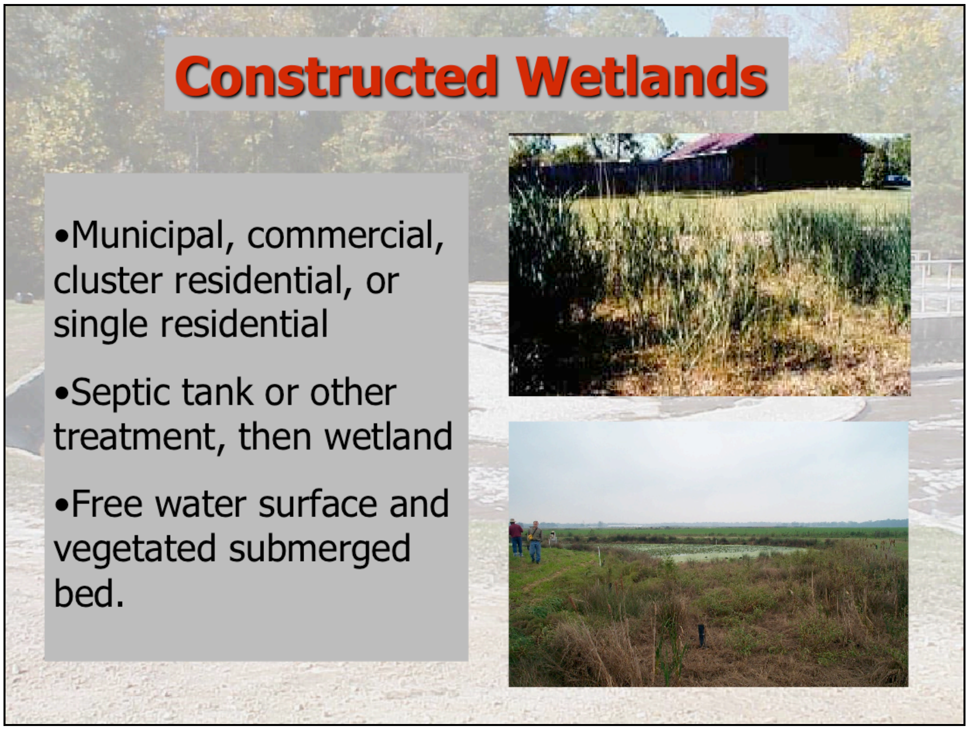
A large community system between >10,000 gpd - <150,000 gpd

EPD has regulations for large community systems. Systems less than 10,000 gpd *(residential and commercial)* are regulated through local health departments.




Overland flow systems are another treatment option. This pictures shows a community system in south Georgia. In these systems, wastewater is treated in a treatment plant then further treated as is flows over the soil surface and through vegetation. For the system to work properly, wastewater should not move into the soil but stay on the soil surface. For this to happen, soil must have a low permeability. These types of systems are most often used to further treat wastewater from a community. Because the water flows downslope and eventually reaches surface water, these systems are discharge systems. This different from drip irrigation or drainfields which are considered non-discharge systems. Overland flow systems have to have National Pollution Discharge Elimination System (NPDES) permits from EPD.

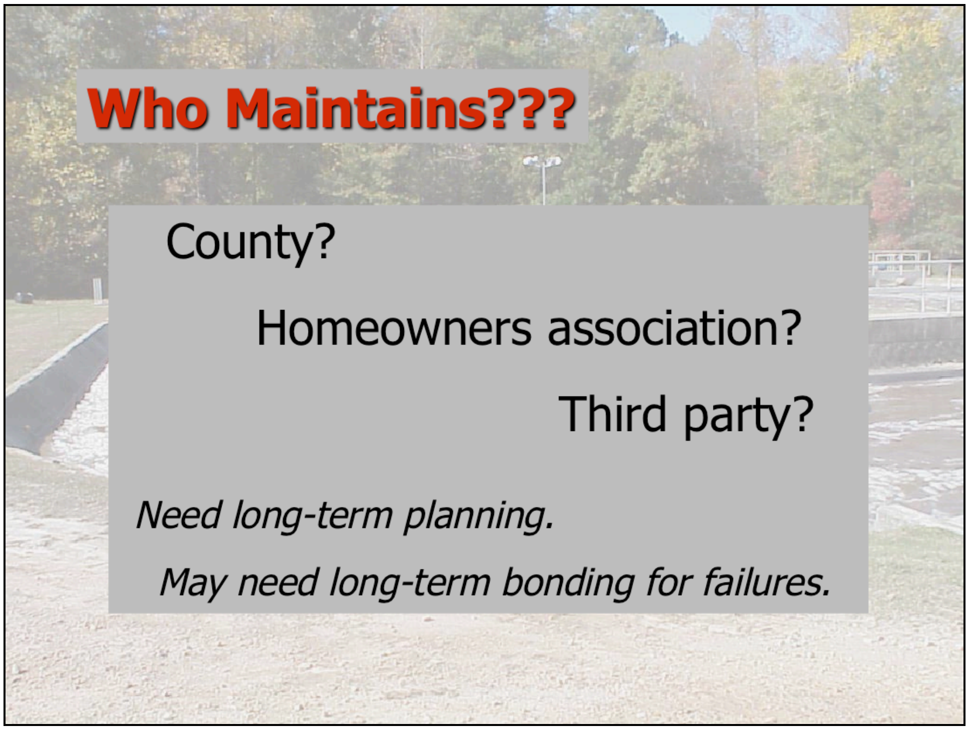

Another natural treatment system is constructed wetlands. Constructed wetlands can be either discharge or non-discharge systems. In a discharge system, the wastewater has some primary treatment and is further treated by the plant/soil system in the wetland. The water is then released to a stream or river. The photo is a picture of a constructed wetland on a farm that is treating lagoon wastewater. Some constructed wetland systems are designed so that all the incoming wastewater is treated and then either evaporates or infiltrates into the sol. These systems would be non-discharge since water doesn't go directly to surface water.



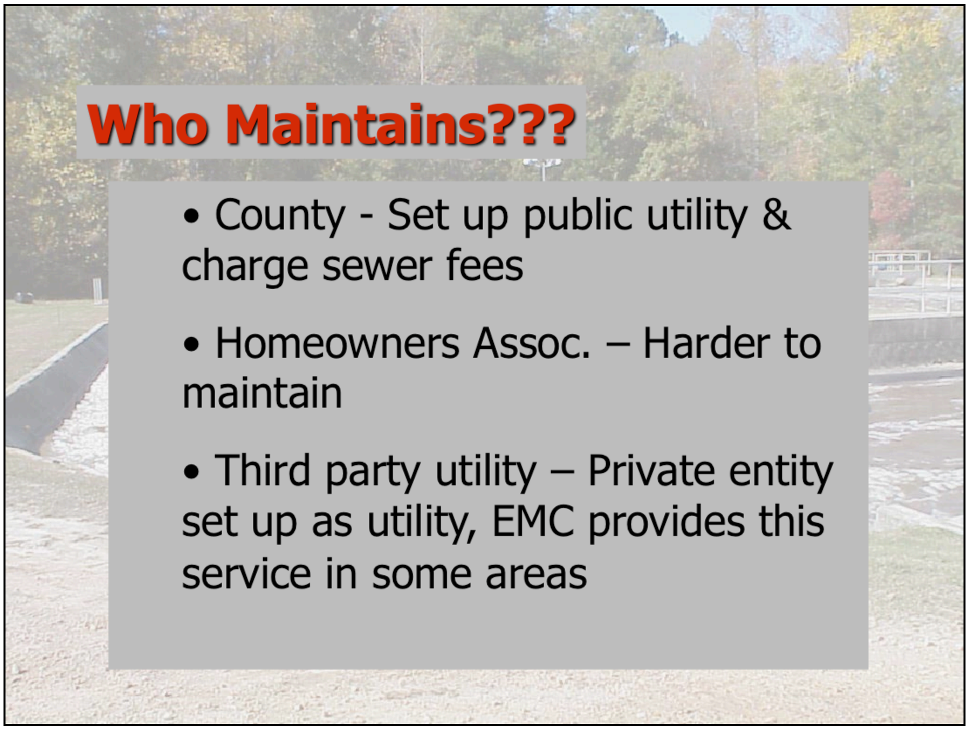

Constructed wetlands can be used for municipal, commercial, cluster residential, or even a single residence. The photo in the top right corner shows an example of a constructed wetland for a single residence. Some constructed wetlands, like the one in the bottom right corner have a free water surface. In these cases, you can see the wastewater on the surface as well as the plants. Other constructed wetlands are built so that the wastewater flows through a porous material such as gravel, and all you see are the plants on the surface. The residential wetland above is an example of that.


There are many factors that come into play when choosing a system. Many of these deal with the specific site. These include: How concentrated is the waste? How many gallons per day need to be treated? Are the soils well-drained? Does water move through the soil easily? How does water move through the subsurface in this area? Is bedrock near the surface? What the site is like – is it on hillslope or is it flat? Are there natural wetlands or sensitive water bodies nearby?

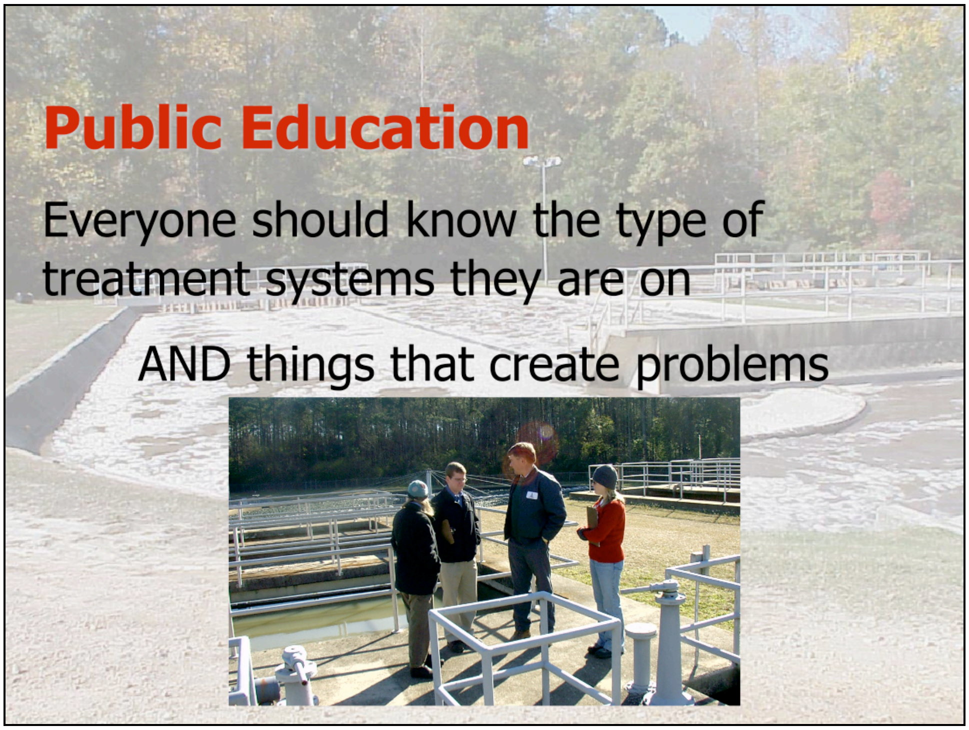
Capital and operating costs also have to be considered. How much does land cost? In high price areas, systems that use a lot of land may not be cost-effective. How much equipment is needed and what are the costs? All these systems need periodic maintenance. How much is maintenance, electricity, and other ongoing costs for the different options?



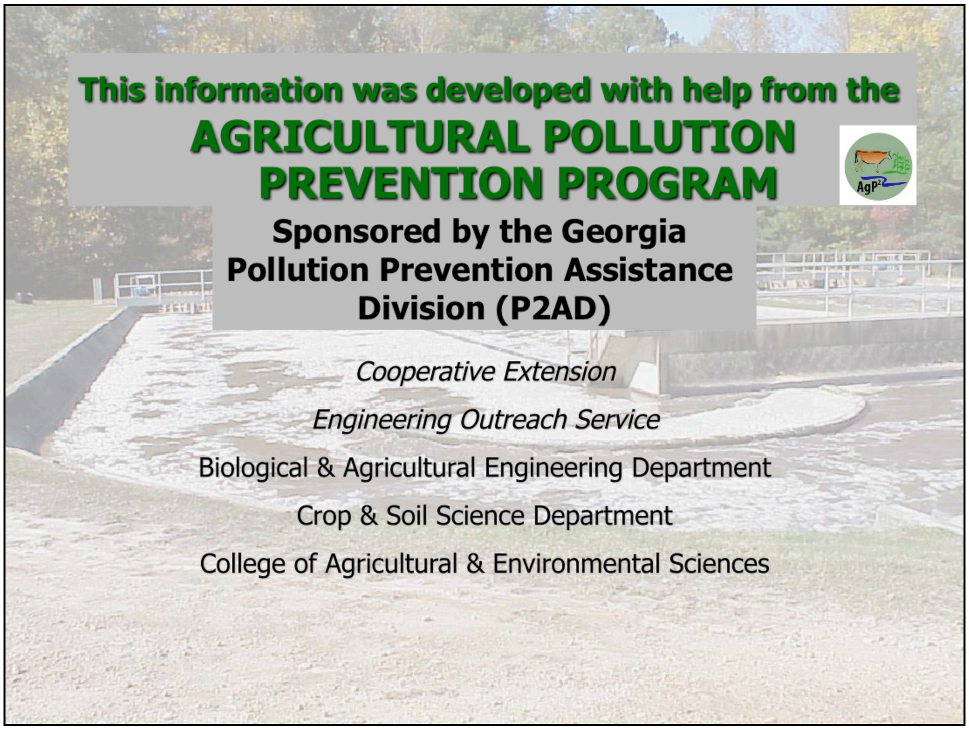

And maybe the biggest question of them all. Who maintains these systems? If *cluster de-centralized* systems are built by developers, will the county take over the operation and maintenance? Homeowners Association? Or will a third party be responsible? This question needs long-term planning and may need long-term bonding depending on the answer.




In some states, the county take over decentralized systems and sets up a public utility. The utility can then charge sewer fees to residents on that system. In other areas, there have been third party utilities, such as an EMC, which charges fees to provided these services. Many areas have found these systems hard to maintain over the long term using a homeowners association.




In any case, public education should be a part of planning to use decentralized wastewater treatment systems. People need to understand the type of system they are on and the potential limitations. Hopefully, education will help prevent or reduce maintenance and operation problems.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