Current Wastewater Technologies

An Overview for Homeowners

Prepared for the City of St. Augustine and the Florida Department of Environmental Protection, Office of Resilience and Coastal Protection, Florida Resilient Coastlines Program

As part of Grant Agreement Number R2130, Assess Vulnerability of OSTDS to SLR and Storm Surge to Develop Adaptation Plans, Ph I, Task 3 – Report of Wastewater Technologies

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EXECUTIVE SUMMARY

This report is part of a project to assess the vulnerability of onsite wastewater treatment disposal systems (OSTDS) to climate change related impacts such as sea level rise (SLR), storm surge, high tide flooding and rising groundwater levels. Coastal areas are at higher risk of experiencing these impacts which puts OSTDS in these areas at higher risk of inundation and failure. This project focuses on the City of St. Augustine and the OSTDSs in their water/wastewater infrastructure and service area. In the study area we have identified 2,938 OSTDS all of which are experiencing rising ground water levels and many of which are at risk of SLR, storm surge and high tide flooding. The City of St. Augustine seeks to understand which areas with OSTDS are at greatest risk and what options might be available for reducing or eliminating these risks.

The purpose of this report is to provide homeowners with a comprehensive overview of current wastewater technologies, both centralized and decentralized, to provide information on contaminant and treatment levels for different circumstances and systems, and to share cost and funding opportunities. The information in this report is intended to help homeowners participate in community discussions and plans to reduce the risks faced by OSTDS from climate change related impacts.

The authors would ask the readers to understand that science and technology are (thankfully) constantly evolving and that new treatment technologies may be available in the near future that are not covered in this report. This report includes information from the Environmental Protection Agency, Florida Department of Environmental Protection and industry professionals in both centralized and decentralized wastewater treatment. We are pleased to have had the input from so many persons active in the area of wastewater treatment and appreciate the time they spent with us.

The authors have made every attempt to recognize source material, and state that no copyright infringement is intended and that we are sincerely grateful to all those who gave their time to answer our many questions.

1. INTRODUCTION

This report is intended for use by homeowners and does not go into in depth details or explanations of the biological, physical, or chemical processes of wastewater treatment or the science of the technologies discussed. The intent of this report is to introduce the homeowner to the broad range of treatment technologies available for treatment of residential (domestic) wastewater so that they may have a simple reference when considering solutions for wastewater treatment. Common treatment processes for centralized and decentralized systems will be covered at the general level, as will costs and funding opportunities. The reader is encouraged to seek other sources for more detailed information on any of the topics covered. Again, I want to emphasize this is a very generalized, high level review, not intended for scientific or engineering audiences.

1.1. The Basics of Domestic Wastewater Treatment

Generally, wastewater treatment systems are managed in either 'Centralized' and 'Decentralized' facilities. Centralized facilities are usually thought of as the larger municipal sewer systems but can include 'STEP' (Septic Tank Effluent Pumping) systems, local 'package plants,' and even 'cluster systems' depending on your point of view. Decentralized facilities include many different types of 'onsite' treatment systems including advanced treatment units and performance-based units (Hallahan 2021). Think of the range of wastewater treatment facilities as existing on a continuum from smallest to largest:

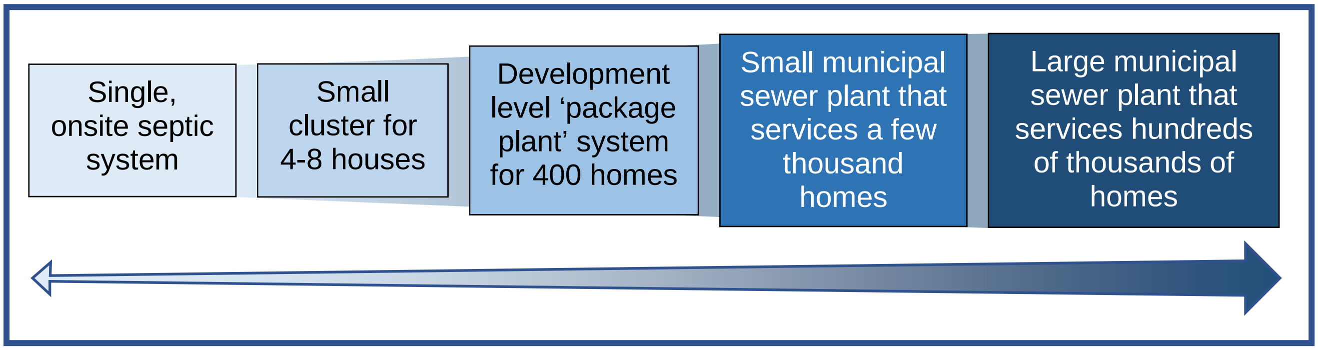

Figure 1-1 The range of wastewater treatment facilities from single, onsite septic systems to large, municipal sewer plants.

The goal of all of these systems is to break down the contents of your wastewater into something that would not be harmful to the environment. These systems originally only processed the waste from our showers, sinks and toilets. Now they also break down what comes out of our clothes washers and dishwashers plus all the modern cleaning products we use, medications we take, food we send down the garbage disposal and processed foods we eat and unfortunately sometimes also the harsher chemicals we use such as paints or super-duty cleaners. The processes available to treat these 'influents' fall within three different categories: physical, biological and chemical (Tchobanoglous and Burton 1991). An example of a physical process is straining to separate solids and liquids. A Biological process is using bacteria to break down organic matter in solids and liquids, and a chemical process might include using chlorine to disinfect effluents. Municipal systems, being bigger and more advanced, do a better job of addressing some of the newer, chemical elements in our wastewater, but even these are not yet advanced enough to treat everything. Onsite systems, which do not usually include a chemical process, can be severely negatively affected by chemicals coming out of our homes and entering our septic systems.

The most common process used to process wastewater are biological processes, and when properly designed and maintained these are also the most efficient (Tchobanoglous and Burton 1991). Think of these as composting systems, some are just bigger than others. In the broadest terms, domestic biological wastewater treatment falls into one of two categories: Suspended Growth or Attached Growth. This refers to the growth of the bacteria that are doing the work of breaking down the waste. In a suspended growth process the bacteria are suspended in the fluid (aka ‘liquor’), in attached growth the bacteria grow on some type of media such as rocks or a plastic shape. In centralized systems the process may include a preliminary step that specifically screens out materials such as sand or objects that could harm the mechanical components of the treatment system. In some biological processes, solids are allowed to settle to the bottom, or they are mixed with the liquids. Solids that are allowed to settle are broken down by anaerobic processes. Liquids with or without solids, move into either the suspended growth or the attached growth process, both of which are aerobic processes. Depending on the design of the system this may be the final step before disposing of outputs or there may be additional steps to further clarify or polish the effluent before it moves out of the treatment process completely.

The table below summarizes what happens in the domestic wastewater treatment process and gives examples for how these activities are accomplished in Centralized and Decentralized treatment systems.

Table 1-1 Summary of Domestic Wastewater Treatment Process and Examples for Centralized and Decentralized Facilities

Stage	Activity	Centralized	Decentralized
Pre-Treatment	Screen out grit or objects that could harm the physical components of the system	Influent Screen Grit Removal Unit	
Preliminary Treatment	Solids settle to the bottom; liquids move to the next step	Sedimentation Tanks or Basins	Tank in Conventional System
Secondary Treatment	Liquids (with or without solids) are processed through a suspended growth, attached growth or combined process	Activated Sludge or Rotating Biological Contactor	ATU Tanks Suspended Fixed Film Unsaturated Media Drainfields
Tertiary Treatment	Possible additional processing for further contaminant reduction or elimination	Various Filters or Chemical Processes UV Treatment Wetland Filtration Lagoons	Performance-Based Treatment Systems Drainfields

2. CENTRALIZED WASTEWATER TECHNOLOGIES

This section will give a general description of some of the most common technologies used to process domestic wastewater in Centralized systems. Virtually no two facilities have exactly the same design as the final design is determined in part by the level of treatment required. The treatment technologies described below are some of the most common for Centralized systems and are usually used in some combination to achieve the necessary treatment.

Figure 2-1 below shows how domestic wastewater is generally handled by a centralized facility. Some pre-treatment may happen at the water supply facility before water is consumed by a household. This pre-treatment may remove fine particles or introduce disinfecting chemicals not present in the water source. The public water supply is consumed by the household then leaves the household as wastewater and is taken up by the collection system that moves it to the wastewater treatment facility. Once the wastewater reaches the facility it may be put through a screening process (Primary Treatment) to remove grit or objects that would harm the plants physical components. If the facility uses an activated sludge process solids and liquids will move into the first treatment tank for mixing, or solids may be allowed to settle out and treated separately from liquids (Secondary Treatment). If the facility produces bio solids that will be disposed of separately these will be separated out and prepared for disposal (Biosolids Treatment). Depending on the design of the facility and their treatment requirements, advanced treatment may follow the secondary treatment. This may include special treatments for nutrients such as nitrogen and phosphorus. Disinfection will be the last step if necessary to further remove infectious organisms. Finally, the effluent is prepared for disposal. This may be discharging to a local waterbody, reused for irrigation in places such as golf courses or certain agricultural applications, or may be injected deep underground through an injection well.

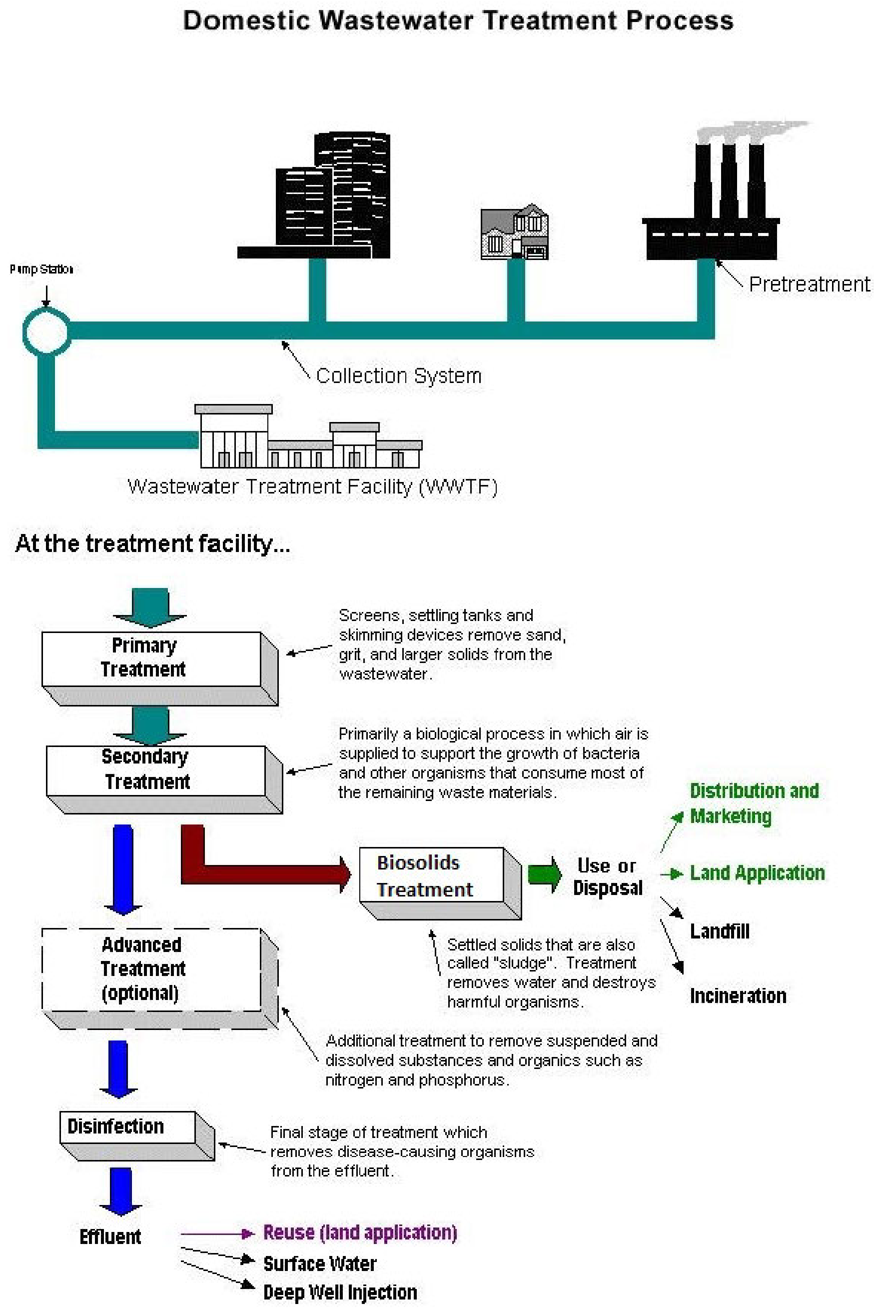

Figure 2-1 Process flow of a typical domestic wastewater treatment process.

Image source: Florida Department of Environmental Protection. *https://floridadep.gov/sites/default/files/dwwprocess_0.pdf*

2.1. Suspended Growth Processes

The Activated Sludge process for wastewater treatment is the most common for suspended growth processes. This process operates by both infusing air and preforming a mixing action of the influent material (liquids and solids). This provides bacteria in a ‘suspended’ manner which break down the ‘liquor’ (mixed material). The liquor moves through a series of these aeration and mixing tanks for some period of time (hours to days), or as in the case of Sequencing Batch Reactors, there may be only one tank for processing. Common variations of the Activated Sludge method include ‘Complete Mixing,’ ‘Sequencing Batch Reactors,’ ‘Extended Aeration,’ and ‘Contact Stabilization’ (Tchobanoglous and Burton 1991).

2.1.1. Complete Mixing

The Complete Mix process involves a continuous flow of influents that are constantly being mixed together. Additionally, as solids and liquids settle out at various points, a portion of each are returned to the mixing tank(s). Some of the sludge is allowed to settle out as waste sludge. If this process provides the necessary level of treatment, the effluent is discharged, otherwise it is moved onto additional treatment processes.

2.1.1.1. Sequencing Batch Reactors (SBR)

Often referred to as a ‘fill and draw’ process, the SBR process happens in one tank and thus the tank is ‘filled, the ‘batch’ is processed, and the tank is then emptied or ‘drawn’ down. Bacteria treat both solids and liquids. After treatment, solids and liquids are separated and each undergo additional processing dependent on how much treatment is still necessary and how the final outputs will be disposed. SBR is well suited for smaller plants (<5MGD – million gallons per day) but is more complex to keep processes balanced within the batch processing.

2.1.1.2. Extended Aeration

Extended aeration is a slower activated sludge process in that the liquor mixture spends much more time in the suspended tank. This process is good for smaller facilities that have a much lower influent rate (< 0.5 MGD). Also, it is most commonly used in ‘package plant’ setups. Package plants are pre-manufactured facilities that can be setup for small communities or neighborhoods.

2.1.1.3. Contact Stabilization

Contact Stabilization refers to using aeration to stabilize the organic matter in the sludge that is being returned to the primary mixing tank. As with Complete Mixing, influents are mixed in the same tank, after which some solids settle out in a second tank. These solids are then contact stabilized before returning to the primary mixing tank.

2.2. Attached Growth Processes

Whereas Suspended Growth processes keep bacteria suspended in the tank, Attached Growth provides a surface for the bacteria to attach to. These surfaces take many forms and are made from several materials. In attached growth processes, the focus is on how the bacteria come in contact with the influent. The most common methods are the ‘Trickling Filter’ and the ‘Rotating Biological Contactor’ (Tchobanoglous and Burton 1991)

2.2.1. Trickling Filter

In this method, influent is introduced into a tank containing the media upon which bacteria is growing. The influent is ‘trickled’ over top of this media and allowed to filter through the bacteria on the media. Commonly these are round tanks, and the influent is introduced through a set of arms extending from a rotating pivot point. These tanks tend to be several feet deep, often 6 feet deep. At the bottom is a collecting tank that collects solids as well as liquids. A portion of the solids and liquids are cycled back through the tank. Treatment is achieved through repeated cycling which places the influents in contact with the bacteria attached to the media.

2.2.2. Rotating Biological Contactor

While the trickling filter trickles the influents over the media, Rotating Biological Contactors rotate the media through the influents. Bacteria are growing on the media which is slowly rotated through influents in a tank. This exposes the bacteria to the influents for processing through both an aerobic process and anaerobic process.

2.3. Further/Additional Processing

If further treatment is necessary, for disinfection or further treatment of infectious organisms, UV disinfection or chemical treatments are available and the most common (Tchobanoglous and Burton 1991).

2.3.1. UV Disinfection

Ultraviolet, or UV, light can be used to kill bacteria or virus by exposing the material to either a natural or artificial UV light source. Ultraviolet light exists within a particular spectrum on the light spectrum. It is the radiation emitted within this spectrum that can act as a bactericide or virucide.

2.3.2. Chemical Treatments

For chemical disinfection, Chlorine is the most commonly used chemical in wastewater treatment. In appropriately managed processes, it can react with various nitrogen compounds in wastewater effluent achieving a desired level of disinfection.

The processes discussed above are only some, though the most common, ways in which centralized wastewater treatment facilities may treat domestic wastewater. Additionally, facilities may combine any of these processes to achieve a required level of treatment. In fact, it should be noted that rarely will there be two facilities with the same treatment design. Facility design will be determined by what is coming in and to what level it needs to be treated. Required treatment level will also depend on how outputs will be disposed.

3. Decentralized Wastewater Technologies

Decentralized Systems are systems that have historically been ‘onsite’ at the property it is providing the waste treatment service for. While most commonly these are for single family residential properties, they may also be for small commercial uses or a small number of homes together. These most commonly consist of a tank and a drainfield. The tank is a watertight concrete or heavy-duty plastic or fiberglass tank that is buried underground. Residential system tank sizes depend on the size of the home and how many people live there. They generally start at a 900 gallon size and can go as high as 3,000 gallons(“Product Listings and Approval Requirements | Florida Department of Health” 2021). Everything leaving the house through the plumbing (toilets, showers, sinks, dishwasher, clothes washer, etc.) enters the tank. Heavy solids sink to the bottom; fats, oils, grease (FOG), and lighter solids rise to the top; and liquids (effluent) flow out into the drainfield (US EPA 2018). The top of the drainfield should be 6” below ground surface, and should have at least 24” from the bottom of the drainfield to the top of the groundwater (FDOH 2018).

In these systems, a large area of concern is what types and quantities of pollutants are leaving the tank and entering the drainfield. These ‘pollutants’ include high concentrations of nitrogen from urine. While nitrogen is a naturally occurring element, in high concentrations it can be harmful to plants and animals. In an ideal situation, there will be a high level of organic matter in the soils beneath the drainfield and this organic matter will be able to convert enough of the nitrogen to harmless nitrogen gas so that the concentrations are no longer harmful. After the effluent leaves the drainfield and soaks through the soils beneath the drainfield, it enters groundwater where it eventually makes its way out to surface waters.

Especially in Florida we have seen the effects of high levels of nitrogen entering surface waterbodies, such as lakes and rivers, from septic systems as well as other sources, in the form of algal blooms, fish kills and reduced aquatic vegetation (Diaz-Elsayed et al. 2017).

In Florida we face several challenges to the 'ideal' situation. First, our soils have a high sand content and little organic material. This allows fluids to move quickly through the soil to groundwater with very little processing of pollutants. An additional challenge, especially in coastal areas, is our groundwater levels are rising – reducing the distance between the drainfield and the groundwater and thus how much of the harmful nitrogen is converted to harmless nitrogen gas. Both of these challenges allow high levels of harmful nitrogen to enter groundwater and make their way out to surface waters. As we saw with the centralized systems, 'treatment' occurs in the biological processes of suspended growth or attached growth where bacteria break down the contaminants. For onsite systems this process has traditionally been completed in the drainfield, but new technologies have improved drainfield treatments and introduced these processes to the tank as well.

3.1. Tank technologies

In recent decades, tank technologies have evolved from the traditional anaerobic (without air) treatment type to several methods of more advanced treatment processes. These range from providing better treatment to pollutants and wastes overall, to specifically treating nitrogen or other elements. There have also been technological advances in drainfields. These have included the design of the drainfield pipes as well as the media below the drainfield and above the soils.

3.1.1. Anaerobic Systems (traditional/conventional)

Anerobic septic systems are the most common and what most people think of when picturing a septic system. They have also been around the longest. In these systems, solids settle to the bottom and are 'digested' in an anerobic (without air) environment while lighter solids float to the top and liquids flow into the drainfield and then into soils (US EPA 2018). The primary form of 'treatment' in these systems is whatever processing happens in the soils below the drainfield. As noted above, in some situations this can be very little treatment.

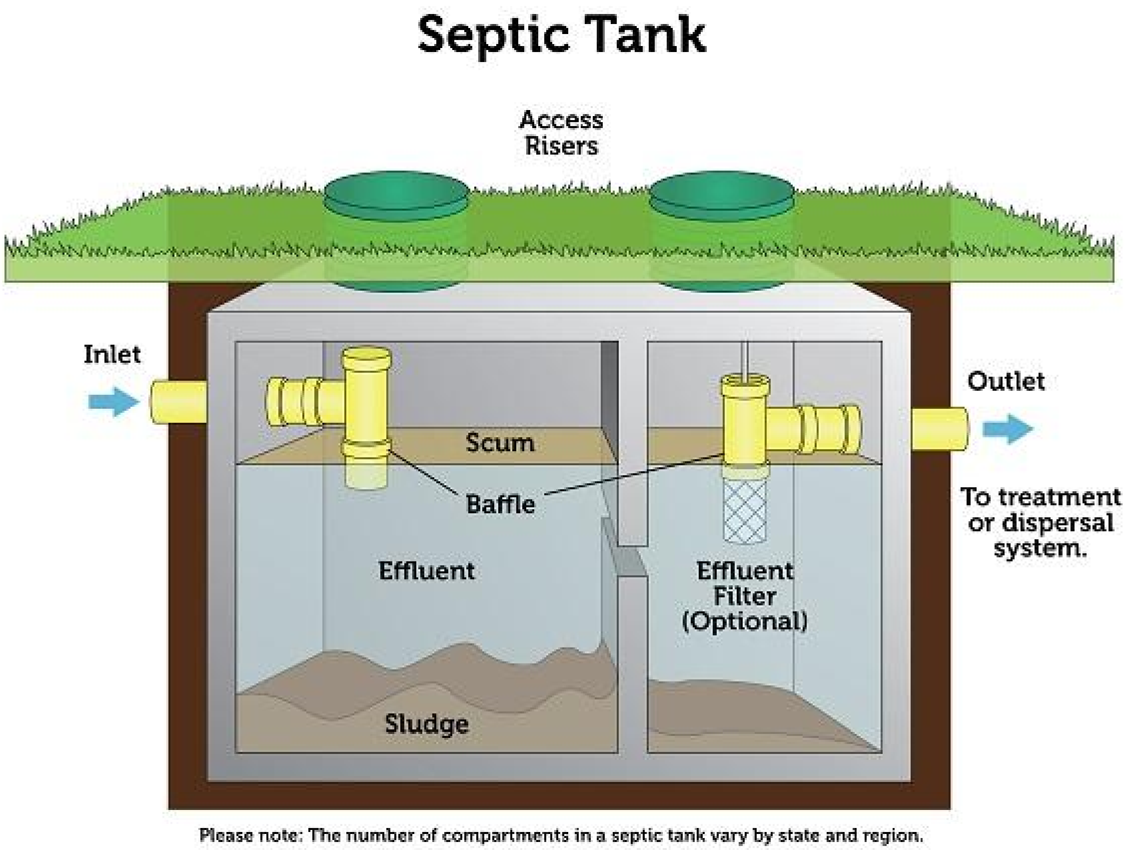

Figure 3-1 Example of a conventional septic tank.

Image Source: EPA, Types of Septic Systems (https://www.epa.gov/septic/types-septic-systems)

3.1.2. Aerobic Treatment Units (ATUs)

These systems introduce air into either the primary or a secondary tank where bacteria digest more of the components of the wastes than they do in a traditional system. ATUs come in several different forms such as 'Suspended,' 'Fixed Film,' and 'Unsaturated' (Groover 2020).

3.1.2.1. Suspended Growth

In a 'Suspended' aerobic treatment there is an aeration tank where air is forced to move in the liquid and bacteria are 'suspended' in this mixture. The moving air keeps the mixture moving and mixing while also keeping the bacteria suspended (Goguen 2018). These bacteria are more effective at reducing pollutants so less harmful materials make it out to the drainfield.

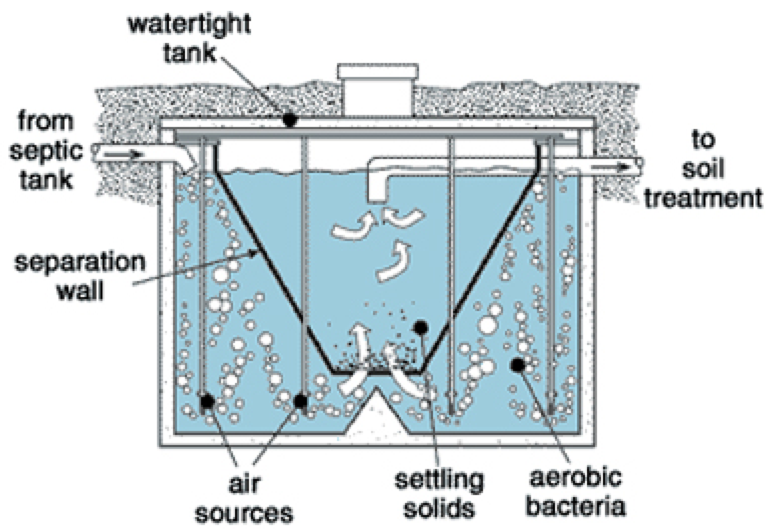

Figure 3-2 Example of a suspended treatment tank.

Image source: AAMS Wastewater, www.aamswastewater.com

3.1.2.2. Fixed Film/Attached Growth

A 'Fixed Film,' or 'Attached Growth' system contain material that the bacteria attach themselves to and then the effluent are sprayed over the material by a rotating arm. This process mimics the suspended treatment system by alternatively exposing the bacteria to air and fluids (Goguen 2018).

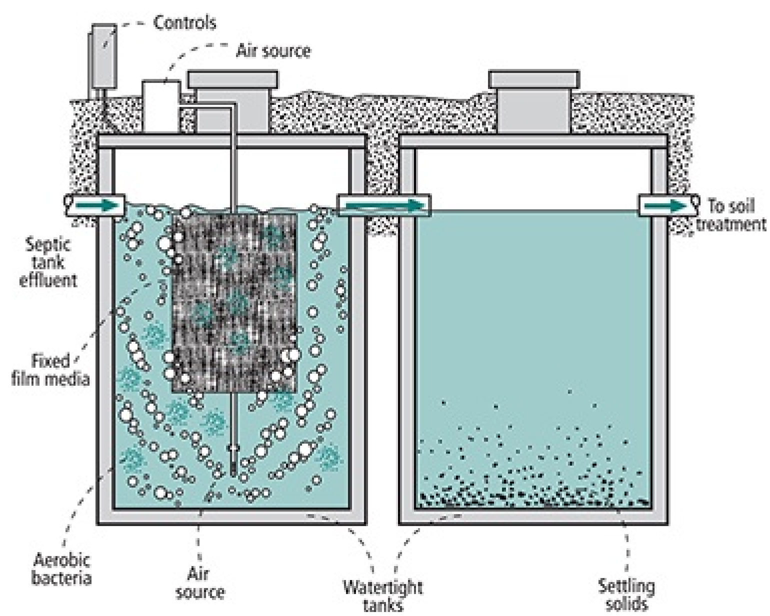

Figure 3-3 Example of a fixed film or attached growth tank.

Image source: National Precast Concrete Association, https://precast.org/2018/01/taking-septic-tanks-to-the-next-level-advanced-treatment/

3.1.2.3. Unsaturated Media Filters

Unsaturated media filters operate by filtering the effluent through a material (media) such as sand before it goes to the drainfield. These are available in both 'single-pass' and 'recirculating' where the effluent may filter through the media only once before going to the drainfield or may be recirculated through the media multiple times before going to the drainfield. There are several different media types than can be used in these systems including sand, gravel, peat or foam (Galbraith 2018).

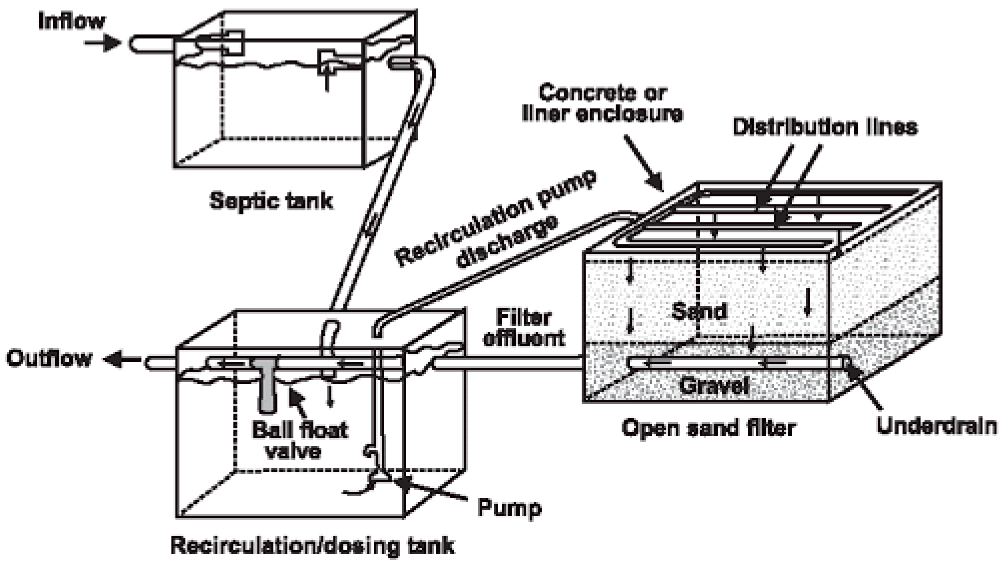

Figure 3-4 Example of a recirculating, unsaturated media tank.

Image source: Missouri Department of Natural Resources, https://dnr.mo.gov/pubs/pub2738.htm

Performance Based Treatment Systems (PBTS) and Innovative Systems are systems designed by a licensed engineer specializing in wastewater treatment and are often used where site conditions require treatment beyond what a conventional or advanced system can achieve. These systems must reach specified treatment levels for $CBOD_5$ (five-day carbonaceous biochemical oxygen demand), TSS (total suspended solids), TN (total nitrogen), TP (total phosphorous) and FC (fecal coliform) (Harriss and Blanco 2013). As part of their design, they may use components of ATUs and also additional treatment technologies such as chemical treatments, UV lights or other technologies.

3.2. Drainfield Technologies

While the drainfield design hasn't changed much from the traditional pipe and trench network, what the trench is filled with and how that 'pipe' is constructed has seen advancement. Also, traditionally the drainfield has been gravity fed, meaning the effluents flow downhill into the network. Today, when site conditions prevent a traditional gravity system from operating, a pressurized system can be installed to make sure effluent moves through the drainfield network.

3.2.1. Traditional rock/gravel aggregate

The most common drainfield design is to put a perforated pipe network in a gravel bed. The gravel is of large enough size to allow space between the rocks for the effluent to flow through. Bacteria will build up on the rocks and provide treatment to the effluent as it flows through (US EPA 2018). One downside of the rock aggregate is that the 'fines,' smallest pieces of rock, may be so small as to clog filtration.

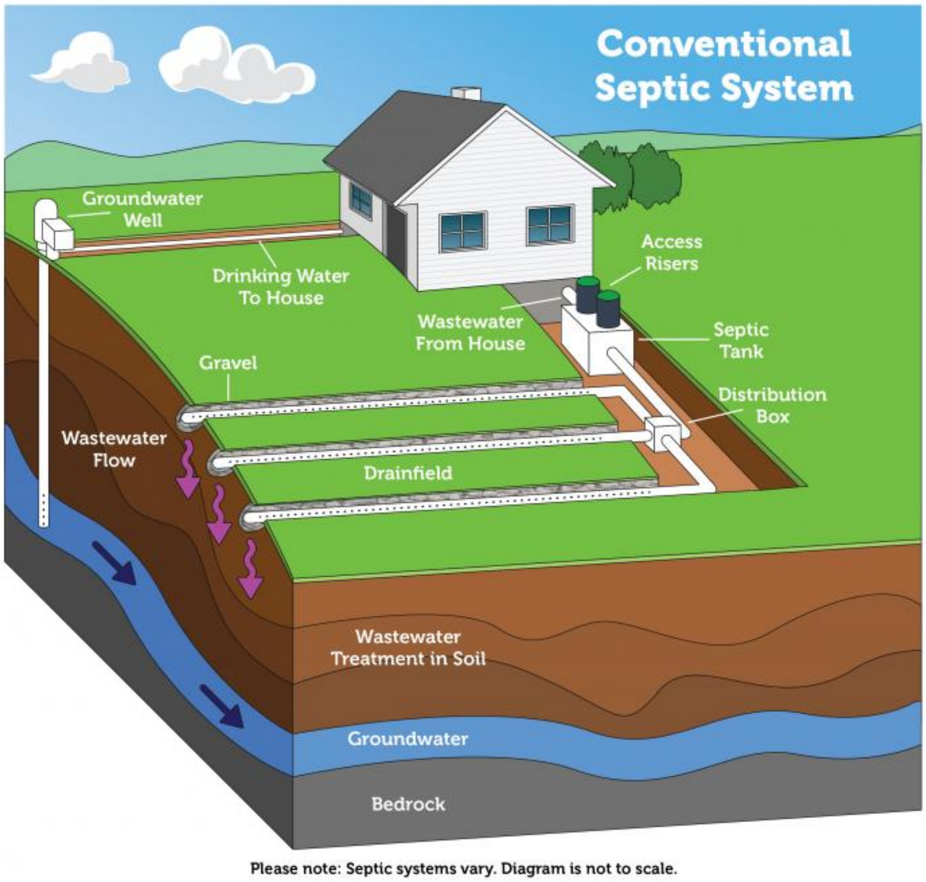

Figure 3-5 Example of a conventional septic system.

Image Source: EPA, Types of Septic Systems (https://www.epa.gov/septic/types-septic-systems)

3.2.2. Engineered Aggregate

Engineered aggregate is a synthetic material that is formed into a shape with lots of surface area for bacteria to attach to. These are often compiled into pre-built units to make installation easier (Infiltrator Water Technologies 2015). These have the benefit of not having any 'fines' to prevent effluent flow and increased surface area for more bacteria to attach.

Figure 3-6 Example of an engineered aggregate unit.

Image Source: Infiltrator Water Technologies, www.infiltratorwater.com

3.2.3. Plastic Chambers

Plastic chambers are like the top half of a circle that is placed as the drainfield network. These can be placed linearly or in the common network fashion like common perforated pipe. Bacteria attach to the plastic chamber as well as the soil under it, building up a mat of biological material to do the processing (Shoaf Precast Inc. 2021).

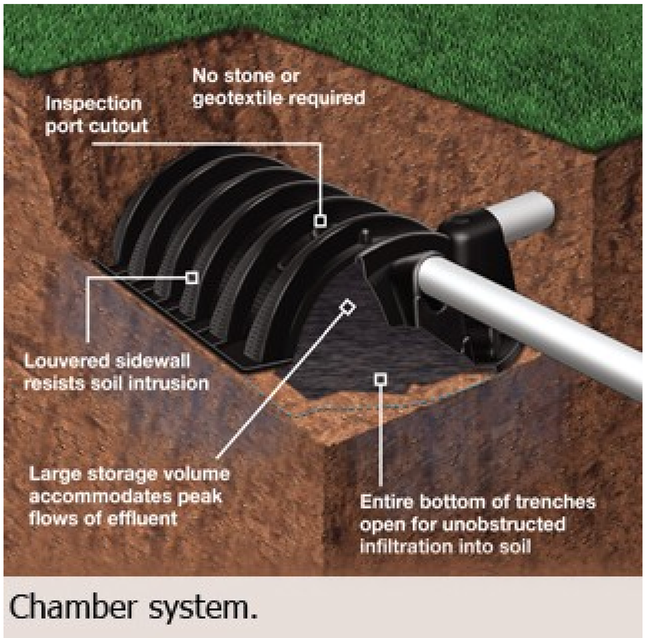

Figure 3-7 Example of a chamber system.

Image source: Shoaf Precast Inc., www.shoafprecast.com

3.2.4. bric Wrapped and Bundled Pipe

Fabric wrapped pipe is exactly what it sounds like. Perforated corrugated pipe is wrapped in a polyester fabric. Bacteria attach to the fabric and the pipe and treat the effluent as it ‘wicks’ around the pipe (Springfield Plastics, Inc. 2021).

Figure 3-8 Example of a fabric-wrapped pipe.

Image Source: Springfield Plastics Inc., www.spipipe.com

3.2.5. In-Ground Nitrogen Reducing Biofilter

This is required in Spring and Aquifer protection areas. It is a layer of filter material (woodchips or other approved material) below the drainfield that will achieve significant nitrogen reductions of up to 65% (FDOH 2020).

3.2.6. Drip Distribution

A pressurized system that regulates the flow of effluent to the drainfield so that it is sent to the drainfield in regular, even doses. This regulates the application of effluent to the soils so there is no over or under saturation that might interrupt the bacteria cycle and potentially kill off the bacteria mat (Hallahan 2012).

Figure 3-9 Example of a drip distribution system.

Image source: Ever Green Septic Design, www.egsd.com

3.2.7. Mound System

Mound systems are most commonly used when the distance between the drainfield and the ground water, or a confining layer of soil such as clay, is not deep enough (24") to allow for sufficient effluent treatment (Parker et al. 2009). The drainfield is raised above ground to create the depth necessary for treatment.

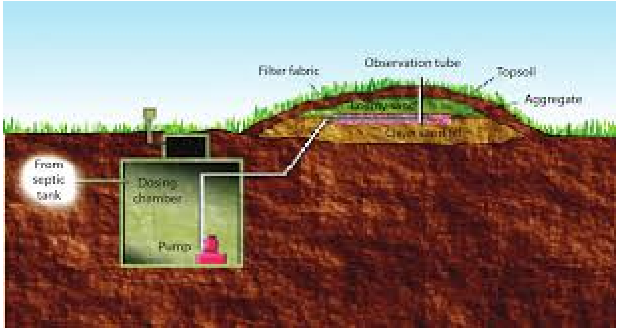

Figure 3-10 Example of a mound system.

Image source: Iowa Department of Natural Resources, www.iowadnr.gov

4. BETWEEN CENTRALIZED AND DECENTRALIZED

Depending on the needs of the community, components of centralized and decentralized treatment systems can be combined to create a facility that serves a small area or community. These can include 'STEP' systems, 'cluster' systems, and 'package plants' (Hallahan 2021). The benefit of these is that they can be customized to the community's needs and can help bridge the wastewater treatment gap for small but growing communities who may not be ready or able to connect to a larger treatment plant.

4.1. STEP Systems

STEP Systems (Septic Tank Effluent Pumping) leave the tank in place on the property but draw the effluent into the collection network to be treated at the central wastewater treatment facility. Solids in the tank continue to break down through their aerobic process and can be pumped out periodically but the higher contaminant loads are treated with the (usually) more advanced technology at the central facility.

4.2. Cluster Systems

Cluster systems, similar to STEP systems, leave the tank on the property to collect and process solids, but transport the effluent to a common location for processing in a drainfield. The drainfield can use the conventional pipe and gravel system of any of the other drainfield technologies available. This can serve a small community of homes that may not be able to connect to a central facility because of distance or physical barriers.

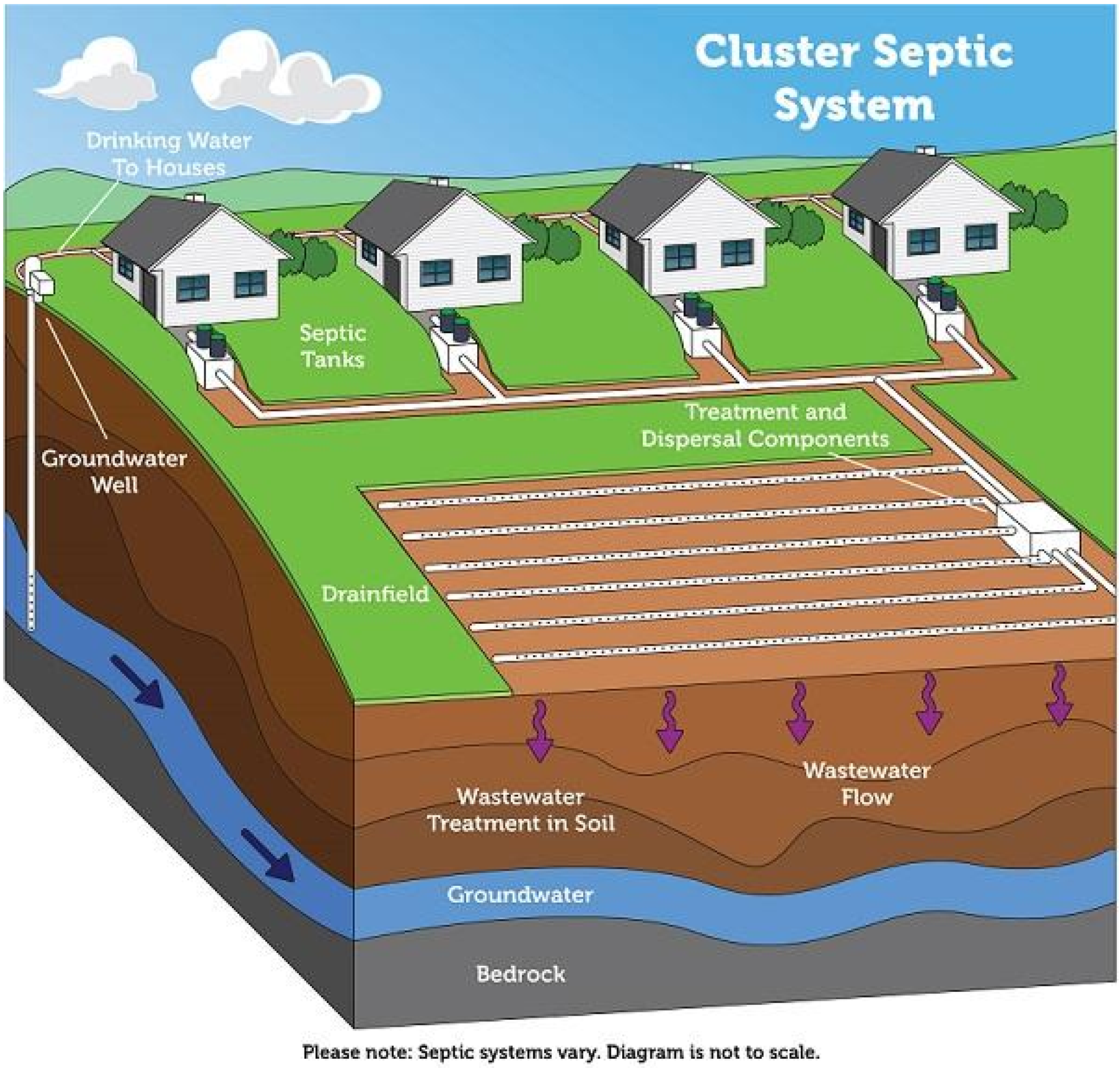

Figure 4-1 Example of a cluster system.

Image Source: EPA, Types of Septic Systems (https://www.epa.gov/septic/types-septic-systems)

4.3. Package Plants

Package Plants, mentioned earlier under the centralized systems extended aeration technology, are pre-built treatment facilities that can be setup and operating much quicker than a centralized facility but are intended to serve local communities such as subdivisions or a few thousand homes.

These local facilities can be operated by the municipality, a Special District (discussed under funding options), or an agency created for their management.

5. Treatment Requirements

Historically, treatment was categorized as ‘primary,’ ‘secondary’ and ‘tertiary,’ but now treatment is focused on maximum levels of contaminants in the effluent, such as a maximum of 10mg/L of Total Nitrogen in the Florida Keys. In this way, both centralized and decentralized treatment systems are similar, in that they have to remove a certain amount of contaminants, although the requirements are slightly different for the two. Since this resource is written for the homeowner we will focus on treatment requirements for onsite or localized systems.

As mentioned, what’s going into the septic system is everything from our toilets, showers, sinks, clothes washer, dishwasher and any other plumbing in your home. What we flush down the drain is not only organic waste from ourselves, but all the chemicals we use for cleaning, medications we ingest that don’t break down in the body, and often times household hazardous waste that shouldn’t go down the drain at all. There are also some surprising items that enter septic systems that shouldn’t: coffee grounds, fats/oils/grease (FOG), cleaning wipes, disposable diapers, kitty litter and cigarette butts to name a few (Harriss and Blanco 2013). None of these items can be broken down in septic systems and could even clog pipes and cause the tank contents to back up into the house. It’s important to recognize that the biological processing done by the septic system happens almost completely in the drainfield in a conventional system. ATUs and PBTS provide increased reductions in the tank with their new technologies and this has greatly improved effluent quality out of the drainfield.

To understand what level of processing takes place in these systems, the table below compares what is going into a conventional septic tank (the raw sewage – influent – from your home), to what is coming out of the drainfield and going into the soils below the drainfield, and also treatment standards for PBTSs, the Florida Keys and drinking water in Florida.

Table 5-1 Comparison of common parameters for influent, effluent, PBTS, Florida Keys Treatment Standard and Florida Drinking Water Standard.

Element	Going into the Septic Tank (mg/l)[1]	Coming out of the Drainfield (mg/l)[1]	Systems meeting NSF 245 Standard (mg/l)[2]	Florida Keys Treatment Standard (mg/l)[1]	Drinking Water Standard (Florida, Class I) (mg/l)[3]
Total Nitrogen	60	60	50% reduction	10	10
Total Phosphorous	10.4	9.8		1	0.01
$CBOD_5$/BOD	420	216	25	10	
TSS	232	61	30	10	

[1] (Harriss and Blanco 2013), [2](Groover 2020), [3](“62-302 : SURFACE WATER QUALITY STANDARDS - Florida Administrative Rules, Law, Code, Register - FAC, FAR, ERulemaking” 2020, 530)

We can see that there is not much nitrogen treatment happening in a conventional system, and area of concern in Florida right now. The NSF 245 standard defines the level of nitrogen reduction required for residential wastewater systems (NSF International 2021) and has the added benefit of CBOD and TSS reductions as well. In all cases, we can see that treatment is necessary to cleaning the effluent to an appropriate level before releasing it back to the environment.

6. Costs

It's difficult to pin down costs for any of these systems. What's provided below is only for reference and should not be relied upon as fact.

Centralized facilities usually don't begin with a blank slate. Generally, there is an existing facility that is looking to expand, and since each facility is a unique design costs will always vary. if you want a 1mgd plant it might be $3/gallon, but changes with economies of scale, so smaller package plant might be at least $5-6 per gallon for the plant. In addition to the physical plant, there are costs for the collection system – the network of pipes around town. These costs vary by length, number of connections, the need to install a pressurized system if there is not enough elevation for a gravity feed system, land acquisitions or easements, road work, labor costs, etc. The collection system may be as much or more than the plant itself (Jarrett 2021).

The City of St. Augustine has received information about several different upgrades they are interested in. Being a low-lying coastal community, they are very vulnerable to the impacts of climate change and their wastewater treatment facility is located in a particularly vulnerable area. They have considered moving the facility to a different location on higher ground. This means not only moving the physical treatment plant but also rerouting portions of the collection system that brings wastewater to the plant for treatment. They estimate to build a brand-new plant would be around $80 million not including design, land acquisition, easements or other costs not related to the physical structure.

They have also looked at certain upgrade projects that would improve operations and treatment. One such project would add a UV disinfection treatment which would replace an acid treatment they currently use at the end of the treatment process. This would result in a higher quality effluent though it would be around $800,000 to install and would pay off in approximately 10 years.

Another upgrade project, rehabilitating the headworks, would improve the primary treatment process where it accepts the influent. This particular project would have the benefit of enabling them to raise some of the structures, which would make them more resilient to flooding. It is estimated this project would cost around $4.5 million (Beach 2021).

For homeowners that may be connecting to the centralized facility, these costs generally include connection from the road to their home. The municipality or authority usually provides the pipe to the road in front of the property and the homeowner covers the connection from there to the house. The cost for this varies based on how far from the road the house is. The longer the distance the greater the cost. A conservative estimate for septic to sewer conversion may be around $12,000. This includes removal of the existing tank and mound (if exists), restructuring the existing plumbing and restoring landscaping (Beach 2021). In this situation there will also be the monthly sewer bill following connection to the central facility. These fees vary too. There is usually a flat fee plus a cost per gallon. Wastewater costs are often estimated based on water use since there is no meter for the outgoing volume. The City of St. Augustine charges a monthly fee of $15.11 for in-city wastewater plus $6.89 per 1,000 gallons of wastewater (St. Augustine Utility Fees 2019).

For an onsite system, costs for the system are only a little less variable because the mechanical components may have standard costs. But, similar to centralized systems, costs for an onsite system may include: system design, shipping costs, site work and labor. System design costs will be impacted in part by the site. If there are setback requirements that make placement tricky, a higher performing unit may be necessary to achieve the treatment standards. Shipping costs can be affected by the type of equipment: a concrete tank will cost more to ship than a plastic or fiberglass tank.

For homeowners installing a new onsite system, a basic conventional system will start around $8,000 if there are no soil or setback challenges. Soil challenges can include soils with a high clay content that do not allow for fluids to filter through soils, or a limiting layer of clay within the 24 inches below the drainfield. These soils will have to be replaced or amended with suitable soils. Setback challenges may occur if the land area available for the septic system is too close to a waterbody or private drinking well. This may result in additional treatment technologies being added to the system. When basic systems face these challenges, it can drive the cost up over $20,000 (Groover 2021).

Other examples of extra costs with basic systems include permit costs which can vary by county, whether the soil evaluator is a private party of the Florida Department of Health, and fees for inspections when extra soil work is needed.

Also possible is the requirement of a mound system because there is not enough depth between the ground surface and the groundwater surface. Mound systems introduce addition costs for the additional soils, inspections and mound stabilization fees.

For a more basic ATU which may only address CBOD and TSS, this can add an additional $2,000-$4,000 for additional permits. These systems require an operating permit and a maintenance entity permit. Plus, the system has to be inspected once a year and have recorded maintenance twice a year. Homeowners may become certified to perform their own maintenance and avoid the hired maintenance costs. For ATUs with more advanced treatment (CBOD, TSS, TN, TP), these costs can go even higher.

Systems installed within the Springs Protected Areas require an In-ground Nitrogen Reducing BioFilter. These are can also be installed in other locations and provide nitrogen reduction benefits. Since these systems do not have any powered components, they do not incur the operating and maintenance fees like the ATUs referenced above. These systems may be completed for around $10,000.

Obviously, these costs add up. Beyond installation costs there are maintenance costs. An ATU or PBTS will provide much higher treatment quality and can be used in locations with less land available but have higher operating expenses. They have electrical components that require electricity to operate, they require more frequent maintenance including annual inspections and run most efficiently during regular loading. These systems can be negatively impacted when under heavy loading (large holiday gatherings) or no loading (everyone is gone on vacation).

Again, these are only general ballpark estimates and homeowners should get a real quote from a licensed engineer or installer. The table below summarizes the estimates presented here.

Table 6-1 Summary of cost estimates

	Estimate example
Centralized	
Large centralized facility	$3/gallon
Small centralized facility	$5-6/gallon
Build a new facility on higher ground	$80 million
Upgrade disinfection to UV treatment	$800,000
Rehabilitate headwords and raise some of the structures	$4.5 million
Homeowner connecting to centralized facility	$12,000
Decentralized	
Install new conventional system	beginning at $8,000, may exceed $20,000
Install new, basic advanced treatment unit	add $2,000-$4,000 to conventional system
Install new conventional system with In-ground Nitrogen Reducing BioFilter	$10,000

7. Funding Opportunities

Thankfully there are many funding opportunities available to help communities who are facing upgrades to their wastewater treatment systems. The state of Florida, both directly and with EPA funds, offers several programs. The programs listed below all support septic upgrade or septic to sewer conversion in some way. This may be planning, design, construction or connection. See the program for specific details.

When looking at funding opportunities, look for programs that can work together. Projects that cross multiple phases (design and construction) may benefit from multiple funding opportunities such as one that only supports design plus one that supports construction. This can be especially helpful when funds must be used within a short period of time such as one year because these projects typically take several years from start to finish.

7.1. Water Quality Grants

Offered annually through FDEP to government entities, the program distributes a total of $25 million to selected applications. There is a minimum 50% local match required unless the entity qualifies as a 'rural area of opportunity' or if there is a public/private partnership pay for performance agreement.

https://protectingfloridatogether.gov/sites/default/files/documents/WaterQuality_PFT_GrantInfoSheet_0.pdf

7.2. FDEP/Division of Water Restoration Assistance

7.2.1. Federal 319 grant (EPA originated) Nonpoint Source Funds

"319 Grants" refers to the section of the Federal Clean Water Act that supports these projects. Total available funds vary each year but is usually around $8-$9 million. Funds are available to local governments (county and city), special districts, water management districts, state agencies, public colleges and universities and national estuary programs in Florida.

https://floridadep.gov/wra/319-tmdl-fund#:~:text=About%20Nonpoint%20Source%20Funds&text=The%20program%20administers%20both%20the,pollution%20from%20land%20use%20activities.

7.2.2. Clean Water State Revolving Funds Loan program (EPA originated)

This is a low interest loan program and segregates loans by 'planning loans,' 'design loans,' and 'construction loans.' Additionally, if a community qualifies as a 'small disadvantaged community,' they may qualify for grants (as opposed to loans). Loans are for 20 years and the interest rate is determined by the community's median household income, poverty index and unemployment index.

https://floridadep.gov/wra/srf/content/cwsrf-program

If a community has received a Clean Water State Revolving Fund loan, they may also apply for a Small Community Wastewater Construction Grant. These must be communities with 10,000 or fewer in population with a per capita income less than the state average.

https://floridadep.gov/wra/srf/content/cwsrf-program

For projects that include Davis-Bacon wage rate and American iron and steel in their projects, they may be eligible for loan assistance in the form of financing rate reductions on construction agreements.

https://floridadep.gov/wra/srf/content/cwsrf-program

7.2.3. Septic Upgrade Incentive Program

This program is currently not available because it has allocated all its funds. Funding for the next state fiscal year is currently in deliberation so check back to see if there will be funding for the next year.

https://floridadep.gov/springs/restoration-funding/content/septic-upgrade-incentive-program

7.3. Florida Resilient Coastlines Program

The Florida Resilient Coastlines Program offers two grant opportunities each year, the Resilience Planning Grant and the Resilience Implementation Grant.

7.3.1. Resilience Planning Grant (RPG)

These grants are available annually to municipalities that are required to have a coastal management element in their comprehensive plan. Funds are available for up to $75,000 and the project must be completed within the fiscal year. Eligible projects include vulnerability assessments (such as for infrastructure of anything that is not required for compliance with the Peril of Flood statute), development of adaptation plans or resilience plans or for regional collaboration efforts.

https://floridadep.gov/rcp/florida-resilient-coastlines-program/content/frcp-resilience-grants

7.3.2. Resilience Implementation Grant (RIG)

The 'implementation' grants are intended to be a 'next step' for communities who have received a 'planning' grant. These grants are available to communities that have a coastal management element in their comprehensive plan and are ready to implement the projects or plans that have already been designed. Funds are available annually for up to $500,000 per community and projects must be completed within the fiscal year.

https://floridadep.gov/rcp/florida-resilient-coastlines-program/content/frcp-resilience-grants

7.4. St. Johns River Water Management District

7.4.1. District Cost-Share Funding

The District supports a cost-share funding program for projects that support core missions including water quality. Project terms are up to two years and funding is available for up to 25% of construction costs for water quality projects.

https://www.sjrwmd.com/localgovernments/funding/districtwide/

7.4.2. Indian River Lagoon Water Quality Improvement Projects

Available to counties and municipalities, public universities, and colleges, regional planning councils, non-profit groups and the Indian River Lagoon National Estuary Program who are within the district boundaries. The program provides $25 million annual to programs designed to improve water quality including sept to sewer conversions. No match is required but is a positive consideration during review.

https://protectingfloridatogether.gov/sites/default/files/documents/IndianRiverLagoon_PFT_GrantInfoSheet_2.pdf

7.5. Florida Department of Economic Opportunity

7.5.1. Florida Small Cities Community Dev elopement Block Grant

This is a HUD program that provides grant funds to Florida for use in Florida small communities to support projects that benefit communities with a majority (51%) of low to moderate income residents. Available funds range from $18 - $26 million on a competitive basis. These funds can be used to support wastewater improvement projects including new sewer or water lines and septic abandonment in cities with less than 50,000 residents or counties with less than 200,000 residents. There are some additional criteria that may be confusing but can be easily explained by a program coordinator.

www.FloridaJobs.org/SmallCitiesCDBG

7.5.2. Regional Rural Development Grant

This program encourages neighboring rural counties to join together to pursue economic and/or tourism development for the improvement of their communities. This may lead to projects that improve quality of life for residents. There are some financial planning and match requirements from the communities. Be sure to work with a coordinator for the best experience.

https://floridajobs.org/community-planning-and-development/community-partnerships/regional-rural-development-grant

7.5.3. Rural Infrastructure Fund

These funds are available to communities whose infrastructure project will result in increased employment, and/or capital investment and diversification in small communities. These projects can include improvements to infrastructure. Here too, the criteria can be confusing but there are many resources to help communities navigate the program.

http://www.floridajobs.org/RIF

7.5.4. Special District Accountability Program

“Counties and municipalities may create special districts to develop and/or maintain various wastewater and sewer systems.” Creating a special district would enable the authority to raise money through bond debt for construction and maintenance of the facility, and to charge fees or tax assessments for repayment of the debt. (Gaskins 2021)

www.FloridaJobs.org/SpecialDistricts

8. Conclusions

The purpose of this document is to provide homeowners information on wastewater treatment technologies for centralized and decentralized systems. The technologies for each are very similar, just operating at different scales. Also important for homeowners is information on costs and funding opportunities. Costs are very difficult to pin down exactly because there are so many variables for both centralized and decentralized facilities. But hopefully the ballpark range estimates provided are useful for context at least.

In the course of developing this report, we learned about some onsite treatment opportunities that are not currently being used in Florida but may be useful given our special soil conditions. One of these includes using a UV or chlorine disinfectant in onsite systems. This is a step that would happen in the tank and would allow for complete treatment in the tank thus eliminating the need for a drainfield. Discharge could take place on the property without issue (Groover 2021). This is not a treatment process that is used onsite in Florida yet so more research should be done to make sure it’s viable, but it shows promise.

Another possibility is to incorporate buoyancy options for tanks that may be at risk from flooding or storm surge (Groover 2021). These can prevent the tank from lifting out of the ground if soils become saturated, an event that could introduce raw sewage property and neighborhood.

This report covered a long list of funding opportunities to assist with septic upgrade or septic to sewer conversion projects. These projects have garnered much attention in recent years, especially here in Florida. But we also saw that these are expensive projects. While there are many programs to help cover these costs one that hasn’t been discussed is Property Assessed Financing. The PACE model (Property Assessed Clean Energy) is one that has been around for awhile and has been used by homeowners to install solar panels and finance the project through their property tax bill. In this way the cost for the upgrade is attached to the property not the individual and the repayment period can be 10 to 20 years. There is some practical sense to this. First, a septic to sewer upgrade is an upgrade to the property. If the homeowner sells the house and moves away during the repayment period, the repayment stays with the properties new owner(s), after all the seller would not dig up the pipe and take it with them. Spreading the project costs out over a period of time may help some homeowners complete a project that were not able to secure funds through other sources. These costs could be attached to a utility bill for smaller monthly payments, instead of the annual property tax bill that may already be a hardship for some homeowners (Office of Energy Efficiency & Renewable Energy and Energy.gov 2021).

Onsite wastewater treatment systems in low lying coastal areas face multiple risks from climate change related impacts. These include flooding, storm surge, sea level rise and rising groundwater levels for example. These impacts could flood drainfields leading to system failure, raw sewage backing up into homes or being released above ground. As communities plan for climate change, considering the impacts to septic systems should be included in adaptation and resiliency plans. This resource provides homeowners information on the technologies of different wastewater treatment systems, some examples of cost and funding opportunities to help communities not just plan but pursue projects to reduce the risks to septic systems.

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10. Terms

Aerobic – an oxygenated environment

Anaerobic - an environment without oxygen

Centralized – managed by a central authority

Decentralized – managed at the onsite or local level

Effluent –liquid leaving a wastewater treatment system or component of the system

Influent – liquid entering a wastewater treatment system or a component of the system

11. Abbreviations

ATU – Advanced Treatment Unit, sometimes also used for Aerobic Treatment Unit

BOD/CBOD – Biological Oxygen Demand/Carbonaceous Biological Oxygen Demand

CDBG – Community Development Block Grant

EPA – Environmental Protection Agency

FDEO/DEO – Florida Department of Economic Opportunity

FDEP/DEP – Florida Department of Environmental Protection

FDOH/DOH – Florida Department of Health

HUD – Housing and Urban Development

OSTDS – Onsite Treatment and Disposal System

PBTS – Performance Based Treatment System

SBG – Sequencing Batch Reactor

SLR – Sea Level Rise

STEP – Septic Tank Effluent Pumping

TN – Total Nitrogen

TP – Total Phosphorous

TSS – Total Suspended Solids

WWTF – Wastewater Treatment Facility