Preferred Wastewater Systems for the Texas Hill Country and Over the Edwards Aquifer:

Economic and Environmental Considerations

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Save Barton Creek Association

Wimberley Valley Watershed Association

The Meadows Center for Water and the Environment
Texas State University

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Acronyms

GPM	Gallons Per Minute
NPDES	National Pollutant Discharge Elimination System
OSSF	On-site Sewage Facility
PE	Professional Engineer
PVC	Polyvinyl Chloride
STEG	Septic Tank Effluent Gravity
STEP	Septic Tank Effluent Pumped
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TLAP	Texas Land Application Permit
UV	Ultraviolet
WERF	Water Environment Research Foundation

Executive Summary

For rural and small communities distant from central sewer systems, or where sensitive watershed conditions call for low impact development practices, decentralized wastewater systems relying on land-based final dispersal of effluent are often the most cost-effective and ecologically responsible wastewater service approach.

Where lots are larger in more spacious developments or outlying rural areas, it's often most cost-effective to use individual onsite systems. Where homes or businesses are clustered into pockets of development, it may be more cost-effective to cluster properties served onto a single wastewater system, managed by a single designated individual, company, or utility district. For a larger number of homes and businesses in towns or small cities, economies of scale tend to favor homes and businesses being served by a centralized wastewater system managed by trained operators and utility service providers. Those three wastewater service categories are described here, each suited to different conditions and types of development. Table 1 below summarizes five case studies exemplifying those basic categories of service.

Table 1: Summary of Case Studies

	Type	**Primary Treatment**	**Secondary Treatment**	**Tertiary Treatment**	**Dispersal**
Westlake Hills Residence	Individual	Two-Compartment Septic Tank with Passive Effluent Filter	Packaged Recirculating Textile Media Filter	None	Subsurface Low-Pressure Dosing
Lake Austin Residence	Individual	Two-Compartment Septic Tank	Single-Pass Intermittent Sand Filter	None	Subsurface Low-Pressure Dosing
Westview Development (Lake Austin)	Clustered	17 STEP/STEG systems serving 104 lots;	None	None	Subsurface Low-Pressure Dosing
Jackson Bend Development (Tennessee)	Centralized	100 STEP/STEG systems serving 100 lots	Recirculating Sand Filter (20,000 gal/day)	UV Disinfection	Subsurface Drip
Development in Fulton, Alabama	Centralized	197 STEP systems serving 197 lots	Packed Textile Recirculating Media Filter Treatment Units	UV Disinfection	Subsurface Drip

The first two case studies describe individual onsite systems, each with a septic tank providing primary treatment, but using different methods for secondary treatment. The three other case studies feature systems serving neighborhoods or small communities, all using some type of small diameter sewer/collection system. For effluent collection systems, primary treatment occurs in a tank(s) located at each property served (gravity or pumped small diameter collection lines). Different methods of secondary treatment are used for the two small community systems discussed, with the type used depending on specific site and soil conditions, method of dispersal and applicable regulatory requirements for the location.

Designs and product lines commonly used today for all three wastewater service categories above provide reliable and cost-effective treatment when properly designed and maintained. Systems today can be designed and built to have very low ongoing maintenance needs over long useful service lives. Systems relying on soil dispersal tend to have far lower operational costs as compared to systems discharging to streams, given the much less costly monitoring and reporting requirements associated with land-based dispersal systems.

Properly sited and designed soil dispersal systems are capable of providing better treatment for a much wider range of pollutants cost-effectively, as compared to wastewater treatment systems that directly discharge into streams.[1] When effluent is dispersed into and percolates down through the soil, countless bacteria naturally residing in these soils and the surface vegetation are able to uptake and/or break down nutrients, pharmaceuticals, personal care products, and household chemicals that would otherwise be directly released into waterways without attenuation. Animal species living in the streams recharging the Edwards Aquifer and the aquifer itself are quite vulnerable to even very low concentrations of these pollutants. Through appropriate Texas Commission on Environmental Quality (TCEQ) rules and permitting processes, these dispersal areas can be dedicated land application areas or may be beneficially used for landscaping, such as in parks or on roadway medians.

This document presents key considerations for choosing a particular wastewater service category to help engineers, developers, and decision-makers choose the appropriate scale of system. It also presents preferred system attributes and case studies for each of the service categories. The approach to wastewater service for Hill Country development can and should be context sensitive, blend well with preservation of the rural setting and our watersheds, and continue to provide reliable low-cost wastewater service for many years.

[1] www.tceq.texas.gov/assets/public/compliance/compliance_support/regulatory/ossf/EffectivenessUtilSAforPharmPersonalCare.pdf

Foreword

By Save Barton Creek Association and Wimberley Valley Watershed Association

The Texas Hill Country is blessed with incredible charm and aesthetic appeal; Its natural environment including creeks, rivers, and springs are a central draw. Many Hill Country residents rely on wells for their drinking water and livelihoods. Creeks and springs serve as important recreational hubs, and help sustain wildlife and livestock. Water in the Hill Country is also a precious limited resource. This report helps us begin to understand how we can protect Hill Country waterways while also meeting the wastewater service challenges of our region.

In the Hill Country, there is a need for approaches to development that serve well on multiple fronts-- that prevent wastewater effluent pollutants from impacting local streams, that consider the water limitations of our drought-prone region, and provide affordable and reliable wastewater systems. Planning for wastewater service in a development can also be considered with other water needs such as the need for non-potable water within and outside buildings, and stormwater planning. This holistic approach to planning water within a development, called One Water, is gaining momentum nationally and in our region.

This report is not a comprehensive guide for how to design the ideal wastewater system for any given development. Instead, its purpose is to familiarize developers, property owners, city planners, and policy-makers with modern, cost-effective wastewater solutions that can meet the unique service needs and conditions of the Hill Country.

Most people are unfamiliar with wastewater systems other than conventional sewer infrastructure in urban settings. Likewise, much of the public has an impression that septic systems installed under current rules are akin to those relied on in decades past, built under much lower standards than exist today. Built properly, several scales of wastewater systems can meet the needs of our region, including the often unconsidered clustered/neighborhood systems that are between a large packaged plant and an individual onsite (septic) system.

Given the water limitations in the Hill Country, it's a no-brainer to reuse wastewater effluent. This report illustrates how decentralized reuse can be the best option, depending on development patterns.

This report does not offer a singular prescription to the challenges faced, but rather, presents new options that many developers and policy-makers may not have considered. We hope that making this information more easily available will encourage thinking beyond the status quo and move us to consider non-discharge wastewater approaches that are best for our communities and environment.

Individual Onsite Wastewater Systems

Individual Onsite Wastewater Treatment is a category of wastewater systems commonly used for larger lots in rural, semi-rural and small community settings.

In Texas, a permitted onsite wastewater system is defined as one that serves a residential or commercial property with domestic wastewater flows of less than 5,000 gallons per day, with the entire system (including effluent dispersal) located on the property where the wastewater is produced.

Preferred System Types

Within this treatment category, systems are designed and built using the recommended practices below:

1. Primary treatment using a septic tank, sized at a minimum per TCEQ's Onsite Sewage System Facilities (OSSF) rules section 30 TAC Chapter 285.91, Table II in Appendices. To avoid excessive pumping and prevent settleable solids from entering the secondary treatment unit, the primary tank should be significantly larger than minimum TCEQ requirements (a minimum capacity of 4 to 5 times the maximum average daily design flow). An effluent filter sized and configured appropriately for the system should be used ahead of either the secondary treatment unit or subsurface soil dispersal system. This will prevent solids 1/8 inch or larger from exiting the primary tank or clogging soil dispersal field lines.

2. Where required and/or appropriate due to location or site conditions, secondary treatment is provided by either a single pass or recirculating media filter. Single pass filters use an appropriate grade of clean sand. Recirculating filters use clean gravel or proprietary media. For "packaged" recirculating media filters, TCEQ maintains a list of state-approved proprietary secondary treatment products on their website.

3. Recommended where surface reuse/application of treated water is to occur: Final polishing via an intermittent sand filter sized to receive secondary treated effluent. This helps ensure that ammonia levels are low enough that odors are never an issue for the system where landscape irrigation occurs.

4. Recommended where disinfection is required where 1) surface reuse/application of treated water is to occur or 2) when secondary treated effluent is to be distributed to a subsurface

soil dispersal system with insufficient soil depth for natural pathogen reduction to occur: Ultraviolet (UV) irradiation is recommended for disinfection of treated effluent because it does not release a chlorine residual to the environment. Chlorine is toxic to aquatic life even in very low concentrations and oxidizes certain types of organic matter found in wastewater effluent, resulting in the formation of troublesome compounds (e.g. trihalomethanes, which are known carcinogens).

Key considerations for individual onsite wastewater systems are provided below, followed by case studies for recommended types of these systems.

Environmental Considerations

1. Onsite wastewater systems can provide any level of treatment necessary for protection of public and environmental health. In many cases, they can provide higher levels of treatment than centralized systems discharging into streams. Onsite systems can be designed and managed to meet all federal and state effluent standards. Soil-based treatment systems can provide superior treatment from natural bio-microbial processes as compared with systems discharging directly into streams in aquifer contributing and recharge areas. This superior treatment includes better treatment of pollutants such as pharmaceuticals and personal care products.

2. Individual onsite systems are routinely designed and successfully used in a variety of challenging site conditions, including shallow depth to groundwater or bedrock, soils with low permeability, steep slopes, and small lots.

3. Use of onsite wastewater systems avoids a costly disruption to roads and other public areas that otherwise would be needed for installing sewer lines.

4. Onsite wastewater treatment systems are required to have watertight gravity and pressure sewer lines, up to the point where effluent is released to the soil. Conventional gravity sewers are commonly subject to infiltration and potential exfiltration of untreated sewage as well as manhole overflows during major rain events. Lift station failures with centralized systems can result in raw sewage discharges, causing major water quality impacts.

5. Onsite wastewater treatment systems can provide water reuse and watershed-based hydrologic benefits-- returning moisture and nutrients to soil systems and recharging aquifers while contributing to overall water conservation.

Individual Onsite Wastewater Systems

6. Onsite systems can be designed and managed for energy efficient operation on properties with solar and/ or wind energy systems. Modern onsite systems are routinely designed that use a small fraction (5 to 10 percent) of the power consumed by some older types of systems. These more energy efficient systems may only need to use electricity a couple of hours daily under normal conditions.

7. Many onsite wastewater systems are passive (no pumps or moving parts). This results in a lower carbon footprint compared to centralized sewer systems.

8. Water infrastructure security has become an increasing concern globally, as water and wastewater systems' grids become more and more automated with internet-based operational controls. Distributed infrastructure, including decentralized wastewater systems, are far less vulnerable to such disruptions and potential failures from either cyber-attacks or major weather events. If disruptive activity of either type occurs, impacts would likely be limited to much smaller areas as compared with community-wide wastewater systems.

9. Covered decentralized and small community treatment systems are less vulnerable to extreme weather events such as floods, hurricanes, and tornados, as compared with open tank activated sludge treatment units. These natural events may cause spills and system failures in traditional open-air treatment systems.

10. Returning phosphorus in wastewater to soils rather than discharging to streams has several important short and long-term environmental benefits. Release of phosphorus to streams is increasingly recognized as a pollution problem worldwide. Meanwhile, phosphorus is one of three macronutrients contained in fertilizers and needed for food production worldwide. Phosphorus for fertilizers is only used in a mineral form, and we are facing a mounting global shortage as stores of phosphate rock become depleted. In recognition of both water quality impacts, and looming shortages, municipal water utilities are increasingly exploring ways to mine phosphate buildup (called struvite crystals) from pipelines and wastewater treatment equipment. A Water Environment Federation sponsored webinar recommends increased reliance on decentralized wastewater systems (soil-based treatment systems) and composting of bio-solids to maintain productivity of our soils naturally while protecting our watersheds.[2]

[2] www.sswm.info/sites/default/files/reference_attachments/VACCARI%202009%20Phosphorus%20-%20A%20Looming%20Crisis.pdf

Individual Onsite Wastewater Systems

Economic Considerations

1. In rural or suburban areas, individual onsite systems are often the most cost-effective option based upon capital costs alone. When evaluating life cycle costs over a reasonable service life (say 30-year), individual onsite systems in many cases will offer the least costly wastewater service based on operation maintenance, and repair costs.

2. Most components of onsite systems are buried, enabling the continued use of open space for foot traffic and recreational activities.

3. For seasonal use properties or homes where owners vacation frequently, significant annual savings can be achieved for properties with onsite wastewater systems where base monthly user charges apply along with flow-based user charges for centralized wastewater systems.

4. Onsite wastewater systems may in some cases be designed by non-engineers, which can result in cost savings.

Policy Information

1. In the State of Texas, residential and commercial onsite wastewater systems with flows up to 5,000 gallons per day are permitted at the county or municipal level. This often results in significantly faster and less costly permitting and can help avoid delays with project construction.

2. Local jurisdictions can adopt more stringent onsite wastewater rules if sufficient technical justification is provided to obtain TCEQ approval for those local amendments. Central Texas jurisdictions that have adopted more protective standards include the City of Austin, the City of Westlake Hills, and the Lower Colorado River Authority.

3. The installation of individual onsite wastewater systems requires training and licensing through TCEQ. TCEQ's rules on On-Site Sewage Facilities in 30 TAC Chapter 285 –Subchapter I Appendixes, outline installer training requirements for different types of onsite wastewater systems in Table IX.[3] In contrast, installation of centralized wastewater systems does not require specialized training and licensing in Texas.

4. Under Chapter 285 of TCEQ rules for onsite wastewater systems, the unrestricted use of treated wastewater for landscaping and other outdoor uses is not allowed, regardless of level of treatment

[3] www.tceq.texas.gov/assets/public/legal/rules/rules/pdflib/285i.pdf

provided. Dedicated irrigation areas, with applicable setback requirements met, are required for all systems. TCEQ's Chapter 210 rules for municipal-scale reuse systems (with those full-time operational checks and controls), less restricted irrigation and reuse activities can occur. However, even subsurface dispersal of primary treated effluent – where that effluent is distributed in a relatively uniform manner into the upper soil and root zone where most evapotranspiration occurs – provides an ecological benefit. Upper soil horizons tend to have higher organic content.

Land/Resources Considerations

1. Individual onsite wastewater systems require larger lot sizes as compared with properties served by clustered or community-scale systems. State rules require that lots served by public water supplies be at least one-half acre, and lots not served by public water supplies must be at least one acre. Those properties not served by public water supplies often have a density that works well with individual on-site systems. Local jurisdictions may require even larger lot sizes, with state approval of those amendments.

2. Many designers and engineers may be less familiar with onsite wastewater systems compared with conventional sewers and centralized treatment systems. Developers and builders will need help from experienced engineers and architects to configure developments in the most efficient ways to facilitate best use of natural land resources and deploy the most cost-effective designs for onsite wastewater systems.

Maintenance Considerations

1. Onsite wastewater systems with secondary or advanced treatment units require an annual maintenance contract. Systems employing surface irrigation of secondary treated effluent require testing and reporting of certain effluent quality parameters, along with a maintenance contract. Minimal requirements for maintenance contracts and reporting for onsite wastewater systems in Texas can be found in Table XII of the Chapter 285 TCEQ rules.[4]:

2. Properly designed and installed onsite wastewater systems can last for many years without problems when properly maintained over the life of the system. However, failure to perform system checks and needed maintenance can result in expensive repairs and system replacements.

[4] www.tceq.texas.gov/assets/public/legal/rules/rules/pdflib/285i.pdf

Individual Onsite Wastewater Systems

3. Owners of onsite systems would benefit significantly from changes to TCEQ rules relative to maintenance requirements. Suggested changes include:

   a. Requirements for periodic re-inspections (with frequency dependent on system type) would help prevent problems and greatly extend system life. An example of a local jurisdiction that requires periodic re-inspections is the City of Westlake Hills.

   b. Current TCEQ rules do not distinguish among types of secondary treatment processes with respect to the required frequency of inspections. Any secondary treatment unit is required to be checked once every four months (3 times annually). However, some commonly used secondary treatment units (e.g. aerated tank units) may require even more frequent service calls, depending on system configuration (e.g. primary settling capacity and system loading). Intermittent sand filters typically need routine preventive maintenance only once annually to continue functioning for decades and reliably produce significantly better effluent quality than aerated tank units.

Individual Onsite Wastewater Systems

Case Studies

Case Study 1: Residential System in Westlake Hills

This system serves a single-family residence and consists of primary treatment including a passive effluent filter, secondary treatment via a packaged recirculating textile media filter, and final subsurface soil dispersal in low pressure-dosed trenches.

The residence is located in the City of Westlake Hills over the Edwards Aquifer recharge zone; therefore, the system is required by the city to have secondary treatment. The recirculating media filter treatment process reliably removes 55-65% of total nitrogen prior to subsurface dispersal of the treated effluent. Sufficient soil exists on the site such that natural pathogen reduction can occur through subsurface soil dispersal in the low-pressure dosed trenches.

This type of system is suitable for a wide range of site conditions, including rocky sites with steep hillsides.

Benefits and Performance:

Advantages of this type of packaged recirculating media filter are that it occupies about one fifth of the area that a recirculating gravel filter would need for the same flows and is able to reliably reduce total nitrogen levels in the treated effluent by two-thirds, prior to final soil dispersal where further nitrogen reduction occurs. This system continues to function well even with seasonal and daily flow fluctuations, unlike aerated tank units which are not recommended for the variable flow conditions. The system includes enclosed watertight treatment units, avoiding odor, vector, and aesthetic issues, and helps avoid saturated dispersal field areas due to added rainfall water entering the treatment portion of the system. The majority of land-area needs for these systems are associated with effluent dispersal areas.

Maintenance for these systems is relatively low. Primary tanks should be checked once every one to two years to see whether the effluent filter(s) needs cleaning or the tank needs pumping. The secondary treatment unit must be checked three times annually per TCEQ rules (currently the minimum requirement for any type of secondary treatment unit), although manufacturer recommendations for regular service checks are typically less frequent once the system has been operational for at least a year, and depending on site and system-specific conditions.

Individual Onsite Wastewater Systems

Case Studies

Photo 1: Recirculating media filter unit (closed).

Individual Onsite Wastewater Systems

Case Studies

Photo 2: Recirculating media filter unit opened for checks/testing.

Photo 3: Primary treatment and pump tank lids in foreground (green lids) and subsurface dispersal field located between the tanks and the wood fence.

The estimated cost for this type of treatment system typically ranges from $25,000 to $35,000 in central Texas Hill Country areas, depending on specific site conditions. This secondary treatment system costs more up-front than many aerated tank units sized for comparable flows. However, long-term costs for this system should be significantly lower due to the higher operation and maintenance costs associated with aerated tank units.

Energy usage for this type of system would be five to ten percent of that needed for an aerated tank unit (which must operate constantly). Sludge pumping needs for this category of treatment process are also significantly lower than for aerated tank systems.

These system types are expected to have very long useful service lives. Primary tank treatment and final subsurface dispersal costs should be comparable to other secondary treatment systems.

Design and Installation Considerations:

TCEQ requires that a contractor installing this type of system be trained and licensed as an Installer II (same requirement as for installation of other types of secondary treatment processes and low-pressure dosed subsurface dispersal or surface irrigation). While the better product manufacturers typically provide good technical support to contractors, it's best to use an installer having significant experience with the methods and materials specified by the engineer/designer on the plans.[5]

It is recommended that tanks be sized for reduced pumping frequencies (every 10 to 15 years), since pumping and septage disposal can be costly ($250-400 per pumping event). It's important to note that sizing calculations for primary tanks should consider the working tank capacities (or "clear liquid zone"), which do not include either built-up sludge at the bottoms of tanks or scum layers at the liquid surface. A study on Septic Tank Pumping Intervals shows proper correlation between primary tank size and flows with pumping frequencies.[6]

High-quality fiberglass tanks can have very long service lives when installed properly. Concrete tanks cost less but tend to be less watertight around concrete lids and access ports and have shorter service lives due to their greater vulnerability to corrosion in septic conditions.

The manufacturer of the secondary treatment unit recommends semi-annual system checks and preventive maintenance once the system has been operational for a year or so. Low-pressure dosed dispersal systems receiving secondary treated effluent have exceptionally low maintenance needs and very long useful service lives, if designed and installed properly.

Case Study 2: Residence on Lake Austin

This system is located at a residence along a tall limestone bluff overlooking Lake Austin in the City of Westlake Hills. It consists of primary treatment via a two-compartment septic tank, secondary treatment via a single-pass intermittent sand filter, and final subsurface soil dispersal in low-pressure-dosed trenches. Soils were very thin over most of the site, but sufficient depth of soil was found in portions of the front yard (fronting Westlake Drive) to install a low-pressure dosed subsurface dispersal system.

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[5] http://www2.tceq.texas.gov/lic_dpa/index.cfm?fuseaction=licall.searchindiv

[6] Bounds, T.R. "Septic Tank Septage Pumping Intervals" 1994. P. 14; Accessed at www.orenco.com/Portals/0/Documents/Misc/ntp-tnk-trb-1.pdf?ver=2017-09-12-140230-347

Photo 4: Completed sand filter in raised area enclosed by stone wall at left of photo, just below taller retaining wall; Primary tank lids (green lids) to left of sidewalk.

Photo 5: Intermittent sand filter under construction inside stone landscaping wall.

Benefits and Performance:

Based on over two years of system monitoring done through the City of Austin's Alternative Wastewater Management Project, this single-pass intermittent sand filter treatment reliably removed approximately 25% of total nitrogen prior to subsurface dispersal of the treated effluent, with excellent natural pathogen reduction (average fecal coliform levels of less than 100 colonies per 100 ml were found over the two years of testing performed). This type of system is also suitable for a wide range of site conditions, although for steep sites the sand filter treatment unit might need to be terraced for compatibility with site topography.

The estimated cost for this type of treatment system typically ranges from $18,000 to $25,000, depending on specific site conditions. Sand filter components (including PVC liners) can be purchased in kits, which can make installations easier for contractors less familiar with these types of treatment systems. These systems are also expected to have very long useful service lives. Primary treatment and final subsurface dispersal costs would be comparable to systems using other types of secondary treatment processes.

These systems have relatively low energy usage, low maintenance needs and long service lives, as long as they are designed and installed properly. Both pumps for this system would operate only about 20 to 30 minutes daily (combined operational time), making energy usage far lower than an aerated tank unit needing to operate 24 hours per day. Sludge removal for this type of system would be the same as for a conventional septic system having just a septic tank and subsurface dispersal field.

Ammonia levels are reliably reduced to very low levels for properties where surface irrigation is to be used, which avoids odors. The excellent quality of effluent reliably produced also provides for a very long useful service life for a subsurface soil dispersal system. This type of treatment system continues to function well even with seasonal variations in use and daily flow fluctuations.

Clustered Wastewater Systems

For this category, a home or business is connected to a single system serving multiple properties. This category may serve two or more residential or commercial properties. These systems are commonly used for developments in rural, semi-rural, and small community settings where it's not cost-effective or otherwise feasible to connect to an existing larger centralized wastewater collection and treatment system.

Preferred Systems:

Within this treatment category, it is recommended that systems employ preferred practices below:

1. Effluent collection system (primary treatment via a septic tank at each property sized in accordance with TCEQ's OSSF rules section 30 TAC Chapter 285.91, Table II), draining by gravity or pumped to a common area where further treatment and final soil-based treatment occurs. Effluent collection systems may use just gravity flow following primary treatment in a septic tank (STEG sewers), be pumped following primary treatment in a septic tank (STEP sewers), or be a combination of the two.

2. For sites with soil/subsurface conditions requiring secondary treatment, or where surface application of the treated water is planned, it is recommended that secondary treatment be provided by either a single pass or recirculating media filter.

3. With reuse, further polishing with an intermittent sand filter may be appropriate to ensure an odor-free high-quality effluent.

4. For surface irrigation systems or as required following secondary treatment, ultraviolet irradiation is recommended over chlorination for disinfection because it does not release chlorine residual to the environment. Chlorine is toxic to aquatic life even in very low concentrations and oxidizes certain types of organic matter found in wastewater effluent, resulting in formation of troublesome compounds (e.g. trihalomethanes, known carcinogens).

Environmental Considerations

1. Like onsite wastewater systems, clustered decentralized wastewater systems using soil dispersal of pre-treated effluent can provide higher levels of treatment than centralized systems discharging to streams and rivers. These systems can be designed and managed to meet all federal and state effluent standards.

2. Clustered wastewater systems enable residential construction on relatively small lots with site conditions not suitable for use of individual onsite wastewater systems. Treatment and dispersal areas serving multiple properties can be located in the more environmentally appropriate areas of

the development. These common use green spaces can contribute favorably to overall aesthetics and public enjoyment of a development and also contribute to better water quality as buffer zones for surface runoff.

3. For new subdivisions, cluster systems can be laid out to maximize cost-effectiveness and environmental and aesthetic benefits for residents. Existing older subdivisions relying on individual onsite systems can often be retrofitted to clustered systems where failures are occurring to multiple individual systems.

4. Cluster systems typically use small diameter effluent sewers (with primary tanks located near buildings on each property served), designed, installed and tested to be watertight. This avoids the use of manholes and infiltration/exfiltration associated with conventional sewers, as well as raw wastewater lift station failures. Soil-based treatment systems have been shown to be capable of providing higher levels of treatment as compared with discharging wastewater systems, especially for contaminants such as pharmaceuticals and personal care products.

5. Operating and maintaining a single treatment and/or final effluent dispersal system serving multiple houses tends to reduce risks compared to individual onsite systems serving those same homes. Systems serving multiple homes can better attenuate any effects of variable or seasonal use and changes in wastewater characteristics among the individual households.

6. Single systems serving multiple homes can take advantage of economies of scale. They can provide higher levels of treatment for comparable or lower costs as compared with individual onsite systems. Systems serving multiple homes can usually be operated and maintained more cost-effectively than the same number of residences served by individual onsite systems, each of which may require a separate maintenance contract.

7. Neighborhood scale/clustered decentralized wastewater systems are far less vulnerable to disruptions and potential failures from cyber-attacks or damaging weather systems, as compared with community-wide systems. If such systems were affected by disruptive activity, impacts would be limited to much smaller areas.

8. Other environmental benefits associated with individual onsite systems that also apply to cluster systems include:

    a. hydrological benefits
    b. very low energy use technologies with passive operational features, which benefits users and reduces carbon footprint

c. adding phosphorus to soils rather than discharging to streams and contributing to water-quality degradation

Economic Considerations

1. In rural and less populated areas, clustered wastewater systems are typically much more cost-effective than extending centralized service over long distances.

2. Users of cluster systems often enjoy lower monthly service fees and long-term costs. Systems relying on subsurface soil dispersal have significantly fewer sampling/ monitoring and reporting requirements for effluent quality under TCEQ rules, as compared to either direct stream discharge or surface irrigation.

3. Given economies of scale, it's usually more cost-effective to serve larger numbers of homes with a given treatment and/or dispersal system than an individual home.

4. As with individual onsite systems, most components of clustered wastewater systems are buried, often enabling continued use of common land areas used for treatment and/or final dispersal of the treated effluent.

5. The use of STEP/STEG collection systems provides for primary treatment on the properties where the wastewater is generated, thereby eliminating this treatment step at common treatment locations and avoiding those associated costs, space and aesthetic considerations. Individual property owners pay for pumping of tanks as needed, thereby greatly reducing sludge management needs for common portions of systems.

6. Additional modular treatment units can be added as needed to meet expanding developments. Developers can economize, not having to pay for unused capacity in early stages of the development.

Policy Information

1. Prior to state level rules changes in 2001, clustered systems with flows of less than 5,000 gallons per day could be permitted through local/county onsite wastewater programs. This was of great benefit to developers and property owners because developments could be phased in around small clusters of homes, each permitted as a single system. This approach tends to have much less rigorous, costly, and time-consuming engineering and planning needs as compared with systems having to be permitted through TCEQ's Municipal Permitting Section. A TCEQ rules

change back to enabling locally permitting for small flow systems less than 5,000 gallons per day would be of great overall benefit to the public.

2. Clustered domestic wastewater facilities using land application of the effluent (via surface irrigation, evaporation, or subsurface soil dispersal) are required to obtain a Texas Land Application Permit (TLAP) permit. Pre-dispersal collection and treatment systems must comply with design requirements of Chapter 217 (Design Criteria for Domestic Wastewater Systems) and any other TCEQ rules chapters applicable to the specific system.

3. Permitting under Chapter 210 of TCEQ rules is required for any water reuse other than those utilizing soil-based dispersal in dedicated areas.

Land/ Resources Considerations

1. By far the largest portion of land area requirements for clustered wastewater systems is associated with the final soil dispersal area. Soil dispersal area needs are based on site-specific conditions, level of pre-dispersal treatment, and required environmental water-quality protections.

2. Beneficial reuse of treated effluent can significantly reduce potable water usage and treatment needs in drought-prone areas like Central Texas. Treated effluent can be used for irrigating areas such as parks and road medians or for toilet flushing if treated to acceptable levels.

3. As with individual onsite systems, fewer engineers and other design professionals are familiar and experienced with the methods and materials used for decentralized wastewater systems relying on final soil treatment and dispersal, as compared with conventional sewers and centralized treatment systems. So here again challenges for developers can occur where help is needed from engineers and architects in laying out developments in the most efficient and cost-effective ways to make best use of natural land and aesthetic resources in developments. In speaking with local permitting authorities, it’s common for unnecessary delays and project expenses to occur due to lack of enough familiarity by design professionals with methods, materials, and permitting requirements that are appropriate for and specific to certain types and configurations of decentralized wastewater systems.

Maintenance Considerations

1. Since treatment and dispersal areas of wastewater systems are located outside individual properties, operation and maintenance activities can occur as needed anytime during the day or night.

2. For projects having primary treatment tanks located on individual lots served by the clustered system, it's important that regular checks occur to ensure that tanks are pumped and effluent filters are cleaned as needed, along with ensuring sound condition of valves, pumps and other equipment.

3. The level of maintenance needed will vary depending on system size, type, and configuration and may range from a few hours annually to a few hours weekly to perform system checks and operational adjustments and maintenance.

Case Study: Westview on Lake Austin[7]

This 104-lot development in Travis County on the Westlake peninsula was originally permitted in the mid-1980's as phase A of Westview on Lake Austin. While the first years of operation had some issues related to the initial installation, following those corrections these systems have functioned well for over 30 years.

Homes in this development are served by a total of 17 clustered wastewater systems of varying sizes. All but two homes are served by septic tank effluent pumped (STEP) collection systems. Two homes are served by a septic tank effluent gravity (STEG) collection system. Based on site evaluations, it was determined that primary treatment followed by subsurface soil dispersal of that effluent could be used for the cluster systems.

Septic tank effluent from homes is either pumped or drains by gravity to dosing tanks located near subsurface dispersal fields. All dispersal field areas are pressure dosed. Subsurface dispersal areas are parks used by residents for outdoor activities.

Permits stipulate that flow from each home is limited to 500 gallons per day for less than 5,500 square foot residences having up to six bedrooms. Where flows from a residence would exceed that level, property owners are required to construct a subsurface dispersal field on their individual lot to receive those added flows.

Benefits and Performance:

The engineer estimated that on-going maintenance of the wastewater systems cost approximately 10-15% of the annual homeowners' fees, or about $10,000-15,000 annually for all 17 cluster systems taken together (on average less than $1,000 per year per residence).

Those costs do not include periodic pumping of the septic tanks, which must be paid for and arranged by individual home owners. The Owner's Association requires that each individual septic tank be pumped as needed. Operation and maintenance instructions are reportedly sent to all homeowners.

Travis County staff state that there have been no reported complaints concerning the performance and functioning of these systems. Should problems such as clogging of dispersal field areas occur with these systems in the future, it would likely be feasible to add secondary/advanced treatment systems in-line between the primary tanks and the dispersal field areas to reduce organic loading to the soils.

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[7] Much of this information was provided by the retired engineer who resided in the development and who for many years was responsible for the care of those systems.

Below are photos of common green space where subsurface soil dispersal (low pressure dosing of effluent) is occurring [photos 6 through 9]. Residents from this development and residents living near the development use the green spaces (dispersal fields) for walking and outdoor activities.

Photo 6 shows the only visible infrastructure (pump tanks and electrical service boxes) in the public use areas associated with the clustered wastewater systems (other than valve covers in the grassy areas). No noise was observed for the pump stations. No odors or saturated conditions were observed in the dispersal areas even following an extended period of wet weather.

Important Notes:

It is critical to provide a funding source for maintaining these community-scale systems. Unfortunately, this development was subject to bankruptcy proceedings in the late 1980's and early 1990's. The developer left no reserve fund for maintaining and repairing the development's wastewater systems. Fortunately, those circumstances have since changed. Currently, the homeowners' association collects $1,010 per residence annually (about $84 monthly) to cover upkeep of the development (including landscaping/mowing, tree trimming, any repairs needed for common use areas, wastewater systems operation/maintenance, etc.)


Photo by Susan Parten, P.E.

Clustered Wastewater Systems

Case Study

Clustered Wastewater Systems

Case Study

Problems found within the first few years of operation included:

- Solenoid valves were improperly wired
- Excessive solids were found in field dosing tanks
- Lightning struck control panels on multiple occasions, blowing fuses and knocking out the pumps and high water alarms (repairs were made)
- As-built drawings were not provided, and many components were placed far from where they were originally planned (e.g. one electric line was forty feet from the location shown on the drawings). Accurate drawings of the systems were later developed.

The resident engineer estimated that approximately $80,000 to $100,000 was spent over a period of several years to make necessary corrections to the seventeen cluster systems, including replacing and rewiring valves, adding effluent filters/screens following primary tanks at each residence, and installing flow meters to track flow from homes.

Non-Discharging Centralized Wastewater Systems

Essentially the same considerations, benefits and challenges associated with clustered decentralized wastewater systems apply to systems serving small communities but with added benefits from further improved economies of scale. There may also be potential disadvantages with centralized systems, such as greater impacts from the larger volumes of wastewater needing management if there are lift station or treatment plant failures.

Two case studies are presented that exemplify modern-day design approaches and the materials/equipment considered most cost-effective and sustainable for communities in the Texas Hill Country.

Preferred Systems:

Within this treatment category, it is recommended that systems include preferred practices below:

1. An effluent collection system with primary treatment via a septic tank(s) would be located at each property served (sized by TCEQ's OSSF rules section 30 TAC Chapter 285.91, Table II), draining by gravity via septic tank effluent gravity (STEG) sewers, or pumped via septic tank effluent pumped (STEP) sewers, to a common area where soil-based treatment occurs. Benefits of this sewering approach are described below. It is recommended that effluent filters be used for each property ahead of the common collection portions of the system. Appropriate isolation valves should also be used for each service connection.

2. For sites with soil/subsurface conditions needing secondary treatment, or where surface application of the treated water is to occur, secondary treatment would be provided by either a single pass or recirculating media filter. Based on industry data, these systems perform more reliably under the variable flow and organic loading conditions typical of small community systems. They have significantly lower operational costs and energy usage compared to systems that use activated sludge/suspended growth processes.

3. Where surface reuse/application of treated water is to occur, further effluent polishing may be appropriate to better ensure a consistently odor-free, high-quality effluent. This can occur via an intermittent sand filter, sized to receive secondary treated effluent.

4. Where reuse/surface application is to occur under TCEQ rules (Chapter 210) for Type 1 or Type 2 reclaimed water, disinfection of the treated effluent using ultraviolet (UV) irradiation is recommended over chlorination because it does not release chlorine residual to the environment.

Chlorine is toxic to aquatic life even in very low concentrations and oxidizes certain types of organic matter found in wastewater effluent, forming trihalomethanes, which are known carcinogens. Where treated effluent is reused for toilet flushing, chlorine is typically needed for at least that portion of the reclaimed water to prevent bacterial build-up in plumbing lines.

Environmental Considerations

1. Effluent sewers eliminate the need for primary treatment at a centralized treatment location and the associated larger scale sludge pumping operations and aesthetic concerns.

2. Wastewater systems relying on soil dispersal of the pre-treated effluent can provide higher levels of treatment than centralized systems discharging to streams and rivers. These systems can be designed and managed so as to meet all federal and state standards.

3. Common use green spaces used for final soil dispersal of treated wastewater effluent can contribute favorably to overall aesthetics and public enjoyment of a development and contribute better water quality in general by serving as green buffer zones for surface runoff.

4. Effluent sewers (primary tanks located near commercial buildings or residences on each property served) use watertight collection lines that can be installed in relatively shallow and narrow trenches, thereby minimizing environmental disruption in the rocky hilly country conditions. This avoids the use of manholes and infiltration / exfiltration associated with conventional sewers, as well as raw wastewater lift stations that are much more vulnerable to failures than effluent lift stations.

5. Systems serving multiple homes can take advantage of favorable economies of scale, with lower capital and operating costs per household. Systems using advanced treatment methods can be operated and maintained more cost-effectively than smaller scale systems treating to the same standards.

6. Other environmental benefits associated with community-scale wastewater systems relying on a soil-based disposition of the treated effluent include watershed-based hydrologic benefits and restoring nitrogen and phosphorus to soils, rather than discharging these wastewater constituents to creeks, which degrades water quality.

Non-Discharging Centralized Wastewater Systems

Key Considerations

Economic Considerations

1. These types of centralized collection and treatment systems avoid the need for soil dispersal field areas on each individual lot, thereby enabling more dense development as compared with onsite wastewater systems.

2. Centralized wastewater systems relying on subsurface soil dispersal of treated effluent often enjoy lower monthly service fees due to significantly fewer requirements under TCEQ rules, as compared to systems that rely on direct stream discharge or surface irrigation.

3. A number of treatment technologies commonly used for small centralized wastewater systems are modular and can be easily phased-in as communities expand.

4. STEP/STEG collection systems eliminate a primary treatment step at central treatment sites, along with those associated costs, space, and odor/ aesthetic considerations. Individual property owners typically pay for pumping of their own settling (septic) tanks as needed, thereby greatly reducing sludge management costs on the larger community system. Anaerobic digestion of sludge naturally occurs in septic tanks, thereby reducing the overall volumes of sludge needing pumping and handling at a centralized sludge treatment facility.

5. Utilities and developers can install small-diameter, much less costly, effluent collection lines (as compared with conventional gravity lines) along streets and easements. This reduces the required investments by a utility or developers – particularly before build-out while there's cost participation by fewer system users – since primary tanks are placed on-line only as homes are built. Because they're conveying only the liquid fraction of the waste stream, effluent sewers are able to convey much higher flows in smaller diameter pipes, as compared with conventional gravity sewers.

6. As lots are sold and build-out occurs, flow-tracking can evaluate the wastewater capacity needs as they evolve. Modular treatment units can be added only as needed, thereby saving communities from having to pay for unused capacity early on in projects where financing can be challenging.

7. Several treatment technologies commonly used in many parts of the U.S. for small centralized systems utilizing soil dispersal are more energy efficient, with lower operation and maintenance requirements, than conventional systems which rely on direct discharge of treated effluent.

Non-Discharging Centralized Wastewater Systems

Key Considerations

Policy Information

1. Community wastewater systems using land application (via surface irrigation, evaporation, or subsurface soil dispersal) are required to obtain a Texas Land Application Permit (TLAP) permit. Pre-dispersal collection and treatment systems permitted through TCEQ's Municipal Treatment Section must also comply with Chapter 217 (Design Criteria for Domestic Wastewater Systems) and any other TCEQ rules applicable to the specific system.

2. Community wastewater systems employing water reuse other than through final effluent dispersal at dedicated, permitted final soil dispersal areas must be permitted under Chapter 210 of TCEQ rules.

Land/Resources Considerations

1. Land area needs associated with centralized wastewater systems relying on land application will depend on a number of factors, including geophysical conditions where final soil dispersal is to occur, applicable regulatory requirements for the given locale, and level of treatment provided before final soil dispersal.

2. Fewer engineers and architects are familiar and experienced with these types of centralized wastewater treatment options for systems relying on final soil treatment and dispersal, as compared with conventional sewers and centralized treatment systems. Challenges can occur in both planning and implementation phases of these projects if professionals experienced with these types of small community systems aren't involved at the earliest stages of planning. It's important to work with design professionals and contractors experienced with the methods and materials suited to the project conditions.

Maintenance Considerations

1. The level of maintenance needed for small centralized wastewater systems varies significantly depending on system size, type, and configuration and may on average require only a few hours weekly or monthly for lower maintenance systems, with other systems having more intense operational needs requiring half- time or full-time operators.

2. For centralized wastewater systems, there are economies of scale for maintenance activities as compared with smaller systems.

Non-Discharging Centralized Wastewater Systems

Key Considerations

3. For STEP or STEG systems, it's important that tanks be pumped and effluent filters cleaned as needed, along with assuring sound condition of valves, pumps, etc. Utility access easements can be assigned during the development process to allow service providers to perform the necessary service checks and maintenance.

Non-Discharging Centralized Wastewater Systems

Case Studies

The two case studies below provide examples of proprietary and non-proprietary treatment technologies in two very different geophysical settings.

Case Study 1: Small Centralized System in Jackson Bend, Tennessee[8]

This small centralized system was constructed to serve a new hundred-lot subdivision in rural Blount County Tennessee. The project was initiated and completed in 2001. The subdivision site was suitable for individual onsite systems, but only at a much-reduced development density. The development sits immediately adjacent to Ft. Loudoun Reservoir, a public water supply and recreational resource.

The system consists of a septic tank effluent pumped (STEP) collection system, including a 1,500-gallon watertight, structurally sound primary treatment tank and ½ HP, 10 GPM STEP pump at each lot. Secondary treatment is provided via a 20,000 gallons per day recirculating sand filter (RSF) with effluent UV disinfection discharging to a three-acre effluent drip dispersal field.

The developer paid all design, permitting, and construction costs and transferred ownership of the completed system to Tennessee Wastewater Systems, Inc., a privately-owned utility regulated by the Tennessee Regulatory Authority.

The total cost to the developer was $5,000 (in 2001 dollars) per lot for collection, treatment, and effluent dispersal. The on-lot portions of the system (paid for by lot owners/builders) included tanks, pumps, and control panels. Appurtenances were an additional ~ $5,000 per lot, bringing the total system cost to approximately $10,000 per lot.
As of 2017, user charges for homes connected to this system were $45 per month.

Benefits and Performance:

Benefits of this type of system include:

- Primary treatment provided at individual residences, thereby enabling use of small diameter effluent sewers having the benefits described above
- Very reliable method of secondary treatment that produces a consistently good effluent quality, thereby greatly extending the life of the soil dispersal system and further minimizing any potential water quality impacts from infiltrating effluent
- Relatively low operation and maintenance needs – including power usage -- as compared with some other commonly used secondary treatment methods.

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[8] Information about this system was obtained from Mr. Michael Hines, P.E. of Southeast Environmental Engineering, and design engineer for the system.

Design Strategy:

This system is very different from typical conventional municipal wastewater projects. The sewers are small-diameter, low-pressure collection pipes installed about 30 inches deep, and do not need manholes. The treatment process uses recirculating distribution of effluent across a coarse sand media.

The secondary treatment process is sensitive to influent wastewater characteristics (it's important that effective primary treatment be provided ahead of the sand filter), media specifications, loading rates, and recirculation controls. Proper design and construction demands that engineers and contractors have proven experience with such systems, which is unfortunately not the case for most engineering consulting firms and construction companies. Most formal engineering training focuses on traditional/conventional centralized wastewater systems methods and materials. Virtually all such projects in Tennessee are permitted as non-discharge systems, rather than NPDES facilities. Many states do not have specified design requirements for recirculating sand/gravel filters nor for effluent drip dispersal systems to serve community scale systems.

TCEQ does have some design guidelines for media filters, though they are relatively limited in scope and do not include many of the details needed for adequate design and construction of a recirculating sand/gravel filter system that could be expected to function well over a reasonably long service life. Chapter 222 of TCEQ rules provides some guidelines for larger scale systems utilizing subsurface drip dispersal in Texas.

The land area required for this system is mostly identical to what is otherwise needed for effluent drip dispersal fields. For this Tennessee system, approximately 20 to 30 lots can be served for each acre of drip area.

With sophisticated telemetry controls on the recirculating sand filter and drip operations, operator visits to the site are minimal, and generally needed only about once or twice a month. Pumping equipment is expected to last about 10 years, with controls generally in the same time frame.

Sand replacement frequencies of 25 or more years are common for these systems (biological buildup can occur over time). Drip line issues needing repair or replacement would be mostly breaks, cuts, or rodent/animal bites in the drip tubes. Depending on influent iron concentrations, tube clogging can also occur. If replacement of the drip lines were needed, this involves installing new drip tubes in between existing lines.

Below are some photos associated with this system.

Photo 10: Primary tank being water-tested.

Photo 11: Residences served by system.

Photo 12: More homes served by the system.

Non-Discharging Centralized Wastewater Systems

Case Studies

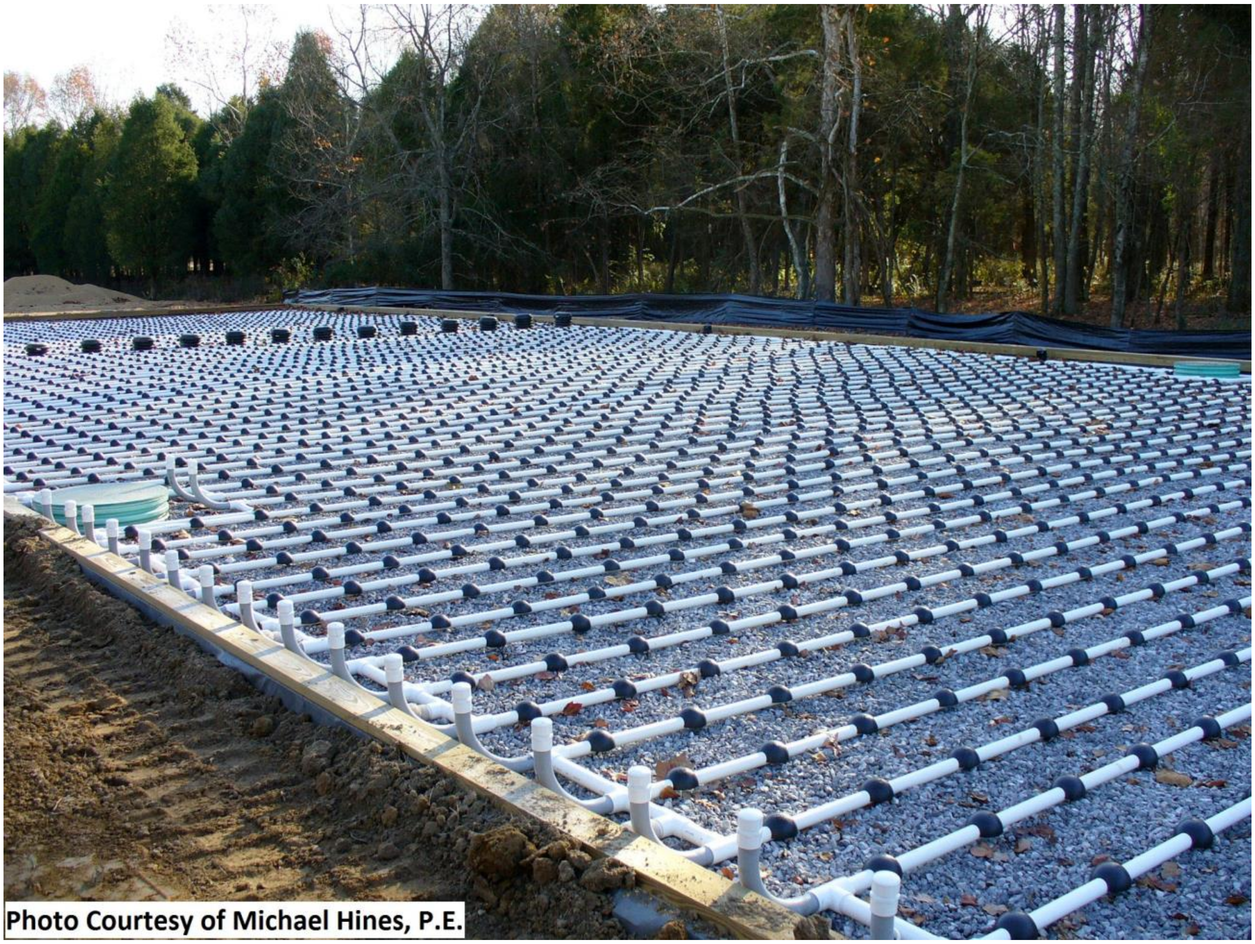

Photo 13: Recirculating sand/gravel filter.

Case Study 2: Sustainable Centralized System in Fulton, Alabama

Fulton provides a good example of a small community that previously relied on individual onsite systems but transitioned to a sustainable centralized collection and treatment system. Information about this project was obtained from Orenco Systems, Inc.

High groundwater tables in Fulton were contributing to failed septic systems, so the town's mayor sought and obtained state and federal funding for the construction of a new community system. The mayor visited other community wastewater systems in the state and was impressed with the low maintenance and performance of certain installations.

Design Strategy:

The new wastewater systems were constructed in two phases – one on the west and the second on the east sides of town and consist of the following:

Phase 1 (completed in 2006), east side of Fulton: 65 Service Connections:

- 65 STEP connections (primary tanks on each lot with an effluent filter and pump that delivers primary- treated effluent into the street collector lines)
- Secondary treatment with nine recirculating packed textile media treatment units (Orenco AX-100)
- Subsurface drip irrigation of the treated effluent
- Monitoring and control via remote telemetry

Phase 2 (completed in 2013), east side of Fulton: 132 Service Connections:

- 132 STEP connections (primary tanks on each lot with an effluent filter and pump that delivers primary-treated effluent into the street collector lines
- Secondary treatment via five recirculating packed textile media treatment units (Orenco 42-ft. long AXMAX treatment units; Each unit has over double the capacity of AX-100 treatment units used in Phase 1 of the Fulton system)
- Disinfection via ultraviolet (UV) irradiation
- Subsurface drip irrigation of the treated effluent
- Monitoring and control via remote telemetry

The new wastewater systems (including pump packages installed at individual lots for pumping effluent into common collectors) were funded entirely through grants and loans. On-lot portions of the system (including de-commissioning existing septic tanks) reportedly cost between about $3,600 (for a 1,000 gallon primary tank) and $4,200 for a 1,500 gallon primary tank. Street collector lines cost approximately $275 total per lot served, on a system-wide basis, bringing the capital costs for the combined primary treatment and collection portions of the system to between $3,900 and $4,500 per lot served.

Benefits and Performance:

Costs for STEP/STEG collection systems can vary significantly, depending on factors such as state/local regulatory requirements, geophysical conditions where construction will occur, primary (septic) tank material of construction, whether rock removal is needed, and where the tank will be installed. Regarding tank material, fiberglass lasts much longer than concrete and is much lighter weight for placement in hard-to-reach spaces but costs significantly more than concrete.

Total costs (including engineering, permitting, on-lot STEP pump packages, street collectors, treatment units and drip dispersal systems) for Phase 1 was approximately $2 million, with a design flow of 25,000 gallons and a maximum daily flow of 45,000 gallons. Total cost for Phase 2, with a design flow of 40,000 gallons daily and a maximum daily flow of 80,000 gallons, was $3.5 million.

Each phase was built with capacity to serve future homes. If a flow of 200 to 250 gallons per day per household were assumed, those capital costs (for collection and treatment) would translate to an average capital cost of $16,000 to $20,000 per household served for Phase 1 and about $17,500 to $21,875 per household served for Phase 2. Monthly user charges for the system are $37 per residential connection.

Operation and maintenance requirements for this system are relatively low. STEP pumps typically last about 25 years and would be relatively easy to replace in the event of a pump failure. Effluent filters in primary (on-lot) tanks need period checks to see if cleaning is needed along with checking sludge/scum build-up in tanks to determine if pumping is needed. The recirculating textile media filter (AX-100 and AX-MAX) units require periodic checks and preventive maintenance such as flushing effluent distribution lines in the system. The costliest part of operating the system is reportedly the monthly sampling and analysis that verifies compliance with effluent quality requirements.

This type of small community collection and treatment system has also been used in Texas, including for a 75-home resort community located on Lake Belton and a 184-home system in New Braunfels.

Some photos of associated with the Fulton, Alabama system are provided below.

Non-Discharging Centralized Wastewater Systems

Case Studies

Photo 14: Residence in Fulton, AL.

Photo 15: AX-100 treatment units, Phase 1.

Photo 16: AX-MAX treatment units, Phase 2.

Photo 17: AX-MAX treatment units, opened.

The Meadows Center
for Water and the Environment

TEXAS STATE UNIVERSITY

MEMBER **THE TEXAS STATE UNIVERSITY SYSTEM**

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