Contract Report 23-001

Cypress Creek/Blanco Watershed One Water On-Site Sewage Facilities Study

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Prepared for

The Meadows Center for Water and the Environment, Texas State University

by

David Venhuizen, P.E., Venhuizen Water Works

February 2023

The Meadows Center for Water and the Environment
Texas State University

MEMBER **THE TEXAS STATE UNIVERSITY SYSTEM**

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Planning and Engineering as if Water and Environmental Values Matter

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1 Introduction

The Meadows Center for Water and the Environment at Texas State University has commissioned a study of the area in Wimberley shown in Figure 1 to assess the prospect that pollution indicated by water quality testing in Cypress Creek where it borders this area derives from On-Site Sewage Facilities (OSSF) – more commonly known as “septic” systems – within this area. This report:

- Reviews the observations gathered by various water quality testing programs;
- Considers whether pollution indicated by these testing results may be due to the OSSFs in the study area;
- Reviews the types of OSSFs installed in the study area;
- Reviews soil conditions in the study area;
- Reviews the options for improving wastewater management in the study area to eliminate pollution of area waters caused by current practices, their costs and regulatory prospects.

Figure 1. Cypress Creek/Blanco Watershed One Water OSSF Study Area

2 Characteristics of the Study Area

As shown in Figure 1, the study area is bounded by the Blanco River to the south, by Cypress Creek along the southeast, by Ranch Road 12 along the northeast, by Rhodes Lane to the north and northwest, and by Leveritts Loop to the west and southwest. The total area is approximately 196 acres. From the Hays County Central Appraisal District map, the area contains approximately 103 property parcels denoted by a parcel number on that map, ranging in size from less than 1/2 acre to over 9 acres, with the majority of the parcels being fractional-acre lots containing one single family residence. The area bordering Ranch Road 12 and the run of Rhodes Lane just off Ranch Road 12 is covered with commercial properties. There is also some open space and vacant parcels. An ephemeral channel, or “wet weather creek”, traverses along the northeastern part of the area, behind the commercial strip along Ranch Road 12, and drains into Cypress Creek. Most of the rest of the area drains mainly by diffuse overland flow. Some of residential areas and some of the open spaces are heavily treed.

Figure 2 shows the soil map of the study area, derived from the NRCS soil survey. The survey lists about 156 acres, or about 80%, of this area as covered by Gruene clay with slopes of 1 to 5 percent (GrC). In particular, the part of the study area where surface drainage is into Cypress Creek is covered by this soil. The typical soil profile of this mapping unit is listed by NRCS as “clay” to 13 inches, “cemented material” from 13 to 22 inches, and “stratified very gravelly loam” down to 80 inches.

Smaller areas along the westerly and southwesterly part of the study area are covered by Lewisville silty clay, 1 to 3 percent slopes (LeB) – about 15 acres – and Bracket-rock outcrop-Comfort complex, 1 to 12 percent slopes (BtD) – about 22 acres. The typical profile of the Lewisville silty clay is listed by NRCS as three layers of “silty clay”, to 15 inches, to 38 inches and to 69 inches. The soils covering the study area are reviewed in more detail in Section 5.

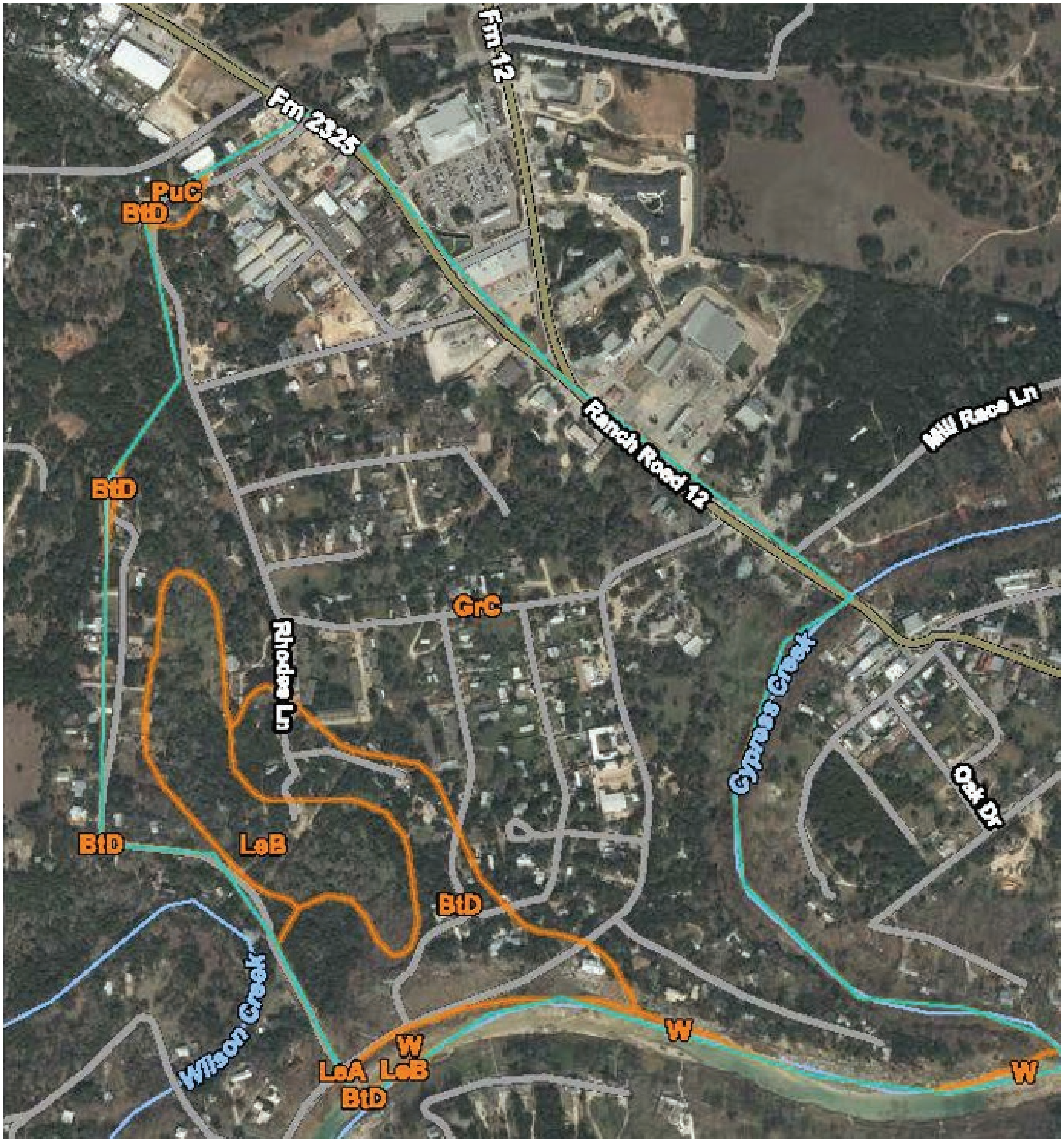

Figure 2. Soil Map in Study Area

3 Review of Water Quality Testing Observations

Water quality monitoring in Cypress Creek has been conducted by the Clean Rivers Program and the Texas Stream Team, and by the Texas A&M Agrilife Research – Soil & Aquatic Microbiology Laboratory (SAML). ***E. coli*** was chosen as the indicator bacteria to show the presence of biologically-derived pollution in Cypress Creek. Unfortunately, the record of these observations is paper thin, offering little evidence that "failing" OSSFs in the study area may be contributing to pollution shown in samples taken from Cypress Creek.

The SAML sampling results are shown in Table 1, derived from a memo setting forth a Bacterial Source Tracking study conducted in 2017. The sampling point that might have been impacted by pollution flowing out of the study area was in Cypress Creek about 500 feet downstream of the Ranch Road 12 bridge over the creek. This point is along the boundary of the study area, just downstream of where the ephemeral channel running behind the lots fronting Ranch Road 12 joins Cypress Creek. ***E. coli*** bacterial isolates from fecal pollution were "fingerprinted" and their DNA were compared to those in a statewide library of known sources. The bacterial isolates were selected randomly and identified using both a 3-way categorization and a 7-way categorization protocol. The calculated "rate of correct classification" for SAML is 100% for the 3-way split and 91% for the 7-way split.

As Table 1 shows, only one isolate, derived from a sample collected during wet weather conditions, was identified as likely from a human source. It is noted that the location of the sampling was adjacent to the commercial center known locally as "The Square", where purported "failures" of OSSFs had been set forth as the justification for installing sewers in that area, which has recently been completed. So at the time of sampling in 2017, the OSSFs on "The Square" were still operating. This being the case, it may be more likely that any human derived pollution observed in the sample came from "The Square" rather than from the study area across Cypress Creek under consideration here.

The data reported by the Texas Stream Team and the Clean Rivers Program were drawn from a presentation given at the Cypress Creek Watershed Protection Plan Committee Meeting held on March 31, 2021. Only one sample collection point among those reported in that effort would be effected by pollution that might issue from the study area. That point is located on Cypress Creek near its confluence with the Blanco River. 20 samples were purported to have been taken. The geometric mean of those samples was reported to be 347.1 MPN/100 mL of ***E. coli***.

The results were shown on graphs, so only estimates of these results can be offered. Two results were in the range of 2,400 MPN/100 mL, one was in the range of 1,600, 4 were around 1,000, one was about 500, 6 were between the Water Quality Standard (WQS) of 126 MPN/100 mL and about 300. Five other results were below the WQS. (Note, only 19 of the 20 reported data points were shown on the graph.) No information indicating the potential sources was reported. Per a chart in the committee meeting report, almost all of these samples were taken while there was low flow in Cypress Creek.

From this information, it is clear that fecal pollution is impacting on the water quality in Cypress Creek. It is not clear how much of this pollution is due to human sources – that is, deriving from wastewater discharged into OSSFs vs. from wildlife and/or pets – and further if it derives from the study area of this project vs. OSSFs on “The Square”. To further review the potential for OSSFs in the study area to be sources of this pollution, the nature of those OSSFs is reviewed.

Table 1. SAML Water Quality Sampling Report

DATE	WEATHER CONDITIONS	E. COLI CFU/100 ML	ISOLATE	3-WAY ID	7-WAY ID	CLOSEST MATCH
8/7/17	Wet	18,000	Cypress Creek 582572-8/7-A	Human	Human	Raw Sewage
			Cypress Creek 582572-8/7-C	Unidentified	Unidentified	Cattle
			Cypress Creek 582572-8/7-D	Livestock and domesticated animals	Cattle	Cattle
			Cypress Creek 582572-8/7-E	Wildlife	Wildlife Non-avian	Feral hog
9/12/17	Dry	276	Cypress Creek 9/12-582589-B	Wildlife	Wildlife Non-avian	Deer
			Cypress Creek 9/12-582589-D	Wildlife	Wildlife Non-avian	Feral hog
			Cypress Creek 9/12-582589-E	Wildlife	Wildlife Non-avian	Coyote
10/16/17	Dry	650	Cypress Creek 10/16-582597-A	Wildlife	Wildlife Non-avian	Duck
			Cypress Creek 10/16-582597-B	Wildlife	Wildlife Non-avian	Feral hog
			Cypress Creek 10/16-582597-C	Wildlife	Wildlife Non-avian	Raccoon

4 Overview of How "Septic" Systems Perform

The focus of attention when discussing on-site wastewater management is often on making the water go "away". This reflects a focus on "disposal" over treatment of this water. But it is obvious that there really is no "away", there really is no such thing as "disposal" in this context. After ***dispersal*** – the proper name for what is being done here – wherever it goes, the water remains in some part of the hydrologic cycle. What is really desired is to prevent the effluent – or more correctly, the pollutants it contains – from causing water quality and public health problems when it gets to wherever "away" is. The point is to safely ***recycle*** water and nutrients back into nature.

Once run into a dispersal field, commonly called a "drainfield", as schematically illustrated in Figure 3, there are only two routes by which the water can get "away". One route is percolation down through soil under the trench. Percolation of septic tank effluent through some minimum depth of ***unsaturated*** soil is the foundation of all regulations governing on-site systems (OSSFs). The "magic number" for required soil depth varies among the states. In Texas, it is 2 feet, somewhat less than the 3 feet it is generally agreed upon in this field is "safe". The intent is that the effluent will receive adequate treatment as it filters through the soil so that a problematic level of pollutants will not run into environmental waters, either directly into groundwater, or via seeps into surface waters. It is that latter route that is under investigation in this study.

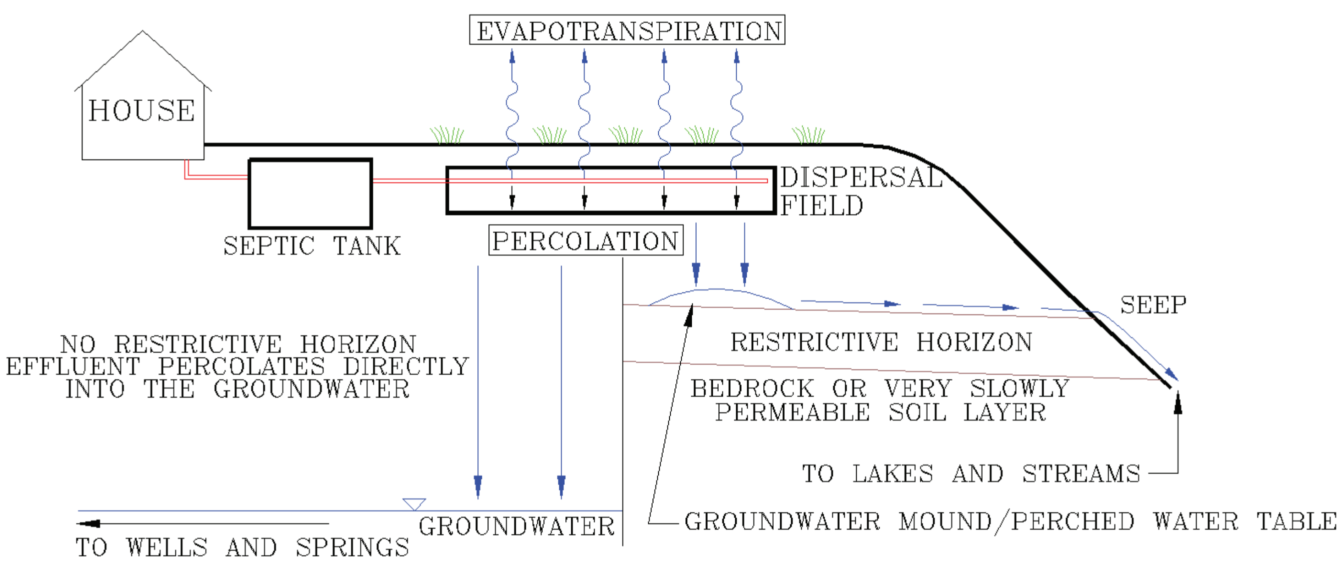

Figure 3. Fate of Wastewater Discharged to OSSF Dispersal Field

The other route by which water can get "away" is less direct. Water can be "wicked" out of the trench and held in the soil by ***matric potential***, which is the suction force caused by air-filled voids in the soil, just like capillary action draws water up a tube. As the soil becomes wetter – that is, as saturation increases – matric potential decreases. At the degree of saturation called "field capacity" matric potential can no longer overcome the force of gravity, and the water starts percolating downward. But, if the soil is sufficiently "dry", matric potential could wick some water to the surface, to be lost to the atmosphere by direct ***evaporation***. If the trench is shallow enough, or if plant roots run deep enough, water held in the soil by matric potential can be taken into the roots, to be lost to the atmosphere by ***transpiration*** out of the leaves.

The combined action of surface evaporation and plant transpiration is called ***evapotranspiration*** (ET). Other than nutrient uptake by plants, ET does not directly eliminate pollutants. But if effluent water is retained in the soil for some time by matric potential rather than percolating on through in short order, a number of biological and chemical mechanisms are provided a better chance to remove pollutants from the water. This matric potential is maintained by the soil moisture deficit created by ET losses. The result is a lower mass loading of pollutants percolating down into the groundwater or out of seeps over the annual cycle when ET is maximized.

With this as background, it is easy to see how conventional trenches fail. One mode of failure is effluent appearing on the surface in or near the dispersal field area. This "hydraulic failure" occurs when water cannot percolate very fast due to "tight" soils or a clogged infiltrative surface. When water is loaded at rates higher than can be lost by ET from the bed area – typically the case under dispersal field sizing allowed by the Texas code – the trench will fill up and seepage to the surface will occur. This is the most recognized mode of system failure. Problems caused by such hydraulic failures include potential for spread of disease and a general nuisance, and water pollution when rainfall runoff washes surfacing effluent into streams.

The other, less recognized failure mode is percolation of effluent to a limiting condition (bedrock, groundwater, or impermeable barrier) without its having received adequate treatment. This "treatment failure" is the mode of failure with which this report is mainly concerned. As shown in Figure 3, this can result in pollution of groundwater or surface waters.

As a general principle, just because ***conventional*** on-site system trenches may fail to function adequately in some soil and site conditions, that does not mean that a strategy of decentralized soil dispersal systems – that is, using "septic" systems for wastewater management – must be abandoned. Examination of Figure 3 reveals that any soil dispersal system consists first of pretreatment – which is only the septic tank in conventional OSSFs – then further treatment in the soil. This suggests two approaches to providing more environmentally sound management where soil resources are limited:

1. Provide pretreatment to a higher quality than is afforded by the septic tank before the effluent is routed to the soil dispersal system.
2. Use dispersal methods which maximize the treatment capabilities of whatever soil resources that are available.

The typical conventional gravity trench design as specified in the Texas code is illustrated in Figure 4, showing both the conventional gravel filled trench design and the more recently popular design using "chambers". Effluent is placed rather deeply in the soil. Greater depth to the infiltrative surface reduces the potential for water loss through evapotranspiration and nutrient (mainly nitrogen) loss through plant uptake. Specifying deep placement of effluent in the soil reflects a focus on "disposal" over treatment.

It is essential, particularly in coarser soils, that a "clogging mat" forms at the gravel/soil interface of a conventional trench (or over the bottom of a chamber trench). (Tyler, et *al.,* 1977) This mat creates a zone of restricted flow, helping to assure that flow through the soil beyond the clogged zone would be unsaturated. Unsaturated flow is necessary to attain good treatment for pollutants of critical concern, particularly bacterial and viral pathogens. As noted previously, under the theory governing conventional dispersal field design, as long as this unsaturated flow path is long enough, "adequate" elimination of pollution is assumed.

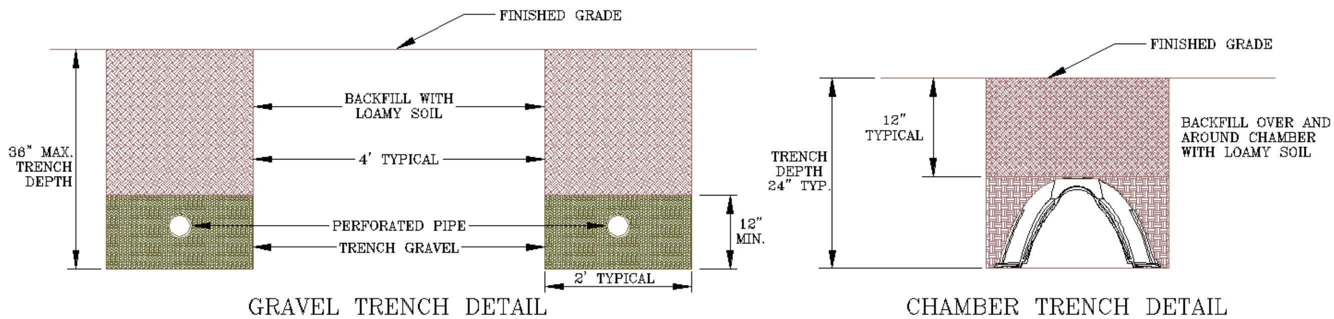

Figure 4. OSSF Gravity Trench Detail

Another feature of conventional trenches is that they are "gravity dosed"; that is, water flows by gravity through the drainfield pipe as it comes out of the septic tank whenever water is run into this tank from the house. This gravity dosing does not generally achieve uniform distribution of effluent over the whole trench, resulting in localized loading rates somewhat higher than the "design" loading rates, a circumstance which has been reported in numerous investigations. (Reneau, *et al.*, 1989, Harper, *et al.*, 1982) Particularly in coarse-grained soils, this non-uniform distribution can result in saturated flow through the soil below areas of the field which do receive effluent.

As pointed out by Otis, Plews & Patterson (1977), the benefits of sidewall absorption are broadly recognized. But little of the trench sidewall is engaged with gravity dosing. Flow peaks are attenuated by house plumbing and the septic tank, so flow surges are not large enough to pond water to any significant depth in the trench. Indeed they are not large enough even to distribute effluent over the entire trench bottom. Significant sidewall absorption would only occur if the entire trench bottom was on the verge of hydraulic failure, forcing effluent to pond in the trench all of the time.

These discussions highlight that maintenance of "proper" operating conditions in a conventional, gravity dosed trench is a delicate "balancing act" between a clogging mat sufficient to assure unsaturated flow in the underlying soil and hydraulic failure from too complete a clogging action. Often, due to localized overloading caused by non-uniform distribution, the portion of the trench receiving flow will become clogged, forcing effluent to flow further down the trench. After a time, this portion also becomes clogged, again because of localized overloading, and effluent is forced yet further down the trench. Finally, the entire trench becomes clogged. This progressive clogging of the trench is known as "creeping failure". (Reneau, *et al.*, 1989, Otis, *et al.*, 1977)

A progressive range of modifications to the conventional trench can be entertained in an effort to enhance the soil's treatment capabilities. The first is to pump the septic tank effluent onto the trench. Pumping effluent into the dispersal field pipe would typically create a large enough flow surge that effluent would run further along the trench length, so distributing the water over more of the trench. This would minimize localized overloading and the consequent potential for creeping failure. This pumped drainfield concept is recognized in the Texas OSSF code.

Inherent in any practical pressure distribution system would be a short-term "dose/rest" loading cycle. The pump would come on and run a dose of effluent to the field. No more effluent would be loaded on the field until another dose builds up in the effluent tank, which, by design, is many hours later. This circumstance limits the amount of effluent loaded on the field at any one time to the dose volume. Intermittent dosing in this manner provides two primary benefits: (1) it minimizes the tendency toward continuous ponding in the trenches and consequent severe clogging, especially in finer soils; (2) it minimizes the potential for development of saturated flow, especially in coarser soils, with consequent poor treatment of the percolating effluent (Reneau, *et al.*, 1989, Cogger & Carlile, 1984).

Treatment in the soil system benefits from enforcing lower localized loading rates. Canter & Knox (1985) and Gerba & Goyal (1985) provide indications that the efficiency of both straining/filtration and adsorption processes are decreased by higher infiltration rates. It is beneficial to go beyond simply assuring unsaturated flow. Employing pressure distribution can ensure that a field is loaded more uniformly, which – assuming the field is appropriately sized – trends to enforce lower flow rates through all areas of the soil system.

A further benefit of pressure dosing generally is that the dose/rest loading cycle provides the opportunity for the soil interface to aerate between doses. A dose may be completely "absorbed" into the soil before the next one is applied, allowing air into soil voids. As noted, this "resting" of the infiltrative surface minimizes the potential for severe clogging of the trench.

The next step is to redesign the trench and the distribution system to take maximum advantage of these benefits of pressure dosing. Shown in Figure 5 is the shallow, narrow trench design favored for use in the low pressure dosed (LPD) system. The total trench length is typically arrayed as a number of parallel trenches. This method was pioneered in North Carolina (Cogger, *et al.*, 1982) and is recognized in the Texas OSSF code. (Unfortunately, however, the Texas regulatory system appears rather unclear on the LPD concept, and allows them to employ wide trenches, even up to 3 feet wide, rather defeating a main purpose of the concept, reviewed below.) A small diameter lateral pipe with drilled holes – typically 1/8" to 1/4" – distributes effluent along the trench. Taking system hydraulics and relative trench elevations into account, the number and/or size of holes in each lateral can be varied to provide a roughly equal flow volume into each trench, thus distributing flow fairly evenly over the entire lengths of all the trenches. These lateral pipes are pressurized so that a minimum head – typically about 2.5 feet – is obtained at the distal end, assuring fairly uniform flow out all the holes.

The field design employs a long total length of these shallow, narrow trenches, which maximizes the ratio of sidewall to bottom area. System design assures that the dose is of sufficient size and the instantaneous flow rate into the trench is sufficiently high that the trench is partly filled by each dose. This enforces maximum utilization of sidewall absorption. (Cogger, *et al.*, 1982, Carlile, 1979) Further, placing the trenches as shallowly as practical offers the obvious advantage of maximizing the treatment effectiveness of whatever depth of soil above a limiting condition is available.

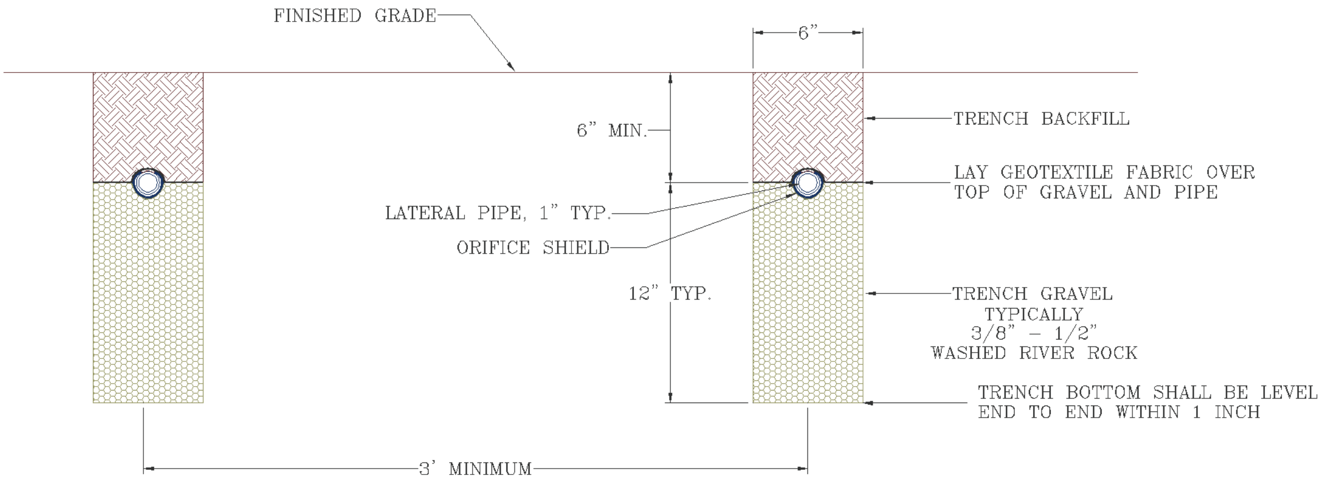

Figure 5. Low-Pressured-Dosed Trench Detail

In addition, shallow placement enhances ET losses when conditions are favorable. The field is typically designed as an array of parallel trenches, as Figure 5 illustrates. When sufficient matric potential exists – that is, when soil moisture level is sufficiently below field capacity – water is "wicked" into the inter-trench spaces. If the infiltrative surface is closer to the ground surface, the soil around it will become drier more quickly and will tend to stay drier during periods of little precipitation and significant ET potential. This occurs throughout the year in the Central Texas climate, being most pronounced from late spring to early fall. Effluent water would be held in this near-surface soil horizon by matric potential, allowing pollutant removal and assimilation mechanisms to work as well as possible.

The effluent loadings themselves make a significant contribution to soil moisture levels, thus decreasing matric potential and the consequent "wicking" action. Therefore, as noted previously, it is beneficial to employ light areal loading rates; that is, to design the field using a lower flow per square foot of field area. This not only helps to maximize ET losses, it results in lower nitrogen loading rates so that a greater portion of the applied nitrogen is likely to be removed by plant uptake, leaving less to percolate to groundwater.

Because effluent would disperse laterally from the trench walls, calculation of field loading rate allows credit for the inter-trench spaces. So, even though the field loading rate is low relative to the bottom loading rate of a conventional trench, the loading rate on the soil interface of the trench is typically somewhat higher than conventional trench bottom loading rates. (Cogger, *et al*., 1982) Even when no treatment beyond the septic tank is provided, it has been found that this higher "face" loading rate rarely causes trench clogging problems. Lack of clogging is credited to the dose/rest loading cycle, which allows the soil interface to aerate between loadings, retarding clogging mat formation. (Reneau, *et al*., 1989, Carlile, 1979, Ronayne, *et al*., undated)

The obvious objection to installing and operating a field in a manner that minimizes clogging mat formation is that conventional system design theory holds that this clogging mat is necessary to assure adequate treatment of effluent in the soil system.

While the clogging mat is itself an effective "retainer" of particulate pollution, its primary function is to restrict flow rate out of the trench into coarser-grained soils, ensuring that unsaturated flow would be maintained. In an LPD system, unsaturated flow is effectively maintained with a dose/rest loading cycle and uniform distribution, which prevent high localized loading rates common in gravity trenches. (Reneau, *et al.*, 1989, Carlile, 1979) Especially in coarse-grained soils, minimizing saturated flow with dose/rest loading rather than by relying on clogging mat formation offers more reliable treatment. Otis, *et al.* (1977) point out the problems of forming and maintaining an adequate, but not overly restrictive, clogging mat in a conventional "disposal" trench or bed.

If enhanced pretreatment is provided, the higher effluent quality offers further assurance that clogging of the infiltrative surface would not be an operational problem. Research and field experience shows that pretreatment to higher quality results in higher acceptance rates by the soil. There is no general agreement on which causative agents play the most active role in clogging mat formation, but most investigators agree that BOD_5, suspended solids and coliforms are primarily responsible. (Ronayne, *et al.*, undated, Siegrist, 1987) A sand filter pretreatment system, for example, would drastically reduce all these constituents below the levels found in septic tank effluent, in particular a 2-5 log (99% – 99.999%) reduction in coliform count. (Venhuizen, 1994)

This suggests that provision of better pretreatment is itself another logical step toward the development of a more environmentally sound management system where there are limited soil resources. When adequate pretreatment is provided, the clogging mat's filtration function is no longer important to the overall level of treatment achieved in the soil system. Also, the lower pollutant loadings should be more readily removed from soil water and assimilated by the soil system. As will be detailed, this is particularly so when applied at low areal loading rates uniformly over the field area with a dose/rest loading cycle.

The "ultimate" dispersal system, made feasible by pretreating the water to provide a high clarity (low solids) effluent, is subsurface drip irrigation. Pioneered by the author in OSSFs in the mid 1980s, this method is now recognized in the Texas OSSF code. This method can maximize the three main factors that enhance the treatment capability of whatever soil resources are available: shallow dispersal, uniform distribution with dose-rest loading, and a low areal loading rate. (Venhuizen, 1995).

As noted in the previous section, bacterial indicator organisms were the parameter chosen to illustrate the water quality degradation in Cypress Creek. So the explicit pollutant removal, or soil treatment, mechanisms that operate to assimilate and remove bacterial pathogens from the water once routed into the soil are examined next.

Septic tank effluent can contain a significant number of pathogens. Gerba & Goyal (1985) report that septic tanks remove 50-90% of bacteria, none of the protozoan cysts, and 50-90% of helminth eggs from domestic wastewater. A number of sources report the level of fecal coliforms – the standard "indicator" bacteria – in septic tank effluent at 10^6-10^8 MPN/100 mL. (Canter & Knox, 1985, Scherer & Mitchell, 1982, Sauer & Boyle, 1977) Once discharged to the soil system, pathogens can be removed by filtration, sedimentation and adsorption, and also by predation of soil fauna. (Reneau, *et al.*, 1989, Gerba & Goyal, 1985, Hagedorn, *et al.*, 1981, Frankenberger, 1988) Being relatively large, cysts and eggs are more readily filtered out in the soil system than bacteria, so if conditions for removal of the latter are favorable, the former should be removed as well.

Physical straining (filtration) is the main limit to travel of bacteria, so bacterial removal efficiency is typically inversely proportional to soil particle size. (Canter & Know, 1985, Hagedorn, *et al.*, 1981) A report on studies set forth by Hagedorn, *et al.* (1981) showed reduction of bacterial levels in septic tank effluent to the levels obtained from "control" soil samples within 61 cm (2 feet) of trench bottoms. They concluded, based on this and similar observations, that "... approximately 30-90 cm [1-3 feet] of soil beneath the base of the drainfield trench was adequate for complete bacterial removal of [sic] septic effluents *provided* the soil has both a layer permeable to effluent flow [to assure unsaturated flow] and another region adequately restrictive to form a clogged zone." [emphasis added]

Similarly, Tyler, *et al.* (1977) state: "At a distance of 1 foot into the soil surrounding the trench there was a 3 Log reduction in bacterial numbers and within the second foot counts are to the acceptable range for a fully treated wastewater." But again this degree of removal assumes the presence of a sufficiently fine-grained soil and/or sufficient crusting in the trench to assure unsaturated flow in coarser textured soils. Underscoring this point, Converse, *et al.* (1991) reported incomplete bacteria removal at 3 feet below the trench in a silt loam soil, which they attributed to saturated flow conditions created by uneven distribution and consequent localized overloading.

These observations highlight the vulnerability of conventional soil dispersal systems, especially in coarser-grained soils. Note in particular the critical function of the clogging mat in obtaining high bacteria removal. As noted above, the manner in which this biomat is formed and maintained makes operation of a conventional system a delicate balancing act between good filtration and too much clogging, which would result in "hydraulic failure" of the field. (Canter & Knox, 1985, Gerba & Goyal, 1985, Crites, 1985, Hagedorn, *et al.*, 1981) Thus, maintenance of unsaturated flow at all points in the conventional drainfield is problematic.

Once retained in the soil, pathogenic bacteria would eventually be predated or die off. Factors affecting their survival in soil are listed by Canter & Knox (1985) and by Frankenberger (1988) to include moisture content, moisture holding capacity, temperature, pH, presence of organic matter, and antagonism from soil microflora. Survival increases with soil moisture, indicating that injection of wastewater nearer the surface – where ET losses would lead to lower moisture levels over much of the year – would be detrimental to bacterial survival rates. Intermittent dosing, with alternating wetting and drying cycles, would also decrease survival. This effect may be minimal when employing a short-term dose/rest loading cycle, but it would be most accentuated in coarse-textured soils with low moisture holding capacity. Poor distribution in conventional gravity-dosed systems result in constant high wetness in those areas receiving the loadings, a factor that would be highly mitigated in a pressure-dosed system. Antagonistic microflora are likely to be more abundant in near-surface horizons, again favoring shallow placement.

Adsorption can also play a significant role in bacterial removal. Canter & Knox (1985) state that this process "... appears to be significant in soils having pore openings several times larger than typical sizes of bacteria"; that is, in coarse-grained soils. Adsorption becomes increasingly effective with increasing clay content and organic fraction. (Canter & Knox, 1985, Hagedorn, *et al.* 1981) In many coarse-grained soil profiles, surface soils tend to have a higher clay content than lower horizons. The organic fraction of a soil profile is largely contained in the upper horizons. This implies that removal through adsorption would be more effective with near-surface dispersal methods.

Reports by Reneau, *et al.* (1989) and by Hargett (1985) indicate the benefits of employing improved dispersal methods. Several studies of septic tank effluent dispersal in shallow LPD systems led to the conclusion that a separation of two feet or less between the trench and a limiting condition would achieve practically complete elimination of indicator bacteria. Mote & Buchanan (1994) found that, using a modified field design in which measures were taken to preclude effluent transport through large soil pores, practically complete removal of bacteria from septic tank effluent was observed at a depth of 18 inches below the point of injection. Duncan, *et al.* (1994) also observed complete elimination of fecal coliforms from septic tank effluent at the 18 inch depth in columns loaded in a manner which simulated an LPD system. A study of pressure-dosed mound systems also found that seepage at the toe of the mound, implying saturated conditions very near the sand/soil interface, contained very low indicator bacteria counts. (Bouma, *et al.* 1975)

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5 Suitability of Study Area Soils for OSSFs

This brings us to considering the general suitability for OSSFs of the soils covering the study area. From the NRCS soil survey, the area where most of the OSSFs for which records were found in the City of Wimberley files is covered with the Gruene clay soil series – see Figure 2. Per the soil survey this soil series has a "typical" profile of "clay" to 13 inches, "cemented material" from 13 to 22 inches, and "stratified very gravelly loam" down to 80 inches. A more detailed review of the Gruene clay soil series is offered in the *Soil Survey of Comal and Hays Counties Texas* (USDA/SCS, 1984), quoted below:

"GrC – Gruene clay, 1 to 5 percent slopes. This is a shallow to very shallow soil on stream terraces. Slopes are convex. The areas are long and narrow in shape and range from 5 to 650 acres in size.

"Typically, the surface layer is very dark grayish brown clay about 13 inches thick. The underlying material to a depth of 22 inches is strongly cemented, massive caliche containing embedded gravel. The underlying material to a depth of about 80 inches is very gravelly loam. The soil is mildly alkaline and noncalcareous above the cemented layer.

"This soil is well drained. Surface runoff is medium. Permeability is moderately slow in the surface layer and very slow in the cemented layer. The available water capacity is very low. The rooting zone is very shallow to shallow. Water erosion is a moderate hazard.

"Included in this soil in mapping are small areas of Lewisville, Krum, and Seawillow soils. Also included are areas of a soil that is similar to this Gruene soil except that it has a gravelly layer in the lower part that is not cemented and another similar soil that has a surface layer of gravelly clay loam. The included soils make up less than 15 percent of a mapped area."

The description of Lewisville silty clay soil in the *Soil Survey* is "Typically, the surface layer is dark grayish brown silty clay about 15 inches thick. The subsoil to a depth of 33 inches is light brown silty clay, and to a depth of 63 inches it is reddish yellow silty clay."

The description of Krum clay soil in the *Soil Survey* is "Typically, the surface layer is dark gray clay about 16 inches thick. The subsoil to a depth of 58 inches is grayish brown clay, and to a depth of 66 inches is a brown clay."

The description of Seawillow clay loam soil in the *Soil Survey* is "Typically, the surface layer is brown clay loam about 8 inches thick. The subsoil to a depth of 38 inches is very pale brown clay loam. About 58 percent of this layer is calcium carbonate (lime). The underlying layer to a depth of 80 inches is very light brown gravelly clay loam."

"Caliche" is understood in the context of soil treatment systems as a rather general term, used to describe a range of calcareous soils found throughout the Texas Hill Country, where Wimberley is located. It is formed in arid and semi-arid regions by leaching and accretion of calcium carbonate by weathering processes. It is typically light colored, and can range from white to pink to reddish brown. A "formal" definition is "a sedimentary rock, a hardened natural cement of calcium carbonate that binds other materials – such as gravel, sand, clay, and silt." (Wikipedia) Thus in general any caliche may be observed as a “cemented material”, such is as listed in the Gruene clay description in the *Soil Survey*.

According to textural analysis, caliche generally grades as a clay loam, a “Class III” soil under the classification system set forth in Chapter 285. (TAC Chapter 285, 2016c) Caliche is typically associated with poor soil drainage. The permeability of a caliche layer is highly dependent on the degree of “cementing” within the layer. Soil drainage, soil thickness, water retention and infiltration rates are highly variable among caliche soils. They are soil and site specific, varying with nature of parent materials, vegetative cover, landform position, landform geometry, microtopography, slope gradient, stoniness, surface crusting, soil degradation, biological activity, and intensity of soil development processes. It is generally agreed that as long as the water can percolate through it – noting that rapid infiltration and drainage occurs in many caliche soils because of high gravel content and the presence of macropores, thus there would be poor treatment potential – caliche would impart a treatment level similar to any clay loam soil. (Wilding, et al., 2000) Because of the somewhat nebulous definition and a rather broad range of “cementedness” and gravel content, describing a soil as “caliche” absent further qualification is marginally useful in regard to choosing an OSSF design to be installed in/over caliche soil.

The NRCS Soil Survey rates the suitability for “septic tank adsorption fields” of Gruene clay as “severe”, due to the presence of the cemented pan. This soil may support environmentally sound OSSFs with very shallow dispersal fields, such as mounds or semi-mounded systems, or that place the infiltrative surface below the “cemented” layer, into the gravelly loam. The degree to which fields installed into that layer may be environmentally sound would depend largely on the amount of soil within that “very gravelly loam”, with rather high potential for the water to migrate with poor treatment if the gravel content is high, so there would be less soil matrix. The degree to which shallow OSSFs would be environmentally sound may depend on how “cemented”, thus impervious, the cemented layer is.

The Soil Survey lists Lewisville silty clay as moderately restrictive for OSSFs because the soil “percs slowly”. Generally, if sized and installed properly, OSSFs in this fairly deep soil with little if any rock can be environmentally sound, but from Figure 2 it appears there would be fairly few OSSFs in this soil in the study area. Also the area covered by this soil does not drain into Cypress Creek, rather toward the Blanco River directly.

The Bracket-rock outcrop-Comfort complex soil is listed in the Soil Survey as severely restricted due the shallow depth to bedrock. It appears from Figure 2 there are fairly few OSSFs that would be located in the areas covered by this soil, and this area also does not drain into Cypress Creek, rather more directly into the Blanco River.

Overall then the study area’s soils are not particularly well suited to the installation of conventional septic tank-gravity trench OSSFs. Most of the OSSFs in the study area are in the area shown in Figure 2 to be covered by Gruene clay, which is problematic, in particular for conventional septic tank-gravity trench OSSFs, as reviewed above. This being the case, it may indeed be plausible that OSSFs in this area may be contributing to the pollution observed by water quality testing in Cypress Creek. It remains to be observed if the OSSFs are mainly that conventional system, or more “improved” designs that may perform better in “restricted” soils.

6 OSSF Records Review

A review of the OSSF permit records maintained by the City of Wimberley was conducted, inspecting a few dozen records ranging over the part of the project study area that generally drains toward Cypress Creek. The majority of the records reviewed dated from before 1997, when the current OSSF code, TAC Chapter 285, was adopted, requiring investigation of the soil profile in the area proposed to house the OSSF dispersal field. Almost all of those older OSSFs are conventional septic tank-gravity trench systems employing the conventional gravel and pipe trench, illustrated in Figure 4. A few of those OSSFs are unlined evapotranspiration (ET) beds. In that type of OSSF, while most of the water would evapotranspirate rather than percolate during dry weather, some pollutants could still percolate with migrating water during wet weather or during long periods of low ET potential.

No soils information was contained in the files of the pre-1997 systems, as at that time the so-called “perc test” had been relied upon to characterize the ability of soils to “absorb” the wastewater, and so to size the dispersal field. Reflecting the historic focus of on-site wastewater management as being all about “disposal” – making this water to “go away” – only hydraulic failure, not treatment failure, was considered as restricting what type of OSSF might be installed. It is therefore possible – indeed as will be seen, likely – that some of these OSSFs were installed in soils in which treatment failures would be prone to occur, with pollutants issuing from the septic tanks migrating into environmental waters. It was also noted that at that time the dispersal field loading rates considered proper were considerably higher than are stipulated by the current code in the same soils – for example, 0.5 gal/sq. ft./day then vs. 0.2 gal/sq. ft./day now, in what is now identified as a “Class III” soil (TAC Chapter 285, 2016a) – creating potential for treatment failures of those systems due to heavier areal loading rates onto the dispersal fields.

Of the records for OSSFs that had been installed from 1997 on, many, but not all, of these records contained a record of observations in soil pits. A few of these OSSFs are conventional septic tank-gravel and pipe gravity trench systems, but the majority of the OSSFs that are conventional septic tank-gravity trench systems employ “chambers” to construct the dispersal field, as illustrated in Figure 4.

Several of the OSSFs installed since 1997 are low-pressure-dosed (LPD) systems, and several others employ pretreatment prior to dispersal. All of the latter utilize the so-called “aerobic treatment unit” (ATU) for pretreatment. These all employ some bastardized variant of the activated sludge process, so are inherently unstable and consume a large amount of power to continuously aerate the wastewater. This is discussed further in Section 9. A few of these ATU systems employ a spray dispersal system (a strange choice in an area with such small lots, as aerosols would drift onto neighboring properties, also discussed further in Section 9) after nominally disinfecting the ATU effluent. During wet weather, when the effluent is sprayed over the surface, stormwater runoff may carry pollutants left in the water after pretreatment directly into surface waters, most particularly in this study area, into Cypress Creek. The other systems using pretreatment units employ a subsurface drip irrigation dispersal field.

7 Soils Observations in OSSF Records

It should be expected that the soils observations in the City of Wimberley OSSF records over the study area would reflect a profile similar to those described above. Yet as will be observed, that is generally not what was reported on the forms found in the City of Wimberley OSSF files. A problem regarding the descriptions of soils in these OSSF records is that those who are credentialed to conduct the site evaluation under the Texas OSSF rules are typically not very well trained in anything but basic evaluation of soil type – as will be observed, in some cases even that is subject to question – and the whole purpose of the evaluation is generally to "qualify" a site for the type of OSSF it is desired to fit onto the site with high assurance that the effluent would "go away" – that is, to not result in "early" hydraulic failure. The evaluation is not really intended to impart much understanding of how well the soils would impart treatment to any water that percolates through them. As was detailed, that is essential to understanding the potential for pollutants to percolate out of OSSF dispersal fields and on into environmental waters.

The forms which are used to report the soils observations are quite basic, requesting only the textural "class" per the Chapter 285 classification scheme, the "gravel analysis", whether there are mottles or a water table present, and if there is a "restrictive horizon". An example of the form is shown in Table 2.

Table 2. Example of OSSF Soil Evaluation Form

Soil Boring Number: 1

Depth (ft.)	Textural Class	Gravel Analysis	Drainage (Mottles, Water Table)	Restrictive Horizon	Observations
0-13"	III	Less than 30%	No Mottles	None	Brown Loam Top Soil.
14-60"	III	Less than 30%	No Mottles	60"	Calich Class III Soil.

Soil Boring Number: 2

Depth (ft.)	Textural Class	Gravel Analysis	Drainage (Mottles, Water Table)	Restrictive Horizon	Observations
0-15"	III	Less than 30%	No Mottles	None	Brown Loam Top Soil.
16-60"	III	Less than 30%	No Mottles	60"	Calich Class III Soil

It is therefore not surprising that in none of the soil profile hole observations was there any notation of a “cemented material”, and that the gravel content was not explicitly characterized. In almost all cases, the gravel content of the soil was listed only as “<30%”, as this is the threshold for a soil to be considered “suitable” for installation of a conventional septic tank-gravity trench OSSF stipulated in Chapter 285. (TAC Chapter 285, 2016b) Therefore, the site evaluator would be highly “motivated” to list the gravel content as less than 30%, and no information on just how the “gravel analysis” was conducted to arrive at that evaluation is ever provided.

Of the records of OSSFs installed prior to 1997, one record, prepared by a P.E., was found that provided detail of the soil profile in the area of the dispersal field. The location of this OSSF is in the area shown in the soil survey to be covered by the Gruene clay series. The soils observations were reported to be:

- 12” of dark brown sandy clay
- Gradually changing below 12” to reddish brown very sandy clay
- At 48” changing to light brown, soft, unconsolidated “caliche”
- Scattered rock fragments, some quite large, at surface
- No groundwater observed down to 6-foot depth
- No evidence of seepage from the cut bank along the road

Note there was no report of a “cemented” layer, and no report of gravel in the layer down to 48”, other than noting rock fragments at the surface and that the material from 48” and down was a “caliche”. The OSSF design response to these soil conditions was reported to be some form of a pressure-dosed system, sized for an application rate of 0.5 gal/sq. ft./day. Today that sort of OSSF would likely be permitted in that “Class III” soil (“sandy clay” – see TAC Chapter 285, 2016c), but it would be sized for an application rate of only 0.2 gal/sq. ft./day. (TAC Chapter 285, 2016a)

All of the OSSF permit files in which a site evaluation report/OSSF soil evaluation form was found listed the following conditions:

- A soil profile of varying depth, from only 7 inches (where a spray dispersal field after pretreatment was proposed) to 60 inches.
- The profiles were described either as uniform over the entire excavation depth or as a surface layer and a lower layer.
- The surface soil layer, where designated separately from a lower soil layer, is variously listed as “Brown Loam”, “Brown Sandy Loam”, “Clay Loam”, and “Brown Clay Loam”. These are all “Class III” soils under the Chapter 285 classification system. (TAC Chapter 285, 2016c) Note that NO soil layer was described as “clay”, which is listed as the surface soil in all the soil types in this area in the *Soil Survey* except the Seawillow soil series. Note also that a “clay” would be a “Class IV” soil under the Chapter 285 classification system (TAC Chapter 285, 2016c), for which a maximum application rate of 0.1 gal/sq. ft./day is stipulated, while a “Class III” soil can be loaded at up to 0.2 gal/sq. ft./day. (TAC Chapter 285, 2016a) Thus the site evaluator is rather “motivated” to list the soil as a “clay loam”, a “Class III” soil, so that the OSSF dispersal field size would be considerably smaller, a rather clear potential to create treatment failures in these OSSFs. No information on how the textural class

was determined is provided in the records.

- Where a deeper soil layer was listed separately, the lower layer is variously listed as “Class III mix”, “Caliche Type Soil”, “Caliche soil and gravel mix”, “Caliche Class III Soil”, and “Class IV Fractured Limestone” (noting this last description makes no sense).
- In all cases the only characterization of “Gravel Analysis” listed is “<30%” or “Less than 30%”, except for one case.
- In that one case, the form lists “Greater than 30%, 80% less than 5.0 mm” in the layer from 9 inches to 48 inches depth in one hole and 8 inches to 46 inches depth in the other. In each case, under “Restrictive Horizon” is listed “Fractured Rock” at the top of these soil layers. It is noted that a low-pressure-dosed system was installed, despite Chapter 285 requiring that there be at least a 12-inch standoff with a suitable soil, containing less than 30% gravel, between the dispersal field trench bottom and a limiting condition of a rock layer. (TAC Chapter 285, 2016d)
- In another case, the soil profiles were listed under “Textural Class” as a “Class III Brown Loam” all the way down to a depth of 60 inches. That record included two pictures – one of which is shown in Figure 6 – of an excavated trench appearing to be about 36 inches deep, showing the soil to clearly be reddish brown below a fairly thin dark brown surface layer, with the reddish brown pile of excavated soil lying next to the trench appearing quite rocky, with many of the rocks appearing to be well over an inch in size. This appears to be a rather “unsuitable” soil in which to install a conventional septic tank-gravity trench system, yet this site was permitted for installation of a conventional leaching chamber system.

Figure 6. Conventional Trench and Spoil Pile

8 Discussion and Summary of Soil Conditions

Based on these observations, the accuracy of soils classification upon which the types of OSSFs installed were based is rather open to question. As noted, the soils evaluator is motivated to render a classification that would allow the relatively inexpensive conventional septic tank-gravity trench OSSF to be installed, and to size the dispersal field at the higher loading rate allowed in a "Class III" soil.

The clues provided by those last two instances in particular are a "smoking gun" indicating that permits have been granted for OSSFs in this study area which should not have been permitted in those soil conditions per the requirements specified in Chapter 285. *These observations offer little assurance that the OSSFs installed in the study area are not suffering treatment failures*, so that water still containing pollutants may be percolating out of these OSSF dispersal fields and migrating into environmental waters.

Therefore, the pollution observed in samples drawn from Cypress Creek may reasonably derive from OSSFs in the study area that experience treatment failures, either continuously due solely to the wastewater inputs, or episodically in wet weather when infiltrating rainwater causes more of the effluent-derived water to percolate below the dispersal field. An open question is how far these pollutants may migrate without being assimilated/treated. To migrate any distance, the water would have to encounter an impermeable layer, as illustrated in Figure 3, as otherwise the water would simply continue to percolate downward, eventually entering groundwater. Percolation of pollution into groundwater would of course be a problem, but not the one with which this study deals, which is the pollution of surface waters. In any case, this area is not recognized as a recharge site, and so it is to be expected that any percolating waters would hit a rock shelf and migrate to surface waters.

The Hays-Trinity Groundwater Conservation District (HTGCD) has advised that the Upper Glen Rose formation is generally near the surface throughout the study area. HTGCD asserted it is common for shallow groundwater systems to develop in this formation, due to the impermeable beds, and often discharge as seep springs that contribute flow to creeks. An Upper Glen Rose monitoring well close to the study area shows that during "wet" conditions the elevation of this groundwater is greater than the elevation of the portion of Cypress Creek that borders the study area. (HCGCD, 2021)

This indicates that during certain conditions water that percolates over the study area is contributing to the segment of Cypress Creek that borders the study area. Thus any water that percolates out of OSSF dispersal fields in this area could readily migrate into Cypress Creek, and so could be a source of the pollution that has been observed in samples drawn from Cypress Creek adjacent to the study area.

To the extent OSSF dispersal fields in the study area contribute to the pollution observed in Cypress Creek, a "cure" for this problem would be to use OSSFs that would be equal to the site and soil conditions in the study area, so that the pollutants – in particular bacterial pollution observed in the Cypress Creek samples, potentially including pathogens – would be either reduced/removed in a pretreatment unit prior to dispersal into the soil or would be introduced into the soil in a manner that would maximize the pollutant removal/assimilation processes acting in the soil, as was reviewed above. These and other options are reviewed in next section.

9 Options for Addressing Wastewater Management in the Study Area

As reviewed previously, some – perhaps many – of the OSSFs in the study area may be ill-suited to the soil conditions that prevail over the study area, and so may be a source of pollution that has been observed in Cypress Creek. If the community determines this is the case, and that measures should be taken to blunt or eliminate that pollution, then various options are available to do that. These include:

- Replacing/upgrading OSSFs in the study area;
- "Enhanced" standards for new (or replacement) OSSFs in the study area;
- Collective systems providing enhanced pretreatment and drip irrigation dispersal;
- Connecting this area to the wastewater system that currently serves nearby areas.

Each of these options is reviewed in this report, illustrating how the option might be implemented, what the expected costs would be, what impact they might have on water conservation as well as pollution reduction, and the regulatory hurdles and opportunities that each may present.

Replacing/Upgrading OSSFs in the Study Area

As reviewed in Section 4, various "improved" types of OSSFs can better deal with less than optimal site and soil conditions and so result in better removal/assimilation of pollutants in the wastewater, so that they will not migrate into environmental waters. As was noted in the Section 6, a majority of the OSSFs in the study area are conventional septic tank-gravity trench systems, the problems and limitations of which were noted in discussions in Section 4. One obvious way to mitigate any pollution that may be deriving from wastewater dispersed into OSSFs in the study area would therefore be to replace at least the conventional OSSFs with some "improved" type of OSSF. In some cases, the site and soil conditions may be so "severe" that an OSSF featuring enhanced pretreatment, beyond the septic tank, and subsurface drip irrigation dispersal may be the advised course of action.

As Section 4 reviewed, the first action to improve the ability of soil treatment mechanisms to better remove/assimilate pollutants in the wastewater is to provide pressure dosing of the dispersal field so that the entire field area is "engaged", rather than only a part of it at a time, as occurs in gravity dosed fields (at least up to the point where the entire field is "ponded", so is at the point of incipient hydraulic failure). In conjunction with pressure dosing, the drainfield design would also be modified so that the benefits of pressure dosing would be maximized. This entails composing the drainfield of a set of shallow, narrow trenches, rather than the wider and deeper trenches featured in gravity dosed drainfields. This low-pressure-dosed (LPD) trench concept is illustrated in Figure 5.

As an example of retrofitting an OSSF, consider the lot on which the trench pictured in Figure 6 was located. As was noted, the appearance of the soil is such that it appears questionable that a conventional septic tank-gravity trench OSSF "should" have been permitted in those soil conditions. Retrofitting an LPD system would better assure the

OSSF would be environmentally sound, that pollutants would not percolate out of the OSSF drainfield and into environmental waters.

An illustration of an LPD retrofit on this lot is shown in Figure 7. Assuming that the existing septic tank were in good condition, it could be retained and used in the LPD system. A pump tank containing the field dosing pump would be added, the LPD field would be installed, and the existing chamber drainfield would be abandoned. Note that the LPD field could be installed in any convenient location on the lot, subject to all statutory setbacks, but could not lie over the existing drainfield. The LPD field shown in Figure 7 is to scale, relative to the lot size, for the design flow rate that the original OSSF was built to accommodate. Note that, while it would not be all that efficient, some irrigation benefit can be provided by the shallow LPD trenches, most efficiently for shrubs and standing crops, like vegetables or fruit trees, not so much for shallow-rooted turf.

Estimates for the installed cost of an LPD retrofit as is illustrated in Figure 7 were solicited from three OSSF installers. The estimates offered were $10,000, $14,000 and $18,000. Note that the cost would not be "linear" with increasing design flow rate, so on a lot with a larger house, so a larger design flow rate, the cost should escalate only "a little". The spread of these estimates reflect the rather "unsettled" conditions in the construction market at present. The installer who offered the highest estimate was particularly cautious regarding materials and products availability and prices, noting that he has experienced long lead times getting tanks, soil, and even gravel.

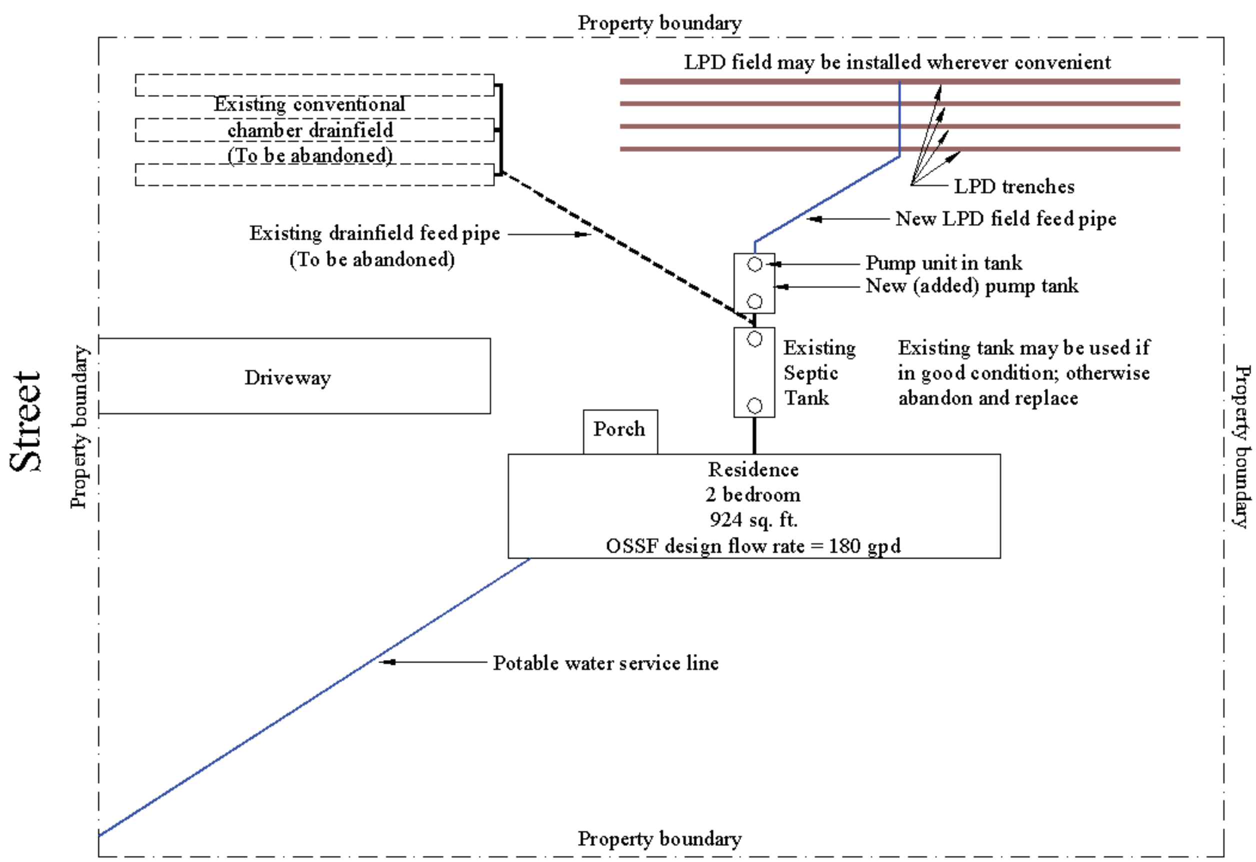

Figure 7. Low-Pressure-Dosed (LPD) OSSF Retrofit

This highlights that the conditions under which such retrofits would be installed may have a significant impact on their costs. Even at the lowest estimated cost of $10,000, it is to be expected that no property owner would undertake to replace the OSSF absent a regulatory order to do so. It is therefore to be expected that any such retrofits would be executed within a publicly sponsored program, implying that multiple such retrofits would be done at a time. If this were the case, it was asked of the installers, under a publicly sponsored program, with project after project lined up to be done, would that induce a lower price per project, since the installer would mobilize to the area once, could combine materials purchases, perhaps more efficiently schedule the work, etc. Only one of the installers responded, who said yes, a lower cost could be expected under those conditions, but did not offer a guess as to how much lower.

As noted, if the site and soil conditions are sufficiently “bad”, the “ultimate” sort of OSSF to render on-lot wastewater management as environmentally benign as it can practically be would provide enhanced pretreatment beyond the septic tank, and then would disperse that highly treated water in a subsurface drip irrigation field. If the drip irrigation field were to be arrayed to serve the highest value landscaping on the lot, assuming that landscaping were irrigated in any case, this method would also result in conservation of potable water supply that would otherwise have been used for that irrigation, so providing a water conservation benefit as well as enhanced pollution reduction.

The sort of treatment unit recommended to provide that high quality pretreatment in the on-lot operating environment is the recirculating packed-bed filter system, illustrated in Figure 8. A thorough review of this treatment technology, showing how and why it is a superior sort of treatment unit in the on-lot operating environment is offered by Venhuizen (2008a and 2008b).

The version of this technology shown in Figure 8 utilizes a filter bed, produced by Orenco Systems, Inc., that has a geotextile fabric filter media, which accommodates a somewhat higher hydraulic loading rate than the more traditional sand or gravel filter media. The sand or gravel media version of the recirculating packed-bed filter, typically called a recirculating sand filter or recirculating gravel filter, would require a filter bed that would serve a house about the size of the septic tank or pump tank shown in Figure 8, thus would take more space and be more visually intrusive on the lot.

While the Orenco filter bed is somewhat more expensive than would be the materials cost for a sand or gravel media filter bed, the Orenco filter bed is “plug and play”, requiring only hooking up the wastewater feed pipe and the filter bed drain pipes, while the sand or gravel filter would incur somewhat greater installation labor. Besides setting the much bulkier tank, this includes installing a spray loop to distribute water over the filter bed, and installing drain pipes and a rock underdrain, and then the sand or gravel filter media over that. All things considered, it is likely that the Orenco filter bed would be the choice of most OSSF owners for implementing this sort of system upgrade.

The so-called “aerobic treatment unit”, abbreviated ATU, is most widely used for “enhanced” pretreatment prior to dispersal in Texas. Those devices, however, are rather ill-suited for coping with the vagaries of the on-lot operating environment, being notorious for experiencing “excursions” in treatment quality because, as EPA states, “...excessive solids build-up will result in high suspended solids washout.” (EPA [2], 2000) These units are sensitive to that because ATUs are all some bastardized version of the activated sludge treatment process, and the performance of an activated sludge process, in particular the "truncated" versions implemented by ATUs, can change in short order, subject to the operating conditions. As EPA states, the treatment system is sensitive to temperature, power interruptions, influent variability, and shock loadings of toxic chemicals, including routinely used household cleaning agents and laundry bleach. (EPA [1], undated)

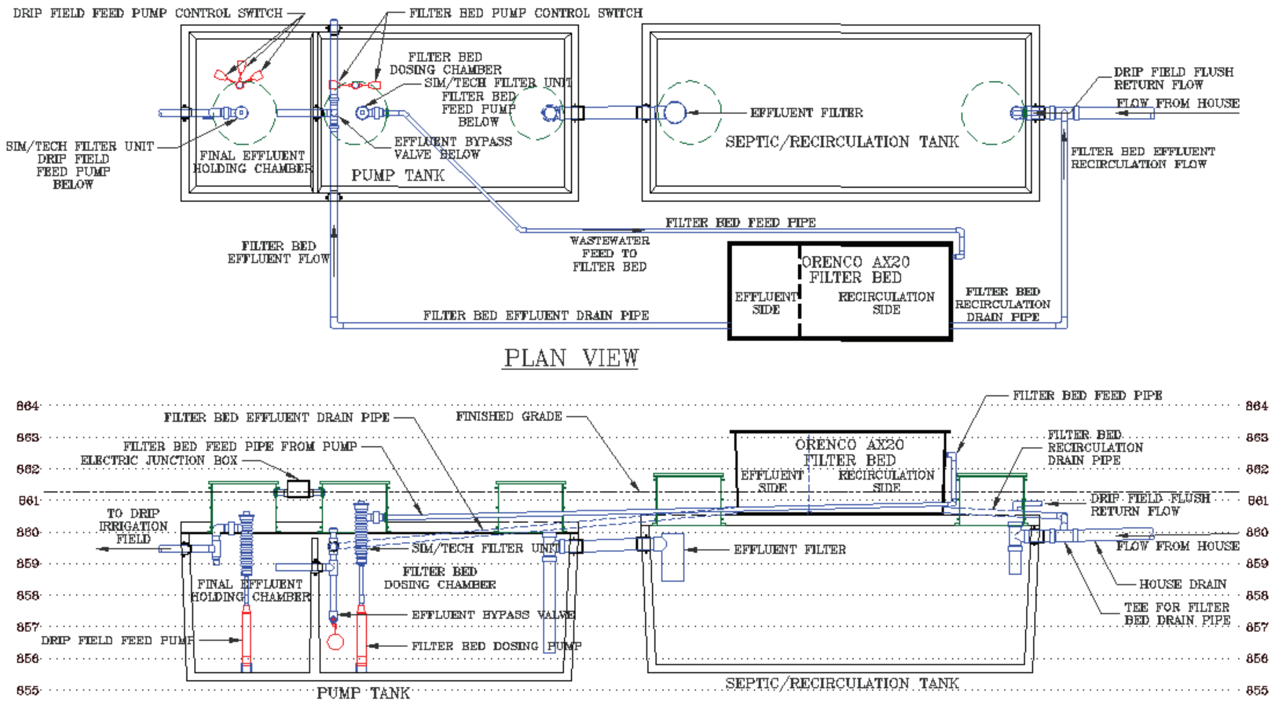

Figure 8. Recirculating Packed-Bed Filter Treatment Unit

The treatment action in an activated sludge treatment unit depends on very few trophic levels of organisms living in concentrations far higher than found anywhere in nature (a trophic level is a rung on the food chain – organisms on a higher trophic level eat organisms on a lower trophic level), thus it is a very truncated ecology that is inherently unstable. The process can only be kept "on track" by maintaining proper operating conditions with constant inputs of energy to aerate the wastewater and by monitoring the process, and pumping out solids (sludge) when needed, to maintain the proper food/microorganism level. In the on-lot environment, as noted, conditions are constantly changing, since flows into the system are episodic, in response to water using activities in the home. Again, due to the nature of the activated sludge technology, this presents a challenge to this technology.

To understand the limits and liabilities of ATUs, one must understand the Texas regulatory environment as it relates to maintenance of OSSFs. The "maintenance" which is required does not entail activities which might "maintain" the system at any given performance level, rather the activities mostly just check operational status of the mechanical components.

One example, although ATU operations and maintenance manuals typically stipulate that a "jar test" (this indicates solids level in the water) be conducted at every maintenance visit to determine if sludge should be removed, this is not routinely done. There is no place to report such an observation on the "official" TCEQ maintenance form. One maintenance contractor related that he does not execute that test, rather his criterion for pumping the system is when sludge starts to become apparent in the effluent pump chamber, a condition that would indicate the system had been "wasting" sludge (solids) into the effluent chamber, thus "failing", for some time. He stated that his criterion results in pumping about every 5 years. (Wheatley, 2008) By contrast, EPA states that sludge removal should be expected on intervals of about "3 – 6 months" in one document (EPA [1], undated) and "8 to 12 month intervals" in another (EPA [2], 2000). EPA also notes, "Wasting is normally accomplished by pumping mixed liquor directly from the aeration tank. Wasting of approximately 75 percent of the aeration tank volume is usually satisfactory." (EPA [2], 2000) This indicates that a significant volume of water (sludge) must be removed from the ATU at least once per year. Nothing close to that ATU maintenance protocol is practiced in Texas.

This highlights that regardless of how diligent a maintenance contractor may be, the Texas rules require only an observation of the ATU once every 4 months, while EPA states, "Inspections every two months are recommended." EPA goes on, "The maintenance process for suspended growth systems is more labor-intensive than for septic systems and requires semi-skilled personnel. Based upon field experience with these units, 12 to 48 man-hours per year plus analytical services are required to ensure reasonable performance." (EPA [2], 2000) The minimal protocol specified by the Texas rules, entailing perhaps 3 – 4 hours per year and which does not require ***any*** measurement of system performance, falls far short of this.

So the ATU is operating "on the edge" even under the best of conditions. This, far more than whether or not the very minimal required maintenance protocol is properly executed, is the reason why studies of ATU's routinely observe a high degree of non-compliance with the "advertised" effluent quality. And when ATU's are "off track", this often creates odors. Since air is being pumped into the wastewater to aerate it, that air has to vent, so any "upset" condition is quite likely to result in odors being detected. And finally, ATUs typically require significantly more energy to operate than would a recirculating packed-bed filter unit, as the "blower" that aerates the water in the ATU runs all the time, while the filter bed dosing pump in the recirculating packed-bed filter unit runs typically less than 5% of the time. Besides imparting greater electricity costs to the system owner, this contributes significantly greater greenhouse gases to the atmosphere, exacerbating climate change.

The recirculating packed-bed filter treatment unit is inherently far more stable and robust than are ATUs. Being a "fixed growth" rather than a "suspended growth" concept – the microbes that impart the treatment effect in the packed-bed filter live attached to the filter bed media, instead of being suspended in the water column, as in the ATU process – the treatment process is inherently more stable just on that basis, as the mean cell residence time is much higher. Also, the basic treatment process does not require any power, as treatment is provided by the microbes as the water flows on by, down through the bed by gravity, with power required only to move water to the top of the filter bed. If power is lost, the microbes sit there, waiting for the water to start flowing again. In the ATU process, if power is lost and aeration of the water ceases, the process degrades in short order. When power is restored, it typically takes some time before the process gets back "on track", while wastewater continues to flow on through, having not been very well treated. There is nothing “in the way”, in contrast to water having to run through the filter bed to get out of a recirculating packed-bed filter unit. And finally there is no routine sludge “wasting” required for the recirculating packed-bed filter process, so that source of effluent “excursions” is absent.

For these reasons, the recirculating packed-bed filter is far more well suited to the on-lot operating environment. It is a process that really can be kept operating well, consistently and reliably producing the expected high effluent quality, with rather minimal routine oversight. Indeed, unlike the ATU, a maintenance effort of only 3-4 hours per years ***is*** a sufficient maintenance and oversight effort.

Figure 9 shows a recirculating packed-bed filter–drip irrigation system retrofit on that same lot as was the LPD retrofit shown in Figure 7. As noted in the next section, while a spray dispersal field might be strictly “legally” permitable on lots of the size that dominate this study area, that would be a very curious choice, fraught with public health issues, so it is presumed the dispersal field would indeed be a subsurface drip irrigation field. As was noted, the drip field could be – “should” be? – located so that it would irrigate the highest value landscaping on the property, to attain the most water conservation benefit. Given that soil depth over the existing drainfield would be at least 12 inches deep, the drip field could even be built over that drainfield, if that were the best location.

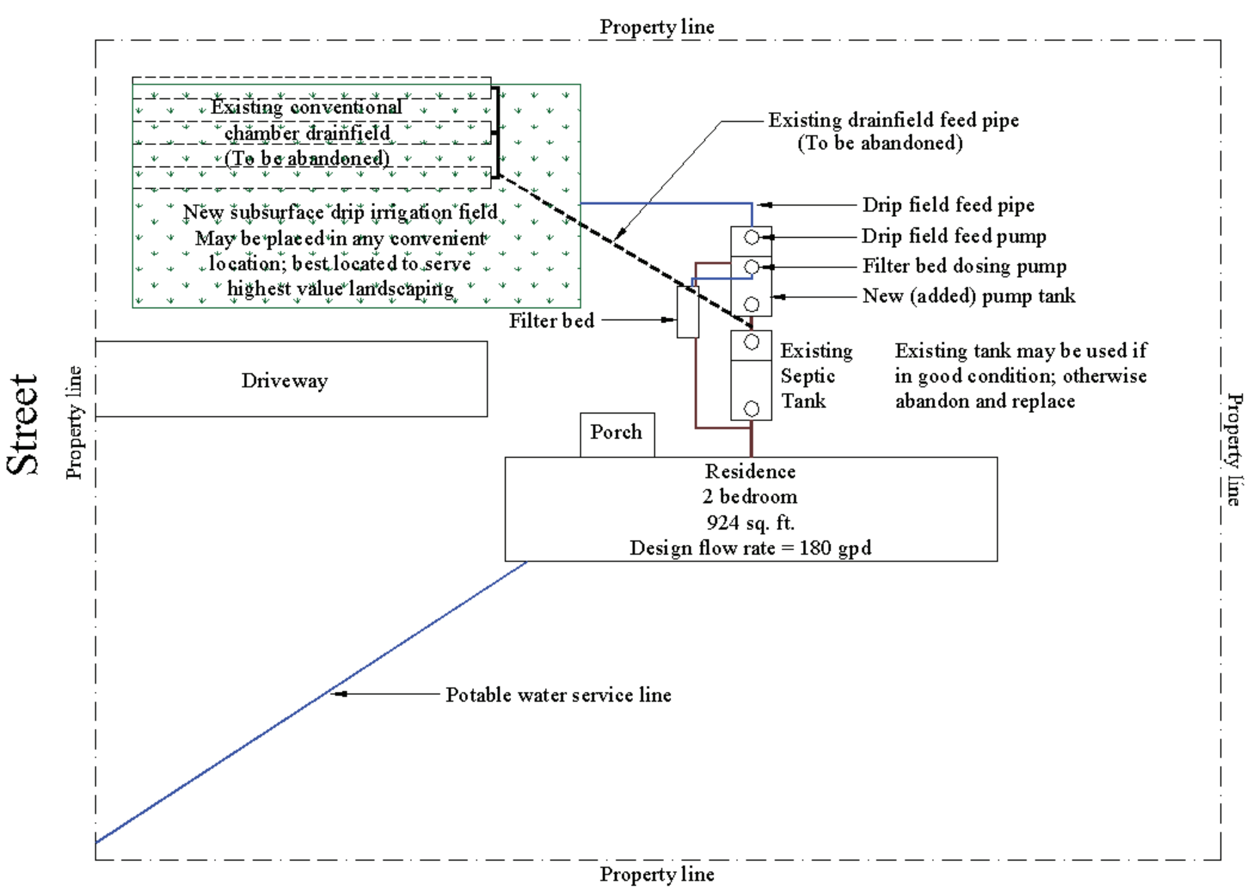

Figure 9. Recirculating Packed-Bed Filter–Drip Irrigation OSSF Retrofit

Based on previous experience, the installed cost of a recirculating packed-bed filter unit and a subsurface drip irrigation field would run in excess of $20,000. Indeed, an ATU-drip field system is likely to also run in that range. So no matter the type of system proposed, this enhanced pretreatment and drip dispersal strategy can only be expected to be pursued on lots with very impoverished soil resources, where a drip field may be the only permitable option.

As this discussion highlights, the cost of retrofitting OSSFs will be a significant barrier to any program that proposes to use retrofits to reduce pollution from OSSFs in the study area. It is certain that there will need to be developed much more evidence that OSSFs are contributing to the pollution than has been observed in Cypress Creek to date for there to be any expectation of broad public support for an OSSF retrofit program. This will be so for any of the strategies aimed at improving or removing OSSFs in the study area, and so this strategy is unlikely to be embraced as the public strategy for pollution reduction, simply due to the costs, unless there is some program to subsidize the costs to the lot owners, justified by an expected reduction in pollution being a public good. But again, identifying OSSFs as the source of any problematic pollution will require a somewhat more robust monitoring program than has been executed to date.

Regulatory barriers to pursuing any broadscale upgrades/replacements of existing OSSFs are essentially the same as would face any program to impose “enhanced” standards for new OSSFs in the study area. Those barriers are reviewed in the following subsection.

“Enhanced” Standards for OSSFs in the Study Area

Any program proposing “enhanced” treatment standards for new OSSFs, whether for the original construction on a lot or to replace an old OSSF, faces one basic barrier. ***The Texas OSSF regulatory system does not recognize treatment failure***, defined as the migration of pollutants through the soil to enter environmental waters at a “remote” location, as illustrated in Figure 3. The only concept of “failure” that rule system, as it actually operates, recognizes is hydraulic failure, the appearance of effluent-derived water on the ground surface in or near the dispersal field. So it is that only OSSFs that are presenting a “nuisance”, the appearance of water on the surface, are required to be remediated. This view will of course have to change before the OSSF regulatory system would provide any support for “enhanced” design standards for determining what sort of OSSF could be installed, based upon the prospects for “lesser” designs to experience treatment failure.

In this study area, another “attitude shift” would need to occur. It was noted that some of the OSSFs installed in this area feature ATU treatment units with surface spray dispersal of the effluent. These are currently approved with minimal requirements for separation of the sprayfield from places where people may be exposed to the spray, or to the drift of aerosols generated by the spray. The statewide rules require a setback of a sprayfield from a property line of only 10 feet. While current rules in Hays County, where this study area is located, have increased the required setback of a spray field from a property line to 20 feet, this is still a cruel joke on a neighborhood with lots as small as those in this study area. Aerosols readily drift 200 feet or more. So as part of any “enhanced” design standards for OSSFs in an area such as this, the banning of spray dispersal would be necessary, for general public health protection. Note that this is so without regard for whether sprayfields would shed pollution, due to washoff of the partially treated water during runoff-inducing storms, which is a concern in regard to pollution of environmental waters.

The sort of OSSF that would be “needed” on any given lot would also depend on the standard of evaluation. For example, the Texas OSSF rule system does not recognize nitrogen as a pollutant that should be controlled, even though in some watersheds – e.g., the Barton Springs watershed in and around Austin – this is a critical pollutant. (USGS, 2011) The concerns about water quality in Cypress Creek due to conditions in this study area have not noted nitrogen as a pollutant of concern, so again in order to evaluate any “enhanced” OSSF design standards, the nature and severity of pollutants that may be issuing from this area needs to be much more thoroughly evaluated.

As has also been noted, a more critical eye by the regulatory system on the soils evaluations may be required. The soil evaluators are motivated to show the soil conditions in the “best light” so that the least expensive conventional septic tank-gravity trench OSSF could be approved. If the soils were evaluated more critically, this may dictate the use of “enhanced” OSSFs as a matter of course. For example, requiring an LPD system instead of a gravity trench system, as it appears may have been indicated on the lot with the soils illustrated in Figure 6.

In any case, a review of soil treatment mechanisms (e.g., Venhuizen, 1995) provides a basis for considering “enhanced” standards for new OSSFs that may stem pollution that may derive from OSSFs. A thorough review of soil treatment mechanisms for a range of pollutants that may be of concern is beyond the scope of this study, but is something that must be undertaken by the OSSF regulatory system if it were to consider the imposition of “enhanced” OSSF design standards. To briefly review the matter, there are two basic strategies that may be employed to provide more environmentally sound management where soil resources are limited:

1. Provide better pretreatment than is afforded by a septic tank before the effluent is routed to the soil dispersal system. The recirculating packed-bed filter–drip irrigation system, illustrated as a possible retrofit in Figure 9, is an example of this strategy.
2. Use dispersal methods which maximize the treatment capabilities of whatever soil resources are available. All soil treatment mechanisms are enhanced by practicing shallow dispersal, using a dose-rest loading cycle, and by applying the wastewater at lower areal loading rates. The most basic example of this can be appreciated by contrasting the LPD system with the conventional gravity trench dispersal field, as illustrated in Figure 4 and Figure 5. And of course, the shallow drip irrigation field loaded at “irrigation rates” is the ultimate application of these principles.

In sum, the OSSF regulatory system can choose to require “enhanced” OSSF designs by recognizing treatment failures, by banning sprayfields, by requiring various pollutants to be more explicitly considered, and by being more “strict” in regard to soils evaluations. But as noted previously, requiring the “enhanced” OSSF designs would have fiscal implications for the lot owners, so unless some program were created to provide public subsidies to implement the “enhanced” designs, the OSSF regulatory system would have to demonstrate a public purpose for being more “strict”; that is, to develop a far stronger case that treatment failures of the OSSFs in this study area are a “significant” contributor to pollution of environmental waters in and around this area. But first, as noted, the regulatory system would have to chose to recognize treatment failure as a cause of action.

Collective Systems with Pretreatment and Drip Irrigation Dispersal

If it were determined that the pollution issuing from the study area is of sufficient severity that a program of broadscale OSSF upgrades is needed to blunt that pollution, then it would very likely be more cost efficient to install collective systems rather than to upgrade individual OSSFs one at a time. A collective system would render a design featuring enhanced pretreatment and subsurface drip irrigation dispersal a more "affordable" option. Collective systems are also more likely to be deemed to merit some public subsidy, which would make the system more fiscally reasonable for the individual lot owners.

As was noted previously, dispersing the treated effluent in subsurface drip irrigation fields can provide a water conservation benefit. To the extent that the drip fields could be arrayed to serve landscaping that would be irrigated in any case, reusing the "waste" water for that irrigation would defray demands on the potable water supply system, pretty much gallon for gallon through the peak irrigation season.

During periods of low ET potential – e.g., during rainy periods and through the winter – the drip field would function as a "drainfield", but one that would provide superior treatment to any water that does percolate "away" rather than being lost via ET. Since every building in the study area already has a drainfield of some type associated with it, this collective strategy only improves the situation, providing higher quality treatment, higher quality dispersal, and collective system management to assure that neither treatment failures nor hydraulic failures would be allowed to develop.

A collective system could be implemented at "small scale" – a few lots gathered into each separate system – or at "large scale" – larger neighborhoods, or perhaps an entire drainage basin, gathered into one system. The larger scale the system, the more of the total investment that must be dedicated to the collection system, to get flow from the buildings to the treatment unit, and to the redistribution system, to get the treated effluent back to drip irrigation fields, on the lots or otherwise distributed over areas where the reclaimed water would best serve irrigation demands. Because these lines do nothing but move the water around, really contributing nothing to resolution of the basic "waste" water management issues, it is expected that the "small scale" strategy would be the more cost efficient strategy. Beyond a capacity of a thousand gallons per day or so, the cost of the treatment unit per gallon/day of design flow rate would not change very much with increasing scale, so there is not much cost penalty to installing more distributed treatment units rather than fewer larger scale units. So the "small scale" strategy, minimizing investment in the collection and distribution lines, is expected to have a lower cost per building served.

A "small scale" treatment unit, utilizing a variant of the recirculating packed-bed filter system called the high performance biofiltration concept, is illustrated in Figure 10. As noted, the treatment unit as shown would have a treatment capacity of 1,000 gpd, which using the statutory design flow rate criterion specified for OSSFs would accommodate six 2-bedroom houses or four 3-bedroom houses. Actual "waste" water flows generated by houses are typically lower than those statutory design flow rates, so the actual number of houses that might be accommodated may be higher.

With the same tankage illustrated in Figure 10, a filter bed unit could be added to this system to increase the design flow rate of the treatment unit to 1,500 gpd, which based upon the statutory design flow rate criteria would accommodate eight 2-bedroom houses or six 3-bedroom houses, or the equivalent flows from commercial buildings or multi-family housing. A modest increase in the tank sizes would allow a fourth filter bed to be added, to increase the treatment unit capacity to 2,000 gpd, allowing it to accommodate larger flow generators or allowing this treatment unit to serve more houses, up to eleven 2-bedroom houses or up to eight 3-bedroom houses, again presuming the statutory design flow rate criteria are applied. Since each of these increases in capacity would incur relatively little increased cost, it is to be expected that the per house cost of larger capacity systems would be lower than is reviewed below.

The small scale collective system strategy is illustrated in Figure 11, showing how it might be arrayed to best serve multiple house lots. Each house would retain its primary septic tank to provide the first stage of treatment under the high performance biofiltration concept. If the existing septic tank were to be found to be damaged, it would have to be replaced as part of the collective system installation. A cleanout/breather unit installed on the outlet of each primary septic tank would transition to a 2-inch effluent sewer line, which would transport the wastewater to the collective treatment unit.

The aim would be to locate the treatment unit relative to the lots it serves so that gravity flow from the primary septic tanks to the treatment unit would be imparted. The treatment unit and the lines to and from the treatment unit would be contained in easements, so that access for maintenance would be assured. A dedicated electric service drop would be provided at the treatment unit location.

A rough cost estimate for the treatment unit materials is $22,000. Assuming the installed cost of the treatment unit would be twice that yields an installed cost estimate of $44,000 for the 1,000 gpd treatment unit. Assuming the installed cost is 3 times the materials costs yields an installed cost estimate of $66,000. A cost of $3,000 is estimated for the electric service drop.

A cost estimate for the pipelines, the effluent sewers running to the treatment unit and the drip field feed pipe running from the treatment unit, is $12,000 for the layout shown. This presumes that there would be no insurmountable barriers to running the lines generally as shown.

A rough cost estimate for the drip field materials is $700 per lot. Assuming the installed cost of the drip field would be 3 times the materials costs, the installed cost per lot would be $2,100, yielding a total installed cost for the 6 drip fields in Figure 11 of $12,600. That is rounded up to $13,000. If it is presumed the installed cost would be 4 times the materials cost, the cost per lot would be $2,800, so the total installed cost for the 6 lots would be $16,800, rounded up to $17,000.

Altogether the estimated installed cost of the small-scale collective system shown in Figure 11 would be $72,000 – $98,000, depending on the level of installation costs. With there being 6 houses served by that system, the cost per house would be $12,000 – $16,333, significantly below the minimum expected cost of a single home system providing enhanced pretreatment and subsurface drip irrigation dispersal, but still a considerable investment. Indicating once again that to justify such an expense would require a much more rigorous showing that pollution impacts in the area’s environmental waters are due to OSSFs in this study area.

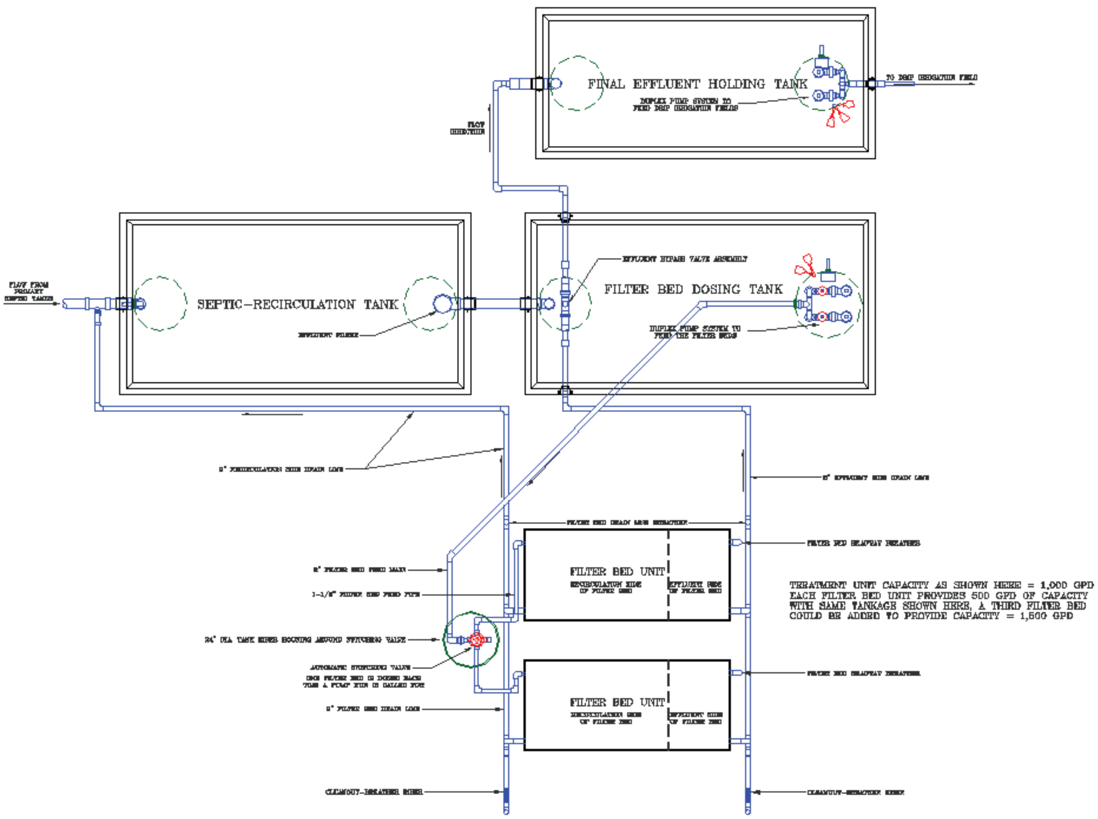

Figure 10. Collective System Treatment Unit

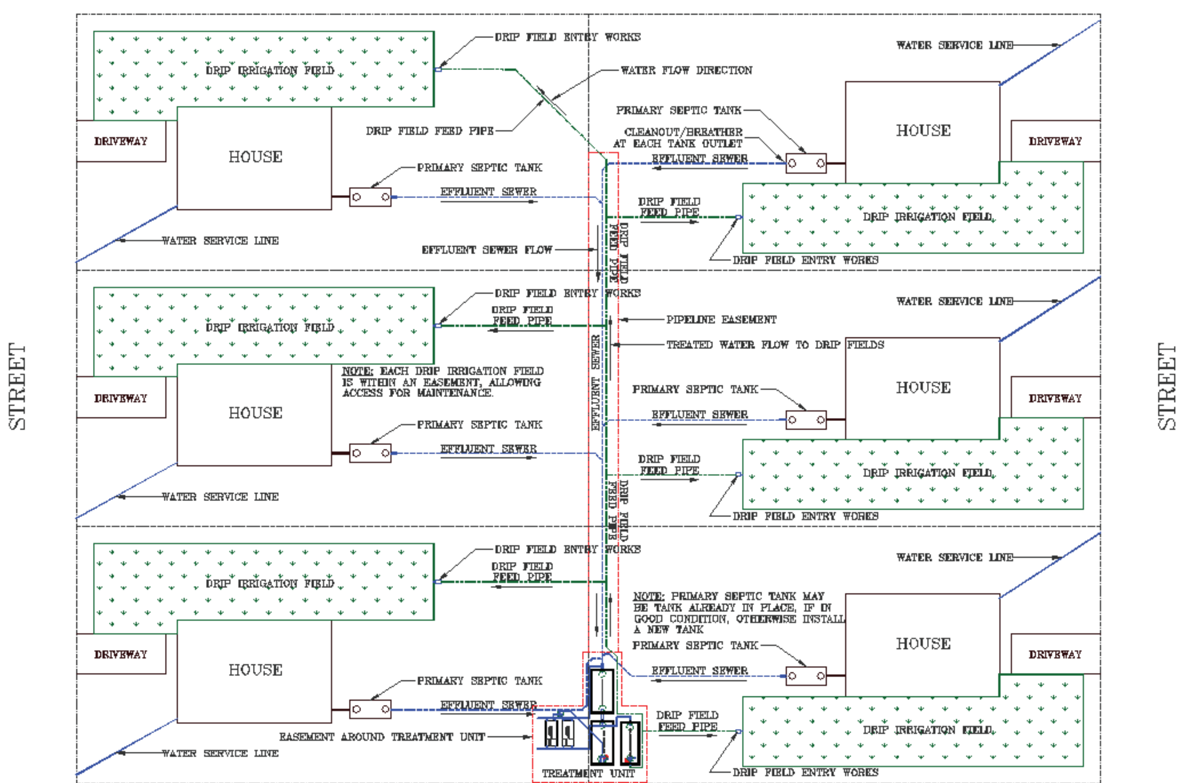

Figure 11. Small-Scale Collective Collection, Treatment & Dispersal System

Connect the Study Area to the Sewer System that Currently Serves Nearby Areas

The City of Wimberley holds a sewer Certificate of Convenience and Necessity (CCN) and has installed a sewerage collection system that collects wastewater from areas of the city south of Cypress Creek. This wastewater flows to a lift station that pumps the wastewater to another lift station owned by Aqua America/Aqua Texas (Aqua) to the north of Cypress Creek, which delivers this wastewater to a treatment plant owned by Aqua. Aqua holds a CCN for parts of Wimberley on the north side of Cypress Creek and for Woodcreek. The area under study here is outside the CCNs of both Wimberley and Aqua. Therefore, a first order of business in order to sewer the study area and deliver that wastewater to the Aqua treatment plant would be to extend one of the existing CCNs to cover this study area.

It would be a matter of the local politics whether the City of Wimberley would extend its CCN and would deliver the wastewater to the Aqua treatment plant under arrangements similar to those for the area it currently has sewered, running the wastewater to current tie-in point, or if Aqua would extend its CCN and directly serve this study area, no doubt by running the wastewater from the study area to the existing tie-in point in the same manner. In either case, this process would entail an application process, the cost of which is estimated to be on the order of $5,000 if the process is uncontested. A contested case for a new CCN or CCN extension might run about $20,000.

It would also be a political decision what portion(s) of the study area would be conventionally sewered. As that matter is opaque at present, here the approach is to consider sewering the whole area, done on a rather "cursory" level as little information is available to detail this process. Since the costs would be spread over fewer properties if only part of the area were sewered, it is presumed that the costs derived below would only be higher under that scenario.

Sewer lines generally run in the street R.O.W. The measured total length of street in the study area is 16,340 l.f. It is roughly estimated that the run of sewer line needed to access all properties would be 80% of the total street length, a distance of about 13,000 l.f. Given the topography of the area, it is guessed that the sewer lines would run to two lift stations, which would pump the wastewater to the Aqua system tie-in point, similarly to the manner in which wastewater from areas of the city south of Cypress Creek are delivered. So the total sewer system for the study area would include 13,000 l.f. of collection lines with manholes – it is roughly estimated that 25 manholes would be required – the 2 lift stations, and the force mains from the lift stations to the tie in point. An estimate of the run of force mains is 3,100 l.f., presuming that the existing force main running along RR 12 into the Aqua lift station can be tapped into, so would not have to be duplicated.

Additionally, service connections would need to be installed for each building. The total number of buildings that would require sewer service in the study area is estimated to be 103, based on that being the number of parcels denoted by parcel number on the Central Appraisal District property map of this area.

Cost estimates for these facilities are drawn from the prices incurred by the City of Wimberley for sewering the area south of Cypress Creek, and for the force main to the Aqua system tie-in point.

The estimates drawn from that listing include:

- $1,800 for a sanitary sewer connection from the building.
- $90/l.f. for sewer lines, including excavation, bedding, backfill and trench shoring.
- $3,800 for a manhole.
- $150,000 for a "small" lift station, appropriate for the study area.
- $80/l.f. for force main.

Based on these estimates, costs for conventionally sewering the study area are as follows:

- 103 parcels x $1,800 = $185,400 for building connections to the sewer lines.
- 13,000 l.f. x $90/l.f. = $1,170,000 for sewer lines.
- 25 x $3,800 = $95,000 for sewer manholes.
- 2 x $150,000 = $300,000 for lift stations.
- 3,100 l.f. x $80/l.f. = $248,000 for force main.

Totaling these costs, this "cursory" estimate for the installed cost of a conventional sewer system to provide wastewater service to the study area is $1,998,400. Adding in an uncontested CCN brings the total cost to $2,003,400. This yields an average cost per property parcel of about $19,450. This is in excess of the estimated cost for individual OSSF replacements assuming LPD systems, and in excess of the estimated cost of small-scale collective systems employing enhanced pretreatment and subsurface drip irrigation dispersal. It is below the estimated cost for an individual OSSF replacement employing enhanced pretreatment and drip irrigation.

Note however that conventional sewering would be an all-or-none proposition at the cost estimated here. Again, it may be that only portions of the study area considered to be problematic could be sewered, but it is beyond the capacity of this study to parse out those areas and estimate the costs only for those areas. The conclusion here, therefore, is that it would be relatively costly to attempt to resolve whatever pollution is being created by OSSFs in the study area by sewering up the area.

Note also that the conventional sewering option would preclude attaining water conservation by reusing the water to defray irrigation demands within the study area. Going to the Aqua system, it is purported that some reuse value is attained through the irrigation of a golf course in Woodcreek. The actual value of that to the local and regional water economy rests on the evaluation of whether this irrigation operation actually defrays potable water demands that would have been incurred for this irrigation in any case, or if this is essentially "make work" dispersal of the reclaimed water.

It is important to understand that, while sewering this area would in theory eliminate pollution in area waters deriving from wastewater systems, conventional sewers leak, with the leakage rate becoming greater as the sewers age, manholes may overflow, and lift stations fail, also creating overflows. So the conventional sewering option carries no guarantees that it would be more effective at blunting pollution than would installing systems that disperse effluent into the soil, if those systems were to be designed to better cope with the soil conditions in this study area.

10 “Soft” Cost of the Options

No regulatory obstacles, other than creating/extending a CCN over this area, can be identified for the sewering option. That cost was accounted for in the estimate for that option. Other engineering costs for the sewer system design and installation are not included in the estimate above. A typical estimate of all such “soft” costs for such a project – including surveying, design engineering, project bidding, and construction observation – is about 15% of the total “hard” costs. Using that estimate, the “soft” costs of the conventional sewering option would be about $2,900 per property.

Such “soft” costs associated with the other options examined in this report were also not considered in estimating their total installed costs. While the total fees for other options would be lower due to the smaller scale of those installations, the number of properties over which they would be spread would be smaller as well. It is roughly estimated that $2,900 per property would cover the “soft” costs for an LPD replacement OSSF – for design and permitting – but the individual lot pretreatment and drip dispersal option, which due to the more detailed design would run more, likely toward $4,000, including the permit fee. In each case, however, if a publicly sponsored program lined up a number of design and permitting processes that would be run concurrently, those costs should be expected to be lower, as several very similar designs could be done “as a piece” and the systems permitted more cost efficiently.

The manner in which small-scale collective systems would be permitted is open to question. Currently such systems, defined as “cluster” systems – collectively serving buildings located on separate fee simple lots – are outlawed under Chapter 285, which governs permitting of OSSFs. This prohibition, set forth in a 2003 revision of Chapter 285, was asserted to be required because TCEQ did not consider the local operating authorities to be equal to the task of assuring that all the owners of properties served by a “cluster” system could be compelled to fiscally participate in the collective O&M, or to assure that proper O&M would consistently be conducted. It is posed that if such systems were to be implemented under a municipal authority, adequate institutional resources to cover these activities could be assured. This may offer an opportunity to “carve out” a niche for permitting such small-scale collective systems by Hays County under Chapter 285, rather than having to obtain a “municipal” permit directly from TCEQ. If so, the design and permitting costs per house for such a system may be quite reasonable, perhaps less than $1,000 per house.

That proposition remains to be tested, however. If instead small-scale collective systems were to be subjected to the much more costly and onerous “municipal” permitting process, permitting costs would depend greatly on whether TCEQ would deem each such system to need an individual permit, or if a number of them could be permitted as a group, under a “general permit”, given that they would all be permitted by the same municipal authority – likely the City of Wimberley in this case – and a unified O&M scheme would cover them all. If the former, permitting costs would skyrocket to likely well over $10,000 per system. In the case of the 6-home system illustrated above, that would impart a permitting cost of at least about $1,700 per house. Adding on design and construction observation fees, this option would most certainly have a “soft” cost somewhat exceeding $2,900.

11 Monthly Wastewater Service Fees

Aqua informs that the monthly service fee for residential and "small" commercial connections is about $90 per month. "Large" commercial connections would be based on their water meter size. Given the nature of the development in the study area, it is expected that $90/month is an appropriate estimate for service fees under the conventional sewerage option.

For an OSSF upgrade with an LPD system, no monthly service fee would be incurred, as no maintenance contract would be required. The only O&M costs would be periodic pumping and pump replacement, each to be expected at multi-year intervals, and the electricity to run the pump. The average monthly cost of those services would be rather negligible, less than $15/month, assuming the tanks are pumped every 3 years and the pump is replaced every 5 years. These intervals are more frequent than is commonly found to be needed, so the actual O&M costs, thus the effective wastewater "service fee" for this option is likely to be no more than $10/month.

A maintenance contract, required for an OSSF that entails enhanced pretreatment and subsurface drip dispersal, is expected to cost in the neighborhood of $500 per year, or about $42/month. The electricity cost to run the pumps would be only a few dollars per month. Tank pumping at 3-year intervals would incur an amortized cost of around $5/month, and pump replacement at 5-year intervals would incur an amortized cost of around $8/month. The total effective wastewater "service fee" for this option is therefore likely to be less than $60/month. Again, those presumed tank pumping and pump replacement intervals are lower than have been typically encountered, so the actual effective fee is expected to be less than $50/month.

For the small-scale collective option, it is to be expected that a maintenance fee on the order of $1,200 per year might be incurred, or about $100/month. Depending on the manner in which such systems are permitted, this might be embodied as an OSSF maintenance contract or as a municipal fee. In the example small-scale collective system shown in Figure 11, 6 houses would be served. This would result in an average monthly fee of about $17 per house per month. Amortized tank pumping costs, again assuming 3-year intervals, would run about $7/month, including both the primary tanks at each house and the treatment center tanks. Amortized pump replacement cost in the treatment unit, presuming 5-year intervals, would run about $20/month. Electricity costs to run the pumps, both to dose water onto the filter beds and to run the reclaimed water into the drip irrigation fields, would be less than $10/month, or less than $2/month/house. Altogether, the effective wastewater "service fee" would be about $45/month/house. Again, with the actual tank pumping and pump replacement intervals likely to be longer than presumed here, that amount is likely to be lower.

These estimates indicate that the conventional sewering option would incur average monthly service fees somewhat greater than the other options. On-going costs of OSSF replacements with an LPD system would incur a small fraction of the conventional sewer service fee, and the options entailing enhanced pretreatment and drip dispersal would incur on-going costs of about ½ or less of the conventional sewer service fee.

12 Summary

The cost estimates for system installation, design and construction observations fees (the "soft" costs), and on-going O&M for each of the options reviewed in this report are shown in Table 3.

Table 3. Cost Comparison of Wastewater Management Options

WASTEWATER MANAGEMENT OPTION	INSTALLED COST PER HOUSE	"SOFT" COST PER HOUSE	O&M COST PER HOUSE/ MONTH
LPD OSSF replacement	$10-18,000	$2,900	$10
Pretreatment/drip OSSF replacement	>$20,000	$4,000	$50
Small-scale collective system	$12-16,000	$3,000+*	$45
Conventional sewerage	$19,450	$2,900	$90

*Depends on how this option may be permitted.

At the level of analysis afforded by this study, the small-scale collective system strategy appears as if it would be the most cost efficient approach for any broadscale OSSF upgrading/replacement program. This would be especially so if only selected parts of the study area were deemed to be in need of OSSF upgrades. For a program of spotted individual OSSF replacements, it appears that the LPD replacement system would likely be the lowest cost approach. The value of this in terms of stemming pollution, however, may depend on whether nitrogen were deemed to be a pollutant of concern in this watershed. It appears that conventional sewerage of this area would be "unaffordable". OSSF replacements employing enhanced pretreatment and subsurface drip irrigation dispersal, being the most expensive strategy, would only be justified for individual replacements on lots with rather impoverished soil resources.

In terms of regulatory issues, as noted the OSSF regulatory system would have be "reformed" in regard to recognizing treatment failure, perhaps including nitrogen impacts, banning sprayfields, and more strictly applying the standards for soils evaluations in order for it to "reasonably" rule that any existing OSSFs "should" be replaced, other than any in which effluent may be surfacing over the drainfield area. For the small-scale collective system strategy, the permitting path needs to be clarified in order to define the actual permitting costs. For the conventional sewerage option, covering this study area with a CCN appears to be the only regulatory issue outside the normal permitting process, which may draw protests due to the cost of sewering, unless some publicly-funded program is created to largely cover those costs.

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