Introduction

Wastewater collection, treatment and disposal options were investigated for Alternatives #9 and #10 for Act 537 Plan descriptions. Alternative #9 involves extending sewer service to Indian Creek Drainage Basin by transporting, processing and disposing of wastewater effluent from the St. Peters Road Area (PSA-7) with a capacity of 36,000 gpd. Alternative #10 involves extending sewer service to the Hosensack Creek Drainage Basin by transporting, processing and disposing of wastewater effluent from the Churchview Road Area (PSA-8) with a capacity of 17,000 gpd and from the Old Zionsville Area (PSA-9) with a capacity of 32,000 gpd.

We have investigated wastewater treatment options for each alternative:

- For *best treatment quality*, we recommend biological membrane filtration for Alternatives #9 and #10.
- For most *cost-effective treatment*, we recommend sequencing batch reactors for Alternatives #9 and #10.

Septic systems were considered but for the reasons discussed below, not the recommended option.

Collection System

Gravity Sewers

Details regarding the design and cost estimate of gravity sewers cannot be determined because no site layout and topography are available. It will be assumed for the cost estimate that the collection system will require one central pump station. The cost of gravity sewers will not be included in the estimate.

Central Pump Station

If the gravity sewer design for either alternative necessitates a central pump station, a standard pump station will be designed. The pump station would include a new duplex submersible grinder pump system inside a fiberglass wet well. Each pump will have the capability of handling the expected peak flows. The wet well will contain a trash basket over the influent gravity sewer to intercept most of the larger objects entering the wet well. A new electrical/alarm panel will also be provided on site. Both the pumps and the trash basket can be easily removed from above grade to perform repairs, eliminating the need to enter a confined space environment. A yard hydrant, a backflow preventer, and a portable gasoline generator will be necessary. Local regulations may affect details of the pump station including the grinder and the trash basket. For conceptual pump station sizing, a peaking factor of 2.5 was applied to each alternatives average daily flow with the pump running for the entire day (1,440 minutes).

Alternative #9 – The total peak sewage flow anticipated for the central pump station from the St. Peters Road area (PSA-7) is approximately 90,000 gallons per day (gpd) or 63 gallons per minute (gpm).

Alternative #10 – The total peak sewage flow anticipated for the central pump station from the Churchview Road Area (PSA-8) is approximately 42,500 gpd or 30 gpm. The total peak sewage flow anticipated for the central pump station from the Old Zionsville Area (PSA-9) is approximately 80,000 gpd or 56 gpm.

Wastewater Treatment Alternatives

Conventional Large Septic System

A conventional septic system is used in areas without centralized wastewater treatment. A septic system typically has prefabricated or concrete cast-in-place tanks that serve as a combined settling and skimming tank, as an unheated unmixed anaerobic digester, and as a sludge storage tank. A soil absorption system that incorporates gravel and disposal trenches follows the sludge storage tank. The soil and gravel perform final effluent treatment. Obviously, the septic bed would have to be designed to achieve the additional effluent treatment. Depending on the local guidelines, modeling may need to be performed to demonstrate that the PADEP DGW standards are met.

Septic System Effluent Characteristics

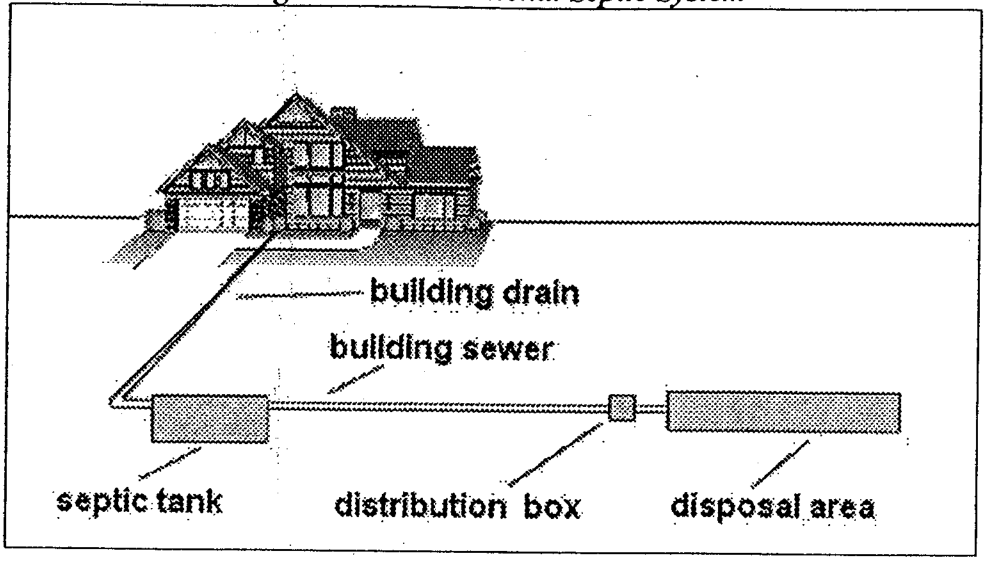
Constituent	Influent Concentration (mg/L)	Effluent Concentration (mg/L)	PA Discharge to Groundwater Regulations (mg/L)
Biochemical Oxygen Demand (BOD_5)	115-200	120-240	25
Total Suspended Solids (TSS)	35-75	65-180	30
Total Nitrogen	6-17	--	10 (1)

Notes –

(1) Total nitrogen regulation is dependent on location.

Figure 1, provides a conceptual representation of a typical septic system layout.

Figure 1 – Conventional Septic System



Subsurface Trickling Filters

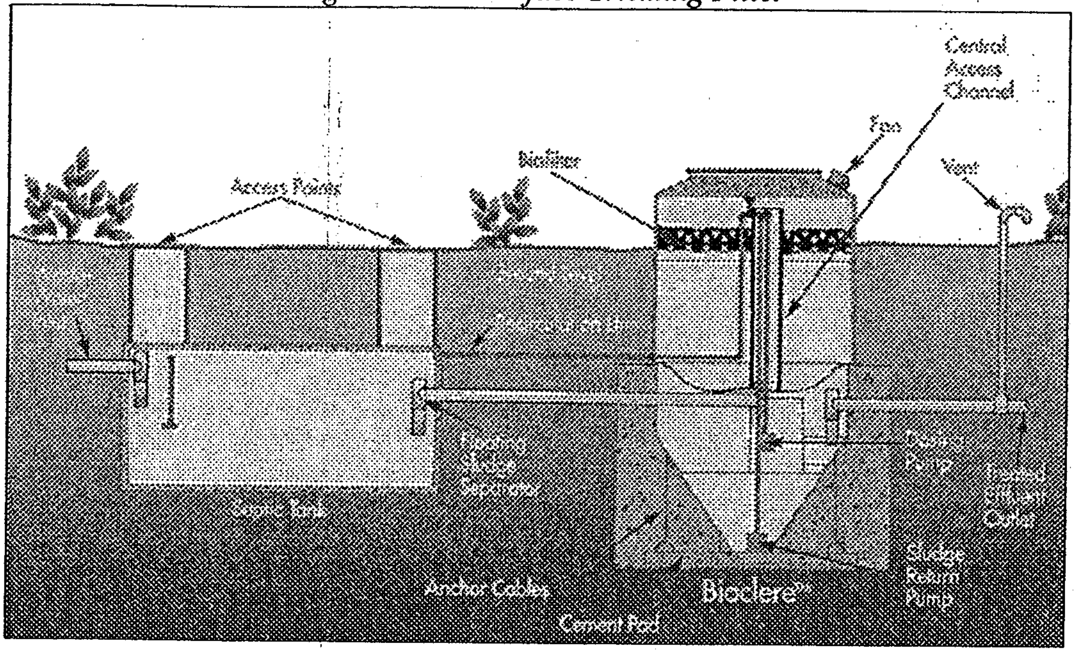
The subsurface trickling filter is a treatment technology that utilizes the well-established trickling filter process (attached growth) but is installed underground. Attached-growth biological treatment processes are often used to remove organic matter found in wastewater and to achieve nitrification. These systems include rotating biological contactors, trickling filters and others. Tricking filters are a form of attached growth wastewater treatment. In a trickling filter, a common practice is for a rotary distributor to evenly apply wastewater over a tower containing plastic media. The wastewater flows or trickles through the numerous crevices and voids within the packing media where it is brought into contact with an established biomass attached to the media. The trickling of wastewater through the media both aerates the wastewater and brings it into contact with the biomass in the wastewater. Secondary sludges are typically returned to the primary tank and clarified wastewater is displaced in the disposal area. Units can be installed in parallel for larger flows or higher levels of treatment. Figure 2 provides a representation of a subsurface trickling filter. Based on published performance, this system is capable of meeting the PADEP DGW standards at the effluent pipe, thereby alleviating the need to have the bed perform additional removal.

Subsurface Trickling Filters Effluent Characteristics

Constituent	**Influent Concentration (mg/L)**	**Effluent Concentration (mg/L)**	**PA Discharge to Groundwater Regulations (mg/L)**
Biochemical Oxygen Demand (BOD_5)	400	13	25
Total Suspended Solids (TSS)	250	17	30

Total Nitrogen	50	<10	10 (1)

Figure 2 – Subsurface Trickling Filter



Sequencing Batch Reactors

The sequencing batch reactor (SBR) process is a sequential suspended growth (activated sludge) process in which all of the treatment steps occur in one tank. SBRs can be designed and operated to enhance removal of nitrogen, phosphorus, and ammonia, in addition to removing TSS and BOD. There are two major classifications of SBRs: the intermittent flow and the continuous flow system. In the intermittent flow style, two tanks are used and one tank is filled then closed when it goes through the five-step process. The other tank fills while the first is undergoing the treatment process. In the continuous flow system, one tank can be used because influent flows continuously during all phases of the treatment process. The five-step process includes:

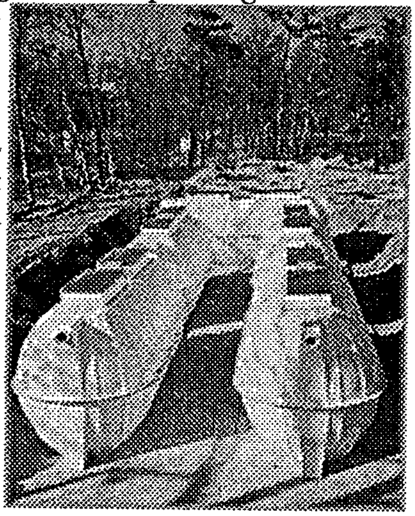
- Filling the tank
- Reaction with aeration and mixing
- Settling
- Draw (decant)
- Idle

Figure 3 is a picture of a typical SBR installation. Based on published performance, this system is capable of meeting PADEP DGW standards at the effluent pipe, thereby, alleviating the need for the disposal bed to provide any additional removal.

Sequencing Batch Reactor Effluent Characteristics

Constituent	**Influent Concentration (mg/L)**	**Effluent Concentration (mg/L)**	**PA Discharge to Groundwater Regulations (mg/L)**
Biochemical Oxygen Demand (BOD_5)	400	12	25
Total Suspended Solids (TSS)	250	26	30
Total Nitrogen	50	4.71	10 (1)

Figure 3 – Sequencing Batch Reactor



Fixed Activated Sludge Treatment

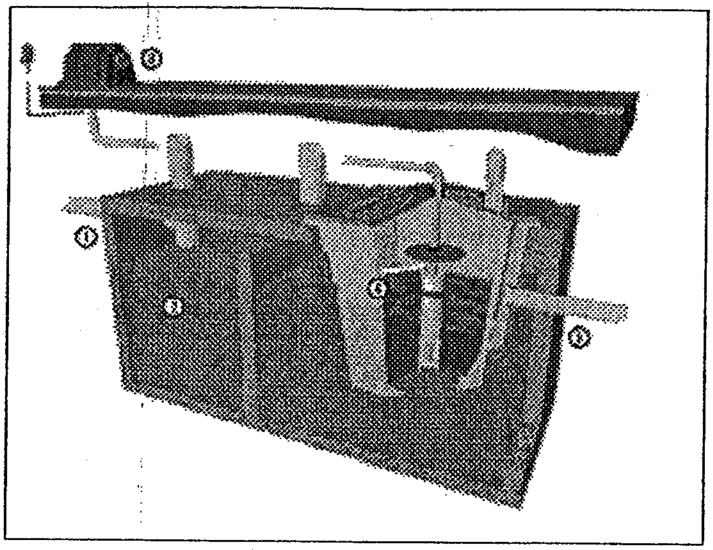
Fixed Activated Sludge Treatment (FAST) wastewater treatment systems can process wastewater from single-family homes, clusters of homes, small communities or even the high strength wastes from restaurants or commercial facilities. FAST is a fixed film, aerated system utilizing a combination of attached and suspended growth, capable of nitrification (the oxidation of ammonia compounds to nitrates) and denitrification (the transformation of nitrates to nitrogen gas) in a single tank. This combination includes the stability of fixed film media and the effectiveness of proven activated sludge treatment, making FAST an effective system.

Separation and settling processes occur in the first compartment of the underground tank which eliminates the need for a separate settling tank. A remote blower (the system's only moving part) delivers volumes of air containing oxygen into the heart of the system. The blower creates an oxygenated environment that stimulates the aerobic bacteria and is an important function of this system. Figure 4 presents a conceptual diagram of the FAST system. Based upon published performance, the FAST system is capable of meeting the PADEP DGW standards at the effluent pipe, thereby, alleviating the need for the disposal bed to provide further treatment.

Fixed Activated Sludge Effluent Characteristics

Constituent	**Influent Concentration (mg/L)**	**Effluent Concentration (mg/L)**	**PA Discharge to Groundwater Regulations (mg/L)**
Biochemical Oxygen Demand (BOD$_5$)	400	≤ 10	25
Total Suspended Solids (TSS)	250	≤ 10	30
Total Nitrogen	50	≤ 10	10 (1)

Figure 4 – Fixed Activated Sludge Treatment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Biological Membrane Filtration

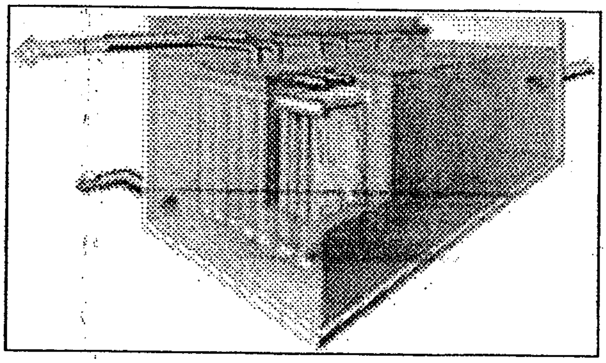
Biological membrane filtration is an advanced form of wastewater treatment that combines the activated sludge process with a submersed microfiltration or ultrafiltration membrane unit to provide superior effluent quality with lower capital, operations and maintenance costs. This system has been widely used to treat wastewater streams generated from small, medium and large housing developments across the country.

An ultrafiltration membrane has a nominal pore size of 0.02 µm and is designed to remove suspended solids, protozoa, bacteria and viruses from wastewater. (A microfiltration membrane has a nominal pore size of 0.4 µm.) The filter membrane effectively replaces the secondary clarifier found in conventional wastewater treatment plants. Eliminating the need for a secondary clarifier significantly reduces both construction costs and the area needed for the plant, allowing the developer to utilize valuable land in a more preferred manner (i.e. leave trees as a buffer between treatment plant and adjacent roads and properties for aesthetic reasons). Figure 5 presents a conceptual diagram of a typical biological membrane filtration treatment plant. Based upon published performance, this system is capable of meeting PADEP DGW standards at the effluent pipe, thereby, alleviating the need for the disposal bed to provide further treatment. Because the treatment levels typically achieved by this system are of such high quality it has been used to provide reusable effluent for a variety of applications (spray irrigation, toilet water, etc.)

Biological Membrane Filtration Effluent Characteristics

Constituent	Influent Concentration (mg/L)	Effluent Concentration (mg/L)	PA Discharge to Groundwater Regulations (mg/L)
Biochemical Oxygen Demand (BOD_5)	400	≤ 10	25
Total Suspended Solids (TSS)	250	≤ 10	30
Total Nitrogen	50	≤ 5	10 (1)

Figure 5 – Biological Membrane Filtration



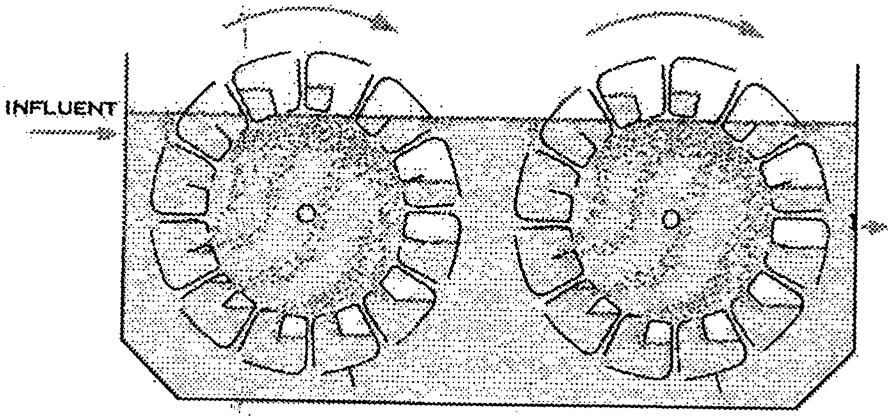
Combination Activated Sludge and Rotating Biological Contactor (RBC)

This system is a combination of attached growth and suspended growth that uses both methods through a mechanical drive system. It functions by changing the speed of rotation of the RBC-like unit for varying oxygen requirements. Rather than being a solely RBC system, air is captured on the downward cycle of the unit pressurizing the air. This air is released at the bottom of the cycle in fine bubbles that replicate an aerator in the activated sludge process. A tertiary filter (cloth or other) is necessary at the end of the process to achieve the solids performance identified in the table below. Figure 6 provides a conceptual process diagram of the main treatment train.

Combination Activated Sludge and Rotating Biological Contactor Effluent Characteristics

Constituent	**Influent Concentration (mg/L)**	**Effluent Concentration (mg/L)**	**PA Discharge to Groundwater Regulations (mg/L)**
Biochemical Oxygen Demand (BOD_5)	400	≤ 10	25
Total Suspended Solids (TSS)	250	≤ 5	30
Total Nitrogen	50	≤ 10	10 (1)

Figure 6 – Combination Activated Sludge and Rotating Biological Contactor



Groundwater Disposal System

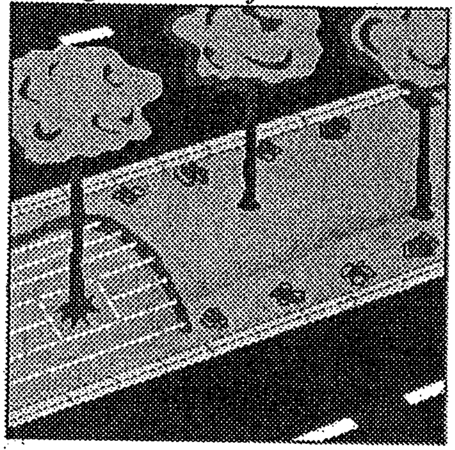
With the exception of septic systems, where the disposal bed must act as the form of secondary treatment, the disposal method for the wastewater treatment systems described above serve primarily as a hydraulic elimination system. The treated water does not have sufficient organic matter to cause the formation of a biological mat slime layer that is typically the cause of septic leach field failure. Therefore, alternative technologies can be explored that are not always successful with conventional treatment.

Subsurface Drip Irrigation

The high level of treatment observed by the previously discussed technologies allows this alternative to be explored. Subsurface drip irrigation is more flexible in its usages than conventional disposal beds. It can be used in smaller areas than conventional systems, or where soil type or steep slopes preclude disposal beds. This system is usually more cost effective especially in sloped areas and regions of non-homogeneous subsurface soil.

Drip irrigation disposal uses drip-lines that are buried approximately six to twelve inches below the surface in biologically active soil where the effluent is pumped slowly and uniformly through the irrigation field. Effluent is uniformly distributed over the entire area using low flow rate, uniformly spaced emitters. The uniform rate of application and its reliability make the system ideal for reuse in landscaping or irrigating agricultural crops.

Figure 6 – Geoflow Installed



Alternative #9 – The effective subsurface drip irrigation area would be approximately 36,000 square feet (0.83 acres) based on the assumption that the hydraulic loading rate is 1 gallon per square foot per day.

Alternative #10 – The effective subsurface drip irrigation area for the Churchview Road Area (PSA-8) would be approximately 17,000 square feet (0.4 acres) based on the assumption that the hydraulic loading rate is 1 gallon per square foot per day. The effective subsurface drip irrigation area for the Old Zionville Area (PSA-9) would be approximately 32,000 square feet (0.74 acres) based on the assumption that the hydraulic loading rate is 1 gallon per square foot per day.

Cost Estimate

The average cost of designing and constructing a pump station, an onsite wastewater treatment system, and a disposal system is as follows:

		Alternative #9	Alternative #10	
		St. Peters Road Area (PSA-7)	Churchview Road Area (PSA-8)	Old Zionsville Area (PSA-9)
Flow (gpd)		36,000	17,000	32,000
Collection System				
	Gravity Sewers	N/A	N/A	N/A
	Pump Station	$ 206,000	$ 206,000	$ 206,000
Wastewater Treatment System				
	Large Septic System	$ 209,800	$ 100,800	$ 185,700
	Subsurface Trickling Filters	$ 269,300	$ 187,200	$ 252,000
	Sequencing Batch Reactor	$ 216,500	$ 102,900	$ 192,600
	Fixed Activated Sludge Treatment	$ 243,800	$ 120,900	$ 218,000
	Biological Membrane Filtration	$ 356,000	$ 323,100	$ 349,100
	Combination Activated Sludge and RBC	$ 241,100	$ 201,300	$ 232,700
Groundwater Disposal System		$ 54,000	$ 25,500	$ 48,000
Construction Cost		$ 154,900	$ 121,300	$ 147,800
Design Cost		$ 100,700	$ 78,900	$ 96,100
Total		$ 771,700	$ 604,400	$ 736,300

For PSA-8, the relatively low average flow (17,000 gpd) makes septic systems seem to be the optimum alternative due to the larger cost differential. However, as the flow rises (PSA-7 and PSA-9), the cost differential shrinks and becomes virtually nil at around >32,000 gpd. If a wastewater treatment system is chosen as recommended below, drip irrigation should be installed as the method of hydraulic elimination because of its cost-effectiveness and ease of installation.

Recommended Treatment System

Best Treatment Quality System – Biological Membrane Filtration

Biological membrane filtration produces the highest quality effluent of the six selected treatment systems. Schoor DePalma recommends biological membrane filtration for providing the best treatment quality and the most reliable treatment. Biological membrane filtration is suggested because of its record throughout the country and its performance capabilities. They are popular on the east coast because they are cost-effective; produce superior effluent quality; take up less space than most treatment systems; and have proven to be reliable and easy to operate. In addition, biological membrane filtration can easily be made to blend into the development without the fear of odors. A detailed breakdown of total cost for a biological membrane filtration wastewater treatment system for each of the scenarios is as follows:

		Alternative #9	Alternative #10	
			Churchview Road Area (PSA-8)	Old Zionsville Area (PSA-9)
Flow (gpd)		36,000	17,000	32,000
Collection System				
	Gravity Sewers	N/A	N/A	N/A
	Pump Station	$ 206,000	$ 206,000	$ 206,000
Wastewater Treatment System				
	Biological Membrane Filtration	$ 356,000	$ 323,100	$ 349,100
Groundwater Disposal System		$ 54,000	$ 25,500	$ 48,000
Construction Cost		$ 184,800	$ 166,400	$ 181,000
Design Cost		$ 120,200	$ 108,200	$ 117,700
Total		**$ 921,000**	**$ 829,200**	**$ 901,800**

Most Cost Effective System – Sequencing Batch Reactor

Septic systems are the least expensive treatment system at the lower flow of 17,000 gpd and only slightly less expensive at the higher flow of 32,000 gpd and 36,000 gpd but their effluent quality is a cause of concern because the necessary septic disposal bed to meet DGW requirements could become costly depending upon the area. The most cost-effective system for treatment level and price is a sequencing batch reactor treatment system. They are easy to install and require minimal maintenance. However, sequencing batch reactors cannot ensure as high a quality wastewater effluent discharge as a tertiary system like a biological membrane filtration system – especially if water reuse may be considered. A detailed breakdown of total cost for a sequencing batch reactor treatment system for each of the alternatives is as follows:

		Alternative #9	Alternative #10	
			Churchview Road Area (PSA-8)	Old Zionsville Area (PSA-9)
Flow (gpd)		36,000	17,000	32,000
Collection System				
	Gravity Sewers	N/A	N/A	N/A
	Pump Station	$ 206,000	$ 206,000	$ 206,000
Wastewater Treatment System				
	Sequencing Batch Reactor	$ 216,500	$ 102,900	$ 192,600
Groundwater Disposal System		$ 54,000	$ 25,500	$ 48,000
Construction Cost		$ 143,000	$ 100,400	$ 134,000
Design Cost		$ 93,000	$ 65,300	$ 87,100
Total		$ 712,500	$ 500,100	$ 667,700