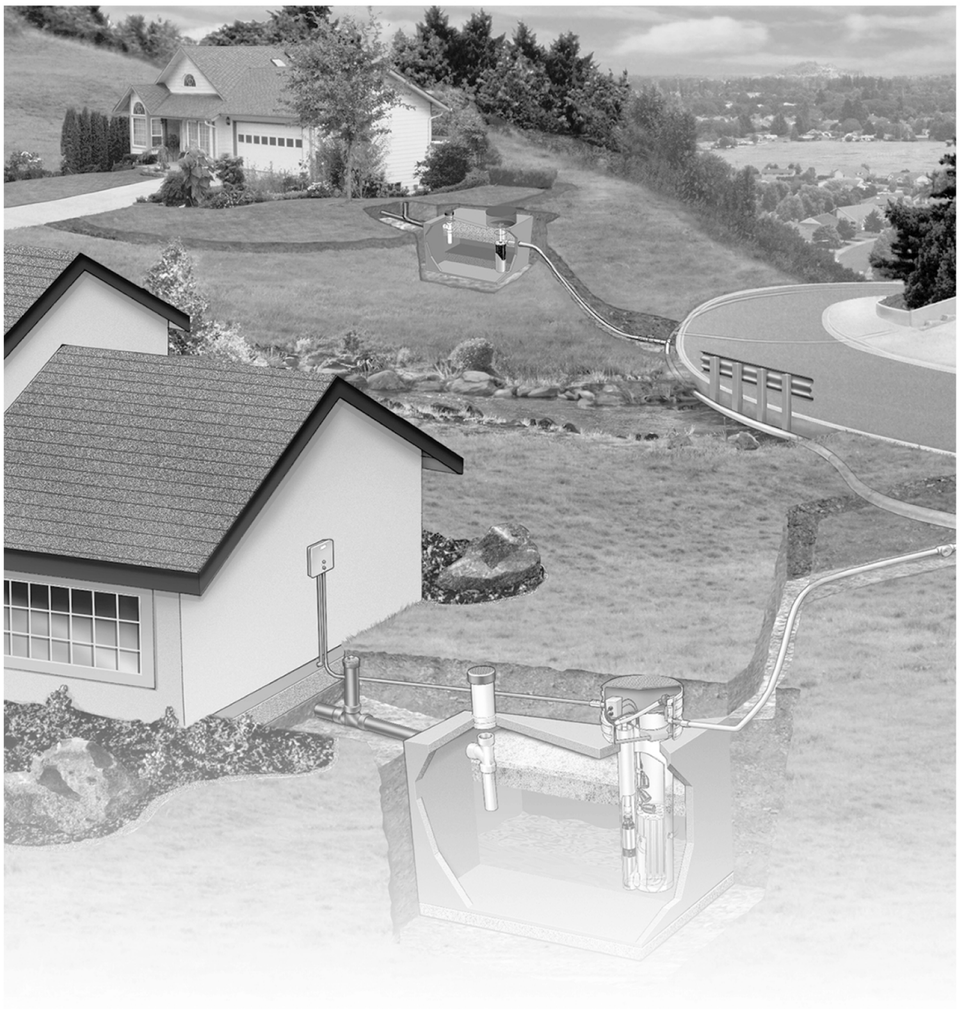
Effluent Sewer Design Manual



A Design Aid for
STEP
(Septic Tank Effluent Pump)
and
STEG
(Septic Tank Effluent Gravity)
Systems

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Definitions

Air release assembly – An effluent sewer component used to expel gasses that can increase head loss in collection lines. Air release assemblies also control the release of noxious sewer gases by using carbon filters and soil filters to adsorb sulfides and other odorous compounds.

Building sewer – The extension from the building drain to the public sewer. For effluent sewer, the connection from the building drain to the inlet of the interceptor tank.

Clean-out – An assembly used at the end of each line (branch and main) and in the building sewer to allow access for maintenance.

Design Average Day Flow (DADF or Q_A) – The average of the daily volume to be received for a continuous 12-month period, expressed as a volume per day (gpd, m^3/day, etc.). For facilities with seasonally high hydraulic loading periods (e.g., recreational facilities, campgrounds), the design average should be based on the daily average flow during the seasonal use period.

Design Maximum Day Flow (DMDF or Q_M) – The largest volume of flow to be received during a continuous 24-hour period, expressed as a volume per day. The Design Maximum Day Flow is highly dependent on the application and collection technology used. For effluent sewer, grinder sewer, and vacuum sewer, a typical value is two times the Design Average Flow ($2Q_A$). For typical large bore Gravity Sewer applications, a typical value for Q_M is four times the Design Average Flow ($4Q_A$) for new construction and can range to over ten times ($10Q_A\pm$) for existing systems, depending on population and system integrity. Existing flow information and regulatory requirements must be carefully evaluated when establishing this design parameter.

Effluent filter or vault – These are solids-screening components with a typical screen mesh size of 1/8 inch (3 mm). They are designed for "mean time between cleaning" (MTBC) frequencies of 2-10 years, depending on whether they are used on commercial or residential applications.

Effluent sewer – A collection system where only "primary treated effluent" is discharged into the public sewer (no solids with diameters larger than 1/8 inch or 3 mm). This typically reduces organic and suspended solids strengths by 50% or more. Effluent sewers can be configured as Septic Tank Effluent Pumping (STEP) systems, Septic Tank Effluent Gravity (STEG) systems, or a combination of both.

Equivalent Dwelling Unit (EDU) – The flow from a typical single-family home or dwelling. Commercial systems can be converted to Equivalent Dwelling Units for the purpose of calculating daily flow.

Flow velocity – The velocity of flow in the mains, submains, and laterals, used to determine both a minimum flow velocity for scouring and a maximum flow velocity for head loss.

Hydraulic Grade Line (HGL) – The surface or profile of water flowing in an open channel or a pipe flowing partially full. In a pipe under pressure, the hydraulic grade line is the level water would rise to in a small, vertical tube connected to the pipe and which is graphically shown on the profile plan drawings. The HGL for a system is used to determine the estimated pressures throughout the system, to size the effluent lines, to determine appropriate pump sizes, etc. In this manual, the HGL is used instead of the energy grade line (EGL) because the velocity head in the system's main lines is negligible, even at peak flows.

Infiltration – The total extraneous flow entering a sewer system underneath the ground surface because of poor construction, corrosion, ground movement, or structural failure of components.

Inflow – The extraneous flow entering a sewer system from sources other than infiltration, such as roof drains, basement sump discharges, land drains (storm sewer catch basins), or open access points (interceptor tank lids/risers poorly fastened, damaged or flooded/low manhole covers, clean-outs, etc.). Inflow is typically man-made and is often intentional.

I&I – The combined effect of Infiltration and Inflow.

Interceptor tank – A primary anaerobic treatment tank that is designed, constructed, and tested following strict protocols to ensure that the tank maintains its structural integrity and watertightness throughout its life.

Isolation valve – A valve (typically, but not limited to, ball or gate valves) used to isolate sections of a public sewer. These are typically located at pipe intersections of mains, submains, or laterals.

Lateral – A sewer line that receives flow from service laterals and discharges into a submain or main, but has no other common sewer tributary to it. Most laterals have a terminal end, however, some may be looped and valved for cleaning purposes and for redirecting the flow in the event of an emergency.

Main – The principal sewer line in which submains and laterals are tributary.

Open space – Includes areas for parks, green space, or other open areas that are publicly accessible and are typically publicly owned but can also be privately owned (as in the case of a private subdivision).

Peak hydraulic flow (Q_P) – The peak instantaneous flow value expected to occur under the highest expected flow condition, typically expressed in volume per minute (gpm, m^3/min, etc.). In an effluent sewer system, Q_P is based on peak day flows because the primary tanks provide surge capacity for flow modulation, and the laterals, submains, and mains are constructed watertight. By comparison, Q_P for gravity systems typically needs to be evaluated on an hourly basis to ensure lift station and wastewater treatment hydraulic capacities aren't compromised.

Pigging port – Device that allows operators to either launch or collect "pigs" (pipe cleaning devices) for the purpose of flushing debris and accumulated solids out of the line.

Plat – A map, drawn to scale, that shows the divisions of a piece of land and clearly designated roads, rights of way, and easements.

Right of way – The legal right, established by usage or grant, to pass along a specific route through property belonging to another, in most cases belonging to the public.

Scouring velocity – The flow velocity required in order to re-suspend and flush settled solids to ensure that solids are effectively moved through the lines and do not form blockages or reduce pipe capacity due to solids deposition.

Septic tank abatement – A project associated with removing on-lot septic systems (either soil-based drainfield or surface discharge) and replacing them with a public sewer collection and treatment system.

Septic Tank Effluent Gravity (STEG) – Screened (filtered to retain solids greater than 1/8 inch or 3 mm) systems that discharge primary treated effluent from interceptor tanks via gravity located sufficiently above the hydraulic gradient of the sewer main to allow discharge into the system without the need for pumping.

Septic Tank Effluent Pumping (STEP) – Screened (filtered to retain solids greater than 1/8 inch or 3 mm) systems that discharge primary treated effluent from interceptor tanks through the use of a pump.

Service connection – The connection from any pressure sewer service lateral to the public sewer. The service connection typically includes a check-valve and a shut-off valve protected by and accessible from a small enclosure.

Service lateral – The transport pipe located on an individual lot that connects to the public sewer. With gravity sewer, this is the same as the building sewer. With effluent sewer, this is a line from the interceptor tank to the public sewer.

Static grade line – A representation of the pressure in a main, submain, or lateral when no flow is present.

Submain – The sewer line in which multiple laterals are tributary. The submain flows into a main sewer.

Thrust block – A mass (typically concrete) located on the outside of an angle fitting and extending back to native soil to prevent surges in flow through a pipe from flexing the fitting and wiggling it in the ground which would — over time — allow the pipe fitting to pull apart.

Total Dynamic Head (TDH) – The total equivalent head (typically in feet or meters) that a fluid must overcome (either by pump or gravity), taking into account the static and frictional losses in the pipes relative to the system's HGL.

1. Planning

1.1 Collection System Technologies

Effluent sewers have saved small communities millions of dollars in capital costs and operation and maintenance costs when compared to large diameter gravity systems. Hundreds of communities have installed effluent sewers during the past several decades, and a number of these systems are now more than 40 years old. Effluent sewers can affordably serve small, spread-out communities, largely because they use small-diameter, shallowly buried, and easy to place PVC or HDPE mains along variable grades to transport primary treated wastewater to a secondary or advanced treatment facility, rather than using large diameter, deeply excavated mains laid at a constant slope. Because the majority of the "easy" gravity sewer systems have been installed, those areas that are left to sewer are more difficult (due to topography and other issues) and lend themselves well to effluent sewer systems. In some cases, effluent sewers should be evaluated even in more densely populated areas.

The Water Environment Research Foundation (WERF), formed in 1989, is America's leading independent research organization dedicated to wastewater and stormwater issues. Throughout the last 25 years, they've developed a portfolio of more than $130 million in water quality research. In 2010, WERF published research information for the four primary types of wastewater collection technologies being used, and ultimately developed an online wastewater planning model for use in evaluating the cost impacts of each of these technologies. This model can be found at: http://www.werf.org/i/c/DecentralizedCost/Decentralized_Cost.aspx. The following table provides the model's sample capital cost and operational cost summary for each technology, based on a 200-unit example.

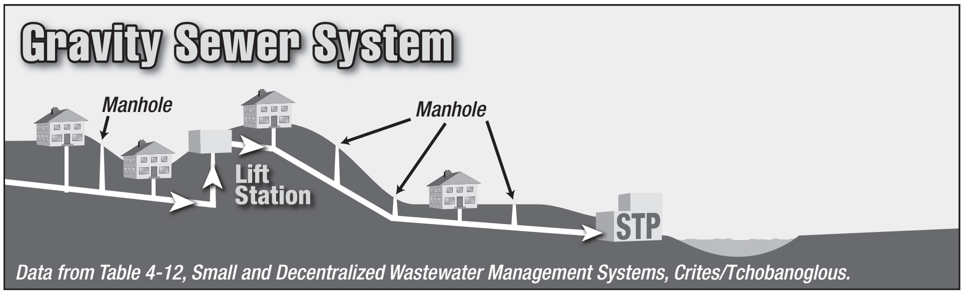
Table 1. WERF Collection Fact Sheet Examples for 200 Homes[1]

Cost Description	Cost Range	Gravity Sewer	Vacuum Sewer[2]	Low Pressure (Grinder) Sewer	Effluent Sewer
Cost of Collection Network	Low	$2,182,000	—	$344,000	$340,000
	High	$3,273,000	—	$516,000	$510,000
Network Annual O&M	Low	$65,000	$82,000	$56,000	$60,000
	High	$97,000	$123,000	$84,000	$90,000
Installation Cost of On-lot	Low	$247,000	—	$997,000	$561,000
	High	$371,000	—	$1,496,000	$842,000
Total Installation Cost	Low	$2,429,000	$1,869,000	$1,341,000	$901,000
	High	$3,644,000	$2,804,000	$2,012,000	$1,352,000
Annual On-lot O&M	Low	$16	$16	$120	$56
	High	$24	$24	$240	$84
Capital Cost/Connection	Low	$12,000	$9,000	$7,000	$5,000
	High	$18,000	$14,000	$10,000	$7,000
Cost - Present Value (2009 $)	Low	$4,472,000	$4,775,000	$4,707,000	$2,452,000
	High	$6,708,000	$7,162,000	$6,106,000	$3,678,000

[1] Source: Water Environment Research Foundation, 2010.
[2] Assumes the use of 100 Valve Pits (one per two homes).

1.1.1 Gravity Sewers

Typically, as depths approach 18-20 feet (5-6 m), gravity sewers use 4 inch (100 mm) diameter service laterals and minimum 8 inch (200 mm) or larger (depending on peak flows) mainlines, installed at a constant slope. Mainlines are regularly installed 6-20 feet (2-6 m) deep, and can be as deep as 40 feet (12 m) with large pump lift stations, depending upon terrain and other factors. Manholes are required at changes in diameter, slope, or direction, and at regular intervals for cleaning and inspection purposes. Primary treatment and solids management occur at the treatment facility. Typical waste strengths for treatment system planning are shown in Figure 1 (Crites and Tchobanoglous, 1998).



Waste Strength	ADWF* 50 gpd/person (189 Lpcd)	AWWF* 120 gpd/person (454 Lpcd)
BOD_5	450 mg/L	187 mg/L
TSS	503 mg/L	209 mg/L
FOG	164 mg/L	68 mg/L

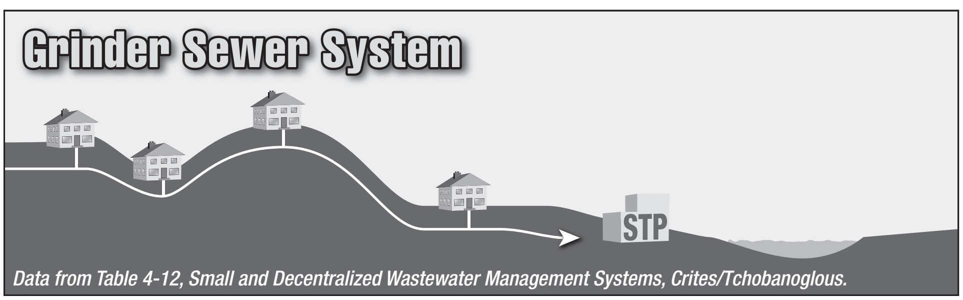
* ADWF: Average Dry Weather Flow
* AWWF: Average Wet Weather Flow

Figure 1. Typical Gravity Sewer System Profile

Costs for gravity sewers vary widely depending on density and topography; those costs provided in Table 1 can be found in WERF Fact Sheet C1: "Performance & Cost of Decentralized Unit Processes: Gravity Sewer Systems," (Water Environment Research Foundation, 2010).

1.1.2 Grinder Sewers

Grinder sewers typically use on-lot basins with capacities of 50 to 150 gallons (200 to 600 L). The basins are equipped with 1 hp to 2.5 hp (0.74 to 1.86 kW) grinder pumps that macerate raw sewage and pump it to the treatment facility. Small-diameter lines that are installed following the contour of the land are used to transport the wastewater to the discharge point, without manholes. Like gravity sewers, minimum scouring velocities (> 2 fps or > 0.6 m/sec) are required to avoid solids deposition. Typical waste strengths for treatment system planning are shown in Figure 2 (Crites and Tchobanoglous, 1998).



Waste Strength	ADWF/AWWF 50 gpd/person (189 Lpcd)
BOD_5	450 mg/L
TSS	503 mg/L
FOG	164 mg/L

Figure 2. Typical Grinder Sewer System Profile

Costs for grinder sewers provided in Table 1 can be found in WERF Fact Sheet C2: "Performance & Cost of Decentralized Unit Processes: Pressure Sewer Systems" (Water Environment Research Foundation, 2010). Grinder sewers also require solids management downstream of the on-lot portion of the system.

Consideration should be taken to select appropriate styles of grinder pump, as progressive cavity style pumps become more common. "The pumps [progressive cavity] are expensive to maintain because of wear on the rotors and the stators…" (Metcalf and Eddy Fourth Edition, 2003).

1.1.3 Effluent (STEP/STEG) Sewers

Effluent sewers use 1000 gallon (3785 L) or 1500 gallon (5678 L) on-lot interceptor tanks to provide primary treatment to wastewater prior to conveying filtered effluent to the discharge point. This reduced-strength, filtered effluent is transported through small-diameter pressure mains either by gravity or by use of a pump. Since the majority of solids are contained and passively digested in the primary tank, scouring velocities are not required. High-head effluent pumps (250 feet or 75 m of head capability), typically 1/2 hp (0.37 kW), accommodate systems with hilly terrain or distant treatment sites. If the interceptor tank's outlet lies above the hydraulic grade line, only an effluent filter is necessary; no on-lot pump is required to transport the filtered effluent. No manholes are required in an effluent sewer system.

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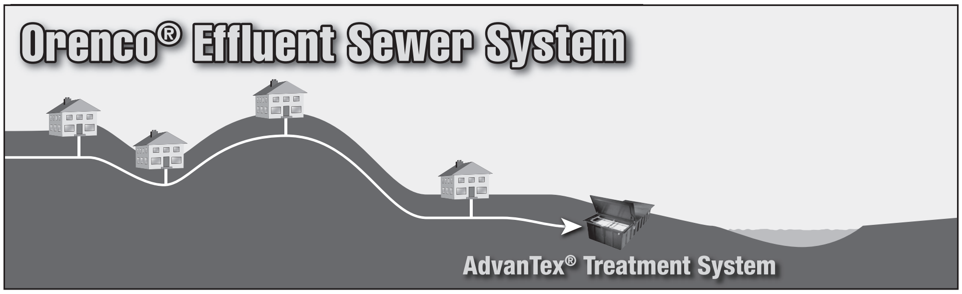


Waste Strength	
	ADWF/AWWF 50 gpd/person (189 Lpcd)
BOD_5	140 mg/L
TSS	30 mg/L
FOG	15 mg/L

Figure 3. Typical Effluent Sewer System Profile

Costs for effluent sewers provided in Table 1 can be found in WERF Fact Sheet C3: "Performance & Cost of Decentralized Unit Processes: Effluent Sewer Systems" (Water Environment Research Foundation, 2010). As the table shows, installed costs for effluent sewers are similar to those of grinder sewers and significantly lower than for gravity sewers. And when operational costs are compared, the life-cycle costs of effluent sewers are shown to be considerably lower than the other collection technologies.

1.2 Collection Technology Comparison

1.2.1 Mainline Installation

Gravity sewers require deep mainline trench excavations (10-40 feet or 3-12 m) that go in slowly with significant disruption to the community. They require manholes at intersections, at changes in slope or direction, and at regular intervals along the lines (typically 200-300 feet or 60-90 m). And, due to their footprint and reliance on topography, gravity sewer installations often result in conflicts with existing utility services, requiring costly change orders and redesigns.

Grinder sewers and effluent sewers share the advantage of using shallowly buried, small-diameter force mains that can be installed with a trencher or directional borer, easily avoiding conflicts with existing utility services at little or no cost. Inexpensive clean-outs replace the expensive manholes found in gravity sewer systems.

Figure 4. Typical Sewer Main Installation: Gravity (left) vs. Pressure (right)

1.2.2 Infiltration & Inflow Impacts

Gravity sewers are non-watertight collection systems. Because of this, infiltration and inflow (I&I) are a constant problem. Collection and treatment systems for gravity sewers must be sized to handle the excess flow caused by I&I to avoid sanitary sewer overflows and regulatory violations. The long-term electrical consumption costs associated with transporting, pumping, and treating excess flows due to I&I are also a consideration. Upgrade projects to lift stations and treatment plants are often driven by the need to deal with I&I. Because gravity sewers are not watertight, exfiltration of raw sewage is another common problem associated with these systems.

Effluent sewer systems and grinder sewer systems are designed to be watertight and are largely immune to I&I, though the on-lot connection can be susceptible to inflow from improper sources (e.g. drains and downspouts that have been plumbed to the interceptor tank).

1.2.3 Operator Response

The vast majority of gravity sewer systems have multiple pump stations in order to "lift" the waste to a higher elevation and convey it to the point of treatment. Large gravity sewers can have dozens of pump and "repump" stations (a repump station is a pump station that moves waste that has already been through a previous pump station). Though most pump and repump stations have some level of redundancy in the pump capacity, an immediate response is required for any alarm condition. Immediate operator response is required when gravity sewers back up into homes and businesses.

Due to the lack of sufficient emergency storage volume in a grinder sewer's on-lot pump basin, an immediate operator response is generally required for these systems. At a minimum, the end user is required to carefully manage usage until the operator responds. The interceptor tanks used in effluent sewers typically have a reserve capacity equal to the flow received during an average day (24 hours minimum), so immediate response is unnecessary and the end user is typically not impacted.

1.2.4 Power Considerations

All three technologies are susceptible to power outages. With gravity sewers, pump stations are typically equipped with emergency backup generators. In addition, the cost to pump can be significant in areas with rolling topography, requiring multiple pump and "repump" stations.

Grinder sewers have on-lot electricity costs that typically range from about $2.00/month/EDU to greater than $2.50/month/EDU for pump operation for 1 hp to 2 hp (0.74 kW to 1.5 kW) pumps. Many existing homes require costly upgrades or separate power drops for the 230 VAC power required to operate them. Lastly, due to the limited head capacity of the pump and the head losses associated with achieving the necessary scouring velocities, larger grinder sewer systems (greater than 1000 connections) can require intermediate lift stations.

Effluent sewer pump systems typically use fractional horsepower (1/2 hp or 0.37 kW) pumps that operate on 115 VAC power, and the cost to operate is about $1/month/EDU. With their high-head capacities and ability to operate without high scouring velocities, thousands of units have been connected without the need for an intermediate pump station.

1.2.5 Impact on Treatment Facilities

Effluent sewer is the only technology that incorporates primary treatment into the collection system. Because primary treatment is integrated into effluent sewer systems, engineers should evaluate various collection and treatment system options together, not independently or separately. As Figure 3 shows, the organic waste strength of an effluent sewer is a fraction of that of gravity sewer (see Figure 1) or grinder sewer (see Figure 2). Gravity systems require larger, energy-intensive, high-cost (capital and O&M) treatment facilities to handle I&I and solids.

Note that biosolids processing and aeration normally represent 80% of the overall electrical usage in a typical activated sludge wastewater treatment facility. Effluent sewers reduce the hydraulic load and organic load, thereby significantly reducing long-term electrical consumption costs. (Electrical Power Research Institute, 2013).

1.2.6. Water Softener Backwash

Water softener salt regenerate (backwash) should not be plumbed into the interceptor tanks in an effluent sewer collection system because the concentration of sodium and chlorides in backwash is considerably greater than the toxicity or inhibitory limit for these constituents established by the EPA for wastewater treatment systems. Nitrogen removal is significantly inhibited in systems receiving backwash from water softeners.

Water softener backwash is essentially a salt- and mineral-laden wastewater, with none of the organic wastewater constituents found in greywater and blackwater. As such, it is bacteria-free and suitable for ground discharge as recognized by many states. Many jurisdictions prohibit salt water regenerate from being discharged to septic systems, advanced treatment systems, and/or sanitary sewer. Instead, there may be a provision for constructing a separate, small dispersal area for the salt-laden backwash. Check local regulations for more information.

In situations where water softener regenerate must be discharged into the effluent sewer collection system and the treatment facility is capable of accepting this type of waste stream, see Section 4.2.1.1, “Compartmentalization,” for allowable configurations.

1.3 Other Planning Considerations

Understanding the long-term operation and maintenance (O&M) needs, equipment repair and replacement requirements, and associated costs is important when selecting and implementing a sustainable wastewater collection system. Gravity sewers, grinder sewers, vacuum sewers, and effluent sewers exhibit different capital and long-term costs, and they impact downstream treatment systems differently. A thorough evaluation of all wastewater collection options, prior to design, comparing capital costs, long-term costs, and social impacts is critical, especially for those communities with a high percentage of household incomes in the low-to-moderate range. A present worth analysis, preferably with a 40-year or longer term, is a necessity. Evaluators should analyze various collection and treatment systems together, not independently, due to the fact that each collection technology provides a different product to the treatment plant.

System owners and engineers should understand approximate system costs and the community’s affordability thresholds before undertaking a preliminary engineering report or feasibility study. Wastewater collection and treatment system costs are well documented throughout the United States and many other countries. With an understanding of affordability thresholds, approximate system costs, and funding options, evaluating the community’s Median Household Income (MHI) can quickly determine the feasibility of providing sewer service to an unsewered area.

According to the United States Environmental Protection Agency (USEPA), if the total cost per household (existing annual cost per household plus the incremental cost related to the proposed project) is less than 1.0 percent of the median household income, it is assumed that the project is not expected to impose a substantial economic hardship on households. If the average annual cost per household exceeds 2.0 percent of median household income, then the project may place an unreasonable financial burden on many of the households within the community. When the ratio falls between these values, communities are expected to incur mid-range impacts and a secondary test is often performed that includes debt indicators, socioeconomic indicators, and financial management indicators (USEPA, 1995). Various state and national funding agencies have adopted an affordability threshold that falls within this range.

As part of the feasibility study or preliminary evaluation, system owners, community leaders, operators, and engineers should visit multiple systems using various collection technologies and consult with system owners and operators. These interviews offer valuable feedback that is difficult to acquire by reading textbooks or making theoretical extrapolations. Even though a phone interview can provide some quality information (USEPA, 1995), there is no substitute for a thorough on-site investigation, seeing a system firsthand, and having a face-to-face discussion with managers and operators to fully understand the benefits and drawbacks of the wastewater collection and treatment systems. Tough questions should be asked with respect to how a suitable technology best fits with the long-term feasibility, sustainability, and affordability of the community’s needs.

2. Design

2.1 Introduction

The purpose of this document is to provide a guideline for designing an effluent sewer collection system. A well planned, quality system design will help with the bid process, reduce installation expenses, streamline the construction sequence, and promote easy operation and maintenance — and will consequently provide a reliable service to utility users and a low life-cycle cost to utility owners.

2.2 System Layout

One of the first tasks in the design process is the preparation of a preliminary system layout of the effluent sewer within the defined service district. This section addresses several of the factors to be considered when developing a preliminary layout. The general goal during preparation of the preliminary layout is to provide service for all current and future users of the wastewater system while minimizing the line sizing and required length of the mains. During the preliminary layout process, it is important to leverage the relatively low cost per lineal foot or meter and the unconstrained alignment requirement of the pressure main to achieve long-term O&M advantages.

Figure 5. Typical Effluent Sewer Layout

2.2.1 Rights of Way, Access, and Easement

The right of way and easements will be defined by the plat if the effluent sewer system is being developed for a new development. For a septic tank abatement project, the public right of way will typically be established already, but the specific right of way locations for the effluent sewer components will need to be identified. Constructing a useable easement is important, since the utility will own tanks and equipment on private property and will require access from time to time to provide O&M. There are three primary types of easements — blanket easements, deeded easements, and centerline easements.

A ***blanket easement*** — where the utility has access to the entire property for construction and service — is ideal, but not always easy to secure due to its perceived unrestricted nature. Therefore, a limited blanket easement is being used in some areas. In this limited blanket agreement, the lot owner grants permission for utility access to portions of their lot necessary for installing, maintaining, or inspecting their system. A map of the lot with all utility-owned assets is provided as the basis for the easement. This limits access to those identified areas (i.e. if all assets are in the front yard, the utility does not need to access the backyard). Sample easement language is found in Appendix 1 of this manual.

A ***deeded easement*** is the most precise, and consequently the most expensive type of easement, and gives little flexibility in the event that site conditions require a modification (i.e. other utilities uncovered during construction within the easement). Because of the time and costs associated with negotiating, surveying, and recording them, deeded easements should be avoided whenever possible.

A ***centerline easement*** is a good compromise and is used whenever a blanket easement cannot be secured. In a centerline easement, a perpetual easement centered on the pipe, tank, or control panel is created. In addition to this perpetual O&M easement, a larger temporary construction easement is typically used to allow for the necessary equipment during installation. This temporary easement expires upon completion of system construction.

2.2.2 Physical Separation from Other Utilities

The location of effluent sewer mains must be carefully coordinated with all other existing or planned utilities within the right of way. Effluent sewer pressure mains are typically installed within the *open space* adjacent to the road and/or property line at a depth of 30 inches (0.75 m) or just below frost depth to prevent freezing, and parallel with the general contour of the terrain. If necessary, the effluent sewer mains can be redirected without difficulty to avoid existing utilities.

Adequate separations from other utilities provide needed room to access the effluent sewer *main* and *laterals* for routine activities such as line tapping and cleaning as well as emergency repairs. Horizontal and vertical separations relative to other utilities, property lines, easements, etc. are typically included in regulatory requirements, and they may vary by jurisdiction. Most jurisdictional criteria centers around horizontal separation from utilities and boundary lines, but also addresses specific criteria for potable water — with vertical separations when public sewer lines are located within specific horizontal distances. Typically, sewer lines must be located vertically lower than potable water lines and reclaimed water lines to prevent cross-contamination and pathogen transfer from the sewer to the water line(s) in the event of a line break.

Many right of ways will have standardized right of way profiles that incorporate locations to install utilities. Generally, effluent sewer pressure mains are installed on the opposite side of the road relative to the water mains.

2.2.3 Water Body, Railroad, and Highway Crossings

Water bodies (lakes, streams, creeks, and rivers) are very important factors to take into consideration when laying out a collection system. These bodies of water will require either a bore underneath or an overhead line attached to a bridge. Though the cost of a small-diameter bore for an effluent sewer is low, it may still require special conditions to be addressed (e.g. casing, insulation, and permits). As such, water crossings should be avoided when possible and limited if necessary.

Railroad and highway crossings should be similarly avoided or limited. Not only is the cost to bore and case the piping high, but the time associated with applying for approval (and subsequent permit) can severely impact a project schedule. The time associated with this process varies by agency and state, but has been known to take up to 1-2 years to complete.

2.2.4 Configuration and Valving for Piping Networks

Most effluent sewer pressure mains are planned for unidirectional flow, where all collection mains typically connect to a “trunk” main that delivers flow to its destination (pressure main, treatment plant headworks, manhole, etc.). The design is rather simple, with easily determined build-out flows and easily defined hydraulic characteristics. From an O&M standpoint, this configuration is functionally adequate. There is a potential risk factor in that damage to the pressure main could potentially interrupt service to all upstream connections, but with the 24-hour storage capability in the interceptor tank and the simplicity of repairs, the customer is only minimally impacted.

The network should be laid out with isolation valves on the upstream section of the line at each significant intersection, allowing for the isolation of service areas in the event of a line break and limiting the number of impacted customers. For lines that serve a small number of homes, this isolation valve can be omitted and the individual unit can be turned off at the service connection. Effluent sewer mains have a relatively low occurrence rate for main breaks; therefore a grid layout or looped layout is typically unnecessary in effluent sewer systems.

2.2.5 Disruption to Residents and Traffic During Construction

A significant benefit of an effluent sewer collection system is that it is constructed within the right of way and not directly in roadways or under road surfaces, avoiding expensive surface restorations. When a road crossing is necessary, it can often be accomplished by directional boring under the road. If an open cut is necessary, the small-diameter and shallowly buried lines require minimal excavation and small construction equipment, so the work can be accomplished quickly. In these cases, the cost associated with traffic control should be mitigated to the greatest extent possible by limiting road crossings. If necessary, services can be shifted to side lots or possible rear lot easements to avoid mains within a busy right of way.

2.2.6 Future Extensions of Service

Because the collection mains for effluent sewer systems are relatively free of solids, sizing lines for future flows is possible without the concern for solids deposition and plugging during the time elapsed until ultimate design flows are achieved. Since maintaining a scouring velocity is unnecessary, sizing lines for future development and flows is an option. Lines can be upsized and valved at a terminal point that can be used for a future extension of service to new areas.

2.2.7 Groundwater

Shallowly buried collection lines for effluent sewers can be directionally bored in high groundwater areas with little impact. The only real challenge is "steering" of the directional bore piping in fine soils with high groundwater. Because effluent sewer systems are watertight, ground water infiltration is eliminated from the right of way collection network.

2.3 Odor and Corrosion Concerns

Concern about odors and corrosion is an important factor when laying out any wastewater collection system. In an effluent sewer collection network, this concern is eliminated since the system is enclosed and under pressure until it reaches the treatment facility and is introduced under the flow line at the plant.

For any collection system that ties into a gravity sewer, the point and method of introduction is critical to reducing impacts from odor and corrosion. As such, the number of connection points in these systems should be restricted whenever possible. See Section 3.9.1 for a detailed discussion of methods for odor and corrosion control.

2.4 Hydraulics

After a preliminary layout is determined, it is then necessary to define the hydraulic parameters throughout the collection network.

2.4.1 Daily Design Flows

Design flows are typically determined by using the number of connections, the population per connection, and a daily per capita flow value. For systems with commercial contributions, each commercial entity will require flow estimation based upon local regulatory values or other flow derivation methods.

Because effluent sewers are watertight and typically under a small pressure head, they greatly reduce the possibility for I&I. Per capita flows for effluent sewer systems are well documented to be in the range of 40-60 gpcd (150-230 Lpcd) with little weekly or seasonal variation (USEPA, 1991).

Therefore, Design Average Day Flow (Q_A) is calculated using:

Equation 1 $$Q_A = EDU\ P_c Q_c$$

where: EDU = Equivalent Dwelling Units
P_c = Population density; capita/EDU
Q_c = Daily per capita flow value; gpcd or Lpcd

For a 100 home development with 3.2 people per household and 50 gpcd, the Design Average Day Flow calculates to:

$$Q_A = \text{(100 connections)(3.2 capita/connection)(50 gpd)} = \text{16,000 gpd}$$

A conservative Design Maximum Day Flow (Q_M) for effluent sewer collection systems is typically calculated by multiplying Q_A by two. Therefore:

Equation 2 $$Q_M = 2Q_A = \text{(2)(16,000 gpd)} = \text{32,000 gpd}$$

Therefore, the Design Maximum Day Flow of an effluent sewer collection system correlates well to the Design Average Flow for deep bore gravity sewer collection systems (Ten State Standards, Metcalf & Eddy, etc.).

2.4.2 Design Flow Rates in the Collection Lines

Pressure sewer designs use relatively simple hydraulics based upon the type of pump being utilized in the system; see Figure 6 for a comparison.

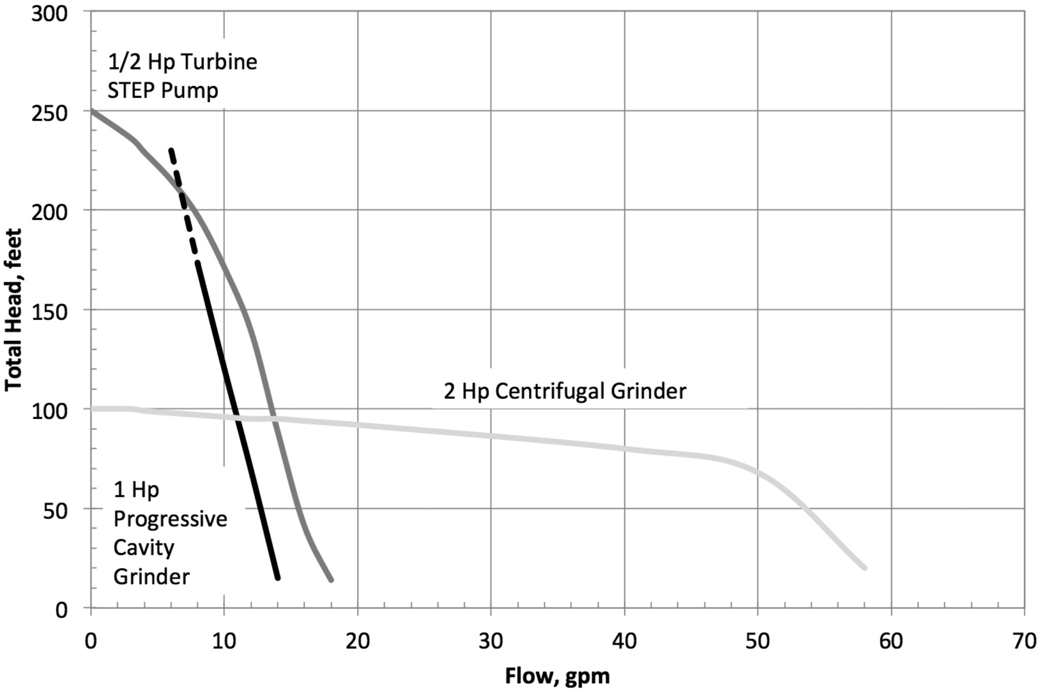


Figure 6. Turbine STEP vs. Progressive Cavity Grinder and Centrifugal Grinder Pumps

Grinder pump pressure sewers often use semi-positive displacement pumps that have a nearly vertical performance curve — that is, they produce relatively little change in flow regardless of pressure. With these pumps, the "probability method," a statistical estimation that uses a lookup table to determine the most likely number of pumps operating at one time for any given population of total pumps, is used for sizing the sewer lines.

With effluent sewers using multistage turbine pumps, the "rational method" is used to determine the flows in the sewer mains. In the rational method, an equation is used to determine the flow based upon the number of Equivalent Dwelling Units connected to the system. As shown in Figure 2-12 of the EPA Manual for Alternative Wastewater Collections Systems (AWCS), the flows calculated from both probability and rational methods are similar. The Simplified Equation is the most common rational method used for determining peak flows in the collection lines (USEPA, 1991).

Equation 3 $$Q_P = A N + B$$

where: Q_P = *Peak flow in collection line, gpm*
A = *Coefficient, typically 0.5 (assumes* P_c = *3 capita/EDU,* Q_c =*150 gpcd)*
N = *Number of Equivalent Dwelling Units*
B = *Factor based upon the quantity and type of pumps used, typically 10-15*

The following expression represents a more detailed and preferable version of the Simplified Equation that takes into account variations in population density and per capita flow usage:

Equation 4 $$Q_P = \left(\frac{P_C}{6}\right)\left(\frac{Q_C}{50}\right) EDU + B$$

where: Q_P = *Peak flow in collection line, gpm*
P_c = *Population density, capita/EDU*
Q_c = *Daily per capita flow value, gpcd*
EDU = Equivalent Dwelling Units
B = Factor based upon the quantity and type of pumps used, typically 10 gpm

Thus, if the population density is 3 and the per capita flow is 50 gpcd (190 Lpcd), this reduces to the Simplified Equation (Equation 3). It is important to note that the factor B is only necessary to include on lines with fewer than 20 connections. Once a line has more than 20 connections, this value becomes less significant and can be removed from the calculation at the discretion of the designer.

For commercial connections, the flow contribution for a facility can be converted into EDUs for the purpose of line sizing, assuming a base flow of 150 gpd (570 L/day) per EDU. For example, a school with 300 students and faculty that includes a gym and showers generates a typical flow of 25 gpcd (96 Lpcd). Therefore the EDU equivalency would be as follows:

Equation 5

$$\#EDU = \frac{Q\text{ gpd}}{150\text{ gpd/EDU}} = \frac{(300\text{ capita})(25\text{ gpcd})}{150\text{ gpd/EDU}} = \frac{7{,}500\text{ gpd}}{150\text{ gpd/EDU}} = 50\text{ EDUs}$$

2.4.3 Frictional Head Loss in the Collection Lines

Once the flow in each pipe section is determined, the pipe diameter can be selected, and the hydraulic grade line (HGL) is determined using the Hazen-Williams equation to calculate head losses in each pipe segment. The basic equation looks like this:

Equation 6

$$V = k\,C\,R^{0.63}\,S^{0.54}$$

where: V = Velocity of flow, fps or m/sec
k = Conversion factor (1.318 for U.S. units, 0.849 for S.I. units)
C = Hazen-Williams coefficient, unitless (120-150 depending on material used)
R = Hydraulic Radius, for full flowing circular pipe R = D/4 (feet or meters)
D = Inside diameter of pipe, feet or meters
S = Slope of energy gradient, feet per feet of length or meters per meter

Equation 6 can be modified for calculating head loss. When using U.S. units, a common form of the modified Hazen-Williams formula is as follows:

Equation 7

$$h_L = \frac{4.727\,L}{D^{4.87}}\left(\frac{Q}{C}\right)^{1.85} = \frac{4.727\,L}{\left(\frac{d}{12}\right)^{4.87}}\left(\frac{Q_P}{449\,C}\right)^{1.85} = \frac{10.557\,L}{d^{4.87}}\left(\frac{Q_P}{C}\right)^{1.85}$$

where: h_L = Head loss in line segment, feet
L = Length of line segment, feet
D = Inside diameter of pipe, feet
Q = Peak flow in collection line, cfs
C = Hazen-Williams coefficient, unitless (120-150 depending on material used)
d = Inside diameter of pipe, inches
Q_P = Peak flow in collection line, gpm
449 = Conversion factor for gpm/cfs

The Hazen-Williams formula modified for head loss (when using S.I. units) is as follows:

Equation 8

$$h_L = \frac{10.67\,L}{d^{4.87}}\left(\frac{Q_P}{C}\right)^{1.85}$$

where: h_L = Head loss in line segment, meters
L = Length of line segment, meters
d = Inside diameter of pipe, meters
Q_P = Peak flow in collection line, cubic meters per second
C = Hazen-Williams coefficient, unitless (120-150 depending on material used)

The Hazen-Williams coefficient, C, varies by pipe material. The most common pipe materials used in effluent sewer systems are PVC and HDPE, which have C values of 150 and 140 respectively. However, many jurisdictions require C values that differ from — and are more conservative than — those specific to the material. For example, Ten State Standards (which regulates designs with gravity sewers and pump stations, not effluent sewer systems) uses a maximum C value of 120, regardless of material (Ten State Standards, 2004). Though this should not apply to effluent sewer (per the foreword to Ten State Standards), some regulatory agencies still require designers to follow Ten State protocol. Therefore, check local regulations for C value requirements.

2.4.4 Flow Velocity in the Collection Lines

Interceptor tanks used in effluent sewer collection systems are very effective in capturing grit and grease as well as settling the majority of waste solids. Experience has shown that solids are not deposited in effluent sewer collection lines, even when flow velocities fall below 1 fps or 0.30 m/sec (USEPA, 1991). Therefore, flow velocity in the collection lines for effluent sewer collection systems is not critical. This means effluent sewer systems can be designed with oversized lines for long-term build-out projects without concern for solids deposition and for pipe plugging, unlike gravity or grinder sewer collection systems.

Velocity is calculated using Equation 6 shown in Section 2.4.3:

$$V = k\,C\,R^{0.63}\,S^{0.54}$$

For full-flow pipes, this equation can be simplified to V= Q/A (flow divided by flow area).

2.4.5 Selecting Pipe Size

Pipe sizing in an effluent sewer system is an iterative process that is typically dependent on the pump selected. Because of the steep performance curve for Orenco's high-head effluent pumps, a single pump model — typically a ½ hp, 10 gpm (0.37 kW, 0.6 L/sec) unit — can be used for all residential connections. As such, the pump performance capability establishes the maximum Total Dynamic Head (TDH) for a piping network. TDH for an effluent sewer collection system is therefore typically expressed as:

Equation 9 $$TDH = h_e + h_p + h_i + h_{hv}$$

where: TDH = Total Dynamic Head, feet or meters
h_e = Elevation head, feet or meters
h_p = Pressure head at the collection line, feet or meters
h_l = Head loss through the service line, feet or meters
h_{hv} = Minor losses through the pump discharge assembly, feet or meters

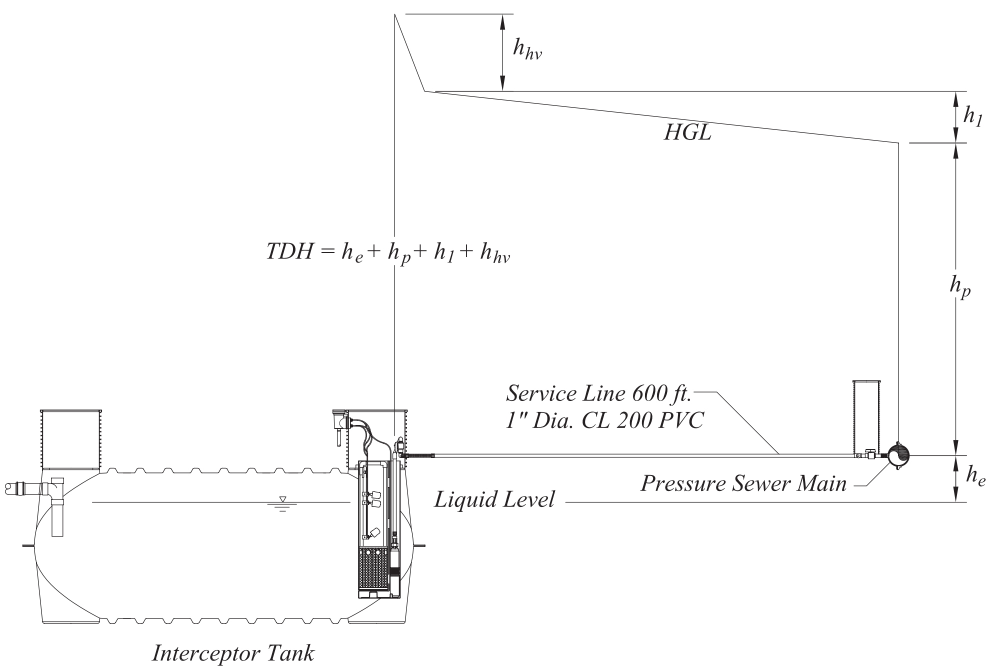


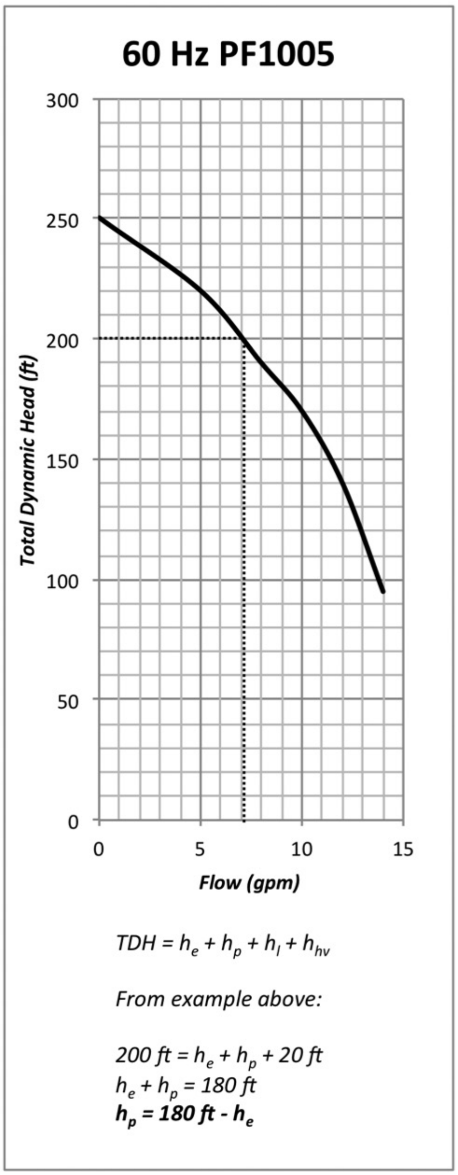
Figure 7. Graphical Representation of TDH in an Effluent Sewer Collection System

The values for h_l and h_{hv} are typically minor; a very conservative value of 20 feet (6 m) can be used when approximating available head for friction loss. For example, with a pump operating at 10 gpm (0.6 L/sec), a 1 inch (25 mm) nominal diameter discharge plumbing assembly, and a 300 foot (94 m) long, 1 inch (25 mm) nominal diameter, Class 200 PVC service line, these losses calculate to:

$$h_l + h_{hv} = \frac{10.557\ L}{d^{4.87}} \left(\frac{Q_P}{C}\right)^{1.85} + 0.033Q^2 = 9.1\text{ft} + 3.3\text{ft} = 12.4\text{ft}$$

So this 20 foot (6 m) value will also account for the elevation difference from the liquid level line in the interceptor tank to the collection line on most sites.

Using a standard 1/2 hp (0.37 kW), 60 Hz, high-head Orenco effluent pump, targeting a TDH of 200 feet (60.9 m) provides an acceptable flow rate of approximately 7 gpm (0.4 L/sec). For 50 Hz models, the acceptable flow rate of 0.5 L/sec (7.9 gpm) is provided at a TDH of 35 m (115 feet). Therefore, the combination of elevation and frictional loss can be estimated using the equations shown below the pump curves in Figure 8:



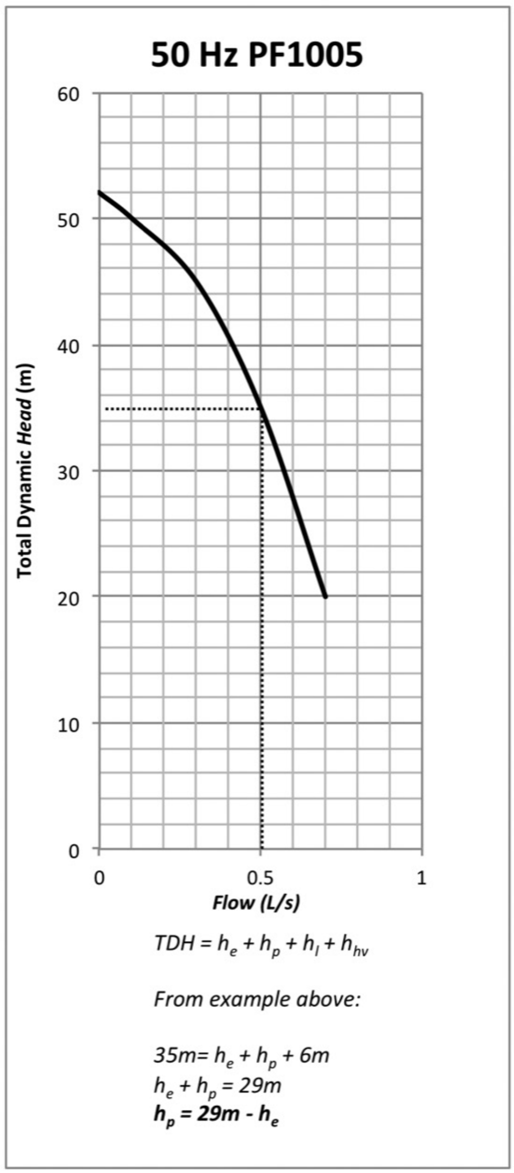


Figure 8. Pump Curves for 60 Hz and 50 Hz Applications

A line profile can be easily generated for the project, highlighting the critical points in the collection system — those with the greatest elevation differences and those with the longest pipe runs. Through these critical points, the elevation can be identified and substituted into the equations provided in Figure 8 to provide for the maximum allowable head loss for any particular critical point. A sample HGL is shown in Figure 9.

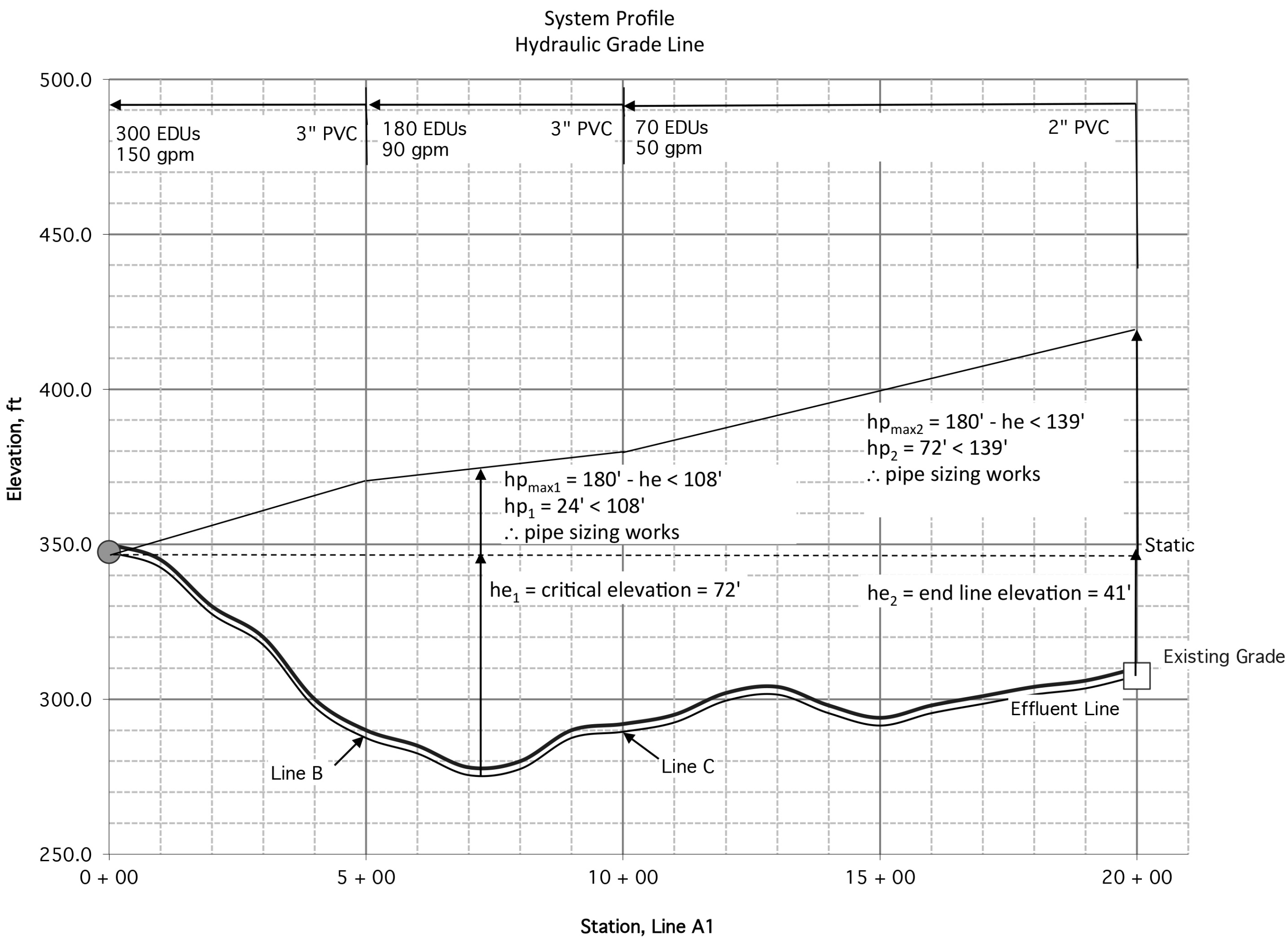


Figure 9. System Profile

When the velocity of flow and corresponding head loss in the collection line becomes excessive, the pipe size or downstream pipe sizes will need to be increased. Figure 10 provides a graphical representation of peak hydraulic flow (in gpm), velocity (in fps), and slope of the energy gradient when using U.S. units and PVC Class 200 piping. To use the graph, determine the hydraulic peak flow using Equations 3 or 4 as provided, and then move horizontally across the page to determine the appropriate pipe diameter based on velocity and slope of the energy gradient. The diagonal line provided is based on 3 people per home and 50 gpcd. In this event, the number of EDUs can be used to move vertically up to the line, and then you can move horizontally to the right to determine the approximate pipe size.

Effluent Sewer Pipe Selection using PVC Class 200

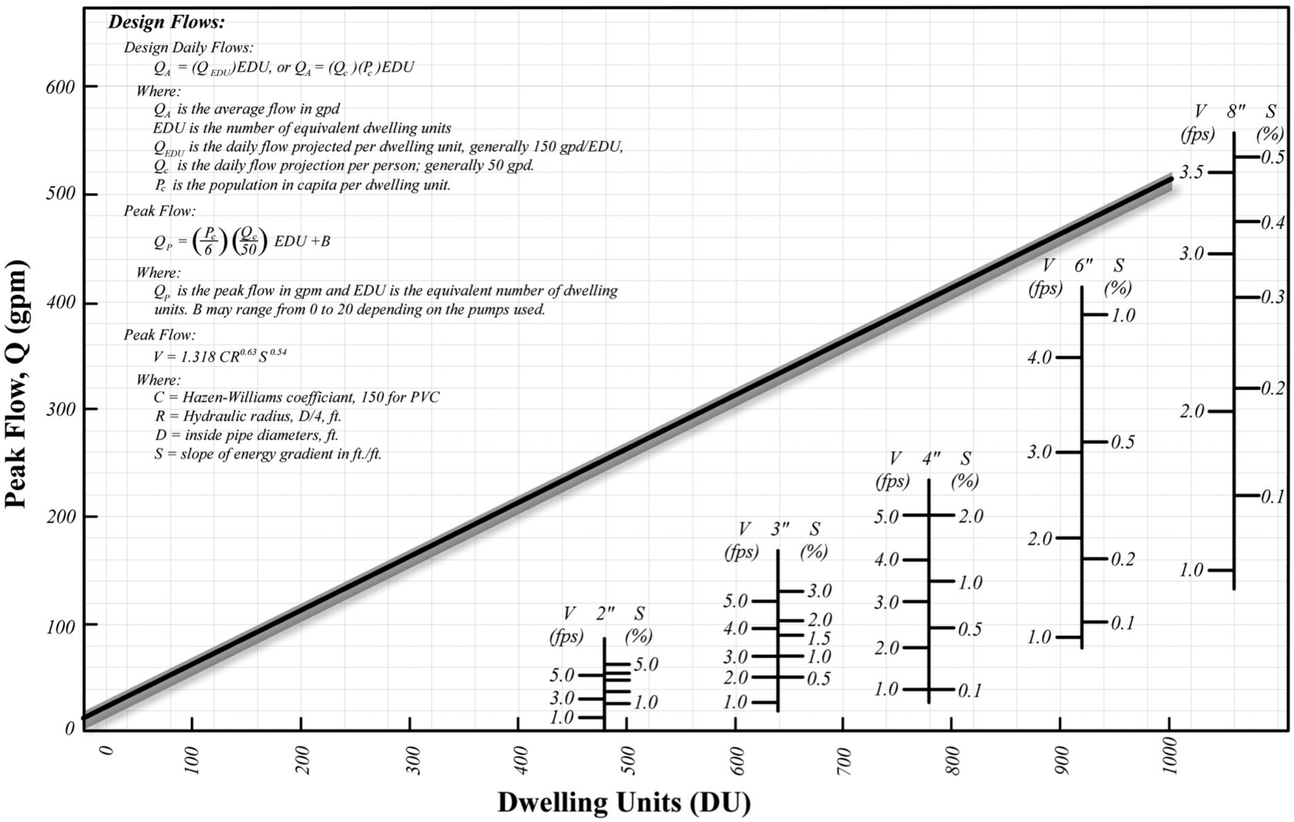


Figure 10. Pipe Selection Graph

Open trench construction using PVC pipe has been the most common construction method used in effluent sewer projects, but with the trend toward septic tank abatement projects in areas with existing infrastructure, directionally bored HDPE has become more common in the past ten years. Table 2 below provides a guide for estimating line diameter to handle hydraulic peak flows for these materials.

Table 2. Typical Line Sizes Using PVC and HDPE Pipe

EDUs	Q_P, gpm (L/sec)[1]	PVC Pipe[2] Size, in. (mm) nominal	Head Loss ft/1000 ft or m/1000m	HDPE Pipe[3] Size, in. (mm) nominal	Head Loss ft/1000 ft or m/1000m
1-50	15-40 (1-2.5)	2 (50)	3.6-22.1	2 (50)	7.2-43.7
51-150	40-90 (2.6-5.7)	3 (75)	3.7-16.2	3 (75)	6.8-29.7
151-250	90-140 (5.7-8.8)	3 (75)	16.3-36.7	4 (100)	8.8-19.7
251-350	140-190 (8.9-12)	4 (100)	10.0-17.5	4 (100)	19.9-34.7
351-500	190-265 (12-16.7)	4 (100)	17.6-32.4	6 (150)	5.3-9.8
501-1000	265-515 (16.8-32.5)	6 (150)	5.0-16.9	6 (150)	9.8-33.4

[1]Assumed P_c of 3, Q_c of 50 gpcd (190 Lpcd), and B value of 15 gpm (1 L/sec); this B value can be dropped after 20 connections, but has been left in for this example.

[2] Nominal diameter shown, Class 200 pipe

[3] Nominal diameter shown, DR11 pipe

2.5 Design Example 1

1. Prepare a plan view of the system. Equivalent Dwelling Units should be grouped into areas (labeled 1-4) relative to their effect on the system, with cumulative EDUs shown at key points, e.g. intersections and area separations, as shown in Figure 11.

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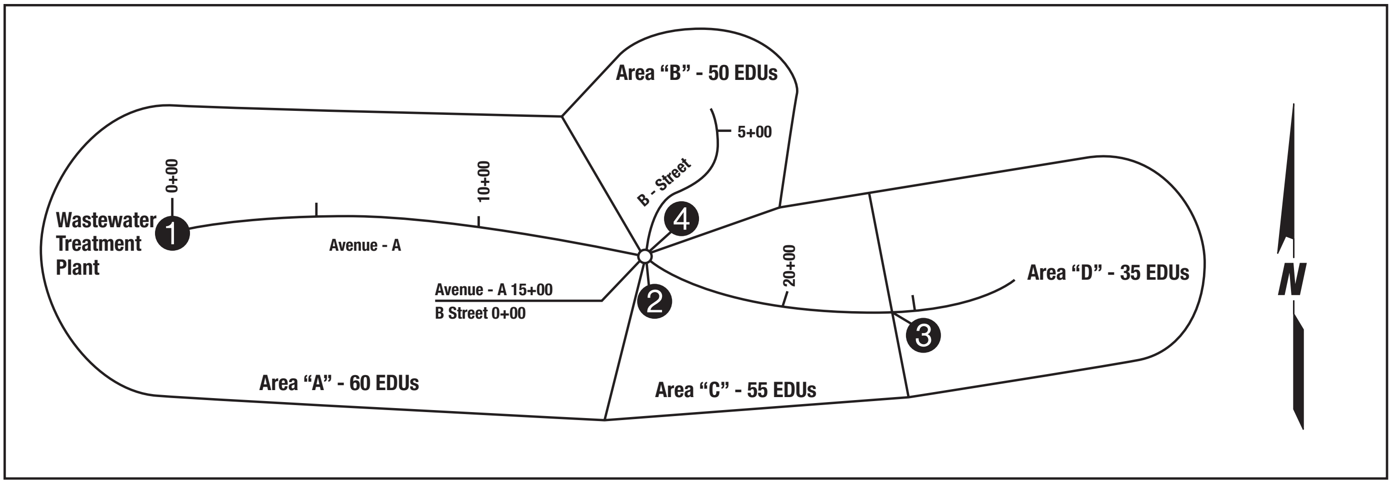

Figure 11. Plan View of Typical System

2. Prepare a profile of the system that shows the ground elevation/contour and then add the pipe elevation to the system.

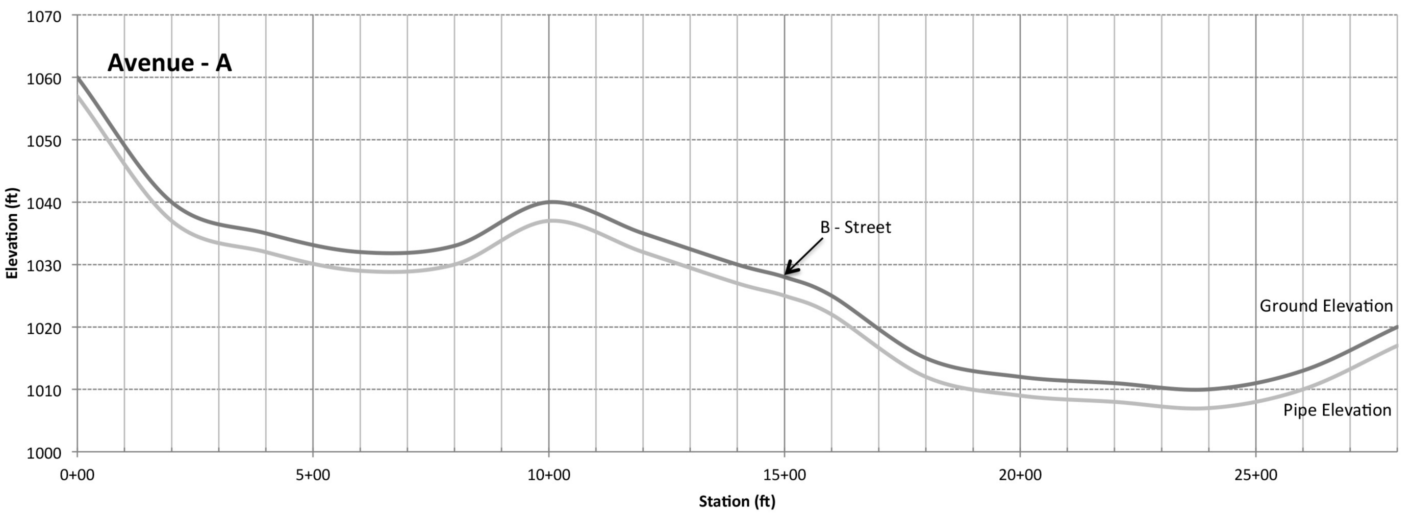

Figure 12. Profile View of Typical System

3. Determine cumulative EDUs to critical points, e.g. intersections and area separations. Use variations in population density or water usage to calculate the peak hydraulic flow, Q_P, using Equation 4. For this example, assume 3 people per household, 50 gpcd (190 Lpcd), and a B factor of 15 gpm (0.94 L/sec).

$$Q_P(\text{gpm}) = \left(\frac{3}{6}\right)\left(\frac{50}{50}\right)\text{EDU} + 15 = 0.5\text{EDU} + 15$$

4. Modify the graph to include the EDUs and hydraulic peak flow values for each section. See Figure 13.

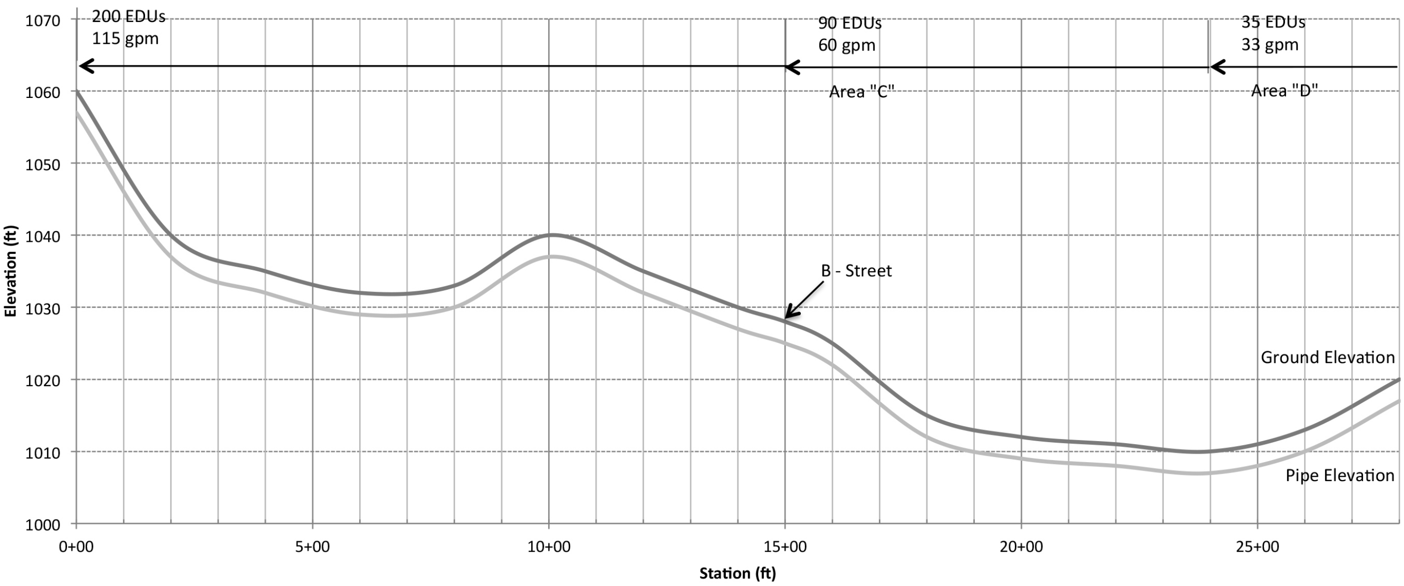

Figure 13. Profile with EDUs and Flows

5. Assuming that Class 200 PVC pipe is used, determine the appropriate pipe size for each of the line segments, using Table 2 and Figure 10 for reference. Sometimes you have to select pipe diameters, calculate critical points within the collection system, and then re-select pipe diameters if critical points exceed pump capabilities.

6. Calculate the friction loss in each segment using Equation 7.

Table 3. Line Sizes Using PVC Pipe

Segment	EDUs	Flow Rate, gpm (L/sec)	Nom. Pipe Size, in. (mm)	Pipe Inside Diameter, in. (mm)	Segment Head Loss, ft (m)
1	200	115 (7.25)	4 (100)	4.072 (103.4)	10.4 (3.2)
2	90	60 (3.8)	3 (75)	3.166 (80.4)	6.4 (1.95)
3	35	32.5 (2.0)	2 (50)	2.149 (54.6)	6.0 (1.83)
4	50	40 (2.5)	2 (50)	2.149 (54.6)	11.0 (3.35)

7. Add the selected line diameters and corresponding cumulative head loss to the profile view. Add the static grade line by drawing a line to the right starting from the discharge point (note: line starts at the pipe, not at ground level). If the line intersects the piping profile, then the pipe becomes the static grade line until it reaches the next high point (see Figure 17 for an example). The static grade line is then again drawn to the right to the end of the mapped segment.

8. Beginning at the point of discharge, plot the hydraulic grade line for Segment 1 (Area "A") on the profile view (again starting at the pipe, not the ground). Then add the hydraulic grade lines for Segments 2 and 3.

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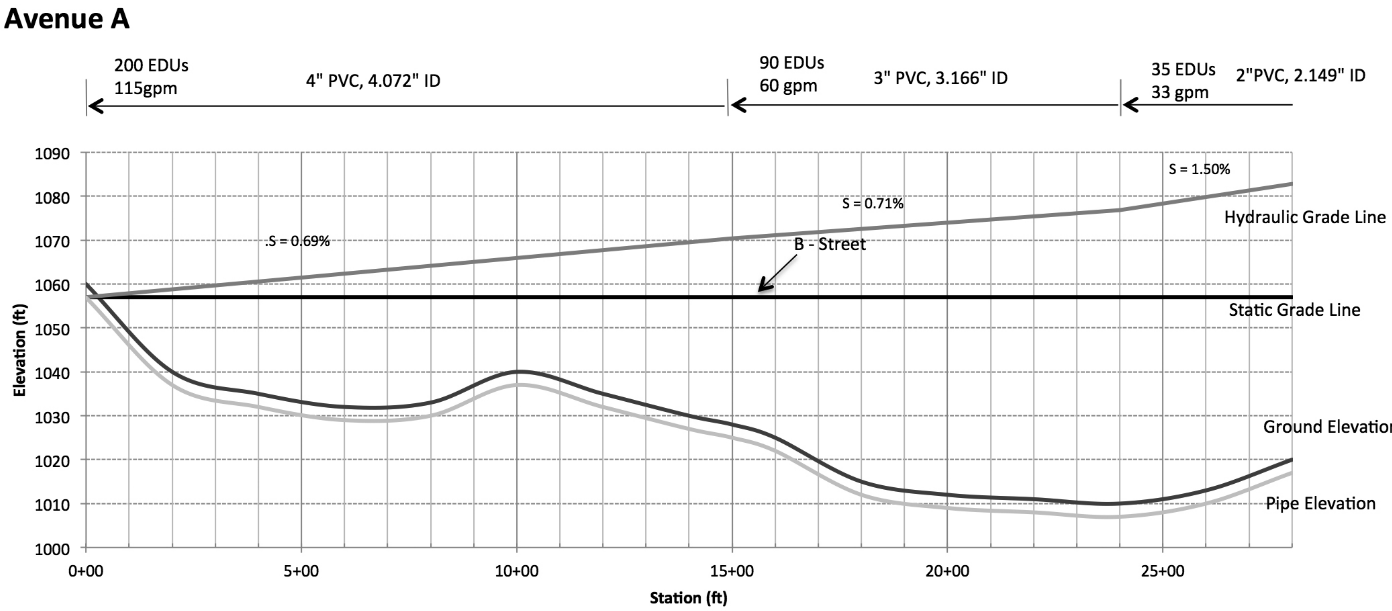

Figure 14. Profile View with Hydraulic Grade Line for Avenue A

9. Lastly, determine the pressure at the point of entry to the main for Area "B" from Figure 14. Looking at the entry point for B Street (station 15+00), the HGL value at this point is 1070 feet. Starting at this value above the static grade line, plot the hydraulic grade line for Area "B."

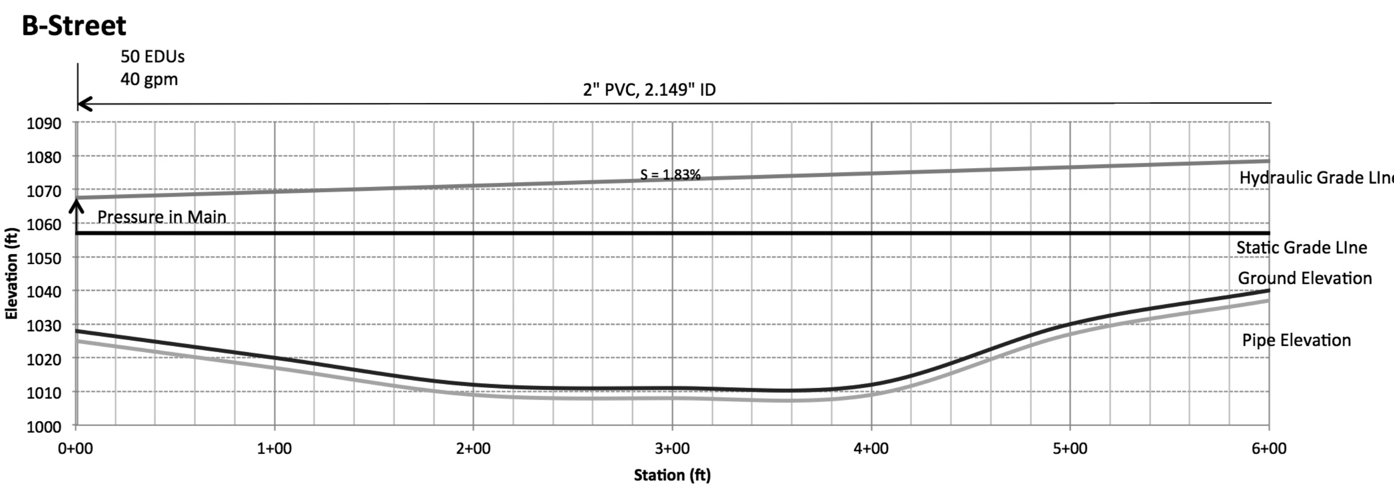

Figure 15. Profile View with Hydraulic Grade Line for B Street

2.6 Design Example 2

Create an HGL using the steps above and the same layout as shown in Figure 11, but with a profile containing a high area near the intersection of B Street and Avenue A.

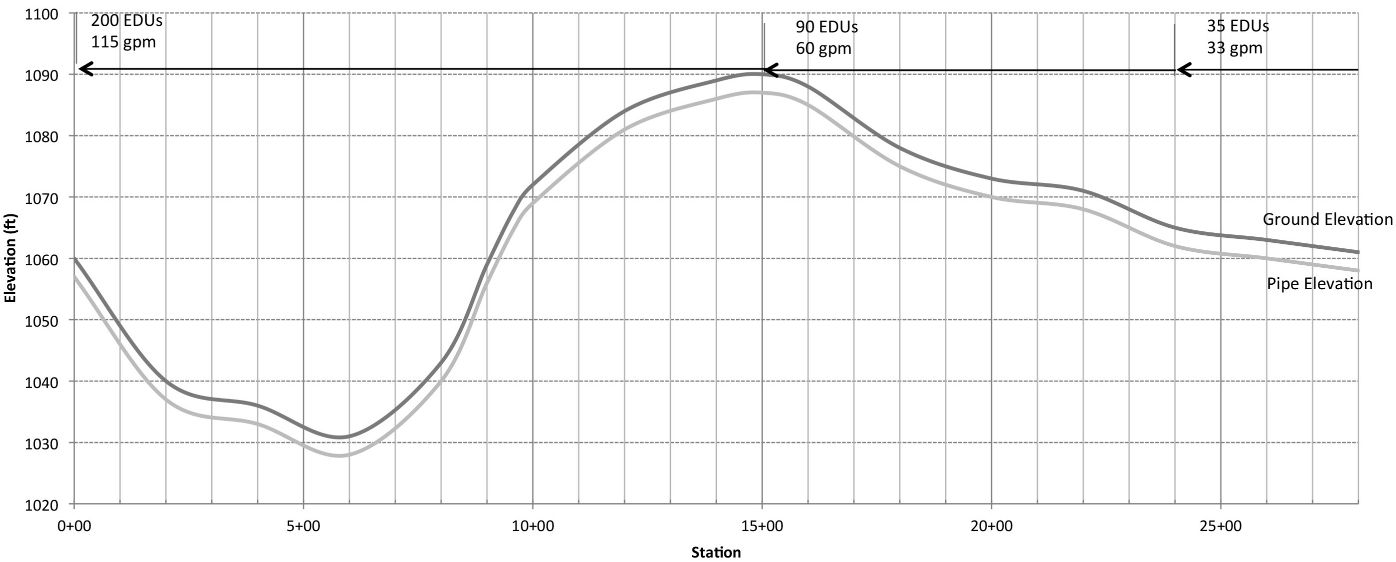

Figure 16. Alternate Profile with EDUs and Flows

Notice that the connections and flows are unchanged. Using the same pipe diameters, the frictional losses will also be unchanged. With that in mind, create the HGL for the system on the new profile. For the section of line between station 9+70 and station 15+00 — where the slope of the ground exceeds the slope of the HGL — the hydraulic grade line becomes the level of the pipe. Where the slope of the HGL exceeds the slope of the ground, the HGL will be continued. In this example, the slope of the HGL doesn't exceed the slope of the ground until the high point at station 15+00. Conservatively, any tank outlet invert that sits at least two feet above the pipe in this section can enter the collection system using an effluent filter on a gravity discharge tank.

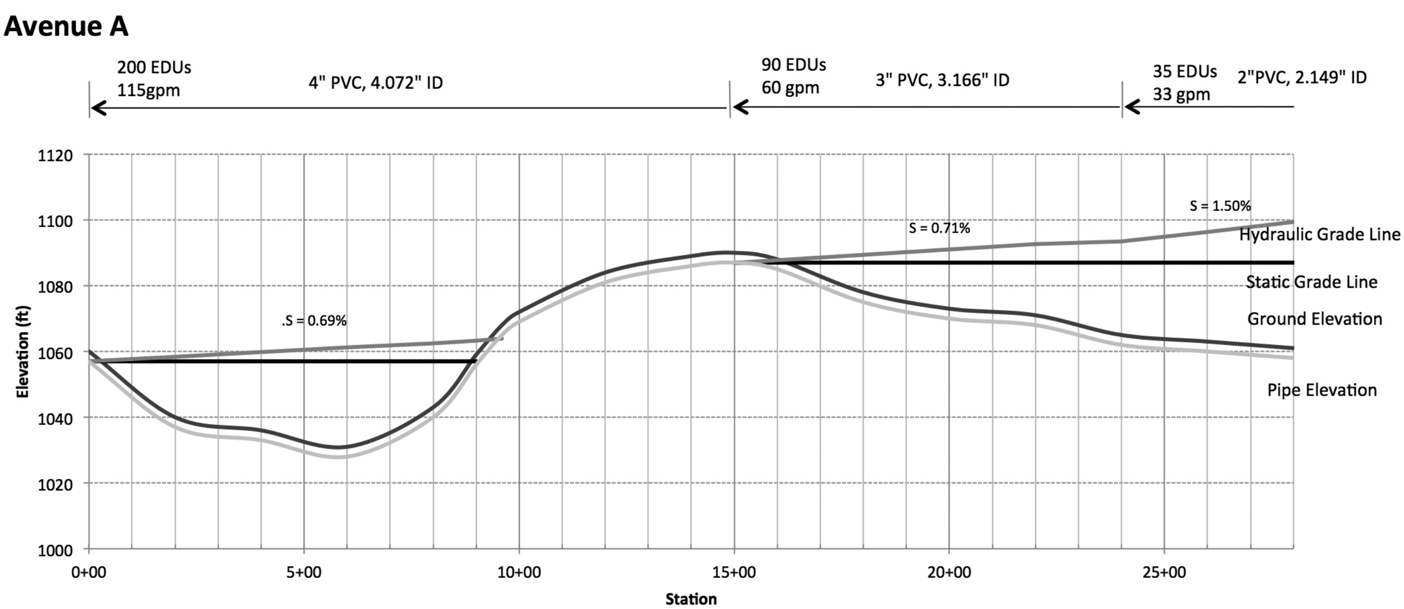

Figure 17. Alternate Profile View with Hydraulic Grade Line for Avenue A

Determine the pressure at the point of entry to the main for Area "B" and plot the hydraulic grade line for Area "B."

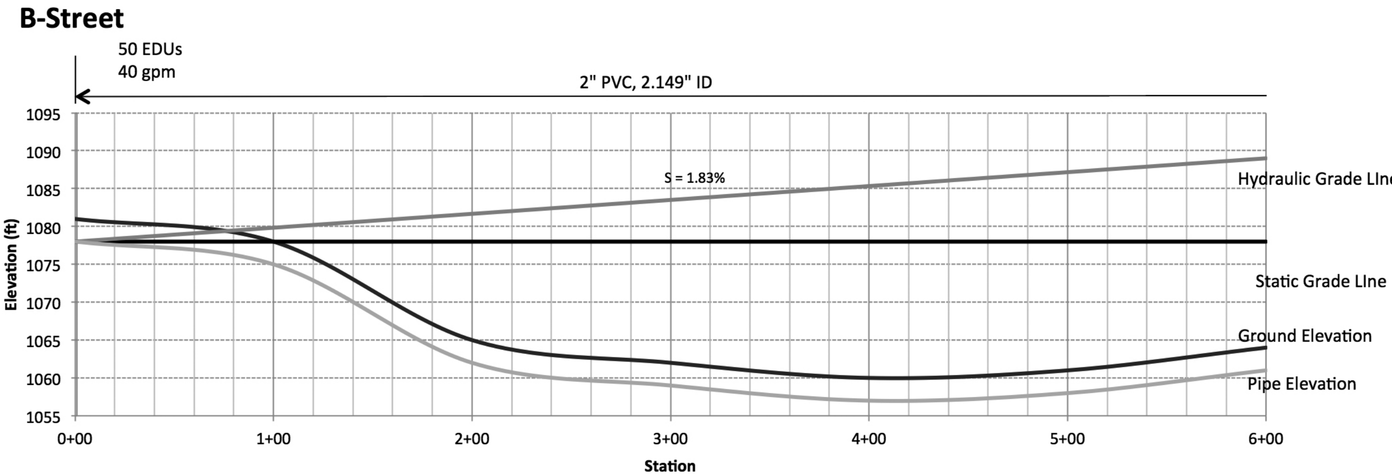

Figure 18. Alternate Profile View with Hydraulic Grade Line for B Street

3. Public Rights of Way

3.1 Introduction

There are a few components of the overall collection system that will be located in the public right of way. Placement of these components should balance the need for utility access for inspection and maintenance with the need to limit access by the general public. Other considerations include vertical and horizontal separation requirements from other utilities that share the public right of way.

3.2 Piping and Fittings

There are two types of piping material that are typically utilized for effluent sewer construction — PVC (Polyvinyl Chloride) and HDPE (High Density Polyethylene).

3.2.1 Pipe Materials

3.2.1.1 PVC Pipe

PVC is an amorphous (non-crystalline) material manufactured from a durable vinyl polymer. The wall thickness for PVC pipe is a fraction of that for HDPE to achieve the same strength; therefore less material is used in the manufacture of PVC, resulting in lower comparative costs. Since there is less material used, PVC is also a lighter material.

PVC pipe contains chlorine and, during the manufacturing process, releases dioxin (a potent carcinogen), and while there is much research and debate regarding the safe usage of PVC (it is commonly used in potable water systems), there are some jurisdictions that opt to restrict its usage. As a consequence, it is not typically specified or used on projects seeking LEED certification.

For pipe sizes of 12 inch (300 mm) diameter or smaller, Class 200 PVC is the most common piping utilized, though Schedule 40 is sometimes used for smaller diameter lines or in areas susceptible to excessive or extreme ground movement. Consideration can be given to the use of Schedule 80 PVC when a thicker walled pipe is appropriate for areas that are less accessible for repair — under paved areas, areas requiring deep bury depth, water crossings, etc. Schedule 80 pipe will induce more head loss than Schedule 40 pipe will, which in turn will induce more head loss than Class 200 pipe (based on inside pipe diameters). Make sure to take this into consideration when calculating friction loss and plotting the hydraulic grade line.

PVC piping that is 2 inches (50 mm) in diameter and smaller typically utilizes solvent welded joints. For pipe sizes greater than 2 inches (50 mm) in diameter, gasketed PVC pipe is most commonly used and thus requires consideration for adequate thrust blocking.

For PVC pipe larger than 12 inches (300 mm) in diameter, DR25 (165 psi or 1120 kPa) and DR21 (200 psi or 1380 kPa) are most common. Based upon typical operating pressures, DR25 PVC is the recommended pipe. DR21 is often used under significant road crossings due to its thicker wall (Winneberger, 1984). For more information on PVC piping, visit the PVC Pipe Association (Uni-Bell) at www.uni-bell.org.

3.2.1.2 HDPE Pipe

HDPE is a semi-crystalline material manufactured from a petroleum-based polyethylene thermoplastic. HDPE pipe is flexible and has the ability to dampen and absorb shock waves, making them less susceptible to damage from surge shocks or ground movement.

HDPE pipe offers an attractive alternative to PVC pipe. Unlike PVC pipe, HDPE pipe is generally fused together rather than glued or connected by gasketed joints or mechanical fittings. Fused connections will provide added assurance against any potential joint failure or joint leak. Also, HDPE pipe has a very high allowable bending radius that can generally mitigate the need for fittings. Lastly, HDPE can be extruded with a green jacket or stripe for easy identification.

HDPE DR11 pipe is typically specified for effluent sewer pressure mains. This pipe has a pressure rating of 200 psi (1380 kPa). It is recommended that HDPE pipe of 3 inches (75 mm) diameter or larger be specified with Ductile Iron (D.I.) outside pipe diameters so that fittings normally utilized with PVC pipe can be utilized on the HDPE connections. When connecting HDPE pipe to mechanical fittings, internal stainless steel stiffeners are required, in addition to pipe restraining that is adequate enough to assure that the pipe end will not pull out of the mechanical fitting. HDPE DR9 (250 psi or 1720 kPa) is often used under significant road crossings due to its thicker wall.

HDPE pipe up to 6 inches (150 mm) in diameter is available on rolls. Many contractors find that HDPE on a roll can be difficult to install at colder temperatures, because the pipe has a tendency to assume the curvature it had on the roll (aka “line memory”). The pipe can be heated prior to installation to assist the installer in laying the pipe flat. Alternatively, pipe of 3 inches (75 mm) diameter or larger is available in 20 foot or 40 foot (6 m or 12 m) lengths. The 40 foot (12 m) lengths are preferred since they will reduce the number of fused joints that are required.

For more information on HDPE piping, visit the Plastics Pipe Institute® (PPI) at www.plasticpipe.org.

3.2.1.3 Fittings for PVC Pipe

Fittings for PVC Pipe with nominal diameters of 6 inches (150 mm) and smaller are typically socket-type Schedule 40 PVC and attached to the pipe with solvent welded joints. Fittings for PVC Pipe with nominal diameters greater than 6 inches (150 mm) should be evaluated based upon the conditions of the job. For these diameters, epoxy coated ductile iron with mechanical joints has historically been used — primarily due to availability issues and the high cost of large diameter PVC fittings. However, PVC has become more affordable over the past decade and should be evaluated for these situations. Other materials include stainless steel or brass.

3.2.1.4 Fittings for HDPE Pipe

While joints can be fused for small-diameter HDPE, mechanical compression type connectors are common. Fittings can be PVC body, HDPE body, stainless steel, or brass. When using HDPE, a transition fitting is often required at the tank, as most pump discharge assemblies are constructed of PVC fittings.

3.2.2 Installation and Construction

3.2.2.1 PVC Pipe Installation

PVC pipe is the material of choice for mainline piping when the method of installation is the traditional open trench. PVC is fairly rigid and requires fittings for changes of direction, including sweeping turns. Trench excavation, backfill material, and compaction should comply with the engineer's specifications, manufacturer's instructions, and local regulations. Fused PVC is beginning to increase its market share for directional boring applications, but still lags behind HDPE.

3.2.2.2 HDPE Pipe Installation

HDPE pipe is the material of choice when the method of installation is directional boring. Being highly flexible, HDPE can be installed on long, sweeping runs, and it can allow for some pipe direction changes without the need for fittings. HDPE can also be used in typical open trench construction. Trench excavation, backfill material, and compaction should comply with the engineer's specifications, manufacturer's instructions, and local regulations.

3.3 Terminal End Clean-Outs and Pigging Ports

The on-lot interceptor tanks remove 70 to 90 percent of the greases, oils, fats, and solids from the waste stream. Effluent sewers that are properly designed, installed, and maintained have demonstrated little or no need for line cleaning.

Traditionally, older STEP collection systems were planned with the inclusion of pigging ports due to the concern that an accumulation of grease and solids would reduce a system's capacity by necking down the flow area and increasing friction losses. In the event that grease or solids reduced hydraulic capacity, "pigging" could clean the line. This was accomplished by introducing a bullet-shaped polyurethane foam device, or "pig," into the line at a "pigging port" and using water pressure to force the pig through. The exterior of a cleaning pig is normally coated with a plastic material in a spiral or crisscross design to aid in scrubbing the pipe's inner walls. Pigging ports would be located at strategic points in the collection lines (significant line size changes, major intersections, etc.). Due to the effectiveness of interceptor tanks in effluent sewer systems, plugging issues do not occur, except in rare instances that are usually isolated to individual service laterals, so pigging devices are typically only used for the removal of construction debris. Orenco no longer recommends pigging ports for effluent sewer designs.

If necessary, effluent sewer mains can be purged of solids and construction debris by open flushing with water. Open flushing can be incorporated into new construction through the provision of a water source and a discharge location. A potable water source, such as a fire hydrant, can be utilized in an emergency, as long as proper backflow prevention is provided, but the use of potable water is discouraged due to concern about cross contamination. The discharge can be blown off through temporary piping that is installed at the end of the main. In an existing main, water can be forced into the main at a quantity adequate enough to provide scouring velocity. The duration of the flushing should be restricted in order to ensure that the treatment plant's capacity is not impacted.

3.4 Mainline Testing and Inspection

Primary inspection for construction contract compliance is generally the responsibility of the utility or its agent (often the consulting engineering firm). For private developments, the design engineer often provides oversight for these activities. During construction and installation, maintenance personnel should be on-site to ensure the integrity of the system, to become familiar with all aspects of the project, and to protect the owner's interest.

As with any wastewater collection technology, a properly constructed effluent sewer is necessary to avoid recurring problems within the system. To assure the effluent sewer's integrity (or in the case of an extension, the integrity AND compatibility with the existing system), diligent inspection is essential. Inspectors must be thoroughly familiar with all construction and testing practices, and they must be especially aware of problems that can arise from faulty installations or equipment.

It is important to rigorously adhere to all hydrostatic testing procedures and requirements. Allowable AWWA leakages should be the maximum, not to be exceeded. Zero leakage should be the goal.

3.4.1 Hydrostatic Test Procedure

1. Fill the line with water to expel air.
2. Pressurize to the desired pressure at the lowest point.
3. Hold for two hours to 5± psi (34± kPa) of test pressure (typically 100-150 psi or 690-1034 kPa).
4. Accurately record time, pressure readings, and amount of leakage.
5. Allowable leakage is calculated using the following equation. For further details, refer to AWWA C 600 Section 4.

Equation 10

$$L = \frac{S D \sqrt{P}}{133,200}$$

*where: L = Allowable leakage for push-on or mechanical joints, gph**
S = Length of pipe tested, feet
D = Nominal pipe diameter, inches
P = Average test pressure, PSI, at lowest location on test section
*Add 0.0078 gal/hr/in of nominal valve size for each metal-seated gate valve pumped against.

Portions of the line that are critical or considered suspect should be left exposed throughout the hydrostatic test to allow visual inspection. Leaks detected visually should be repaired regardless of test results. The use of dye during initial filling and testing of a mainline section makes isolating leaks much easier, especially in areas experiencing high ground water.

Check-valve failure in service lines is difficult to diagnose and may misrepresent mainline integrity. Therefore, service line connections should remain closed until mainline testing has been concluded. Accurate records must be kept to assure all service line connections have been opened after the mainline system has been approved.

Testing long segments of line should be avoided whenever possible. A lengthy segment of line may pass the leakage test, yet still have an isolated leak that is excessive and which could prove to be a problem later. Testing shorter segments of line reduces this possibility and more readily isolates any leaks. The most common recommendation is to limit the test length to 12,000/D, where D is the diameter in inches, and the length of the segment is in feet.

Because air is compressible and escapes from pipelines more rapidly than does liquid, it is important that all air is purged from a section of line prior to hydrostatic testing. Failure to do so may give misleading test results, possibly causing the section of line to appear to fail the test.

3.5 Pipe Restraints

PVC piping should be restrained during testing in order to withstand the test pressure. For PVC bell & spigot pipe, bell restraints are recommended rather than thrust blocking. If fusion welded HDPE pipe is utilized, no pipe restraints are required. Working pressures in effluent sewer mains are typically well below the test pressures for newly installed mains.

3.6 Isolation Valves

Mainline valves are necessary to isolate sections of lines and to reroute flows in the event of a line break or other emergency. Traditional design guidelines for valve placement in effluent sewers are normally consistent with water main valving. In practicality, since effluent sewer mains are operated at much lower pressures than water mains, the likelihood of an effluent sewer main breaking due to excessive pressures or water-hammer effects is low. In fact, breaks are typically limited to pipes that are physically damaged by contractors or to pipes that were improperly bedded and backfilled. Because of this limited risk, valving plans should minimize the number of valves.

3.6.1 Valves for Use with PVC

Ball valves can be used for lines 3 inches (75 mm) and smaller in diameter, but become cost prohibitive above that size. Gate valves are typically used for line diameters larger than 3 inches (75 mm), though the designer can consider the use of plug valves since they may be more reliable in wastewater applications. When cast iron or ductile iron valve bodies are used, it is important that the interior of the valve be lined with a material appropriate for wastewater application. Fusion bonded epoxy is common. To assure quality, the manufacturer should apply the lining.

3.6.2 Valves for Use with HDPE

The use of HDPE pipe requires additional considerations and offers other possibilities relative to valving. If traditional cast iron or ductile iron valves are used in conjunction with HDPE pipe, internal stainless steel pipe stiffeners will be required for connection to the pipe. Alternately, fused valves can be considered, although the serviceability of fusion welded HDPE valves is a concern.

Another possibility when using HDPE piping is reducing or eliminating any mechanical valving altogether. While the designer may still want to install mechanical valving at critical points or on larger mains, small mains could be planned with the intent of utilizing a specially designed crimping tool to isolate or shut down a main. If a crimping concept is utilized in association with looped service mains, breaks could conceivably be isolated while limiting service disruption to a small number of customers. Additionally, the capital cost and the ongoing maintenance costs associated with valves would be reduced or eliminated.

3.7 Air and Vacuum Release Valves

Excessive air and gas accumulation may diminish a system's hydraulic capacity by increasing system head losses. An initially liberal placement of manual air release assemblies is encouraged (with occasional placement of automatic air release valves in areas of obvious air accumulation). Locate air release valves at the critical high points and the high points on pressure-sustaining devices where it is necessary to keep the system purged of air. For long, flat runs, air release valves may be placed at reasonable intervals (2000± feet or 600± m) along the mainline to address air accumulation issues.

Manual air release assemblies can be purchased inexpensively. Most manual air release assemblies consist of a line tap or a tee and a pipe extended to grade that is terminated in a meter box with a lever (stainless steel) actuated ball valve. A typical manual air release assembly is shown in Figure 19.

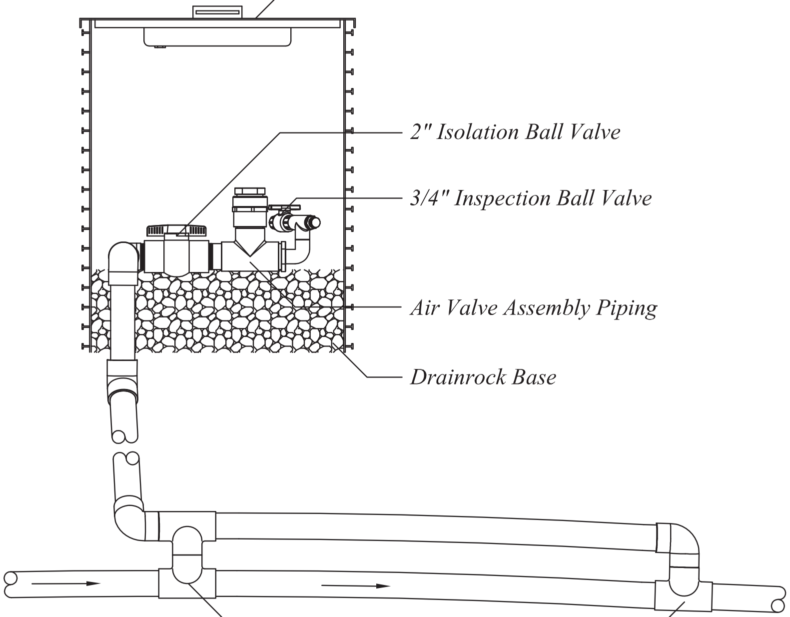

Figure 19. Typical Manual Air Release for Effluent Sewer Lines

When manual air release assemblies are installed, it is critically important that system operators understand that the air releases must be opened regularly by hand until the operators can document that no air entrapment is occurring. Through regular operation, operators can document those manual air release valves that can have an extended time interval between openings. In many cases, proper documentation will show that manual air releases can be ignored unless elevated line pressures are noted. While the manual air release is not being used, it will require little in the way of maintenance. If a manual air release is located where air pockets accumulate regularly, it can be converted to an automatic air release.

Generally, manual air releases should be appropriate for any pipe deflection that is less than 6 feet (2 m) in the vertical dimension. Accordingly, the use of automatic air release assemblies can typically be limited to pipe deflections greater than 6 feet (2 m), and to those mains deemed critical due to the nature or quantity of customers they serve.

Because of minimal solids in the collection lines of effluent sewer systems, designers can use automatic air releases typically used in water systems, as long as they have a stainless steel vent port (see Figure 20). Many first-time effluent sewer designers utilize large precast structures, cast iron lids, unnecessary piping, and expensive, solids-handling air release assemblies. While robust, these air release standards can easily be 3-5 times more expensive than the water system valves. When overly expensive automatic air release assemblies are used liberally, the installed cost of the mainline can escalate substantially, and O&M costs for the assemblies can become unnecessarily excessive.

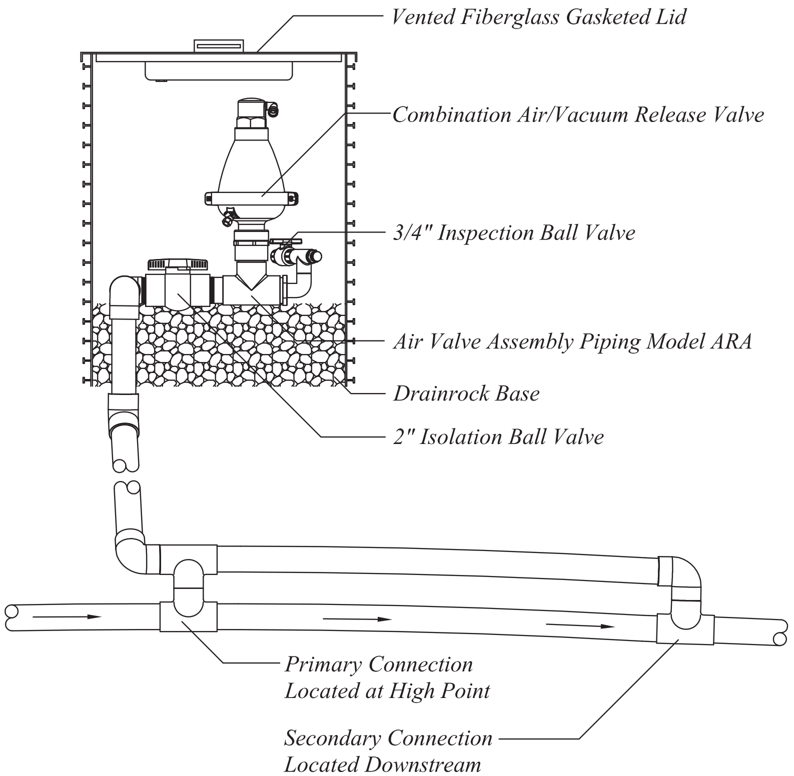

Figure 20. Typical Automatic Air/Vacuum Release for Effluent Sewer Lines

Automatic air release assemblies should be inspected annually or more frequently, depending on their performance. All automatic air release assemblies should be vented through activated carbon filters or soil beds to scrub odors.

3.8 Pressure Sustaining Devices

Since the development of the high-head effluent pump — with its low-flow, high-pressure operational characteristics — the need for pressure sustaining devices has become much less significant, and they are rarely used in today's effluent sewer designs. When effluent sewers were first developed, they used single-stage centrifugal pumps. These pumps had limited head capacity and operated at high flows when there was little head pressure in the line. Pressure sustaining devices were used to reduce the impact of excessive head loss caused by the two-phase flow where air or gas accumulations in the lines were expected to cause excessive head losses. High-elevation points in the lines had to be carefully evaluated to determine where pressure sustaining was necessary, in order to maintain upstream static pressures in those portions of the system higher in elevation than the point of discharge. Pressure sustaining devices were as simple as a standpipe (where the terrain allowed), or as sophisticated as roll seal valves that used a predetermined hydro-pneumatic pressure to establish the upstream static pressure.

3.9 Odor Control

Sulfide odor and sulfuric acid corrosion issues can occur in any type of wastewater collection system, regardless of type or size. Although this is discussed in textbooks as well as national design and operational manuals, sewer odor and corrosion control issues in wastewater applications are all too often ignored at the time of design. Designers who ignore sulfide production in gravity sewer designs claim that the wastewater stream will always maintain a sufficient level of dissolved oxygen (DO) and thus, sulfide issues shouldn't be critical or need attention. Nevertheless, all wastewater contains vast colonies of microorganisms and a healthy supply of organic matter that is their food. These microorganisms require oxygen, and when they consume the free oxygen in the wastewater stream, reactions occur that produce sulfides. Sulfide production is inevitable in all phases of wastewater collection and treatment. To prevent odor problems, it is critical that designers pay great attention to predicting when and where sulfides will be generated, prevent odor problems through design as much as possible, and become thoroughly familiar with aeration and chemical control methods.

In a properly designed effluent sewer system, odors are very rare and avoidable. Mainlines aren't exposed to the atmosphere, gases from septic tanks are individually expelled through house vents (typically in unnoticeable amounts), and gases that are exhausted from air release valves are vented through carbon filters, soil beds, or other appropriate odor-scrubbing methods. However, when any pressure line is opened to atmosphere (i.e. connected to a gravity manhole), the possibility for odor is high, and measures should be taken to reduce the impact of the odor.

The rotten-egg odor of hydrogen sulfide (H_2S) is the odor most often associated with domestic wastewater processes. While it can originate from many sources, not always sewer related, the public's natural inclination is to blame the public sewerage system. It's the responsibility of maintenance personnel to respond to these odor complaints.

Odors originating from a spill or broken pipe are usually easy to trace. A leaking manual air release valve or a very active automatic air release valve is a likely place for odors to originate because of the expelling and liberation of sewer gases. Soil absorption beds or carbon filters are useful for preventing complaints in these cases.

3.9.1 Methods for Controlling Sulfide Odors and Corrosion

3.9.1.1 Mainline Air Injection

Using a compressor to inject air into large municipal lift stations and force mains can be effective, but only if the line velocity is sufficient to maintain two-phase flow (keeping large bubble segments rolling along the crown of the pipe) and the air has been applied to the ascending lines with adequate air releases. The bubbles rise and tend to collect or coalesce at the soffit, or high points of the pipe, so the compressor and the pumps have to run continuously to ensure the retention time in the pipe is less than the time that it takes the oxygen demand to strip the dissolved oxygen (DO) from solution. The oxygen uptake rate (OUR) can be measured, and the retention time in the pipe can be estimated in order to determine the amount of air needed.

Injecting air into pressure mains is inefficient. It increases line pressure (head loss), exacerbates gas pocket collection at high points, and increases chances of corrosion. When considering air injection, the cost analysis must address the power consumption required to maintain adequate line velocity and to overcome additional head loss caused by two-phase flow. In most cases, this additional operating cost alone amounts to several hundred dollars per month.

3.9.1.2 Aeration

Pre-aeration of STEP/STEG effluent that is free of solids, grease, and oil is simple, typically requiring minimal effort by operational personnel. Energy costs are minimal, and when pre-aeration is utilized, a degree of secondary treatment occurs in the collection mains.

Cascading aerators are effective at elevating dissolved oxygen levels and liberating 25-50% of the dissolved sulfide (H_2S), depending on the pH level of the effluent. The hydrogen sulfide released by the aerator is filtered through activated carbon or other odor-scrubbing means before exhausting to the atmosphere. The sulfides (H_2S, HS^-, S^{2-}) that are not released remain in solution and are further oxidized by the dissolved oxygen. The actual degree of sulfide reduction is dependent on many factors and will have to be determined with each field application.

Aeration at the end of the pressure main, before the effluent is discharged to a gravity line or treatment process, is more efficient and manageable than mainline injection, especially for effluent sewers where solids and organic strengths are reduced considerably by the primary treatment occurring in the interceptor tanks. Figure 21 illustrates a typical effluent sewer end-of-line aeration unit. End-of-pipe aeration using venturi aspirators to create smaller, more efficient microbubbles has proven to be the most cost-efficient method for controlling odors in effluent sewer applications.

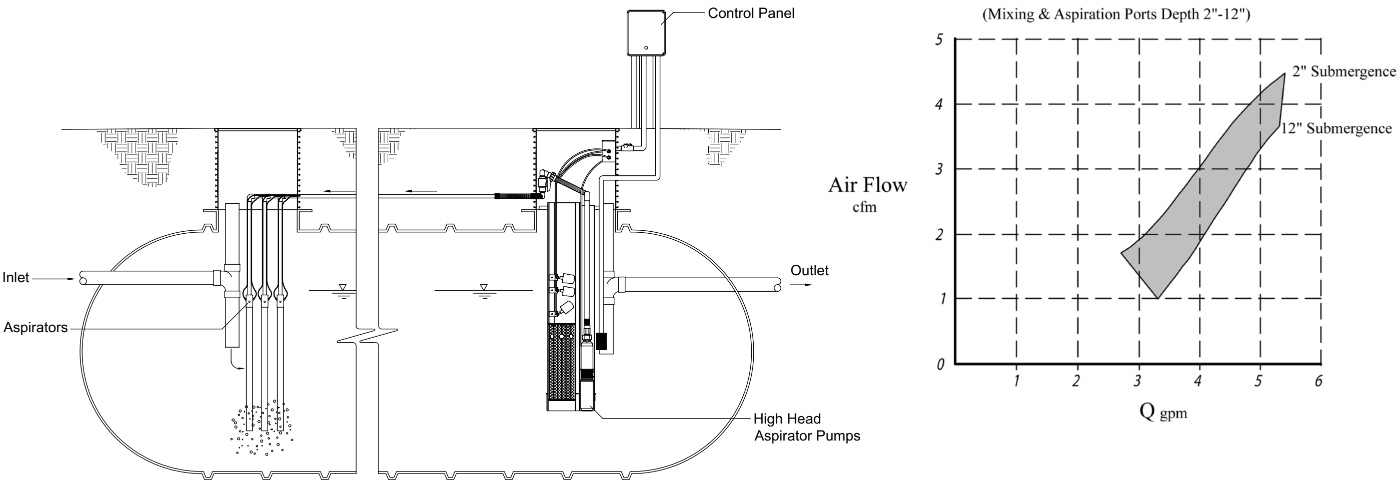

Figure 21. Typical STEP/STEG Aeration Tank with Aspirators

3.9.1.3 Chemical Control

Chemical supplements such as Cl_2, H_2O_2, $NaNO_3$, $Ca(NO_3)_2$, O_3, O_2, NO_3^-, etc. can be injected into the wastewater stream. These compounds limit the production of sulfides by inhibiting anaerobic microbial activity through disinfection or pH control, by providing a supplemental source of oxygen to support aerobic microbial activity, or by directly reacting with the sulfides in a sacrificial compound. Chemical addition is more expensive than aeration, generally, and requires greater monitoring and maintenance. For systems that require chemical supplements, Table 4 below lists a few treatment options.

Table 4. Treatment Options for Sulfide Control

Method	Dosage	Reaction time	Advantages	Disadvantages
Chlorination (Cl_2)	$\frac{9\ mg/L}{mg/L\ H_2S}$	Instantaneous	• Low installation cost • Instantaneous reaction with H_2S and other odor-causing gases • Good for disinfection • Supplemental when used for disinfection	• Large concentrations are toxic to aquatic life as well as beneficial microbes • High chemical cost ($0.30/lb) • May require dechlorination
Hydrogen peroxide (H_2O_2)	$\frac{1\text{-}3\ mg/L}{mg/L\ H_2S}$	15-30 min	• Excellent source of DO • Low installation cost • Excellent for oxidizing other problem compounds • Nontoxic to aquatic life	• Overdosing may produce sulfuric acid; strict control is necessary • Explosive when stored in a sealed container; H_2O_2, H_2O, plus O_2 builds high pressures (severe if 30% or greater concentration of H_2O_2 is exposed to heat) • High chemical cost ($1.10/lb) and maintenance cost ($3.45/gal 50% concentration peroxide)
Ozonation (O_3)	1-2 mg/L-hr	10-15 sec (allow 30 min)	• Nontoxic • Good virucide • Contributes to high DO • Quick reaction time (15 sec)	• On-site generation from air requires 12 kWh/lb O_2 • High initial cost to generate from air • Technology not yet refined • Toxic gas sometimes requires site preparation
Oxygenation (O_2)	10-15 mg/L-hr	15-30 min	• Cost • Simple maintenance	• Design transmission lines for greater head losses • High re-aeration rate
Air injection (20%± O_2)	1 cfm/ 1-in. diameter		• Nontoxic • Nonchemical • Contributes DO • Simple construction • Low cost to install for commercial applications	• Requires ascending pipe line and positive air release • High cost to maintain • Could cause air binding or excessive pressure losses • Long detention time is necessary
Sodium Nitrate ($NaNO_3$) or Calcium Nitrate $Ca(NO_3)_2$	1.5 gal /1000 gpd	2 hours	• Storage • Dispensing	• Deposits • Cost $2.25-$3.40 per 1000 gpd • Adds nitrogen to waste stream, which could impact treatment facility if dose is excessive
End-of-Line Aeration Venturi Aspirator	3 to 6 cfm	5 minutes ±	• 1500 gallon tankage per 10,000 gpd • 20 to 40% BOD_5 reduction • Power consumption $2.50± /10,000 gpd	• Sludge accumulation in tank
Bio-Magic	0.5 gal/1000 gpd	Instantaneous	• Non-hazardous • Storage • Dispensing	• Cost $6.25 per gallon
Thioguard® (Magnesium Hydroxide)	0.1 gal/1000 gal	N/A	• Non-hazardous • Storage • Dispensing	• Raises pH, must be handled by plant • Cost $6.00 per gallon

3.9.1.4 Odor Control through Discharge Design

Effluent sewer mainlines should pump directly to the point of treatment whenever economically and logistically feasible. Because effluent sewer collection is a critical tool used in the expansion of many existing gravity systems, these connections should be carefully planned.

Discharging effluent from any pressure sewer main or force main into an existing gravity sewer main will create a significant risk for H_2S release. Discharges into gravity sewer systems should be treated by aeration, air injection, or chemical addition prior to discharge. Additionally, the discharge should be designed with the following goals in mind:

1. Introduce the incoming pressure flow into a manhole, avoiding any splashing or turbulence of the incoming waste stream that would liberate H_2S.

2. Orient the incoming pressure pipe directly into the flow stream of the manhole using a flexible material, and keep it submerged whenever possible.

3. Reduce the incoming flow velocity to the same velocity as the design for the pipe run that exits the manhole. This can be achieved by laying pressure pipe of equal size and gradient upstream of the manhole. The laying length of the incoming pipe should be of adequate length to assure that incoming flow is entering the manhole by gravity flow rather than pressurized flow.

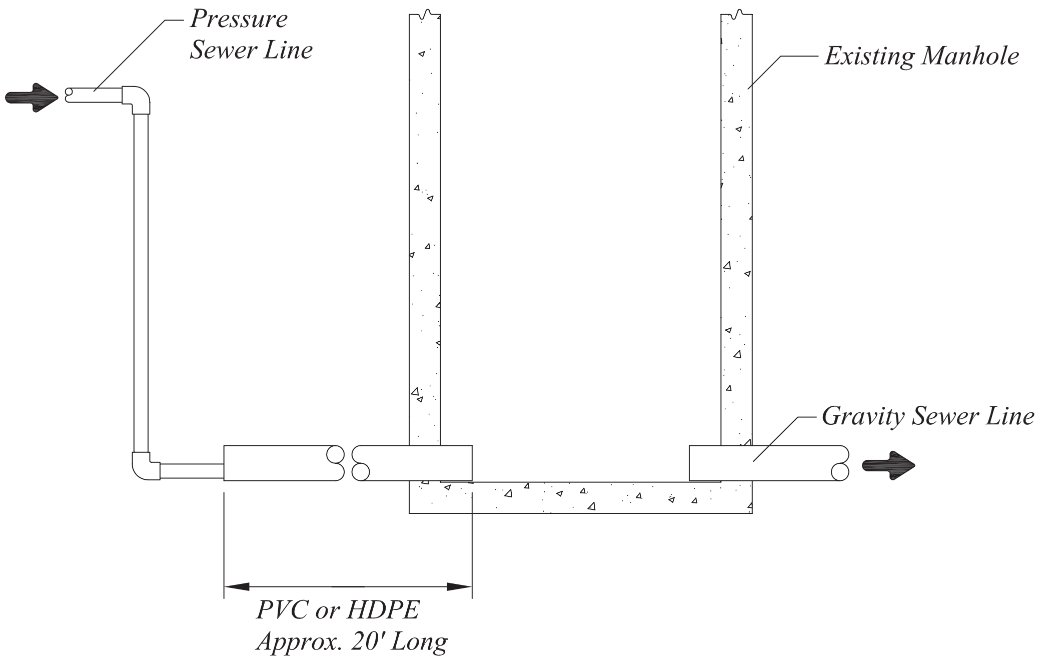

Figure 22. Method for Tying an Effluent Sewer into a Gravity Sewer

3.10 Freeze and Damage Prevention

Underground effluent sewer components are normally buried below the frost depth. In extremely cold climates where frost depth is significant, underground components may be protected by insulation or heating tape. Tank access risers should be backfilled with pea gravel or other measures to prevent frost heave from separating the riser from the tank. Bridge crossings and air release valve locations are especially susceptible to freezing. All bridge crossings, valve boxes, and air release valve assemblies should be protected with appropriate insulation for freeze protection. Continuous water movement inhibits the freezing process, so as long as the system maintains even a slight flow, mainlines shouldn't freeze unless conditions are extreme.

An effective permit system to control excavation in the right of way can minimize accidental damage to effluent sewer mains. Prior to digging, excavators and contractors should be required to call the sewer utility to request location of the effluent sewer lines. Marking the route of lines with offset warning signs, keeping as-built plans current and available, and burying toning wire and warning tape with the lines simplify the process of locating the lines and help prevent damage. District personnel should be able to mark the sewer's location within a few hours of a request. The best way to avoid line ruptures is for an inspector to be present during excavations.

Operators of the Glide, Oregon, system — one of the oldest effluent sewers — report that in thirty-four years there have been fewer than six mainline breaks in their 20 mile (32 km) system. Typically, breaks are reported as the result of new service line connections being made, excessive settlement due to inadequate pipe bedding, or the installation of another utility. Repairs generally take little time and cause little or no disruption of normal operations within the community. This low frequency of line damage is attributable to the quality of the installation, the offset marking system, local utility one-call locates, and the lines being located where damage is unlikely.

4. Private Property On-lot Connections

4.1 Introduction

The on-lot portion of any collection system is essential for the system's overall success. With gravity sewer, homeowners are responsible for everything on their private property. On the face, this may sound great for the utility — its employees typically don't have to enter onto private property to perform their duties. But in reality, the majority of I&I comes from the private property portion of the system, and there is little that the utility can do other than provide for conveyance and treatment capacity for this excess flow.

The on-lot portion of an effluent sewer project should be owned and operated by the utility — even if local or state regulations allow homeowner operation. Utility ownership of on-lot components allows the district to easily identify I&I issues and more effectively manage or eliminate them through proper utility control.

Reactive and preventative maintenance procedures associated with on-lot components are infrequent and involve minimal labor. For example, the City of Lacey, Washington, has been installing effluent sewer since the early 1990s and has a very thorough record of service events. As of 2013, there were over 3000 total connections. Their reactive maintenance calls have steadily declined as they have improved their operational procedures and, as of 2015, they are expending fewer than 2 hours per month for every 100 connections for alarm calls. On average, each home is visited once every fifteen (15) years for reactive maintenance.

4.2 Interceptor Tanks

4.2.1 Tank Sizing for Single-Family Residences

Interceptor tanks for single-family residences are sized both to accomplish acceptable primary treatment and also to provide for reasonable septage removal intervals. Figure 23 represents the findings of a statistical study of the pumpout intervals for the Glide, Oregon, effluent sewer (Bounds, 1989). From this study, a 1000 gallon (3785 L) tank would need septage removal every 11-12 years for a typical family of three, based on a 95% confidence level — meaning 95% of the tanks will go longer than 11-12 years before pumping will be necessary. On average, the pumpout frequency would extend to around 28 years for a family of three (P_c = 3/EDU). Tanks for households of ten or more may be sized according to the multiple user guide; see Table 6.

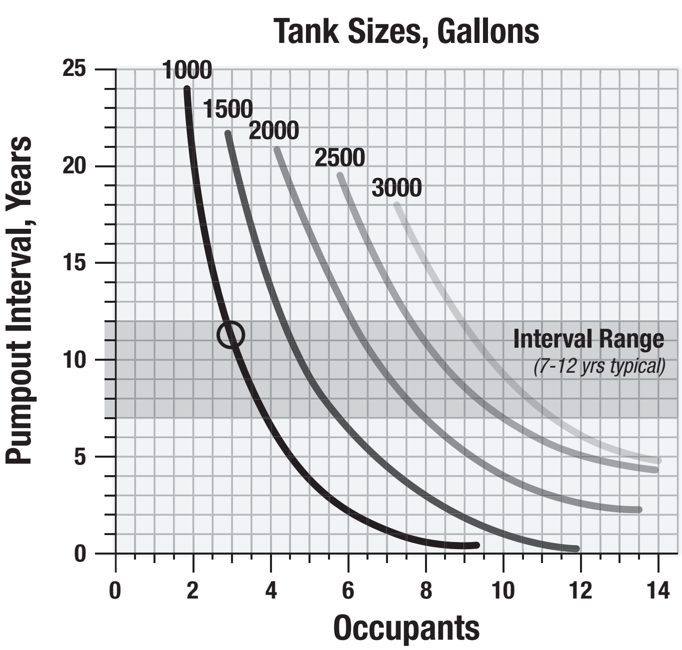

Figure 23. Pumping Intervals at 95% Level of Confidence

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The interceptor tank serves several critical functions:

- It provides sufficient hydraulic retention time (HRT) for capturing grease, grit, and other substances that settle or float.
- It allows sufficient storage capacity for sludge and scum so that septage pumping intervals are infrequent.
- It provides reserve space or surge capacity adequate for 24-48 hours of normal operation before a system malfunction must be corrected, thus eliminating the need for emergency after-hour maintenance. The reserve space must also allow for adequate tank ventilation back through the inlet plumbing.
- It provides an operating zone sufficient to modulate peak inflows without causing nuisance alarms.
- It provides the most energy-free, cost-effective method of primary treatment available for non-industrial sewage — BOD removal of 65% or greater, TSS removal of 70% or greater, grease and oil removal of 90% or greater, and conversion of urea and organic nitrogen to ammonia (NH_3).
- It provides long-term storage that allows for the effective digestion and reduction of organic matter by as much as 80% with a microbial population (biomass) as little as 1/20th of that required by aerobic processes.

An interceptor tank in an effluent sewer maintains a slightly lower liquid level than does a typical septic tank followed by a drainfield. If a pumping system malfunctions, a 1000 gallon (3785 L) tank serving a single-family home with three or four occupants provides for about one day of usage before exhausting the reserve space (typically, this is a minimum of 200 gallons or 757 L). This minimizes the need for emergency response maintenance. During a power outage, the safe period of use is even longer since electrical appliances such as washing machines, dishwashers, and water heaters do not function, thus reducing water use during that period.

4.2.1.1 Compartmentalization

Over the years, there has been continuing controversy over single-compartment versus two-compartment tanks. Evidence of significant benefits to effluent quality that would support compartmentalization of tanks, as they are presently constructed, is statistically inconclusive. It is the consensus of most experts in the field that emphasis should be placed on hydraulic loading, velocity through the tank, and retention time; and that single-chambered tanks are most efficient. Most also contend that the compartment's size, shape, and method of baffling is not critical; in fact, a smaller pumping compartment is better because it preserves the primary purpose of the tank, which is to accumulate, digest, and store solids.

In 1982, Dr. Robert W. Seabloom at the University of Washington reported that the effluent quality produced by single-compartment tanks is substantially superior to that produced by equivalent-sized, double-compartment tanks (where the primary compartment is approximately 2/3 of total, relative to the single-compartment tank). He asserted that effective particulate removal was a direct function of the tank's surface area and overflow rate. He also asserted that baffling, which reduced the net surface area, caused an increase in the overflow rate and resulted in diminished BOD and TSS removals. The data collected showed an 81% TSS reduction in single-compartment tanks versus 48% reduction in double-compartment tanks, and 54% BOD removal in single-compartment tanks versus 46% removal in double-compartment tanks. Settleable solids concentrations between the single-compartment and double-compartment tank went from 0.6 mL/L to 0.2 mL/L, thus improved by a factor of three, an important consideration in jurisdictions that regulate settleable solids discharges. This led the researchers to conclude that multiple compartments actually reduce the effectiveness of a septic tank, besides being more costly. The lower costs of single-compartment tanks are bonuses not to be overlooked (Seabloom, 1982).

John H. Timothy Winneberger explains the effect of velocities and turbulences on the migration path of particles traveling through septic tanks and concludes, like Seabloom, that slow velocities through long tanks yield the highest effluent quality. Winneberger makes two principal generalizations. First is "the geometric shape of a tank, as such, seems not to be critical. It is the management of flow-through that is of concern" and, second, "the size of that second chamber matters little" (Winneberger, 1984) (Seabloom, 1982).

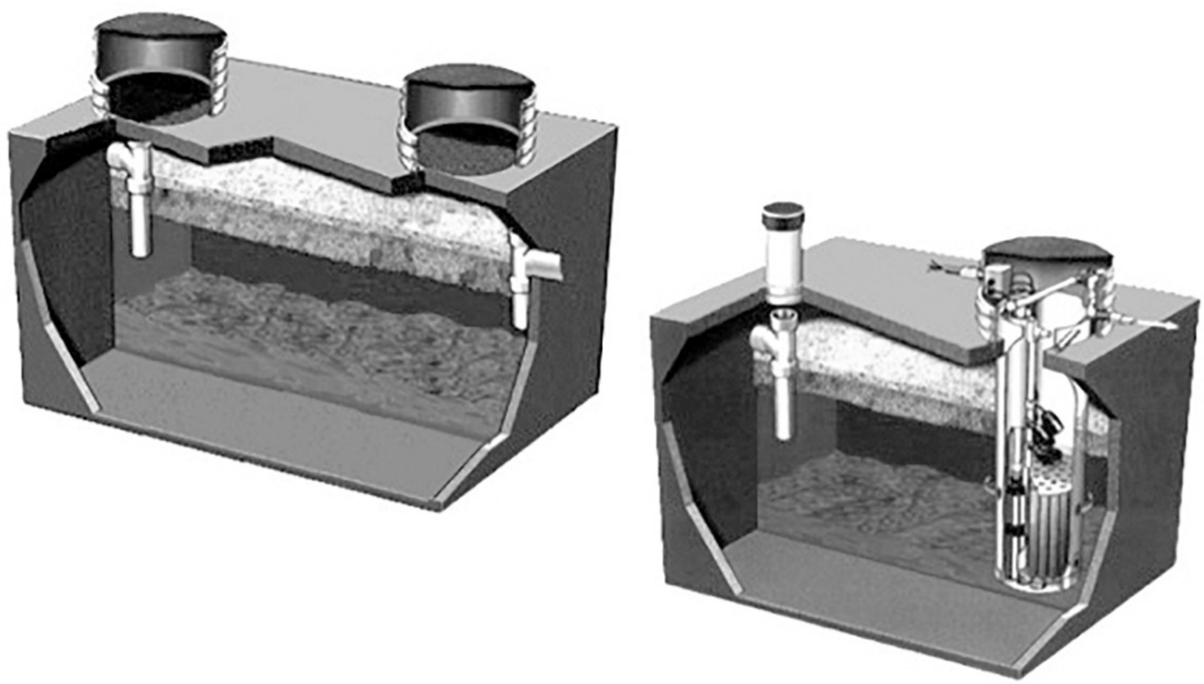
Despite this information, on-lot portions of effluent sewer systems are still being installed with little thought given to flow rates or theoretical retention times, based on the erroneous assumption that compartmented tanks will separate and contain solids, greases, and other floatable material in the first chamber. Frequently, the result is an overloaded collection and/or primary treatment system that is rendered partially or completely ineffective — a costly disaster for the community or individual that has to deal with the mess and pay for the corrective measures.

Regardless of the number, size, or shape of supplemental compartments, the primary or first compartment's capacity should be designed based on hydraulic loading, velocity through the tank, reserve capacity, solids storage capacity, and HRT. Too little primary capacity can lead to excessive pumpout frequencies — again, an unnecessary and costly O&M issue to deal with. The difference in price between a 1500 gallon (5678 L) single-compartment tank and a small 1000 gallon (3785 L) two-compartment tank is relatively negligible, although the larger tank is a bit more costly to install. A larger tank reduces pumping occurrences by a factor of four or more when servicing a family of three. Ultimately, there will be less organic matter to dispose of due to more complete digestion. Excessive hydraulic loads on holiday weekends or washdays will have less effect on the surge capacity of the larger tank. The money saved on unnecessary pumping could wisely be spent on proactive servicing and monitoring.

4.2.2 Tanks for High Flow Installations

High flow sites can include commercial, industrial, institutional, and multi-family dwellings. In each instance, they generally have one or more on-lot primary tanks followed by a pump tank. (See Figure 24.) The primary tank just preceding the pump tank may be equipped with one or more effluent filters, but effluent filters are not always used with a filtered pump vault. Note that a separate pump tank is not always used, and the filtered pump vault can be located at the end of the last tank.

A two-compartment tank with an overflow tee baffle shall be used for systems that include the discharge of water softener regenerate (backwash). The backwash must be plumbed so that it enters the interceptor tank in the second compartment and does not interfere with the clarification and anaerobic digestion occurring in the first compartment.



Primary Tank "A" **Pump Tank "B" with Effluent Pump**

Figure 24. Typical Configuration for Multiple-User Tanks

Equation 11 can be used in conjunction with Table 5 to determine the number and size of effluent filters to be used in the primary tank(s). Primary tank sizing should have a minimum of 2 days of detention time, while the pump tank sizing should have a minimum of 25% of expected flow. (See Table 6.) For pumping equipment, refer to Section 4.2.5.

Equation 11 $A_F = 0.0044\ PQ_C\ (MTBC)$

where: A_F = *Filter area, ft*^{2}
P = Population
Q_C = *Daily per capita flow value, gpcd*
MTBC = Mean time between filter cleaning, years
0.0044 = Coefficient of clogging

Table 5. Filter and Flow Area Chart

Series	Filter Area, ft^2 (m^2)	Flow Area, ft^2 (m^2)
FT15-36	50.5 (4.7)	15.2 (1.4)
FT12-36	30.0 (2.8)	9.0 (0.84)
FT08-36	14.6 (1.4)	4.4 (0.41)
FT04-36	5.1 (0.5)	1.5 (0.14)

Table 6. Sizing Guide for Multiple-User Primary Tanks

EDUs	Flows[a]	Primary Tank, "A"	Filter(s)[b]	Pump Tank "B"
6 - 15	2250 gpd (8.5 m^3/day)	4500 gal (17 m^3)	(1) FT12-36	1000 gal (3.8 m^3)
16 - 30	4500 gpd (17 m^3/day)	9000 gal (34 m^3)	(2) FT12-36	2000 gal (7.6 m^3)
31 - 45	6750 gpd (25.5 m^3/day)	13,500 gal (51 m^3)	(3) FT12-36	4000 gal (15 m^3)
46 - 60	9000 gpd (34 m^3/day)	18,000 gal (68 m^3)	(4) FT12-36	4500 gal (17 m^3)

a. Equivalent Dwelling Unit flow (150 gpd/EDU, or 570 L/day per EDU).

b. Effluent filters and flow-modulating orifices are sized according to peak flows, daily flow, and tank depth.

When considering a multiple-user tank to serve multiple residences or a community cluster, careful attention should be given when comparing both capital and ongoing O&M costs. Capital costs include the tank, larger pumps, and the cost of gravity sewer fronting the homes. In areas of relatively flat topography, the cost of installing a multiple-user tank at substantial depth can be very high. The cost for installing the tank will also increase drastically when high water tables, problem soils, or rock are a factor. Additional considerations include any capital costs associated with land acquisition for the tank site, bringing a power drop to the site, generating back-up emergency power, and monthly electric meter costs. Another operational consideration is the increased risk for I&I — negating one of the main benefits of pressure sewers in the first place. Finally, venting and odor mitigation may also be an issue with multiple-user tanks. With the volume of wastewater and digestion that occurs, the concentration of odors is higher than that of a single-family home application, and may therefore require special attention.

From an O&M perspective, many operators incorrectly believe that multiple-user tanks are more cost effective than individual tanks for each home. However, multiple-user tanks negate a main advantage of effluent sewers: small-diameter pipe. Plus, total septage pumping costs for clustered tanks are typically significantly higher, as initial tank sizing accommodates only a 2-3 year pumping schedule — losing the benefit of long-term anaerobic digestion. And that frequency generally assumes that people do not liberally flush more inorganic solid wastes into the system — a common practice in community gravity systems where the solids are comingled and managed off-site. Many of these systems require frequent pumping (every 9-18 months) because there is no ability to identify sources of system abuse (e.g. solid waste flushing, downspout connection to system, etc.). When these costs are evaluated, individual tanks are typically more cost effective and allow for a more efficient proactive maintenance program.

4.2.3 Multiple-User Pump Tanks for STEG Systems

Despite the ability to monitor for system abuse, many of the same considerations exist for multiple-user pump tanks collecting from STEG units at homes and businesses as exist for multiple-user STEP tanks. The typical minimum number of connections required for this type of configuration (STEG to pump tank) to be cost effective over individual STEP units is 20-30, depending on terrain, distance between homes, and the amount of other costs as described in the previous section. As a result, this method of collection is seldom used.

4.2.4 Tank Design Criteria

4.2.4.1 General Criteria

Watertightness is a mandatory requirement for all interceptor tanks used in effluent sewer systems; leaky tanks are unacceptable. New tanks, designed to be watertight, should be installed in all user locations, including sites with tanks serving existing septic systems. Many septic tanks sold in the U.S. are of antiquated designs — structurally unsound and not designed for watertightness. In areas with high groundwater, leaky tanks allow infiltration that can overburden a system's pumps and downstream treatment facilities. In areas where high groundwater is not a problem, leaky tanks exfiltrate, and the tank's scum layer lowers to the discharge ports, causing solids and grease carryover and subsequent maintenance and pollution problems. Using existing tanks is strongly discouraged, because the cost and the time involved to test and evaluate existing tanks are prohibitive, and the majority of tanks end up requiring replacement during the construction process.

Explicit details and specifications are necessary to ensure quality interceptor tank construction. The cost of a high-quality tank is minimal when compared to the cost of maintaining and rectifying a system with low-quality, leaky tanks. Even so, strict quality control must be uniformly enforced to assure that high-quality interceptor tanks are sourced and installed.

Following are guidelines for quality tanks for standard locations. In areas where burial depth must be more than four feet (1.2 m) or where traffic or other loading is expected, additional support may be necessary.

a. Top = 500 pounds per square foot (psf) or 24 kPa (The tank should be capable of supporting long-term unsaturated soil loading in addition to the lateral hydrostatic load.)

b. Lateral Load = 62.4 pounds per cubic foot (pcf) or 1000 kg/m^3 (The tank should be capable of withstanding long-term hydrostatic loading with the water table maintained at ground surface.)

c. Concentrated Wheel Load = 2500 pounds or 1135 kg (The tank and accesses should be capable of supporting short-term wheel load in addition to the unsaturated soil loading.)

d. Soil Bearing = 1000 psf or 48 kPa (Soil bearing is site specific and must reflect the worst case conditions.)

e. Cold weather installations requiring deep burial need special consideration.

f. All tanks must successfully withstand an above ground static hydraulic test.

g. The inlet plumbing must penetrate at least 18 inches (460 mm) into the liquid from the inlet flow line. If the submerged scum depth is expected to be greater than 18 inches (460 mm), the inlet fixture should be extended into the liquid 2 inches (50 mm) below the expected lowest scum depth. The inlet plumbing must allow for natural ventilation back through the building sewer and vent stack.

h. Tanks must be manufactured with access openings 20 inches (510 mm) in diameter and of the configuration shown on the manufacturer's drawings. Modification of completed tanks should not be permitted.

4.2.4.2 Warranty and Guarantee

The general specifications should include a Manufacturer's Guarantee for replacement or repair of interceptor tanks for a minimum period of two years from the date of final acceptance. The warranty should guarantee watertightness and structural integrity under the design loads specified in the bid documents.

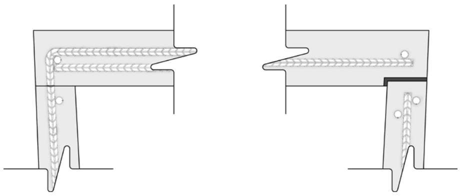
4.2.4.3 Materials

Concrete and fiberglass are the most common tank materials used in effluent sewer systems. Due to low cost and widespread availability, concrete is the most common tank material. When acceptable concrete tanks are unavailable, quality fiberglass tanks are recommended. For many reasons, including susceptibility to corrosion or poor strength characteristics, steel or polyethylene tanks are rarely used in effluent sewer systems. Regardless of tank style or material, all tanks must undergo a thorough evaluation, strict quality assurance, pre-approval by the design engineer, and quality control protocols to assure acceptable performance. To assure quality and watertightness, it is critical that tanks are carefully specified and then pre-approved.

4.2.4.3.1 Concrete

The walls, bottom, and top of the reinforced-concrete tanks are usually designed spanning the shortest dimension using one-way slab analysis. Stresses in each face of monolithically constructed tanks are determined by analyzing the tank cross-section as a continuous fixed frame. Whenever possible, mid-seam or clamshell tanks should be avoided. Tanks should typically also have a minimum wall thickness of at least 3 inches (75 mm), with 4 inches (100 mm) preferred.

The walls and bottom slab should be poured monolithically. The method of connecting the top to the walls of the tank, as shown in Figure 25, is critical to the tank's short- and long-term structural strength. Casting the top in place, with wall reinforcement extending into the top slab, will produce a much stronger and stable tank than setting it in place.



Top Corner Cast-In-Place **Top Corner Set-In-Place**

Setting the top in place instead of casting it in place...
• Reduces the strength in the top by 45%±.
• Reduces the strength in the walls by 25%±.
• Reduces the strength in the bottom by 40%±.

Figure 25. Cast-In-Place vs. Set-In-Place Tops

When concrete tanks are specified, it is very important for the designer to specify tanks that meet the following criteria:

a. **Concrete:** It must achieve a minimum compressive strength of 4,000 psi (27.5 MPa) in 28 days. The design of the concrete mix will depend on the gradation of the aggregate and should be determined by a professional engineer. A common 4000 psi (27.5 MPa) ready mix design has a cement content of six and one half (6-1/2) sacks per cubic yard and maximum aggregate size of 3/4 inch (19 mm).

b. **Water/Cement Ratio:** To ensure proper curing and ultimate strength, it's important to keep the water/cement ratio low, 0.35 ±.

c. **Air-entraining:** Air-entraining agents may be required depending on the mix design, although they are not usually necessary for small concrete tanks. Air-entrainment without additives is usually 1-2%.

d. **Fiber Additives:** These may be used to enhance watertightness by controlling concrete shrinkage but should not be considered a substitute for rebar re-enforcement.

e. **Protective Coatings:** Sealants such as "Thoroseal®" may be used inside and out for supplemental watertightness protection. The manufacturer's directions must be followed exactly.

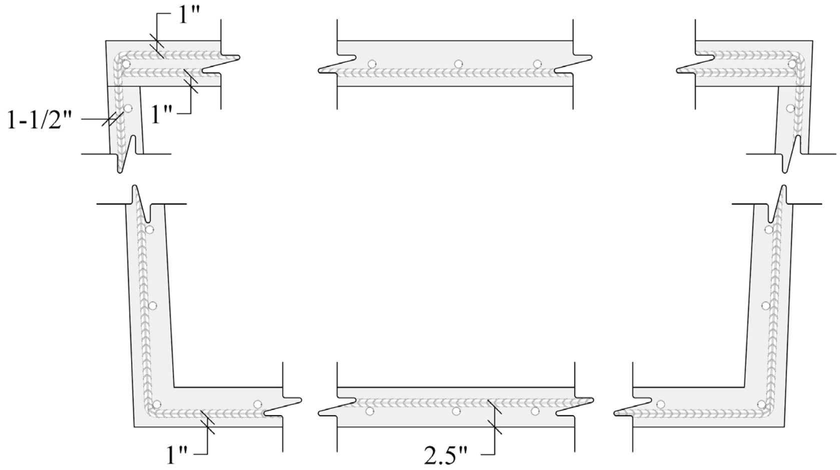
f. **Form Release:** This shall be Nox-Crete® or equal. Diesel or other petroleum products are not acceptable.

g. **Vibration:** Tank molds must have attached vibrators to ensure adequate flow of concrete down the walls and across the bottom. Excess vibration can cause the aggregate to segregate.

h. **Curing:** Proper curing techniques are necessary to ensure watertight tanks. Tanks may not be moved until they have cured for seven (7) days or have reached two-thirds of the design strength.

i. **Test Cylinders:** These must be taken from each batch of concrete and tested until the minimum compression strength has been obtained.

j. **Reinforcing Steel:** This must be Grade 60, fy = 60,000 psi (414 MPa). A structural engineer must determine size and placement; wire fabric is not acceptable. Misalignment of reinforcement as shown in Figure 26 can result in a significant reduction in the strength of the tank.



Misalignment	1/4"	1/2"
3" Thick Wall:	30%	50%
4" Thick Top:	20%	35%
5" Thick Top:	15%	25%

Figure 26. Reduction in Strength Caused by Misalignment of the Reinforcement

4.2.4.3.2 Fiberglass

There are two primary manufacturing processes for fiberglass tanks. Tanks laid up by hand are manufactured by shooting fiberglass and resin onto a mold and hand rolling out the material to a specified thickness. This does little to assure consistent wall thickness and resin application, and requires strict and laborious effort to ensure a quality end product. Often, the result is an inferior grade tank that is prone to failure under hydraulic loading, delamination, and wicking over time. Tanks manufactured by the injection-molding or resin-transfer molding process offer a high-quality product at a higher cost than hand-rolled tanks. When fiberglass tanks are specified, it is very important for the designer to specify tanks that meet the following criteria:

a. **Glass fiber and resin content** must comply with IAPMO IGC 3-74; have a glass content of no less than 35%; and have no exposed glass fibers.

b. **Metal parts** must be 300 series stainless steel.

c. **Wall thickness** must average at least 1/4 inch (6.4 mm) for hand layup with no wall thickness less than 3/16 inch (9.5 mm). No delamination is allowable.

d. **Holes** specified in the tank must be protected with a sufficient application of resin on all cut or ground edges so that no glass fibers are exposed and all voids are filled.

e. **Neoprene gaskets**, or approved equal, must be used at the inlet to join the tank wall and the ABS inlet piping. ABS Schedule 40 pipe and fittings must be used at the inlets.

Calculations must address strength, buckling, deflection (3% of the tank diameter, based on service load, including long-term deflection lag), and buoyancy.

The material properties and laminates considered in this analysis are fiberglass reinforced polyester resin, using grades of resin and fiberglass considered acceptable for use with septic tank construction. The thicknesses for different regions of the tanks shall be described and shown in shop drawings for each individual tank. Typical minimum strength properties are listed below:

- Tensile Modulus, psi (MPa) 1,000,000 (7,000)
- Ultimate Tensile Strength, psi (MPa) 11,000 (76)
- Ultimate Compressive Strength, psi (MPa) 21,000 (145)
- Ultimate Flexural Strength, psi (MPa) 18,000 (124)

Fiberglass tanks must be analyzed using finite element analysis for buried structures. In lieu of calculations for fiberglass tanks, the supplier may elect in-situ performance testing. In-situ testing of each tank model must include the use of a strain gauge and a deflection gauge.

a. The tank must be subjected to external forces equal to twice the actual load.

b. Maximum initial deflection based on test loading must not exceed 3% of the tank diameter.

c. Performance testing must be evaluated by a Registered Professional Engineer (P.E.). The P.E. will have the sole responsibility to determine the maximum external loading on any of the tank models.

4.2.4.4 Testing

The importance of watertight interceptor tanks cannot be overstressed. To assure a watertight installation, testing procedures are necessary. Every tank should be tested at the factory and again after installation. The test for watertightness after installation is as follows:

1. Fill the tank with water to a level that is 2 inches (50 mm) above the riser-to-tank connection and let it stand for 2 hours.

2. Measure the water loss. The tank passes the test if there is no water loss during the two-hour period. For concrete tanks, however, some water absorption may occur during this first 24-hour period. If the water level in a concrete tank falls during this time period, refill the tank and let stand 24 hours. After this period, refill the tank and determine the exfiltration rate by measuring the water loss during the next 2 hours. Any additional water loss is counted as leakage and is cause for rejection.

Note: Refer to the manufacturer’s instructions to determine backfill requirements relating to this watertight test. Concrete tanks may require backfill cover to prevent hydrostatic uplift damage to the top joint of the tank.

4.2.4.5 Buoyancy

Improper septage pumping procedures on a buried tank may result in the tank suddenly “floating” to the surface and causing damage to piping, landscaping — or worse — injuring maintenance personnel. The following is a list of methods that may be used, as additional precautions, to ensure tank submergence in areas subject to periodic or permanent high ground water:

1. Require a minimum cover where high groundwater is present or may be present (evaluation must be provided after identifying site specific soil conditions).

2. After setting the tank, pour an additional thickness of concrete over the top at least equal to the amount of counter-buoyancy necessary (3 inches or 75 mm minimum); extend the sides of the concrete pour a minimum of 12 inches (300 mm) beyond the sides of the tank.

3. Add more thickness to the walls, top, and/or bottom of the concrete tanks to increase the weight, increasing antibuoyancy measures.

4. Properly secure or attach a concrete collar or ballast to the tank. Allow sufficient time for the concrete to cure before completing the backfilling.

Tank manufacturers must provide buoyancy calculations and recommended countermeasures for all interceptor tanks that are submitted to the design engineer for approval.

4.2.4.6 Interceptor Tank Installation

All tanks shall be installed in strict accordance with the manufacturer’s instructions and state/local regulations.

4.2.4.7 Interceptor Tank Accessories

Watertight risers with grommets for electrical and plumbing access and a securable lid with a gasket allow easy access to the equipment for maintenance and for septage pumping. Access risers over both the inlet and outlet side of the tank are typical.

4.2.4.7.1 Access Risers

Access risers are required for access to internal vaults and for septage pumping. Access risers must be constructed to be watertight and attached to the tanks in a manner that provides a watertight seal. Access risers should extend 3 inches (75 mm) above original grade to allow for settlement and to ensure positive drainage away from the access. Access risers for inspection ports should be a minimum nominal diameter of 18 inches (450 mm, nominal). Access risers containing simplex pumping assemblies or electrical splice boxes should be a minimum nominal diameter of 24 inches (600 mm, nominal) and of sufficient diameter to allow removal of internal vaults without removal of splice boxes (if internal splice boxes are used) or other components. Risers should be a minimum nominal diameter of 30 inches (750 mm, nominal) when the depth of bury is 36 inches (914 mm) or greater or when duplex pumping assemblies are used (the nominal pipe diameter can be reduced to 24 inches or 600 mm when hanging-style discharge piping is used). All other risers should be a minimum nominal diameter of 24 inches (600 mm, nominal) and may vary in height depending on the depth of bury of the various tanks.

Adhesive required to adhere the PVC or fiberglass risers to either fiberglass or ABS tank adapters should be a two-component methacrylate structural adhesive or approved equal. To ensure product compatibility, a single manufacturer must supply risers, lids, and attachment components. The riser material shall be PVC as per ASTM D-1784 and tested in accordance with AASHTO M304M-89. The risers must be constructed of non-corrosive material and designed for burial in soil. Risers must have a minimum stiffness of 10 psi (68.9 kPa) when tested according to ASTM D2412.

4.2.4.7.2 Electrical and Discharge Grommets

To assure a watertight seal, the manufacturer must factory-install grommets for discharge piping, vent piping, and/or the electrical conduit to assure a watertight seal. Grommets should be made of EPDM rubber.

4.2.4.7.3 Riser-to-Tank Attachment

All attachment components must be constructed of waterproof, non-corrosive materials, and cast into the tank lid whenever possible. Adhesives and sealants must be waterproof, corrosion-resistant, and approved for the intended application. The riser-to-tank connection must be watertight and structurally sound. The riser-to-tank connection must be capable of withstanding a vertical uplift of 5000 pounds (2270 kg) to prevent riser separation due to tank settlement, frost heave, or accidental vehicle traffic over the tank. The riser-to-tank connection is one of the most common sources of infiltration, therefore it requires special design and oversight to ensure the joint has proper integrity. Acceptable non-corrosive materials for the adapter are PVC, ABS, fiberglass, or stainless steel. Acceptable bonding material is a two-component methacrylate structural adhesive.

4.2.4.7.4 Lids

The access lid must be made of fiberglass. Polyethylene and other plastics are not acceptable. A fiberglass access lid should be furnished with each access riser, as appropriate, and it must meet the following requirements:

a. Lids must be waterproof, and corrosion and UV resistant.

b. Lids must have a non-skid finish.

c. Lids must be flat, with no noticeable upward dome (a crown or dome of no more than 1/8 inch or 3.2 mm is allowable).

d. Lids must not allow water to pond on them.

e. Properly attached lids should form a watertight seal with the top of riser.

f. Lids must be capable of withstanding a truck wheel load (54 in.^{2} or 0.034 m^2) of 2500 pounds (1135 kg) for 60 minutes with a maximum vertical deflection of 3/4 inch (75 mm).

g. Lids must be provided with tamper-resistant stainless steel fasteners and a tool for fastener removal. Tamper-resistant fasteners include recessed drives, such as hex, Torx, and square. Fasteners that can be removed with common screwdrivers, such as slotted and Phillips, or fasteners that can be removed with standard tools, such as pliers or crescent wrenches, are not considered tamper-resistant. To prevent a tripping hazard, fasteners may not extend above the surface of the lid.

Optional components may include the following:

a. Traffic bearing lid: The traffic bearing lid should be a cast iron frame and cover, part number 6024, 3060, 4036, as manufactured by Sather Manufacturing Co., Inc., or approved equal, which will fit over a standard lid. The cover must have the word SEWER cast into it.

b. Foam insulation: Rigid closed-cell foam insulation of 2 inch or 4 inch (50 mm or 100 mm) thickness must be attached to the underside of the lid or cast into the lid itself. Any fasteners shall be made of corrosion-resistant stainless steel. The insulation must have an R-value of no less than 10 per 2 inch increment (R5 per inch or 25 mm).

4.2.5 Effluent Pumping Equipment

Engineers working on the Glide/Idleyld Park STEP system in the mid-1970's introduced the concept of vaults that fit directly into the interceptor tank and house the effluent pump. Effluent enters the vault through 1-3/8 inch (35 mm) diameter holes located between the interceptor tank's scum and sludge layers. Effluent entering the vault from this clear zone is relatively free of solids. The pumps originally specified at Glide were standard cast iron effluent pumps with pumping rates sometimes exceeding 60 gpm (227 L/min). At such high flow rates, solids tend to be conveyed into the collection system, increasing maintenance and reducing the capacity of the treatment plant. In the mid-1980's, a means was introduced to screen the effluent before pumping that made it feasible for the first time to use turbine pumps in an effluent sewer while minimizing the solids passing through the tank to 1/8 inch (3.2 mm) mesh size or smaller. (See Figure 27.)

COMPONENT LOCATION

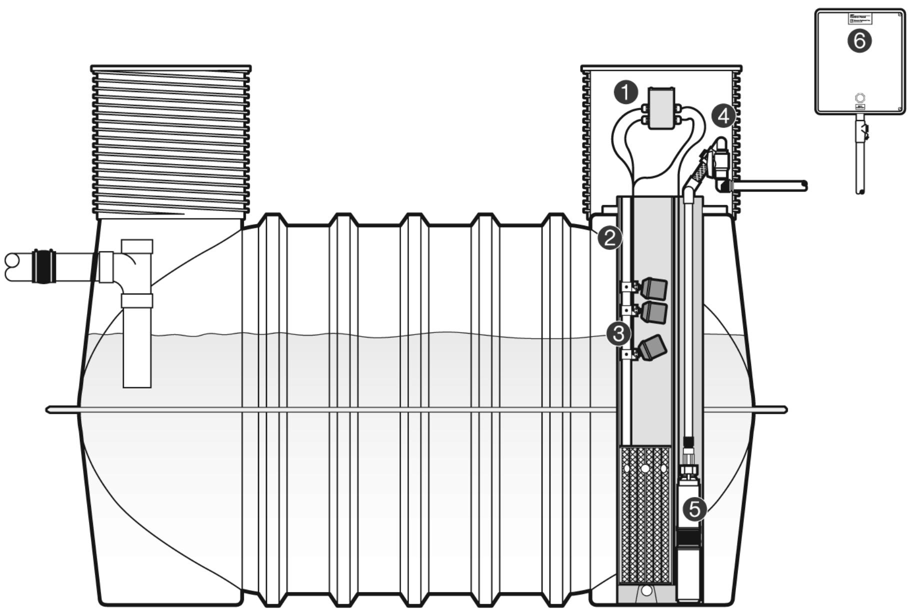


Figure 27. Typical Interceptor Tank with Turbine Effluent Pump System

COMPONENTS

Orenco ProSTEP™ effluent pumping packages include the following components:

1. PVC splice box
2. Biotube® pump vault
3. Float switch assembly
4. Discharge plumbing assembly
5. Effluent pump
6. Control panel

Tanks, risers, lids, and tank accessories are sold separately.

As effluent enters the pump vault, it surrounds multiple 1/8 inch (3.2 mm) mesh screen tubes where particles larger than 1/8 inch (3.2 mm) are trapped. The screen's surface area, depending on occupancy loading, may range from 8 ft^2 to 15 ft^2 (0.74 m^2 to 1.4 m^2), which effectively lowers the concentration of suspended solids in the effluent by a factor of 2.5 before the effluent is discharged into the collection line. Biological growth on the surface of the screen may also enhance treatment. Since 1983, effluent sewer systems have consistently reported that screened septic tank effluent is significantly lower in BOD and TSS than is unscreened effluent (USDA, 1998).

If the average daily flow per dwelling of 150 gallons (570 L) is dosed an average of three times per day, each cycle delivers about 50 gallons (190 L) of effluent into the collection line. The liquid level in each tank is established by level controls (drawdown limited to 2-4 inches or 50-100 mm) that are preset according to the tank's dimensions, the rate of sludge and scum accumulation, and the minimum hydraulic retention time deemed adequate for the settlement of solids.

The flow and pressure in the main and submains are fairly low for significant portions of the day. As a consequence of the flat performance curve of the standard effluent pumps used before 1983 (see Figure 28), pumping rates often exceeded 60 gpm (227 L/min), which tended to pass greater solids into the collection system, increasing maintenance costs and consuming more of the biological capacity of the treatment plant. Because of the high amperage of these pumps, the lives of the pumps were decreased. With the development of the screened pump vault and the use of the high-head turbine effluent pump, the ideal pump rate of 10 gpm (38 L/min) or less could be achieved. At 10 gpm (38 L/min), the contents of the septic tanks are barely disturbed and solids carryover is minimized. Low flow rates also make it possible to use smaller collection pipes throughout the system.

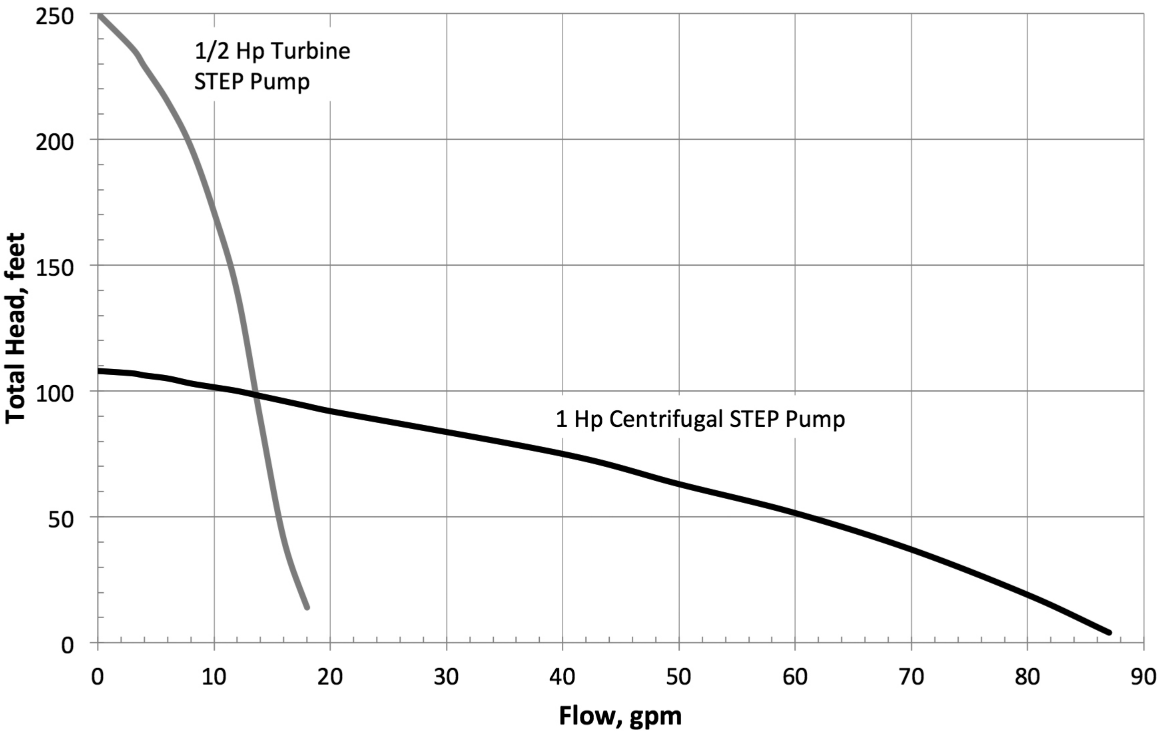


Figure 28. Comparison of Turbine Effluent Pump vs. Centrifugal Pump

Turbine effluent pumps' high-head capacity often makes it feasible for a single 1/2 hp (0.37 kW) model to serve every location in the system. The lower power requirement of the smaller motor also means that expensive electrical renovations are unnecessary, making the pump particularly suitable for existing infrastructure. In systems where pumps of various flow and power capabilities are used, operator familiarity with pump characteristics, power requirements, and troubleshooting procedures is essential.

4.2.5.1 Pump Options

Typically, high-quality submersible turbine type pumps are common in STEP systems because of their extreme resistance to corrosion, high cycle life, light weight (30 pounds or 13.6 kg), and ability to pump 5-20 gpm (19-76 L/min) at discharge heads greater than 200 feet (60 m). Another advantage is their ability to operate for extended periods in the "no discharge" condition, or at heads greater than the maximum "shut-off" head. Additionally, the use of submersible turbine pumps will often allow the use of one pump model to service all of an effluent sewer's residential connections.

Pump selection, being one of the critical elements of a STEP package, must be fully understood by the design engineer. Manufacturers that offer components for STEP system construction are often able to produce less expensive components, but generally do so by sacrificing quality, service life, and efficiency, while increasing repair and component (liquid end and/or motor) replacement costs.

A high quality turbine pump offers the following distinct advantages over centrifugal effluent pumps:

- Turbine pumps have a much longer anticipated service life. While a centrifugal pump may last 8-10 years on average, a turbine pump can easily last 20-30 years or more on average.
- The pump curve for a turbine pump is very steep with a very high shut-off head. A centrifugal pump has a very flat pump curve and a relatively low shut-off head. Accordingly, one model of turbine pump will service a very large system with varied head conditions. In the same system, several models of centrifugal pumps may be necessary to provide service. Also, as the number of connections increases in a STEP system that utilizes centrifugal pumps, it may become necessary to replace pumps that have reached shut-off head. Figure 28 shows a comparison of the pump curves.
- Because of their head capacity, turbine STEP pumps eliminate the need for lift stations and pressure sustaining valves; and they allow for smaller pipe sizes.

- Residential turbine effluent pumps typically weigh less than 30 pounds (13.6 kg), which is 50% to 70% lighter than a cast iron centrifugal pump. Accordingly, they are easy for a single STEP operator to service, with less risk of lifting injury.
- Quality turbine pumps can easily be separated into liquid and motor ends so that either end can be replaced independently should it fail. Partial motor replacement can provide long-term cost savings for the STEP system operator. Also, some motors have had exceptional life cycles that can be maximized through replacement of the liquid end only. Turbine pumps that are not repairable should be avoided.

While it is strongly recommended that the designer utilize turbine pumps, the designer must also be fully aware of varying quality in turbine pumps. As STEP systems have transitioned to the use of turbine pumps, more vendors have offered turbine pumps for wastewater applications. Again, the designer must understand that a poorly selected turbine pump can easily compromise a well-designed STEP system. When evaluating turbine pumps, the following criteria should be utilized for comparison and preparation of specifications:

- All turbine effluent pumps must be UL-listed or CSA-approved for wastewater applications.
- The pumps should be rated for continuous operation with 24 hour “run dry” capability.
- Generally, turbine pumps require 1/8 inch (3.2 mm) screening. This is achieved through an influent screen and a secondary screen on the pump itself. The flow-through area of the secondary screen should be compared. Additionally, the pump should be inspected to assure that the screen is not compromised by inadequate fitting to cord inlets or to the pump itself that could allow larger particles to bypass the screen. Pumps should be able to pass 1/8 inch (3.2 mm) solids.
- The specification should be reviewed to determine the configuration of the impeller stack. Floating stack designs are much more durable than fixed stack designs.
- The specifications should be reviewed to assure that lightning protection is provided.
- The specifications should be reviewed to assure that thermal overload protection is provided to protect the unit from rapid cycling, brownouts, etc.
- The pump leads should be extra heavy duty SOOW, rated for 600 V.
- The pump’s liquid end should be repairable by removal and replacement of internal components.
- The pump should have a long and proven track record of documented performance.

4.2.5.1.1 Pump Selection – Single-Family Homes

Wastewater flows for single-family dwellings typically range from 40-60 gpcd (150-230 Lpcd); 50 gpcd (190 Lpcd) is a commonly used design parameter and is the value used in calculations contained in this design manual. When the per capita population is not known, the number of individuals is assumed to average three per dwelling. Therefore, average daily flow per single-family dwelling unit is 150 gallons (570 L).

The flow rate through the interceptor tank should allow maximum settlement of solids; adequate retention of fat, grease, and oil; and an efficient power rating, but not promote excessive pump run-time. Pumps are typically 1/2 hp (0.37 kW) and 115 VAC (230 V for 50 Hz applications). The ideal discharge rate for a single-family residential turbine pump is 5-10 gpm (19-38 L/min). For connections operating at low system pressures (e.g. near point of discharge), it may be practical to use an orifice plate to modulate the discharge rate below 9 or 10 gpm (34 or 38 L/min).

4.2.5.1.2 Pump Selection – Multi-Family, Commercial, or Industrial Properties

In many applications, large tanks are utilized to serve multi-family, commercial, or industrial properties. Examples include apartment or condominium complexes, schools, offices, industries, institutions, and commercial businesses.

Pumps for large flows should be sized to assure adequate pump cycles. Additional pumps should be added in duplex through quadruplex configuration to assure adequate pump redundancy, hydraulic capacity, and filter sizing. Table 7 shows recommended pump configurations relative to flow volumes.

Table 7. Sizing Guide for Large Flow Pumps

EDUs[a]	Flow, gpd (m^3/day)	Pumping Assembly[b]
6 - 15	1,500 (5.7)	Duplex......... 10 gpm (0.63 L/sec)
16 - 25	3,000 (11.4)	Duplex......... 20 gpm (1.26 L/sec)
26 - 35	4,500 (17)	Triplex......... 20 gpm (1.26 L/sec)
36 - 45	6,000 (22.8)	Triplex......... 20 gpm (1.26 L/sec)
46 - 55	7,500 (28.4)	Quadruplex.. 20 gpm (1.26 L/sec)

a. Equivalent Dwelling Unit flow (150 gpd/EDU or 570 L/day per EDU).

b. Design flow shown is per pump; two turbine pumps will fit in one screened vault.

4.2.5.2 Splice Boxes

There are two options for splicing of electrical cables for on-lot pumping systems — internal or external splice boxes. External splice boxes are mounted outside of the access riser, whereas internal splice boxes are located within the access riser. External splice boxes are preferred, as they allow easy at-grade access to the splice connections, and they free up the effective working space within the riser. Either option requires boxes that are UL-approved for wet locations, equipped with up to four (4) electrical cord grips, and have appropriately sized outlet fitting(s). Orenco splice box cord grips provide a gastight seal. Splice boxes should also include UL-listed, waterproof, butt splice connectors.

4.2.5.3 Conduit Sealing

Always follow local and state code for sealing conduit. For commercial applications and those deemed classified per National Fire Protection Agency, NFPA820, state and local regulations dictate the use of conduit seal kits and their location. Electrical services for single-family homes are deemed unclassified per NFPA820. Conduit sealing is required; locating the conduit sealing adjacent to the splice box is strongly recommended for all on-lot STEP units, as water can enter the conduit and make its way into the splice box.

Additionally, while not required by code (NEC/NFPA), to protect against electrical shorting due to infiltration, the wire nuts used to connect conductor ends should be rated as water-resistant. Wire-nuts that are specified and provided by the manufacturer are required by code (NEC/NFPA) to be used (substitution to a non-water resistant connector would be a code violation). There are a lot of options for conduit sealant, but make sure that you select a sealant that is easy-to-use and UL-classified, such as Dottie's RTV Silicone Sealant or an appropriately rated equivalent.

4.2.5.4 Level Controls

Mercury and mechanical float switches have proved to be reliable and accurate when used correctly. Dozens of types of float switches are available, so it is important that the system designer specify exact model numbers. For single-family applications, a typical assembly would include three floats — High-Level Alarm, On/Off, and Low-Level Alarm/Redundant Off. Float switches should always be securely attached to a support stem designed for that purpose. Strapping float switches to a pump discharge pipe is bad practice, as pump vibration tends to loosen the straps and cause the float switches to slip their settings. When float switches are strapped to the discharge pipe, the switches have to be readjusted any time the pump is removed.

Float switch settings are based on a minimum separation between the "alarm" and the "on" level and the drawdown between "on" and "off." With three quarters of the scum layer submerged, the lowest normal "off" level for the tank in Figure 27 should be no less than 11.5 inches (292 mm) above the center of the vault discharge ports.

4.2.5.5 Discharge Assembly

Discharge assemblies for single-family homes are typically of 1 inch (25 mm) nominal diameter; discharge assemblies for multiple-user tanks may require assemblies of 1-1/4 inch to 2 inch (32 mm to 50 mm) nominal diameter, depending on the flow requirements. To avoid corrosion, components should all be PVC. For easy pump removal, a PVC union, check-valve, and a flexible hose segment should be included. All fittings should meet a minimum rating of 150 psi (1000 kPa). When a tank is located above the static grade line, an anti-siphon valve is necessary. For cold weather applications with deep bury tanks, modified cold weather discharge assemblies are necessary. Two styles of discharge piping are provided as options — the hanging discharge assembly (HDA) and the flexible hose and valve discharge assembly (HV100BFCX) as shown in the figure below.

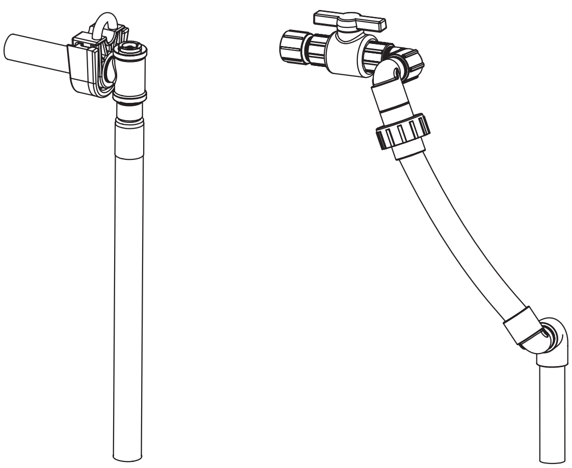


Figure 29. Hanging Style (HDA) and Flexible Hose and Valve Discharge Assemblies

The hanging style assembly provides a notched quick disconnect for removal of the pump; the hose and valve style utilizes a union for pump disconnection and removal.

4.2.5.6 Filtered Pump Vault

A filtered pump vault is required to house the pumping assembly, to ensure that no gross solids are pumped out of the tank into the system, and to provide a barrier between the tank contents and pump chamber. A similar apparatus filters the discharged effluent in gravity (STEG) units as shown in Figure 30. When comparing filtering options, it is very important to consider the filter's surface area and flow-through area. Additionally, the filter should be recommended for STEP applications. Using filters recommended for septic application or using filters with inadequate flow-through area can cause frequent filter clogging and unnecessary cleaning costs.

Typically, the filter should have an effective screen area of no less than 14.5 ft^2 (1.35 m^2). In residential applications, these screens normally require cleaning only as often as the tank requires pumping. The pump vault should consist of a 12 inch (300 mm) diameter polyethylene vault with eight (8) 2 inch (50 mm) diameter holes evenly spaced around the perimeter, located appropriately to allow for maximum sludge and scum accumulation before requiring pumping (approximately 70% of minimum liquid level). A screened filtering assembly consisting of 1/8 inch (3.2 mm) mesh polypropylene tubes shall be housed in the pump vault. A flow inducer that accepts one or two high-head effluent pumps is attached to the vault. Using Equation 11 and solving for the MTBC, this vault calculates to:

$$\text{MTBC} = \frac{14.5\ \text{ft}^2}{(3\ \text{capita})(50\ \text{gpcd})(0.0044)} = 22\ \text{years}$$

For single-family applications with four or fewer bedrooms, the filter may be reduced to have a minimum effective screen area of no less than 10.1 ft^2 (0.94 m^2), though a preventative maintenance schedule of every 5± years is recommended to evaluate whether the screens need to be cleaned. The filtered pump vault shall consist of an 8 inch (200 mm) diameter polyethylene vault with eight (8) 1-3/8 inch (35 mm) diameter holes evenly spaced around the perimeter, located appropriately to allow for maximum sludge and scum accumulation before requiring pumping (approximately 70% of minimum liquid level). A screened filtering assembly consisting of 1/8 inch (3.2 mm) mesh polypropylene tubes shall be housed in the pump vault. A flow inducer that accepts a single, high-head effluent pump is attached to the vault.

4.2.5.7 Control and Alarm Panels

Pump control/alarm panels for on-lot effluent sewer pumps should be UL- or CSA-listed and should be equipped with fiberglass enclosures, current-limiting circuit breakers with thermal magnetic tripping characteristics, HOA (hand, off, automatic) switches, audible and visual alarms, silence relays, and fused alarm circuits that are separate from the pump circuit. They may also have monitoring devices such as hour meters and counters.

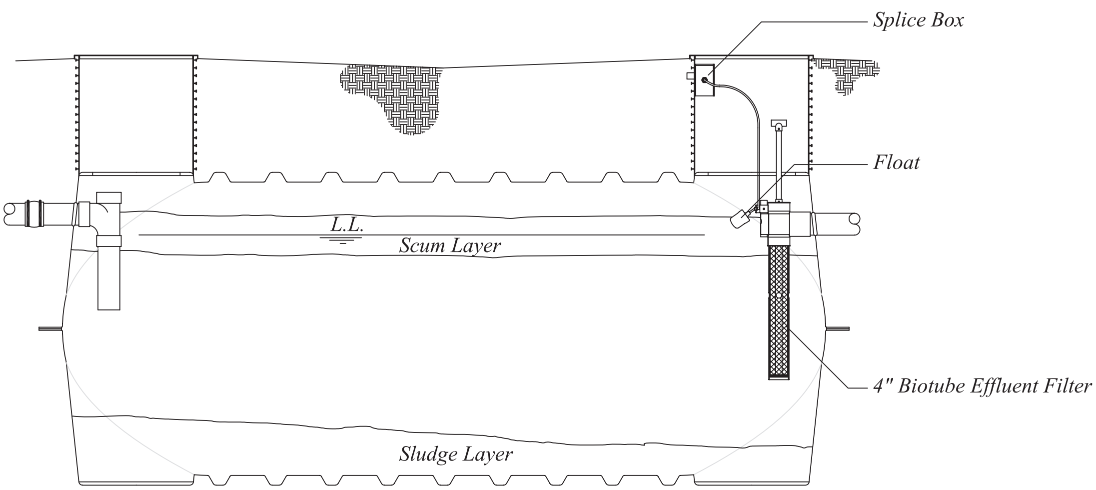
The control/alarm panel should be located on a post positioned near the residence or, if necessary, on a side of the house in a non-living area (due to a small “thump” that occurs when the motor contactor engages) at a height of about 5 feet (1.5 m) for convenience and accessibility. It should be close to the pump, within line-of-sight, and out of direct exposure to the elements. A high liquid level in the tank activates an alarm light and a buzzer, which may be silenced by pressing an illuminated “PUSH TO SILENCE” button on the front of the control panel. The alarm light stays on until the high level condition is corrected, and then the alarm circuit automatically resets. When an alarm occurs, the user calls the district’s phone number on the panel cover. An operator should be on call 24 hours-a-day in order to respond to line breaks or treatment plant problems that require immediate attention; on-site problems, however, can generally be responded to during convenient work hours, usually within 24 hours of the call.

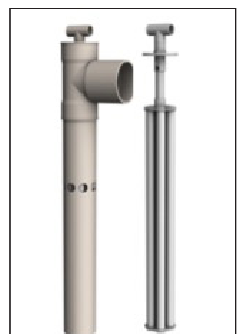
Control panels are now available that offer remote monitoring and provide alarms or alerts when water levels are too low (potential leaking tank or siphoning), when too much water is passing through the system (inflow or stuck toilet valve), or when a brownout occurs. The panels can even notify the operator that the system is short-cycling and may require servicing. They can also dose at predetermined times, regardless of varying inflows, in order to reduce the collection system’s hydraulic gradient. This function can also be configured in panels without telemetry features. Generally, these systems connect to a centralized monitoring system through existing phone lines or Ethernet cables. Using remote monitoring can make the STEP system invisible to the homeowner, since operators can note and respond to alarms prior to the activation of a local alarm. Remote monitoring also offers more efficient opportunities for accumulating operating data for each individual system; this data can be utilized to analyze and predict system problems before they occur.

In remote areas where service personnel must travel long distances to reach sites, control panels with remote monitoring ability offer the best value. Remote monitoring allows the operator to review and troubleshoot a problem with an on-site STEP unit without physically driving to the site. This helps operators avoid unnecessary travel time.

4.2.6 STEG Installations

Based on the site’s topography, interceptor tanks may be installed sufficiently above the hydraulic gradient of the mainline (in hilly terrain) to allow discharge into the system without pumping. In these cases, tanks are equipped with screened gravity discharge assemblies, referred to as Septic Tank Effluent Gravity (STEG) systems. See Figure 30. Screens in these units are easily removable for cleaning, and they seldom require attention.





4” Biotube® Filter

Figure 30. Typical Interceptor Tank with Effluent Gravity Discharge (STEG)

Effluent filter assemblies are designed and constructed to ensure ease of maintenance and to prevent solids from leaving tanks. To accomplish this, their bottoms are tightly sealed, and the influent holes are located in the vertical sides of the assemblies. Removable screens, inserted into the plastic vaults, reduce solids carryover by trapping particles 1/8 inch (3.2 mm) and larger, in the annular space between the screens and the inside of the vaults. Effluent passes through the screens and discharges to the collection system through flow control orifices that are sized to modulate peak inflows. The tops of the effluent filter assemblies are vented and capped to prevent scum carryover in case a leaky building sewer or broken valve elevates tank liquid levels. To warn of excessive inflow or need for maintenance, a sensor float connected to an alarm may be attached to the effluent filter assembly. Though the surface area of the filter units is far less than that of a pumped unit, it still has a calculated MTBC value in excess of 7 years. The filter units are simple to clean by removing and tapping on the outlet tee to remove the solids. They should be serviced each time the tank is monitored for sludge and scum accumulation.

4.2.7 Service Connections

Service connections are very important because they allow you to isolate an individual system, as well as prevent the main from draining into someone's system or yard (in case of a transport line break). These connections consist of a shut-off valve and check-valve and they are installed for each individual connection. Service connections can be installed even before the structure to be serviced is built, so that once ready, a system can be easily connected to the mainline, removing the need to expose the main, submain, or lateral pipe to "hot tap" or "live tap" in a connection.

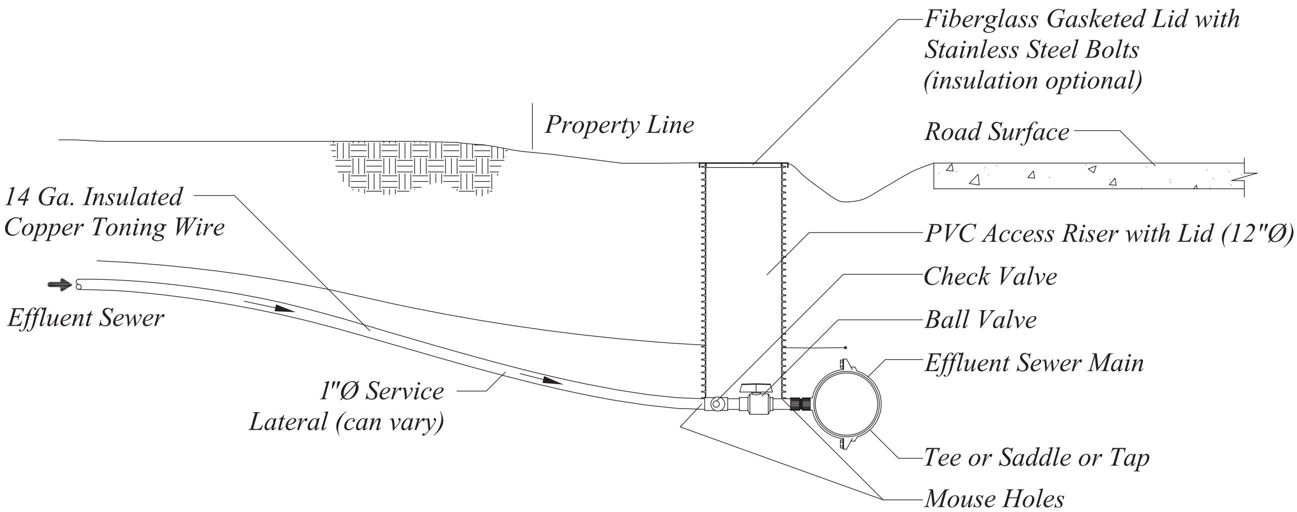


Figure 31. Typical Service Connection Detail

4.2.8 Detailed Specification

For detailed specification information, please see Orenco document number NSP-EFS-SPEC-1.

5. Recordkeeping

5.1 As-Built Map

An as-built map of the effluent sewer system is necessary to record the final location of shut-off valves, clean-outs, air release assemblies, pressure sustaining valves and other components and equipment. The project specifications should clearly call for the contractor to keep an accurate and up-to-date as-built map of any in-field alterations, to the point of requiring newly installed equipment to be added to an as-built prior to any request for payment for the installed equipment.

A master copy of the as-built map should be kept current at all times while copies of revised as-built maps should be distributed to all field personnel. These maps are especially beneficial to new employees and others unfamiliar with the system and should be a part of each operator's portfolio.

5.2 Maintenance Activities and Recordkeeping

The operation and maintenance of an effluent sewer collection system is typically divided into two activities: proactive maintenance (PM) and reactive maintenance (RM). The key to the lowest life-cycle cost is to identify the appropriate balance for these activities, both with the rights of way components and with the on-lot systems.

After the initial installation, each site should be visited within the first year of operation to ensure that any installation issues are corrected within the installation warranty period. Tank settling is the most commonly identified installation issue (this is not typically identified during the system startup).

System maintenance protocols can vary greatly. Most existing systems have been operated with varying degrees of emphasis placed on PM activities, the frequency of which is dictated by the most sensitive components. Extremely aggressive PM programs have been able to reduce RM service calls to a point that they become relatively insignificant in O&M costs. However, an overly aggressive PM program can also result in higher overall O&M costs when PM activities unnecessarily target components that have a significant level of reliability (e.g., discarding an entire pump when cleaning or replacing the pump's liquid stack is all that was needed; or unnecessarily pumping out the tank for equipment servicing, or at frequencies that do not allow proper accumulation and digestion of sludge and scum to occur).

The "run-to-fail" O&M protocol emphasizes RM. In this approach, maintenance is only performed when equipment fails. Essentially, the operator waits for an alarm. This approach has some significant implications and should not be considered an option. While daily O&M costs (at least in the early years) may be extremely low, the increasing frequency of major repairs and replacement activities will escalate as the system suffers from neglect. Additionally, public perception of a run-to-fail approach is generally poor, because this approach often places the customer in a more responsible position of identifying system alarms and reporting them to the management entity.

The most cost-efficient O&M approaches for effluent sewer balance PM and RM to achieve the lowest overall O&M cost. The systems that typically achieve the lowest overall O&M cost tend to establish PM cycles based on each component. Thorough and accurate maintenance records should be kept on all PM and RM activities. These records help identify trends, so that appropriate maintenance schedules can be created for the project.

In the rights of way, air release assemblies (a discussion of manual vs. automatic was covered in section 3.7) are typically inspected semi-annually or annually, and mainline valves are typically exercised annually. With accurate documentation, inspection frequencies can often be adjusted based upon where they are located in the system, and actual frequencies may be adjusted to annual or quarterly schedules. Mainline valve exercising frequencies may be adjusted based on valve size and system impact.

For the on-lot components, the most significant cost is normally septage pumping and removal. Many designers and jurisdictions have made the mistake of establishing overly conservative required pumpout intervals — this policy unnecessarily creates a cost burden on the district and users. Intervals that are too short inhibit primary treatment and force users to pay significantly more for service and pumping. Philip, et al. determined that it takes about three (3) years to establish sufficient volatile organic acid concentrations for the methane formers, which means that the tank becomes more efficient after the third year (Philip, 2003). Pumpout frequencies based on 95% confidence levels are already conservative by a factor of two (2±) over typical averages. So the establishment of a tank monitoring program — and pumping only when necessary — is essential to control costs.

Inspection of effluent screens, pumps, and controls can be performed in conjunction with tank monitoring. Filter cleaning often occurs only as frequently as the tank is pumped, but filters should be initially inspected (along with the pump and controls) every 3± years. As the records of high-quality effluent sewer components are verified by experience, these minimum frequencies may be extended.

6. Orenco Support for Projects

Orenco and many of its distribution and sales partners support the designer and system owners throughout the evaluation, design, construction, and operation of effluent sewer systems that utilize Orenco equipment. Orenco and its business partners shift responsibility for support based on the type of application and the experience of the partner. References to “Orenco” in this section refer to the appropriate party responsible for support.

6.1 Evaluation and Planning Support

In the evaluation and planning process, Orenco’s experience and relationships with project owners and operators of existing effluent sewer projects provide the evaluators access to sources that have been through the project process. Orenco has numerous case studies and project bid tabulations that will give the evaluators a strong understanding of actual installed and operational costs and can provide technology comparisons to assist in the evaluation process. Orenco can also provide presentation materials, examples of easements and ordinances, and support at public meetings through this process.

6.2 Design Support

In addition to this design manual, Orenco can provide design assistance and other materials throughout the project. This assistance includes evaluating project layouts, providing specifications and detail drawings, and providing a plan review with comments and recommendations.

6.3 Installation Support

Orenco provides installation training for our equipment and will consult with work crews to help ensure proper installation. Orenco will also provide training to the project inspectors and an inspection checklist for use when reviewing installed systems.

6.4 Operation and Maintenance Support

Orenco also provides training to the operators of Orenco effluent sewer systems and provides sample maintenance forms to use for documenting these activities. After the system is operational, Orenco has a staff of asset management specialists that assist operators with troubleshooting, reviewing activities, and helping to guide operational and management protocol to provide for the most efficient operational plan for their system.

Bibliography

Bounds, T.R. (1989). *Glide Audit 1986-1987 Summary of Sludge and Scum Accumulation Rates.*

Bounds, T.R. (1997). *Design and Performance of Septic Tanks*, Site Characterization and Design of Onsite Septic Systems ASTM STP 901, M.S. Bedinger, A.I. Johnson, and J.S. Fleming, Eds., American Society for Testing Materials, Philadelphia, 1997.

Crites, R. W., Tchobanoglous, G. (1998). *Small and Decentralized Wastewater Management Systems*. McGraw Hill.

Electrical Power Research Institute (2013). *Electricity Use and Management in Municipal Water Supply and Wastewater Industries*. EPRI and Water Research Foundation.

Erlenbach, D., Lachapelle, P., (1998). *Planning Guide for On-Site Greywater/Watewater Disposal Systems for Recreational and Administrative Sites Part II*. USDA Technology & Development Program.

Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers (2004). *Ten State Standards: Recommended Standards for Wastewater Facilities*.

Metcalf and Eddy Fourth Edition (2003). *Wastewater Engineering Treatment and Reuse*. McGraw Hill.

Philip, H. M. et al. (2003). Septic Tank Sludges: Accumulation Rate and Biochemical Characteristics. *Proceedings of the Second International Specialized Conference on Design and Operation of Small Wastewater Treatment Plants*. Trondheim, Norway.

Seabloom, R. W. (1982). *Septic Tank Performance Compartmentalization, Efficiency, and Stressing*. University of Washington, Department of Civil Engineering.

USEPA (1991). *Alternative Wastewater Collection Systems Manual*.

USEPA (1995). *Interim Economic Guidance for Water Quality Standards*. USEPA, Office of Water.

Water Environment Research Foundation (2010, April). *Decentralized Systems Performance and Costs Fact Sheets*. Retrieved from WERF Web Site: http://www.werf.org/i/c/DecentralizedCost/Decentralized_Cost.aspx

Winneberger, J. H. (1984). *Septic Tank Systems: A Consultant's Toolkit Volumes 1 & 2*. Ann Arbor Science.

Appendix 1: Access Easement Sample Language

The following language has been found to effectively create a blanket easement for wastewater access. However, the language is a suggestion only – the facts in every case inevitably require variations. Drafting easements is essentially rendering legal advice, and that responsibility ultimately rests with the legal counsel of the specific District.

In consideration of the prospective benefits to be derived from the locating, constructing, and maintaining a pressure sanitary sewer by (insert District name), the undersigned hereby grants to (insert District name), a (insert entity type) of the State of (insert State name), a perpetual easement for the purpose of constructing, installing, maintaining, and inspecting pressure sewer service lines, interceptor tanks, pumping equipment, and facilities incidental thereto on the following described property in (insert County name), (insert State name):

Part of (insert legal description of the subject property at the highest allowable level of description), as more particularly described in that instrument recorded at (insert volume, page name, etc. of the granting deed) of (insert County name), (insert State name).

A. The undersigned releases (insert District name) from any and all claims necessarily incident to such installation, construction, maintenance, or inspection and is responsible for repair and maintenance of the sewer line between the interceptor tank and the structure being served.

B. (Insert District name) will be responsible for routine maintenance and inspection, but the undersigned must pay for repairs caused by abuse or misuse of the system.

C. (Insert District name) may use roads upon the above described property for access for all purposes mentioned herein, if such roads exist, otherwise by such route as shall occasion the least damage and inconvenience to the undersigned. The undersigned shall not erect any structure or excavate or substantially add to or diminish the ground cover within 10 feet of any facilities or within 5 feet of any service lines installed by (insert District name).

The rights, conditions, and provisions of this easement shall inure to the benefit of and be binding upon the heirs, successors and assigns of the parties hereto.

DISCLAIMER: This language is illustrative only. Each lawyer must depend on his or her own legal research, knowledge of the law, and expertise in its usage or manipulation.

Appendix 2: STEP/STEG Installation Checklist

SYSTEM OWNER: ______________________ DATE: ______________________

SITE ADDRESS: ______________________

____

______________________ SYSTEM PROVIDER: ______________________

CONTRACTOR: ______________________ INSPECTOR: ______________________

AS-BUILT SITE DIAGRAM

Please draw an as-built sketch of the site including approximate location of buildings, property boundaries, trees, fences, existing septic systems, existing wells, new septic tank, recirculation tanks, pump basins, sewer piping, etc. Include dimensions.

YES	NO	PRE-INSTALLATION	DATE/INITIAL:
________	________	Tank Location Approved per Engineer	
________	________	Panel Location Approved per Engineer	
________	________	Electrical Supply (# circuits/disconnect)	
________	________	STEP Equipment Package Reviewed and Approved	
________	________	Certificate of Origin	
________	________	Service Connection Located	
________	________	Review Riser-to-Tank Connection and Piping-to-Tank Method	

YES	NO	TANK INSTALL (per Manufacturer)	DATE/INITIAL:
______	______	Tank Warranty	
______	______	Date Manufacture Specified	
______	______	Factory Leak Test Documentation	
______	______	Inlet Connection Approved	
______	______	Certificate of Origin	
______	______	Riser-to-Tank Connections Approved	
______	______	Tank is Level and Properly Bedded	
______	______	Passes Leak Test/Water Tight Test (tank filled 2 inches or 50 mm above tank/riser connection)	

YES	NO	PUMPING SYSTEM	DATE/INITIAL:
______	______	Splice Box Location Acceptable	
______	______	Pump Vault/Screen Easily Accessible for Maintenance	
______	______	Discharge Assembly Installed Correctly	
______	______	Service Lateral Properly Bedded and Depth is Sufficient	
______	______	Toning Wire Present	
______	______	Check Valve Installed Correctly	
______	______	Control Panel Location and Height Acceptable	
______	______	Conduit Wiring Acceptable (waterproof wire nuts used)/Seal Offs (panel and splice box)	
______	______	Service Connection Valve Box/Accessibility	

YES	NO	START UP	DATE/INITIAL:
______	______	Risers Backfilled to Grade (within 2 inches of lid)	
______	______	Appropriate Sized Pump Circuit Breaker	
______	______	Circuit Breaker Marked Appropriately	
______	______	Separate Alarm Circuit (preferred, not required)	
______	______	Pump Operation Voltage _______ Amps_______	
______	______	Float Operation Alarm _______ On/Off _______ Low Level _______	
______	______	Float Settings Accurate (record dimensions from top of tank)	
______	______	Alarm: On/Off _______ Low Level _______	
______	______	Controls: Audible Alarm _______ Visual Alarm _______	
______	______	Emergency Call Sticker in Place	
______	______	All Lids In Place and Locked	
______	______	Homeowner's Manual Delivered to Homeowner	
______	______	Site Pictures Attached	

Inspector Signature: ____ *Date:* ______________________________

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