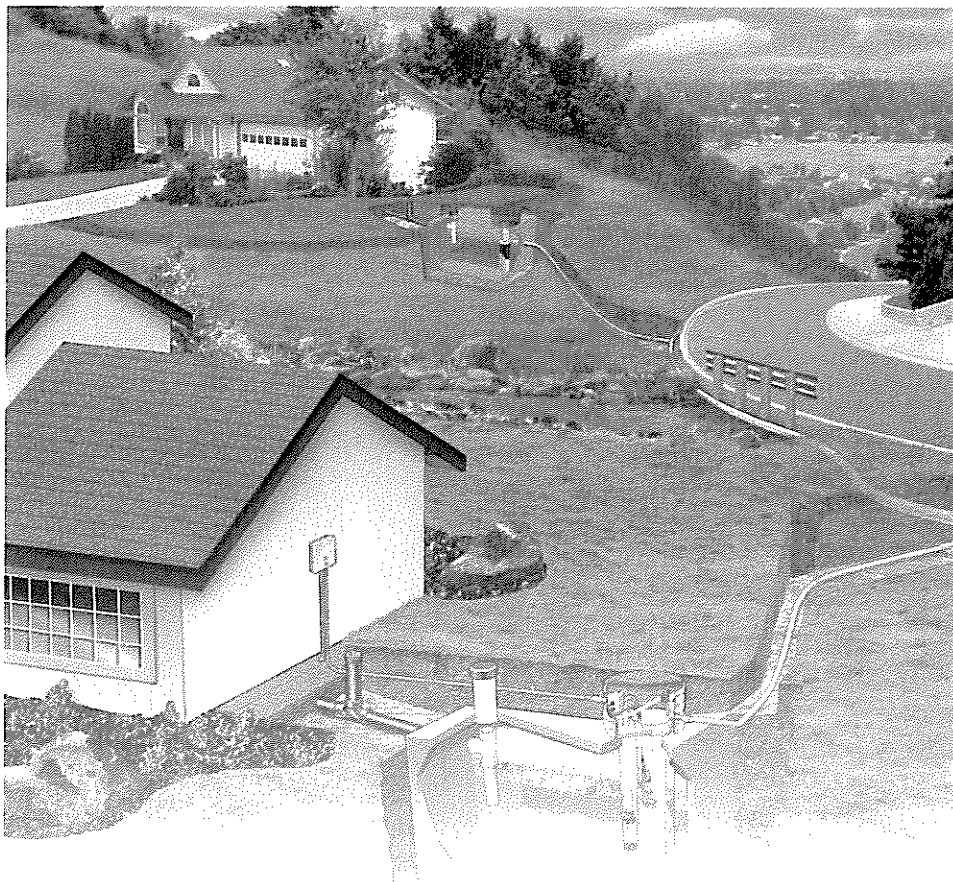


Effluent Sewer Design Manual



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



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Table of Contents

Definitions	1
1. Planning	3
1.1 Collection System Technologies	3
1.2 Collection Technology Comparison	5
1.3 Other Planning Considerations	6
2. Design	8
2.1 Introduction	8
2.2 System Layout	8
2.3 Odor and Corrosion Concerns	10
2.4 Hydraulics	10
2.5 Design Example 1	16
2.6 Design Example 2	20
3. Public Rights of Way	22
3.1 Introduction	22
3.2 Piping and Fittings	22
3.3 Terminal End Clean-Outs and Piging Ports	23
3.4 Mainline Testing and Inspection	24
3.5 Pipe Restraints	24
3.6 Isolation Valves	25
3.7 Air and Vacuum Release Valves	25
3.8 Pressure Sustaining Devices	27
3.9 Odor Control	27
3.10 Freeze and Damage Prevention	31
4. Private Property On-lot Connections	32
4.1 Introduction	32
4.2 Interceptor Tanks	32
5. Recordkeeping	48
5.1 As-Built Map	48
5.2 Maintenance Activities and Recordkeeping	48
6. Orenco Support for Projects	50
6.1 Evaluation and Planning Support	50
6.2 Design Support	50
6.3 Installation Support	50
6.4 Operation and Maintenance Support	50
Bibliography	51
Appendix 1: Access Easement Sample Language	52
Appendix 2: STEP/STEG Installation Checklist	53

List of Figures

Figure 1. Typical Gravity Sewer System Profile	4
Figure 2. Typical Grinder Sewer System Profile.	4
Figure 3. Typical Effluent Sewer System Profile	5
Figure 4. Typical Sewer Main Installation: Gravity (left) vs. Pressure (right)	5
Figure 5. Typical Effluent Sewer Layout	8
Figure 6. Turbine STEP vs. Progressive Cavity Grinder and Centrifugal Grinder Pumps	11
Figure 7. Graphical Representation of TDH in an Effluent Sewer Collection System	13
Figure 8. Pump Curves for 60 Hz and 50 Hz Applications.	14
Figure 9. System Profile	15
Figure 10. Pipe Selection Graph	16
Figure 11. Plan View of Typical System	17
Figure 12. Profile View of Typical System	17
Figure 13. Profile with EDUs and Flows	18
Figure 14. Profile View with Hydraulic Grade Line for Avenue A.	19
Figure 15. Profile View with Hydraulic Grade Line for B Street.	19
Figure 16. Alternate Profile with EDUs and Flows	20
Figure 17. Alternate Profile View with Hydraulic Grade Line for Avenue A.	20
Figure 18. Alternate Profile View with Hydraulic Grade Line for B Street	21
Figure 19. Typical Manual Air Release for Effluent Sewer Lines.	26
Figure 20. Typical Automatic Air/Vacuum Release for Effluent Sewer Lines	27
Figure 21. Typical STEP/STEG Aeration Tank with Aspirators	29
Figure 22. Method for Tying an Effluent Sewer into a Gravity Sewer	31
Figure 23. Pumping Intervals at 95% Level of Confidence	32
Figure 24. Typical Configuration for Multiple-User Tanks	34
Figure 25. Cast-In-Place vs. Set-In-Place Tops.	37
Figure 26. Reduction in Strength Caused by Misalignment of the Reinforcement.	38
Figure 27. Typical Interceptor Tank with Turbine Effluent Pump System	41
Figure 28. Comparison of Turbine Effluent Pump vs. Centrifugal Pump	42
Figure 29. Hanging Style (HDA) and Flexible Hose and Valve Discharge Assemblies	45
Figure 30. Typical Interceptor Tank with Effluent Gravity Discharge (STEG).	46
Figure 31. Typical Service Connection Detail	47

List of Tables

Table 1. WERF Collection Fact Sheet Examples for 200 Homes	3
Table 2. Typical Line Sizes Using PVC and HDPE Pipe.	16
Table 3. Line Sizes Using PVC Pipe	18
Table 4. Treatment Options for Sulfide Control	30
Table 5. Filter and Flow Area Chart	35
Table 6. Sizing Guide for Multiple-User Primary Tanks	35
Table 7. Sizing Guide for Large Flow Pumps	44

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, m³/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 Homes¹

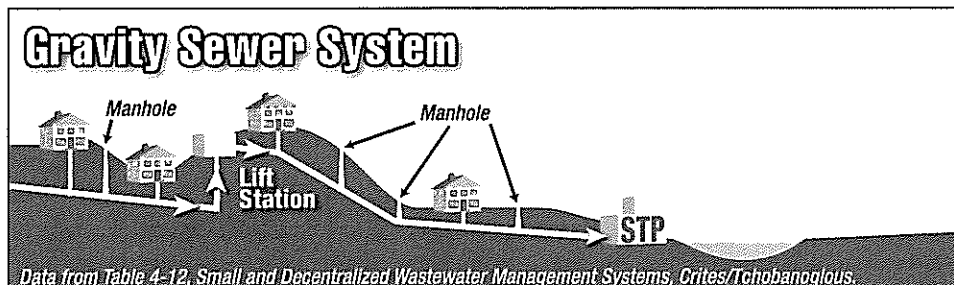
Cost Description	Cost Range	Gravity Sewer	Vacuum Sewer ²	Low Pressure (Grinder) Sewer	Effluent Sewer
Cost of Collection Network	Low	\$2,182,000	—	\$344,000	\$340,000
	High	\$3,273,000	—	\$516,000	\$510,000
Network Annual O&M	Low	\$65,000	\$82,000	\$56,000	\$60,000
	High	\$97,000	\$123,000	\$84,000	\$90,000
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*	AWWF*
	50 gpd/person (189 Lpcd)	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

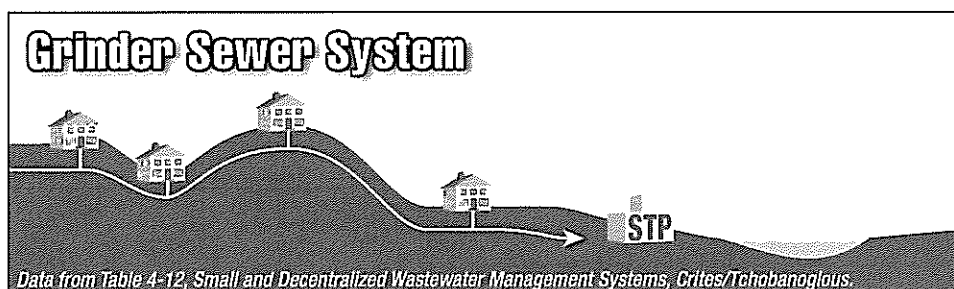
* ADWF: Average Dry Weather Flow
* AWWF: Average Wet Weather Flow

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	

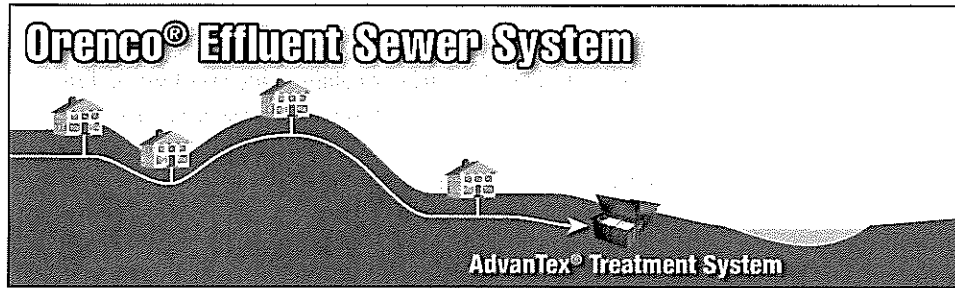
Figure 2. Typical Grinder Sewer System Profile

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.



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 grey-water 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 linear foot or meter and the unconstrained alignment requirement of the pressure main to achieve long-term O&M advantages.

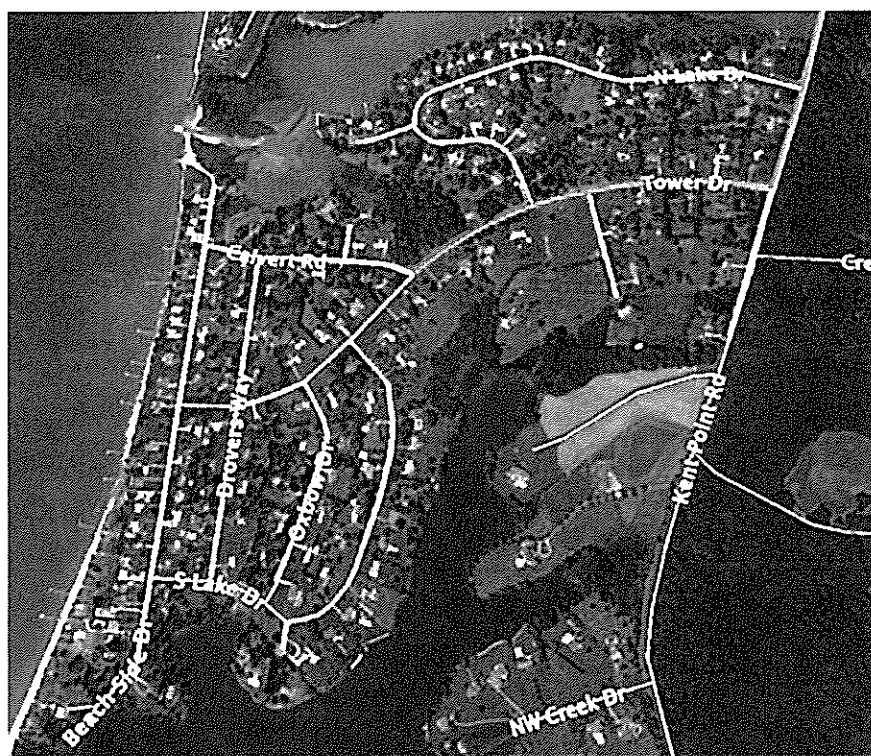


Figure 5. Typical Effluent Sewer Layout

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:

$$Q_A = (100 \text{ connections})(3.2 \text{ capita/connection})(50 \text{ gpd}) = 16,000 \text{ gpd} \quad = 160 \text{ gpd/house} \quad \text{Head} = 175 - 225$$

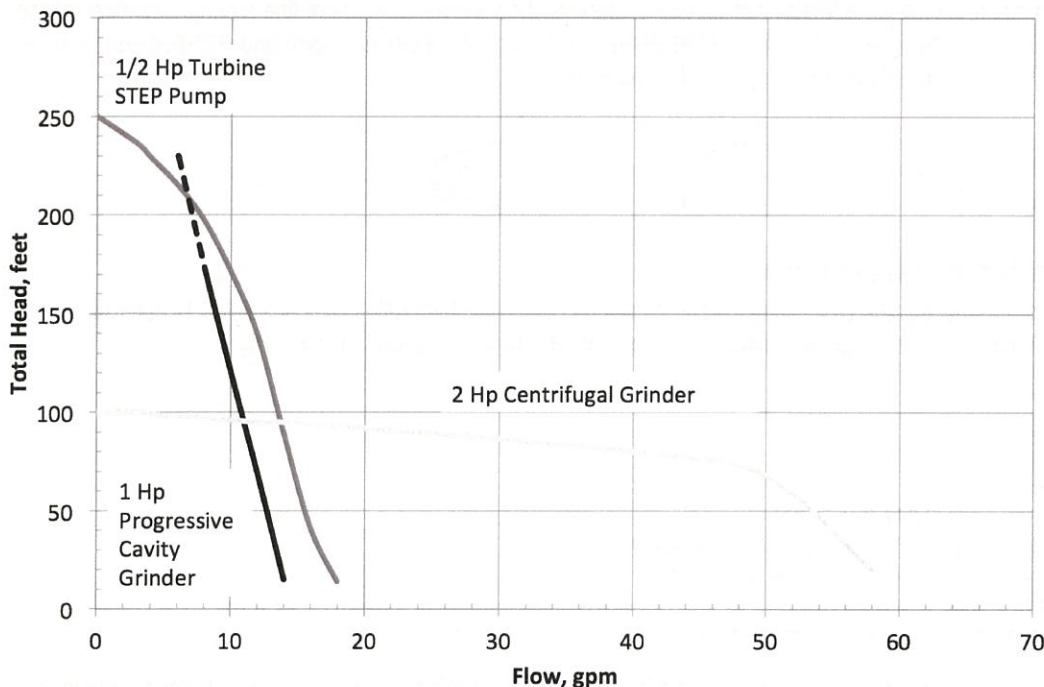
A conservative Design Maximum Day Flow (Q_M) for effluent sewer collection systems is typically calculated by multiplying Q_A by two. Therefore:

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

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.



Say 10 gpm e'

Progressive Cavity
Grinder curves close to
STEP pump curve

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 $Q_p = AN + B$

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

$$Q_p = 0.5(496) + 12.5$$

$$Q_p = 260 \text{ gpm}$$

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 $Q_p = \left(\frac{P_c}{6}\right)\left(\frac{Q_c}{50}\right) \text{ EDU} + B$

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

Say (1) EDU = 200 gpd = 80 gpd/pp, 2.4 per hour

$$\left(\frac{2.4}{6}\right) \frac{80}{50} \cdot 496 + 10 = 327 \text{ gpm}$$

$$+ 15 = 332 \text{ gpm}$$

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:

$$\text{Equation 5} \quad \# \text{EDU} = \frac{Q \text{ gpd}}{150 \text{ gpd/EDU}} = \frac{(300 \text{ capita})(25 \text{ gpcd})}{150 \text{ gpd/EDU}} = \frac{7,500 \text{ gpd}}{150 \text{ gpd/EDU}} = 50 \text{ EDUs}$$

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:

$$\text{Equation 6} \quad V = k C R^{0.63} S^{0.54}$$

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:

$$\text{Equation 7} \quad h_L = \frac{4.727 L}{D^{4.87}} \left(\frac{Q}{C} \right)^{1.85} = \frac{4.727 L}{\left(\frac{d}{12} \right)^{4.87}} \left(\frac{Q_p}{449 C} \right)^{1.85} = \frac{10.557 L}{d^{4.87}} \left(\frac{Q_p}{C} \right)^{1.85}$$

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:

$$\text{Equation 8} \quad h_L = \frac{10.67 L}{d^{4.87}} \left(\frac{Q_p}{C} \right)^{1.85}$$

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.

DEC says 1 Ft/sec. min.

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 $TDH = h_e + h_p + h_l + h_{hv}$

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

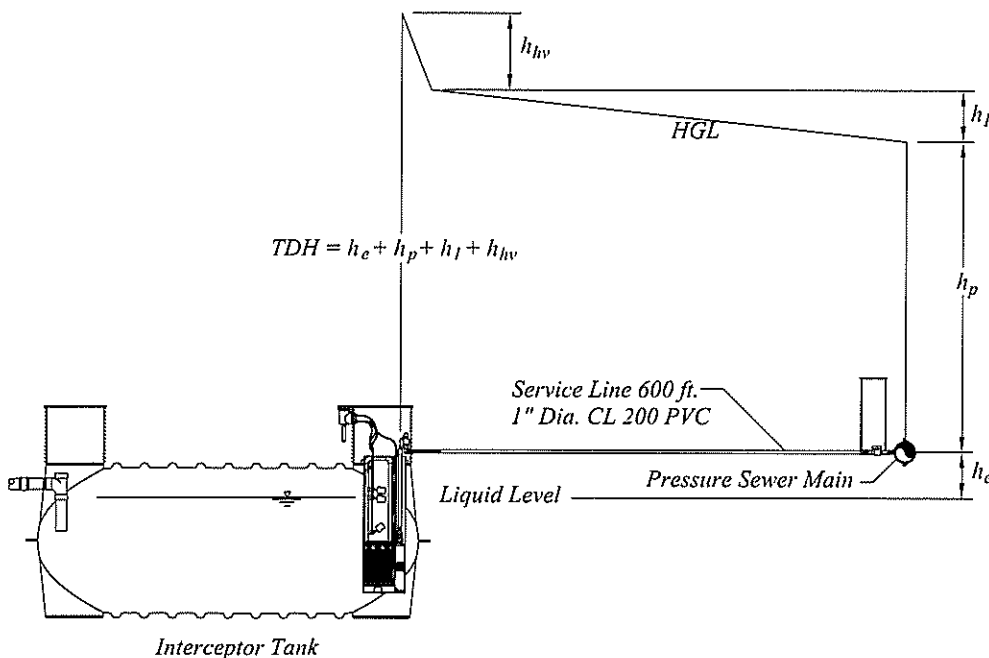


Figure 7. Graphical Representation of TDH in an Effluent Sewer Collection System

The values for h_i 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:

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

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:

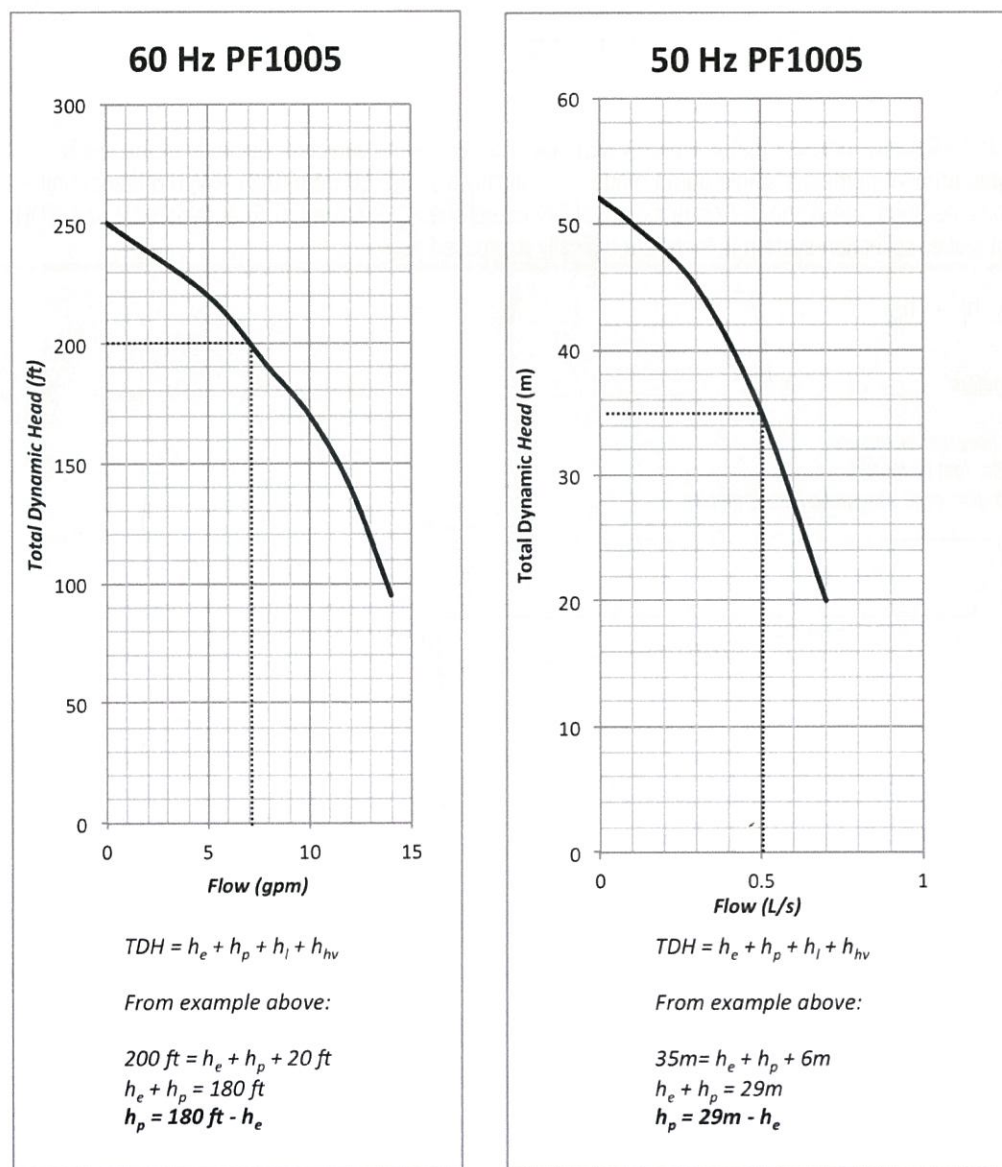


Figure 8. Pump Curves for 60 Hz and 50 Hz Applications

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.

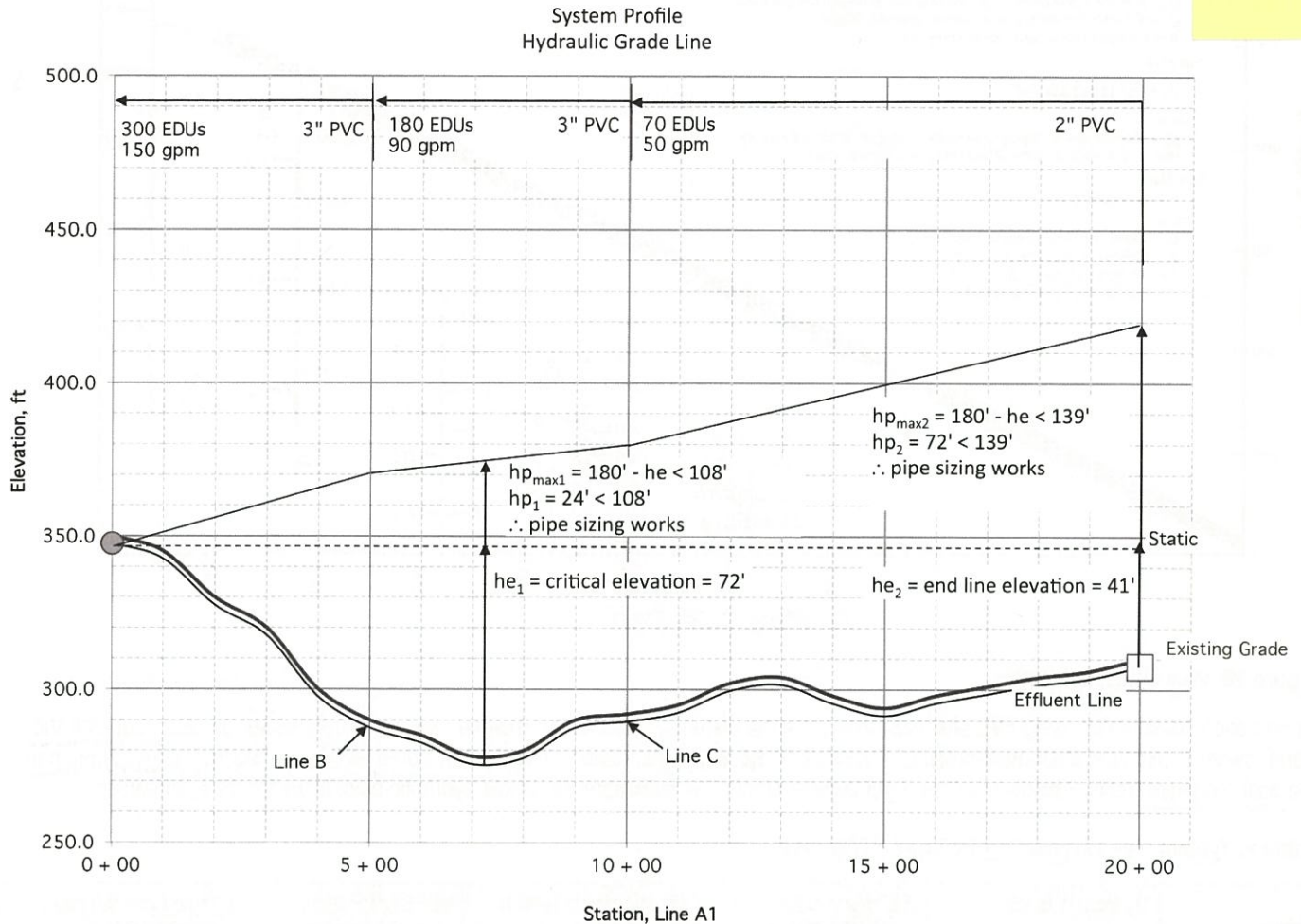
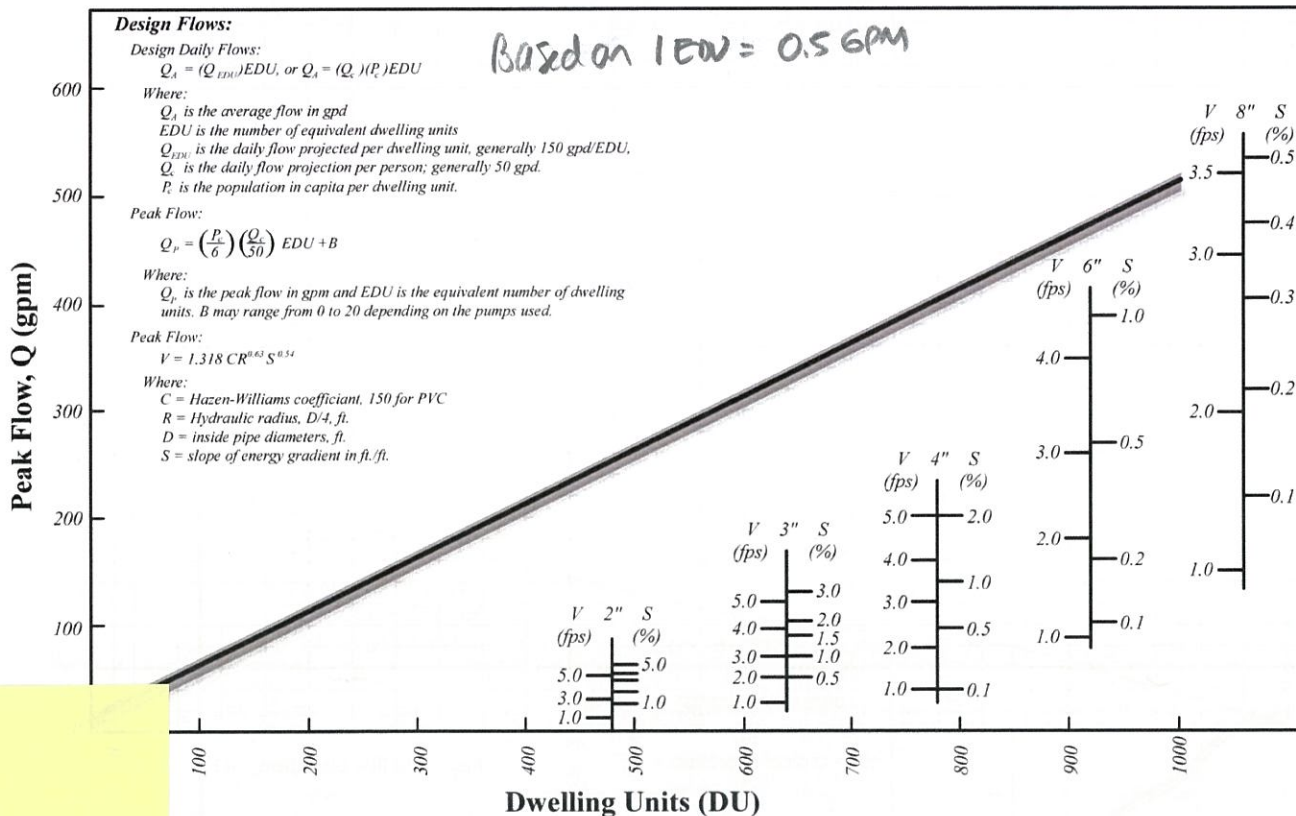


Figure 9. System Profile

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

¹Assumed 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 *C = 140?*

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.

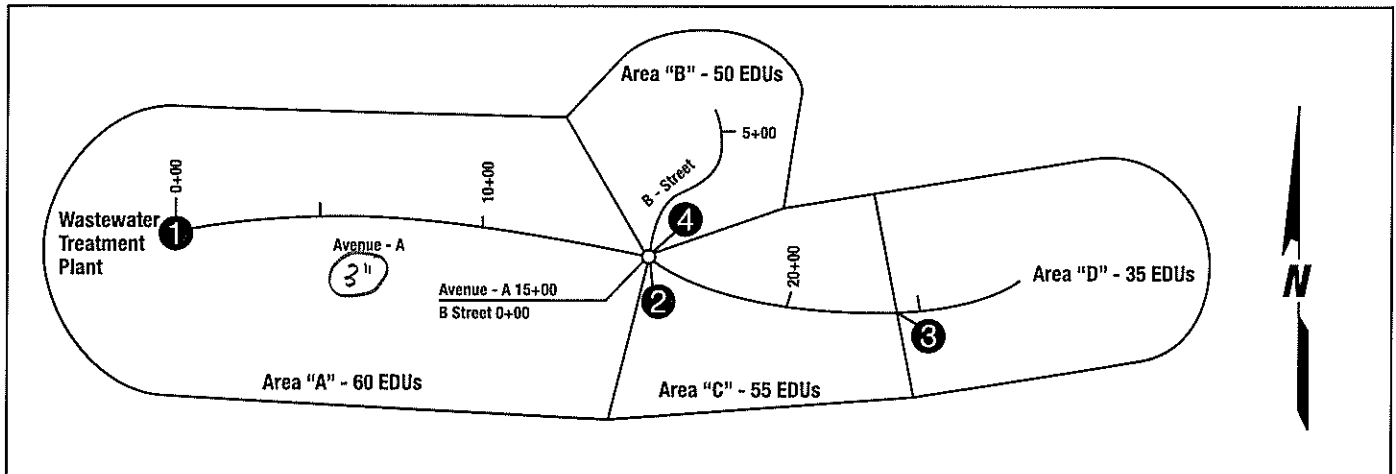


Figure 11. Plan View of Typical System

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

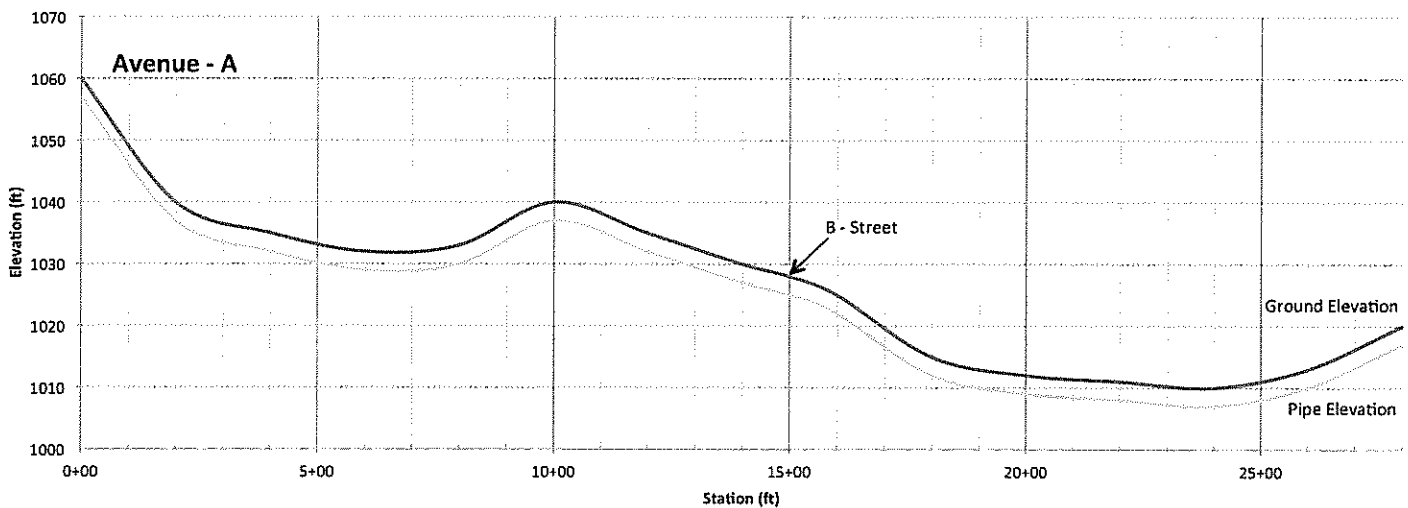


Figure 12. Profile View of Typical System

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).

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

$$\frac{2.4}{6} \left(\frac{50}{50}\right) \text{EDU} + 1$$

4. Modify the graph to include the EDUs and hydraulic peak flow values for each section. See Figure 13. $0.64\text{EDU} + 15$

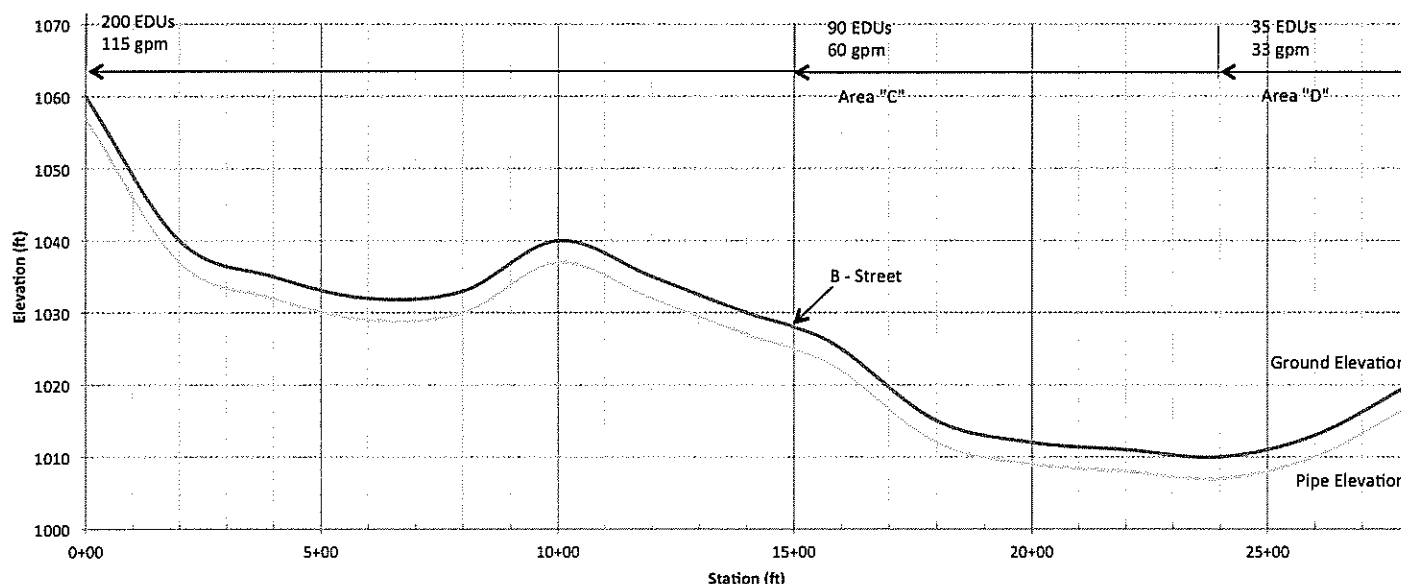


Figure 13. Profile with EDUs and Flows

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.

Avenue A

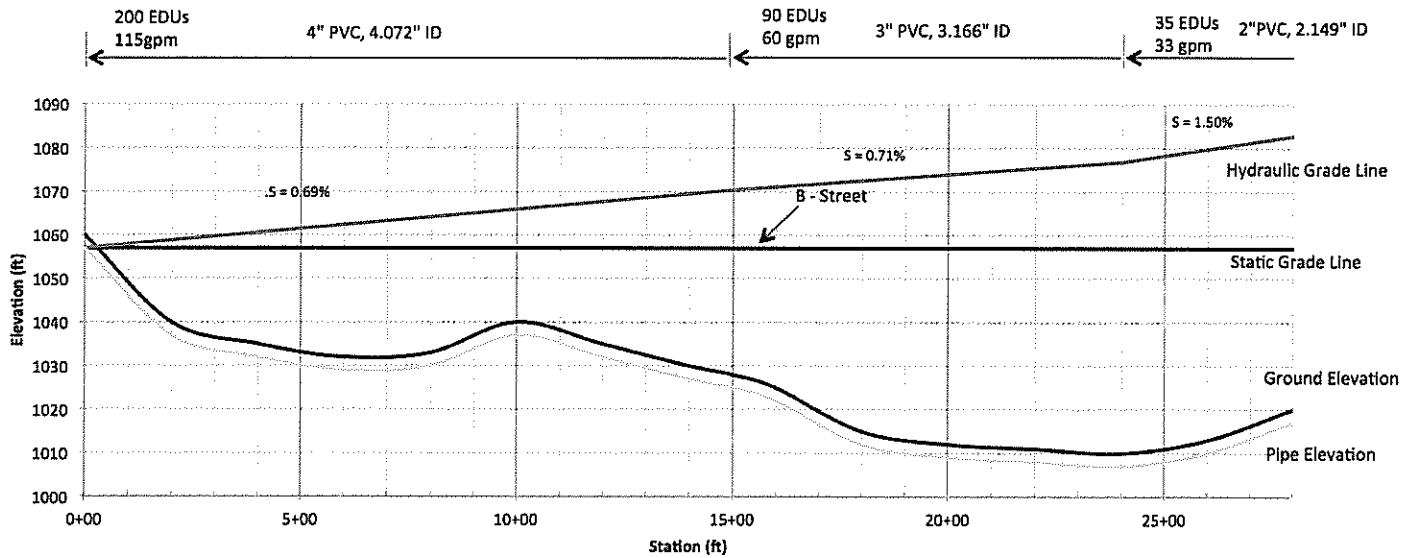


Figure 14. Profile View with Hydraulic Grade Line for Avenue A

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."

B-Street

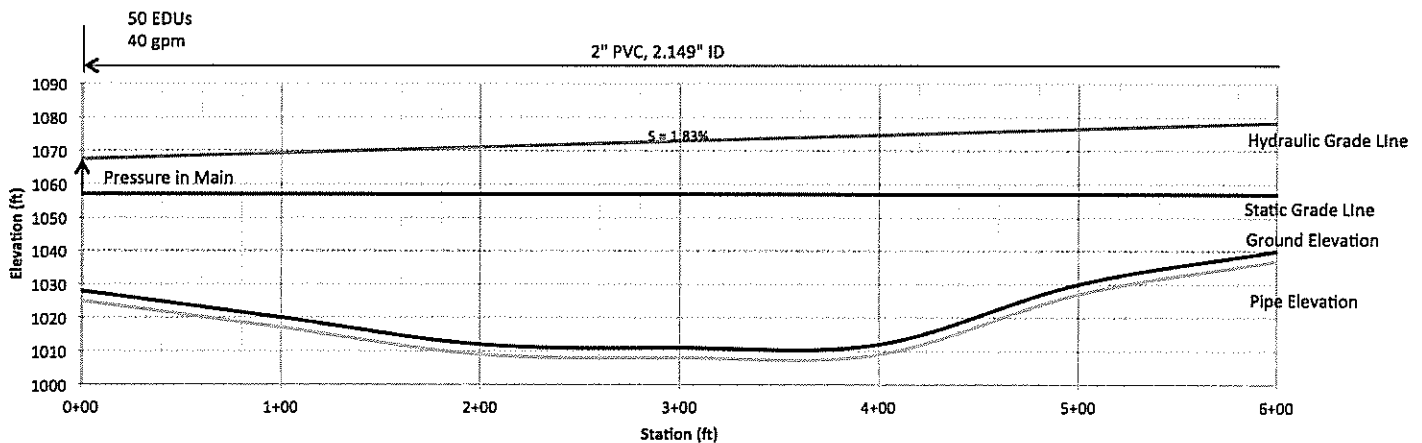


Figure 15. Profile View with Hydraulic Grade Line for B Street

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.

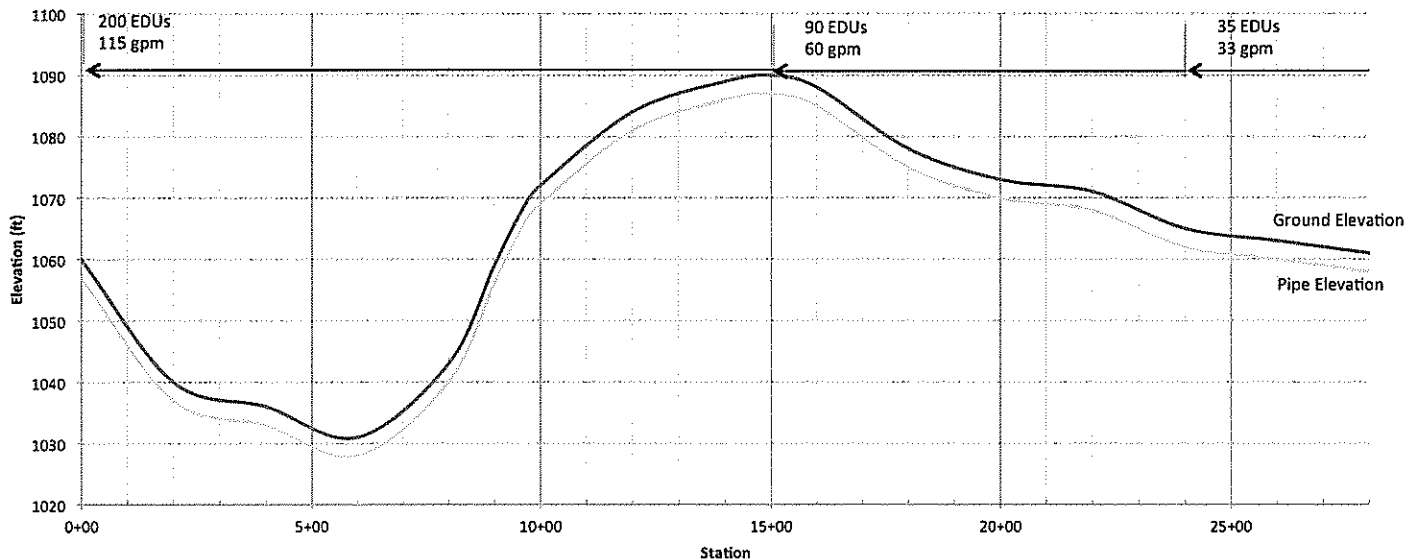


Figure 16. Alternate Profile with EDUs and Flows

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.

Avenue A

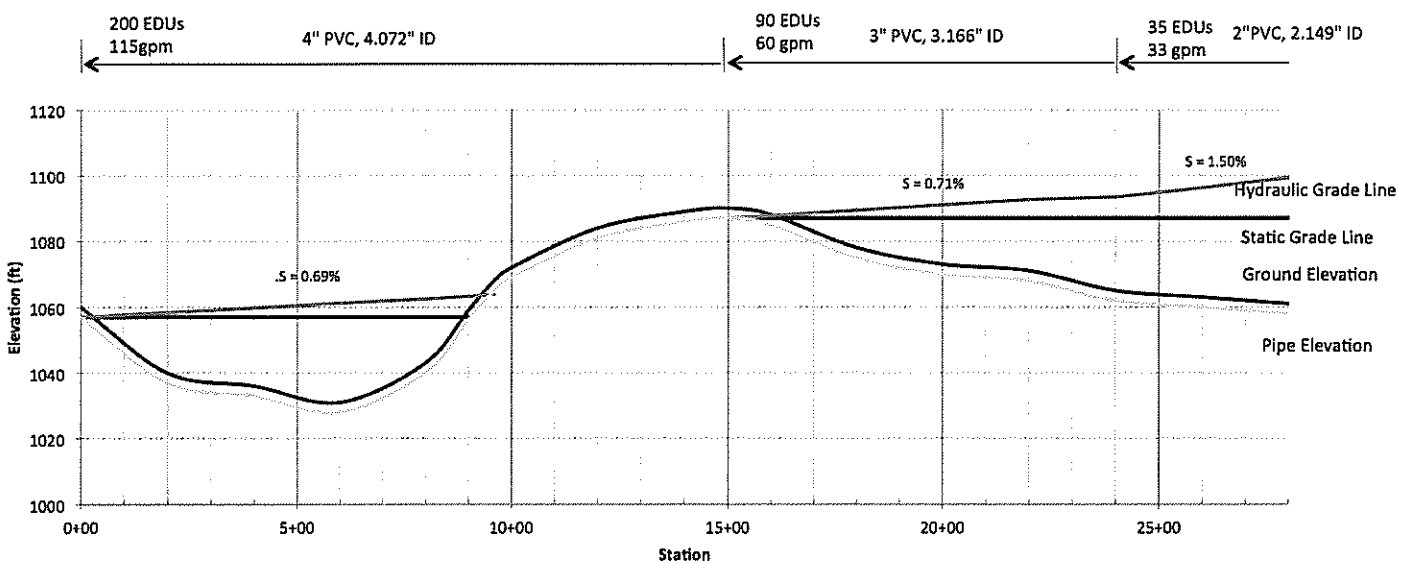


Figure 17. Alternate Profile View with Hydraulic Grade Line for Avenue A

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

B-Street

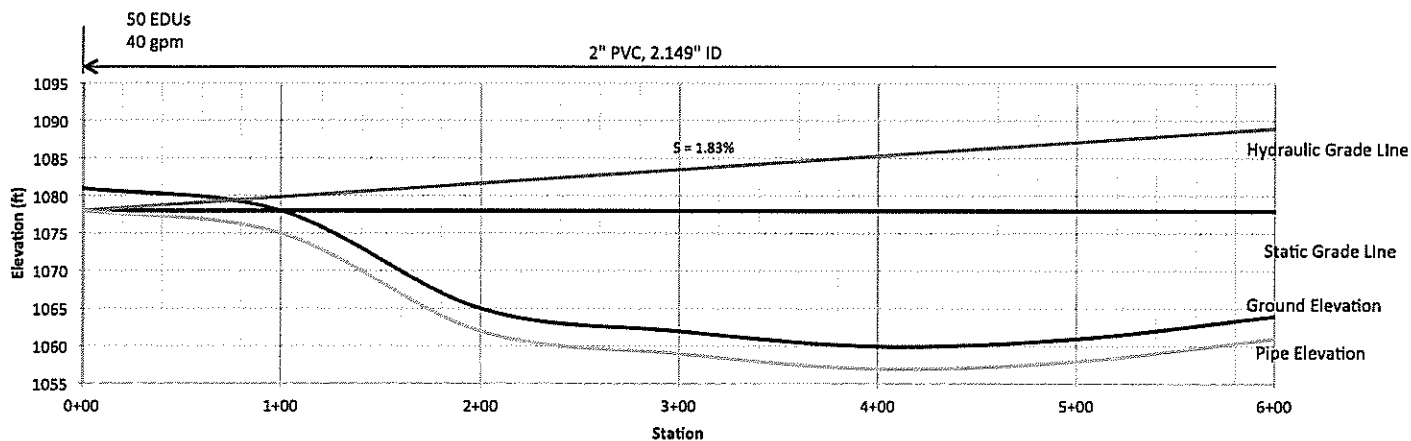


Figure 18. Alternate Profile View with Hydraulic Grade Line for B Street

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