



Alternative Wastewater Collection Systems - Low Pressure and Small Diameter Gravity Sewers

An Online Continuing Education Course for Engineers

Course Number: EN-1010

Credit: 1 Hour / 1 PDH / 1 CPD

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1. INTRODUCTION

Conventional Wastewater Collection Systems

Conventional wastewater collection systems are the most popular method to collect and convey wastewater. These systems transport sewage from homes or other sources by gravity flow through buried piping systems to a central treatment facility. Pipes are installed on a slope, allowing wastewater to flow by gravity from a house site to the treatment facility. Pipes are sized and designed with straight alignment and uniform gradients to maintain self-cleansing velocities. Manholes are installed between straight runs of pipe to ensure that stoppages can be readily accessed. Pipes are generally eight inches or larger and are typically installed at a minimum depth of three feet and a maximum depth of 25 feet. Manholes are located no more than 400 feet apart or at changes of direction or slope.

Conventional wastewater collection systems are usually reliable and consume no power. However, the slope requirements to maintain adequate flow by gravity may require deep excavations in hilly or flat terrain, as well as the addition of sewage pump stations, which can significantly increase the cost of conventional collection systems. Manholes and other sewer appurtenances also add substantial costs to conventional collection systems.

Alternative Systems

Alternative wastewater collection systems are often implemented in situations where conventional wastewater collection systems are not feasible. Typically, it is desirable to use conventional wastewater collection systems based on a proven track record. However, in areas of hilly or flat terrain, the use of conventional wastewater collection systems may require deep excavation, significantly increasing the cost of conventional collection systems.

Where deep excavation is a concern, it may be beneficial to use an alternative wastewater collection system. This course discusses two alternative systems of wastewater collection: pressure sewers and small diameter gravity sewers.

Pressure sewers are used in sparsely populated or suburban areas in which conventional collection systems would be expensive. Pressure sewers differ from conventional gravity collection systems because they break down large solids in the pumping station before they are transported through the collection system. Their watertight design and the absence of manholes eliminates extraneous flows into the system.

Small diameter gravity sewers generally use smaller diameter pipes with a slight slope or follow the surface contour of the land, reducing excavation and construction costs. As long as the head of the sewer is at a higher invert elevation than the tail of the sewer's invert elevation, flow will continue through the system in the intended direction.

Thus, alternative sewer systems may be preferred in areas that have high groundwater that could seep into the sewer, increasing the amount of wastewater to be treated. They also protect groundwater sources by keeping wastewater in the sewer.

2. PRESSURE SEWERS

Pressure sewers are particularly adaptable for rural or semi-rural communities where public contact with effluent from failing drain fields presents a substantial health concern. Since the mains for pressure sewers are, by design, watertight, the pipe connections ensure minimal leakage of sewage. This can be an important consideration in areas subject to groundwater contamination. Two major types of pressure sewer systems are the **septic tank effluent pump (STEP)** system and the **grinder pump (GP)**. Neither requires any modification to plumbing inside the house.

In STEP systems, wastewater flows into a conventional septic tank to capture solids. The liquid effluent flows to a holding tank containing a pump and control devices. The effluent is then pumped and transferred for treatment. Retrofitting existing septic tanks in areas served by septic tank/drain field systems would seem to present an opportunity for cost savings, but a large number (often a majority) must be replaced or expanded over the life of the system because of insufficient capacity, deterioration of concrete tanks, or leaks. In a

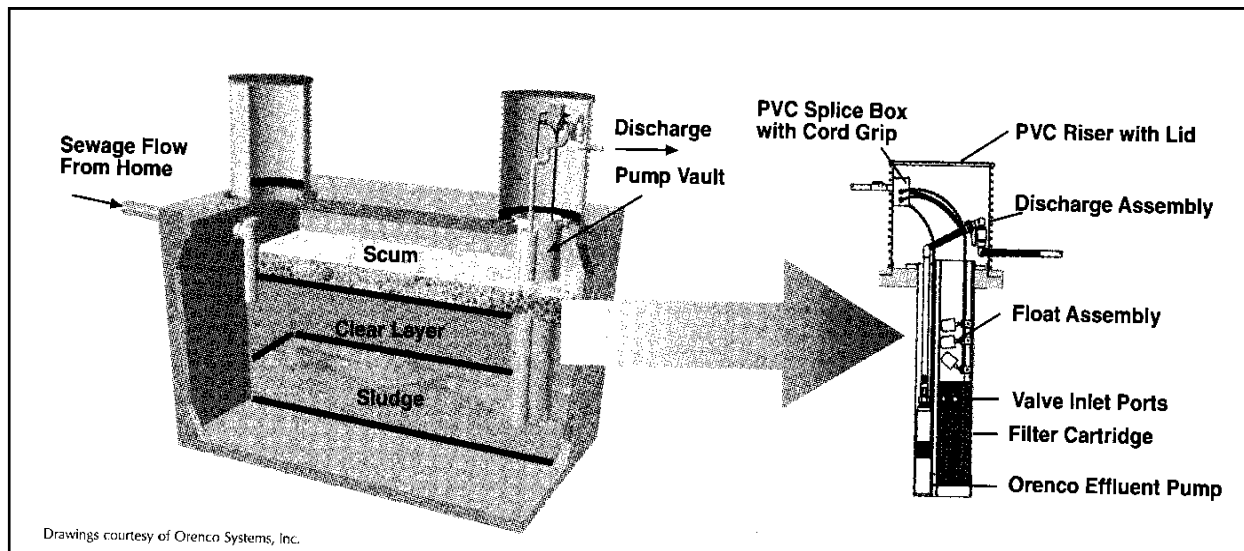
GP system, sewage flows to a vault where a grinder pump grinds the solids and discharges the sewage into a pressurized pipe system. GP systems do not require a septic tank but may require more horsepower than STEP systems because of the grinding action. A GP system can result in significant capital cost savings for new areas that have no septic tanks or in older areas where many tanks must be replaced or repaired. Figure 1 shows a typical septic tank effluent pump, while Figure 2 shows a typical grinder pump used in residential wastewater treatment.

The choice between GP and STEP systems depends on three main factors, as described below:

Cost: On-lot facilities, including pumps and tanks, will account for more than 75 percent of total costs, and may run as high as 90 percent. Thus, there is a strong motivation to use a system with the least expensive on-lot facilities. STEP systems may lower on-lot costs because they allow some gravity service connections due to the continued use of a septic tank. In addition, a grinder pump must be more rugged than a STEP pump to handle the added task of grinding, and, consequently, it is more expensive. If many septic tanks must be replaced, costs will be significantly higher for a STEP system than a GP system.

Downstream Treatment: GP systems produce a higher TSS that may not be acceptable at a downstream treatment facility.

Low Flow Conditions: STEP systems will better tolerate low flow conditions that occur in areas with highly fluctuating seasonal occupancy and those with slow build out from a small initial population to the ultimate design population. Thus, STEP systems may be better choices in these areas than GP systems.



Source: C. Falvey, 2001.

FIGURE 1. TYPICAL SEPTIC TANK EFFLUENT PUMP

APPLICABILITY

Pressure sewer systems are most cost effective where housing density is low, where the terrain has undulations with relatively high relief, and where the system outfall must be at the same or a higher elevation than most or all of the service area. They can also be effective where flat terrain is combined with high ground water or bedrock, making deep cuts and/or multiple lift stations excessively expensive. They can be cost effective even in densely populated areas where difficult construction or right of way conditions exist, or where the terrain will not accommodate gravity sewers.

Since pressure systems do not have the large excess capacity typical of conventional gravity sewers, they must be designed with a balanced approach, keeping future growth and internal hydraulic performance in mind.

ADVANTAGES AND DISADVANTAGES

Advantages

Pressure sewer systems that connect several residences to a "cluster" pump station can be less expensive than conventional gravity systems. On-property facilities represent a major portion of the capital cost of the entire system and are shared in a cluster arrangement. This can be an economic advantage since on-property components are not required until a house is constructed and are borne by the homeowner. Low front-end investment makes the present-value cost of the entire system lower than that of conventional gravity sewerage, especially in new development areas where homes are built over many years.

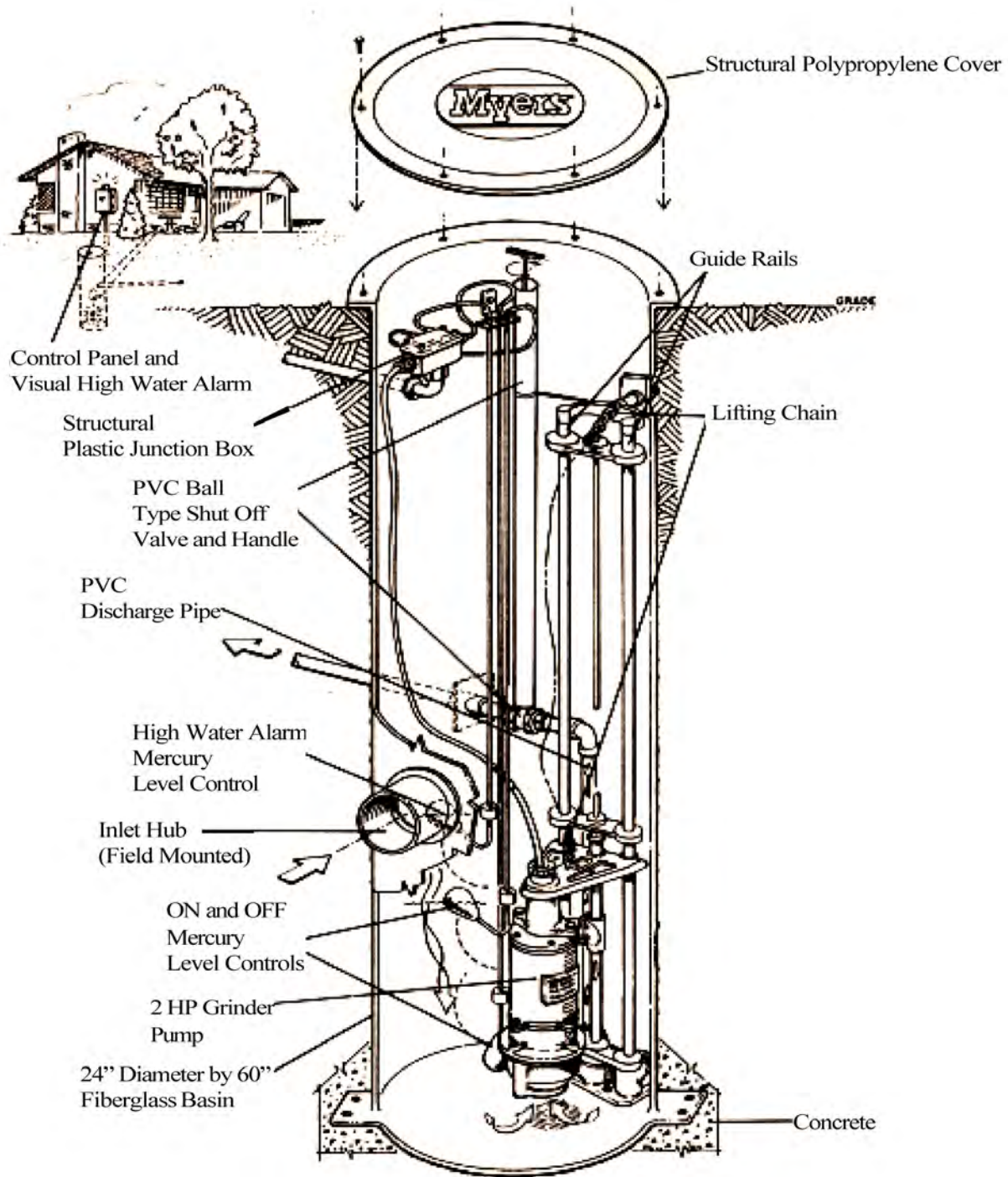


FIGURE 2. TYPICAL GRINDER PUMP

Because wastewater is pumped under pressure, gravity flow is not necessary and the strict alignment and slope restrictions for conventional gravity sewers can be relaxed. Network layout does not depend on ground contours: pipes can be laid in any location and extensions can be made in the street right-of-way at a relatively small cost without damage to existing structures.

Other advantages of pressure sewers include:

- Material and trenching costs are significantly reduced due to smaller diameters and depth reductions.
- Low-cost pipe and manhole assemblies are available. Manholes are spaced apart than in a gravity system.
- Infiltration is reduced due to pipe diameter reductions in pressure systems.
- The user pays less to operate the pumps. An increase in elevation may replace multiple pumps. Bills for central stations and the pressure system are reduced.
- Final treatment may be substantially reduced in hydraulic and organic loading in STEP systems. Hydraulic loadings are also reduced for GP systems.
- Because sewage is transported under pressure, more flexibility is allowed in siting final treatment facilities and may help reduce the length of outfall lines or treatment plant construction costs.

Disadvantages

- Requires much institutional involvement because the pressure system has many mechanical components throughout the service area.
- The operation and maintenance (O&M) cost for a pressure system is often higher than a conventional gravity sewer due to the high number of lift stations. However, lift stations in a conventional gravity sewer can reverse flow.
- Preventive maintenance calls are frequently scheduled for GP systems of pressure sewers. STEP systems require pump-out of septic tanks every three year intervals.
- Pumping is necessary so the system knows how to deal with surges and how to avoid overflows. Other maintenance costs are higher.
- Pumps that can share the load when force main is limited.
- Power outages can result in overflows if standby generators are not available.
- Life cycle replacement costs are expected to be higher because pressure sewers have a lower life expectancy than conventional systems.

Odors and corrosion are potential problems because the wastewater in the collection sewers is usually septic. Proper ventilation and odor control must be provided in the design and non-corrosive components should be used. Air release valves are often vented to soil beds to minimize odor problems and special discharge

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