Chapter 6

Collection System Technologies

CHAPTER 6

COLLECTION SYSTEM TECHNOLOGIES

6.1 INTRODUCTION

A. **Purpose.** The purpose of this chapter is to identify and screen collection system alternatives that could be used to provide sanitary sewer service to the planning area(s) identified in the Needs Assessment Report.

B. **Description of Existing Collection Systems and Proposed Extensions.** A detailed description of the existing collection system can be found in Chapter 4 of the Needs Assessment Report. Figure 6-1 illustrates the extent of the existing collection system and the properties served.

As discussed in Chapter 1, the 2007 WWFP recommended sewer extensions to several wastewater Areas of Concern (AOC). Sewer extension into the Stewarts Creek Area (Area H-1) and the construction of a new pump station at the intersection of West Main Street and Lincoln Road has proceeded to construction, and these two projects are scheduled for completion in 2012. Since the 2007 WWFP, evaluations have continued to develop the other planned sewer extensions. A draft technical memorandum (attached as Appendix 2-1 in the Needs Assessment Report) dated November 2008 investigated possible phasing for the implementation. This phasing and the proposed sewer extensions are illustrated on Figure 6-2.

The existing collection system and planned sewer extensions will be considered in future evaluations for new sewers to address the current wastewater and nutrient management needs.

6.2 COLLECTION SYSTEM ALTERNATIVES

A. **Introduction.** The layout and design of a collection system depends on several factors. The key factors include the type of collection system technology, the topography of the service area, utilities located in the road right-of-way (ROW), groundwater elevations, and the location of the treatment and treated water recharge site(s). Some of these factors will be decided at the end of this study, while many of the site-specific factors would be decided when a system is designed.

The installation of a wastewater collection system in the road ROW is disruptive to traffic activity. This will be particularly true in Barnstable, which has some narrow streets and increased automobile and pedestrian traffic during the summer season. The use of trenchless technology to install a collection system must be considered during the planning and design processes to minimize disruptions. Trenchless technology is technology that allows installation of wastewater collection and transmission mains without digging a trench in the road ROW.

At the beginning of the planning process for a potential collection system, the system coverage must be estimated to calculate system length and system costs. Each type of collection system technology offers some flexibility on how (or where) individual sewers are installed, but the overall system coverage for the various technologies will generally be the same.

Several types of sanitary sewer collection systems are in use throughout the United States, each with advantages and disadvantages. Careful analysis must be performed during design in the area being sewered to determine the feasibility of a particular collection system. The purpose of this chapter is to identify and screen collection system alternatives which could be used to provide sanitary sewer service to the planning area(s) identified in the Needs Assessment Report. The chapter presents several different types of collection systems and the associated advantages and disadvantages of each.

B. **Gravity Sewers and Lift Stations.** The most prevalent type of collection system is a traditional gravity sewer. This type of system involves the installation of sewers at a constant downhill gradient. The slope is designed to maintain a sufficient velocity within the sewer line to ensure that all solids stay suspended within the waste stream. The minimum size of a typical sanitary sewer is 8 inches. The pipe size increases proportionally with the expected wastewater flow. Figure 6-3 illustrates a typical gravity sewer. The sewer is installed at a constant slope until its depth becomes so great that a sewage pumping station (lift station) is needed to “lift” the flow to a wastewater treatment plant or to another gravity sewer. In flat terrain, several lift stations may be required before the flow is pumped to a treatment facility. Figure 6-4 illustrates several types of pump stations that are common in residential neighborhoods. They are typically placed in buildings that allow them to be consistent with adjacent buildings.

In most situations, homes along a gravity sewer connect into the system with gravity service connections from the building to the collector sewer. Houses that are below the street elevation use small pumps and a small diameter force main (1 ½ to 2 inches) for discharging to the collector sewer.

The installation cost and ease of construction of a gravity sewer depend greatly upon the topography within a particular area and on the specific soil types. In areas where topography is consistently increasing or decreasing, the sewers can be installed close to minimum depth. In very hilly areas, deep sewers and/or lift stations may be required. This can significantly increase construction costs when compared with other options.

Advantages of gravity sewers include the following:

- A properly designed and installed gravity sewer requires little maintenance.
- A gravity system can be easily expanded to serve additional areas.
- The potential for odors in a properly designed gravity sewer is low.
- A gravity system is reliable, since it is not dependent upon electrical power for operation. When lift stations are used on collector sewers, electrical generators are provided to supply power during a power outage.

Disadvantages of gravity sewers include:

- Gravity sewers are installed at a constant slope, and thus can require deep excavations as the topography changes. They also have practical limitations in depth.
- If not installed properly, gravity sewers are prone to infiltration from groundwater, which reduces the wastewater carrying capacity of the pipe, increases pumping costs, and can affect treatment capacity and process effectiveness at the downstream treatment facility.
- May be limited by availability of appropriate lift station locations.

C. **Low Pressure Sewers with Grinder Pumps.** This type of collection system requires the installation of grinder pumps to serve each building or group of buildings. Wastewater flows by gravity into a pump chamber, where the sewage is shredded and pumped into a low pressure sewer, eventually discharging to a gravity main or directly to a treatment facility. This type of technology has become more widely used over the past 10 years, and is particularly suited to areas where there is a need to minimize excavation. Figure 6-5 illustrates a low pressure sewer with grinder pumps.

The typical pressure in this type of system is 5 to 40 pounds per square inch (psi). Pressure systems can be expanded to serve additional areas up to a design limit of 60 psi. Typically, systems can be expanded to serve a large number of additional homes, but the overall expansion capability tends to be less than that of a gravity sewer.

When connecting the pressure sewer lines into a gravity line or directly to a lift station, odor control systems may be required at the discharge point to mitigate odors created in the pressure sewer pipe. Also, manholes at the discharge point should be protected from corrosion resulting from high hydrogen sulfide concentrations.

Advantages of a pressure sewer include the following:

- The collection main is installed at a relatively shallow depth and is independent of grade changes. This allows shallower excavation, lower piping construction costs, and less overall disruption to the area due to a shorter installation construction period.
- A pressure sewer can serve areas of hilly terrain or marginal slope.
- The pressure sewer in the street is not subject to infiltration as a gravity sewer would be.
- The shredding action of the pump eliminates the need for a larger-size collection system. Pressure sewers tend to be much smaller diameter than a typical sanitary sewer, ranging from 1-1/2 inch to 4 inches, depending upon the expected design flow.

Disadvantages to this type of system include the following:

- Each building or group of buildings in the system would have to be equipped with a pump unit, which increases operation and maintenance requirements. Spare parts must be maintained for these units to minimize disruption of service.
- Each pump unit is dependent upon electrical power for proper operation; since the pumps are located at individual homes, municipal backup electrical power is typically only provided with mobile generators. Storage capacity is typically built into each pump chamber (normally 60 gallons). However, in a prolonged power outage, it would be possible for the wastewater flow to exceed this capacity and back up into the pipelines

within the structures. This can be remediated by providing electrical connections on each pump unit to allow a service crew to connect a portable generator (the mobile generators identified previously) and pump out each unit during times of prolonged power outage.

- This system is more sensitive to seasonal flow conditions than a gravity sewer. In areas with extreme seasonal fluctuations, minimum flow conditions must be carefully quantified to be sure the sewage flow can properly travel through the system. If inadequate flow exists, solids can harden within the sewer and cause blockages.

D. **Septic Tank Effluent Sewers.**

1. **General.** Septic tank effluent sewers use either new or existing water tight septic tanks and are designed to transport septic tank effluent to a treatment facility. The use of septic tanks prevents a large portion of solids and grease from entering the sewer.

Septic tank effluent sewer systems require septic tank maintenance, including routine pumping and treatment of septage. Each septic tank should be inspected during sewer construction to replace those tanks that provide inadequate service. Inadequate tanks include those that are prone to infiltration, are insufficient in size, have inappropriate inlets or outlets, or do not meet current Title 5 requirements.

When connecting septic tank effluent into existing gravity systems, odor control systems may be required at the discharge point and downstream pump stations to mitigate odors caused by the hydrogen sulfide content in the effluent. Manholes at the discharge point should be protected from corrosion, which can occur as a result of the high hydrogen sulfide concentrations.

There are two types of septic tank effluent collection systems: (a) septic tank effluent pump systems; and (b) septic tank effluent gravity systems. A discussion of each system is presented in the following sections.

2. **Septic Tank Effluent Pump (STEP) System.** The STEP system involves the installation of an effluent pump immediately downstream of the septic tank (or in the septic tank), which pumps the effluent to a pressure sewer. Thus, the system is very similar to a pressure system. Figure 6-6 illustrates the main features of a STEP system

The STEP system has the following advantages:

- The system can serve in areas of hilly or flat terrain.
- The piping can be installed at shallow depths, reducing construction costs and overall disruption associated with excavation.
- The pressure sewer in the street is not subject to infiltration, as a gravity sewer could be.
- Septic tank effluent pumps tend to be less expensive than grinder pumps because the need for a shredder is eliminated.
- Few solids are transported in the system, which reduces the potential for sewer blockages caused by solids deposition.

The STEP system has the following disadvantages:

- The septage must be periodically pumped from the individual septic tanks and transported to a WWTF for treatment.
- The system relies on electrical power to operate the pumps and will not function during power outages.
- A large number of pumps are required, which creates greater maintenance requirements of this system when compared to a gravity sewer.
- Hydrogen sulfide buildup is common within these pipelines, increasing the potential for odors and corrosion.
- A treatment plant that receives flow from this type of system must be carefully designed because it will not receive the higher organic loading that is needed for biological nitrogen removal treatment processes.

3. **Septic Tank Effluent Gravity (STEG) System.** The STEG system can be used to transport effluent from septic tanks to a pumping station or treatment facility. Layout of the system is very similar to a gravity system.

Advantages of STEG sewers include the following:

- A flatter slope can be maintained in comparison with gravity sewers, because most of the larger solids have been removed in the septic tank. The flatter slope will allow the piping to be installed at shallower depths.
- The lack of solids allows smaller diameter pipes to be installed. Sizes typically range from 4 to 6 inches versus 8 inches or greater for a typical gravity sewer.
- Cleanouts can be installed instead of manholes, reducing installation costs.
- Very little maintenance is required on this type of system when compared to a pressure or vacuum system unless lift stations are used.

STEG sewers have the following disadvantages:

- The septage must be periodically pumped from the individual septic tanks and transported to a WWTF for treatment.
- Hydrogen sulfide buildup is common within these pipelines, which increases the potential for odors and corrosion.
- They are not adaptable to hilly terrain.
- A treatment plant that receives flow from this type of system must be carefully designed because it will not receive the higher organic loading that is needed for biological nitrogen removal treatment processes.

E. **Vacuum Sewers.** Vacuum sewers are smaller in diameter than traditional gravity sewers and rely upon a vacuum created within the pipeline to draw the sewage towards a lift station. A vacuum pump located at the lift station pumps air out of the sewer, creating a vacuum inside the sewer. Sewage from individual homes flows by gravity to a vacuum valve pit. As sewage fills a chamber in the bottom of the valve pit, a sensor activates an automatic vacuum valve. When the valve opens, sewage is drawn into the sewer because of the pressure difference between the sewer and atmospheric pressure outside the valve. Each subsequent opening of the valve draws the sewage further downstream until it reaches the lift station, where it is pumped to a gravity sewer or treatment facility. Figure 6-7 illustrates the main features of a vacuum sewer system.

Advantages of vacuum sewers include:

- Vacuum sewers can be installed at shallow depths, which can reduce installation costs and excavation time.
- The infiltration potential tends to be low. Infiltration can occur if a pipe leaks or breaks in areas where the line is completely submerged in groundwater.
- Vacuum stations can be equipped with emergency generators, which allow the system to remain in operation during power outages.

A vacuum system has the following disadvantages:

- A vacuum must be constantly maintained in the pipeline for the system to work. Malfunctions in the line can affect the entire system and must be fixed quickly to keep the system operational. Leaks or malfunctions may also be difficult to locate.
- There is potential for odor generation at the lift station due to the vacuum pump air flow. This air flow must be treated to minimize odors.
- This type of system is not readily adaptable to hilly terrain.
- To design a properly operating system, the design flows must be estimated as accurately as possible, and a detailed route survey must be performed. Vacuum systems are sized for specific cases and cannot be easily expanded to serve additional homes.
- Careful design of pipe materials is needed to avoid the vacuum pipe breakage problems that have occurred at the Provincetown vacuum sewer.
- Careful design of valve pit venting is needed to avoid the valve freezing problems that have occurred in northern climates.

F. **Combination of Technologies.** In many cases, the combination of terrain, soil conditions, and congestion of an area prevents one single type of sewer system from being cost effective. In these situations, the combination of two or more methods may achieve an optimum solution. The combination most widely used is pressure sewers discharging to gravity sewers.

In some cases, it is not feasible to combine methods due to the inherent characteristics of the specific technology. Septic tank effluent systems are designed to transport only liquids using a small diameter pipe. Thus, any other type of system which carries solids should not be able to connect into this system. Also, septic tank effluent systems are designed to lessen the organic loading to a treatment plant, and this advantage would be minimized if a septic tank effluent system discharged into a sewer carrying all the solids.

When considering a combination of technologies during design, a careful review should be made of the local conditions, and cost estimates should be prepared which include construction as well as operating and maintenance costs.

G. **Screening of Collection System Technologies.** The screening of collection system technologies is based on the description provided for each technology, the respective advantages and disadvantages, and the screening criteria established earlier in this report. A summary of collection system technologies and a side-by-side comparison of screening criteria are included in Table 6-1.

Wastewater collection with gravity sewers and lift stations is a widely used, simple, and reliable technology. Gravity sewers can easily be expanded to accommodate additional flows. The relative cost of gravity sewers depends on environmental conditions and increases with the number of lift stations required and depth of excavations.

Pressure sewers are less widely used than gravity sewers, but have relatively low construction costs and are adaptable to changes in topography. Public acceptance of pressure sewers may be low due to the need for a pump at each individual home or business. In addition, pressure sewers rely on electrical power, and flow backup can occur during power outages if mobile generators are not utilized.

The main advantage of septic tank effluent systems (both STEP and STEG) is the reduced amount of solids transported in the collection system and the reduced potential for sewer blockage caused by solids deposition. Unfortunately, the lack of organic solids in the sewage delivered to the treatment plant will make the nitrogen removal process more difficult. These systems also require periodic pumping of the individual septic systems, which adds a high operational cost and potential for odor generation. They also do not lend themselves to being added to existing collection systems that transport all the solids.

Vacuum sewers have maintenance requirements similar to low pressure systems and require significant staff training for implementation and operation. Vacuum sewers are not easily expandable and require accurate flow estimates prior to construction. The capital costs of vacuum sewers are comparable to gravity systems.

The following collection system technologies are identified for possible future use in Barnstable:

1. Gravity sewers and lift stations.
2. Pressure sewers with grinder pumps.
3. Vacuum sewers.

As discussed previously, these technologies are typically selected during preliminary design or detailed design of the system based on site specific considerations of topography, depth to groundwater, potential traffic impacts, and flow variations in the neighborhoods being served. The three technologies identified will be included in the alternative management plans.