CHAPTER 4: WASTEWATER COLLECTION SYSTEMS

DEFINITION OF WASTEWATER COLLECTION SYSTEMS
Wastewater collection systems gather the used water from our homes, businesses and industries and convey it to a wastewater treatment plant. This type of system is also called a sanitary sewer. A similar system known as a storm water collection system conveys water resulting from runoff of rain and snow from buildings and paved and unpaved areas to a natural watercourse or body of water, usually without treatment. This type of system is also known as a storm sewer. In the past, some sanitary sewers and storm sewers were combined into one system. Unfortunately, during heavy rains the wastewater treatment plants served by combined sewers often became hydraulically overloaded and washed out into the receiving stream causing a complete treatment system failure. For this reason, combined sewers are now uncommon.

WASTEWATER COLLECTION SYSTEMS OPERATORS
The ancient Romans were one of the first civilizations to employ wastewater collection through clay pipes and covered cannel sewers. They understood all too well the importance of maintaining sanitary conditions. Modern wastewater collection systems are a sophisticated combination of components that include; gravity sewer lines, force mains, manholes, and lift stations. They represent one of the largest financial investments of public money for our municipalities. Why is it then that the personnel charged with operating and maintaining wastewater collection systems often feel as though they are the lowest paid employees in the entire city?

Because these systems are underground where the public does not see them they are all too often “out of sight, out of mind”. The general public rarely understands that operation and maintenance of wastewater collection systems is critical to maintaining the modern sanitary conditions we all take for granted. Only when the system fails, (such as during a sewer back-up), does the public take notice of the wastewater collection system. Wastewater collection system operators have a very dangerous, important job and are deserving of respect for their skill and dedication.

WASTEWATER COLLECTION SYSTEM DESIGN

GRAVITY SEWER LAYOUT
The largest component of a wastewater collection system is usually the gravity sewer. Gravity sewers follow the topography of the surrounding area, (lay of the land), to take advantage of the natural slope. They are designed to provide a flow velocity between 2 and 8 feet per second (fps), with 2.5 fps being ideal. If the velocity is too low, settleable solids will deposit in the sewer lines, if the velocity is too high, erosion and damage of the collection system will occur. Gravity sewers are divided into the following sections:

Building Sewers
A building sewer connects a building’s internal plumbing to the public wastewater collection system. The building sewer may begin at the stub-out, the property line or some distance (such as 2 to 10 ft.) from the building’s foundation. Where the building sewer ends marks the end of the building owner’s responsibility for maintenance and repairs. Beyond the building sewer, the wastewater collection system operators are responsible for maintenance, cleaning and repairs. This division should be clearly spelled out in local sewer ordinances.

Lateral and Branch Sewers
Lateral and branch sewers are the upper ends of the wastewater collection system. Sometimes they are located in easements, although this should be avoided where possible due to problems of access and limited work space.

Main Sewers
Main sewers collect the flow from numerous lateral and branch sewers and convey it to larger trunk sewers.

Trunk Sewers
Trunk sewers are the main “arteries” of the wastewater collection system and convey the wastewater from numerous sewer mains to a wastewater treatment plant or to an interceptor sewer.

Intercepting Sewer
Sewer interceptors receive the wastewater from trunk sewers and convey it to the wastewater treatment plant.

CHARACTERISTICS OF GRAVITY SEWERS
The following items are considered when determining the characteristics of a sewer line:

Slope of Sewer
As stated before, the slope of the sewer should follow the lay of the land as closely as practical provided the slope is adequate to produce gravity flow and maintain the minimum velocity (2 fps). Some areas will be too flat to permit exclusively gravity flow because the sewer lines would have to be buried excessively deep.

Design Flow
Wastewater collection systems are designed to convey the peak flow from a service area when the area has reached its maximum population density and has been fully developed.
commercially and industrially. Population estimates, growth projections and comparison to similar areas are all used to determine the maximum expected volume to be contributed by a service area. Domestic wastewater flow is often calculated by multiplying the estimated population in a service area by the per capita flow. In New Mexico the per capita flow ranges from 60 to 125 gallons per day per person. Businesses and industries will contribute varying flows and so must be accounted for differently. In addition to the expected wastewater flows, allowances must be made for infiltration and inflow, (I & I are discussed later in this text). Also, because the actual flow of wastewater in the collection system will vary during a 24-hour period, (minimum flow during the early morning hours and maximum flow around 10:00 AM to 12:00 PM), a peaking factor must be used in order to ensure the sewer will handle the maximum instantaneous flow. Peaking factors of 2.5 – 3.5 times the total daily flow are often used to size wastewater collection systems.

Velocity
The wastewater in a sewer line should move at a speed that will prevent the deposition and buildup of solids in the sewer; this is called a “scouring velocity”. A minimum velocity of 2 fps has been shown by experience to provide this scouring or self-cleaning velocity. Not all lines will maintain a scouring velocity at all times throughout the day. However, the sewer should be designed to provide a scouring velocity at average flows or, at the very least, during peak flows.

Pipe Size
A sewer line should be at least large enough to allow the use of the cleaning equipment available. When sized properly, a sewer line should flow one half full during average daily flows. The air space above the half full sewer line helps to maintain aerobic conditions in the wastewater and provides some room for error in determining design flow.

Location and Alignment
Lateral, main and trunk sewers are generally constructed near the center of public roadways so that the length of building sewers is equalized and access is convenient. Pipes are generally laid as straight as possible to facilitate cleaning and for ease of installation. In order to avoid contamination, sewer lines must be located at least 2 ft. vertically below and 4 ft. horizontally away from potable water distribution lines.

Depth
Sewer lines are typically placed at a depth of 4 to 8 ft. The depth and width of a trench, the backfill materials and the method of compaction determine the load placed on the sewer line and therefore influence which piping materials are appropriate.

Wastewater Collection System Construction
Piping and Joint Materials
The materials used to construct sewers are selected for their resistance to deterioration by the wastewater they convey, strength to withstand surface loads, resistance to root intrusion, their ability to minimize leakage and their cost. Great care should go in to the selection of materials and their installation because they may be in service for many, many years. The following is a list of common wastewater collection system piping materials and their attributes:

Asbestos Cement Pipe, (AC)
Asbestos cement is a watertight pipe that is resistant to deterioration by most types of wastewaters. AC pipe is subject to corrosion by hydrogen sulfide that combines with
moisture to form sulfuric acid near the top of the pipe, (known as “crown rot”). For this reason, AC pipe should not be used where the release of hydrogen sulfide can occur. Joints are made of sleeve and rubber gasket couplings. OSHA restricts the use of AC pipe due to its asbestos content.

**Cast and Ductile Iron, (CI and DI) Pipe**
Cast and Ductile Iron pipe is very rigid and can resist heavy surface and earth loads. Although costly, CI or DI pipe should be used for bridge crossings and where lines are shallow and subject to heavy traffic loads. Joints are typically rubber or caulk gasketed mechanical push-on type or leaded (in old installations).

**Reinforced or Non-reinforced Concrete, (RC and C) Pipe**
Reinforced and non-reinforced concrete pipe is very rigid and can withstand significant surface loads. Similar to AC pipe, it is subject to crown rot. Coal tar epoxy or plastic linings are sometimes used to retard the corrosive action. Rubber-gasketed bell and spigot joints are common but proper installation is important or they may leak. Mortar or bituminous filled bell and spigots are also used.

**Vitrified Clay, (VC) Pipe**
Vitrified clay pipe is rigid but is subject to cracking caused by root intrusion. VC pipe is resistant to acid, caustics, solvents, gases and other material that are sometimes present in wastewater. Joints usually consist of bells and spigots with factory formed resilient compression joints made of polyvinyl chloride/ polyurethane or consist of rubber couplings held in place with stainless steel compression bands (band seal couplings). Older installations used bells and spigots sealed with mortar.

**Fiberglass Reinforced, (FR) Pipe**
Fiberglass reinforced pipe is semi-flexible and resistant to corrosion by most compounds found in wastewaters. There is some evidence that FR pipe is subject to damage by hydrogen sulfide. Joints are made with rubber-gasketed bell and spigot. Installation should be done with great care because experience has shown this pipe to be subject to failure within several years of installation due to unanticipated surface loadings.

**Acrylonitrile Butadiene Styrene, (ABS) Pipe**
ABS pipe is flexible and resistant to most substances found in wastewater. However, petroleum products will soften and erode ABS, (these products are normally prohibited from being discharged into sanitary sewers). Joints are solvent (chemical) weld or gasketed bell and spigot. ABS pipe will deflect into an oval when improperly installed so construction inspection should ensure that cleaning tools can pass through new lines.

**High Density Polyethylene, (HPDE) Pipe**
Although relatively new, HDPE pipe is gaining in use for sanitary sewers. HDPE pipe is flexible, durable and resistant to most substances found in wastewater. HPDE is installed in long sections and thermally butt-welded in

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<table>
<thead>
<tr>
<th>Joint #</th>
<th>Joint Description</th>
<th>Joint Used With:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Caulked Bell and Spigot</td>
<td>AC, CI/DI, RC, C</td>
</tr>
<tr>
<td>2</td>
<td>Band Seal Coupling</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mortar or Bituminous Filled Bell and Spigot</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Polyvinyl Chloride/ Polyurethane</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Rubber Gasket in Bell and Spigot</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Solvent Cemented Coupling</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Butt Welded (not shown)</td>
<td></td>
</tr>
</tbody>
</table>

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Table 4.1 - Common Types and Joints for Sewer Pipe

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the field. It is often used for force mains and small diameter low pressure sewer lines.

**Polyvinylchloride, (PVC) Pipe**

PVC is flexible and resistant to most substances found in wastewater. Joints are commonly made with a rubber gasket and a factory-formed bell and spigot or a solvent cement welded coupling joint can be used in diameters up to 8 inches. Various grades are available for specific applications. Because it is inexpensive and easy to work with, PVC pipe is currently the most commonly installed pipe. However, PVC pipe is subject to damage by heavy external loads and therefore care should be given to the selection of the grade used for specific applications.

**Pipeline Installation**

**Excavation**

Most sanitary and storm sewers are constructed within excavated trenches. Excavation is an inherently dangerous activity. Many laws exist which pertain to excavation safety. These laws are in place to protect you! Refer to Chapter 2 Safety Practices and Regulations for an overview of excavation safety related subjects. Before beginning any excavation the nearby utility lines (natural gas, water, electric and telephone) must be identified in order to avoid damaging them. In New Mexico a free service known as New Mexico One Call is available for utility line location prior to excavation work. In Albuquerque, the phone number is 260-1990. For all other cities, towns, villages and outlying areas call 1-800-321-2537. 48 hours notice is required, (not including weekends or holidays).

If you damage utilities during an excavation you or your employer will be liable for all the associated costs and the headaches can multiply very rapidly. Most excavations are done with a backhoe, although trenching machines are becoming more popular. Situations also exist when the use of “trench-less technologies” is more attractive than an open excavation. Trench-less technologies include; in-situ pipe liners, pipe bursting, and boring and micro-tunneling machines. Some examples of their applications would be the rehabilitation of sewers with infiltration problems, sewer replacement in areas with limited access and installations where the surface over the sewer cannot be disturbed.

**Controlling Line and Grade**

Line and grade controls for the sewer are used first to determine the location and depth of the sewer trench and second for laying the sewer pipe to the proper line and grade. There are several ways to establish and maintain the line and grade of the trench and pipe including; the string line method and the fixed beam laser method. Initial reference points are established using surveying equipment and then the construction crew will use one of the methods to maintain line and grade.

**Pipe Bedding**

Pipe placed into a trench must be properly bedded in order to properly support the pipe. This is one area that requires great care and yet is often done in a slip-shod manner. The ideal bedding material is crushed rock aggregate. Sand and pea gravel can be used but must be compacted carefully. Native material can be used but extreme care must be taken to excavate the trench bottom to true grade in order to produce an undisturbed and compacted trench bottom. Regardless of what type of bedding material is used, it is placed in the trench bottom and compacted and then carefully compacted around the sides of the pipe after the pipe has been laid. The depth of the bedding, and the bedding’s compaction directly affect the load that can be placed on the pipe.

![Figure 4.3 - Methods of Pipe Joining](image-url)
**Laying Pipe**
Most manufacturers of sewer pipe will furnish instructions for laying and joining their pipe. Read and understand the manufacturers instructions before attempting to lay pipe. Pipe should be handled with care to avoid damaging the joints. Only small diameter pipe (< 10 inches) should be moved by hand. Large pipe should be moved with a forklift or a backhoe equipped with a pipe sling. When installing bell and spigot pipe a small amount of bedding material should be removed to accommodate the bell so that the pipe is properly supported.

**Joining of Pipe**
Differot joints of small diameter, a block and bar can be use to force uch as a “come-a-long” and sling is used. Pipe should be placed so that the bell end faces upstream. For other types of joints, refer to the manufacturers instructions for joining the pipe.

**Trench Backfilling**
The placing of backfill material over the pipe has three essential elements. (1) The pipe must be protected from movement, breakage and crushing caused by the backfill material, (2) the backfill material should be compacted in layers until the excavation has been filled completely, and (3) the ground surface should be restored.

**Service Connections (Taps)**
A service connection is the point of contact between the building sewer and the wastewater collection system. For new installations, taps, (known as stub-outs), are installed along with the sewer lines at places close to where future buildings are anticipated to be located. In existing systems, the collections system operators may be responsible for making new service taps to the sewer system. There are several methods of tapping into existing lines and providing stub-outs for new lines. They include; Clamp-on Saddle Tees, Insertion Wyes and Tees, Epoxy Bonded Saddle Tees, and Synthetic Rubber Wedged Insert Tees. However service taps are made, they should provide a tight seal to prevent root intrusion and infiltration. Also, the tap should be made in such a way that the building sewer does not protrude into the sewer lateral or main. This is because

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**Figure 4.4 - Building Sewer Connections (taps)**
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protrusions can cause blockages and interfere with cleaning equipment.

**Manholes**

Manholes are structures installed in lateral, main, trunk and interceptor sewers for the purpose of allowing access for maintenance and cleaning operations. Manholes are also placed at changes in sewer direction, elevation, slope, pipe size and at junctions. Drop manholes are used when the difference in elevation of an incoming and outgoing sewer line cannot be accommodated by a drop in the manhole channel without creating excessive turbulence and splashing. Manholes in straight runs of sewer lines should be spaced no farther apart than the distance that can be cleaned by the available equipment, (usually 300 – 500 ft).

Manholes are sometimes equipped with steps and sometimes entered using ladders. The corrosive gasses in the collection system can cause steps to deteriorate so use care if they are used for entry.

Be aware that manholes are considered confined spaces and their entry is therefore subject to OSHA regulations. See Chapter 2 - Operator Safety, for an overview of confined space entry regulations and procedures.

Manholes can be constructed from materials such as; brick, pre-cast concrete barrels and fiberglass. The most common manhole installation in New Mexico is the pre-cast concrete manhole with a poured in place base. Manholes of this type have six (6) constituent parts. They are:

1. A poured in place concrete base with channels and a sloped bench.
2. The inlet/ outlet piping, sealed where it penetrates the barrel section.
3. Pre-cast concrete barrels that fit together and are sealed with mortar or bituminous material.
4. A concentric or eccentric cone section.
5. Level adjustment rings for raising the grade of the manhole lid.
6. Standard tight fitting manhole cast iron ring and cover.

**Gravity Sewer Maintenance**

**Sewer Cleaning Methods**

From the time that sanitary sewers were first used by early civilizations, methods of cleaning them have been employed. Because wastewater carries solids, scum and grease, collection system lines require regular cleaning to clear blockages. Collection lines also provide a good place for roots to grow and therefore blockages caused by root intrusions are very common. There are many ways to clean sewer lines. Some are more effective on grease, some on roots and others on sand and sediment blockages. The methods employed around New Mexico often have as much to do with tradition as with economics and effectiveness. The following sewer cleaning methods are common to New Mexico:

**Hand Rodders**

Hand rodders represent the oldest style of cleaning equipment. Hand rodders are typically made of a coil of spring steel or attachable segments of spring steel that can be forced into a sewer line to dislodge a blockage. Because they are non-mechanical they are reliable, however some blockages, such as roots, are difficult to clear with hand rodders. Also, hand rodders are typically limited in length to around 100 ft and therefore their effectiveness is limited to their length and the eagerness of the operator. Because they can be used in areas where the access to the sewer is limited hand rodders should be a part of every collection.
Figure 4.6 - Pre-Cast Concrete Manhole

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SEWER RODDING TOOLS AND USES

ROUND STOCK CORKSCREW
For rodding through sewers where conditions are unknown.

SAND LEADER
Used to guide rods across the top of built-up materials in the line by the flipping action of blades.

SQUARE STOCK CORKSCREW
For removing heavy root growth. Sharpened cutting edge will tear loose roots and remove other rigid obstructions when pulled backwards.

ROOT SAW
Used for power sawing of stubborn root masses in the sewer pipe.

DOUBLE CORKSCREW
A double-pronged tool to remove miscellaneous obstructions.

DOUBLE SAND CORKSCREW
The boring action of the corkscrew helps to pull rod through lines impacted with sand, gravel, and similar buildups. This tool must be kept moving since it may settle into built-up material and become stuck.

SPRING BLADE ROOT CUTTER CHUCK
This cutter with the proper size blades is used in preventive maintenance work in sewers. Should be rotated at high speed (Power Rodding Machine) and PULLED slowly through the line while rotating to effect a thorough scouring of the pipe. NOTE: This tool is not designed to be pushed into a sewer line.

AUGER
This tool is useful for cutting long stringy roots and for loosening sedimentary deposits in sewer pipe.

PORCUPINES
The turn-type porcupine is used in lines up to 12 inches in diameter. Its function is to scour lines of light buildups in conjunction with water flushing of sewer lines.

Figure 4.7a - Sewer Rodding Tools and Uses
SEWER RODDING TOOLS AND USES

SPEARHEAD BLADES
Used in small pipes to remove hard deposits and break up hard obstructions such as glass, bottles, cans, and plaster.

PULLOUT TOOL
Used to encircle rod coupler to push rods into or pull rods out of line.

BULLET NOSE
It’s designed to be screwed into end of coupler for least resistance when rodding through heavy roots.

ASSEMBLY TURNING HANDLE
Used for assembling nuts and couplers for turning rods; spring loader pin engages hole in coupler.

PICK-UP TOOL
Used to snare broken sectional sewer rods.

BAR TURNING HANDLE
Used to secure into hole in coupler for turning, pushing, and pulling rods.

ASSEMBLY WRENCH
Used for holding and turning nuts and couplers in assembly rods and tools.

ROD END SWIVEL
Used for pulling cables and wires through a pipe and is designed to be free turning under load at the end coupling.

RATCHET TURNING HANDLE
Used with locking pin through pullout tool and coupler to turn rods.

Figure 4.7b - Sewer Rodding Tools and Uses
system operator’s toolbox, no matter how large or small the system is.

**Power Rodders**

Power rodding machines use a rotating steel rod or flexible cable to turn a rodding tool in the sewer line to clear blockages. Steel rods are either continuous or sectional, flexible cables are continuous but can have sections added to increase their length. Both are stored in a reel-type cage that allows them to be fed out while rotating. The rotating reel may be driven by a motor, a small engine or a power take off (PTO). A variety of power rodder tool heads exist for clearing different types of blockages.

Power rodders are typically mounted on a specialized truck or trailer that includes storage for tools, various cutters, etc. Power rodders are capable of clearing the worst blockages caused by roots, grease and sediment. After a line has been cleared with a power rodder it should be flushed or hydraulically cleaned to restore full flow capacity.

**High Velocity Hydraulic Cleaning Machines, (Jet Rodders)**

High velocity hydraulic cleaning machines, (also known as jet rodders), use water pressure to propel a nozzle and its attached hose through the sewer line. The nozzle is equipped with jets that scour debris loose and move it toward a manhole where it can be removed. Jet rodders consist of a water supply tank, a high-pressure pump and an auxiliary engine for driving the pump. These units have a powered drum reel capable of holding at least 500 ft of hose, (usually one-inch I.D. for large machines). Many different nozzles are available for accomplishing different cleaning chores. These machines can be mounted on a small trailer or a purpose built truck. They are commonly mounted on a utility vehicle that combines a jet rodder and a vacuum device for removing grit and debris from the sewer. Jet rodders are effective at opening blockages and removing grease or sediment. With a root cutting attachment they can remove roots from sewer lines, although they are not usually as effective as a power rodder at this task. One added benefit of jet rodding machines is that with a wash down gun attachment they can be used to clean manholes and lift stations and for other cleaning jobs where pressurized water is not easily available.

**Performing Cleaning and Maintenance Operations**

Pipeline cleaning and maintenance operations fall into one of three categories, these are preventive maintenance, emergency clearing of line blockages (sewer back-ups) and emergency repairs to the system. The old adage "an ounce of prevention is worth a pound of cure" is certainly true when it comes to collection systems preventive maintenance.
Pipeline cleaning preventive maintenance programs generally have three aims:
1. Minimize the number of stoppages per mile of sewer.
2. Minimize the number of odor complaints.
3. Minimize the number of lift station failures.

Preventive maintenance can include activities such as; cleaning problem areas to avoid line blockages, chemical treatments to prevent root growth and removal of sediment from lines and manholes. If the preventive maintenance program is well thought out and conducted on a regular basis, problems in the collection system will be minimized. This will result in fewer sewer back-ups, a reduction of odors (and the resulting complaints) and lift station call outs will be reduced. All individuals served by the collection system benefit from these reduced problems but it is the operator that has to deal with a lift station failure or a sewer back-up (always on Super-Bowl Sunday) that benefits the most from preventive maintenance.

Unlike preventive maintenance activities that are performed even when the system is working well, dealing with sewer back-ups and making emergency repairs involves returning the system to operation. When an operator encounters a sewer back-up the aim should be to correct the problem as quickly as possible. Finding the best method of correcting the problem comes first. Things to consider include:
- Does this line have a history of previous stoppages? (A root or grease problem for example).
- Are trees growing near the line?
- Has a new connection been installed in the area recently?
- Have repairs been made recently either to the sewer or to other utilities or the street?
- Are there any ground or surface indications, such as settlement or a sinkhole?

With these things considered the best approach to correcting the problem can be chosen. Usually rodding operations are conducted from the manhole immediately downstream of the blockage rodding upstream toward it. This allows easy access to the line (it is not submerged under wastewater) and provides the best position to remove debris that is released by the cleaning operation. This debris (roots, grease, sand and sediment) should not be allowed to move further down the collection system because it will likely cause another blockage. If a large blockage has been cleared and it is obvious that a large amount of septic wastewater was trapped behind the blockage the operators of the wastewater treatment plant should be notified so that they can take actions that will help the treatment plant accommodate the septage.

Because of traffic control and safety issues collection system work such as clearing sewer back-ups and emergency repairs should be performed by a minimum of two operators.

**RECORDS**
Whenever a blockage is cleared or a repair or maintenance activity has been performed a complete record should be made for future reference. The record should include all the important information including where and when the incident occurred, distance and cause of blockages, line size, manhole number and a note on the kind and amount of material removed.

**LIFT STATIONS**

**PURPOSE OF LIFT STATIONS**
Lift stations are used to raise wastewater from a lower elevation to a higher elevation. Pumps are used to move wastewater through a discharge pipe known as a force main. After discharge from the force main, wastewater resumes gravity flow. The location and design of lift stations is decided by economics and practicality. Some of the reasons that a lift station may be required include:
- Excavation costs to maintain gravity flow and scouring velocity become excessive.
- Soil stability is unsuitable for trenching.
- Ground water table is too high for installing deep sewers, and
- Present wastewater flows are insufficient to justify extension of sewer main and lift station offers economical short-term solution.

Lift stations should be designed to move the wastewater with maximum efficiency. The pumps size and type should be selected to provided the most constant flow rate possible to minimize surges of flow at the downstream gravity sewer or the wastewater treatment plant. The appearance should blend in with the surrounding area and odors, noise and rubbish should be dealt with immediately.

**TYPES OF LIFT STATIONS**
Lift stations can be described with two broad categories: Wet Well type and Dry Well type.

**Dry Well Lift Stations**
Dry well lift stations contain two chambers. One for collecting the wastewater before it is pumped and the other to contain the pumps, motors, valves, electrical controls and auxiliary equipment in a dry well where access is easy for service. Dry well lift stations range in size from just large enough for a man to enter to large installations that may even be constantly manned.
**Wet Well Lift Stations**

Wet well lift stations contain only one chamber, the wet well where wastewater is collected before it is pumped. The pumps may be located above the wet well, (which is known as a suction lift pumping arrangement), or the pumps may be located inside the wet well itself, (submersible pumps). Both locations have their advantages and disadvantages. Suction lift pumps can be above ground or in a shallow pit where they can be easily serviced and repaired, but these types of pumps are prone to losing their

Dynamic pumps are often classified by suction conditions. In wastewater there are commonly two types of lift stations: **dry well** and **wet well**. The primary difference between the two is the number of tanks. The wet well has one tank and the dry well has two.

**Sewage Lift Station**

![Figure 4.9 - Sewage Lift Stations](image)

Dynamic pumps are often classified by suction conditions. In wastewater there are commonly two types of lift stations: **dry well** and **wet well**. The primary difference between the two is the number of tanks. The wet well has one tank and the dry well has two.

**Wet Well Lift Station**

**Dry Well Lift Station**

**Wet Well Suction Lift**

When the pump is placed above the level of water from which you intend to pump, the pump is said to be in a **suction lift condition**.
Figure 4.10 - Submersible Pump in Wet Well
prime, particularly when they age. If a pump loses prime, the motor will run and the impeller will turn but the pump will not in a shallow pit where they can be easily serviced and repaired, but these types of pumps are prone to losing their prime, pump anything. Submersible pump installations never lose prime because the pump intakes always have standing water over them (suction head condition). However, because the pumps are located in the wet well they can be hard to access if not designed properly. Equipment located in the wet well should be kept to a minimum. Discharge valves, check valves and other equipment that requires periodic maintenance should be located in a concrete vault or small room adjacent to the wet well. When submersible pumps are used in wet well lift stations they should be designed to be removed from the surface without entry into the wet well, (which is considered a confined space).

**Lift Station Components**

**Pumps**
Lift stations generally employ centrifugal pumps, pneumatic ejectors or screw type pumps, (centrifugal pumps are the most common in New Mexico). Review Chapter XXX, Pumps and Motors for information of pump configuration, operation and maintenance.

**Wet Well**
The wet well can be constructed of pre-cast concrete rings (similar to manhole rings), poured in place concrete, fiberglass or metal. It should be designed to withstand characteristics common in the wastewater it will pump. The wet well should be sized so that the pumps will not have to cycle too often, which can cause unnecessary wear, yet not so large that the wastewater becomes septic due to excessive holding times. (This can also be altered to some extent by changing the operating levels by adjusting the pump controls).

**Hardware**
The hardware uses in lift stations should be either high-grade aluminum or stainless steel to prevent corrosion.

**Bar Racks**
It is often desirable to include a bar rack at the inlet to the wet well of a lift station to catch large objects and rags before they enter and damage the pumps. If bar racks are included they must be made of the appropriate material (aluminum or SS) and they must be easily cleaned without entry into the wet well.

**Dry Well**
Dry well structures commonly have two or more floor levels. Pumps and valving are located on the lowest level while electrical controls and motors are often located on an upper level. A sump pump is provided to removed seal water or any water that leaks into the dry well. Ventilation and atmospheric monitoring are provided to prevent dangerous conditions from developing.

**Valves**
Valves are of critical importance to lift station O & M but they are frequently neglected, abused, misused and installed at improper locations. The major valves found in wastewater lift stations are:
- Pump suction and discharge isolation valves (gate valve, plug valve or knife valve). Isolation valves are used to section off the pump when service is required. These valves should not be used to throttle (control) the flow into or out of the pump because the valve and pump could be damaged.
- Discharge check valves, (swing check or ball check valves). Check valves prevent water from flowing backward through the pump when the pump shuts off. Hard closing or noisy check valves indicate that something is wrong, such as air trapped in the force main.
- Cross connection control valves. These are discussed later in this text.

**Electrical Systems**
All but the smallest lift stations are provided 3-phase electrical service so that the system will work efficiently and for practicality. Many lift stations have emergency back-up generators to maintain pumping during power outages. If a generator is not provided a transfer switch should be included so that a portable generator could be rapidly hooked up to maintain pumping during times of loss of power.

**Alarms**
Because the failure of a lift station could result in damage to homes, property and the environment all lift stations should be equipped with some type of audible and visual alarm at a minimum. For large installations a computer will automatically contact operators in the event of a failure or the system will be monitored through telemetry. A “high water alarm” should be included for every installation.

**Motor Control Center (MCC)**
The pump motor controls are located in a motor control center. This is typically an electrical box with switches for operating the pumps in either hand (manual) mode, in automatic mode or for turning them off. For this reason these are known a H-O-A switches (Hand-Off-Auto). MCC panels usually include pump starter coils, which allow the 110 V switch to engage the higher voltage motor circuit and a system for alternating lead and lag pumps. Alarm lights and reset buttons will also be located on the MCC panel.
**Hours Recorders**
The pumps in a lift station should be equipped with equipment hours recorders so that the total run time of each pump can be compared. If one pump in an automatic alternating duplex lift station runs much more than the other it is an indication that something is wrong, such as a leaking check valve. Also, flow through the lift station can be established if the pumping rate and operating hours are known.

**Pump Controls**
All lift station pump controls are similar in that they control the pumps based on the level of water in the wet well. Controls vary greatly in how they accomplish the task. Common lift station control systems used in New Mexico include:

- **Float controllers.** Floats are one of the oldest pump control devices. As the water in the wet well rises, the float (a ball attached to a rod) rises with it until a switch is triggered which turns the pump on. When the pump lowers the level to a pre-set point an actuator shuts the pump off.

- **Electrode Controllers (probes).** Electrode controllers utilize electrode probes or leads that are an open circuit until the water level rises, wetting both electrodes and allowing current to flow which enacts the control circuit on the pump to turn it on. When the water level drops and the upper probe becomes exposed, the circuit opens and the pump shuts off. This type of control is subject to problems caused by grease and rags.

- **Pneumatic Controllers (bubblers).** Pneumatic controllers work by sensing the pressure required to force air bubbles out of a tube located near the bottom of the wet well. When the wet well is full, it takes more pressure to force bubbles out of the tube (due to the higher head created by the standing water). The on off set points for the pumps on this type of controller are actually pressure set points. Bubblers rely on an air pump, similar to a fish aquarium pump, to provide air so that the pressure can be measured as bubbles are forced out the tube near the bottom of the wet well. If the tube becomes clogged by a rag or grease, or the air pump fails the system will stop working. If the length of the bubbler line changes, (accidental damage while removing a pump for example), the system will function incorrectly, if at all.

- **Mercury Float Switches.** Mercury float switches are one of the most common types of lift station controls. They consist of a float that contains a sealed chamber with two electrodes and a small amount of mercury (quicksilver). When the float is in one position (vertical, while hanging for example) the mercury is pooled away from the electrodes and the circuit is open. When the float is tilted to the other position (horizontal, while floating) the mercury flows down to the electrodes and the circuit is completed which triggers the pump control to turn the pump on. Mercury float switches can be purchased as either normally open (on switch) or normally closed (off switch) when in the vertical position. The floats must be kept clean so that they will tilt when

**Figure 4.11 - Pneumatic Controllers**

**Figure 4.12 - Mercury Float Switch**
floating and they must be lowered carefully back down into the wet well after they have been cleaned and checked.

**Force Mains**
A force main is the discharge line for the lift station. The discharge lines of the pumps come together in a manifold and then enter the force main. Air accumulation in force mains can create a problem known as a water hammer, which is a high pressure shock wave that travels up and down a force main. This problem is associated with pump check valves slamming, sometimes repeatedly, which causes damage to valves and piping. Air release valves are normally installed at the high points in force mains to automatically blow off accumulated air.

**TROUBLESHOOTING LIFT STATION PROBLEMS**
Lift station problems can be summarized in the following four categories:
1. Power [power outage, electrical circuit failure, motor burned out].
2. Control System [pump control failure, telemetry system failure].
3. Pumping System [pump failure].
4. Structural [grit deposits, plugged force main or check valve].

Experience is often the best tool in the operator’s toolbox when it comes to troubleshooting. All but the very simple electrical problems (changing fuses) should be left to a licensed electrician unless proper training has been given to operators. Most lift station failures can be prevented through a well thought out preventive maintenance program.

**INFILTRATION AND INFLOW (I & I)**
Ground water that enter into the sewer system through broken joints and leaking manhole barrels is referred to as infiltration. Storm water that enters manhole covers and illegal connections like gutter drains routed into house clean outs is known as inflow. Both infiltration and inflow can contribute significant amounts of water to the wastewater collection system. Once in the collection system the I & I becomes wastewater that must be treated by the treatment plant. Some treatment plants become hydraulically overloaded during storm events from inflow or during the spring run-off from infiltration. Because of this the identification and control of infiltration is important to the wastewater collection system operator.

**IDENTIFICATION OF I & I**
Studies conducted to identify I & I can be very elaborate involving engineering consultants and costing large amounts of money or they can be basic and conducted by system operators. The size of the system and the extent of the problem will dictate what measures are necessary.

Methods that are commonly used for identifying the location and extent of infiltration and inflow are:
- **Late Night Survey.** Very little flow should be occurring in the collection system in the early morning hours (2:00 AM – 4:00 AM). By surveying manholes for clear water that is near ground temperature a generalized idea of the extent of infiltration can be made. (This may not work in all areas of larger systems).
- **Closed Circuit Television (CCTV) inspection.** CCTV inspection is often used to identify infiltration problems. A purpose built camera is inserted into the collection lines and the line is video taped so problem areas can be analyzed. A thorough line cleaning prior to video tapping is very important.
- **Smoke Testing.** Smoke testing is used to identify broken joints and leaking manhole barrels that could allow infiltration to enter the system and to identify illegal taps (customer not paying sewer fee) or connections to the sewer system that would allow storm water to enter. For this test smoke is forced into the collection system by an engine driven fan located over a manhole opening.
- **Flow Records.** Wastewater treatment flow records often are used to identify storm events that introduce inflow into the collection system. Also, flow records that show a constant early morning flow during periods of run-off can be used to identify infiltration. Chart recording flow measurement devices allow the volume and duration of I & I to be characterized.

**CONTROL OF I & I**
Numerous methods are available to designers and engineers to correct infiltration and inflow problems once they have been identified. These include sewer replacement, slip lining (in-situ form), pipe bursting, chemical grouting and improvement of storm sewers. Not many of these options are within the capabilities of the average collections department, so contractors most often perform them. Collections crews do have the ability to minimize some infiltration and inflow problems, such as repairing or replacing individual deteriorated manholes, raising manhole rings and covers in area that flood, and repairing broken joints when they are discovered. Whenever possible, collection system operators should work to limit I & I so that the treatment plant can perform its job of treating wastewater.
CROSS CONNECTION CONTROL
A cross connection is a connection between a potable (drinking) water system and water from an unsafe or unknown source. A common place in wastewater collection systems where this can occur is on the seal water line for a lift station pump. When potable water is used as the seal water supply and no protection is in place, a direct cross connection exists. Without protection, wastewater from inside the pump could enter and contaminate the potable water system. Several devices for controlling cross connections exist.

The use of these devices is related to the “degree of hazard” that exists to the potable water system. An air gap device offers the highest degree of protection and is commonly used in wastewater applications.

Several excellent programs are available to train operators about the dangers of cross connections and the devices used for control cross connections.

AS-BUILT PLANS
At the start of a sewer construction project, the inspector should obtain two sets of the plans for the project. One copy is the working plan that will be used to guide the construction project. The other copy is known as the “as-built” plans. Any daily construction that deviates from the working plan should be recorded on the as-built plan by the inspector. This plan then becomes the true record of where stub-outs and taps are placed, where lines and manholes are located, etc.

The as-built plans reflect what actually exists underground. Because of this fact, they are invaluable to the collection system operators. When a project is completed, the as-built plans are submitted to the project engineer who either files them directly or has a revised drawing made. These plans should always be kept available to collections system workers.

All too often few or no maps exist of the wastewater collection system. Although some collections workers may feel that this offers “job security”, the headaches brought about by not having proper plans to work with probably offsets this feeling.

References
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Office of Water Programs, California State University, Sacramento, Operation & Maintenance of Wastewater Collection Systems, Vol. 2, 5th ed., Chapter 8