

IV SEWER

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PIPING DETAILS
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CONSTRUCTION
PROTECTION OF WATER SUPPLIES
MISCELLANEOUS REQUIREMENTS
TESTING

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SEWER MAINS

STANDARD SPECIFICATIONS

PART I – GENERAL

Related Work Specified Elsewhere

Standard Specifications – Excavation, Backfill and Compaction
Minimum Design Standards – Sewage System

DESCRIPTION

Work specified in this section includes furnishing and installation of sewage piping, manholes, service connections and lines, and testing requirements for the sewage collection systems.

Sewers shall be constructed of such size and laid to such grades as approved by the City. The City must be notified at least 24 hours prior to when pipe will be laid. No pipe shall be laid or covered until it has been inspected by the City.

Pressure sewer lines shall conform with applicable sections of these specifications and with the sections of Water Line Standard Specifications as they apply to installation and testing of piping lines under pressure.

Certification of Compliance

Certificate of Compliance shall be submitted to the Engineer stating all pipe and materials furnished under these specifications do in fact comply with all referenced specifications.

Referenced Standards

Uni-Bell PVC Pipe Association - Recommended Practice for the Installation of Polyvinyl Chloride Sewer Pipe (UNI-B-5) latest revision

Uni-Bell PVC Pipe Association – Recommended Practice for Low Pressure Air Testing of Installed Sewer Pipe (UNI-B-6) latest revision

ASTM C12 – Recommended Practice for Installing Clay Sewer Pipe

PART II – PRODUCTS

PIPE MATERIALS

Polyvinyl Chloride (PVC) Pipe

Conformance	SDR 35, 3034 PVC sewer or heavier walled
Pressure Rating	Gravity, open channel flow
Joints	Uni-Bell bell and spigot, elastomeric gasket
Service	Gravity sewer lines, sewer service lines
Maximum Warp	1/16 inches per foot
Conformance	ASTM 1785 or AWWA C900
Pressure Rating	150 psi working pressure
Joints	Uni-bell bell and spigot, elastomeric gasket
Fittings	AWWA C151/A21.51
Service	Pressure sewer lines
Conformance	Schedule 40 PVC
Pressure Rating	150 psi working pressure
Joints**	Solvent weld conforming to ASTM D2564 & D2855 (Specifications and Recommended practices for Solvent-Cemented Joints with PVC pipe)
Fittings	Schedule 40 – solvent cemented per ASTM D2564
Service	Force mains less than 3” in diameter only

Ductile Iron Pipe and Fittings

Conformance	AWWA C151/A21.51
Class	Class 50
Lining	Cement Mortar
Coating	Polyethylene wrap tubes, tape seal ends
Pressure Rating	100 psi working pressure
Joints**	Push on, Super Bell-tite

**Joints shall be approved by the City prior to purchasing the pipe and fittings.

MANHOLE MATERIALS

Bases, Risers, Cones and Tops

Precast manhole sections shall be constructed in accordance with the latest revision of ASTM C478 including the use of 4000 psi concrete and the amount, type, and location of reinforcement. Precast sections shall have a minimum wall thickness of five (5) inches.

The manhole sections shall have a minimum inside diameter for four (4) feet. The sections shall be provided with ends so formed that when the manhole risers and tops are assembled they will make a continuous and uniform manhole with no leakage or infiltration. The watertight flexible

gasket joints must be approved by the City prior to purchasing the materials (see below). Openings for pipe shall be formed in the manhole. Where possible, neoprene pipe boots shall be installed in the precast manhole for all pipes passing through the manhole. Watertight seals shall be used at all plastic-to-concrete connections to prevent leakage.

Conical tops for manholes shall be eccentric cones with a minimum height of three (3) feet and five (5) foot maximum. The eccentric cones shall have a uniform taper from the diameter of the manhole to a minimum clear opening two (2) feet in diameter. The eccentric cone shall terminate about twelve (12) inches below the finished ground or street surface.

Flat slab lids shall be used on all manholes with a depth of five (5) feet or less, and shall be installed to provide the maximum allowable working space in the manhole. Flat slab tops shall have a minimum thickness of six (6) inches for manhole sections four (4) feet and less in diameter. An inch increase in slab thickness will be required on manholes greater than four (4) feet and up to six (6) feet in diameter. Reinforcing in the slab shall conform to ASTM C478 with reinforcement in both directions and additional reinforcement at the openings. Complete details of the slab construction shall be provided to the City for approval before being purchased.

The manhole sections and tops shall be substantially free of fractures, cracks, and surface roughness. The planes of the ends of the manhole sections shall be perpendicular to their longitudinal axis. All manhole sections shall be marked with the date of manufacture and the name or trademark of the manufacturer.

Manhole sections may be rejected for any of the following reasons:

1. Fractures or cracks passing through the shell, except for a single end crack that does not exceed the depth of the joint
2. Defects that indicate imperfect proportioning, mixing, and molding
3. Surface defects indicating honeycombing or open texture
4. Damaged ends where such damage would prevent making a satisfactory joint.

Concrete manholes constructed on the jobsite shall be made with concrete conforming to the specifications for 3500 psi concrete, 6 sack mix, and shall have a minimum wall thickness of six (6) inches. Forms for the manhole and the amount and type of reinforcement will be approved by the City. The use of poured-in-place manholes will be discouraged except under special circumstances approved by the City. At a minimum, dimensions and quality of the poured-in-place manholes shall meet the specifications for precast manholes as above.

Frame and Cover

When located within road or highway rights-of-way, the manhole frame and cover shall be made of cast iron and have a clear opening of twenty-four (24) inches. In highway rights-of-way, the manhole must also comply with Highway Department specifications. All wrought iron and cast iron shall be free from imperfections, thoroughly cleaned while new, and coated with two coats of asphalt varnish or equal. No iron shall be installed until it is protected in this manner. Where

approved by the City, in non-traffic areas, the manhole frame and cover may be cast from an alloy of aluminum with physical properties exhibiting strength comparable to cast iron. The cover shall weigh about sixty pounds and the total assembly about 150 pounds. In traffic areas cast iron covers will be required. The assembly shall have a clear opening of twenty-four (24) inches.

A good fit will be required between the frame and cover to prevent rattling in traffic and avoid inflow. To insure good fit, the seat in the frame on which the cover rests and the matching face of the cover shall be machined. Provisions for opening the manhole shall consist of a pickhole or notch along the edge of the cover. Other means of opening the manhole shall be approved by the City before the material is purchased.

Manhole Steps

Epoxy-coated cast iron, aluminum alloy, plastic or other approved corrosion-resistant metal steps shall be built into each manhole. The steps shall be at least nine (9) inches wide and shall protrude approximately five (5) inches from the wall of the manhole, and shall be held in the wall by at least four inches of bar on each side. The steps shall be designed to provide an edge that will prevent the foot from slipping off the side of the step. Standard manufactured manhole steps shall be used. Reinforcing steel or other steel bars and material bent to form a step will not be permitted. Steps shall be spaced evenly at twelve (12) inch intervals with each step being directly below the next. Spacing from the rim to the first step shall be between fifteen (15) and eighteen (18) inches.

Non-Shrink Grout

Commercial factory-mixed product made especially for intended use in maintaining water-tight manholes. Must be approved by City.

Plastic Gasket Joints

Preformed flexible plastic conforming to Fed. Spec. SSS-S-00210 (GAS-FSS), Type I Rope and Form ASTM C433.

All manhole joints shall be sealed with an approved sealant that will provide a water-tight joint. The sealant shall be flexible gasket material such as Ran-Nek flexible plastic gaskets with primer or equal. All pipes entering or leaving manholes shall have a flexible waterstop.

PART III – EXECUTION

PREPARATION

Excavation

Excavation shall be in accordance with the Excavation, Backfill, and Compaction Standard Specifications except as modified in this section of the specifications and the Minimum Design Standards for Sewer. Excavated materials not required for backfill shall be removed from site as directed by the Engineer.

Excavation for manholes and other accessories to have twelve (12) inch minimum clearance on all sides.

Excavation shall not be carried below the required level. Excess excavation below required level shall be backfilled with earth, sand, gravel, or concrete, as appropriate, for proper backfill and use, and shall be thoroughly tamped to achieve the density required in the pipe zone or manhole foundation as appropriate.

UNDERGROUND OBSTRUCTIONS

The Contractor shall proceed with caution in the excavation and preparation of the trench so that the exact location of underground structures, both known and unknown, may be determined. Hand excavation shall be used where necessary. If required, the Contractor will excavate and locate existing utilities ahead of trench excavation in order that necessary grade changes or utility adjustments may be known ahead of time. The Contractor will be responsible for notifying all appropriate utilities such as gas, electric, telephone, cable, etc. when working in areas where there may be such utilities.

The Contractor shall preserve intact any underground utilities encountered during construction unless they interfere with new pipelines or structures being installed. When underground utilities will interfere with proposed construction, notify the utility and the City and make suitable arrangements to adjust the proposed construction. In case any such utilities or other structures are accidentally broken, they shall be immediately replaced in a condition at least equal to that in which they were found, at the Contractor's expense.

HANDLING AND STORAGE

Exercise proper precautions in unloading, handling, stockpiling, and installation in order to prevent damage to materials and to insure delivery and installation in a sound and acceptable condition. Special care shall be taken to protect the plastic on the spigot ends from any contact with the earth.

Remove any broken or damaged materials from the construction site and do not use in any portion of the construction. Any damaged, broken, or otherwise defective materials which are included in the construction shall be removed and replaced by the Contractor at no expense to the Owner. Handle pipe using wide slings; the use of hooks or other equipment which could damage pipe will not be permitted. During pipe handling, protect against impact shocks and fall.

INSTALLATION

Excavation and preparation of the trench bottom shall be in accordance with Excavation, Backfill, and Compaction Standard Specifications, as should all backfill and compaction.

Laying Sewer Pipe

Lay pipe in accordance with the applicable portions of the publications referenced in standards for the type of materials being installed.

Begin pipe laying at the lowest point, unless otherwise directed by the Engineer, and install the pipe with the spigot ends pointing in the direction of flow. A firm bed must be prepared for each pipe to the required depth true to line and grade with uniform bearing for the pipe barrel and the material hollowed out underneath the bell so that the body of the pipe shall be supported for its entire length upon the bed so prepared. Adjustments to line and grade shall be made by scraping away or adding properly compacted bedding materials under the pipe and not by using wedges and blocks or beating on the pipe.

All changes in grade and direction shall be made at manholes. Lay all pipe straight between changes in alignment and at uniform grade between changes in grade, unless directed otherwise by the City. If, in making any joint, previous lengths are disturbed, such lengths must be uncovered and re-laid.

Provision shall be made for expansion and contraction of the pipe in the trench.

Avoid the introduction of excavation material or other foreign substances into the pipe interior. The interior of the pipe shall be carefully freed of all dirt, joint compound, and foreign material of every description as the work progresses. Seal open ends of the pipeline with a tight-fitting plug at all times, except during actual pipe laying. Lower pipe into the trench carefully, do not let pipe fall in from the trench bank. All water must be kept out of the pipe and bell hole until the joint is completed, and no water shall be allowed to rise in or about the pipe until the trench has been filled at least one (1) foot above the pipe. No length of pipe shall be laid until the previous length has had sufficient backfilling placed about it to hold it securely in place.

During construction, the Contractor shall provide and maintain adequate equipment to properly remove and dispose of all excessive water entering the trench or any other work areas. Use of the sewer under construction for disposing of the water will not be permitted unless specifically authorized by the City. Before any pipe is laid, the trench shall be dry and shall be kept dry while joints are completed. Adequate precautions shall be taken by the Contractor to prevent possible uplift. If any portion of the pipeline does float, that entire portion shall be re-laid to line and grade. In areas where unstable soil is encountered below the bottom of the pipe, the Contractor shall excavate such material to the limit determined by the City and backfill with approved bedding material.

Basic surveying and control and stationing will be provided by land surveyors retained by the Developer. Basic control shall be set with stakes, spikes, shiners, or crosses set at the surface and on an offset from the sewer line. Benchmarks shall be provided within two hundred (200) feet of each manhole. The Contractor shall transfer line and grade from these control points to the construction work in a manner approved by the City, with spot checks by the City's representative. The preservation of stakes and other line and grade references provided by the City is the responsibility of the Contractor.

In most cases, line and grade of the sewer shall be set with a laser alignment system approved by the City. The laser shall be a type that projects a low-power, coherent, red beam along an optically straight path for an operational distance of three hundred (300) feet or more. It shall be approved for use for sewer alignment and be compatible with solvent and other materials used in making pipe joints. Line and grade shall be transferred to the bottom of the trench using an

accurate method recommended by the manufacturer and satisfactory to the City for the particular laser.

The laser shall be located in the trench bottom unless otherwise approved by the City. When the equipment is placed in the trench, it shall be positioned in such a manner that the laser will describe the center of the conduit. As each pipe section is installed, a special target or template shall be placed in the pipe's end and the vertical and horizontal alignment checked. The beam projected through the previously placed conduit sections shall also be used to provide line and grade for trench excavation and placement of bedding materials. The light beam shall be periodically checked against surface control points to insure its correct vertical and horizontal alignment. Reasonable care must be taken to insure that the conduit line is properly ventilated.

Pipelines shall be checked by the Contractor to determine whether any displacement or other damage has occurred after the trench has been backfilled approximately two (2) feet above the pipe. If this check shows the pipeline to be out of alignment, broken, or otherwise damaged, the defects will be corrected by the Contractor before proceeding with other pipe laying. The City may require lamping or other testing at this stage of backfill or may decide to only test the completely backfilled lines. It shall be the responsibility of the Contractor to check his work as he proceeds.

PIPE JOINTING

Pipes should be supported free of the bedding or foundation during the jointing process to avoid disturbances of the sub-grade. Care shall be taken in jointing to insure that the bell and spigot are dry, clean, and free of any foreign materials. For solvent weld joints, brushes shall be natural bristle with a width equal to the joint depth.

Joint materials vary with the type of pipe used and with the manufacturer. All joints shall be properly made using the jointing methods and materials recommended by the manufacturer. All joints shall be sufficiently tight to meet the requirements of infiltration and exfiltration tests.

Prior to joining, the pipe shall be set in position and checked for line and grade, using care to keep the joint absolutely free of dirt. When final grade is okayed, the joint shall be carefully pushed home using approved leverage methods so as to not damage the integrity of the pipe. Care shall be taken so that the bell end of the pipe will not be deflected to the extent that the gasket is pinched or rolled. Adjustments in line and grade may then be made by working bedding material in around the pipe. If O-ring gaskets are used, immediately after completing each joint, the gasket seating shall be checked around the entire circumference of the pipe by visual and finger inspection. The pipe shall be secured in place by installation of the bedding material tamped under and along it up to springline. This haunching material shall be compacted to 95% Standard Proctor for all flexible pipes, e.g., PVC pipes.

If come-alongs or other mechanical devices are used to aid in making compression-type joints, proper steps shall be taken to avoid damage to the pipe or displacement of the bedding material. Walking on the pipe or otherwise disturbing any conduit after jointing will not be permitted.

Prior to making a solvent weld joint, all water shall be removed from the trench and the pipe shall be clean and dry. Trench and pipe shall remain dry until welded joint has had time to cure.

The length of the cure time shall be as stated on the welding solvent as corrected for the temperature. The minimum curing time shall be two hours for the rapid set solvent.

Trench excavation and preparation, as well as backfill and compaction of sewer lines and services, shall conform with recommendations found in Uni-Bell UNI-B-5 Recommended Practice for Installation of PVC Sewer Pipe and with the City's Excavation, Backfill, and Compaction Standard Specifications unless otherwise superseded herein.

Unless other protection work is directed, trenches shall be backfilled immediately after the pipe has been installed and inspected. Water shall not be permitted to rise in unbackfilled trenches after the pipe has been installed. Backfill material in the pipe zone shall consist of clean earth free from hard lumps, brush, junk, or large rocks equivalent to select bedding in the Excavation, Backfill, and Compaction Standard Specifications. The backfill material shall be hand-placed and tamped to a level of one (1) foot over the top of bedded pipe. No rocks with any dimension greater than three-quarter (3/4) inch will be placed in this area. Tamping shall be accomplished so that the line will not be misaligned in the horizontal or vertical direction. The remainder of the trench shall be backfilled in a manner to obtain a minimum density equal to 98% of the density of undisturbed sides of the trench outside the public right-of-way and 95% Standard Proctor density in the public right-of-way unless more stringent specifications are required for the area by other specifications. No rock in excess of four (4) inches in maximum dimension shall be used in the backfill above the pipe zone. Water shall be added to the backfill material in such quantity to obtain optimum moisture content for the required density.

For clay pipe, the section between the first two manholes of all sewer projects shall be tested before further construction to permit initial observation of the quality of construction workmanship and to determine whether the specified results are achievable with joint proposed for use.

Wyes and Risers

The Contractor shall place wyes, stubs, and risers where required by the approved construction plans. Wyes shall be angled upwards so that the upper invert of a one-eighth band connected to the fitting will have an elevation equal to or higher than the inside crown of the sewer main. Riser connections shall be installed where the elevation of the top of the branch is more than twelve (12) feet below finished ground. Riser connections shall ordinarily reach to a grade of eight (8) feet below finished ground surface. Water-tight plugs shall be installed in each branch pipe or stub. Wye and riser locations shall be marked as described above in Materials. Details for service line connections and pipe laying are covered below, and construction details are shown on typical drawings. As Built measurements shall be made by the Contractor to reference the wye or riser connection to the nearest manhole before backfilling.

SERVICE INSTALLATIONS

In general, materials for service lines must meet the above specifications for each type of material. All installation work shall conform to applicable portions of the pipe manufacturer's installation instructions, in addition to the requirements on the City Standard Drawing for sewer service and contained herein.

Unless otherwise approved by the City based on native soil types, all service pipe shall be bedded on three (3) inches of well-graded sand conforming to select bedding material in the standard specifications for Excavation and Backfill.

Sanitary sewer service lines shall be constructed on the shortest and straightest route possible. When necessary, the service may be constructed with one horizontal one-eighth (1/8) bend between the house plumbing and the sanitary sewer main when constructed with adequate cleanouts. At no time shall the service line be any closer than five (5) feet to the side property line, and no service line may be constructed through or in front of any adjoining property. When possible, the service line shall be located ten (10) feet uphill of the downhill property line. Service lines installed during main line construction shall extend across the front utility easement and be plugged with a compression stop.

Measurements shall be taken of the distances of the service line from a manhole, the main, and the depth from back of the sidewalk to invert at dead-end stub. In addition, when a curb is present, the location shall be marked on the curb by a backwards “2” symbol. The end should also be marked with a #20 copper wire with yellow insulation and shall be run from the plugged end up to twelve (12) inches below the ground surface and tied off to a twenty-four (24) inch piece of 2x4 lumber or by a length of 2x4 lumber from the end of the pipe to one (1) foot above the ground.

In no instance shall a trench extend beneath an existing sidewalk or curb unless excavation conforms with City standards for concrete structure removal. The pipe shall typically be bored, jacked, or tunneled through the earth under the curb or sidewalk. Alternately, Contractor may remove the existing sidewalk back to joints on either side of the trench, backfill in accordance with the Standard Specifications for backfill, and then replace the sidewalk.

Where full-bodied service wyes have not been installed in the main sewer, the main shall be cut and a section of pipe installed with full-bodied wyes and full-bodied repair clamps or, if allowed by the City, the service may be tapped by machine drilling a hole in the pipe sized to fit the saddle for the service line such that the tap is smooth and water-tight. The drilling machine and method of drilling shall be approved by the City. The City’s representative shall inspect the main and saddle at every tap prior to backfilling. In the event the tap is covered before it is inspected, it shall be dug out by the Contractor and any concrete or mortar around the fitting shall be removed to allow visual inspection of the tap and the main. If the main sewer line is cracked or broken during the process of locating and/or tapping, it shall be repaired immediately by replacing the broken section, in which case a full-bodied wye shall be installed.

A manhole shall be installed instead of a service tap when a six (6) inch connection is to be made to an eight (8) inch or smaller main. Whenever the service line is more than 50% of the main line, the service should enter at a manhole. Service taps to existing manholes shall be done in accordance with the Manhole section of these specifications.

Sewer service pipe shall be laid in accordance with the Pipe Laying portion of these specifications. Sewer and water service lines must be a minimum of ten (10) feet apart horizontally. If not, concrete or sealed ends PVC encasement of the sewer line will be required. Minimum fall on six (6) inch sewer service lines shall be one-eighth (1/8) inch (1%) per foot, and for four (4) inch pipe 1/4 inch per foot (2%). These minimum slopes will only be allowed if

the line is engineered and line and grade are controlled by an approved method. Minimum cover of the sewer service shall be three (3) feet at the property line.

Before a Contractor or property owner shall begin to build a basement or any inhabitable structure below ground, the Owner or Contractor shall insure that the level of the most adjacent sewer manhole cover is six (6) inches in elevation lower than the flood level of the lowest fixture or drain in said basement. This requirement will be waived if the contractor or Owner installs a sewer lift station or an approved backflow prevention valve. Any such lift station shall have approval of the City prior to installation, but shall remain the property or responsibility of the individual user.

MANHOLE CONSTRUCTION

Base Construction

The cast-in-place manhole base shall be constructed of 3500 psi, 6 sack concrete, and be a minimum of six (6) inches thick. Concrete for the base will be confined in some manner as it is poured. The base may be formed or the concrete may be poured against undisturbed earth if the sidewalls of the excavation are sufficiently strong and high to support the concrete during compaction.

Inverts

The main sewer shall be carried through manholes by split pipe wherever practical. Concrete foundations shall extend at least eight (8) inches below the bottom of the pipe and shall be benched up to at least two (2) inches over the top of the pipe. The concrete manhole floor between the sewer pipe and the outer portions of the bench shall be flush with the top edges at the pipe springline and shall slope upward at two (2) inches per foot.

Wherever grade and alignment permit, the sewer shall be laid continuously through the manhole locations and the manhole built later. In such cases, the foundation shall be poured as above and the floor of the manhole sloped upward at two (2) inches per foot out from the springline of the pipe. When pouring the base, care must be taken to prevent floating of the pipe. After the manhole is built, the upper half of the pipe shall be cut out and the rough edges smoothed with cement grout.

When it is not practical to use split pipe through manholes due to breaks in alignment, grade, or elevation of intersecting pipes, the sewer inverts shall be made of smoothly troweled monolithic concrete with a semicircular bottom of the same diameter as the adjacent sewer section. The invert channel shall be U-shaped with side heights equal to the diameter of the sewer pipes which they connect. They shall be so finished that there will be no angular offset to offer obstruction to floating sewage of any kind.

When there are changes in the size of sewers, size of inverts shall be made gradually and evenly. Changes in the direction of the sewer and entering branches shall be made with curves having as large a radius of curvature as possible and at a minimum equal to 1.5 times the diameter of the sewer pipe. Elevation changes through the manhole shall occur uniformly from one side of the manhole to the other. Inverts shall be plastered with cement mortar and left smooth and clean.

Where called for on the plans, a pipe bell shall be stubbed out and plugged. The bell shall be placed as close to the manhole wall as possible.

Any invert that has been constructed without proper elevation change through the manhole, without proper changes in direction, without proper slopes on the benches adjacent to the channel, lacking proper channel width, or that prevents free flow of sewage due to roughness or other reasons, shall be repaired by the Contractor at his expense prior to preliminary acceptance by the City.

Assembly of Precast Manholes

Precast manhole sections shall not be placed on the foundation until after it has reached sufficient strength to provide support without damage. If the manhole base was not installed level so that the manhole sections will rise vertically, the first precast section shall be placed on cement mortar made with a mixture of one part Portland cement, two parts sand, and water as required not to exceed six gallons per sack. The mortar shall be of a proper consistency and thickness to provide a level base for the manhole section. The mortar shall, at minimum, be at least one (1) inch thick and five (5) inches wide. The base of the section to be placed on the mortar shall be thoroughly soaked with water before it is installed. The first precast section shall be carefully lowered onto the bench so that the mortar bed will be forced out from under the section evenly on all sides. The mortar shall be allowed to set up before the remaining manhole sections are placed.

If the base is level, it shall be primed and a suitable sealant such as Ran-Nek or equal applied. The bottom of the manhole section shall be primed and set in place over the gasket material. Gasket material shall be applied in compliance with manufacturer's recommendations. Subsequent sections of the manhole shall be installed in the same manner. The top of the manhole shall consist of an eccentric cone or a flat slab, as determined by the conditions at the location, and shape shall be installed as herein specified.

The manhole sections shall be so aligned that the manhole steps provide a vertical ladder located over the largest portion of the bench on the manhole base. The steps shall not be located over the channel or in front of the pipe of an intersecting sewer in a drop manhole.

All openings for sewer pipes or for placing of the manhole sections shall be made in a water-tight manner. If repair is necessary, it shall be made with concrete made of the same proportions as used in the base. The filling shall be bonded tightly to the surface of the holes and shall be sound and free from shrinking cracks. Other sealing materials may be used with City approval.

Drop Manholes

Drop manholes shall conform to the requirements of other portions of these specifications for base, invert, and manhole construction. Drop manholes will be required where the difference in elevation between the incoming sewer and the manhole invert is greater than two (2) feet. The drop will occur in a vertical pipe located adjacent to the manhole as shown on the typical drawing. The invert in the manhole base shall be constructed to receive the incoming sewage and to channel it into the lower sewer. A mortar dam, or other acceptable dam, shall be constructed in the invert of the incoming sewer where it intercepts the wall of the manhole. The

vertical drop pipe and the two 1/8 turns shall be encased in concrete as shown on the plans. The hole made in the manhole at the intersection of the incoming sewer shall be sealed in accordance with these specifications to a watertight condition.

Frame and Cover Finish

All manholes shall be constructed to an elevation such that when the manhole frame and cover are in place, the cover will be flush with the finished surface of the paved street. If the street is not paved or if the manhole is located in an alley or an unimproved area, the cover shall be four (4) inches below finished grade. The manhole cover frame shall be concreted to the top grade ring or to the top of the manhole.

UNDERDRAINS

Where excessive groundwater is encountered, and in other areas where it is deemed advantageous or necessary, gravel or piped underdrains shall be installed. Underdrains shall daylight to the nearest suitable point as approved by the City. In no case shall water from underdrains be directed into a sanitary sewer. The trench shall be excavated to the required depth and width and backfilled with underdrain bedding material. Where underdrain pipe is required, it shall be installed to a true line and grade and held in place with underdrain bedding material. Additional underdrain bedding material shall then be placed to a level four (4) inches over the top of the underdrain pipe and the sewer pipe installed. The sewer pipe shall be bedded to springline and this bedding covered with a layer of six mil polyethylene plastic sheeting conforming to ASTM D2103. Underdrain pipes shall be provided with cleanouts within each manhole installed on the sewer line. Underdrain pipe shall be continued under manholes by use of suitable bend and other fittings.

LIFT STATIONS AND FORCE MAINS

The need for pumping facilities and the design of these facilities shall be discussed with the City prior to beginning design. The use of lift stations is discouraged unless truly necessary. The City reserves the right to dictate the location and type of pumping facilities to be constructed and to require extra maintenance services from the developer.

Where necessary and with approval of the City, force mains shall be constructed from pumping facilities to tie into the gravity collection system. At design average flow, a cleansing velocity of at least two (2) feet per seconds shall be maintained. Force mains shall enter the gravity sewer system at a point not more than two (2) feet above the flow line of the receiving manhole. Automatic air relief valves shall be placed at high points in the force main to prevent air locking. Such valves shall be designed to handle sewage and be equipped with fittings to allow cleaning.

Adequate sanitary protection shall be provided on all force mains.

INVERTED SIPHONS

The use of inverted siphons is discouraged, especially in low flow and intermittent flow situations. If the City does approve the use of a siphon system, the system shall have not less than two (2) barrels, with a minimum pipe size of six (6) inches and shall be provided with necessary appurtenances for convenient flushing and maintenance. The manholes shall have

adequate clearances for rodding. In general, sufficient head shall be provided with pipe sizes selected to secure velocities of at least 3.0 feet per second for average flows. The inlet and outlet details shall be arranged so that the normal flow is diverted to one (1) barrel and so that either barrel may be out of service for cleaning.

LEAKAGE TESTING

Infiltration Test

An Infiltration Test shall be used only when excessive groundwater prevents satisfactory testing by the Exfiltration Test. In addition, the Infiltration Test must be performed after backfilling, after services are installed, but before any service connections are functioning, and at a time when the groundwater is over the entire section of pipe at or near its maximum level.

The procedure for conducting an Infiltration Test shall be as follows:

1. Clean the pipe section (manhole-to-manhole reach of sewer) being tested by propelling a snug-fitting inflated ball, or other adequate method, through the pipe with water.
2. Determine the groundwater table. The groundwater table shall be determined for each section of sanitary sewer tested.
3. Plug the upstream pipe outlet from upstream manhole of the sections being tested with a plug which will assure a tight seal against flow from the upstream portion of the sewer system. Also plug all house laterals and any other connections to the section being tested.
4. Install a 90-degree V-notch weir in the downstream manhole of the section being tested. Weir must be installed plumb and sealed to the pipe wall surface.
5. A sufficient period of time must be allowed to permit the infiltrated waters to collect and flow over the weir. Water shall flow over the weir for at least thirty (30) minutes prior to taking measurements.
6. The head (H) of water flowing over the weir must be measured accurately and the measurement taken at least eighteen (18) inches from the crest of the weir.
7. Discharge over the 90-degree V-notch weir shall be calculated according to:
 - a. $Q = 3240 H^2$
 - b. H = Head in inches
 - c. Q = Discharge in gallons per day

The allowable infiltration shall be fifty (50) gallons per inch of pipe diameter per mile of pipe per day. When there is significantly more than two (2) feet of groundwater above the top of the pipe at the highest point of the section being tested, 10% additional infiltration above the permitted 50 gal/in-dia/mi/day limit will be allowed for every two (2) feet of additional head.

Exfiltration Test

An Exfiltration Test may be conducted wherever the groundwater level is below the crown of the pipe at the highest elevation of the section of sanitary sewer being tested. If the groundwater level is above the crown of the pipe, an Infiltration Test should be used.

The procedure for conducting an Exfiltration Test shall be as follows:

1. Clean the pipe section (manhole to manhole reach of sewer) being tested by propelling a snug-fitting inflated ball, or other adequate method, through the pipe with water.
2. Plug the downstream pipe outlet to the manhole with a plug which will assure a tight seal against water leakage. Also plug all house laterals and any other connections to the section being tested.
3. If the upstream manhole is to be used as a reservoir for maintaining the pressure head on the sewer pipe, the inlet sewer pipe or pipes must be plugged. If a standpipe is to be used as a reservoir for maintaining the pressure head on the sewer pipe, the standpipe must be connected to other sewer pipe in the upstream manhole by a tightly sealed connection.
4. The amount of water (volume required to fill the section of sewer under test plus the manhole or standpipe) shall be calculated.
5. Water shall then be introduced through the manhole or standpipe. The amount of water introduced shall be metered. The amount of water introduced to fill the sewer should be approximately equal to the calculated amount. If the amount of water required to fill the sewer pipe is significantly greater than the calculated amount, it is an indication of a leak or leaks and consequent saturation of the backfill around the sewer pipe. Saturation of the backfill will invalidate the test.
6. The level of water in the manhole or standpipe shall be at least two (2) feet above the crown of the pipe at the highest section of sanitary sewer being tested.
7. After filling the pipe, at least one hour shall be allowed for water absorption in the pipe. For some materials, up to six hours may be required. After the absorption period, the manhole or standpipe shall be refilled to the established measuring mark and the test begun.
8. If the upstream manhole is used as a reservoir for maintaining the pressure head on the sewer pipe, the difference in water surface elevation from original to final level in a two-hour period shall be used to calculate the water lost. The water lost in a two-hour period shall be converted into gallons per day. If a standpipe is used as a reservoir for maintaining the pressure head on the sewer pipe, the standpipe shall be refilled periodically during the two-hour test period to maintain an essentially constant head of water on the test section of the pipe. The amount of water added shall be measured and shall be used to calculate the loss in gallons per day.

The Allowable Exfiltration shall not exceed 50 gallons per inch diameter per mile per day. The internal water head shall be two (2) feet higher than the top of the pipe or two (2) feet higher than the groundwater level, whichever is greater.

If the sanitary sewer line fails to pass the Exfiltration Test, a re-test shall be permitted only after the groundwater conditions surrounding the pipe return to a condition similar to those existent at the beginning of the test period. The groundwater elevation shall be determined prior to initiation of the second test.

Air Test

An Air Test shall be conducted under all conditions of groundwater levels surrounding the sanitary sewer pipe. If the groundwater is above the crown of the pipe, the air pressure shall be increased by an increment equal to the pressure exerted by the groundwater over the pipe.

All persons conducting an air test must be made aware of the fact that an Air Test may be dangerous if improperly conducted. The following procedure is taken from Uni-Bell UNI-B-6 Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe. Air Testing shall be conducted in conformance with UNI-B-6.

Responsibility

Only lines tested after backfilling to final grade will be considered for acceptability. However, this test may also be used by the installer as a presumptive test to determine the condition of the line prior to backfilling. Unless otherwise specified, the Contractor shall furnish all the necessary equipment and be responsible for conducting all low pressure air tests. In addition, the Contractor is responsible for any necessary repair work on sections that do not pass the test. No sealant shall be used in any newly installed sewer.

The City shall witness all low-pressure air tests and verify the accuracy and acceptability of the equipment utilized. The Engineer approves Contractor proposed methods of repair in the event one or more sections fail to pass the low-pressure air test.

Safety

Safety during testing shall be the sole responsibility of the Contractor.

Plug Restraint – It is extremely important that all plugs be installed and braced in such a way that blowouts are prevented. As an example of the hazard, a force of 250 pounds is exerted on an eight (8) inch plug by an internal pipe pressure of 5 psig, and a force of 2,250 pounds is exerted on a twenty-four (24) inch plug by an internal pressure of 5 psig. The sudden expulsion of a poorly installed plug or of a plug that is partially deflated before the pipe pressure is released is very dangerous. Every plug shall be positively braced against the manhole walls, and no one should be allowed in the manhole adjoining a line being tested so long as pressure is maintained in the line.

No internal pressure of more than 9 psig will be permitted except for leak location equipment where the plugs are firmly tied together.

Relief Valve – A pressure relief valve set at 9 psig shall be included in the test apparatus to avoid over-pressurizing and displacing temporary or permanent plugs. As an added safety precaution, the pressure in the test section should be continuously monitored to make certain that it does not at any time exceed 9 psig.

Equipment

Plug Design – Either mechanical or pneumatic plugs may be used. All plugs shall be designed to resist internal testing pressures without the aid of external bracing or blocking. However, the Contractor should internally restrain or externally brace the plugs to the manhole wall as an added safety precaution throughout the test.

Singular Control Panel – To facilitate test verification by the inspecting Engineer, all air used shall pass through a single, above-ground control panel.

Equipment Controls – The above-ground air control equipment shall include a shut-off valve, pressure regulating valve, pressure relief valve, input pressure gauge, and a continuous monitoring pressure gauge having a pressure range from 0 to at least 10 psi. The continuous monitoring gauge shall be no less than four (4) inches in diameter with minimum divisions of 0.10 psi and an accuracy of ± 0.04 psi.

Separate Hoses – Two separate hoses shall be used to: 1) connect the control panel to the sealed line for introducing low-pressure air; and 2) a separate hose connection for constant monitoring of air pressure build-up in the line. This requirement greatly diminishes any chance for over-pressurizing the line.

Pneumatic Plugs – If pneumatic plugs are utilized, a separate hose shall also be required to inflate the pneumatic plugs from the above-ground control panel.

Line Preparation

Laterals, Stubs and Fittings – During sewer construction all service laterals, stubs and fittings into the sewer test section shall be properly capped or plugged so as not to allow for air loss that could cause an erroneous air test result. It may be necessary and is always advisable to restrain gasketed caps, plugs, or short pipe lengths with bracing stakes, clamps, and tie-rods or wire harnesses over the pipe bells.

Test Procedure

Plug Installation and Testing – After a manhole-to-manhole reach of pipe has been backfilled to final grade, prepared for testing, and the specified waiting period has elapsed, the plugs shall be placed in the line at each manhole and secured.

It is advisable to seal test all plugs before use. Seal testing may be accomplished by laying one length of pipe on the ground and sealing it at both ends with the plugs to be checked. The sealed

pipe should be pressurized to 9 psig. The plugs shall hold against this pressure without bracing and without any movement of the plugs out of the pipe. No persons shall be allowed in the alignment of the pipe during plug testing.

It is advisable to plug the upstream end of the line first to prevent any upstream water from collecting in the test line. This is particularly important in high groundwater situations.

When plugs are being placed, the pipe adjacent to the manhole shall be visually inspected to detect any evidence of shear in the pipe due to differential settlement between the pipe and the manhole. A probable point of leakage is at the junction of the manhole and the pipe, and this fault may be covered by the pipe plug and not revealed by the air test, but will appear during manhole testing.

Line Pressurization – Low-pressure air shall be slowly introduced into the sealed line until the internal air pressure reaches 4.0 psig greater than the average back pressure of any groundwater above the pipe, but not greater than 9.0 psig. If groundwater is present, refer to “Determination of Ground Water Elevation and Air Pressure Adjustment.”

Pressure Stabilization – After a constant pressure of 4.0 psig (greater than the average groundwater back pressure) is reached, the air supply shall be throttled to maintain that internal pressure for at least two minutes. This time permits the temperature of the entering air to equalize with the temperature of the pipe wall.

Timing Pressure Loss – When temperatures have been equalized and the pressure stabilized at 4.0 psig (greater than the average groundwater back pressure), the air hose from the control panel to the air supply shall be shut off or disconnected. The continuous monitoring pressure gauge shall then be observed while the pressure is decreased to no less than 3.5 psig (greater than the average back pressure of any groundwater over the pipe). At a reading of 3.5 psig, or any convenient observed pressure reading between 3.5 psig and 4.0 psig (greater than the average groundwater back pressure), timing shall commence with a stop watch or other timing device that is at least 99.8 percent accurate.

A predetermined required time for a 1.0 psig pressure drop shall be used to determine the line’s acceptability. If a specified pressure drop of 0.5 psig is allowed by the City, then the required test times for a 1.0 psig pressure drop must be halved. All requirements for a specified 0.5 psig drop are given in parentheses.

Determination of Line Acceptance – If the time shown in Table I (or Table II) for the designated pipe size and length elapses before the air pressure drops 1.0 psig (or 0.5 psig), the section undergoing the test shall have passed and shall be presumed to be free of defects. The test may be discontinued once the prescribed time has elapsed, even though the 1.0 psig (or 0.5 psig) drop has not occurred.

Determination of Line Failure – If the pressure drops 1.0 psig (or 0.5 psig) before the appropriate time shown in Table 1 (or Table II) has elapsed, the air loss rate shall be considered excessive and the section of the pipe has failed the test.

Line Repair or Replacement – If the section fails to meet these requirements, the Contractor shall determine, at his own expense, the source or sources of leakage, and he shall repair or replace all defective materials and/or workmanship to the satisfaction of the Engineer. The extent and type of repair which may be allowed, as well as results, shall be subject to the approval of the Engineer. The completed pipe installation shall then be re-tested and required to meet the requirements of this test.

Manhole Testing

All sanitary sewer manholes shall be tested for leakage by plugging the inlet and outlet sewer pipes with tight plugs, filling the manhole with water to a depth of five (5) feet above the top of the pipe or three (3) feet above the existing groundwater level, whichever is greater, and allowing one hour for saturation of the manhole material. After the one-hour saturation period, the manhole shall be refilled to the original level. Four hours after refilling, the difference in water surface elevation from the original to the final level shall be measured and converted into gallons per hour lost through manhole leakage. If water depth drops more than four (4) inches during test, water shall be added to maintain the same head during the test.

The allowable leakage for manholes shall be 0.4 gallons per hour per foot diameter of the manhole.

INSPECTION CLEANING AND LAMPING

Final acceptance of the sewer line shall be based on an inspection for compliance with all items in these specifications. No pipe spalls, rocks, dirt, joint compounds, cement mortar, and other trash and obstructions shall be left in a sewer pipeline of any size of type. If this debris is removed by flushing, the manhole outlet shall be bagged or plugged before construction so that this debris will not be carried into or contaminate the existing lines.

All lines laid shall be lamped from manhole to manhole, in order to determine the accuracy of line and grade and presence of obstructions. The lines when lamped shall reveal 92.5% of the cross sectional area of the pipe. The Contractor shall remedy, at his own expense, any poor alignment or any other defects in workmanship or materials. Acceptance of construction will be based upon re-inspection of the sewer after appropriate repairs and connections are completed.

When, due to unusual circumstances, it is necessary, the City may require that completed sewer lines be inspected by means of a television camera. The Contractor will provide certified video tape records, identified by stations of all lines so inspected.

Flow of any kind into the existing sewer system shall not be allowed until the sewer has been satisfactorily completed and such a connection is approved by the City.

RESTORATION AND CLEAN-UP

The Contractor shall restore or replace all removed or damaged roadbase, paving, curbing, walks, sod, shrubbery, fences, irrigation ditches, or other structures or surfaces to a condition at least equal to that before the work began and to the satisfaction of the City. The construction site

shall be left neat and orderly. Restoration and cleanup shall also comply with the Standard Specifications for Excavation, Backfill, and Compaction.

Surplus materials, tools, and temporary structures shall be removed by the Contractor. All dirt, rubbish, and excess earth from excavations shall be disposed of by the Contractor, and the construction site shall be left clean and orderly.

The Contractor shall maintain the surface over the trenches in approved condition against any settlement or deterioration throughout the warranty period.

SEWER SYSTEM SPECIFICATIONS

MINIMUM DESIGN STANDARDS

PLAN APPROVAL

In addition to the requirements for plan approval in the General Requirements, the plans shall clearly show the lots and blocks to be served and the location of the sanitary sewer mains with reference to property lines. All service wyes shall be stationed for proper control and for future location. Profiles shall give dimensions, grade, rim elevations, and invert elevations into and out of the manholes of the sewer to be constructed. The plan view shall include topographic information with at least five (5) foot contours for all lots in the service area.

DESIGN FLOW

The design shall include consideration for providing service to the entire area tributary to the outfall point. Estimates of residential sewage contribution shall be based on 75 gallons per capita per day with a peak hour factor of 2.5. Minimum residential population density shall be figured on a basis of 3.5 persons per house, 3.5 houses per acre, and 70 percent of total land area developed as residential unless otherwise zoned, subdivided, or restricted.

Institutional, commercial, and industrial sewage contribution estimates shall be based on the design criteria set by the Colorado Department of health with review by the City. Allowance shall be made for infiltration flow of 250 gallons per day per inch diameter per mile of pipe. Design flow shall be the sum of the peak flow as computed above and the flow due to infiltration as determined above or by actual field experience if worse.

Sewers fifteen (15) inches in diameter and smaller shall carry the design flow at a maximum flow depth of half the pipe diameter. Sewers eighteen (18) inches in diameter and larger may be designed to flow up to three quarters full at design flow rate. The minimum velocity at the design flow rate shall be 2.0 feet per second (fps). Where actual flow will be much below normal for several years, the minimum velocity shall be achieved by suitable grades at the partial design flow.

PIPING DETAILS

Piping materials shall meet the requirements specified in the Standard Specifications for Sewer Mains. In most cases pipe shall be SDR 35 PVC. Use of materials other than PVC pipe shall be permitted only with prior approval of the City.

Normally sanitary sewer mains shall be eight (8) inch diameter or larger to facilitate maintenance. Service connections shall be four (4) inch diameter or larger. Six (6) inch sewer mains may be installed under special conditions where two or three residential connections will

be made to the line, if approved by the City. Smaller force mains may be used under certain conditions with approval of the City.

The following minimum grades shall apply unless hydraulic (flow) requirements above supersede the grade criteria:

Sewer Diameter	Minimum Grade (%)
4 inch	2.0 or 1/2 inch per foot
6 inch	0.64
8 inch	0.40
10 inch	0.28
12 inch	0.22
15 inch	0.15
18 inch or larger	as approved by the City

When pipe is exclusively PVC, the minimum grade can be reduced by approximately 20% with approval by the City.

Under specific conditions, slopes slightly less than those required for the 2.0 feet per second velocity when flowing full may be permitted. Such decreased slopes will only be considered where the depth of flow will be 0.3 of the diameter or greater for design average flow. Whenever such decreased slopes are selected, the design engineer must furnish, with his report, computations of the depth of flow in such pipes at minimum, average, and daily or hourly rates of flow. It must be recognized that decreased slopes may cause additional sewer maintenance expense and, if in the City's opinion the expense will be excessive, it will not permit the reduced slopes.

Sewer on slopes of 20% or greater shall be anchored securely with concrete anchors or equal. Spacing shall be not over thirty (30) feet on center for slopes from 20-35% and not over twenty (20) feet for slopes 35-50%. Where velocities greater than fifteen (15) feet per second are attained, special provisions shall be made to protect against displacement by erosion and shock.

Manholes shall be provided at every change in direction or grade, or connection with other sewer main; maximum spacing shall be four hundred (400) feet for lines fifteen (15) inches or smaller, and four hundred fifty (450) feet for lines eighteen (18) inches and larger. A minimum of 0.10 foot drop shall be provided in manholes with a maximum change in direction of 45 degrees for lines eighteen (18) inches and larger, and 0.20 feet for changes in direction greater than 45 degrees. For lines less than eighteen (18) inch, 0.10 foot of fall through the manhole is required for changes in direction of less than 60 degrees and 0.20 feet for greater than 60 degrees. Sewer lines shall be straight and not curved between manholes in both line and grade. Manholes shall be stubbed out with suitable size pipe wherever future extension of the sewer is anticipated. Services 6" in diameter and greater shall enter the sewer main at a manhole.

Provide a flexible joint in the pipe twelve (12) to eighteen (18) inches from all manhole walls and other solid structures.

Cleanouts may be provided instead of a manhole at deadends if the total length above the last manhole is less than fifty (50) feet and serves a maximum of two (2) residential connections. Where underdrains are to be constructed under sewer mains (or other locations), cleanouts or manholes shall be provided at each manhole or at four hundred (400) foot maximum intervals for the underdrain. Use of drop manholes must be approved by the City. In general, drop manholes should be provided when the change in elevation through the manhole is in excess of 24 inches.

Minimum cover on sewer mains shall normally be eight (8) foot to ground surface. Bury of seven (7) to fourteen (14) feet is considered normal. Depths outside this range will require specific approval of the City.

SERVICE CONNECTIONS

Full body wyes shall be provided in the sewer main for service connections at each building site located inside the property line at a minimum of five (5) feet and shall be shown on the plans. Whenever possible, service lines shall be installed perpendicular to the main and shall be located ten (10) feet inside the downhill property line. Tapping saddles will only be allowed with approval of the City for circumstances which necessitate their use. Fittings shall be angled upwards so that the upper invert of one-eighth bend connected to the fitting will have an elevation equal to or higher than the inside crown of the sewer main. Service lines shall be stubbed across the property line through the width of the utility easement and the end sealed with a watertight seal and marked with a 2x4 brought to grade. Minimum cover for service lines shall be three (3) feet at property line where there will be no basements. Minimum slope of 4" service lines shall be two percent. Riser connections shall be installed where the elevation of the top of the fitting is more than twelve (12) feet below finished ground surface. See Standard Specifications and typical drawing for more detail on service stub-ins and connections.

Sewer mains shall be extended to a point at least ten (10) feet up from the lowest lot corner adjacent to the sewer main of the uppermost lot to be served and terminate in a cleanout. Service connections will not be allowed at manholes except when the diameter of the service line is 50% or more of the main, in which case a special manhole shall be added for that purpose. Only with the approval of the City may service connections be allowed immediately above or below a manhole.

CONSTRUCTION

In general, construction shall conform with the Standard Specifications for Sewer Mains and for Manholes, as well as with the Excavation and Backfill Specifications. Select bedding shall extend from six (6) inches below the pipe barrel to springline (half-way up the pipe).

Compaction in this region is critical to support the pipe and must be 95% Standard Proctor. The first one (1) foot of backfill over the pipe shall be hand-placed, hand-compacted, select material as defined in the Excavation and Backfill Specifications.

In places where the sewer has less than four (4) feet of cover, provisions shall be made to protect pipe from impact loading. An approved cut-off wall shall be constructed on the lower side of crossings such as under open ditches, canals, or creeks, to prevent water from following the

sewer trench. Where design velocities exceed 15 fps, special provisions shall be made to protect against pipe displacement by shock and/or erosion.

Underdrains, where required, shall be formed by substituting 1-1/2 inch well-graded, washed rock or gravel for the sewer pipe bedding and covering the sewer pipe and bedding with plastic sheeting or geotextile appropriate to the application and approved by the City.

PROTECTION OF WATER SUPPLIES

There shall be no physical connection between a public or private potable water supply system and a sewer, or appurtenance thereto would permit the passage of any sewage or polluted water into the potable supply.

Whenever possible, sewer mains and service lines should be laid at least ten (10) feet horizontally, from any existing or proposed water main. Should local conditions prevent a lateral separation of ten (10) feet, a sewer may be laid closer than ten (10) feet to a water main if it is laid in a separate trench, or if it is laid in the same trench with the water mains located at one side on a bench of undisturbed earth with at least five (5) feet of horizontal separation. Unless there is at least ten (10) feet horizontal separation, the elevation of the crown of the sewer must be at least eighteen (18) inches below the invert of the water main.

Whenever sewer must cross under water mains, the sewer shall be laid at such an elevation that the top of the sewer is at least eighteen (18) inches below the bottom of the water main. When the elevation of a sewer cannot be buried to meet the above requirement, the water main may be relocated to provide this separation or the sewer pipe shall be encased by either a single joint of PVC or ductile iron pipe for a distance of ten (10) feet on each side of the sewer. When possible, one full length of water main shall be centered over the sewer so that both joints will be as far from the sewer as possible.

When sewer lines or services cross above water mains or services, the water mains must be protected at a minimum by installation of an impervious and structural sewer (e.g., ductile iron pipe or heavy-walled PVC pipe) and/or impervious and structural encasement for a distance of ten (10) feet on each side of the water pipe. In all cases, there shall be no joints within ten (10) feet on each side of the water line. When the sewer line is above the water, then a casing shall be required and the ends of the casing shall be sealed in a watertight manner with a reducing no-hub gasket or other approved method. Both lines should be pressure-tested to assure watertightness.

There shall be a minimum clear distance vertically of eight (8) inches between the uppermost part of the lower utility and the lowermost part of the upper utility, including casings to allow for proper bedding. In all cases, suitable backfill or other structural protection shall be provided to preclude settling and/or failure of any of the pipes.

The City shall have final review authority of all proposed designs which do not provide adequate separation. These requirements for protection of the water system against contamination from non-potable water conveyances shall apply equally to water mains and service connections.

MISCELLANEOUS REQUIREMENTS

Rain water leaders, roof drains, surface drains, or groundwater drains shall not be connected to the sanitary sewer. Each sanitary sewer service system shall be separate from the drainage system.

Grease and sand/oil traps shall be installed where required by the provisions of the Colorado Uniform Plumbing Code or determined to be necessary by the City Building Official and/or Engineer to protect the City sewage collection and treatment facilities. Grease and sand/oil traps shall be maintained in accordance with good operating practice so as to prevent grease and sand/oil from being discharged to the City collection system. Improperly maintained grease traps are a hazard to safety, health and public welfare.

TESTING

Testing of sewer lines and services, manholes, and appurtenances shall conform with the requirements of the applicable portions of the Standard Specifications of the City regarding lapping, in- and ex-filtration, and pressure testing.

TABLE I

**MINIMUM SPECIFIED TIME REQUIRED FOR A 1.0 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q = 0.0015**

1 Pipe Diameter (in)	2 Minimum Time (min:sec)	3 Length for Minimum Time (ft)	4 Time For Longer Length (sec)	Specification Time for Length (L) Shown (min:sec)							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	3:46	597	.380L	3:46	3:46	3:36	3:46	3:46	3:46	3:46	3:46
6	5:40	398	.854L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	133	7.692L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	10.470L	19:50	26:10	34:54	43:37	42:21	61:00	69:48	78:31
24	22:40	99	13.674L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	25:30	88	17.306L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30	28:20	80	21.366L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15
33	31:10	72	25.852L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36	34:00	66	30.768L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46

TABLE II

**MINIMUM SPECIFIED TIME REQUIRED FOR A 0.5 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q = 0.0015**

1 Pipe Diameter (in)	2 Minimum Time (min:sec)	3 Length for Minimum Time (ft)	4 Time For Longer Length (sec)	Specification Time for Length (L) Shown (min:sec)							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	1:53	597	.190L	1:53	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	.427L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3:12
8	3:47	298	.760L	3:47	3:47	3:47	3:47	3:48	4:26	5:04	5:42
10	4:43	239	1.187L	4:43	4:43	4:43	4:57	5:56	6:55	7:54	8:54
12	5:40	199	1.709L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
15	7:05	159	2.671L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
18	8:30	133	3.846L	8:30	9:37	12:49	16:01	19:14	22:26	25:38	28:51
21	9:55	114	5.235L	9:55	13:05	17:27	21:49	26:11	30:32	34:54	39:16
24	11:20	99	6.837L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17
27	12:45	88	8.653L	14:25	21:38	28:51	36:04	43:16	50:30	57:42	46:54
30	14:10	80	10.683L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
33	15:35	72	12.926L	21:33	32:19	43:56	53:52	64:38	75:24	86:10	96:57
36	17:00	66	15.384L	25:39	38:28	51:17	64:06	76:55	89:44	102:34	115:23