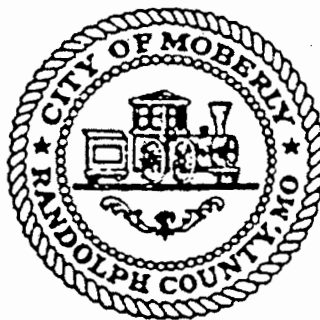

STANDARD SPECIFICATIONS FOR SANITARY GRAVITY SEWER SYSTEMS

CITY OF MOBERLY, MISSOURI



August 19, 2005

STANDARD SPECIFICATIONS FOR SANITARY GRAVITY SEWER SYSTEMS
CITY OF MOBERLY, MISSOURI

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PART 1 - GENERAL

1.1 PURPOSE

A. The standard specifications in this document apply to all sanitary sewer facility design and construction projects intended to be dedicated to the City of Moberly for maintenance. Design, plans and specifications of all sanitary sewer facilities proposed to be constructed, altered or reconstructed by any person or corporation, private or public, within the City boundaries, shall be submitted to the City for review and approval. Such design, plans and specifications shall be prepared and sealed by a Professional Engineer, registered in the State of Missouri.

1.2 SUMMARY

A. The work covered by this document includes the following:

1. Design requirements for sanitary sewers.
2. Utility trench excavation and backfill.
3. Excavation support systems.
4. Dewatering necessary to lower and control groundwater levels and hydrostatic pressures to permit excavation and construction to be performed in near-dry conditions.
5. Sanitary sewers, service connections, and manholes.

1.3 DESIGN REQUIREMENTS FOR SANITARY SEWERS

A. General Requirements

1. Size and Shape: The minimum diameters of pipe for sanitary sewers shall be eight (8) inches. Sewers shall not decrease in size in the direction of the flow.
2. Materials: Sanitary sewers shall be polyvinyl chloride (PVC) pipes, and materials for pipes and appurtenances shall conform to the requirements of Part 2 of these specifications.
3. Bedding
 - a. The Project Plans and Project Specifications shall indicate the specific type or types of bedding, cradling, or encasement required in the various parts of the sanitary sewer construction.
 - b. Special provisions shall be made for pipes laid under or overfills or embankments in shallow or partial trenches either by specifying extra-strength pipe for the additional loads due to differential settlement, or by special construction methods, including ninety (90) percent modified proctor compaction of fill, to prevent or to minimize such additional loads.
 - c. Compacted granular backfill shall be required in all trench excavation within public (or private) streets rights-of-way or areas where street rights-of-way are

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- anticipated to be dedicated for public use. Under areas to be paved, the compacted granular backfill shall be placed to the subgrade of the pavement. Under unpaved areas, the compacted granular backfill shall be placed to within two (2) feet of the finished surface.
- d. Pipes having a cover of less than three (3) feet shall be encased in concrete, unless otherwise directed by the City.
 - e. If the storm and sanitary sewers are parallel and in the same trench, the upper pipe shall be placed on a shelf and the lower pipe shall be bedded in compacted granular fill to the flow line of the upper pipe.
4. Pipe or Conduit Under Streets and Pavements: Any pipe or conduit material beneath a highway, road, street, or pavement, or with reasonable probability of being so located, shall have ample strength for all vertical loads, including the live load required by the highway authority having jurisdiction, but in no case shall provide for less than an AASHTO HS-20 loading. For other locations, the minimum live load shall be the HS-10 loading. Special considerations may be required for adverse conditions. Compacted granular backfill shall be utilized to the base of the pavement.
5. Alignment: Sanitary sewer alignments are normally limited by the available easements which in turn should reflect proper alignment requirements. Sanitary sewers shall be aligned:
- a. To be in a straight line between structures.
 - b. To be parallel with or perpendicular to the centerlines of straight streets. Deviations may be made only with approval of the City.
 - c. To make angular changes in alignment with a manhole located at an angle point.
 - d. To avoid angular changes in direction greater than necessary and any exceeding ninety (90) degrees.
6. Location: Sanitary sewer locations are determined primarily by the requirements of service and purpose. It is also necessary to consider accessibility for construction and maintenance, site availability and competing uses, and effects of easements on private property. Sanitary Sewers shall be located:
- a. To serve all property conveniently and to best advantage.
 - b. In public streets, roads, alleys, rights-of-way, or in sewer easements dedicated to the City.
 - c. On private property along property lines or immediately adjacent to public streets, avoiding crossing through the property.
 - d. At a sufficient distance from existing and/or proposed buildings (including footings) and underground utilities or other sewers to avoid encroachment and reduce construction hazards.
 - e. To avoid interference between house connections to foul water or sanitary sewers and storm water sewers.
 - f. In unpaved or unimproved areas whenever possible.
 - g. To avoid sinkholes and creeks.

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- h. No sanitary lateral clean outs or sewer vents shall be placed within the area of the storm water overflow path.
- 7. Flowline: The flowline of sanitary sewers shall meet the following requirements:
 - a. The flowline shall be straight or without gradient change between the inner walls of connected structures.
 - b. Gradient changes in successive reaches normally shall be consistent and regular, with small or insignificant differences in successive reaches. Gradient designations less than the nearest 0.001 foot per foot, except under special circumstances, shall be avoided.
 - c. For sanitary, the hydraulic grade line shall not rise above the intrados (inside crown) of the pipe.
 - d. When the grade of a sewer is twenty (20) percent or greater, a concrete cradle or collar is required. For grades exceeding fifty (50) percent, a special design is required.
- 8. Manholes: Manholes provide access to sewers for purposes of inspection, maintenance and repair. They also serve as junction structures for connecting lines. Requirements of sewer maintenance determine the main characteristics of manholes.
 - a. Manholes shall be located at changes in direction, changes of pipe size, flowline gradient, and at junction points with connecting sewers.
 - b. Spacing of manholes shall not exceed four hundred (400) feet for pipe sewers thirty-six (36) inches in diameter and smaller and five hundred (500) feet for pipe sewers forty-two (42) inches in diameter and larger.
 - c. Manholes on sewers eight (8) inches through thirty-six (36) inches shall be a minimum of forty-eight (48) inches in diameter and/or have a square bottom section with sides of forty-eight (48) inches, depending on the sewer diameter.
 - d. Manholes on sewers greater than 36" in diameter shall be special structures. Special structures shall be designed by a Professional Engineer registered in the State of Missouri.
 - e. At stream and channel crossings, manholes shall be located on both sides of the crossing at changes in pipe material. The manholes shall be a minimum of ten (10) horizontal feet from the top of the bank on both sides of the crossing.
 - f. All manholes on sanitary sewers that are built within the 100-year flood limits, the storm water overflow path, or in other areas determined to be subject to flooding shall be provided with lock-type watertight manhole covers.

B. Design Requirements

- 1. General: all sanitary sewers shall be designed and constructed as to conform to these design requirements. Hydraulic calculations must be submitted as part of the plan review for all public sewer construction. Calculations must be submitted for the existing and ultimate upstream development condition.

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2. Gradients

- a. The following minimum slopes of sanitary pipe sewers are those giving at least three (3) feet per second velocities flowing full, based on Manning's formula using an "n" value of 0.013 unless otherwise directed by the City. Slopes greater than these minimums, shall be used wherever possible.

<u>Pipe Size</u> <u>(Inches)</u>	<u>Minimum Slope in Feet</u> <u>Per 100 Feet (% Grade)</u>
8	1.0
10	0.6
12	0.6
15	0.4
18	0.3
21	0.3
24	0.2
27	0.2
30	0.2
36	0.1

- b. For sewers with a design grade less than one (1) percent, field verification of the pipe grade will be required for each installed reach of sewer prior to any surface restoration or installation of any surface improvements.
 - c. The City may require the submittal of revised hydraulic calculations for any sewer reach having an as-built grade flatter than the design grade by more than the design grade by more than 0.1 percent. Based on a review of this hydraulic information, the City may require the removal and replacement of any portion of the sewer required to ensure sufficient hydraulic capacity and cleansing velocity of the system.
3. Depth and Minimum Cover: Sewer depths shall be determined primarily by the requirements of pipe or conduit size, utility obstructions, required connections, future extensions, and adequate cover. The minimum depth requirements shall be as follows:
- a. For sewers which may be extended in the future, the minimum depth shall be nine (9) feet below the finish grade to flowline, except where upstream topography indicates that this depth is not necessary as determined by the City.
 - b. The minimum depth of sewers shall be not less than three (3) feet plus the sewer diameter. The flowline of the sewer must have a vertical distance from the low point of a basement or low floor of not less than 2.5 feet plus the sewer diameter. The minimum depth shall be increased as required to ensure a minimum of two

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- (2) percent slope and 2.5 feet of cover for a six (6) inch house lateral.
 - c. At stream and channel crossings, a minimum depth of two (2) feet shall be allowed where greater depths cannot be achieved. Where this minimum cover cannot be achieved, Class 52 ductile iron pipe with restrained joints must be used unless otherwise directed by the City. Stream and channel crossings must be protected with grouted rock blanket.
 - d. Sewer depths at manholes shall be sufficient to ensure the use of standard manholes. Special manholes will only be allowed upon approval by the City.
4. Flow Design: All lateral and sub-main or collecting sewers shall be designed on the basis of an average per capita use of not less than one hundred (100) gallons per day, and on that basis shall be designed with capacities of four hundred (400) gallons per capita per day at peak flow unless otherwise directed by the City. Sanitary flow from day schools with gymnasiums, showers and cafeterias shall be computed on the basis of thirty (30) gallons per capita per day discharged in eight (8) hours. On this basis the daily peak flow rate shall be 90 x 4 gallons per capita per day for the lateral sewers. Sanitary flow from tourist camps and trailer courts shall be computed on the basis of 2.5 persons per each unit for each twenty-four (24) hour period at fifty (50) gallons per capita per day times a peak factor of four (4). Sanitary flow from apartments, boarding schools, and condominiums and other smaller facilities shall be computed at the same rate as residential property. Sanitary flow from all other types of institutions, commercial property, industrial plants, etc, shall be separate and individual studies based on a conservative ultimate anticipated flow multiplied by the peak factors applicable to each case. In the case of industrial flow, when the rate and volume can be predetermined with a reasonable degree of accuracy, no dilutions or diminishing factor shall be applied against this flow in the outfall, sub-trunk, or truck sewers.
5. Population Factors: Family population factors for the various areas in the City are to be determined from the latest United States Census Tracts. An acceptable figure is 3.7 persons per household unit.

6. Sanitary Flow Table

<u>Population Unit</u>	<u>Cubic Feet/Second</u>
One Person @ 400 gallons per day	0.00062
One Household Unit @ 3.7 persons @ 400 gallons per capita per day	0.00229

Basic Formula:

$$\text{Flow in Cubic Feet/Second} = \text{Population} \times \text{Flow (in G/C/D)} / 646.317$$

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7. Infiltration: An additional amount of flow due to infiltration shall be included. All sanitary sewers shall be limited to a maximum of two hundred (200) gallons per inch of diameter per day per mile of line, as required by MDNR Specifications, when tested by appropriate water of low pressure air testing. In addition, there shall be no visible leaks.
8. Connections to Manholes
 - a. Foulwater drops are required when sanitary flow enters a manhole at a height more than two (2) feet above its flowline. If an inside drop is to be used, a forty-eight (48) inch diameter manhole is required. Two inside drops are not allowed into one manhole. Sewer lines shall not enter the manhole in the transition conical section, or through a joint. The slope on incoming pipes should be limited to a maximum one (1) percent for inside drops; slopes greater than this require an outside drop structure. Manhole inverts should be shaped to ensure proper flow through drop structures. The largest size to be used for an outside drop is twelve (12) inches.
 - b. If it is necessary to enter a manhole with a force main this should be done within twelve (12) inches of the flowline of the manhole, and the manhole invert should be shaped to ensure proper flow through the structure.
 - c. The number of lines coming in to one manhole should be kept to a minimum. A special detail may be required to ensure the proper constructability and maintenance of the structure.
 - d. Pipes entering and exiting manholes at the flowline should project through the center of the structure and the manhole invert should be shaped to ensure proper flow through the structure.
 - e. Private house lateral connections should be made to the main sewer, not to the manholes. However, lateral connections will be allowed to a terminal manhole.
 - f. All connections to sanitary manholes are subject to City review and approval and will be made at the City's discretion.
 - g. Connections to existing structures may require rehabilitation or reconstruction of the structure being utilized. This work will be considered part of the project being proposed.
9. Adjusting Manholes to Grade: When a project requires a manhole to be adjusted to grade, a maximum of twelve (12) inches of rise is allowed if not previously adjusted. When adjustments to raise or lower a manhole are required, the method of adjustment must be stated on the project plans and approved by the City.
10. Storm Sewers Crossing Over Sanitary Sewers: When a storm pipe crosses over a sanitary sewer and the vertical clearance is less than two (2) feet, the sanitary sewer must be encased in concrete through the crossing and for ten (10) lineal feet each side of the crossing unless otherwise directed by the City.
11. Location in Conjunction with Water Service: Sanitary sewers shall be at least ten (10) feet horizontally from any existing or proposed water main. On crossings, the sanitary sewer shall have a minimum vertical clearance of eighteen (18) inches between the outside of the water main and outside of the sanitary sewer.

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1.4 QUALITY ASSURANCE

A. Utility Trench Excavation and Backfill

1. Codes and Standards: Perform trench excavation work in compliance with applicable requirements of governing authorities having jurisdiction.
2. Testing and Inspection Service: The Contractor will retain a qualified independent testing agency to perform sampling and testing of soil and backfill materials proposed for use in work, to provide field testing facilities for quality control during backfilling of excavations, to provide for all testing necessary to control the specified quality of backfill materials obtained from material suppliers.

B. Excavation Support Systems

1. Supervision: Engage and assign supervision of the excavation support system to a qualified professional engineer foundation consultant.
2. Engineer Qualifications: A professional engineer legally authorized to practice in the State of Missouri experienced in providing successful engineering services for excavation support systems similar in extent to that required for this Project.
3. Regulations: Comply with OSHA regulations and other codes, ordinances, and laws of governing authorities having jurisdiction.

C. Dewatering

1. Operator Qualifications: Perform dewatering operations with supervisory personnel having at least 10 years experience in field of dewatering.
2. Maintain adequate supervision and control to ensure that stability of subgrades and excavated and constructed slopes are not adversely affected by water, erosion is controlled, and flooding of excavation or damage to structures does not occur.

D. Sanitary Sewer System

1. Environmental Agency Compliance: Comply with regulations pertaining to sanitary sewerage systems. All sanitary sewer improvements shall comply with the Missouri Department of Natural Resources regulations.
2. Utility Compliance: Comply with regulations pertaining to sanitary sewerage systems. Include standards of water and other utilities where appropriate.
3. Each PVC pipe length shall be marked with the manufacturer's name, nominal pipe size, cell classification, ASTM designation, and pipe stiffness.
4. All pipes shall be factory air tested with gasket in place and marked accordingly.

1.5 JOB CONDITIONS

- A. Before starting work, verify governing dimensions and elevations. Verify condition of adjoining properties. Take photographs to record any existing settlement or cracking of structures, pavements, and other improvements. Prepare a list of such damages, verified by dated photographs, and signed by Contractor and others conducting investigation.

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- B. Survey adjacent structures and improvements, employing qualified professional engineer, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

1.6 PROJECT CONDITIONS

- A. Site Information: Perform site survey, research public utility records, and verify existing utility locations.
 - 1. The Contractor shall notify the proper utility companies at least two (2) business days before construction is started adjacent to such utilities.
 - 2. The Contractor shall excavate, locate, and verify existing utilities in advance of his operations where deemed necessary.
- B. Locate existing structures and piping to be closed and abandoned.
- C. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted under the following conditions and then only after arranging to provide acceptable temporary utility services.
 - 1. Notify the Owner and the City not less than two (2) business days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without receiving City's written permission

PART 2 - MATERIALS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal:
 - 1. A-LOK Products, Inc.
 - 2. Capco Pipe Company, Inc.
 - 3. Certainteed, Inc.
 - 4. Diamond Plastics, Inc.
 - 5. Fernco
 - 6. Extrusion Technologies, Inc.
 - 7. Neenah Foundry Co.
 - 8. M.A. Industries, Inc.
 - 9. Lamson Vylon Pipe
 - 10. Uponor ETI Company
 - 11. PSI, Inc.

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2.2 PIPE BEDDING AND BACKFILL (PVC PIPE)

A. The pipe bedding shall extend from six (6) inches beneath the pipe to six (6) inches above the top of the pipe crown and shall be naturally or artificially graded mixture of gravel and sand, and having a particle size distribution as follows:

For Plastic Pipe

<u>Sieve</u>	<u>Percent Passing by Weight</u>
1/2 inch	100
No. 200	< 5

B. The backfill 6 inches above the pipe crown may be earth backfill as described in paragraph 3.9D. Granular backfill is required from 12 inches above the pipe crown when located as described in paragraphs 3.9E, 1 - 4.

C. Controlled Low Strength Material (CLSM) as described in paragraph 2.3.C and 2.5.B may be used in lieu of granular materials with the approval of the City.

2.3 TRENCH BACKFILL

A. Earth Backfill: Satisfactory soil materials are ASTM D 2487 soil classification groups GW, GM, SM, SW, GC, ML, MC, and CL. free of rock or gravel larger than 2 inches in any dimension, debris, waste, frozen materials, vegetation and other deleterious matter. Unsatisfactory soil materials are ASTM D 2487 soil classification groups GP, SP, OL, OH, CH, and PT.

B. Granular Backfill: MoDOT 1007 Type 5 crushed stone.

C. Controlled Low Strength Material: As an alternate to earth or granular backfill; trenches, boring pits, and vertical shafts (for boring) may be filled with controlled low strength material (CLSM). CLSM shall consist of Type I Portland Cement, Class "C" Fly Ash, Clean River Sand, and potable Water. Portland Cement shall conform to ASTM Specification C 150; Sand shall conform to fine aggregate as specified in ASTM C 33 and Fly Ash shall conform to ASTM C 618, Class C. Additives may be used with City's approval.

2.4 COMPACTION EQUIPMENT

A. Approved power equipment capable of obtaining the specified compaction, and operated in strict accordance with the manufacturer's instructions and recommendations. Equipment shall be maintained in such condition that it will deliver the manufacturer's rated compactive effort.

B. Jetting of backfill material shall be forbidden.

2.5 MATERIAL APPROVAL

- A. Samples of all materials proposed for use in the work shall be submitted to the Engineer for approval prior to placing orders. Samples shall be representative and shall be clearly marked to indicate the source of the material and its intended use on the project.
- B. Required CLSM Mix Type and Qualities: Use the following mix types at the locations approved by the City and where indicated in other Specification Sections by reference:
 - 1. Mix CDF – (Controlled Density Fill):
 - a. 28-day unconfined compression strength of $f'c=80$ to 120 psi
 - b. water to cement ratio = 1.0 minimum to 1.15 maximum
 - c. aggregate conforming to ASTM designation C3-90
 - d. allowable shrinkage less than 1 percent
 - e. fly ash to cement ratio shall be 7:1 minimum to 9:1 maximum
 - f. slump shall be 9 inches to 11 inches
 - 2. Mix CDF With Air – (Controlled Density Fill With Air Entrainment):
 - a. Shall meet the flowability and strength requirements of mix CDF
 - b. water to cement ratio shall be 1.0 or less
 - c. air content shall not exceed 33.0 percent
 - d. materials shall conform to the same ASTM descriptions as mix CDF

2.6 MATERIALS FOR EXCAVATION SUPPORT SYSTEMS

- A. General: Provide adequate shoring and bracing materials, which will support loads imposed. Materials need not be new, but should be in serviceable condition.
- B. Structural Steel: ASTM A 36.
- C. Steel Sheet Piles: ASTM A 328.
- D. Timber Lagging: Any species, rough-cut, mixed hardwood, nominal 3 inches thick, unless otherwise indicated.

2.7 PIPE AND FITTINGS

- A. All piping arriving at the job site shall have factory-applied identification marking as defined in the applicable product standard. Installation of piping shall be in accordance with requirements found elsewhere in this specification, the product standards where listed below, and manufacturer's written requirements. Applicable standards for field-testing are given for each type of pipe. Fittings shall be as recommended by the piping manufacturer, with identification markings on each fitting. Fitting of the insert type or saddle type may be used only with written approval from the City.

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B. PVC Gravity Pipe (Diameters less than 21"): ASTM D3034, Type PSM or ASTM F679 with minimum SDR of 35 or ASTM F794. PVC shall be certified by the compounder as meeting the requirements of ASTM D1784, cell class 12454C. The pipe shall have a minimum pipe stiffness of 46 psi (317 kPa).

1. Joints: Pipe shall be bell and spigot type. Finished joints shall conform to the requirements of ASTM D3212.
2. Gaskets: Gaskets shall be in accordance with the requirements of ASTM F477.
3. Installation: Installation shall be in accordance with ASTM D2321.

C. PVC Gravity Pipe (Diameters greater than or equal to 21"): ASTM F1803 with minimum 0.9-inch wall thickness or ASTM F794. PVC shall be certified by the compounder as meeting the requirements of ASTM D1784, cell class 12364A for ASTM F1803 pipe. The pipe shall have a minimum pipe stiffness of 46 pounds per square inch (317 kPa).

1. Joints: Pipe joints shall be bell and spigot type. Finished joints shall conform to the requirements of ASTM D3212.
2. Gaskets: Gaskets shall be in accordance with the requirements of ASTM F477.
3. Installation: Installation shall be in accordance with ASTM D2321.

D. Casing Pipe for Jack and Bore

1. Casing Pipe in all locations, unless otherwise approved by the City, shall be smooth wall, welded carbon steel pipe in accordance with ANSI B36.10 as follows:

Casing Pipe Nominal Diameter (Inches)	Minimum Wall Thickness (Inches)
6 to 16	0.188
18 to 22	0.250
24 and 26	0.281

2. The inside diameter of the casing shall be four (4) inches (minimum) larger than the bell or coupling of the pipe encased or as indicated on the Contract Drawings.
3. The interior, exterior, and field-welded joints shall be coated with Tnemec Series 46H-413 Hi-Build Tneme-Tar coal-tar epoxy or approved equal.
 4. Shop surface preparation shall meet the minimum requirements of SSPC-SP6.
 5. Field surface preparation shall meet the minimum requirements of SSPC-SP11.
 6. Coating shall be shop applied with the exception of 8" on either side of field-welded joints, which will be field applied after welding and surface preparation is complete.
 7. Required dry film thickness: 14-20 mils

E. Casing Spacers

1. Casing spacers shall be used to install the carrier pipe inside the casing pipe. To provide support around the periphery of the carrier pipe as it is pushed through the casing, each spacer shall be a two-piece shell made from stainless steel of a minimum 14-gauge thickness.
2. The shell shall be lined with a ribbed PVC extrusion with a retaining section that overlaps the edges of the shell and prevents slippage.
3. Bearing surfaces (runners) shall be ultra high molecular weight polymer for abrasion resistance and a low coefficient of friction. The runners shall be attached to support structures (risers) at appropriate positions to properly support the carrier within the casing and to ease installations. The runners shall be attached mechanically by punched riser section and bolt heads welded for strength. Riser shall be made of stainless steel of a minimum 10-gauge. All risers over 6" in height shall be reinforced and welded to the shell. Standard positioning within the casing will require the height of the risers and runners combined shall be sufficient to provide not less than three fourths inch between the casing pipe and the outside diameter of the bell.
4. Casing spacers shall be centered and restrained. Centered positioning within the casing will require the risers and runners to be dimensioned to center the carrier pipe in the casing with a top clearance of one half inch minimum.
5. All welds and metal surfaces shall be chemically passivated.
6. Stainless steel casing spacers shall be manufactured by Cascade Waterworks Mfg. Co. of Yorkville, IL, or manufactured by PSI, Inc. of Houston, TX or prior approved equal.
7. To avoid the transfer of earth and live loads to the carrier pipe, the space between the carrier and casing pipes should not be filled completely.
8. Wooden skids shall not be acceptable.

F. Casing End Seals

Shall be constructed of 1/8-inch thick specially compounded synthetic rubber and designed to accommodate the carrier/casing differential.

G. Anchorages

1. Clamps, Straps, and Washers: ASTM A506, steel.
2. Rods: ASTM A276, Type 304 stainless steel.
3. Bolts: ASTM A307, steel.
4. Cast-Iron Washers: ASTM A126, gray iron.

2.8 MANHOLES

- A. Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for rubber gasket joints or bituminous mastic sealant.

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1. Base Section: 6-inch minimum thickness for floor slab and 5-inch minimum thickness for walls and base riser section.
 2. Riser Sections: 5-inch minimum thickness, 48-inch diameter and lengths to provide depth indicated.
 3. Top Section: Concentric cone type, where top of cone is sized to match grade rings.
 4. Gaskets: ASTM C 443 (ASTM C 443M), rubber or mastic sealant (AASHTO M-198B).
 5. Grade Rings: The combination of reinforced-concrete grade rings and the frame shall not exceed 18 inches total thickness, and shall match a 24-inch diameter frame and cover.
 6. Steps: ASTM C 478, PS1-PF manhole step as manufactured by M.A. Industries, Inc. or approved equal. Cast insert for steps or drill hole into sidewalls at 12- to 16-inch intervals located 90 degrees from the direction of flow of the manhole and shall not be over or opposite a major pipe. Omit steps for manholes less than 60 inches deep.
 7. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section. Pipe connectors shall be A-LOC (A-LOC Products, Inc.) or approved equal.
- B. Precast Concrete Drop Manholes: Specifications for manholes shall be the same as Section 2.8.A above. Drop pipe and accessories shall meet the following specifications:
1. Drop pipe shall be PVC pipe with solvent welded elbow at bottom. Pipe shall be installed below flow line of incoming pipe.
 2. Drop pipe shall be attached to interior face of manhole by a minimum of three "Flared-Leg Brack-it" (D021 or Equal) attached with 3/8" x 3" stainless steel bolt with approved anchor. A 3/4" stainless steel band shall be wrapped around pipe and attached to bracket. A minimum of three band and bracket assemblies shall be used or maximum three (3) ft spacing between brackets.
- C. Manhole Frames and Covers: ASTM A 48, Grade 60-40-18, heavy-duty ductile iron. Include 22-inch minimum inside diameter by 7- to 9-inch riser with 4-inch minimum width flange, and 24-inch diameter cover. The frame and cover unit shall not weigh less than 284 lbs. The frame shall be of a design to readily accept the external chimney seal described in Paragraph D of Section 2.8. The cover shall be checkered or knobbed with lettering, equivalent to the following, and cast into cover: SANITARY SEWER.
- Refer to Section 1.3, Paragraph A.8.e: Where manholes are subject to possible surface water intrusion, the cover shall be bolted down by a minimum of three stainless steel bolts. The cover shall have concealed pickholes.
- D. Manhole Chimney Seals: An external or internal chimney seal shall be installed between the manhole frame and masonry chimney in accordance with the manufacturer's instructions. External or Internal Chimney seals shall be manufactured by Cretex (2002

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S. West Ave., Waukesha, WI 53189, 800-345-3764, www.cretexseals.com) or approved equal conforming to the following requirements:

External or Internal Chimney seals shall consist of a flexible rubber sleeve, extension, and stainless steel compression bands. The rubber sleeve and extension shall be molded from a high grade rubber compound conforming to the applicable requirements of ASTM C-923, with a minimum tear resistance of 1500 psi and a hardness of 48. The sleeve shall have a minimum thickness of 3/16" and shall be available in heights of 6 and 9 inches. The compression bands used to compress the sleeve against the manhole and frame shall be 16 gauge stainless steel conforming to ASTM A-240, type 304, with a minimum width of 1 inch.

E. Manhole External Joint Seals: An external joint seal shall be installed on each section joint of the manholes in accordance with the manufacturer's instructions. The external joint seal shall meet the requirements of ASTM C-877, type II. External joint seals shall be CretexWrap External Manhole Joint Seals or approved equal conforming to the following requirements.

External joint seals shall consist of a collar 9" to 18" wide with an outer layer of polyethylene, with a minimum tensile strength of 4000 psi and a minimum tear resistance of 1500 psi, and an under layer of rubberized mastic that is reinforced with a woven polypropylene fabric. Two 5/8" steel straps shall be located within the collar 3/4 inches from each edge. The straps shall be confined in tubes that isolate them from the mastic and allow them to slip freely when mechanically tightened and locked around the manhole joint. The collar shall be furnished with a minimum of 6" overlap and a closing flap to cover any remaining exposed strap.

2.9 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350R:

1. Cement: ASTM C 150, Type II
2. Fine Aggregate: ASTM C 33, sand
3. Coarse Aggregate: ASTM C 33, crushed gravel
4. Water: Potable
5. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain
6. Reinforcement Bars: ASTM A 615, Grade 60, deformed steel
7. Design Mix: $f_c = 4000$ psi, coarse aggregate size No. 57, 1" maximum, air entrainment 3.0 to 6.0 percent by volume, slump 4", water/cement ratio not to exceed 0.45

B. Structure Channels and Benches: Factory or field formed from concrete. Portland-cement design Mix R1, 4000-psi minimum, with 0.45 maximum water-cement ratio.

1. Include channels and benches in sanitary sewerage and storm drainage manholes.

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- a. Manhole Channels: Concrete invert, formed to same width as connected piping, with height of the vertical sides to 3/4 of the pipe diameter. Form curved channels with smooth, maximum practical uniform radius and slope.
 - i. Invert Slope: 2 inches through manhole
- b. Manhole Benches: Concrete, sloped to drain into channel.
 - i. Slope: 1 inch per foot (1:12)

2.10 PROTECTIVE COATINGS

- A. General: Include factory- or field-applied protective coatings to structures and appurtenances according to the following:
- B. Precast Concrete Coating – Exterior Surface: 1- or 2-coat, asphalt waterproofing conforming to ASTM D449, Type C, 15-mil minimum thickness, except where otherwise indicated. Apply coating on all manholes.
- C. Precast Concrete Coating – Interior Surface: Surface preparation shall be such that all surfaces are clean, dry, and free of all foreign contaminants. Remove form fins and ridges greater than 1/8 inch. Fill air pockets or lugholes greater than 1/4 inch diameter with a filler that is compatible with coal tar epoxy coating. Supply written confirmation of this compatibility. For barrier coat, apply one coat of Tnemec Series 66 Epoxoline, thinned to 25-30 percent solids, at 2.0 – 3.0 mils DFT, or approved equal. For finish coat, apply one coat of Tnemec Series 46H-413 Tnemec-Tar at 16.0 – 20.0 mils DFT, or approved equal.

PART 3 - INSTALLATION

3.1 TRENCH EXCAVATION

- A. Jacking (tunneling using outside casing pipe and inside carrier pipe) shall be shown on the drawings as the method of installation for a segment of the gravity sewer. The requirements of this Article apply.
 - 1. A plan clearly outlining the method of installation must be submitted to the City for review prior to the start of this work.
 - 2. The installation of the casing pipe shall be carried out without disturbance to existing embankments, roadways, or other structures.
 - 3. A smooth casing pipe of sufficient strength shall be forced into the bored hole to give a tight fit against the sides of the bored hole and to provide adequate clearance around the carrier pipe bell. The casing pipe shall be advanced from the lower end unless otherwise approved by the City, and shall be maintained accurately to line and grade during the installation operation.

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- 4. Casing spacers of an approved material shall be rigidly fastened to the barrel of the carrier pipe. After placing the carrier pipe within the casing, a synthetic rubber end seal shall be placed over each end of the casing pipe.

- B. Trenches shall be excavated to a width which will provide adequate working space and sidewall clearances for proper pipe installation, jointing, and embedment. However, the limiting trench widths from the bottom of the trench to an elevation one foot above the top of installed pipe, and the minimum permissible sidewall clearances between the installed pipe and each trench shall be excavated with vertical sides.

- C. Stipulated minimum sidewall clearances are not minimum average clearances but are minimum clear distances, which will be required.

- D. Cutting trench banks on slopes to reduce earth load to prevent sliding and caving shall be used only in areas where the increased trench width will not interfere with surface features or encroach on right-of-way limits. Bottom of such slopes shall not be closer than one-foot above the top of the pipe. Cost of such excavation and backfill shall be at the expense of the Contractor.

- E. No more trench shall be opened in advance of pipe laying than is necessary to expedite the work. Unless otherwise authorized by the City, no more trench shall be excavated in a day than can be laid in during that working day.

- F. Backfilling shall begin as soon as practicable but do not commence until after sewers, drains, sewerage and drainage structures, pipe, conduit and other equipment and appurtenances have been placed in trench or similar excavations have been properly constructed or installed, as applicable, and inspected. Backfill shall be placed in such a manner as not to disturb, damage, or subject such facilities to unbalanced loads or forces.

3.2 SPECIAL TRENCH EXCAVATION AND BACKFILL RESTRICTIONS

- A. The Contractor shall maintain vehicular access along the existing roads at all times. Where construction activities cross the existing roads, the work shall be scheduled to minimize interference with vehicular traffic. The Contractor shall provide temporary vehicular access roads, where required, around construction work. Temporary graveled vehicular access roads shall have a minimum width of 12 feet and shall be maintained by the Contractor during use and removed, as directed by the City, after vehicular access has been re-established along existing roads.

3.3 OBSTRUCTIONS

- A. Remove all obstructions encountered within the trench area or adjacent thereto. The City may, if requested by the Contractor, approve minor changes in trench alignment to avoid major obstructions, provided such alignment changes can be made within the permanent easement or right-of-way lines and without adversely affecting the intended function of

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the facility. The Contractor shall pay any additional costs resulting from such alignment changes.

3.4 GRADE

A. Excavate the trench to the lines and grades shown or as established by the City with proper allowance for pipe thickness and for pipe bedding. If the trench is excavated below the required grade, correct any part of the trench excavated below the grade, at no additional cost to the City with granular material of the type specified for pipe bedding. Place the granular material over the full width of trench in compacted layers not exceeding 6 inches deep to the established grade with allowance for the pipe bedding.

3.5 SHORING, SHEETING, AND BRACING (EXCAVATION SUPPORT) OF TRENCHES

A. Bracing and Shoring: It shall be the responsibility of the Contractor to maintain all work in compliance with current Occupational Safety and Health (OSHA) standards. In addition, trenches including embankments, shall be shored or otherwise supported when the trench is more than five (5) feet in depth and examination of the ground by a competent person provides no indication of potential cave-in. In lieu of shoring the trench sides above the 5-foot level may be sloped to preclude collapse, but shall not be steeper than a 1-foot rise to each foot horizontal.

B. Wherever a trench box is used in place of sheeting or shoring, care shall be taken to prevent the pipe from moving when the trench box is moved. The pipe shall be secured to prevent longitudinal movement.

3.6 STORAGE OF EXCAVATED MATERIAL

A. During trench excavation, place excavated material only within the approved working area. Do not obstruct any roadways or streets. Conform to all Federal, State, and local codes governing the safe loading of trenches with excavated materials.

3.7 REMOVAL OF WATER

A. At all times, provide and maintain ample means and devices to promptly remove and dispose of all water entering the trench excavation during the time the trench is being prepared for the pipe laying, during the laying of the pipe, and until at least the backfill of the pipe zone has been completed. These provisions shall apply during the noon hour as well as overnight. Do not, under any circumstances, permit the dewatering process to interfere with or allow water to enter the construction area of any other Contractor. Provide the necessary means and devices, as approved, to positively prevent such occurrences.

B. Dispose of the water in a manner to prevent damage to adjacent property and prevent interference with adjacent areas. Drainage of trench water through the pipeline under construction is prohibited.

3.8 FOUNDATION STABILIZATION

- A. When, in the opinion of the City, the existing material in the bottom of the trench is unsuitable for supporting the pipe, excavate below the subgrade of the pipe, as directed by the City. Backfill the trench to subgrade of pipe bedding with material as specified for the pipe bedding and as directed by the City. Place the material over the full width of the trench and compact in layers not exceeding 6 inches in thickness to meet the required grade.

3.9 TRENCH BACKFILL

A. Pipe Bedding

1. The pipe bedding shall be defined as a layer of granular material extending from a point six (6) inches below the bottom of the pipe to a point six (6) inches above the top of the pipe. Pipe bedding material shall be in accordance with Section 2.2.
2. Minimum trench width shall be the outside diameter of the pipe plus twelve (12) inches. The pipe shall be placed in the center of the trench, horizontally. Place the specified thickness of bedding material over the full width of trench. Grade the top of the bedding ahead of the pipe laying to provide firm, uniform support along the full length of pipe.
3. After each pipe has been graded, aligned, and placed in final position on the bedding material and shoved home, sufficient pipe bedding materials shall be deposited and compacted under and around each side of the pipe and back of the bell or end thereof to hold the pipe in proper position and alignment during subsequent pipe joining and backfilling operations.
4. In PVC pipe trenches, the bedding material shall be placed under and around the pipe in uniform layers not exceeding 6 inches in uncompacted thickness and compacted to 85 percent of maximum dry density as determined by ASTM D 698.
5. Place the bedding material simultaneously on both sides of the pipe, keeping the level of backfill the same on each side. The material shall be carefully placed and "walked in" around the pipe to ensure that the pipe barrel is completely supported and that no voids or uncompacted areas are left.

- B. Bell Holes: Excavate bell holes at each joint to permit proper assembly and inspection of the entire joint. No part of any bell or coupling shall be in contact with the trench bottom, trench walls, or granular embedment when the pipe is joined.

- C. Push the backfill material carefully onto the granular material and do not permit free fall of the material until at least 2 feet of cover are provided over the top of the pipe. Under no circumstances allow sharp, heavy pieces of material to drop directly onto the pipe or the tamped material around the pipe.

D. Final Earth Backfill

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1. Earth backfill will, generally, be limited to use in present and future unsurfaced areas where subsequent settlement will not cause a problem.
2. Compacted earth backfill will be required for the full depth of the trench 6 inches above the pipe zone. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
3. Percentage of Maximum Dry Density Requirements: Compact soil to not less than the following percentages of maximum dry density according to ASTM D 698:
 - a. Under lawn or unpaved areas, compact the top 6 inches below subgrade and each layer of backfill or fill material at 95 percent maximum dry density.
 - b. Under undeveloped field areas, compact the top 6 inches below subgrade and each layer of backfill or fill material at 95 percent maximum dry density.

E. Granular Backfill:

1. Granular backfill will be required in present graveled roadways, gravel surfaced areas, future pavement areas, and in areas where pipes lie above or cross other pipelines. Subsequent settlement must be held to a minimum in these areas. Granular backfill will also be required under manhole base sections.
2. Granular backfill will be required in all trenches excavated under or within five (5) feet of pavements, driveways, sidewalks, structures, or as directed by the City.
3. Place material in lifts not to exceed 8-inch loose thickness and compact each lift to 98 percent of maximum dry density at optimum moisture content as determined by ASTM D 698.
4. Under manhole base sections, place granular backfill course material on prepared subgrades.
 - a. Compact granular backfill at optimum moisture content to required grades, lines, cross sections and thickness to not less than 98 percent of maximum dry density as determined by ASTM D698.
 - b. When thickness of compacted granular backfill is 6 inches or less, place materials in a single layer.
 - c. When thickness of compacted granular backfill exceeds 6 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.

F. Water Settling of Trench Backfill: Water settling of trench backfill will not be considered an acceptable compaction procedure, and will not be permitted unless specifically approved by the City.

G. Jetting of Trench Backfill: Jetting of trench backfill will not be considered an acceptable compaction procedure and will not be permitted unless specifically approved by the City.

H. Controlled Low Strength Material (CLSM)

1. CLSM shall be placed as discharge from the transit mix truck around the sewer pipe and to the required elevation in a continuous placement with proper precautions taken to prevent flotation. No vibration or compaction is required.
2. The ends of backfill placements shall be bulkheaded with earth stanks or other means suitable to keep backfill material in its intended place.
3. CLSM may be placed to the subgrade elevation of the pavement and the pavement replaced within 24 hours of placing the CLSM.

I. Cold Weather Placing of CLSM: Protect CLSM work from physical damage or reduced strength, which could be caused by frost, freezing actions, or low temperatures.

1. When air temperature has fallen to or is expected to fall below 40 degrees F (4 degrees C), uniformly heat materials as necessary before mixing to obtain a CLSM mixture temperature conforming to Table 1.4.1 of ACI 306 Report and maintain protection for minimum times as noted in Table 1.4.2 of ACI 306 Report. The rate of cooling should be gradual and should not exceed 40 degrees F per 24-hour following the cessation of heat application.
2. Do not use frozen materials or materials containing ice or snow. Do not place CLSM on frozen subgrade or on subgrade containing frozen materials.

3.10 FIELD QUALITY CONTROL

A. Quality Control Testing During Construction: Contractor shall retain a testing service to inspect pipe subgrade, bedding, and pipe backfill and obtain approval of the City before further construction work is performed. Allow field density tests to be performed in accordance with ASTM D1556 (sand cone method), ASTM D2167 (rubber balloon method), or ASTM D2922 and D3017 (nuclear method) as applicable.

1. Slumps and compressive strengths of CLSM shall be tested as requested by the City and not to exceed one set of tests per 100 cubic yards.

B. Have at least two field density tests taken at locations and elevations as directed, but in no case less than two tests per 500 lineal feet of trench backfill under structures, pavements, or sidewalks, unless otherwise approved by the City. When backfilling in present and future unsurfaced areas, a minimum of one field density test is required per 1000 lineal feet of trench.

C. Clear interior of piping and structures of dirt and superfluous material as the work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

1. In large, accessible piping, brushes and brooms may be used for cleaning.
2. Place plug in end of incomplete piping at end of day and whenever work stops.
3. Flush piping between manholes and other structures, if required by authorities having jurisdiction, to remove collected debris.

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- D. Test new piping systems and parts of existing systems that have been altered, extended, or repaired for leaks and defects. The testing methods should take into consideration the range in groundwater elevations projected and the conditions during the test.
1. Do not put into service before inspection and approval.
 2. Schedule tests, and their inspections by authorities having jurisdiction, with at least 24 hours' advance notice.
 3. Submit separate reports for each test.
 4. Deflection Test: Deflection tests shall be performed on all pipe. The test shall be run no less than thirty (30) days after final backfill has been placed.
 - a. No pipe shall extend a deflection of five percent (5%).
 - b. If the deflection test is to be run using a rigid ball or mandrels, they shall have diameters equal to ninety-five percent (95%) of the inside diameter of the pipe and the tests shall be performed without mechanical pulling devices.
 5. Leakage Tests: Test pressure shall be five (5) pounds per square inch (psi). Leakage shall be tested using water or low pressure air. The leakage outward or inward (exfiltration or infiltration) shall not exceed twenty-five (25) gallons per inch of pipe diameter per mile per day for any section of the system. The air test, if used, as a minimum shall conform to the test procedure described in ASTM F1417 entitled Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe. The testing methods selected should take into consideration the range in groundwater elevations projected and the situation during the test.
 6. Leaks and loss in test pressure constitute defects that must be repaired.
 7. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.
 8. Manholes: Test pressure (vacuum) for manholes shall be ten (10) pounds per square inch (psi). Perform hydraulic test according to ASTM C 969 or air pressure (vacuum) testing according to ASTM C 1244. External joint seals are to withstand 13-psi air test.

3.11 MAINTENANCE OF TRENCH BACKFILL

- A. The Contractor shall maintain all backfilled trench surfaces until all work has been completed and officially accepted. Such maintenance shall include, but not be limited to, the addition of appropriate backfill material above the pipe zone to keep the backfilled trench surface smooth, free from ruts and potholes, and suitable for traffic flow.

3.12 SETTLEMENT

- A. Any settlement in trench backfill, which occurs during the warranty period and is attributable to construction procedures, such as improper removal of shoring or insufficient compaction, shall be corrected by the Contractor at his own expense. Any piping or facilities damaged by such settlement shall be restored to their original condition at the Contractor's expense.

3.13 EXCESS MATERIAL DISPOSAL

- A. Excess materials such as vegetation, rubble, broken concrete, debris, asphaltic concrete pavement, excess soil, spoil and slurry from boring operations, and other materials not designated for salvage, shall become the property of Contractor and shall be removed from the job site and legally disposed of. The Contractor must comply with all relevant regulations, right-of-way, work space and permit agreements. The Contractor is responsible for acquiring any required disposal permits.
- B. The Contractor is responsible for transporting all excess materials to the disposal site and paying any disposal costs. Excess material will be transported in a manner that prevents accidental spillage onto roadways.
- C. Excess spoil and slurry will not be discharged into sanitary or storm drain systems, ditches, or waterways.
- D. Excess materials shall be removed from the site on a daily basis, such that the site is maintained in a neat and orderly condition. No stockpiling of excess materials on-site shall be permitted.
- E. The Contractor shall meet all applicable environmental regulations for handling, storing, transporting, and disposing of excess materials.

3.14 DEWATERING

- A. Provide an adequate system to lower and control groundwater in order to permit excavation, installation of sewers, construction of structures, and placement of fill materials under dry conditions. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of structure foundations, drains, sewers, and other excavations.
- B. Reduce hydrostatic head in water-bearing strata below structure foundations, drains, sewers and other excavations to extent that water level and piezometric water levels in construction areas are below prevailing excavation surface.
- C. Prior to excavation below groundwater level, place system into operation to lower water levels as required and then operate it continuously 24 hours a day, 7 days a week until drains, sewers and structures have been constructed, including placement of fill materials, and until dewatering is no longer required.
- D. Dispose of water removed from excavations in a manner to avoid endangering public health, property, and portions of work under construction or completed. Dispose of water in a manner to avoid inconvenience to others. Provide sumps, sedimentation tanks, and other flow control devices as required by governing authorities.

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- E. Provide standby equipment on site, installed and available, for immediate operation if required to maintain dewatering on a continuous basis in event any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, perform such work as may be required to restore damaged structures and foundation soils at no additional expense.
- F. Dewatering shall not be paid for directly, but shall be considered as incidental to the various items to which it applies and the cost shall be included in the contract price.

3.15 SHORING

- A. Protect the site from caving and unacceptable soil movement. Wherever shoring is required, locate the system to clear permanent construction and to permit forming and finishing of concrete surfaces. Provide shoring system adequately anchored and braced to resist earth and hydrostatic pressures.
- B. Shoring systems retaining earth on which the support or stability of existing structures is dependent must be left in place at completion of work. If wood is part of the shoring system near existing structures, use pressure preservative treated materials or remove as backfill is placed.
- C. Do not place shoring where it will be cast into or included in permanent concrete work.
- D. Remove sheeting, shoring, and bracing in stages to avoid disturbance to underlying soils and damage to structures, pavements, facilities, and utilities.
- E. Repair or replace, as acceptable to Engineer, adjacent work damaged or displaced through installation or removal of excavation support system.

3.16 IDENTIFICATION

Provide green 3-inch wide warning tape along centerline of pipe fourteen (14) to eighteen (18) inches above crown of pipe and at outside edges of underground structures. Plastic warning tape shall be lettered : "WARNING – SANITARY SEWER". In addition for non-ferrous pipe, Use 12-ga solid copper warning wire over nonferrous piping and over edges of underground structures. Place 14 to 18 inches directly above pipe crown.

3.17 PIPE INSTALLATION, GENERAL

- A. General Locations and Arrangements: Location and arrangement of piping layout take into account many design considerations. Install piping per City approved plan, or in the event of a conflict, as directed by the City. When connecting to existing sewer lines, the Contractor shall verify the invert elevation of the existing sewer prior to constructing the new sewer to that location.

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- B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's recommendations for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.
- C. Pipe that is to be bedded in a concrete cradle or encased in concrete shall be placed in proper position on temporary supports of preshaped wood blocks or bricks with wood wedges. If necessary, anchor or weight the pipe to prevent flotation when the concrete is placed. Place concrete for cradles, arches, or encasement uniformly on each side of the pipe. The concrete shall be deposited within 5 feet of its point of placement. Concrete placed beneath the pipe shall be sufficiently workable so that the entire space beneath the pipe can be filled without excessive vibration.

3.18 RELATION TO WATER LINES

- A. Horizontal Separation: Sanitary sewer lines shall be laid at least ten (10) feet horizontally from any existing or proposed water main. The distance shall be measured edge-to-edge. Less horizontal separation between a sanitary sewer line and water line is allowable where it is not practical to maintain a 10-foot separation, provided that the water main is in a separate trench or on an undisturbed earth shelf located on one side of the sanitary sewer and that a vertical separation of at least 18 inches between the bottom of the water line and the top of the sanitary sewer line can be maintained. When this vertical separation between the water line and sanitary sewer line cannot be maintained, either the water line or the sanitary line shall be relocated.
- B. Crossings: Sewers crossing water mains shall be laid to provide a minimum vertical distance of eighteen (18) inches between the outside of the water line and the outside of the sanitary sewer line.
- C. The Contractor shall notify the City for any potential violations of these criteria before installing the sewer as shown on the drawings.

3.19 MANHOLE INSTALLATION

- A. General: Install manholes, complete with accessories, as indicated.
- B. Set tops of frames and covers flush with finished surface where manholes occur in pavements. Set tops 1 inch above finished surface in lawns. In areas other than lawns or pavements, set tops at specified elevations.
- C. Place precast concrete manhole sections as indicated, and install according to ASTM C 891.
- D. Provide rubber joint gasket complying with ASTM C 443 or apply bituminous mastic sealant at joints of sections to provide an effective watertight joint

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- E. Manhole steps shall be installed either by casting inserts in wall or by drilling into wall per manufacturer's recommendations.
- F. Manhole frame shall be set on a full bed of mastic.
- G. Apply asphalt waterproofing to exterior surface of manhole.

END OF SPECIFICATIONS