

Division II

Section 2200

Sanitary Sewers



**DIVISION II
CONSTRUCTION AND MATERIAL SPECIFICATIONS**

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SEWERS**

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**DIVISION II
CONSTRUCTION AND MATERIAL SPECIFICATIONS
SECTION 2200 SANITARY SEWERS**

2201 SCOPE

This Division governs all work, materials and testing required for installation of gravity and pressure pipelines of the respective types and sizes shown on the Plans for the particular location and conforming to the requirements of these specifications. All pipelines shall be constructed to proper line and grade as shown on the Plans and shall result in an unobstructed, smooth and uniform conduit.

2202 GENERAL

2202.1 Description

Sanitary sewer construction shall consist of furnishing all labor, materials and equipment for the complete installation of sewers and appurtenances in accordance with the contract documents, standard drawings, approved shop drawings, general Provisions and these specifications.

2202.2 Specification Modifications

It is understood that throughout this section these specifications may be modified by appropriate items in the Special Provisions or notes on the Contract Drawings.

2202.3 Revisions of Standards

When reference is made to a Standard Specification i.e. ASTM, ANSI, AWWA, MCIB, the Specification referred to shall be understood to mean the latest revision of said specification as amended at the time of the Notice to Bidders, except as noted on the Plans or in the Special Provisions.

2203 MATERIALS

2203.1 General

This section governs materials that may be required to complete pipeline construction, exclusive of structures, as shown on the Plans and/or as provided for in the Special Provisions.

1. Requirements: Furnish pipe of materials, joint types, sizes, and strength classes indicated or specified. Higher strengths may be furnished at the Contractor's option at no additional cost to the Owner.
2. Manufacturer: The manufacturer shall be experienced in the design, manufacture and commercial supplying of the specific material.
3. Inspection and Testing: Inspection and testing shall be performed by the Manufacturer's quality control personnel in conformance with applicable standards. Testing may be witnessed by Owner, Engineer, or approved independent testing laboratory. The Contractor shall provide three (3) copies of certified test reports indicating the materials

conform to the specifications.

4. Handling: Equipment and methods shall be adequate to protect the pipe, joint elements and prevent shock contact of adjacent units during moving or storage. Damaged sections that cause reasonable doubt as to their structural strength or water-tightness will be rejected.

2203.2 Pipe, Fittings, Joints, Coatings, and Linings

1. ~ General: Furnish Pipe and fittings of materials, joint types, sizes, strength classes, coatings and linings as indicated and specified.
2. ~ Acrylonitrile-Butadiene-Styrene (ABS) and Polyvinyl Chloride (PVC) Composite Sewer Pipe and Fittings (When approved by the City Engineer): Pipe and fittings shall conform to ASTM D 2680, except as otherwise specified herein.
 - a. General: Furnish maximum pipe lengths, normally produced by the manufacturer except for fittings, closures and specials. All field cuts that result in an exposed end section shall be sealed in accordance with the manufacturers' recommendation.
 - b. Design: Pipe shall consist of two concentric thermoplastic tubes integrally braced across the annulus with resultant annular space filled with inert material to provide continuous support between inner and outer tubes. Bell-end shall be factory attached solvent weld coupling.
 - c. Joints: Pipe joints and fittings shall be solvent cement or elastomeric type conforming to ASTM D 2680. Natural rubber gaskets will not be accepted.
 - d. Fittings: Fittings defined as tee (T) or wye (Y) connections suitable for assembly to four (4) inch or six (6) inch building service lines shall be bell end with a minimum wall thickness conforming to SDR 35 and shall be provided by the pipe manufacturer. A special design is required for service connections 8 inch and larger. Saddle tees or wyes will not be permitted during sewer main installation.
3. ~ Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings: Pipe and fittings shall conform to ASTM D 2751, except as otherwise specified here-in.
 - a. General: Furnish maximum pipe lengths, normally produced by the manufacturer, except for fittings, closures and special.
 - b. Design: Pipe shall have an integral wall bell and spigot joint and a minimum wall thickness conforming to SDR 23.5 for buried depths 16 feet or greater and SDR 35 for less than 16 feet.
 - c. Joints: Pipe joints and fittings shall be solvent-cement or elastomeric conforming to ASTM D 2680. Gaskets for elastomeric joints shall conform to ASTM F477. Joint tightness shall also conform to ASTM D 3212. Natural rubber gaskets will not be accepted.
 - d. Fitting: Fittings defined suitable for assembly to four (4) inch or six (6) inch building service lines shall be bell-end with a minimum wall thickness conforming to SDR 23.5 for buried depths 16 feet or greater and SDR 35 for buried depths less than 16 feet.
4. Ductile-Iron Pipe and Fittings: Pipe and fittings shall conform to ANSI A21.51, except as otherwise specified herein.
 - a. General: Furnish maximum pipe lengths normally produced by the manufacturer except for fittings, closures and specials.
 - b. Design: All ductile iron pipe shall meet the requirements of ANSI A21.50 and ANSI A21.51 and shall be of the thickness class specified therein or shown on the

drawings. Ductile iron pipe shall be used only when specified by plans or proposal and must be approved prior by City Engineer. When specified by the plans, ductile iron pipe shall be furnished with flexible joints capable of deflecting a minimum of twelve and one-half degrees (12-1/2). Deflection of a gravity sanitary sewer line direction is not considered to be acceptable by KDHE standards. This type of application may be used with Force Mains

- c. Joints: mechanical and push-on joints for pipe and fittings shall conform to the requirements of ANSI A21.11. Flanged joints for ductile iron pipe and fittings shall conform to the requirements of A21.10. Gaskets shall be neoprene or other synthetic rubber material. Natural rubber gaskets will not be acceptable.
 - d. Fittings: Fittings shall be in accordance with ANSI/AWWA C 110 and shall have a pressure rating of not less than that specified for the pipe. Fittings used with ductile iron pipe shall be ductile iron or cast iron. Fittings for pipe with mechanical joints shall have mechanical joints. Fittings for pipe with push-on joints shall have either mechanical joints or push-on joints.
 - e. Castings: Pipe and fittings shall be furnished with exterior bituminous coating conforming to ANSI A 21.51.
 - f. Linings: Pipe and fitting linings shall conform to the following:
 - (1) Pipe shall have an interior cement-mortar lining conforming to ANSI/A 21.4 or 40 mil polyethylene lining in accordance with ASTM D 1248.
 - (2) Pipe and fittings shall have an interior coating not less than one (1) mil in thickness which conforms to all appropriate requirements for seal coat in ANSI/A 21.4.
 - g. Polyethylene Encasement: Pipe and fittings shall be installed with a polyethylene tube encasement having a thickness of 0.008" (8mils) and conforming to ASTM D-1248, Type 1, Class C, Grade E-1 material.
5. Polyvinyl chloride (PVC) Pressure Rated Plastic Pipe (SDR) and Fittings: Pipe and fittings shall conform to ASTM D2241, except as otherwise specified herein.
- a. General: Furnish maximum pipe lengths normally produced by the manufacturer, except for fittings, closures and specials. Pipe shall be used only for pressure flow systems.
 - b. Materials: The pipe shall be made of OVC plastic pipe having a cell classification of 12454 B or 12454 C as defined in ASTM D 1784.
 - c. Design: Pressure flow systems, i.e., force mains, shall have the wall thickness shown on the plans, with a minimum wall thickness not less than SDR 32.5 with a minimum burst pressure not less than 400 psi conforming to pipe materials designation codes PVC 1120, PVC 1220, or PVC 2120.
 - d. Joints: Pressure flow systems shall be joined in accordance with ASTM D 3139 with particular attention given to Section 5.3.
 - e. Fittings: Fittings for pressure flow systems shall have a minimum wall thickness conforming to SDR 32.5 and minimum hydrostatic design stress of 400 psi conforming to pipe materials designation codes PVC 1120, PVC 1220, or PVC 2120.
6. Type PSM polyvinyl chloride (PVC) Sewer Pipe and Fittings: 8 through 15 inch diameter pipe and fittings shall conform to ASTM D 3034 and pipe having diameter 18" through 27 inch shall conform to ASTM F679 except as otherwise specified herein.
- a. General: Furnish maximum pipe lengths normally produced by the manufacturer except for fittings, closures, and specials.

- b. Materials: The pipe shall be made of PVC plastic having a cell classification of 12454 B or 12454 C or 13364 B as defined as ASTM D 1784.
 - c. Design: Pipe shall have an integral bell and spigot joint. Wall thickness shall be SDR 35, SDR 26, or SDR 21 as shown on plans. If for any reason the depth of cover on SDR 35 pipe becomes greater than 15 feet, the contractor shall immediately notify the design engineer.
 - d. Joints: Joint tightness shall conform to ASTM D 3212. Joints shall be push-on type only with the bell-end grooved to receive a gasket. Elastomeric seal (gasket) shall have a basic polymer of synthetic rubber conforming to ASTM F 477. Natural rubber gaskets will not be accepted.
 - e. Fittings: Fittings defined as tee (T) or wye (Y) connections suitable for assembly to four (4) inch or six (6) inch building service lines shall be bell-end with a minimum wall thickness conforming to SDR 35 and shall be furnished by the pipe manufacturer. A special design is required for service connections 8 inches and larger. Saddle tees or wyes will not be permitted during sewer main installation.
7. Reinforced Concrete Pipe and Fittings: Pipe and fittings shall conform to ASTM C 76 except as otherwise specified herein.
- a. General: Furnish maximum lengths normally produced by the manufacturer except for fittings, closures and specials.
 - b. Design: Pipe shall be Class III, Class IV, or Class V, wall B as shown on plans. Fine aggregate shall be natural sand conforming to the requirements of MCIB Section 4 – Materials. Reinforcement may be circular or elliptical. Elliptically reinforced pipe shall be marked in accordance with Section 17.2, ASTM C 76 for correct installation. Modified or special designs are prohibited unless so specified in the Special Provisions.
 - c. Joints: Pipe and fittings shall be furnished with either spigot groove type joint with O-ring gasket or steel end joint with spigot groove and O-ring gasket conforming to ASTM C 361 and ASTM C 433. The basic polymer for O-ring gaskets shall be synthetic rubber and shall conform to ASTM C 361 and ASTM C 433.
 - d. Fittings and Specials: Provide strength equal to design D-loads of adjacent pipe and be fabricated as one of the following types:
 - (1) Steel cylinder segments not less than U.S. No. 16 gauge lined with three-fourths (3/4) inch concrete or mortar and reinforced concrete exterior.
 - (2) Concrete pipe sections shall be cut while still green, reinforcing exposed and welded together at junctions and miters. Splice shall be built up to nominal wall thickness with mortar or concrete. Miters shall not exceed 30 degrees at deflection angles between segments. Minimum center line curve radius shall not be less than twice the pipe diameter.
8. Vitrified Clay Pipe and Fittings: Pipe and fittings shall conform to ASTM C 700 Extra Strength except as otherwise specified herein.
- a. General: Furnish maximum pipe lengths normally produced by the manufacturer with either bell-end or plain-end except for fittings, closures and specials.
 - b. Design: VCP shall be used only when specified by plans or proposal and must be approved prior by City Engineer.
 - c. Joints: All pipe joints shall conform to ASTM C 425 with synthetic rubber seals. All compression couplings for clay plain-end pipe shall conform to ASTM C-594.
 - d. Fittings: Where specified, the Contractor shall provide fittings suitable for

connection to house or building sewers. Fittings shall be VCP material and manufactured as an integral part of the pipe.

2203.3 Pipe Embedment Materials

1. Scope: Pipe embedment materials shall be furnished and installed to complete the work shown on the Plans or as called for in the Contract Documents.
2. Bedding Aggregate: All materials used for crushed stone pipe bedding shall conform to the requirements of MCIB Section 4 – Materials for Coarse Aggregate – Table 2, Column III, modified to meet the following graduations:

Sieve Size Gradations	Percentage Passing
No. 4	0-5
No. 8	0-2

3. Concrete for embedment and encasement:
 - a. Concrete shall test not less than a twenty-eight (28) day compressive strength of 3000 psi and shall otherwise conform to Section 2210.3.6
 - b. Reinforcing steel when required shall be placed as shown on the Plans and shall conform to Section 2210.3.7

2203.4 Backfill Materials:

1. Scope: Backfill materials shall be as required and/or permitted to complete the work shown on the Plans or called for in the Contract Documents.
2. Granular Backfill Material: Granular backfill material shall meet the gradation requirements as outlined in Section 2202.2
3. Select Earth Backfill Material: Select earth backfill shall be finely divided job excavated material free from debris, organic matter, rocks larger than one (1) inch and/or frozen materials.
4. Other Earth Backfill: Other backfill may be job excavated material free from debris and organic matter. No rock greater than one foot in its longest axis shall be placed in any trench excavation as backfill.

2203.5 Tunneling, Boring and Jacking Materials:

1. Scope: This section governs the furnishing of all materials necessary for the construction of tunnels at locations shown on the Plans or where constructed at the Contractor's option when approved by the Engineer.
2. General: Furnish materials and necessary accessories with strengths, thicknesses, coatings, and fittings indicated, specified and/or necessary to complete the work.
3. Steel Liner Plate: Steel tunnel liner plates shall be Armco "Standard," Commercial Shearing and Stamping Company "Commercial," Republic "Truscon Paneled Out," or equal and shall be galvanized in accordance with ASTM A 123. The design and shape of the liner plates shall be such that assembly can take place entirely from within the tunnel liner. Liner plates shall be capable of withstanding the ring thrust load and transmitting this from plate to plate. The minimum outside diameter shall be four (4) feet and the minimum wall thickness shall be United States Standard Gauge 12 (0.2046 inches). Sufficient sections shall be provided with one and one-half (1 ½) inch or larger grouting

holes located near the centers so that when the plates are installed there will be one line of holes on either side of the tunnel and one at the crown; the lower line of holes on each side shall not be more than five (5) feet apart and unless otherwise approved, shall be staggered. Bolts and nuts shall conform to ASTM A 153, A 307, A 325 and A 449 as applicable. Steel liner plates shall have bolted joints in both longitudinal joints in adjacent rings when assembling.

4. Steel Casings: Steel casings for bored or jacked construction shall be steel pipe conforming to ASTM A 139 with a minimum diameter as shown on the Plans. Corrugated steel casing pipe will be considered on a case-by-case basis.

a. Minimum wall thickness shall be in accordance with the following table:

Diameter of Casing-Inches	Nominal Wall Thickness-Inches	
	Under Railroads	All Other Uses
16	0.312	0.188
18	0.312	0.250
20	0.375	0.250
22	0.375	0.250
24	0.406	0.281
26	0.438	0.281
28	0.469	0.312
30	0.469	0.312
32	0.500	0.312
34	0.500	0.312
36	0.500	0.344

b. Steel shall be Grade B under railroads and Grade A on all other uses.

c. Steel pipe shall have welded joints in accordance with AWWA C 206.

5. Reinforced Concrete Pipe: Reinforced concrete pipe used as casing shall conform to ASTM C 76 except as otherwise specified under Section 2203.2.7. and as specified herein.

a. Design: Provide ASTM C 76 circular pipe of the strength class required for the jacking of pipe when determined by method set forth in the latest printing of Concrete Pipe Design Manual prepared by the American Concrete Pipe Association.

b. Joints: Reinforced concrete pipe used for casing pipe shall be provided with steel end joint with a groove in the spigot end for an O-ring gasket. The O-ring gasket shall be synthetic rubber. Both joint and gasket shall otherwise conform to ASTM C 361.

c. Interior Protection: Interior protection is not required for reinforced concrete pipe used for casing conduit.

6. Casing Conduit Grout: Casing conduit grout shall be pumpable grout resulting in minimum set strength of 400 psi. in 28 days.

7. Sand: sand used as fill in casing conduits shall be a clean sand and thoroughly dry. All sand fill shall conform to the requirements under Section 2210.3.6.

8. Wood Skids: Wood skids shall be provided as indicated on the Plans. The wood shall be pressure-treated with a preservative in accordance with ASTM D 1760. Cut surfaces shall be given two (2) heavy brush coats of the same preservative.

2204 SITE PREPARATION

2204.1 Scope

This section governs normal project site preparation for construction.

2204.2 General

1. Contractor shall do all clearing necessary for performance of his work and shall confine his operations to that area provided through easements, licenses, agreements and right-of-way. The Contractor's entrance upon any lands outside of that area provided by easements, licenses, agreements or public rights-of-way, shall be at the Contractor's sole liability.
2. The Contractor shall not occupy any portion of the Project Site prior to the date established in the Notice to Proceed without prior approval of the Engineer.

2204.3 Obstructions

1. General: Natural obstructions, existing facilities and improvements encountered during site preparation shall be removed, relocated, reconstructed or worked around as herein specified. Care shall be used while performing site preparation work adjacent to any facilities intended to remain in place. Except as otherwise specified, the Contractor shall be responsible for any damage to existing facilities and improvements and any repairs required shall be promptly made at the Contractor's expense. Waste materials shall be disposed of in a satisfactory manner off the work site. Restoration of utilities damaged by the Contractor shall be restored as directed by the utility company at no additional cost to the Owner. Unless otherwise provided in Basis of Payment no separate or additional payment will be made for any work in connection with removal, relocation or restoration of obstructions and existing facilities.
2. Surface Obstructions:
 - a. Sidewalks, curb and gutter, drainage structures and similar obstructions shall be tunneled under if tunneling is best suited, otherwise the obstruction shall be cut in straight lines or removed to the nearest construction joint if located within five feet of the center-line of the trench. In no case shall the joint or line of cut be less than one foot outside the edge of the trench. Surface obstructions removed to permit construction shall be reconstructed as specified and to the dimensions, lines and grades of original construction. Back-fill of tunneled sections shall be performed in accordance with Section 2207. All restoration shall be in accordance with Section 2208.
 - b. Mailboxes shall be maintained in the manner that the Postal Service requires to prevent interruption of mail delivery.
 - c. Site preparation shall include where necessary and permitted the removal of trees, shrubs, brush, crops, and other vegetation within the limits of the easement (right-of-way) or as may be provided for in licenses, permits and agreements. The following procedures for protection of existing greenery are required.

- (1) Trees: All reasonable effort shall be made to save as many trees as possible. Trees are defined as six inches in diameter and greater when measured at a point three feet above the ground surface. If trees can be saved by trimming, this shall be done in accordance with acceptable pruning practices.

All trees within easements or right-of-way provided, which are specifically to be removed or saved have been marked on the plans with the following notations.

- (a) Trees marked "S" shall be saved
- (b) Trees marked "X" shall be removed
- (c) Trees marked "R" shall be removed and replaced.

Trees to be removed shall be completely removed, including stump and large roots, unless such removal may result in damage to existing pipelines. In that event, trees shall be sawn off not more than four (4) inches above the ground and the stump shall be removed to twelve (12) inches below finish grade. Any tree replaced shall be outside the permanent sewer right-of-way and shall be like species of nursery stock. (Generally, 2 to 2 ½ inch caliper).

- (2) Small Plants and Flowers: At least two weeks prior to the start of construction, property owners shall be notified by the contractor of the proposed starting date. The purpose of this notification is so that the property owners can remove any small plants or flowers that they, the property owners, desire to save.

- d. Fences: Fences interfering with construction, and located within public rights-of-way or as may be allowed for in permits or agreements, may be removed by the Contractor only if the opening is provided with a temporary gate that will be maintained in a closed position except to permit passage of equipment and vehicles unless otherwise herein specified. Fences within temporary construction easements may be removed by the Contractor provided that temporary fencing is installed in such a manner as to serve the purpose of the fencing removed. The contractor shall locate and record all fence corners prior to removal. All fencing removed shall be restored by the Contractor to the condition existing prior to construction unless otherwise specified in the Special Provisions. The Contractor is and shall be solely liable for the straying of any animals protected or corralled or other damage caused by any fence so removed.
- e. Property Pins: The Contractor shall preserve all property corners, pins or markers. In the event any property corners, pins, or markers are removed by the Contractor, such property points shall be replaced at the Contractor's expense and shall be reset by competent surveyors properly licensed to do such work. In the event such points are section corners or Federal land corners, they shall be referenced and filed with the appropriate authority.
- f. Sodded and Landscaped Areas: Sodded and/or landscaped thoroughfares and areas on or adjacent to improved property shall be disturbed only to the extent required to permit construction. Such areas shall not be used as storage sites for

construction supplies and insofar as practicable shall be kept free from stockpiles or excavated materials.

3. Subsurface Obstruction:

- a. Where existing utilities and service lines are to be encountered, the Owner thereof shall be notified by the Contractor at least 48 hours (not including weekends and/or holidays) in advance of performing any work in the vicinity. All excavation, pipeline installation and backfilling work in the vicinity of such utilities shall be accomplished in the manner required by the respective Owner and, if requested, under their direct supervision. The Contractor shall be responsible for any and all damages to a public or private utility that may occur as the result of the construction.
- b. The Contractor shall make a reasonable effort to ascertain the existence of obstructions and shall locate obstructions by digging in advance of machine excavation where definite information is not available as to their exact location. Where such facilities are unexpectedly encountered and damaged, responsible officials and other affected parties shall be notified and arrangements made for the prompt repair and restoration of service.
- c. Private Sewer Facilities: The Contractor shall make every reasonable effort to protect private sewer facilities. They are not shown on the Plans. When these facilities are disturbed or damaged by the work, the Contractor shall make necessary repairs to the facilities for continuous service prior to the close of the work day at no cost to the Owner.

2205 EXCAVATION

2205.1 Scope

This section governs the methods and procedures required for pipeline excavations for open cut and tunneling.

2205.2 General

The terms “excavation” and “trenching” shall mean the removal and subsequent handling of all material required to perform the work.

1. All pipeline excavation work shall be accomplished under supervision of a person experienced with the materials and procedures which will provide protection to existing improvements, including utilities and the proposed pipeline.
2. The alignment, depth, and pipe sub-grades of all sewer trenches shall be determined by overhead grade lines parallel to the sewer invert.
3. When pipe is to be installed in embankment or fill, the embankment shall be constructed in accordance with City of Manhattan’s Technical Specifications and shall be built up to a plane at least 18 inches above the top of the pipe prior to the excavation of the sewer trench.
4. The Contractor shall not open more trench in advance of pipe laying than is necessary. Four hundred (400) feet will be the maximum length of open trench allowed on any line under construction. All open trenches shall be adequately protected.
5. In the event hazardous wastes as defined by the Resource Conservation and Recovery Act of 1976 (PL94-580) are encountered, work shall be halted and the Engineer shall be

notified. Work shall be resumed only after the Engineer notifies the Contractor. Regulation of removal, handling and disposal of hazardous wastes is the responsibility of Federal and State Agencies.

2205.3 Unclassified Excavation

Unclassified excavation is defined as the removal of all material encountered regardless of its nature. All material excavated will be considered as Unclassified Excavation unless the Special Provisions specify Classified Materials.

2205.4 Rock Excavation

Rock excavations is defined as the removal of all rock ledges 6 inches or more in thickness, detached rock or boulders having a volume of more than 1 ½ cubic yards and shale occurring in its natural state, head and un-weathered. A rock ledge is defined as a continuous body of rock that may include inter-bedded seams of soft materials. Such inter-bedded soft material less than 12 inches in thickness will be included in the measurement of rock excavation. Such seams 12 inches or greater in thickness will be included only in the measurement of earth excavation.

2205.5 Earth Excavation

An Earth excavation is defined as the removal of all material not defined as rock.

2205.6 De-Watering

The Contractor shall remove any water that may accumulate or be found in the trenches and other excavations made under the Contract.

The Contractor shall form all dams, flumes or other works necessary to keep the excavation clear of water while the sewers and their foundations, and other foundation works, are being constructed. All water shall be removed from such excavation in a manner that will not damage property.

2205.7 Blasting

When blasting is permitted by the Engineer and Fire Marshall, the Contractor shall use the utmost care to protect life and property. The Contractor shall comply with all laws, ordinances, and the applicable safety code requirements and regulations relative to the handling, storage and use of explosives and protection of life and property, and he shall be responsible for all damage thereto caused by his or his subcontractor's operations.

The Contractor shall provide insurance as required by the General Provisions and Covenants and Special Provisions before performing any blasting. The governing agency shall be notified at least 24 hours before blasting operations begin.

2205.8 No Blasting Areas

No blasting of any kind for rock excavations or any other purpose will be allowed if so noted on the Plans.

2205.9 Open-Cut Method (Trenching)

1. Scope: This item establishes the requirements to be followed for pipeline excavation performed by the open-cut method (trenching).
2. General: Excavations for pipelines shall be accomplished by the open-cut method (trenching) except as specified or approved by the Engineer. Trenching shall be with a minimum inconvenience and disturbance to the general public.
The Contractor shall sort and stockpile the excavated material so the proper material is available for backfill.
3. Trench Depths: All trenches shall be excavated to depths required for proper pipe embedment. Over depth excavation shall be required when the sub-grade is unstable. Over depth excavations shall be backfilled with granular pipe embedment material unless otherwise directed by the Engineer.
4. Trench Walls: Undercutting of trench walls is not permitted.
5. Trench Widths:
 - a. Minimum Widths: Trench widths and pipe clearances shall be not less than that shown in the following table.

**MINIMUM TRENCH WIDTHS
AND PIPE CLEARANCES
(INCHES)**

Nominal Pipe Diameter	Trench Width 1	Pipe Side Clearance 2	Soil/Incompressible Pipe Bottom Clearance
4	22	6	4/6
6	22	6	4/6
8	22	6	4/6
10	24	6	4/6
12	27	6	4/6
15	30	6	4/6
18	34	6	4/6
21	39	7	4/9
24	43	7	4/9
27	48	8	4/9
30	54	8	4/9

Measured below a horizontal plane six (6) inches above the top of the pipe line.
Measured from the outside face of pipe barrel to inside face of trench.

- b. Maximum Widths: The allowable maximum trench widths hereinafter specified apply only to that portion of the trench below the horizontal plane parallel to and

six (6) inches above the top of the pipe.

The allowable maximum widths may be exceeded at manholes, bore pits, tees, and in unstable earth material. Where the maximum trench width is exceeded the Contractor shall provide the appropriate strength class of pipe embedment to provide safe support strength to the pipeline.

When trench width exceeds those in the tables shown for Vitrified Clay Pipe or when the side clearance exceeds two and one-half (2 1/2) times the outside pipe diameter at either side of a flexible conduit, it shall be the Contractor's responsibility at no additional cost to the Owner to provide bedding adequate to develop the required lateral support for the pipe and/or provide a pipe of sufficient strength class to accommodate the loading conditions as approved by the Engineer.

- c. Trench Slope: The trench width above a horizontal plane six (6) inches above the top of the pipe may vary and side sloping is permissible unless otherwise specified.
 - d. Trench Shields: When trench shields are utilized by the Contractor, said shields or any part thereof shall not extend lower than six (6) inches above the top of the proposed pipeline nor shall the maximum allowable trench width be exceeded.
6. Clay Pipe Trench Width Tables: The trench width tables list trench widths that are the minimum and maximum allowed. If the maximum trench width is exceeded, the Contractor shall so inform the Engineer prior to installation of pipe embedment material and/or pipe. Unless otherwise specified, H-20 Truck Loading Tables shall be used. All delays caused by the Contractor's failure to immediately notify the Engineer when over width trenching occurs will not be grounds for an extension of the contract time limit or additional payment

MAXIMUM TRENCH WIDTH (Inches)

Pipe: Extra Strength Vitrified Clay ASTM C 700
 Embedment: Class B
 Soil: Non-Cohesive (K ' = 0.165) 120 pcf (No Live Load)

<u>Cover Depth (feet)</u>	<u>Nominal Pipe Size (inches)</u>								
	8	10	12	15	18	21	24	27	30
2.5-10	a	a	a	a	a	a	a	a	a
10-12	a	a	a	a	a	a	a	68	71
12-14	a	a	42	45	49	54	60	63	65
14-16	a	a	40	43	46	51	57	59	62
16-18	a	37	39	41	45	50	54	57	59
18-20	34	36	38	40	44	48	52	55	57
20-22	34	36	37	40	43	47	51	53	56
22-24	34	35	37	39	42	46	50	52	54
24-26	33	35	37	39	42	46	50	51	53
26-28	33	35	36	38	41	45	49	51	53
28-30	33	34	36	38	41	45	48	50	52

Cover depths designated “a” are not critical and width does not govern.
 Coves depths designated “b” result in loads exceeding safe support strength.

MAXIMUM TRENCH WIDTH (Inches)

Pipe: Extra Strength Vitrified Clay ASTM C 700
 Embedment: Class B
 Soil: Non-Cohesive (K ‘ = 0.165) 120 pcf (H-20 Truck Loading)

2.5-10	a	a	a	a	a	a	a	a	a
10-12	a	36	39	45	51	56	62	65	68
12-14	a	36	38	43	48	54	58	61	64
14-16	a	34	37	43	46	51	57	60	62
16-18	33	34	37	41	45	50	54	57	59
18-20	33	34	37	40	44	48	52	55	57
20-22	33	34	37	40	43	47	51	53	56
22-24	33	34	37	39	42	46	50	52	54
24-26	33	34	37	39	42	46	50	51	53
26-28	33	34	36	38	41	45	49	51	53
28-30	33	34	36	38	41	45	49	50	52

Cover depths designated “a” are not critical and width does not govern.
 Cover depths designated “b” result in loads exceeding safe support strength.

MAXIMUM TRENCH WIDTH (Inches)

Pipe: Extra Strength Vitrified Clay ASTM C 700
 Embedment: Class B
 Soil: Cohesive (K ‘ = 0.130) 120 pcf (No Live Load)

<u>Cover Depth (feet)</u>	<u>Nominal Pine Size (inches)</u>								
	8	10	12	15	18	21	24	27	30
2.5-10	a	a	a	a	a	a	a	a	a
10-12	a	a	a	a	4	54	60	64	67
12-14	a	a	38	42	46	50	55	59	61
14-16	a	33	37	39	43	48	53	55	57
16-18	a	33	36	38	41	46	50	52	55
18-20	31	32	35	37	40	44	48	50	53
20-22	30	31	34	36	39	43	47	49	52
22-24	30	31	33	35	38	42	45	48	b
24-26	29	31	33	34	37	41	44	47	b
26-28	29	30	32	34	37	41	44	b	b
28-30	29	30	32	34	36	40	43	b	b

Cover depths designated “a” are not critical and width does not govern.

Cove depths designated “b” result in loads exceeding safe support strength.

MAXIMUM TRENCH WIDTH (Inches)

Pipe: Extra Strength Vitrified Clay ASTM C 700
 Embedment: Class B
 Soil: Cohesive (K ‘ = 0.130) 120 pcf (H-20Truck Loading)

<u>Cover Depth (feet)</u>	<u>Nominal Pine Size (inches)</u>								
	8	10	12	15	18	21	24	27	30
2.5-10	a	a	a	a	a	a	a	a	a
10-12	a	a	a	a	4	54	60	64	71
12-14	a	34	38	42	46	50	54	57	59
14-16	a	33	37	39	43	48	53	55	57
16-18	32	33	36	38	41	46	50	52	55
18-20	31	32	35	37	40	44	48	50	53
20-22	30	31	34	36	39	43	47	49	b
22-24	30	31	33	35	38	42	45	48	b
24-26	29	31	33	34	37	41	44	47	b
26-28	29	30	32	34	37	41	44	b	b
28-30	29	30	32	34	36	40	43	b	b

Cover depths designated “a” are not critical and width not govern.

Cove depths designated “b” result in loads exceeding safe support strength.

9. Maximum Trench Widths for Reinforced Concrete and Ductile Iron Pipe: When reinforced concrete and ductile iron pipe is utilized, the strength class and the maximum allowable trench width as established by the Engineer will be shown on the Plans.
10. Option to Trenching: Contractor may perform excavation by tunneling methods as set forth herein at no additional cost to the Owner provided prior written approval for each such location is obtained from the Engineer.

2205.10 Tunneling, Boring and Jacking:

1. Scope: This item establishes the requirements to be followed for pipeline excavation performed by tunneling, boring and jacking methods.
2. General: Tunneling includes all underground horizontal excavations necessary to install the pipeline. The Contractor shall submit to the Engineer, prior to actual work, a written description of his proposed tunneling operation. It shall include the types and locations of shafts, methods to provide safe support strength for the pipeline when the shafts or bore pits exceed maximum allowable trench widths and other features that would affect the pipeline.
 Tunneling shall be done with a minimum inconvenience and disturbance to the general public and abutting property owners.
3. Tunnel Cross Section: The tunnel shall be circular in cross section and of the size specified. The Engineer may submit alternate size and shape for consideration.
4. Construction

- a. General: All tunnel excavation shall provide an excavation conforming to the outside diameter of the casing and/or carrier conduit. The excavation shall be to an alignment and grade which will allow the carrier conduit to be installed to proper line and grade as shown on the Plans and as established in Section 2206.2.9-Installation.
- b. Excavation: Conduct excavation in a manner to prevent disturbing overlying and adjacent material. Perform dewatering and chemical soil stabilization or grouting if necessary, due to existing field conditions.

2206 INSTALLATION

2206.1 Scope

This section governs construction methods and procedures for the installation of gravity and pressure pipelines and appurtenances.

2206.2 General

All pipeline installations shall conform to the following requirements:

1. Governmental Requirements: Sanitary sewer line installation shall comply with applicable State and County Health and Environment Departments requirements. See Special Provisions for governing requirements.
2. Trench Dewatering: Contractor shall maintain a dry and stable trench, obtain necessary permits, and provide for the proper method of discharging such water from the work site at all times until pipeline installation is completed to the extent that hydrostatic pressure flotation or other adverse effects will not result in damage to the pipeline. Proper dewatering techniques are the Contractor's responsibility. All work performed by the Contractor which is adversely affected by his failure to adequately dewater trenches will be subject to rejection by the Engineer. The Contractor shall repair and/or replace the affected pipeline without additional compensation.
3. Drainage Course Crossing Encasement: Any pipeline crossing a well-defined drainage course having less than three (3) feet of cover over the pipe shall be encased in concrete. The length of encasement shall be as shown on the plans or if not shown as specified by the Engineer.
4. Trench Shoring and Bracing: All shoring, bracing or blocking shall be furnished and installed as necessary to preserve and maintain exposed excavation faces, to protect existing improvements, to protect the proposed pipeline and to provide for safety. Shoring or other methods for support of trench walls is the responsibility of the Contractor and shall be accomplished by methods that will not adversely affect pipeline alignment, grade and/or structural integrity. All bracing, sheeting and/or shoring installed below a horizontal plane six (6) inches above top of proposed pipe shall not be disturbed or removed after pipe and/or pipe embedment has been installed unless otherwise specified. The bottom skids of a trench shield shall not extend lower than six (6) inches above top of proposed pipe.
5. Pipe Embedment: All pipe embedment shall conform to Class B unless otherwise specified. Installation shall be in strict conformance with instructions for the appropriate Class being utilized.

All Class A concrete embedment for rigid conduits shall begin and end at a pipe joint.

6. Bedding Installation:

- a. The trench sub-grade shall be prepared to provide a uniform and continuous pipe support between pipe bells and joints.
- b. Place and densify embedment material by shovel slicing or vibrating and prepare embedment material so that the pipe will be true to line and grade after installation.
- c. After each pipe has been brought to grade, aligned, and placed in final position, deposit and densify by shovel slicing sufficient bedding material under the pipe haunches and on each side of the pipe to hold the pipe in proper position during subsequent pipe jointing, bedding, and backfilling operations. Place bedding material uniformly and simultaneously on each side of the pipe to prevent lateral displacement.
- d. Place pipe that is to be bedded in Class A (concrete) embedment in proper position on temporary supports consisting of wood blocks or bricks with wood wedges. When necessary, anchor or weight the pipe to prevent flotation when the concrete is placed.
- e. Place concrete for Class A (concrete) embedment or encasement uniformly on each side of the pipe and deposit at approximately its final position. Do not move concrete more than five (5) feet from its point of placement
- f. If unstable sub-grade conditions are encountered and it is determined by the Engineer that the bedding specified will not provide suitable support for the pipe, additional excavation to the limits determined by the Engineer will be required. This additional excavation shall be backfilled with material approved by the Engineer.

7. Pipe Embedment Designations and Descriptions:

- a. Class A. Embedment - Concrete Cradle, Ash or Encasement:
 - (1) All Class A embedments require A 480-1-4 concrete except as otherwise specified. After initial set of concrete, one (1) foot of backfill material should be placed over the conduit or concrete. The backfill above this point shall not be placed nor sheeting removed until at least forty-eight (48) hours after placement of the concrete. Time requirements may be adjusted by the Engineer to obtain structural integrity.
 - (2) Class A embedments for all pipe shall be installed with reinforcing steel of not less than $p = 0.4\%$, where p is the ratio of the area of steel to the area of concrete, or as otherwise specified. Reinforcing steel shall be uniformly spaced and have a minimum lap of sixteen (16) bar diameters.
- b. Class B Embedment The pipe shall be bedded in granular material, with a minimum thickness below the pipe as specified in Section 2205.9.5.
 - (1) First Class: The granular material shall be placed to the horizontal center line of the pipe. The backfill from the horizontal center line to a level not less than twelve (12) inches above the top of pipe shall be carefully placed select earth backfill compacted to eighty-five percent (85%) of maximum density at an optimum moisture + or -2% as defined in AASHTO T99 or ASTM D 698. The select material shall be free from debris, organic matter, frozen material and rocks larger than one (1) inch. Class IV and Class V embedment materials, as defined in ASTM D 2321, shall not be used for bedding, haunching, or initial backfill of flexible pipe.

- (2) First Class Modified: The backfill shall be the same as for First Class except all of the material used to a level not less than six (6) inches above the top of the pipe bell or coupling shall be bedding aggregate.
- c. Class C Embedment: The pipe shall be bedded in granular material with a minimum thickness beneath the pipe as specified in Section 2205.9.5.

It shall be sliced under the haunches of the pipe to a height one-sixth (1/6) of the outside diameter of the pipe. Backfill above the bedding to a point twelve (12) inches above the top of pipe, shall be carefully placed select earth backfill compacted to eighty-five percent (85%) of maximum density as defined in AASHTO T99 or ASTM D 698.

- 8. Tees, Wyes and Building Service Lines: Tees (Ts), wyes (Ys), and building service lines shall be installed as shown on the Plans or specified herein.
 - a. Tees, wyes and saddles shall be installed at forty-five (45) degrees with pipe springline for pipe sizes 8 through 16 inch diameter. Tees, wyes and saddles shall not be installed in pipe sizes greater than or equal to eighteen (18) inch diameter.
 - b. Building service lines shall be installed with a straight alignment and at a uniform grade not less than two (2) percent unless otherwise specified and shall be embedded with Class B embedment. When a building service line grade exceeds twenty (20) percent, pipeline anchors shall be installed as required under Section 22062.1.1, with the first anchor not more than twelve (12) nor less than seven (7) feet upstream of the tee or wye.
 - c. The Contractor shall maintain an accurate record for submittal to the Engineer of location, size and direction of each tee, wye, saddle and/or location, size and length of each building service line. Locations shall use the pipeline stationing as shown on the Plans or the distance from the first downstream manhole. In the event such records are not kept or are lost before final acceptance of the work, the required information shall be re-determined by the Contractor at no additional cost to the Owner.
 - d. Service lines shall be terminated and capped one foot on the public side of right-of-way or easement lines. A wye with a forty-five (45) degree bend attached shall be installed two (2) feet inside, property side, of the property line on each lateral. A cleanout and cap installed vertically from the forty-five (45) degree bend shall protrude four (4) feet above existing grade of the ground. The cap shall be solvent welded to the pipe push on connections will not be permitted.
- 9. Gravity Sewers: All gravity sewers shall be installed to the alignment, elevation, slope, and with pipe embedment as specified and/or shown on the Plans. Maintain the following tolerances from true alignment and grade between adjacent manholes:

Alignment	6 inches
Grade	+ 1 inch

Joint deflection shall not exceed the maximum allowable deflection per joint according to ASTM C 425, ASTM C 594 and AWWA C 600. Only one correction for alignment and/or grade shall be made between adjacent manholes.

- 10. Pressure Sewers (Force Main): All pressure sewers shall be installed with required pipe

embedment to depths shown on the Plans (not less than 42 inches) and to a continuous slope when not shown. Approved air relief valves shall be installed at all locations shown on the Plans or where required by the Engineer.

The Contractor shall block and anchor the pipeline to accommodate thrust and testing forces at pipe deflections, bends, tees, and plugs in accordance with the Contract Documents. All damage caused by the Contractor's failure to provide adequate thrust supports shall be corrected by the Contractor at no additional cost to the Owner.

11. Anchors: Pipelines shall be anchored in accordance with the table below:

PIPELINE ANCHORS

<u>Percent of Grade</u>	<u>Center to Center Max. Spacing (Feet)</u>
15-20	100
20-35	36
35-50	24
50	16

The anchor shall be of concrete or other material approved by the Engineer. Concrete anchors shall have a minimum thickness of twelve (12) inches. The anchor shall extend not less than one (1) foot into undisturbed earth on the sides and bottom and one (1) foot above top of pipe. In incompressible material, the above dimensions may be six (6) inches each side and bottom. The anchor shall support a joint fitting.

12. Pipe Laying: All pipe shall be installed in accordance with the pipe manufacturer's recommendations, except as modified herein.
- a. Pipe laying shall not proceed if the trench width as measured at the top of pipe exceeds the maximum allowable trench width, If this occurs, the Contractor shall submit to the Engineer for approval a better bedding for the pipe or pipe of sufficient strength to provide safe supporting strength.
 - b. All pipe and fittings shall be stored and handled with care to prevent damage thereto. Do not use hooks to transport or handle pipe or fittings. Do not drop pipe or fittings.
 - c. Rejected pipe and fittings shall be marked and removed from the Project Site at no cost to the Owner. All pipe and fittings shall be examined for soundness and specification compliance prior to placement in the trench, and rejected pipe or fittings shall not be incorporated into the pipeline. Check the class or pipe strength to be sure proper pipe is installed.
 - d. Clean joint contact surfaces prior to jointing. Use lubricants, primers, or adhesives as recommended by the pipe or joint manufacturer.
 - e. Pipe laying normally shall begin at the lowest point.
 - f. Unless otherwise required, lay all pipe straight between manholes. Excavate bell holes for each pipe joint. When jointed, the pipe shall form a true and smooth pipeline.
 - g. Pipe connecting to a structure shall be supported with Class A embedment, cradle or encasement to the first joint outside the structure excavation. If flexible wall connections are used, Class B embedment may be used in lieu of concrete embedment provided the height of backfill does not exceed the covers depths in Section 2205.9.6., which would result in loads exceeding the pipe's safe

- supporting strength.
- h. All pipelines shall be plugged at the end of each day's progress. Plugs or other positive methods of sealing shall be utilized at all times to protect any existing system from entrance at stormwater or other foreign matter.
 - i. When a sanitary sewer line crosses an existing pipeline, other than waterlines, and the clearance is less than two (2) feet, special embedment may be required. (Please reference City of Manhattan's Sanitary Sewers and Appurtenances Technical Specifications, Section 5505)
13. Connection at Pipes of Dissimilar Materials: The connection of pipes of different materials shall be made using approved transition coupling and shall provide a permanent and watertight connection that will withstand the hydrostatic test pressure.

2206.3 Detailed Installation Requirements

All pipes shall be installed in accordance with the following standards:

1. ASTM D-2321 - ABS Solid Wall, ABS Composite Wall,
2. ASTM D-2321 - PVC Solid Wall, PVC Composite Wall.
3. ANSI/AWWA C 600 - Ductile Iron Pipe.
4. ASTM C 12 – Vitrified Clay Pipe.
5. Reinforced Concrete Pipe - Installed in accordance with American Concrete Pipe Association's "Installation Manual."

2206.4 Casing and Carrier Conduits

Casing and carrier conduits shall be installed at required locations by methods acceptable to the Engineer. Installation of the carrier conduit shall be completed prior to installation of the adjacent portions of the pipeline to allow for adjustments.

1. Casing Types:

Conform with one of the following design concepts (other methods may be submitted to the Engineer for approval).

- a. Method A: The steel casing conduit is considered a temporary construction means for the installation of the carrier conduit therefore, cathodic and corrosion protection is not required provided that the carrier and its joints are structurally designed to withstand all possible loadings (live, earth and superimposed) which would otherwise be supported by the casing conduit, and to withstand all pressures necessary to install the required grout. All exterior voids around the casing conduits shall be filled with casing conduit grout (2203.6). Interior void between the carrier and casing conduits shall be filled with sand conforming to Section 2210.3.6. Sand shall be applied under pressure to fill all of the voids without adversely affecting the carrier conduit, joints, alignment and grade.
- b. Method B: The steel casing conduit is considered a permanent installation to protect the carrier conduit and to support all loads, therefore, cathodic and corrosion protection and watertight removable end seals are required for the casing conduit. Care shall be exercised to prevent the carrier conduit from floating and receiving any load transfer from the casing conduit unless it is designed for such loading. The void between casing and carrier conduits shall be treated as shown on the drawings. Cathodic and corrosion protection for method B shall be

provided by two magnesium anodes, one at each end of the casing pipe, with a lead wire connected to the encasement pipe by thermite welding..

- c. Reinforced Concrete Casing Pipe: Reinforced concrete casing pipe is a rigid conduit and shall be installed in accordance with recommended procedures in the latest printing of the Concrete Pipe Design Manual prepared by American Concrete Pipe Association.
2. Casing Installation: Installation of casing shall be supervised by a foreman experienced in such work. Casing shall be installed by a combination of augering and jacking. Alignment and gradient shall be such that the carrier conduit can be installed to line and grade shown on the drawings.

Welding shall be performed by a person experienced with the type of welding necessary. All welds shall conform to AWWA C 206.

3. Liner Plate Installation: Liner plates shall be assembled immediately following the excavation. Advance liner plates or casing continuously with excavation. All voids between liner and surrounding earth shall be filled with casing conduit grout forced in under pressure. As the pumping through any hole is completed, it shall be plugged to prevent the back-flow of grout. After lining installation is complete, it shall be cleaned of all debris and all leaks sealed.
4. Carrier Conduit Installation: After completion of the installation of the casing, the carrier conduit shall be carefully pushed or pulled through the casing in a manner that will maintain proper jointing of the pipe joints and provide required gradient and alignment. Pipe skids shall be provided as indicated on the Plans. The skids shall be securely strapped to the pipe with steel strapping material at least three-quarters (3/4) inch wide.
5. Sand Fill: The annular space between lining and sewer pipe shall be filled with sand from end seal to end seal unless otherwise specified. The fill shall be placed inside the casing in a manner that will not disturb the alignment and/or grade of the sewer pipe. Sand used in casing conduits shall be as specified in Section 22103.6. Sand shall be blown into the casing so that all space is filled.
6. End Seals: Construct end seals after sewer pipe has been installed and approved. Brick shall be in accordance with ASTM C 32, Grade SS or SM and mortar in accordance with ASTM C 270.
7. Initial Testing: Air pressure and/or ex-filtration test as required shall be successfully performed on the carrier conduit prior to filling the void between casing and carrier conduits with sand or the sealing of the ends of the casing conduit.
8. Carrier Conduit Installed Without Casing: Carrier conduits installed without casing shall be assembled at the entrance to the auger hole and carefully pushed or jacked through the opening using a method designed to prevent disturbing the assembled joints. Auger holes shall be sized to accommodate the carrier conduit with a minimum of annular space around the conduit. When finally in place, carrier conduit shall be true to the line and grade required on the Plans.

2207 BACKFILL

2207.1 Scope

This section governs the furnishing of all labor, equipment, tools and materials to properly backfill trenches and structures.

2207.2 General

1. All trash and debris shall be removed from the pipeline excavation prior to backfilling.
2. Unless otherwise specified, all sewer trenches and excavation around structures shall be backfilled to the original surface of the ground with suitable earth or earth and rock when an earth and rock mixture is used, it shall be placed and thoroughly consolidated with sufficient earth to completely fill all voids between the rocks.
3. The backfill material shall be placed in lifts not to exceed 1 foot in depth. Each lift shall be compacted to the required density prior to the next lift being placed.
4. Commercial sand backfill shall not be used.
5. In areas marked "garden" or "flower garden," the original topsoil shall be replaced to original elevation and depth. (Minimum depth shall be twelve (12) inches).
6. Backfill material shall be carefully placed to avoid damage to or displacement of the pipe and other exposed utilities or structures.
7. Backfill shall not be placed when material contains frost, is frozen, or a blanket of snow prevents proper compaction. Contractor shall remove waste material, trees, organic material, rubbish, or other deleterious substances.
8. No rock whose greatest dimension exceeds six inches shall be placed within two (2) feet of the top of the pipe in any excavation as backfill. No rock greater than one foot in its largest axis shall be placed in any trench excavation as backfill.

2207.3 Backfilling in Street or Alley Right-of-way and Under Pavement

1. Under areas to be paved, the backfill materials from the top of the pipe embedment (as defined in Section 2206.2.7.b.) to a point 6 inches below top of sub-grade shall be compacted in such a manner so as to obtain 95% of maximum density at optimum moisture plus or minus 2% as determined by ASTM D 698. Outside of areas to be paved the backfill material shall be compacted so as to obtain 90% of maximum density at optimum moisture plus or minus 2% as determined by ASTM D 698. Required compaction and percentage of maximum density must be obtained before pavement is placed.

2207.4 Backfilling in Areas Other Than Street or Alley Right-of-Way

1. From the top of the pipe embedment (as defined in Section 2206.2.7.b.) to a point at grade the backfill material shall be compacted to no less than 90% of maximum density at optimum moisture plus or minus 2% as determined by ASTM 698.

2207.5 Backfill around Structures

1. No backfill shall be placed over or around any structure until the concrete or mortar has attained a minimum strength of 2000 psi and can sufficiently support the loads imposed by the backfill without damage.
2. The Contractor shall use utmost care to avoid any wedging action between the side of the excavation and the structure that would cause any movement of the structure. Any damage caused by premature or unbalanced backfill or by the use of equipment on or near a structure will be the responsibility of the Contractor.
3. No rock larger than four (4) inches maximum dimension shall be placed within one (1) foot of the exterior surface of any structure.

2208 RESTORATION

2208.1 Scope

This section covers all work required in surface restoration on private and public properties that are disturbed by construction.

2208.2 General

The Contractor shall restore the project site to conditions equal to or better than those existing prior to entry unless otherwise specified.

1. Maintain adequate safety signs, barricades and lights until final restoration of work area is completed.
2. Public property shall be restored to the requirements of the public body having jurisdiction.

2208.3 Clean-Up

The Contractor, upon completion of installation and backfill operations, shall prepare the area for final grading including but not limited to the following items:

1. Clean-up shall follow the backfilling operations as closely as possible.
2. Excess material shall be removed from the site including material that has washed into the stream beds, storm water facilities, streets, etc.
3. Tools, equipment and construction material shall be removed except for in designated storage areas along the pipeline route.
4. Restore surface and sub-surface drainage and provide temporary wash checks where necessary.

2208.4 Finished Grading

The Contractor shall finish grade the area to lines and grades shown on the Plans or if not shown, to those that existed prior to the area being disturbed. Special attention shall be directed to assure surface drainage. The area shall be smoothed by raking or dragging.

2208.5 Seeding

The requirements set forth under Section 2401 - Seeding shall be used as if fully written herein.

2208.6 Sodding

The requirements set forth under Section 2402 - Sodding shall be used as if fully written herein.

2208.7 Pavement Replacement

1. Scope: This section covers the furnishing of all labor, equipment, tools and materials in the performance of all work for the replacement of pavement including sidewalks, driveways and curbing as shown on the Plans and in the Special Provisions.

2. Definition: Pavement replacement as used herein shall mean reconstruction of the entire structural section of all pavements removed in excavated areas, including sidewalks, driveways and curbing and all damaged pavement surfaces outside of excavation limits.
3. General:
 - a. Replacement of pavement shall proceed in accordance with the traffic control plans and/or approved construction schedule.
 - b. Prior to pavement replacement, all edges that were previously cut but have been subsequently damaged shall be re-cut and all adjacent undermined and heaved pavement shall be removed.
 - c. Removed pavement shall be replaced in conformance with the requirements of applicable portions of Section 2200 - Paving or Section 2300 - Incidental Construction.
4. Non-Standard Pavement: Pavement sections not conforming to Section 2200 of these Specifications shall be replaced in accordance with requirements of the jurisdictional agency.

2208.8 Fences

All fencing damaged and/or removed existing prior to construction shall be restored to a condition not less than that which existed prior to construction.

2208.9 Walls

Retaining and architectural walls, if disturbed or damaged, shall be restored architecturally and structurally to conditions not less than that which existed prior to construction.

2208.10 Trees, Shrubs and Bushes

Any tree, shrub or bush replaced shall be planted outside the permanent sanitary sewer right-of-way and shall be of the same species as the removed tree, shrub or bush. Any tree, shrub or bush species that is prohibited by local restrictions shall be substituted with a related species. Replacement planting shall conform to the guidelines ANSI-Z60.1-1980 "American Standard for Nursery Stock" specified by the American Association of Nurserymen. The contractor shall notify the property owners at least two weeks prior to the start of construction so property owners can remove small plants and flowers.

2209 TESTING

2209.1 Scope

This section governs the furnishing of all labor, equipment, tools and materials, and the performance of any or all acceptance tests.

2209.2 General

The Contractor shall furnish all labor, equipment, materials and reports for the required acceptance tests. All pipelines, including building service lines, shall undergo and pass all required tests to determine soundness and workmanship. Pipelines that do not conform to the

project requirements shall be repaired and/or replaced and shall be retested until the pipeline meets the project requirements. Test results shall be recorded by the Contractor and a copy shall be submitted to the Engineer. No testing shall be performed before backfill and compaction operation has been completed.

2209.3 Alignment and Grade Alignment, grade and visible defects shall be checked as follows:

1. Visual Internal Inspection
 - a. Contractor shall clean pipe of excess mortar, joint sealant and other dirt and debris prior to inspection.
 - b. Sewer will be inspected by flashing a light between manholes and/or by physical passage to determine the presence of any misaligned, displaced, or broken pipe and other defects.
2. Television Inspection: Sewer lines installed under this project are subject to inspection by dosed circuit television at the Owner's expense.

2209.4 Infiltration – Exfiltration

Hydrostatic or air pressure tests shall be conducted on sewers before acceptance by the Owner. For sewers with a diameter less than twenty-four (24) inches, the infiltration - exfiltration shall not exceed two hundred (200) gallons per day per inch of nominal diameter per mile of sewer line for any section of the system. For sewers with a diameter twenty-four (24) inches or greater, infiltration - exfiltration shall not exceed six thousand (6,000) gallons per day per mile of pipe.

1. Infiltration: Where sewers are laid within the ground water table, infiltration testing shall be conducted. Where evidence of infiltration is discovered by the Engineer, the Contractor shall install weirs or other suitable flow rate measuring devices adequate to determine to the satisfaction of the Engineer that the specified infiltration limit is not exceeded for that reach of gravity sewer. Where the specified infiltration limit is exceeded, the Contractor shall repair or replace the defective reach of pipeline at no additional cost to the Owner. Following repair of the pipeline, the Contractor shall re-measure infiltration flow rates and make additional repairs until an acceptable infiltration flow rate is achieved.
2. Exfiltration: Exfiltration tests shall be performed by the Contractor using one or a combination of methods as set forth below. Each section of gravity pipeline between manholes and/or structures after backfill shall be tested after backfill has been completed.
 - a. Hydrostatic Tests for Gravity Systems
 - (1) Test section shall be filled not less than twelve (12) hours prior to testing. Refill test section prior to performing test
 - (2) Perform at depths of water as measured above center line of pipe of not less than 2 feet nor more than 10 feet (consideration shall be given for water table above said center line). Maintain test as necessary to locate all leaks but not less than two hours.
 - b. Hydrostatic Tests for Pressure Systems:
 - (1) Conformance Procedure: Perform hydrostatic pressure and leakage tests. Conform to AWWA C 600 procedures as modified herein. Tests shall apply to all pressure sewers.
 - (2) Sectionalizing: Test in segments between sectionalizing valves, between a sectionalizing valve and a test plug, or between test plugs. Contractor shall furnish and install test plugs at no additional cost to the Owner, including

all anchors, braces, and other devices to withstand hydrostatic pressure on plugs. Contractor shall be responsible for any damage to public or private property caused by failure of plugs. Limit fill rate of line to available venting capacity.

- (3) Pressure Test: Conduct at 1.5 times maximum operating pressure determined by the following formula:

$$P_{pt} = (1.5) (.433) (OP-GE), \text{ in which}$$

P_{pt} = test pressure in psi at gauge elevation

OP = operating pressure in feet as indicated for highest elevation of the hydraulic gradient on each section of the line.

GE = elevation leakage.

- (4) Leakage Test: An allowable leakage test shall be conducted after the pressure test has been satisfactorily completed. The Contractor shall maintain on the new main for at least two (2) hours a minimum pressure of not less than that determined by the following formula:

$$P_{lt} = 0.433 (OP-GE), \text{ in which}$$

P_{lt} = test pressure in psi at gauge elevation

OP and GE - as defined in Section 2209A.2.b. (3)

Leakage shall be defined as the quantity of water that must be supplied into the newly laid pipe to maintain the specified leakage test pressure after the air has been expelled and the pipe has been filled with water. No main or section thereof will be accepted if and while it has a leakage rate in excess of that determined by the following formula:

$$L = 0.00007 N D P, \text{ in which}$$

L = allowable leakage in gallons per hour

N = number of joints in the length of main tested

D = nominal diameter of the pipe in inches

P = average test pressure during the leakage test in psig

Should the actual leakage exceed the allowable leakage, the test pressure shall be maintained so that the leakage may show up on the surface of the ground. All leaks shall be repaired and the leakage test repeated as necessary until the main passes the leakage test.

c. Air Testing of Gravity Systems:

- (1) Contractor may perform air tests for all pipe (except concrete) for all sizes.

- (2) Contractors shall furnish all facilities required including necessary piping connection, test pumping equipment, pressure gauges, bulkheads, regulator to avoid over pressurization, and all miscellaneous items required.
- (3) The pipe plug for introducing air to the sewer line shall be equipped with two taps. One tap will be used to introduce air into the line being tested through suitable valves and fittings, so that the input air may be regulated. The second tap will be fitted with valves and fittings to accept a pressure test gauge indicating internal pressure in the sewer pipe. Additional valve and fitting will be incorporated on the tap used to check internal pressure so that a second test gauge may be attached to the internal pressure tap. The pressure test gauge will also be used to indicate loss of air pressure due to leaks in the sewer line.
- (4) The pressure test gauge shall meet the following minimums:
 - Size (diameter) 4-1/2 inches
 - Pressure Range 0-15 psi
 - Figure Intervals 1 psi increments
 - Minor Subdivisions 0.05 psi
 - Pressure Tube Bourdon Tube or diaphragm.
 - Accuracy +/-0.25% of maximum scale reading
 - Dial White coated aluminum with black lettering, 270 degrees arc and mirror edge.
 - Pipe Connection Low male 1/2 inch N.P.T.

Calibration data will be supplied with all pressure test gauges. Certification of pressure test gauge will be required from the gauge manufacturer. This certification and calibration data will be available to the Engineer whenever air tests are performed.

- (5) Plug ends of line and cap or plug all connections to withstand internal pressure. One of the plugs provided must have two taps for connecting equipment. After connecting air control equipment to the air hose, monitor air pressure so that internal pressure does not exceed 5.0 psig. After reaching 4.0 psig, throttle the air supply to maintain between 4.0 and 3.5 psig for at least two (2) minutes in order to allow equilibrium between air temperature and pipe walls. During this time, check all plugs to detect any leakage. If plugs are found to leak, bleed off air, tighten plugs, and again begin supplying air. After temperature has stabilized, the pressure is allowed to decrease to 3.5 psig. At 3.5 psig, begin timing to determine the time required for pressure to drop to 2.5 psig. If the time in seconds for the air pressure to decrease from 3.5 psig to 2.5 psig is greater than that shown in the table below, the pipe shall be presumed free of defects.

<u>Pipe Size</u>	<u>Required Time per 100 LF</u>	<u>Maximum Required time</u>
4"	20 sec	60 sec
6"	45 sec	2 minutes 15 sec
8"	1 minute 10 sec	3 minutes 47 sec.
10"	1 minute 50 sec	4 minute 43 sec.

12"	2 minutes 38 sec	5 minutes 40 sec.
15"	4 minutes 8 sec.	7 minutes 5 sec.
18"	5 minutes 56 sec.	8 minutes 30 sec.
21"	8 minutes 5 sec.	9 minutes 55 sec.
24"	10 minutes 34 sec.	11 minutes 20 sec.
27"	12 minutes 45 sec.	12 minutes 45 sec.
30"	14 minutes 11 sec.	14 minutes 11 sec.

If air test fails to meet above requirements, repeat test as necessary after all leaks and defects have been repaired and backfilled. Prior to acceptance, all constructed sewer lines shall satisfactorily pass the low pressure air test.

- d. In areas where ground water is known to exist, install a one-half inch diameter capped pipe nipple approximately 10" long through manhole wall on top of one of the sewer lines entering the manhole. This shall be done at the time the sewer is installed. Immediately prior to the performance of the line acceptance test, ground water level shall be determined by removing pipe cap, blowing air through pipe nipple into the ground so as to clear it, and then connecting a clear plastic tube to pipe nipple. The hose shall be held vertically and a measurement of height in feet of water shall be taken after the water stops rising in this plastic tube. The height in feet shall be divided by 2.3 to establish the pounds of pressure that will be added to all readings.

2209.5 Deflection Test

- 1. General: Semi-Rigid & Flexible pipelines shall be tested for deflection by pulling a mandrel through the entire length thereof.
 - a. The mandrel (go/no-go) device shall be cylindrical in shape and constructed with nine (9) evenly spaced arms or prongs. Mandrels with fewer arms will be rejected as not sufficiently accurate. The dimension of the mandrel shall be as listed in the accompanying table. The "D" mandrel' dimension shall carry a tolerance of + or - 0.01 inch. Allowances for pipe wall thickness tolerances or ovality (from heat, shipping, poor production. etc.) shall not be deducted from the "D" dimension but shall be counted in as a part of the five (5) percent or lesser deflection allowance. Contact length (L) shall be measured between points of contact on the mandrel arm. The length shall not be less than as shown in the accompanying table.
 - b. The Engineer shall be responsible for approving the mandrel. Proving rings shall be used to verify this.
 - c. The mandrel shall be hand-pulled by the Contractor through all flexible sewer lines. Any sections of sewer not passing the mandrel test shall be uncovered and the Contractor, at no additional cost to the Owner, shall re-round or replace the sewer to the satisfaction of the Engineer. These repaired sections shall be retested.
 - d. The testing shall be conducted after final trench backfill.

D and L Dimensions For
9 Arm Mandrel

<u>Nominal Diameter</u>	L	D		
		<u>SDR35</u>	<u>SDR26</u>	<u>SDR21</u>
8"	8"	7.52"	7.37"	7.41"
10"	10"	9.40"	9.21"	9.24"
12"	12"	11.19"	10.96"	10.96"
15"	15"	13.7"	13.42"	NA
18"	18"	16.76"	NA	N/A
21"	21"	19.74"	NA	NA
24"	24"	22.21"	N/A	NA
27"	27"	25.03"	NA	N/A

2209.6 Television Testing

1. General: The City of Manhattan Sewer Maintenance Crew will TV all completed mains when they have pass the deflection testing and exfiltration testing. Any defects indicated by the visual or television inspection shall be corrected by the Contractor without additional compensation prior to final acceptance of the project by the City. The lines shall be retested and re-inspected after repairs have been made by the Contractor.

2209.7 Soil Density Tests

1. General: Compaction tests shall be performed as specified in the Special Provisions. If so specified, all compaction tests shall be performed by a testing laboratory approved by the Engineer.
 - a. Testing Methods: Testing shall be in accordance with the following:
 - (1) Maximum Density: Maximum density shall be determined by the standard proctor analysis method as defined by AASHTO T99 or ASTM D 698.
 - (2) Density of Soil in Place: The density of soil in place shall be determined by the analysis methods as defined by ASTM D 1556, or ASTM D 2167, or ASTM D 2922.
 - b. Testing Requirements:
 - (1) Trenches crossing perpendicular to areas to be paved: One test per 12 inches (12") lift. If any two consecutive tests pass (not counting retests), frequency can be decreased to one test per two lifts. A failed test will require additional compaction efforts, retesting and passage of three additional consecutive test within the immediate area or the removal (if more than one lift) and re-compaction of all material down to the level of the last test that passed. Once a test has failed, and the appropriate action taken to rectify the problem, the frequency of testing shall revert to one test per lift until two consecutive tests pass. Roadway widths (back-to-back) greater than thirty-one feet may require additional testing as specified in the contract documents.

- (2) Other trenches under areas to be paved: Two tests per 12 inches (12”) lift per 100 feet of trench. If any four consecutive tests pass (not counting re-tests), frequency can be decreased to two tests per two lifts within 100 feet of trench. A failed test will require additional compaction efforts, re-testing and passage of three additional consecutive tests within the immediate area or the removal (if more than one lift) and re-compaction of all material down to the level of the last test that passed. Once a test has failed, the frequency of testing shall revert to two per lift per 100 feet of trench until four consecutive tests pass.
 - (3) Trenches outside of areas to be paved: One test per two 12 inches (12”) lift per 100 feet of trench. If the first test passes, frequency can be decreased to one test per four lifts within 100 feet of trench. A failed test will require additional compaction efforts, re-testing and passage of three additional consecutive tests within the immediate area or the removal (if more than one lift) and re-compaction of all material down to the level of the last test that passed.
- c. Additional Tests: The Engineer may require additional density tests with payment as follows:
 - (1) Test results conforming to specified densities will be paid for by the Owner.
 - (2) Test results not conforming to specified densities shall be paid for by the Contractor at no additional cost to the Owner.
 - d. Method of Payment: The Contractor shall pay all costs for density tests

2210 MANHOLES AND SPECIAL STRUCTURES

2210.1 Scope

This section governs the furnishing of all labor, equipment, tools, and materials, and the performance of all work incidental to the construction of manholes, drop manholes and special sewer structures complete with covers, steps, fittings and appurtenances as required in accordance with the Plans and Special Provisions.

2210.2 General

As used herein special structures refers to manholes on large sewers, special junction structures, metering stations and similar structures constructed on the pipeline.

Manholes and special structures may be constructed of precast concrete sections, cast-in-place concrete.

2210.3 Manhole Materials

1. Non-Shrink Grout: Non-shrink grout shall be in the plastic state and show no expansion after set as tested in accordance with ASTM C 827 and shall develop compressive strength not less than three thousand (3,000) pounds per square inch with a trowelable mix within twenty-four (24) hours per ASTM C 109. The placement time shall be not less than forty-five (45) minutes based on initial set per ASTM C 191.

2. Waterproofing: Waterproofing shall be a coal-tar coating and conform to ASTM D 450. Exterior surfaces shall be coated with Tnemec “46-450 Heavy Tnemecol” or approved equal. Where specified, interior surfaces (which are exposed to raw sewage and sulfide gases) shall be coated with Tnemec “46-449 Heavy Duty Black” or approved equal. The minimum dry thickness for all waterproofing shall be 14.0 mils.
3. Precast Concrete: Precast concrete manholes shall conform to ASTM C 478 with the following modifications.
 - a. Wall thickness not less than one-twelfth (1/12) of inside diameter or four (4) inches, whichever is greater, shall be used when the manhole depth is less than sixteen (16) feet; one-twelfth (1/12) of inside diameter plus one (1) inch or five (5) inches, whichever is greater, shall be used when manhole depth is sixteen (16) feet or greater.
 - b. Cement, Fine Aggregate, Coarse Aggregate and Water used in the manufacture of precast manholes shall be as specified in Section 2210.3.6
 - c. Developed bases shall be used where practical. The diameter of the base pad shall be eight (8) inches greater than outside diameter of the manhole.
 - d. Pipe openings shall be circular or horseshoe shaped with surfaces grooved or textured to improve mortar bond. Flexible gaskets shall be used with developed base manholes. Flexible gaskets shall be A-Lock, or approved equal.
 - e. The minimum distance from the invert of the downstream pipe to the top surface of the base shall be three (3) inches.
 - f. Joints between manhole sections, adjustment rings, and below the ring and cover shall be sealed with preformed bitumastic sealants, Kent-Seal, Ram-Nek, E-Z Stick or approved equal. The minimum bead dimension shall be one inch.
4. Manhole and Special Concrete: Manhole and special concrete shall conform to “The Mid-West Concrete Industry Board Incorporated” (MCIB) Specifications and to the requirements therein for the MCIB Mix Number specified on the drawings or as provided herein.
 - a. Standard Concrete: Standard concrete used for concrete encasements and embedment, thrust blocks, pipe anchors, pipe collars, etc. shall be MCIB Mix Number A 480-1-4 (3000 psi 28-day strength), unless otherwise specified.
 - b. Structural Concrete: Structural concrete used for aerial crossing piers, wetwell walls, manhole walls, bases, inverts, flat slabs, etc. shall be MCIB Mix Number A 558-1-2, (4000 psi 28-day strength), unless otherwise specified.
 - c. Admixtures: Air-entraining admixtures shall provide an air content within the range of 4 1/2 to 7 1/2 percent by volume as measured by the pressure method (ASTM C 231). The air entraining admixtures shall meet the requirements of ASTM C 260.
 - d. Portland Cement: Portland cement shall conform to ASTM C 150 Type I. Where high early strength is desired, Type III can be used.
 - e. Fine Aggregate: Fine aggregate shall be clean, natural sand meeting the requirements of ASTM C 33. Grading shall be within the limits as set forth by MCIB.
 - f. Coarse Aggregate: Coarse aggregate shall be limestone meeting the requirements of ASTM C 33. The sum total of all deleterious material shall not exceed the requirements of ASTM C 33.
 - g. Water: Water shall be clean and free from deleterious substances. Only potable water will be acceptable without testing.

5. Reinforcement steel: Reinforcement steel shall conform with the following minimum requirements.
 - a. Design: Reinforcing steel shall conform to one of the following.
 - (1) Welded Wire Fabric – ASTM A 185.
 - (2) Reinforcing Bars - ASTM A 615, Grade 40, or Grade 60.
 - (3) Fabricated Steel Bar and Rod Mats - ASTM A 184, Grade 40, or Grade 60.
 - b. Fabricating Tolerances: Tolerances for concrete reinforcement shall conform to the following requirement
 - (1) Sheared length = +/- 1 inch.
 - (2) Stirrups, ties, and spiral = +/- 2 inches.
 - (3) All other bends = +/- 1 inch.
6. Iron Castings: Casting shall conform to the requirements of ASTM A 48, Class 30. Castings shall be clean and without surface defects that will impair serviceability. Plugging or filling of holes or other defects will not be permitted. Parting fins and pouring gates shall be removed.
 - a. Rings and Covers: Rings and covers shall meet the following minimum requirements.
 - (1) Bearing surfaces between the ring and cover shall be machine finished or ground to assure interchangeability and a non-rocking & in any position.
 - (2) Provision shall be made for opening, such as concealed pick hole(s).
 - (3) Bolt-down type manhole rings shall be anchored to the manhole walls with not less than four (4) three-fourths (3/4) inch diameter steel bolts embedded a minimum of fourteen (14) inches, except where the entire ring is embedded in a concrete top slab.
 - (4) Rings and bolt-down covers shall be provided with machined surfaces, O-ring gaskets and five-eighths (5/8) inch hex head brass cover bolts. Cover bolt heads shall fit flush or below the top of the cover. The O-ring rubber gasket shall be neoprene or other synthetic, sixty (60) plus or minus five (5) hardness when measured by ASTM D 2240 type durometer.
 - (5) For street and out of street it should be the Deeter 1256 Ring and Cover. This will be one standard lid and ring. One inch thick by 24" diameter lid.
 - b. Steps: Steps are not permitted

2210.4 Manhole Site Preparation: Manhole site preparation shall be governed by Section 2204.

2210.5 Manhole Excavation

1. Excavation: Excavation for manholes and special structures shall be governed by this Section and Section 2205. It shall be achieved in a suitable and orderly manner providing a minimum disturbance to the general public.
2. Depth of Excavation: Depth of excavation shall be to that required for proper installation of the manhole or structure. Over-depth excavation may be required by the Engineer if the subgrade is unstable. Over-depth excavation due to unstable subgrade shall be backfilled as required by the Engineer. Over-depth excavation occurring through an oversight by the Contractor shall be backfilled as required by the Engineer at no additional cost to the Owner.
3. Side Clearances: Side clearances outside the manhole and/or structures shall be no greater than to allow for fanning, connection of piping, proper application of special

coatings, if required, and to permit inspection. When concrete is to be placed directly against excavated faces, excavation shall be sufficiently outside of the manhole or structure to provide not less than three (3) inches of concrete cover over the steel reinforcement

2210.6 Manhole Installation

Manhole installation shall be governed by this Section and Section 2206. It shall be performed by the Contractor on a schedule that will provide an orderly progression of the work.

1. Bases:
 - a. Precast developed bases shall be reinforced in accordance with ASTM C478.
 - b. If preferred developed bases are not used, poured concrete bases shall be used. Developed bases shall be installed on a maximum of 4 inches of crushed rock. Depths exceeding this amount shall be filled with mass concrete.
 - c. Poured-in-place bases shall have a minimum thickness of eight (8) inches. When poured-in-place bases are used, the invert shall be poured monolithically with the base. The bottom wall sections shall be embedded in the base section a minimum of three (3) inches. The bottom precast wall section shall not be set upon a previously poured base. Solid concrete blocks shall be used for supporting and leveling the wall section prior to pouring the base.
2. Inside Dimensions: The minimum horizontal clear distance in the barrel of the manholes shall not be less than four feet unless otherwise specified on the Plans.
3. Precast
 - a. Delivery: Precast concrete components shall not be delivered to the job until representative concrete control cylinders have attained at least 80 per cent of the specified minimum design strength.
 - b. Inspection: Precast concrete shall be inspected when delivered. Rejection of defective or cracked precast concrete components shall be in accordance with ASTM C478.
 - c. Wall Thickness: Wall thickness shall conform to the requirements of Section 2210.3.3
 - d. Construction: Precast sections shall be cleaned of all dirt, grass, and other deleterious matter. Seal each joint (including adjustment rings and castings) with a double bead of preformed bitumastic joint sealant. Lift holes shall be patched with non-shrink grout
4. Cast-In-Place:
 - a. Wall Thickness: Wall thickness shall conform to the dimensions as shown on the drawings.
 - b. Construction: Reinforcement steel shall be placed as shown on the drawing. Tie-holes shall be patched with non-shrink grout Wall sleeves, where required, shall be installed as shown on the drawings. Water stops shall be installed at the wall and slab connection and shall be of the size, thickness and material as shown on the drawings.
 - c. Waterproofing: Interior protective coatings, where required, shall conform to the material specifications. Application shall conform to the manufacturer's recommendation.

5. Top Slabs: Thickness shall conform to the dimensions and reinforcement steel shall be placed as shown on the drawings.
6. Pipe Stubs: Stubs shall be installed at the locations, angles, elevations and of the materials as shown on the drawings. A water-tight removable stopper shall be installed in each pipe stub. Pipe stubs shall be installed so that a pipe joint will be two (2) feet or less from the outside manhole wall.
7. Inverts: Inverts shall be structural concrete and steel-troweled to produce a dense, smooth finish. The invert channel shall be "U" shaped in cross section and extend upward one-half of the inside pipe diameter. Smooth transitions shall be formed for pipes of different sizes, elevation and bends. The invert bench shall be sloped to drain.
8. Top Elevation: The finished top elevation of manhole castings shall conform to the following unless otherwise shown on the plans or directed by the Engineer.
 - a. In paved or future paved areas, the top of the casting shall conform to the slope of the pavement and be 1/8 inch below the finished pavement elevation.
 - b. In non-pavement areas, the top of the casting shall be not more than six (6) inches above the surrounding ground nor less than the sod's upper root limit. The final elevation shall be at a point where water will not pond over the manhole cover.
9. Manhole Adjustment: All new manholes will be provided with adjustment ring(s) underneath the casting as shown on Plans. The joints shall be sealed with preformed bitumastic sealant. The maximum allowable adjustment distance between the top of the cone and the bottom of the casting shall be 12". If the top of an existing manhole is required to be raised to an elevation that will exceed the maximum adjustment distance or lowered more than the adjustment rings will allow, all vertical adjustments shall be made to the barrel of the manhole.
10. Castings: Castings shall be installed with the mud ring inserted inside the manhole opening and resting on a minimum of two rows of preformed bitumastic sealer. Bolt-down castings shall be held in place as shown on the Plans.

2210.7 Manhole Backfilling Manhole backfilling shall be governed by Section 2207.

2210.8 Restoration: Restoration shall be governed by Section 2208.

2210.9 Manhole Testing

1. Scope: This section governs the required testing of manholes and structures not otherwise set forth.
2. General: All manholes shall be vacuum tested.
3. Vacuum Testing: Testing will be done in compliance with ASTM C1244. All pipes and other openings into the manhole shall be plugged. All plugs shall be securely braced to prevent the plug from being drawn into the manhole.

Air shall then be pumped out of the manhole until a vacuum is created inside of the manhole equal to ten inches (10") of mercury on an approved vacuum gauge. The removal of air will then be stopped and the test time will begin.

The vacuum must not drop to below 9 inches (9") of mercury within a 60 second test period for a four-foot (4') diameter manhole, 75 seconds for five-foot (5') diameter manhole and 90 seconds for a six-foot (6') diameter manhole. If more than a one-inch (1") drop in vacuum occurs within the test period the manhole shall be considered

unacceptable. Contractor shall excavate the manhole and make necessary repairs. Upon completion of repairs the manhole shall be backfilled again and retested.

2211 MEASUREMENT AND PAYMENT

2211.1 Measurement

The quantities of completed work will be measured in the following units. All measurements will be plan measure except for authorized changes.

1. Pipe
 - a. Open Trenched Measurement of various size, type and depth of pipe will be to the nearest 0.1 foot for each line between structures and made to the inside face of the connecting structure.
 - b. Tunneled, Bored or Jacket Measurement will be to the nearest 0.1 foot for the limits of tunneling, boring or jacking as shown on the plan.
 - c. Embedment or Encasement Concrete: Embedment or encasement will be measured by the lineal foot of each size and type.
 - d. Manhole: Measurement will be made for the applicable type, size and depth of manhole as listed in the proposal. The depth shall be determined by measuring from the top of the casting to the outlet pipe flow line to the nearest 0.1 foot where applicable.
 - e. Seeding: Measurement will be made in accordance with Section 2400.
 - f. Sodding: Measurement will be made in accordance with Section 2400.
 - g. Pavement and Curbing: Measurement will be made in accordance with Section 2200.
 - h. Driveways and Sidewalks: Measurement will be made in accordance with Section 2300.

2211.2 Payment will be made at the respective unit or lump-sum price listed in the proposal and shall be full compensation for all labor, materials, and equipment necessary to complete the respective unit in place. There will be no separate measurement or payment for any item of work not specifically identified and listed in the proposal, and all such work shall be considered a subsidiary item with all costs pertaining thereto included in the prices for other items listed in the proposal. At the Engineer's option, partial payment may be made for any lump sum item listed in the proposal, providing that the Contractor is diligently and satisfactorily pursuing full completion of such partially complete item in accordance with the approved job progress schedule.

Division V
Section 5200
Sanitary Sewers &
Appurtenances
Design





**DIVISION V
DESIGN CRITERIA**

**SECTION 5200
SANITARY SEWERS AND APPURTENANCES**

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**DIVISION V
DESIGN CRITERIA**

SECTION 5200 SANITARY SEWERS AND APPURTENANCES

SECTION 5201 GENERAL

5201.1 INTRODUCTION: This document sets design standards for sanitary sewers to be accepted by the City of Manhattan. It is intended to assist professional engineers by outlining minimum requirements for design.

These criteria cover design factors and provide guidelines for evaluations of plans and specifications by the City of Manhattan. These criteria are not intended to cover extraordinary situations and in such instances, deviations from the criteria may be allowed where justified upon the approval of the City Engineer.

The design of sanitary sewers shall be sealed by a professional engineer licensed in the state of the project site. The designer shall submit such additional design information as the City Engineer requires. Design calculations, soil studies, and field survey data are examples of pertinent design information necessary for plan review.

Qualified construction observation is required. Unless otherwise provided, this service shall be performed by the designer.

Where the term "shall" is used in this document, it is intended to mean a mandatory requirement insofar as any confirmation by the City Engineer is concerned. Other terms like "should", "recommend", and "preferred" indicate discretionary use.

5201.2 COMPLIANCE:

- A. Master Plans: The proposed design shall be in accordance with master plans for the indicated area if formulated. Otherwise, a pre-design conference is required.
- B. Material Preference: Polyvinyl Chloride (PVC) is the preferred material sewer pipe and fittings of the City of Manhattan
- C. Other Requirements: It shall be the responsibility of the designer to comply with all standards and ordinances applicable to the project. The designer shall refer to the City Engineer for a complete listing of standards, codes, and ordinances required for conformance.

Other applicable design standards include the most recent published edition of the following:

1. Kansas Department of Health and Environment Minimum Standards of Design for Water Pollution Control Facilities.
2. Applicable ASTM Standards.

3. Latest adopted version of the international building code as adopted to date.

All designs shall meet the minimum required by these standards.

SECTION 5202 SUBMITTALS

5202.1 General: Proper preparation with timely and complete distribution are essential elements of the submittal process.

5202.2 Pre-design Conference: (Required for projects not planned to conform to the masters plan or meet minimum standards) A pre-design conference with City engineer, the designer, the developer where applicable, and representatives of the State regulatory agencies where appropriate, shall be conducted prior to any extensive design effort. A report or plan outlining the scope and objectives of the proposed project shall be prepared and shall be made available prior to the conference. A primary consideration in the proposed project development is conformance to current sanitary sewer master plans and other adopted policies of the City.

The design engineer shall demonstrate an understanding of local sanitary sewer ordinances, sanitary sewer standard specifications and documents, sanitary sewer rights-of-way, easement policies (both public and private) and State standards for sanitary sewerage facilities at the pre-design conference.

A preliminary schedule indicating proposed dates for design submittals, construction drawings and specifications reviews, construction bidding and award schedule, construction period, and conforming to construction records submittal shall be presented at the pre-design conference.

The design engineer shall be responsible for preparing minutes of the pre-design conference and furnishing a copy to all conference attendants within one week following the conference. The purpose is to provide mutual understanding and documentation for reference of principal matters covered at the conference. Proposed dates for furnishing the Preliminary Design Memorandum submittal and Final Design submittal and distribution shall be included in the conference minutes.

5202.3 Preliminary Design Submittal:

A. Purpose: The design engineer shall prepare a preliminary design memorandum and preliminary plans and distributed as agreed at the pre-design conference for reviews and approvals prior to beginning final design work. The preliminary design memorandum shall be a condensed version of the final design submittal but must contain sufficient detail to display adequate knowledge of the overall project requirements and scope.

The purpose of a preliminary design memorandum is to establish a common understanding through review comments, among all principal representatives involved in the project as to requirements and objectives of the project. Decisions and agreements reached at the pre-design conference. as included in the conference

minutes, shall be reflected in the preliminary design memorandum.

The preliminary design memorandum shall outline the project from concept through detailed implementation. It shall briefly present the purpose and scope of the proposed sanitary sewer project and follow with a more detailed description of the project including:

1. General location and information concerning the area to be served, including service area boundaries. .
 2. Relative location of the project to existing sanitary sewerage facilities within and adjacent to the proposed service area.
 3. Review of planning studies to determine land use, population projections and other factors affecting: wastewater discharges within the proposed service area as to both quantity and quality.
 4. Estimates of present and future design flows within the proposed service area with consideration of expansion of facilities to serve upstream areas where applicable. (See Section 5203 Design Flows).
 5. Consideration of treatment of wastewater from service area in either existing or new facilities.
- B. Facilities Requirements: Following an assessment of project area limits and sanitary sewerage service needs the design engineer shall evaluate sanitary sewerage system facilities requirements to meet the present and future needs including:
1. Review available information concerning service area topography, geology. Sub surface soil types and ground water table elevation range and assess affects on design construction and operation of the project.
 2. Preliminary routing of proposed gravity sewers and lift station force mains where applicable.
 3. Preliminary site selections for lift stations and site access where applicable.
 4. Preliminary sizing based on capacity requirements and available slope along proposed routes and consider additional capacity requirements based on overall master planning for future expansion. (See Section 5204 Sewer Line Sizing).
 5. Lift station sizing, including holding basins and other site development and associated force main sizing. (See Section 5204 Sewer Line Sizing and Section 5207 Lift Stations.)
 6. Proposed construction material alternates for sewer pipe, manholes, castings and other construction based on established standards of the City Engineer.
 7. Determine temporary construction and permanent easement requirements and

other site access needs.

8. Prepare location drawings showing proposed facilities on current topographic map suitable for exhibit display.
9. Prepare preliminary opinion of project cost including construction, engineering, fiscal, legal and administrative with separate allowances for easements, rights-of-way, and lift station sites using the best information available without appraisals. A contingency should also be included.

C. Distribution: The design engineer shall make distribution of the preliminary design memorandum and plans as established at the pre-design conference. Reasonable time shall be allowed for comments on the preliminary design submittal by reviewing parties with corresponding dates set for receipt of review comments and the final design submittal.

5202.4 Final Design Submittal: The final design submittal shall consist of construction drawings or plans, specifications and contract documents, adequate in detail and clarity for project bidding and construction.

Construction drawings shall be prepared from onsite surveys, aerial mapping, and/or lidar data, and other project site investigations. Existing surface and subsurface obstacles, utilities and other conditions affecting the design and construction of the project shall be indicated and identified on the construction drawings with reasonable detail and accuracy.

A. Construction Drawings:

1. General: Project construction drawings are a graphic representation of the location and detailed description of the work to be performed. The drawings along with the contract specifications and documents are the directives and guides to be followed in converting a project design into a usable sewerage facility.

After review by the City Engineer, the design engineer shall make any required revisions to the construction drawings and submit to KDHE for review and permit approval. Bids shall then be received for construction of the project. After completion of the project, the construction drawings shall be revised to reflect any changes or modifications to the original bid drawings and any pertinent field information discovered during construction shall be noted.

2. Content and Organization:

a. Cover Sheet: The cover sheet for the drawings shall include the following:

1. City Engineer's name, with name and number designation of the project and year.
2. General location map showing section, township and range with

project location indicated and locations of highways, streets, rivers, and other identifiable landmarks sufficient to provide convenient access to the project site.

3. Name and seal of the design engineer.
 4. Name and signature of the approving authority, date of approval and construction permit number.
 5. North arrow and graphic scale.
 6. Legends, abbreviations, sheet index, sheet titles, and general notes and comments shall appear either on the cover sheet or on the following General Layout Sheet.
- b. General Layout Sheet: The general layout sheet shall contain a map or plat depending on the size of area over which the project is located, at an engineering scale necessary to show the entire system on one plan sheet of minimum size of 24" x 36". All elements of the project shall be identified and pipe sizes and limits of each size shown. Street names, references to USGS township, range, section lines and quarter section lines, easement and right-of-way location, and names of surrounding developments shall be shown. A table of the coordinate values for each manhole shall be shown based on the WGS 84 state plane coordinate system. Directional flow arrows shall be showed on pipes with design discharge in CFS.

Sheet numbering, usually one (1), project identification, design engineer identification. Professional Engineer's seal, revisions and record of issue identification blocks, north arrow, and scale shall be shown.

Abbreviations, legends, list of drawings and sheet titles, general notes and comments, if not shown on the cover sheet, shall be included on the general layout sheet.

- c. Sewer Plan: Sewer plan shall be on plan and profile sheets of minimum size of 24" x 36" and shall be drawn directly above the sewer profile. Normally the sewer plan should be drawn with lower stationing starting at left and ending at the right side, with direction of flow from right to left. A single plan and profile shall be shown on each sheet.

The sewer plan view shall show the sewer survey alignment with the final location of the sewer center line relative to the field survey alignment by using angles and stationing. The plan view shall present the proposed design including the surface topography and utilities which are located along, across, or near the proposed sewer alignment, and any other existing, or proposed improvements or conditions in the vicinity of the proposed construction.

Temporary construction and permanent easements and rights-or-ways and

project site access easements shall be shown in plan view on the drawings, Property owners, both private and public, within the easements and right-of-way shall be shown by name and property lines.

Survey elevation reference points (bench marks) shall be described and elevations with datum plan (U.S.G.S., etc.) shall be clearly identified on the plan strips.

In addition, the following shall govern sewer plan drawings:

1. Scale: 50 feet to one inch (Max): 10 feet to one inch (Min.)
 2. North arrow shown on all plan areas of each sheet shall be positioned up or to the right..
 3. Matching line with the matching project station must be clearly indicated.
 4. Lot lines, lot numbers, block numbers, minimum finish floor elevations, building locations, and building designations shall be shown.
 5. Stationing shall be indicated at every 100 feet. All public storm, sewer, public and private utility crossings shall be shown with their intermediate stationing indicated
 6. Manholes, with internal diameters and identification numbers or letters, special structures, wye and tee locations shall be indicated and stationed.
 7. Horizontal angles between incoming and outgoing pipes at manholes and other structures shall be indicated.
 8. The existing sewer facility that is being connected to by the proposed project shall be identified by previous project number and/or name, previous project stationing or manhole identification.
- d. Sewer Profile: Sewer profile drawings shall be on plan and profile sheets and located directly below the sewer plan drawing of the respective profiled section of sewer. Layout arrangements by stationing and flow direction shall be as described for the sewer plan drawing under 5202.4.A.2.c.

Sewer profile drawings shall be continuous profiles of all sewer runs showing existing and proposed surface elevations. At all structures, the location (stationing) including the top casting and invert (in and out elevations) shall be indicated. Between structures, the pipe size and length, special pipe embedment, on encasement and tunneling or pipe casing shall be shown including the limits of each if not continuous throughout. In addition, the grade (slope) of the pipe between structures shall be shown as a percent expressed to the nearest hundredth.

Sewer profile drawings shall also conform to the following:

- (1) Scale: Vertical - 10 feet to one inch.

Horizontal - 50 feet to one inch to match plan drawing.

- (2) Stationing at every even 100-foot (4+00. etc.) shall be indicated with intermediate stationing to locate and/or indicate limits of existing facilities or new construction including manholes.
 - (3) Profile drawings shall provide material type and size of other utilities. Existing and proposed underground utility facilities crossing or paralleling within 100 feet of the new sewer alignment shall be indicated, based on best information available from utility owners and records.
 - (4) Subsoil and other subsurface conditions. as desired by each City Engineer.
 - (5) Parallel creek flow lines within 200 feet horizontal distance from the sewer alignment shall be shown at the proper elevation with dashed lines on the profile.
- e. Sewer Details: A standard detail sheet showing each type of standard manhole connections for dissimilar pipe materials between manholes, concrete encasement alternatives, sewer installation inside carrier pipe casings and liner plate runnels, special structure details not requiring additional drawings and other appropriate details shall be provided following the plan and profile sheets, unless reference is made to the City Engineer's approved standard details.
- f. Right-of-Way Easement Sheets:
1. General: Right-of-way and easement sheet(s) shall be provided with most plan sets. The right-of-way/easement sheet shall be of minimum size of 24" x 36" and the size shall match all other sheets of the plan set. The scale may be the same as the plan/profile sheet. Only on small projects, where the required information could be included on the plan-profile sheets without undue clutter may this sheet(s) be eliminated. When a separate easement sheet is not provided the right-of-way and easement documentation shall be differentiated by utilizing such features as "hatching" or "gray shading" in order that the plan sheet remains clear and legible.
 2. Required Information: Right-of-way and easement (sheets) shall identify lot dimensions, ownership boundaries, owners names, address, tract and lot numbers, areas of each ownership, easement boundaries, areas of each easement, and the construction limits. Sufficient data shall be provided to identify the size and shape of each ownership and easement boundary,

including dimensions, bearings and angles. All proposed and existing easements and/or rights-of-way intended to be used as part of the project shall be identified survey centerlines and/or base lines which relate the right-of-way to the construction plans shall be identified. A legend shall be included for clarification. A north arrow and bar scale shall be shown.

- g. Record Drawings: Record drawings conforming to construction records shall be prepared and maintained during the life of the project. Recording details and submittal shall be as outlined in 5202.5 - Conforming to Construction Records Submittal.

- B. Construction Specifications: The technical specifications for sewer projects shall be in conformance with Section 2200.

5202.5 Conforming to Construction Records Submittal: During construction of the project the Contractor shall keep one record copy of all Specifications, Drawings, Addenda, Modifications and Shop Drawings at the site in good order and annotated to show all changes made during the construction process. These documents shall be available to the design engineer and shall be delivered to him for preparation of Mylar reproducible drawings conforming to construction records. The reproducible drawings shall be given to the City Engineer along with two complete sets of black line prints of the drawings at the end of the project.

A record of the locations of all sewer wyes and tees, and other buried facilities such as existing Utility lines, in addition to all construction changes and noteworthy underground soil conditions shall be accurately indicated on the construction record drawings. Unless otherwise required by the sewer entity measurements to underground locations shall be made in the upstream direction from the center of the nearest downstream manhole cover.

SECTION 5203 DESIGN FLOWS

5203.1 General: Sanitary sewers shall be designed to provide capacity for the anticipated maximum hourly quantity of sewage and industrial wastes, with approved allowance for infiltration and other extraneous flows. It should be noted that the infiltration and extraneous flow allowances vary widely within any given area depending on a number of conditions. The values presented in this section are minimum general unit design flows. The design engineer should be cautious in the use of these values as a set rule since local conditions may cause variance from any value noted herein.

5203.2 Design Period:

- A. Collectors Sewers: Sewers of the size up to and including a nominal diameter of eighteen (18) inches shall be designed for ultimate development using existing and/or projected land use for the estimated ultimate population of the area served.
- B. Larger Sewers: Sewers with a nominal diameter of larger than eighteen (18) inches shall be designed for a minimum design period of not less than twenty five (25)

years using existing and/or projected land use. A longer design period shall be justified by a cost-effectiveness calculation using the "present worth" method.

5203.3 Design Flow Factors:

- A. General: Sanitary sewers shall be designed to provide capacity for the anticipated maximum hourly quantity of wastewater (hourly peak flow), including appropriate allowance for infiltration and inflow. Actual measured flows shall be used whenever reliable wet and dry weather flow measurements are available.
- B. Capacity: In the absence of actual measured flows, the following minimum hourly peak design flows, by land use, shall be used (an infiltration/inflow allowance is included):

Land Use	Minimum Hourly Peak Design Flow Rate (Cubic Feet per second per Acre)
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Residential Housing:

One-and two-family dwellings	0.005
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Apartments: (Actual density to be considered)

a. One through three stories	0.020 cfs/ac
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b. Four-story and above	0.022
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Commercial: (Actual density and tenant types to be considered)

a. Small stores, offices and miscellaneous businesses	0.010
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b. Strip Shopping centers	0.015
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c. Regional Shopping Centers	0.015
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d. High rise	0.017
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Industrial: (Actual density to be considered)

a. Light	0.015
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b. Heavy	As directed by the City Engineer
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- C. Limitations: These design factors shall apply to watersheds of 300 acres or less. Design factors for watersheds larger than 300 acres shall be as follows unless otherwise directed

by the City Engineer:

Area in Acres	Minimum Hourly Peak Design Flow Rate (Cubic Feet per Second per Acre)
301-500	0.017
501-1,000	0.015
1,100-3,000	0.015-0.010 with linear decrease based on watershed

SECTION 5204 SEWER LINE SIZING

5204.1 Gravity Lines: All public sewer lines shall be at least 8 inches in diameter. The downstream sewer pipe shall have the same or larger nominal diameter as the upstream pipe unless otherwise approved by the City Engineer. All public sewers shall be designed to have velocity of not less than 2.0 feet per second when flowing full. The maximum velocity, when flowing full should be less than 10 feet per second. For maximum velocities, greater than 10 feet per second special consideration shall be given to protect against erosion. All public sewers up to, and including, 18 inches in diameter shall be designed to carry the design flow at two-thirds full, and sewers larger than 18 inches shall be designed to carry the design flow at three-fourths full.

All velocity and flow calculations shall be by Manning's Formula using the following equation

$$Q = \frac{1.486 * (A) * (R^{2/3}) * (S^{1/2})}{n}$$

Q = Discharge in cubic feet per second

A = Cross sectional area of flow in square feet

n = Roughness coefficient of 0.013 (use regardless of pipe material type)

R = Hydraulic radius (R = A/P) in feet

S = Slope in feet per foot

P = Wetted perimeter in feet

For straight sewer alignment between structures, the following minimum slopes shall be used. Subject to the approval of the City Engineer, these minimum slopes shall be steepened to account for additional energy losses when curved sewer alignment is used.

Sewer Size In inches	Minimum Slope in %* n=.013
8 inch	0.400
10 inch	0.248

12 inch	0.194
15 inch	0.145
18 inch	0.114
21 inch	0.092
24 inch	0.077
27 inch	0.065
30 inch	0.057
33 inch	0.051
36 inch or greater	0.045

*Exceptions to the minimum slope 8 inch diameter sewer may be approved where a lift station can be eliminated. In these instances a slope of 0.30% may be allowed with prior KDHE approval on a case by case basis with adequate documentation.

All building sewer lines are governed by the City's local plumbing code.

5204.2 Inverted Siphons should have no less than two barrels with a minimum pipe size of 6 inches and shall be provided with necessary appurtenances for convenient flushing and maintenance. For easy hydraulic removal of solids, the following maximum grades are recommended on the rising leg: 6-inch pipe – 11 ½ degrees, 8 to 12-inch pipe – 22 ½ degrees, greater than 12-inch pipe – 45 degrees. The manholes shall have adequate clearance for rodding and in general sufficient head shall be provided and pipe sizes selected to maintain velocities of at least 3.0 feet per second for average flows. The inlet and outlet head losses should be addressed. The details shall be arranged so that the average flow is diverted to 1 barrel and so that either barrel may be taken out of service for cleaning.

Additional Information – Inverted Siphon:

The manholes located at the beginning and the end of the inverted siphon (upstream and downstream manholes) shall have a minimum internal diameter of 5 feet. This can be accomplished by providing a large hinged access door on the manholes and also provide an access road to one of the end manholes (preferably the upstream to permit convenient flushing) and at a minimum once each day based on initial upstream development. The inlet and outlet elevations shall be established based on hydraulic design to avoid surcharging the upstream line during design peak flow. The upstream manhole structure shall be designed so that the average daily flow is normally diverted to the flow barrel and so that either barrel may be taken out of service for cleaning.

The upstream manhole shall have either a vent for discharge of air or an air jumper pipe shall be connected between the upstream and downstream manholes. When air jumper pipes are utilized with an alignment that does not permit self-draining, some provision for automatic dewatering shall be included.

The final decision to permit the installation of an inverted siphon lies with the KDHE.

5204.3 Force Mains: All force mains for public sewers shall have at least a 4-inch nominal diameter except force mains with grinder pump installations may have a smaller size diameter when necessary to insure an adequate flushing velocity. Force mains shall have a velocity in excess of 2 feet per second at design average flow. Force mains should have normal operating velocity in suction lines between 2 feet per second and 8 feet per second and in discharge lines between 3 feet per second and 8 feet per second. Construction and pumping costs are factors that should be considered before selecting the size of the force main. Flat sections of force mains 100 feet or longer in length should not be installed on a zero slope.

Air and Vacuum Relief Valves: Air relief and vacuum relief valves shall be provided in the lift station discharge piping and force main to adequately vent air and gas and to allow entrance of air as required. Air relief valves shall be sized to prevent line entrapped gas blockage. Vacuum relief valves shall be sized to protect the discharge pipe from collapsing.

SECTION 5205 SEWER ALIGNMENT AND LOCATION

5205.1 Gravity Lines:

- A. Straight Alignment: All sewers shall be designed on straight alignment between manholes unless otherwise directed or approved by the City Engineer.
- B. Curved Alignment: Subject to the approval of KDHE, sewers 24 inches in diameter or larger with curvilinear alignment and gradient may be used. If permitted the following limitations apply:
 - 1. The maximum allowable deflection at any pipe joint shall not exceed 80% of either the pipe manufacturer's maximum allowable deflection per joint or that allowed by the applicable ASTM Specification.
 - 2. In no case will the radius be less than 150 feet.
 - 3. Curved sewers in street right-of-way shall be concentric with the street horizontal alignment.
 - 4. The designer shall include in the plans supporting information for horizontal curvature as necessary for staking, construction and design consideration.

C. Location:

1. General: Sanitary sewers should be located within streets or alleys or, if necessary, in a permanent easement on private property. Imposed loading shall be considered in all locations. Manholes should be located outside of paved areas and not within water courses.

Not less than three (3) feet of cover shall be provided over the top of the pipe in street and alley right-of-way. In all other areas, not less than thirty (30) inches of cover shall be provided over the top of the pipe. Sanitary sewers shall be located deep enough to serve existing basements proposed basements or the first floor of buildings with no basements.

2. Easements: Where public sanitary sewers are located outside of existing rights-of-way a minimum permanent easement of ten (10) feet (five feet from the centerline in each direction) and the necessary temporary construction easement shall be provided. In addition, provisions shall be made for access to maintain the entire sanitary sewer system. The types and sizes of equipment used for sewer maintenance shall be considered for both manhole location and access easements.

3. Streams:

- A. Alignment: Sewers crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible and shall be on a constant grade. Sewer systems shall be designed to minimize the number of stream crossings. Sewers adjacent to streams shall be located outside of the stream bed and sufficiently removed to provide for future possible stream widening and to prevent siltation during construction.

- B. Cover Depth: The top of all sewers crossing streams shall be at a sufficient depth below the natural bottom of the stream bed to protect the sewer line.

All sewers crossing drainage ways with less than 3 feet of cover depth shall be encased in concrete plans. In no case shall the top of the encasement be above the stream bed.

- C. Structures: Manholes or other structures shall be located as they do not to interfere with the free discharge of flood flows of the stream as required by the agency governing the stream.

- D. Materials: Sewers crossing streams shall be concrete encased unless designed using reinforced concrete pipe or ductile iron pipe.

- E. Stream Crossing Restoration: Stream crossing restoration information shall be submitted and approved by KDHE as a part of the permit approval process. The submitted information shall insure that the stream channel and banks have been restored to better than pre-existing conditions and measures have been to address

scour and erosion possibilities.

4. Aerial Crossings: This type of installations should be avoided except when no feasible alternative is possible because of terrain or infrastructure constraints. All aerial sewer crossings must be prior approved by the City Engineer. When joints are allowed by the City Engineer support shall be provided. The support shall be designed to prevent frost heave, overturning, and settlement.

Aerial crossings shall be designed using CL 52 Cement Lined DIP insulated with a Polyurethane Foam and wrapped in 20 Gauge Galvanized Spiral Lock pressure pipe. Pre-approved product: Insulated tech piping or equivalent.

The aerial crossing shall be located so as not to interfere with the flow of the stream as required by the agency governing the stream.

Precautions against freezing such as insulation and increased slope shall be provided. Expansion jointing shall be provided between above-ground and below ground sewers.

5. Utility Protection:

- a. Water Line: Sanitary Sewers are to be designed to pass a minimum of 2 vertical below water lines measures from outside diameter of pipe to outside diameter of pipe. In instances where the sewers do not pass 2 vertical feet below a water line, either a minimum of 6" of concrete encasement of the sanitary sewer must be installed to a distance of 10 feet in each direct from the outside edge of the water line pipe, or DIP pipe shall be used for the location meeting the same distances as encasement. This protective measure applies to all crossings where the sanitary sewers pass above water lines, and to public lines and service connection lines located in easements and rights-of-ways. The crossing shall be arranged so that the sewer joints will be equal distance and as far as possible from water main joints.

Water and sanitary sewer lines shall not be placed in the same trench or excavation.

- b. Water Works Structures: Sewer line, i.e., house connections, laterals, trunk lines, interceptors, force mains, etc., shall not be constructed within a 100 foot radius of a public water supply well. Greater separation may be required where soil and drainage conditions indicate the need for greater protection.

Sewer lines constructed of cast iron or solvent welded plastic pipe materials may be constructed within 10 feet of a private water supply well. Sewer lines constructed of non-watertight materials must be at least 50 feet from a private water supply well.

- c. Gas, Electric, Telephone, Storm Sewers and Other Utility Lines: A minimum horizontal distance of five (5) feet should be maintained between parallel sanitary sewer lines storm sewers and utility lines other than water lines.

The vertical separation between storm sewers and sanitary sewers should be two (2) feet minimum. If tees and wyes are installed, they should be routed from under gas, electric, telephone, storm sewer and other utility lines.

6. Steep Grades: Sewers on 15 percent slope or greater shall be anchored securely with concrete anchors or approved equal, where spaced as follows: Not over 100 feet for grades 15-20 percent; not over 36 feet center to center for grades 20 percent to 35 percent; not over 24 feet center to center for grades 35 percent to 50 percent: and not over 16 feet center to center for grades 50 percent or greater.

5205.2 Force Mains: Force mains should be placed in the street or alley right-of-way or if necessary in a permanent easement on private property.

Force mains shall be placed at least forty-two (42) inches below the finished grade and generally may follow the topography of the terrain. The location of force mains with respect to water mains and other Utilities, aerial crossings, stream crossings and steep grades shall be the same as for gravity sewers.

5205.3 New Development Building Services:

- A. Where sewers are located in the street or alley right-of-way a connection (wye, tee, saddle or stub) shall be provided for each building site in new development. The connection shall be extended with a service line to the property line of the building site. The connection shall be designed to provide a vertical angle of not less than thirty (30) and no more than forty-five (45) degrees to the horizontal centerline plane of the sanitary sewer.
- B. In conformance with the applicable plumbing code, a minimum drop shall be provided of not less than 3.0 feet between the basement floor elevation and sanitary sewer flow line elevation at the point of service line connection. The minimum basement floor elevation which sanitary sewer service can be provided shall be indicated. Consideration shall be given in providing sufficient depth where extra long connections, deep building service connections, or other atypical conditions may exist. Service line stubouts shall be referenced to the downstream manhole and the centerline of the sewer. Stubouts at angles other than 90 degrees off of the sanitary sewer shall be referenced by providing the angle between the sewer line and the service line and distance along the service line stubout.

SECTION 5206 SEWER APPURTENANCES

5206.1 MANHOLES:

- A. General: Manholes shall conform to the standards of the City of Manhattan.
 1. Supplied manholes shall conform to ASTM C478.
- B. Manhole Casting:

1. Flooding: When located in areas subject to inundation by flooding or sheet flow, un-vented and bolted covers shall be provided.
 2. Internal Pressure: When designed to function with internal pressure, un-vented, gasketed and bolted covers shall be provided and rings shall be anchored to manhole walls.
 3. Vandalism: When located in areas where theft and vandalism are expected bolted covers may be required.
 4. Larger than 15-inch Diameter Sewers: When the diameter of the manhole's outgoing sewer is at least 15-inches, bolted covers shall be provided.
- C. Inverts: The difference in elevation between the invert of any incoming sewer and the invert of the outgoing sewer shall not exceed 24 inches except where required to match crowns. When a sewer joins a larger one, the crown of the smaller sewer shall not be lower than the crown of the larger. The drop through manholes shall be as tabulated below.

Deflection Angle Range (degrees)	Drop through Manhole (feet)
0 to less than 10	0.1
10 to less than 45	0.1
45 and greater	0.2

- D. Drop Manholes: Drop manholes should be avoided when possible. Freefall drop manholes shall not be used. Inside drops are discouraged and shall require special approval by the City engineer. Where inside drops are used, the incoming flow shall be piped to the manhole invert.

An outside or inside drop pipe, when an inside pipe is used, with a fall greater than 2 feet, a minimum 60" diameter structure shall be provided for a sewer entering a manhole at an elevation of 24 inches or more above the manhole invert. The outside drop pipe shall be protected against breaking or settling by the use of concrete encasement. For pipe diameters of 8 inches to 12 inches, the drop pipe shall have the same nominal diameter as that of the incoming sewer. For larger pipe sizes, a minimum 12-inch diameter drop pipe shall be provided.

- E. Diameters: The minimum horizontal clear distance within the barrel of manholes shall be 48-inches.
- F. Adjustment Rings: The minimum inside diameter of manholes shall be 42 inches. The minimum diameter of entry ways shall be 22 inches.
- G. Steps: Manholes shall not be equipped with steps. Maximum number of adjustment ringers should not exceed a total height of 24 inches.

- H. Cleanouts and Lamp holes: The use of cleanouts and lamp holes is prohibited.
- I. Manhole Location: Manholes shall be installed at the end of each line, changes in pipes size, grade at intersections and at changes in alignment except for curved sewer. The distances between manholes shall not be greater than 400 feet for sewers 18" and smaller and 500 feet for sewers 21" and larger. When a sewer is located in an easement not abutting street or alley right-of-way, access shall be provided to all manholes

SECTION 5207 LIFT STATIONS

5207.1 General:

- A. Lift stations are pumping facilities which are used to convey wastewater from a point beyond which gravity flow is not practical.
- B. All lift stations shall have at least two pumps with the size and number of pumps such that the rated capacity of the lift station can be met with the largest pump out of service.
- C. The time between starts for any given pump shall be a minimum of 10 minutes with maximum number of starts per hour not to exceed that recommended by the pump motor manufacturer.
- D. Unless equipment or facilities are provided which will limit the size of solids reaching the pump suction lift station pumps shall be capable of passing 3-inch diameter sphere.
- E. Air and Vacuum Relief Valves: Air relief and vacuum relief valves shall be provided in the lift station discharge piping and force main to adequately vent air and gas and to allow entrance of air as required. Air relief valves shall be sized to prevent line entrapped gas blockage. Vacuum relief valves shall be sized to protect the discharge pipe from collapsing.
- F. All equipment in the lift station wet well and that equipment or which can be exposed to gases from the wet well shall conform to the National Electric Code Class I, Group D, Division 1.
- G. The City of Manhattan's Sanitary Sewer Lift Station Detail Sheet shall be submitted to KDHE along with pertinent information concerning float settings and other project specific information as required by KDHE as part of the permit approval process.

5207.2 Types: Acceptable types of lift stations are as follows:

- A. Dry well:
 - 1. Flooded suction

2. Wet well mounted with vacuum primed
3. Wet well mounted with self-priming pumps

- B. Wet well:
- a. Submersible pump and motor
 - b. Wet well centrifugal with motor located above the wet well

5207.3 Layout and Siting:

- A. Lift stations shall be located on public properties or on easements allowing for construction and access for maintenance of lift station structures, piping, valves, electrical service and all other required appurtenances.
- B. A detailed general layout detail of the proposed lift station site that includes the routing of commercial power, orientation of wet well and valve vault, control panel, and site access shall be submitted to KDHE. In addition to the general project layout required for all sanitary sewer projects.
- C. Lift station sites should be fenced to adequately protect the lift station equipment.
- D. All weather vehicular access shall be provided to lift station sites. Adequate vehicular turnaround shall be provided. Lift station structures and equipment shall be suitably protected from vehicular damage.
- E. To allow for maintenance, access shall be available to all mechanical equipment. Means of access shall meet all applicable requirements of the latest edition of applicable OSHA regulations. Access doors and hatches to lift station structures and control panels shall be equipped with lockable features.
- F. Lift station wet and dry wells shall be vented with vent openings which prevent entrance by birds, small animals and rain. Wet well vents shall be equipped with odor control facilities where required. Wet and dry wells may be ventilated continuously or intermittently. Wet wells shall be ventilated at the rate of at least 12 air changes per hour if vented continuously and at the rate of at least 30 air changes per hour if vented intermittently. Dry wells shall be ventilated at the rate of at least 6 air changes per hour if vented continuously and at the rate of at least 30 air changes per hour if vented intermittently.
- G. Allowance shall be made for removal of all equipment and piping through access openings.
- H. Adequate space shall be provided around piping and equipment located inside structures such that personnel can perform all tasks as required for maintenance, removal and replacement of equipment.
- I. A hoisting system for maintenance of the lift station shall be provided when an alternate means for equipment removal is not available.
- J. Lift station structures and equipment shall remain fully operational and accessible

during the 25-year flood. Lift station structures and electrical and mechanical equipment shall be protected from damage by the 100year flood.

5207.4 Power Supply:

- A. Pumping facilities shall be designed to operate using available utility power. The design of the pumping facilities shall be coordinated with the supplying electric utility and meet their requirements. Transformers may be required to provide proper voltage for the lift station.
- B. Autotransformer starters shall be used when required by the electric utility or by the City of Manhattan.
- C. Provision for continued operation during power outages shall be made and based on protection of property safety considerations and the most cost effective alternative which affords the protection acceptable to the City. Acceptable options include: overflow retention basins, standby power generating equipment, alternate electric power supply or alternate pump motor.
- D. Normal utility power supply shall provide power for pump motor starting as well as lights, ventilation and other auxiliary equipment necessary for safe and proper operation of the lift station. Sequencing controls shall be provided for staging the starting of pump motors unless the power supply is adequate to start all pump motors simultaneously while other electrical equipment is in operation.
- E. Transfer from normal power to emergency or alternate power may be accomplished automatically or manually. When manually transferred, adequate storage of wastewater shall be provided to allow time for the transfer to be implemented.

5207.5 Monitoring and Control:

- A. All monitoring and control equipment shall be located outside of the wet well.
- B. Alarm systems shall be provided which activate in the event of any of the following:
 - 1. Power or pump failure
 - 2. Use of a standby or lag pump
 - 3. Unauthorized entry
 - 4. High wet well level
- C. A telemetry system shall transmit alarm signals to the desired location and/or audio-visual alarms provided locally at the discretion of the City.

5207.6 Appurtenances:

- A. The proper type of isolation valves shall be provided in the suction line of each pump between the wet well and the pump (this shall not apply to submersible or to vacuum primed lift stations) and in the discharge piping of each pump after the

check valve. Isolation valves shall not be located in the wet well.

- B. Check valves shall be provided in the discharge piping of each pump, located between the pump and the isolation valve and not located in the pump wet well. Check valves shall be the swing or ball check type. Swing type check valves shall be the outside lever type and shall be horizontally mounted. Ball type check valves may be either horizontally or vertically mounted.
- C. Surge protection facilities shall be provided as required to protect the force main and lift station from surge conditions.
- D. A sump pump or other suitable means shall be provided to remove water or sewage from the dry well as required protecting equipment located in the dry well.
- E. Corrosion of underground surfaces shall be minimized through use of passive or active cathodic protection systems use of appropriate coatings or use of other acceptable means.