City of Marysville

Sanitary Sewer Specifications

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SECTION I

Design Data

1.1 SANITARY SEWER DATA

All sanitary sewers shall be designed in accordance with the latest guidelines for sewer design and installation as required by the Ohio Environmental Protection Agency and as specified herein. Design shall also be in accordance with 'Recommended Standards for Wastewater Facilities' latest edition, published by The Wastewater Committee of the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. (10 States Standards)

The minimum size of gravity sanitary collector sewers shall be eight (8) inches unless otherwise approved by the ENGINEER prior to design. Six (6) inch sewer pipe shall be used for house lateral connections. The house connections shall be of premium joint construction and shall be of the same material as the collector sewer.

1.2 DESIGN FACTORS

The sanitary sewers shall be designed using the area "tributary" to the sewer at each sewer section. Design criteria shall be based on the following information:

a) Projected number of people per acre
b) Average sanitary flow of 100 gallons per person per day
c) A peaking factor versus average flow curve; (see 2.3)
d) Infiltration per 100 acres based on density

The average daily flow per acre shall be obtained by multiplying the average sanitary flow (100 gallons per person per day**)** by the number of persons per acre. Design flow shall be developed by multiplying the average daily flow by a peaking factor and then adding the infiltration per 100 acres. Infiltration flow based on population density shall be as follows:

Density (People/Acre)	Infiltration (cfs/100 acre)
2	0.05
4	0.05
12	0.1

The sewer shall be sized and graded to provide for the design flow. A Manning coefficient of N=0.013 shall be used for design purposes.

The sewers shall be sized on the maximum allowable zoning in any adjacent area but not less than four (4) persons per gross acre.

1.3 PEAKING FACTOR

PEAKING FACTOR = $5.0/[Q_{(ave)(mgd)} \times 10]^{1/6}$
MIN. PEAKING FACTOR = 2.5
MAX. PEAKING FACTOR = 8.0

1.4 DATA SUBMISSION

The data and calculations upon which the sewer line is based shall be submitted to the ENGINEER at the time of the General Plan. The information shall be type written on 8 1/2" x 11" paper and shall include the following:

A. Average domestic flow in each sewer.
B. I/I flow in each sewer.
C. Peak flow in each sewer.
D. The capacity of each sewer.

1.5 DESIGN CRITERIA

All sewers shall be designed in accordance with EPA requirements except amended herein.

A. All sewers 8" or greater shall terminate with Manholes.
B. All sewer lines shall be extended to the property lines as determined by the ENGINEER.
C. A single ditch is required for all lateral sewers.
D. All sewers shall be bored under all state, county, and township roads. Sewers greater than 8" in diameter may apply for a variance to open-cut country and township roads by applying with the proper authorities.
E. All sewers for new lots are to be located along the roadway. No rear yard sanitary mains will be approved.
F. All sewers shall be located outside of, but no more than 5-feet', from the right-of-way line.
G. All sewer capacities shall not exceed the following percentages of pipe flowing full capacities:

8” through 15” diameter	50%
18” through 27” diameter	75%
30” and larger diameter	92%

1.6 GENERAL PLAN REQUIREMENTS

The following items shall be submitted as a General Plan:

A. Design Data covered in Section 2.4.
B. A 2' contour topographical map with a I"=200' scale to show the tributary area.
C. Proposed lot layouts and building types (ex. residential, apartments, commercial, industrial, etc.)
D. Proposed sewer sizes percent of grade, and invert elevations.
E. Location and size of any sewage pump station and force main.
F. Location, type and capacity of any temporary wastewater treatment facilities.

1.7 DETAILED PLAN REQUIREMENTS

Detailed plans submitted to the ENGINEER for review shall contain, as a minimum, the following items**:**

A. All plans shall be drawn and printed on standard 2' x 3' cut sheets.
B. The cover sheet shall include the following information:
    1) Name of Proposed Development.
    2) A location map showing the location of the proposed development in reference to state, city, county, and township roads.
    3) The name of the Owner of the proposed development.
    4) The name of the Engineering Firm responsible for the design of the proposed system.

5) The registration stamp of the project engineer.
6) The submission date.
7) A location shall be provided for the approval signature of the City Manager, Public Service Director, and City Engineer.

C. An index sheet shall next appear which shows the routes, sizes, and manhole locations of the proposed system. The scale of this sheet shall be not less than 1" = 200'. This sheet shall index the sheet number of the detailed plan sheet for each individual sewer.

D. The detailed design of the proposed system shall appear such that the plan for each individual section of sewer appears directly above the profile of that same sewer. These plan/ profile sheets shall have a scale not greater than 1" = 50' horizontal and 1" = 5' vertical.
The detailed design sheets shall include the following items:
1) Property Lines.
2) Existing or proposed utilities.
3) Proposed lateral locations.
4) Existing structures.
5) Existing and Proposed final grade elevations.
6) Easements.

E. A miscellaneous detail sheet shall also be included to show the following items if applicable:
1) Standard Manholes.
2) Drop Manholes.
3) Wye Connections.
4) Risers.
5) Connections to existing Manholes.

As a part of the detailed plan submittal, the owner shall include the following items**:**

A. A detailed-Engineer's estimate as to the amount of materials required to complete the work. Sewer pipe shall be broken down into 0'-8' deep, 8'-12' deep, 12'-16' deep, 16'-20' deep, etc.
B. The Sanitary Sewer Data sheet as required by the E.P.A.
C. The Lift Station Data Sheet as required by the E.P.A.
D. A description and plat of each required easement.

1.8 PLAN SUBMISSION

A. Preliminary Planning

A preliminary plan and report for the sewer the said lands must be prepared by a Professional Engineer, licensed to practice in the State of Ohio, experienced in such work and to have the said plans and report presented to the City Engineer in quadruplicate for review. The Engineer shall, within 30 calendar days of the date of submission, give written notice of either approval or disapproval. If in his opinion additional information is required, he shall request it and shall within 30 days of receipt of same, shall either approve or disapprove. The notice of disapproval shall include a general statement of the reason for such action.

B. Detail Planning

After approval of the preliminary plan and report, the Owner may proceed and have detailed plans, specifications, and estimates of cost of construction prepared by a Professional Engineer, licensed to practice in the State of Ohio and experienced in such work.

Prior to submission of the plans for review, the Owner shall deposit with the Engineer a sum estimated by him to be sufficient to pay all costs of review of the plans, specification, and estimate of cost, including any cost incidental to submission to other agencies.

On completion of the detailed plans, specifications, and estimate of cost and payment of the review deposit the Owner shall submit electronic copies of the documents to the City Engineer for his review and approval. Documents may be sent via CD or flash drive to 209 South Main Street, Marysville, Ohio, 43040. The Engineer will give written approval or disapproval within 30 calendar days following submission. In the event of disapproval a written notice specifying generally the reason therefore shall be given. In the event of approval, it shall be indicated by his signature in the place provided on the plans.

Following approval by the Engineer he shall forward electronic copies of the plans, specifications, and estimates of costs to the City, to the Ohio Environmental Protection Agency and to any other agencies from which approval is required. Notwithstanding approval of the Engineer which shall be technical in nature, approved by the City shall not be complete until the City has, by resolution approved the plans, specifications, estimates of cost and other material submitted. The City will consider action of other agencies and other factors such as, but not limited to, ecological, sociological, traffic, safety, or effect on water quality and flow in rendering their approval and acceptance of the plans.

Prior to construction, the Owner shall digitally submit detailed shop drawings of all structures, piping and equipment for which such information was not included in the detail plans and specifications to the Engineer. This submission shall include pump and equipment performance data for all such to be furnished. The Engineer shall within 14 days of submission return a digital copy to the Owner with his acceptance or rejection noted thereon.

SECTION II

Pipe Materials

2.1 CONCRETE PIPE (GRAVITY SEWERS)

Concrete pipe may be used on 12" and larger sewers and shall be lined with approved PVC liner.

Concrete Pipe. Concrete sewer pipe and fittings shall meet the requirements of ASTM C76, Wall B.

A. Testing.

Testing of concrete sewer pipe, when so directed by the ENGINEER, shall be made in accordance with ASTM C497. All equipment necessary to conduct the pipe test shall be provided by the CONTRACTOR. Hydrostatic testing of the pipe barrel shall be as specified under the pipe joints.

B. Inspection.

All pipe and fittings will be inspected by the ENGINEER or his authorized representative immediately prior to installation and all rejected or damaged pieces must be completely removed from the project. Pipe acceptable to the ENGINEER shall be substituted for rejected or damaged pieces at the CONTRACTOR'S expense.

C. Class

The classification of concrete pipe shall be determined by the most up-to-date version of the American Concrete Pipe Association's fill height tables (Resource # 16-201). The 2017 update to these tables can be found in Appendix A of these documents.

Pipe Joints. Concrete sewer pipe joints shall be flexible, watertight joints conforming to ASTM C443. The CONTRACTOR shall furnish evidence of satisfactory performance of the joint for previous installations.

A. Testing.

Testing of concrete sewer pipe joints when so directed by the ENGINEER shall be made in accordance with ASTM C443 with modifications as specified below. The CONTRACTOR shall provide all equipment necessary to conduct the pipe joint tests.

1. Test Specimens. The ENGINEER or his authorized representative may initially and periodically select random sewer pipe for test purposes. The tests shall be performed on not less than two specimens and not more than 1 percent of the total pipe length of each size and class of pipe required for the project.

Test Modification. Two sections of pipe shall be assembled with outer ends bulkheaded, and hydrostatically tested to 20 feet of water (8.6 pounds per square inch pressure) for a period of 2 hours. With the assembled pipe under pressure, the pipe shall be deflected to the maximum amount. Continuing the hydrostatic pressure, a shear load of 150 pounds per inch of diameter shall be applied to the unsupported spigot end of the pipe immediately adjacent to the joint. During the entire testing period, there shall be no visible leakage at the joint. The pipe barrel shall not show excessive leakage during the entire testing period. Moisture appearing on the surface of the pipe in the form of patches or beads adhering to the surface shall not be considered as excessive leakage.

2.2 DUCTILE IRON

Ductile Iron Pipe. Ductile iron sewer pipe shall meet the requirements of ANSI A21.51 (AWWA C 151).

Material. The chemical constituents shall meet the physical property recommendations of ASTM A330 to insure that the iron is suitable for satisfactory drilling and cutting.

Unless otherwise shown in the plans or the special specifications, the thickness of the barrel of the pipe shall not be less than the thickness computed using the method of ANSI A21.50, AWWA Manual H-3 except for the following loading conditions: unit weight of soil, 130 lbs. Per cubic foot; truck wheel loads of 16,000 lbs.; laying condition B; depth of cover, 8 feet or 2.5 feet, whichever produces the greatest load in conjunction with live load; working pressure 150 lbs. Per square inch; surge pressure 100 lbs. Per square inch.

The minimum wall thickness shall be:

	Size	**Class**
Force Mains	4" - 20"	53
	24"	54
Gravity Sewer	4" - 24"	50

The minimum thickness for larger diameter pipe shall be as shown on the plans.

Cutting. Whenever ductile iron pipe requires cutting to fit in the line, the work shall be done by skilled mechanics in a satisfactory manner so as to leave a smooth end at right angles to the axis of the pipe.

Coatings. The pipe and fittings shall be coated outside with a bituminous coating base in accordance with ANSI A21.6 (AWWA Cl06) and lined inside with polyethylene complying with ANSI/ASTM D-1248 unless otherwise noted.

Joints. Ductile iron pipe shall be provided with either of the following joints.

Mechanical and push-on joints including accessories shall conform to ANSI A21.11 (AWWA C111).

Flanged joints shall conform to ANSIA.21.10 (AWWACIIO) or ANSIBI6.1. Flanged joints shall not be used in underground installations except within structures. All flanged joints shall be furnished with 1 1/6-inch thick red rubber or asbestos fiber gaskets. The bolts shall have American Standard Heavy Unfinished Hexagonal Head and Nut dimensions all as specified in American Standard for Wrench Head Bolts and Nuts and Wrench Openings (ANSI B18.2). For bolts of 1-3/4 inch in diameter and larger, bolt studs with a nut on each end are recommended. Material for bolts and nuts shall conform to ASTM Al07.

Fittings. Cast iron or ductile iron standard and special fittings shall conform to the latest ANSI Specifications A2 1.10 (AWWA Cl10) for short bodied fittings, with end conditions as specified and permitted under pipe joints to accommodate the piping layout as shown on the plans.

Fittings shall be suitable for the following working pressures unless otherwise specified:

Pressure (psi)

Size	Cast Iron	Ductile Iron
2" - 12"	250	-
14" - 48"	150	-
3" - 24"	-	350
30" - 48"	-	250

Fittings shall be coated and lined as specified for pipe.

Connections. Connections to different sewer pipe materials shall be as shown on the plans or with adapters or couplings approved by the ENGINEER.

2.3 POLYETHYLENE (PE) PLASTIC PIPE (FORCE MAINS)

Polyethylene (PE) Plastic Pipe. PE plastic material shall conform to the latest ASTM Specifications D1248, with the following classification:
Type: III
Class: C-20 N.M. or less in average particle size
Category: 5
Grade: P34
Identification: D1248-IIIC5-P34

PE plastic pipe shall be manufactured from the material specified, and shall meet the following design criterion as determined by the latest ASTM Specification D2837.

The Hydrostatic Design Basis shall be not less than 1,420 psi.

A manufacturers' certificate that the material was manufactured and tested in accordance with the appropriate ASTM Specification shall be furnished to the ENGINEER prior to installation of the pipe.

The ENGINEER will inspect all pipes or his authorized representative immediately prior to installation and all rejected or damaged pieces must be completely removed from the project. Pipe acceptable to the ENGINEER shall be substituted for rejected or damaged pieces at the CONTRACTOR'S expense.

Pipe Joints. PE Pipe joints shall be thermally joined in conformance with the latest ASTM Specification D2657, except when connecting to pipe of a different material where the joints shall be flanged. Flanged joints shall consist of a ductile iron slip on flange, designed to fit behind a thermally joined PE stub end. Flanges shall be drilled in accordance with the standard 125-pound template shown in the latest ANSI Specification B16.1. Bolts and nuts shall be cadmium plated.

2.4 POLY-VINYL CHLORIDE (PVC) PIPE (FORCE MAINS)

At the direction of the ENGINEER, PVC pipe may be substituted for the other materials listed above.

PVC Pipe: PVC pipe material shall conform to the latest ASTYI Specification D-1784. The pipe shall conform to AWWA C900 or AWWA C905 for standard dimension ratios and shall be a minimum DR 21.

A manufacturer's certificate that the material was manufactured and tested in accordance with the appropriate AWWA Specification shall be furnished to the ENGINEER prior to installation of the Pipe.

All pipes will be inspected by the ENGINEER or his authorized representative immediately prior to installation and all rejected or damaged pieces must be completely removed from the project. Pipe acceptable to the ENGINEER shall be substituted for rejected or damaged pieces at the CONTRACTOR'S expense.

Pipe Joints: Joints shall be bell and spigot types with a rubber-sealing ring except when connecting to pipe of a different material where joints shall be flanged or mechanical joints.

Fittings (Pipes 3" and Larger): All fittings (tees, bends, etc.) shall be mechanical joint cast iron with a rubber gasket for plain end PVC pipe. Fittings for all pipe sizes shall be suitable for a working pressure of 250 psi. Fittings shall be coated and lined as specified for cast iron pipe.

Fittings (Pipes Smaller than 3"): All fittings (tees, bend, etc.) shall be Socket-Type Poly (Vinyl Chloride) (PVC) Plastic pipefitting, Schedule 80, meeting ASTM D2467.

2.5 POLY-VINYL CHLORIDE (PVC) PIPE (GRAVITY SEWERS)

PVC pipe may be used on 6", 8", 10", 12", and 15" pipe sewers where the entire length between adjacent manholes is 28 feet deep or less. PVC pipe shall not be installed in excavations deeper than 28 feet from finished grade.

PVC Pipe: PVC pipe material shall have a cell classification of 12454C as defined by the latest ASTM Specification D-1784. The pipe and fittings shall conform to ASTM D-3034, SDR-35.

Testing shall be performed in accordance to the Flexible Pipe testing specification (4.4) contained herein prior to the installation of any pipe.
The ENGINEER will inspect all pipes or his authorized representative immediately prior to installation and all rejected or damaged pieces must be completely removed from the project. Pipe acceptable to the ENGINEER shall be substituted for rejected or damaged pieces at the CONTRACTOR'S EXPENSE.

Pipe Joints: Joints shall be bell and spigot types with a rubber-sealing ring.

Fittings: Pipefitting shall be manufactured to the same requirements as the pipe previously specified. Joints shall be bell arid spigot types with a rubber-sealing ring. Wyes shall be of the "pre-molded" type and not "cut-in" type.

2.6 LARGE DIAMETER PVC GRAVITY SEWER PIPE

Approved PVC Large Diameter Gravity Sewer Pipe may be used on 18" – 24" pipe sewers where the entire length between adjacent manholes is 28 feet deep or less. PVC Gravity Sewer Pipe shall not be installed in excavations deeper than 28 feet from finish grade without prior approval from the Engineer.

PVC Large Diameter Pipe: Large Diameter PVC Gravity Sewer Pipe material shall conform to the latest ASTM Specification D-679, TYPE 1, SDR 35. PVC pipe material shall have a cell classification of 12454C as defined by the latest ASTM Specification D-1784.

Testing shall be performed in accordance to the Flexible Pipe testing specification (5.4) contained herein prior to the installation of any pipe.

The ENGINEER will inspect all pipes or his authorized representative immediately prior to installation and all rejected or damaged pieces must be completely removed from the project. Pipe acceptable to the ENGINEER shall be substituted for rejected or damaged pieces at the expense of the CONTRACTOR.

Pipe Joints: Joints shall be bell and spigot types with a rubber-sealing ring.

Fittings: Pipefitting shall be manufactured to the same requirements as the pipe previously specified. Joints shall be bell and spigot types with a rubber-sealing ring. Wyes shall be of the "pre-molded" type and not "cut-in" type.

Deflection Testing: Deflection testing shall be performed in accordance with Specification 5.5 DEFLECTION TESTING. Mandrel Specifications are detailed in Standard Drawing SAS-20.

SECTION III
Sewer Installation Requirements

3.1 HANDLING

Pipe, fittings, valves, hydrants and accessories shall be loaded and unloaded by lifting with hoists or skidding so as to avoid shock or damage. Under no circumstances shall such materials be dropped. Pipe handled on skid ways shall not be skidded or rolled against pipe already on the ground.

Pipe shall be handled so that the coating and lining will not be damaged. If, however, any part of the coating or lining is damaged, the repair shall be made in a manner satisfactory to the ENGINEER.

3.2A GRAVITY SEWERS

General: All flexible pipe shall be installed in accordance with ASTM 2321-(Underground Installation of Flexible Thermoplastic Sewer Pipe). Only a Class 1 material (ASTM 2321-6.1.1), such as ODOT 703.11 Type 3 (#57) stone, shall be used for bedding and initial backfill.

Trench Excavation: The trenches in which the sewers and appurtenances are to be constructed shall be excavated in all cases in such a manner and to such widths as will accommodate the building of the structures they are to contain. Excavation shall be stopped at the depths outlined under "Bottom Preparation" for the type of pipe being installed. Unauthorized excavation below grade shall be filled with compacted granular backfill (City of Columbus 912).

Where blasting is necessary, the CONTRACTOR shall take all reasonable precautions to prevent injury to persons and to prevent damage to the work being built or to existing structures.

No blasting shall be done within forty (40) feet of the end of the sewer, waterline or other structure without specific permission from the ENGINEER. Blasts shall be property covered and the waterline, sewer or other structure property protected. Warning shall be given to all persons in the immediate vicinity. Blasting methods and protective measures used by the CONTRACTOR shall be approved by the ENGINEER. The CONTRACTOR/OWNER shall meet and satisfy all claims for damages resulting from blasting, and shall save the ENGINEER harmless from such claims.

Trench Width: Widths of trenches shall dictated by Standard Drawing SAS-01. If, for any reason, excessive trench width occurs at depths which would impose critical loads on the pipe, the CONTRACTOR shall provide gravel or stone backup, extra strength pipe or concrete encasement as may be directed by the ENGINEER.

Foundation: The sewers are to be built on good foundation. Such measures as necessary and as directed by the ENGINEER shall he used to prevent settlement. Where the bottom of the trench at sub-grade is found to be unstable or to include ashes, cinders, all type of refuse, vegetable or other organic material, or large pieces of fragments of inorganic material which, in the judgment of the ENGINEER should be removed, the CONTRACTOR shall excavate and remove such unsuitable material to the width and depth ordered by the ENGINEER. Before the pipe is laid, the sub-grade shall be made by back filling with compacted granular backfill (City of Columbus 912) in 3 inch layers. The layers shall be thoroughly tamped as directed by the ENGINEER so as to provide a uniform and continuous bearing and support for the pipe at every point between bell holes, except that it will be permissible to disturb and otherwise damage the finished surface over a maximum length of 18 inches near the middle of each length of pipe by the

withdrawal of pipe slings or other lifting tackle. The finished sub-grade shall be prepared accurately by means of hand tools.

Drainage: Should water be encountered, the CONTRACTOR shall furnish and operate suitable pumping equipment of capacity adequate to de-water the trench, dispose of such water, and to maintain drainage conditions, satisfactory to the ENGINEER. During laying and joint making operations, the water level in the working area shall be maintained at an elevation at least two (2) inches below the bottom of the bell of the pipe until, in the opinion of the ENGINEER, water damage to complete joints will not occur. Trenches shall be kept water-free and dry during laying, bedding and jointing for as long a period as required to give a watertight joint. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the ENGINEER.

Pipe Laying and Bedding: Pipe and special fitting shall be protected during handling against impact shock and free fall. Pipe shall be kept clean at all times and no pipe shall be used in the work that does not conform to the appropriate ASTM specifications.

Grade and line stakes at regular intervals, not to exceed fifty (50) feet, will be placed at any convenient offset from the centerline of the pipe. A Laser Beam shall be placed in the downstream manhole to set pipe depth on straight runs of sewer.

The bottom man or pipe layer shall carefully prepare the bed for the pipe both from a grade and a line standpoint. All rock or stones protruding above the prepared bed shall be removed so that in no case will rock touch the pipe.

The laying of pipe in finished trenches shall commence from the lowest point, with the spigot ends pointing in the direction of flow. All pipes shall be laid with abutting and true to line and grade. They shall be carefully centered, so that when they will form a sewer with a uniform invert. When the pipe is being installed is provided with rubber seal joints, bell holes shall be excavated in the bedding material to allow for unobstructed assembly of the joint.

Preparatory to making pipe joints, all surfaces of the portions of the pipe to be jointed or of the factory-made jointing materials shall be clean and dry. Lubricants, primers, adhesives, etc., shall be used as recommended by the pipe or joint manufactures specifications. The jointing materials or factory fabricated joints shall then be placed, fitted, joined and adjusted in such a workmanlike manner as to obtain the degree of water tight that is required. In the event that pipe previously laid is disturbed due to any cause, the same shall be taken up, the joints cleaned and the pipe re-laid in accordance with the foregoing specifications.

The trench shall be excavated to a point between 4 and 6 inches below the barrel of the pipe. All loose material shall be removed from the trench bottom and a bed prepared using ODOT 703.11 Type 3 (#57) stone. After the pipe is laid, graded and aligned, Class 1 material such as ODOT 703.11 Type 3 (#57) stone shall be brought up to a point 12” above the top of pipe the full width of the trench. At times when pipe laying is not in progress, the open ends of the pipe shall be closed by a watertight plug or other approved means.

Timbering: Unsupported open cut for sewers will not be permitted where soil conditions necessitate unusually wide trenches causing damage to street pavement, trees, structures, poles, or other private or public property. During the progress of the work, whenever and wherever it is necessary either to provide safe working conditions or to avoid the danger of damage to existing structures or structures being built, the CONTRACTOR shall, at their expense, support the sides of the excavation by adequate and suitable sheeting, shoring, and bracing.

Such trench support material and equipment shall remain in place until backfilling operations have progressed to a point where the supports may be withdrawn without endangering structures. No sheeting, shoring or bracing will be paid for by the OWNER unless left in place on written order of the ENGINEER. The OWNER will pay the CONTRACTOR for the timber left in place, as ordered by the engineer at the rate indicated in the "General Specifications"

Backfilling: Back filling shall begin twelve (12) inches above the top of the pipe. Machine back filling may be utilized if moved along the trench and not dumped directly on previously placed material. The backfill material shall conform to the requirements of compacted granular backfill (City of Columbus item 912). All backfill shall follow the requirements listed in Standard Drawing SAS-01.

3.2B TRENCH DAMS

The contractor shall place cutoff trench dams of native clay or impervious soil across and along the trench between adjacent manholes to retard and resist the movement of groundwater through the trench. The trench dam shall be carefully compacted and shall be 6 feet in length, as measured along the sewer centerline and shall be benched into undisturbed trench sides from the subgrade or top of cradle to within 5 feet of the existing surface. If the sewer is in rock or hardpan, the trench dam shall extend to the top of whichever is greater. Where the pipe cover is less than 5 feet, the dam shall extend to within 1 foot of the existing surface. The trench dam shall have a minimum of 3 feet of compacted material above the crown of the pipe.

3.3 FORCE MAINS

Protection of Trees: Special care shall be taken to avoid damages to trees and their root system. Machine excavation shall not be used when, in the opinion of the ENGINEER, it would endanger tree roots. In general, where the line of trench falls within the limits of the limb spread, the leaving of headers across the trench to protect roots will be required. The operation of all equipment, particularly when employing booms; the storage of materials; and the deposition of excavation shall be conducted in the manner which will not injure trees, trunks, branches or their roots unless such trees are designated by the ENGINEER for removal.

Trench Excavation (Earth): The trenches in which the mains and appurtenances are to be constructed shall be excavated in all cases in such a manner and to such widths as will accommodate the building of the

mains and appurtenances they are to contain. Machine excavation shall be stopped at the depths outlined under "Bottom Preparation" for the type of pipe being installed. Unauthorized excavation below grade shall be filled with compacted granular material (City of Columbus item 912), at the expense of the CONTRACTOR.

Trench Excavation (Rock): Where excavation is made in rock or boulders, the trench shall be excavated at least 6 inches below and on each side of the pipe barrel for pipes 24 inches in diameter or less, and 9 inches for pipes larger than 24 inches in diameter. The pipe shall then be bedded in ODOT 703.11 Type 3 (#57) stone placed on the trench bottom in accordance with the requirements for "Foundation" contained herein. Bulkheads of native clay soil shall be placed across the trench at 100 feet intervals to resist the unnatural movement of groundwater through the granular material. Said bulkheads shall be carefully compacted and shall extend approximately 3 feet in a direction parallel to the pipe and shall extend from the bottom of the trench to a height of one-half foot above the top of the pipe or to the top of the rock if in rock excavation. Unauthorized excavation below grade shall be filled with compacted granular material (City of Columbus item 912), at the expense of the CONTRACTOR.

Where blasting is necessary, the Contractor shall take all reasonable precautions to prevent injury to persons and to prevent damage to the work being built or to existing structures.

No blasting shall be done within forty (40) feet of the end of the main or other structure without specific permission from the ENGINEER. Blasts shall be properly covered and the main, or other structure properly protected. Warning shall be given to all persons in the immediate vicinity. Blasting methods and protective measures used by the CONTRACTOR shall be approved by the ENGINEER.

The word "rock" wherever used as the name of an excavated material, shall mean boulders and solid masonry larger than one-half cubic yard in volume, or solid ledge rock and masonry which, in the opinion of the ENGINEER, requires for its removal drilling and blasting, wedging, sledging or barring, or breaking up with a power operated hand tool. No soft or disintegrated rock which can be removed with a hand pick or power operated excavator or shovel; no loose, shaken or previously blasted rock or broken stone in rock fillings or elsewhere; and no rock exterior to the limits of measurement, which may fall into the excavation, will be measured or allowed when extra payment for rock excavation is set forth.

Trench Width: Widths of trenches shall dictated by Standard Drawing SAS-01. If, for any reason, excessive trench width occurs at depths which would impose critical loads on the pipe, the CONTRACTOR shall provide gravel or stone backup, extra strength pipe or concrete encasement as may be directed by the ENGINEER.

The width of excavation for manholes shall be as excavated, but not to exceed twelve (12) inches outside the footer and the depth shall not exceed six (6) inches below the footer.

Where the sewer is located adjacent to or in pavement, the CONTRACTOR shall be required to maintain vertical sides on all trenches using full sheeting and bracing if necessary. Maximum top width of trench permitted under such conditions shall be four (4) feet, plus the inside diameter of the pipe

Bottom Preparation: Bell holes shall be provided at each joint to permit the jointing to be made properly.

Ledge rock, boulders and stones shall be removed to provide a minimum clearance of at least 6 inches below and on each side of the pipe barrels, valves and fittings for pipe 24 inches in diameter or less, and 9 inches for pipes larger than 24 inches in diameter.

The trench shall be excavated to a point not less than one-fourth the nominal pipe diameter, and in no case less than four (4) inches below the barrel of the pipe. All loose material shall be removed from the trench bottom and a bed prepared using granular material consisting of crushed stone or pea gravel which will conform to the following:

Pipe Size	AASHTO No.
6" - 12"	7, 78, or 8
15" - 30"	67, 68, or 6
30" +	57

Foundation: The sewers are to be built on good foundation. Such measures as necessary and as directed by the ENGINEER shall be used to prevent settlement.

Where the bottom of the trench at sub-grade is found to be unstable or to include ashes, cinders, all type of refuse, vegetable or other organic material, or large pieces of fragments of inorganic material which, in the judgment of the ENGINEER should be removed, the CONTRACTOR shall excavate and remove such unsuitable material to the width and depth ordered by the ENGINEER. Before the pipe is laid, the sub-grade shall be made by back filling with compacted granular backfill (City of Columbus item 912) in 3 inch layers. The layers shall be thoroughly tamped as directed by the ENGINEER so as to provide a uniform and continuous bearing and support for the pipe at every point between bell holes, except that it will be permissible to disturb and otherwise damage the finished surface over a maximum length of 18 inches near the middle of each length of pipe by the withdrawal of pipe slings or other lifting tackle. The finished sub-grade shall be prepared accurately by means of hand tools.

Where the bottom of the trench at sub-grade is found to consist of material which is unstable to such a degree that, in the opinion of the ENGINEER, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, the CONTRACTOR shall construct a foundation for the pipe, consisting of piling, timbers, or other materials, in accordance with plans prepared by the ENGINEER.

Drainage: Should water be encountered, the CONTRACTOR shall furnish and operate suitable pumping plant equipment of capacity adequate to de-water the trench, dispose of such water, and to maintain drainage conditions, satisfactory to the ENGINEER. It is essential that the discharge of the trench de-watering pumps be conducted to natural drainage channels, drains or sewers.

Pipe Laying: Proper implements, tools and facilities satisfactory to the ENGINEER shall be provided and used by the CONTRACTOR for the safe and convenient prosecution of the work. All pipe, fittings, valves and hydrants shall be carefully lowered into the trench piece by piece by means of a derrick, ropes or other suitable tools or equipment, in such a manner as to prevent damage to the sewer materials and protective coatings and linings. Under no circumstances shall sewer materials be dropped or dumped into the trench.

The bottom man or pipe layer shall carefully prepare the bed for the pipe both from a grade and line standpoint. All rock or stones protruding above the prepared bed shall be removed so that in no case will rock touch the pipe. The pipe and fittings shall be inspected for defects and, while suspended above grade, be rung with a light hammer to detect cracks.

Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the line. During laying operations, no debris, tools, clothing or other materials shall be placed in the pipe.

After placing a length of pipe in the trench, the spigot end shall be centered in the bell and the pipe forced home and brought to correct line and grade. Pipe and fittings which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipe and fittings of proper dimensions to insure such uniform space. Precautions shall be taken to prevent dirt from entering the joint space.

The laying of pipe in finished trenches shall commence from the lowest point, with the spigot ends pointing in the direction of flow. All pipe shall be laid with ends abutting and true to line and grade. They shall be carefully centered, so that when laid they will form a sewer with a uniform invert.

Preparatory to making pipe joints, all surfaces of the portions of the pipe to be jointed or of the factory-made jointing material shall be clean and dry. Lubricants, primers, adhesives, etc. shall be used as recommended by the pipe or joint manufacturers' specifications. The jointing materials or factory fabricated joints shall then be placed, fitted, joined, and adjusted in such a workmanlike manner as to obtain the degree of water-tightness required. In the event that pipe previously laid is disturbed due to any cause, the same shall be taken up, the joints cleaned and the pipe re-laid in accordance with the foregoing specifications. Trenches shall be kept water-free and dry during laying, bedding and jointing for as long a period as required to give a watertight joint. After the pipe is laid, graded and aligned, the bedding material shall then be brought up halfway on the pipe for the full width of the trench using granular material so placed as to fill the space under the lower part of the pipe.

The remaining side fill and the backfill to a point 12" over the top of the pipe shall be made with the same granular material or in accordance with the requirements for trench backfill herein.

At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the ENGINEER.

The cutting of pipe for inserting valves, fittings, or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe or cement lining and so as to leave a smooth end at right angles to the axis of the pipe.

The flame cutting of pipe by means of an oxyacetylene torch shall not be allowed.

Deflections in pipe joints in excess of the manufacturer's recommendations will not be permitted.

No pipe shall be laid in water or when, in the opinion of the ENGINEER, trench conditions are unsuitable.

Push-On Joints: The surfaces with which the rubber gasket comes in contact shall be cleaned thoroughly just prior to assembly. The gasket shall then be inserted into the groove in the bell. Before starting joint

assembly, a liberal coating of special lubricant shall be applied to the spigot end. With the spigot end centered in the bell, the spigot end is pushed home.

Setting Valves: Valves shall be set and jointed to the pipe in the manner heretofore specified under "Pipe Laying". Valves shall be set on a firm foundation so that no load will be transferred to the connecting pipe. Valves in mains shall, where possible, be located on the street property lines extended unless otherwise shown on the plans. A valve box (or masonry pit where specified) shall be provided for every valve. A valve box shall not transmit shock or stress to the valve and shall be centered and plumb over the operating nut of the valve, with the box cover flush with the surface of the finished pavement unless otherwise shown.

Anchorage: All plugs, caps, tees and bends shall be provided with a reaction backing or movement shall be prevented by attaching suitable metal rods, clamps, or anchored fittings as shown or specified.

Reaction backing shall be 4,000 psi concrete as specified elsewhere in the specifications. Backing shall be placed between solid ground and the fitting to be anchored; the area of bearing on the pipe and on the ground in each instance shall be that shown. The backing shall, unless otherwise shown, be so placed that the pipe and fitting joints will be accessible for repair. Reaction backing shall follow the requirements listed in Standard Drawing SAS-17.

Timbering: Unsupported open cut for mains will not be permitted where soil conditions necessitate unusually wide trenches causing damage to street pavement, trees, structures, poles, or other private or public property. During the progress of the work, whenever and wherever it is necessary either to provide safe working conditions or to avoid the danger of damage to existing structures or structures being built, the CONTRACTOR shall, at his expense, support the sides of the excavation by adequate and suitable sheeting, shoring and bracing. Such trench support material and equipment shall remain in place until back filling operations have progressed to the point where the supports may be withdrawn without endangering structures. No sheeting, shoring or bracing will be paid for by the OWNER unless left in place on written order of the ENGINEER. The OWNER will pay the CONTRACTOR for timber left in place, as ordered by the ENGINEER at the rate indicated in the "General Specifications".

Trimming: All excavated material and all materials used in construction of the work shall be piled in a manner that will not endanger the work and that will leave sidewalks and driveways, hydrants under pressure, valve pit covers, valve boxes, curb stop boxes, fire and police call boxes, or other utility controls unobstructed and accessible until the work is completed. Gutters shall be kept clear or other satisfactory provisions made for street drainage, and natural watercourses shall not be obstructed. During the progress of the work, all material piles shall be kept trimmed up and maintained in a neat, workmanlike manner.

Cleaning Up: All surplus sewer main materials furnished by the CONTRACTOR, all tools, temporary structures, stones and all other debris shall be removed from the site by the CONTRACTOR. All dirt, rubbish and excess earth from the excavation shall be hauled to a dump provided by the CONTRACTOR and the construction site left clean to the satisfaction of the ENGINEER.

The CONTRACTOR shall be responsible for the condition of the trenches for a period of one year from the date of the final acceptance.

3.4 SUPPLEMENTAL FOR PE/PVC PIPE

The following specifications for the installation of PE/PVC pipe are supplemental to the force main installations specifications.

Storage: Care shall be taken during transportation, handling, storing, and installation to insure that the PE/PVC pipe is not scored, or otherwise abused. Avoid use of cables or hooks without protection, dropping or dragging over rocks, sharp objects or other obstructions, stacking of PE/PVC pipe to a height which would cause excessive deformation of lower pipe.

PE/PVC pipe which is deformed in excess of 5 percent of its internal diameter shall be rejected by the ENGINEER.

PE/PVC pipe which has scratches, gouges, or cuts exceeding 10 percent of the wall thickness shall be rejected by the ENGINEER.

Trench Back Filling: All backfill material shall be free from cinders, ashes, refuse, vegetable or organic material, boulders, rocks, or other material which in the opinion of the ENGINEER is unsuitable.

All trenches shall be back filled by hand, from a minimum of 4 inches below the pipe to 12 inches above the top of pipe, with No. 57 stone placed in layers of 4 to 8 inches and homogeneously compacted to 80-85 percent modified proctor. Back filling material shall be deposited in the trench for its full width on each side of the pipe, fittings, and appurtenances simultaneously.

From 12 inches above the pipe to the grade shown on the drawings or specified herein, the trench shall be back filled by hand or by approved mechanical methods.

3.5 WYES, RISERS, AND HOUSE SERVICES

Wye Branches: The Contractor shall furnish and install where designated herein or directed by the ENGINEER, wye branches of the proper size and type as shown on Standard Drawings SAS-02 & SAS-03. The wye branches shall be of the same joint, strength and material as the main sewer. In general, branches shall be placed in the main sewer opposite each lot or property to which service shall be extended. Wye branches shall be extended to terminate no less than 13' from a manhole.

Trench Dams: All service lines shall have a trench dam installed per Section 3.2B, and conform to Standard Drawing SAS-04.

Riser Pipe: Where the cover on the wye branch is in excess of 12’-0" below average ground service, sufficient riser pipe shall be added to terminate (to the nearest even length of riser pipe) at a depth of 10'-0" below the ground surface, provided the property being served will not require additional depth. Method of construction is shown by Standard Detail SAS-03.

Deep socket adapters, GPK Products or equal, are required on risers unless laterals are on a 1:1 slope or flatter. The riser pipe shall be of the same joint, strength and material as the main sewer.

All wye fittings shall be SDR-35 sewer pipe and shall have a two foot (minimum) service extension installed prior to the service being capped and backfill being placed over the mainline lateral sewer

The CONTRACTOR shall provide and install 4" by 4" lumber wye poles at all wye locations as constructed. Wye poles shall extend above existing or proposed grade whichever is higher, a minimum of 4'-0". A 3' length of ¾" diameter steel pipe or rod shall be attached to the wye pole 2" below final grade. Cost to be included with various sewer items. Wye Poles to be painted pink.

House Servicing: House services are to be extended from the wye branch specified above and are to terminate as designated on Standard Drawing SAS-02.

Services to be extended from main sewers over 10'-0" deep, where the property being served does not require the full depth, may be brought up to grade in the manner described above for riser pipe with payment for all pipe as house service only. Services from main sewers with less than 10'-0" depth will be extended on a straight uniform grade from the main to the point of terminus as indicated by Standard Detail SAS-02. Depths of services at the point of termination will be supplied by the ENGINEER, but in general will be held to a minimum of 8'-0" when the depth of the main permits. Minimum grade for 6 inch house service shall be two (2%) percent. Unless otherwise shown on the plans or directed by the ENGINEER, all house services shall be installed in a trench with a maximum width at the top of the pipe barrel of 24 inches. Preceding specifications for sewer pipe, joints and installation are applicable for all house services.

If it becomes necessary to cut a wye into an existing main, no saddles or Fernco coupler can be used on the connection.

3.6 INTERCEPTIONS AND CONNECTIONS

The CONTRACTOR shall provide all labor, tools, material and equipment necessary for intercepting existing sewers and connecting new sewers to existing manholes.

This work shall include neatly breaking out existing sewers within new manholes, plugging with concrete, sewers to be abandoned within new and existing manholes, connecting into and reshaping inverts within existing manholes to accommodate the new sewers, and temporarily plugging new sewers, and temporarily plugging new sewers within existing manholes. All plugs and connections shall be done in a workmanlike manner and made watertight. The materials and installation of materials shall be in accordance with the other specifications contained herein.

3.7 RIVER CROSSINGS & FLOWING STREAMS

Description: The CONTRACTOR shall furnish all labor, materials, and equipment necessary to install the river crossings as shown on the plans.

General: It is the intent of the plans and specifications to install the river crossings in such a manner as to protect the sewer from erosion and to restore, as much as practicable, the river banks and bottom to their original condition.

Sewer Protection: The sewer will be protected from erosion either by concrete encasement around the pipe or by a concrete slab level with the top of rock above the pipe.

River Bank Restoration: The river banks will be restored by back filling the sewer pipe trench with mechanically compacted earth to the original ground surface. The river banks will be graded, fertilized, and seeded, or protected from erosion immediately following the completion of the crossing. Riprap shall be utilized for bank protection on outside curves in streams and rivers, where directed by the ENGINEER.

River Bottom Restoration: The river bottom trench above the concrete will be back filled with excavated river bottom material.

Construction Procedure: The CONTRACTOR shall use either of the following methods to install the river crossings:

Option 1: The CONTRACTOR shall construct an earth embankment from the riverbank to a point beyond the centerline of the river. The slopes of the earth embankment shall be protected from erosion by covering them with 6 mil polyethylene sheeting. The sheeting shall extend from the river bottoms to an elevation 2 feet above the water level. The sewer pipe shall then be installed in a trench excavated through the embankment. The embankment and material and any excess trench excavation shall be removed to an off-site disposal area.

The same procedure shall be used to install the remainder of the river crossing.

Option 2: The CONTRACTOR shall construct a cofferdam of sand bags or inflatable bags, from the riverbank to a point beyond the centerline of the river. The sewer pipe shall then be installed in a trench within the cofferdam. Any excess trench excavation shall be removed to an off-site disposal area. The cofferdam shall then be removed.

The same procedure shall be used to install the remainder of the river crossing.

3.8 INTERFERENCE WITH TRAFFIC

Maintaining Traffic: All railroad crossings and certain road and street crossings indicated on the plans shall be accomplished by installing an encasement pipe by boring, tunneling, or jacking in a manner prescribed by the plans and specifications with vehicular traffic maintained at all times. With prior approval of the City Engineer at other locations, the CONTRACTOR may close the street to through traffic for minimum periods of time with proper notice to local occupants of all premises, police and fire protection authorities and other public authorities as applicable. The CONTRACTOR shall so schedule his work that this time is a minimum and shall whenever possible make suitable provisions for access by local residents, school buses, police and fire emergency vehicles, and mail delivery vehicles. The CONTRACTOR shall keep fire hydrants and other public utility valves accessible at all times.

At street or road crossings where the CONTRACTOR is permitted to open cut the sewer trench, the crossings shall be completed, cleaned up, temporary pavement in place, and open to traffic within 12 hours

from the time the street or road is closed to through traffic, unless specific approval is received for a longer period. All open cuts within the Right-of-Way must follow Standard Drawing STR-04.

When it is required that the street or road be closed to traffic, the CONTRACTOR shall furnish, erect and maintain barricades, suitable and sufficient red lights and other lights or reflecting material at the limits of the project, where side streets intersect and at other points of public access to the project. The CONTRACTOR shall furnish, erect and maintain advance warning signs and barricades on side streets at the first street intersection beyond the one closed by construction indicating "Street Closed, Local Traffic Only". Forty-eight (48) hours before any closure occurs a Maintenance of Traffic plan must be submitted to the City Engineer for his/her approval.

The CONTRACTOR shall furnish, erect and maintain detour marking signs on temporary routes.

Throughout construction, the CONTRACTOR shall furnish, erect and maintain such lights, signs and barricades as may be required for the protection of any local traffic permitted on the street.

Whenever one-way traffic is established, at least two flagmen shall be used. The flagmen shall be equipped and shall perform their duties according to the standard for flagging traffic contained in the Ohio Manual of Uniform Traffic Control Devices.

All lights, signs, and barricades shall be in accordance with the latest edition of the Ohio Manual of Uniform Traffic Control Devices.

Where the work is performed in the sidewalk or crosswalk area, the CONTRACTOR shall provide lights, barricades, etc., that may be needed for the protection of pedestrian traffic.

If in the opinion of the ENGINEER proper maintenance of traffic facilities and proper provision for traffic control are not being provided and the safety of the public is thus endangered, the ENGINEER may take the necessary steps to place them in proper condition and the cost of such services will be charged to the OWNER.

3.9 SANITARY SEWER SERVICE CONNECTIONS

There shall be no storm or clean water connections to the sanitary sewer i.e. footer drains, downspouts, etc.

Forty-eight (48) hours written notice shall be given prior to the start of any construction. This notice shall include the name and address of the OWNER, the name of the CONTRACTOR (Sewer Tapper) and the location of the property (street, address and subdivision lot number - do not give lot numbers assigned by realtors unless they coincide with the subdivision lot number). No permit will be issued unless this information is submitted in writing.

All services shall be a minimum of 6" nominal diameter and shall be laid on an even grade of not less than 2 percent.

Approved materials are as specified Section II of these specifications. All transition connections shall be made with adapters or flexible connections approved by the ENGINEER. Installation shall be in

accordance with Section 3.2A of these specifications as well as the requirements listed in Standard Drawings SAS-02 and SAS-03.

3.10 ENCASEMENT PIPES

This work shall consist of furnishing and installing an encasement pipe of a sufficient size, minimum size if so stated, to permit the installation of the carrier pipe therein and the encasing of the carrier pipe as shown on the plans or as specified. All utility encasement shall follow Standard Drawing SAS-18.

General: Crossings constructed on the right-of-way of private companies or public agencies shall conform to the requirements and regulations of the respective companies and agencies. The OWNER will acquire the necessary permits and crossing rights from the respective authorities involved. The CONTRACTOR/OWNER shall be responsible for the payment of any costs due to the authority's requirements, of whatever nature, including watchmen and supervision by the authority's forces. Where work under this item involves railroads, the CONTRACTOR shall perform his work in such a manner so as not to interfere with the operation of the railroad and shall save the railroad harmless from any claims resulting from the operations or omissions of the CONTRACTOR. The CONTRACTOR shall perform his work below the track level and shall not obstruct the roadbed of the railroad.

The CONTRACTOR shall, before beginning work on the crossings, submit to the ENGINEER the work schedule and shop drawings together with a description of the methods and materials to be used in constructing the crossing.

The CONTRACTOR shall submit with his proposal evidence to prove to the satisfaction of the ENGINEER that he has had previous experience in this type of work or that he will have a superintendent with the required experience continuously employed on the construction until the crossing work is completed.

Encasement Pipe: The encasement pipe shall meet the requirements of the private or public authority involved. Detailed drawings of the encasement pipe proposed for use shall be submitted to the ENGINEER for approval.

Construction: The crossing shall be accomplished by boring and jacking.
When boring and jacking the encasement pipe, extreme care shall be taken to maintain grade and alignment of the pipe. After the carrier pipe has been installed in the encasement pipe, the backfill shall be tightly tamped around the ends of the encasement pipe, unless otherwise noted.

All shoring, blocking, or other special supports, if required, shall be provided by the CONTRACTOR.
In the event that a boring is started and not completed for some reason, the hole shall be filled with either sand or grout injected under pressure.

3.11 TUNNELS

Description: This work shall consist of excavating for, furnishing and installing a tunnel liner of a sufficient size, minimum size if so stated, to permit the installation of the carrier pipe therein and the encasing of the carrier pipe as shown on the plans or as specified.

General: Tunnels constructed on the right-of-way of private companies or public agencies shall conform to the requirements and regulations of the respective companies and agencies. The OWNER will acquire the necessary permits and crossing rights from the respective authorities involved. The CONTRACTOR shall be responsible for the payment of any costs due to the authority's requirements, of whatever nature, including watchmen and supervision by the authority's forces. Where work under this item involves railroads, the CONTRACTOR shall perform his work in such a manner so as not to interfere with the operation of the railroad and shall save the railroad harmless from any claims resulting from the operations or omissions of the CONTRACTOR. The CONTRACTOR shall perform his work below the track level and shall not obstruct the roadbed of the railroad**.**

The CONTRACTOR shall, before beginning work on the tunnel, submit to the ENGINEER the work schedule and shop drawings together with a description of the methods and materials to be used in constructing the tunnel. The CONTRACTOR shall submit with his proposal evidence to prove to the satisfaction of the ENGINEER that he has had previous experience in this type of tunneling work or that he will have a superintendent with the required experience continuously employed on the tunnel construction until the tunnel work is completed.

Liner Plates: Design and shape of the liner plates shall be such that erection and assembly of the liner plates can be completely and readily performed from inside the tunnel. Plates shall be accurately curved to suit the tunnel cross section, and all dimensions shall be of such size and accuracy that plates of the same curvature will be interchangeable and readily handled in the tunnel.

Design thickness of the liner plates shall be sufficient to support the loads above and around the tunnel, with deflection of the lining ring not exceeding 3 percent of the tunnel diameter. Minimum thickness shall be 3/16 inch. The liner plates shall also meet the requirements of the private or public authority involved.

Detailed drawings of the liner plates proposed for use shall be submitted to the ENGINEER for approval. Bolts and nuts provided shall be coarse threads of free fit for ease in assembly. Bolts shall be of proper size for the thickness of liner plates used.

Installation of Liner Plates: Liner plates shall be installed to the proper alignment and grade as shown on the plans. Care shall be taken to avoid loss of ground beyond the tunnel lining, and to assure bearing against the ground all around the tunnel. Where excessive amounts of ground are removed, the space between the liner plates and ground surface shall be back filled or packed with hay and afterwards consolidated by means of grouting.

The excavation shall be carefully done to avoid loss of ground as noted heretofore. In unstable ground, the face of the tunnel shall be supported by means of breast boards removed individually and advanced as the face of the excavation is mined down and liner plates installed. In running of raveling ground where the material will not remain in place long enough to excavate space for liner plates, wood spieling boards, shields or other methods suggested and approved by the ENGINEER may be used. Such approval, however, shall not relieve the CONTRACTOR of responsibility for the safe and rapid prosecution of the work.

Pressure Grouting: The space remaining outside the liner plates shall be grouted under pressure through grout holes provided in the tunnel periphery longitudinal spacing of the holes shall be at a maximum spacing of five (5) feet. The pressure grouting shall preferably begin in the lower quadrants of the tunnel with the upper holes being open and proceed upward simultaneously on each side of the tunnel until the voids are filled. The pressure shall be such that it will not cause distortion of the liner plates. Grout stops shall be provided at the ends of the tunnel to allow pressure grouting for the full length of the tunnel. The sand-cement grout shall have a ratio of 6:1.

Fill Material: After the sewer has been installed inside the tunnel, the space remaining between the sewer and the tunnel liner shall be completely filled with grout having a sand-cement ration of 5:1 or concrete containing a minimum of 4.5 bags of cement per cubic yard.

Type of Liner Plate: The liner plates shall be provided with flanges with bolt holes in both sides and both ends for attaching adjacent plates. The corners of the plates shall be practically square to prevent inflow of material through openings between flanges when the plates are bolted together.

3.12 EXISTING UTILITIES AND STRUCTURES

Where existing utilities and structures are indicated as being in the line of the proposed improvement, the CONTRACTOR shall expose them, as directed by the ENGINEER. This work is to be done sufficiently in advance of the construction operations to permit adjustments in line or grade, if required, to eliminate interference's. Existing pipes or conduits crossing the trench, or otherwise exposed shall be adequately braced and supported to prevent trench settlement from disrupting the line or grade of the pipe or conduit, all in accordance with the directions of the ENGINEER. Utility services broken or damaged shall be repaired at once to avoid inconvenience to customers. Storm sewers shall not be interrupted overnight. Temporary arrangements, as approved by the ENGINEER, may be used until any damaged items can be permanently repaired. All items damaged or destroyed by construction and subsequently repaired must be properly maintained by the CONTRACTOR.

Where it is necessary to relocate an existing utility or structure, the work shall be done in such a manner as is necessary to restore it to a condition equal to that of the original facility. No such relocation shall be done until approval is received from the authority responsible for the utility or structure being changed.

3.13 STUBS AND PLUGS FOR FUTURE CONNECTION

Where required by the ENGINEER, stubs and plugs shall be provided for future service to non-sewer areas. The maximum length of stubs and plugs shall be 5'.

SECTION IV
Sewer Testing

4.1 GRAVITY SEWERS

The CONTRACTOR shall be required to conduct tests to determine that it is watertight of the sewer when completed. The tests shall be observed by the ENGINEER, but the CONTRACTOR shall furnish all labor, equipment and materials, required in connection therewith.

Sanitary Sewer Leakage Testing

All sanitary sewer lines, including service connections, shall be substantially watertight and shall be tested for excessive leakage upon completion and before connections are made to the service by others.

For gravity flow sewers, the sewer shall be subjected to exfiltration testing, by the ASTM F1417 OR UNI-B-6 (low pressure air) test method regardless of pipe material.

The requirements set forth for maximum leakage shall be met as a condition for acceptance of the sewer section represented by the test. All testing shall be performed by the Contractor without any direct compensation being made therefore, and the Contractor shall furnish all necessary equipment and materials including plugs as required

The time of duration permitted for the above pressure drop shall be determined by the Uni-B-6 tables or the ASTM F1417 tables. (Gravity Sewer Lines)

All manholes are to be vacuum tested in accordance with ASTM C-1244 (10 States Standards).

It is understood that each section, as above described, must be tested and determined by the ENGINEER to conform to this paragraph before such section is accepted by the ENGINEER. It is further understood that, if the leakage does not come within the limits specified, the CONTRACTOR will be required to do such work as may be necessary in order to insure conformance even to the extent of reconstructing the defective section or sections.

When PVC or ABS pipe is used, a deflection test shall be performed. Pipe deflection shall not exceed 5%. All installed pipe shall be tested for deflection sixty (60) days or more after the trench has been back filled to finish grade. The method of testing shall be subject to the approval of the ENGINEER. If rigid balls or mandrels are used to test the pipe deflection, no mechanical pulling devices shall be used. Any lines which fail the test must be repaired and re-tested. Mandrel dimensions and testing shall follow the requirements listed in Standard Drawing SAS-20.

Smoke and dye testing shall be performed on all lateral sewers constructed to new or existing houses if so required by the ENGINEER.

4.2 FORCE MAINS

Hydrostatic Tests: After the pipe has been laid and back filled, all newly laid pipe, or any valve section thereof, shall be subjected to a hydrostatic pressure and leakage test.

Each valve section of pipe shall be slowly filled with water and the specified test pressure shall be applied by means of a pump connected to the pipe in a manner satisfactory to the ENGINEER. The CONTRACTOR shall furnish the pump, pipe connections, and all other necessary apparatus and assistance

to conduct the test. Gauges for the test shall be furnished by the CONTRACTOR or by the OWNER, at the OWNER'S option. The pipe shall be tested in maximum lengths of 5,000 feet.

Before applying the specified test pressure, all air shall be expelled from the pipe. The duration of each pressure and leakage test shall be two hours. During the test, the main shall be subjected to a hydrostatic pressure of 150 lbs. per square inch at the lowest elevation.

Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valve section thereof, necessary to maintain the specified leakage test pressure after the pipe has been filled with water and the air expelled.

No pipe installation will be accepted until the leakage is not in excess of 10.48 gallons per inch diameter per mile of pipe per 24 hours. Should any test of pipe laid disclose leakage greater than that specified, the CONTRACTOR shall at his own expense locate and repair the defective joints, pipes, fittings, or the like until the leakage is within the specified allowance, and the line again tested until proven satisfactory to the ENGINEER. The formula $L=(SD(P^{0.5}))/148000$ determines allowable leakage per hour, in gallons.
L= Allowable Leakage
S = Length of line in feet
D = Diameter of Pipe in inches
P = Test Pressure of Pipe (Formula uses square root of pressure.)

4.3 SEWER ACCEPTANCE POLICY

Test Period: After the completion and successful operation of the Project or such part thereof for a period of ten days by the CONTRACTOR, the CITY shall have the right to take full charge and control thereof and operate the same for a period of 30 days before conditional acceptance. During the above ten day period, the CONTRACTOR shall furnish all necessary fuel, oil, light, power and attendance. The ten day successful operation shall constitute substantial completion.

Defects: If within the 10 (ten) day test period specified above, and any defects appear in the work, materials, apparatus, workmanship, or subsidence of the PROJECT or failure in the operation or performance of any part thereof of guarantee required hereunder due to the failure, neglect or refusal of the CONTRACTOR to comply with the terms and provisions of these specifications for the work, such defect or failure shall be repaired, restored, corrected or made good to the satisfaction of, and without cost to, the CITY All engineering, inspection, legal and other costs and expense to the CITY occasioned by or resulting from such defect or failure shall be paid by the CONTRACTOR or DEVELOPER or OWNER upon demand by the CITY

Conditional Acceptance: At the expiration of the 30 day test period provided for above, the CONTRACTOR having fully completed the work to be performed in this PROJECT, the CITY shall conditionally accept the PROJECT.

The provisions of the paragraph defects shall apply to any defect in the work, materials, apparatus or workmanship of the PROJECT or failure in the operation or performance of any part thereof or guarantees required hereunder determined by the Sanitary Engineer to have occurred, developed or appeared during a period of 365 calendar days after the date of conditional acceptance.

Final Acceptance: Upon the expiration of the 365 calendar days after the date of conditional acceptance the Engineer shall satisfy himself by test, examination or otherwise that the work has been finally and fully completed in accordance with the specifications, and shall make a final statement of the work done on this PROJECT to the CITY.

Guarantees: The OWNER shall obtain all equipment guarantees in the name of the CITY OF MARYSVILLE. Said guarantees shall be so written that the first day of use shall coincide with the first day following Conditional Acceptance.

4.4 FLEXIBLE PIPE TESTING AND ACCEPTANCE POLICY

Flexible pipe (PVC, ABS, ABS COMPOSITE) shall be tested at least once a year for compliance with current ASTM standards. The minimum testing for each type and size of pipe is as follows:

1) PVC PIPE

a)Pipe and Fitting Dimensions.
ASTM 3034 Section 7.2 and 7.4.

b)Pipe Flattening.
ASTM 3034 Section 8.6.

c)Impact Resistance.
ASTM 3034 Section 8.7.

d)Pipe Stiffness.
ASTM 3034 Section 8.

e)Extrusion Quality.
ASTM 3034 Section 8.9

Flexible pipe manufacturers/suppliers shall have 6", 8", 10”, 12”, and 15" pipe tested in accordance with the above standards, by an independent testing laboratory. A certified copy of the results shall be provided to the ENGINEER. Only pipe which has been tested in the last twelve (12) months and meets all of the above testing requirements will be permitted for use in the City of Marysville.

From the above information, a list of manufacturer’s type and size of flexible pipe which may be used in the City of Marysville, shall be published. Manufacturers/suppliers shall qualify pipe each new calendar year. Additional testing shall be provided by the ENGINEER to verify the results provided. Any failures will disqualify the use of that product for the remaining calendar year.

Main line sanitary sewer CONTRACTORS shall supply a 5' piece (bell end) of each type and size of pipe they are proposing to use, two (2) weeks prior to the start of construction. CONTRACTORS shall only use

pipe which has previously been approved. The sample pipe may be spot tested in accordance with current ASTM standards to verify the testing results provided by the pipe manufacturers. Should the City of Marysville obtain any testing results which do not meet ASTM standards, it shall disqualify the use of that size and brand of pipe for the remaining calendar year.

Licensed Sewer Tappers shall provide the City of Marysville with a 5' piece (bell end) of approved 6" pipe that they will use at the time that they secure the Tapper's license. Random tests will be performed on this sample to verify the test results supplied by the pipe manufacturer. Any pipe tested by the City of Marysville which does not meet the appropriate ASTM standards shall not be used the remaining calendar year. Sewer Tappers may change brands of pipe throughout the calendar year at the approval of the ENGINEER; further testing may be required.

4.5 DEFLECTION TESTING

The CONTRACTOR shall be required to conduct tests to determine the roundness of the sewer when completed if flexible pipe is used. The tests shall be observed by the ENGINEER, but the CONTRACTOR shall furnish all labor, equipment and materials, required in connection therewith. All deflection testing shall follow the requirements listed in SAS-20.

When P.V.C. pipe is used, pipe deflection shall not exceed 5% if tested after SIXTY (60) days or 7 1/2% if tested after ninety (90) days of installation. A rigid mandrel shall be used to test the pipe deflection and it shall be sized in accordance with Standard Drawing SAS-20. Any sewers which fail the tests must be replaced or re-rounded and re-tested. No mechanical pulling devices shall be used.

Prior to final acceptance of completed flexible sewer lines, the Contractor shall, at his expense, perform a pipe deflection test on all main line sanitary sewers and storm sewers where required. All lines shall be measured for vertical ring deflection no sooner than 60 days after completion of backfilling operations, provided in the judgment of the engineer, sufficient settlement of the backfill has occurred. The Engineer shall be the sole judge as to when sufficient settlement has occurred. The maximum limit of vertical deflection shall not exceed 5 percent. The 5 percent shall be calculated using the applicable ASTM or AASHTO procedures. The test shall be accomplished by manually pulling a City of Marysville approved "go, no-go" mandrel with 9 arms. The mandrel shall meet the requirement listed in Standard Drawing SAS-20.

The Contractor shall be responsible to provide all equipment and labor, including mandrel, to perform and conduct the required test. The Contractor shall also be responsible to notify the *Engineer* at least 48 hours in advance of the anticipated date of the testing for scheduling of personnel needed to monitor the testing operations. In areas where deflections exceeds the 5 percent limit, the Contractor, at no additional expense to the City, will correct the problem area(s) as directed by the Engineer by one of the following procedures:

1. Trench shall be re-excavated, the backfill and pipe removed and replaced in accordance with the original plans and specifications. If in the opinion of the Engineer or his representative the pipe has been damaged the pipe shall be replaced with new pipe and installed per the plans and specifications. The failed sections of pipe corrected by this method shall be retested no sooner than 30 days after the correction is made or as otherwise directed by the Engineer.

2. The failed section(s) will be re-rounded by an approved company providing this service. Methods, types of equipment, and company to provide service shall be submitted in writing to the *Engineer* for approval at 5 working days in advance of performing this procedure. This method may only be used if approved by the Engineer and it is determined that the deflection has not exceeded 10 percent of the base inside diameter of the pipe, by pulling a 9 arm "go, no-go" mandrel having a diameter equal to 90 percent of the base inside diameter of the pipe. After either procedure 1 or 2 is completed, the repaired area(s) will be retested prior to final acceptance.

4.6 COMPACTION TESTING

The CONTRACTOR shall conduct the testing necessary to determine the compaction of back fill where compaction is required on the plans. The tests shall be performed by a Soils Testing Firm licensed to do such work by the ENGINEER. The CONTRACTOR shall furnish the required testing.

Compaction tests shall be performed on each layer of back fill compacted to determine the quality of his work. No material shall be added to a compacted backfill area until each layer meets the compaction requirements specified herein. Certified copies of the testing results performed under the direction of a Licensed Professional Engineer, shall be provided to the ENGINEER upon completion of the backfill and prior to mandrel testing. Information given to the ENGINEER shall include the elevation of the test, the length and width of the layer tested, the Maximum Laboratory Dry weight of the material tested and the compaction achieved. Any backfill or portion thereof which does not meet the compaction requirements specified shall be redone.

4.7 SEWER LINE VIDEOTAPING

All sanitary trunk lines are to be camera/video taped at the time of testing. A copy of the video files, submitted via with a summary report shall be given to the City ENGINEER.

SECTION V
Manholes

5.1 MANHOLES

All wastewater manholes shall follow the requirements listed in SAS-07.

Description: Manholes shall be built where shown on the plans or where required by the ENGINEER. They shall be substantially built in conformity with the requirements of the plans and specifications. All sanitary sewer manholes may be either pre-cast or cast in place concrete.

Concrete: Portland cement concrete used in the construction of manholes and inlets shall be of the class shown on the drawings and as specified in Section "Concrete". No mortar or concrete shall be placed in water, and no water shall be allowed to flow over or against the concrete before it has set for a period of time deemed sufficient by the ENGINEER to prevent damage to the structure.

Concrete Reinforcement: Reinforcement used in the construction of manholes and inlets shall be as shown on the drawings as specified in Section "Concrete Reinforcement".

Foundation. When a pre-cast concrete manhole base is used, a Class "B" concrete pad for the base foundation shall be used. The pad shall extend a minimum of 6 inches beyond the outside wall of the manhole base and shall be 4 inches thick with a plus or minus 1 inch tolerance. On manholes 12 feet deep or less from finished grade, the pad may be either pre-cast or cast in place. Manholes deeper than 12 feet the pad shall be cast in place. In order to utilize a cast in place pad sooner, solid concrete blocks shall be used in conjunction with the cast in place pad to provide a level bearing surface for the manhole base. The CONTRACTOR shall submit with the approval drawings a leveling block layout designed for a bearing surface not to exceed 2,000 pounds per square foot. At least 12 hours shall elapse between casting the concrete pad and placing the remainder of the manhole (risers and transition sections), except in or adjacent to roadway sections. In roadway areas the concrete leveling blocks shall be so arranged to support the total manhole weight placed during the 12 hour period, but not to exceed 2,000 pounds per square foot.

Cold Weather: If the work is carried on in cold weather, the CONTRACTOR shall, at his own expense, provide the necessary means for heating concrete, brick, and mortar and for complying with all the requirements of the ENGINEER to thoroughly protect the masonry and concrete work during and after construction, from damage by frost. No work shall be done on any masonry or back filling during such days as in the opinion of the ENGINEER, are unsuitable for good workmanship.

Completion: All sewers, manholes, and inlets, upon their completion, are to be left clean and free from rubbish and kept so until the acceptance of the work. Repairs or alterations made up to the manholes after performing the leakage test may be justification for a retest of the section of sewer involved; see Section "Leakage Test".

Sanitary Sewer Manholes**:**

A. Inverts: Where there are changes in the direction of the sewer or entering branches to the manhole, the centerline of the invert shall have a true curve of as large as radius as the size of the manhole will permit. Manhole base channelization shall follow the requirements of Standard Drawing SAS-06.

B. Watertight: Manholes shall be watertight structures. Seals shall follow the requirements listed in Standard Drawing SAS-12.

C. Pre-case Reinforced Concrete Manhole Sections: Manhole sections shall conform to the requirements of ASTM C478, except that the minimum wall thickness shall be equal to the requirements of ASTM C76 Wall B. Joints of the manhole sections shall be formed entirely of concrete employing a round rubber gasket conforming to ASTM C443, and when assembled, shall be self-centering and make a uniform watertight joint. Lift holes, if provided, shall be made watertight.

D. Grade Adjustment: Pre-cast reinforced concrete manhole sections may be used in any combination to obtain the desired depth. Pre-cast concrete adjusting rings shall conform to ASTM C478.

E. Slope: The slope through the manhole (influent line to effluent line) shall be minimum of 0.1 feet unless written permission is obtained from the Engineer to use less.

F. Externally Sealed: All Sanitary Manholes must be externally sealed using a wraparound product encapsulation system, meeting the requirements of ANSI/AWWA C216-94, WrapidSeal or approved equal. Wrapidseal shall follow the requirements listed in SAS-12.

G. Chimney Seals: All manholes shall have "Cretex" Interior chimney seals or approved equal. Chimney seals shall follow the requirements listed in SAS-12.

5.2 MANHOLE APPURTENANCES

Frames and Covers: Manhole frames and covers shall be gray iron castings of the heavy duty pattern as noted on the plans. The cover and seat shall have machined bearing surfaces to prevent rocking and rattling. All covers shall have the words "MARYSVILLE SANITARY SEWER" cast on them and shall have a concealed pick hole. Covers shall be vented unless otherwise shown on the plans. In addition, where indicated on the plans, the manhole frames and covers shall be of the heavy duty watertight type with gasket seal and bolted lid. All manhole covers shall follow the requirements listed in SAS-08.

A. Standard: Manhole frames and covers shall be Neenah R-1762, East Jordan or equal with "MARYSVILLE SANITARY SEWER" cast into lid.

B. Watertight: Watertight manhole frames and covers shall be Neenah R-1916-C East Jordan or equal and shall be provided where designated by the ENGINEER.

C. Solid Covers: Solid covers shall be provided on all manholes in pavement areas and/or where designated by the ENGINEER.

Manhole Vents: Where designated by the ENGINEER, vented manholes shall be provided and constructed according to the detail as shown on Standard Drawing SAS-11.

Manhole Steps. Manhole steps shall conform to the requirements of ASTM C478 except that the steps shall be as noted on the plans. The distance between the top of casting and the first step shall not exceed 24 inches. Manhole steps shall be polypropylene as detailed on Standard Drawing SAS-09.

Manhole Connections: The sewer pipe to manhole connections on all sanitary sewers shall be flexible and watertight. The sewer pipe barrel at the spring line shall not extend more than 1 inch beyond the inside face of the manhole. To maintain flexibility in the connection, a 1 inch space shall be left between the end of the pipe inside the manhole and the concrete channel; this space shall be filled with a waterproof flexible joint filler.

All stub connections shall be pipe with the same joint, strength and specification as the sewer pipe. The stub shall be plugged and blocked with a stopper compatible with the sewer pipe joint and as approved by the ENGINEER. Any metal that is used shall be type 300 series stainless steel. The connection may be any of the following types:

A. Rubber sleeve with stainless steel banding
   1. KOR-N-SEAL as manufactured by National Pollution Control Systems, Inc.

   2. Lock Joint Flexible Manhole Sleeve as manufactured by Interpace Corporation.

   3. or equal.

B. Rubber gasket compression
   1. Press Wedge II as manufactured by Press-Seal Gasket Corporation.

   2. Dura-Seal II as manufactured by Dura Tech Inc.

   3. Link-Seal as manufactured by Thunderline Corporation.

   4. or approved equal.

C. Drop Manhole Connections

   1. Drop manhole connections shall be provided for sanitary sewers when called for on the plans or as directed by the ENGINEER. Pipe and fittings shall meet the requirements of ASTM C700 with ASTM C425 joints.

Manhole Markers: Manhole markers shall be installed according to the detail as shown on Standard Drawing SAS-13 when required by the ENGINEER.

SECTION VI
Lift stations

6.1 LIFT STATIONS-GENERAL

General: Lift Stations will be dealt with on an individual basis. The OWNER/DEVELOPER shall check with the CITY OF MARYSVILLE ENGINEER prior to beginning of design of any Lift Station for the latest requirements. Lift stations shall follow the requirements listed in Standard Drawing SAS-19.

Pumps: Pumps shall be the submersible type designed for either wet pit or dry pit application depending upon the use. Pumps shall be manufactured by FLYGT. A "stainless steel" rail system and lift chain, and base elbow adapter, shall be provided for removing the pump without entering the Wet Well. All FLYGT

submersible pumps shall be “N” or “CP” series and include a mix-flush system. Pump monitoring shall include FLYGT FLS and FLYGT SUBMEG-D. All Pumps and control panel shall be from a single source.

Wet Well: The Wet Well shall be constructed of poured in place reinforced concrete or pre-cast concrete sections in the diameter required on the individual plans but in no case less than eight (8) feet. The Wet Well shall be covered by a concrete slab with an "aluminum" access door and minimum four (4) inch diameter vent with insect screen. The access doors shall be lockable with handles and hold open devices. The liquid level in the wet well will be detected using both an ultrasonic transducer manufactured by Siemans-Miltronics. A four float backup level control system shall be provided. Floats shall override PLC and act independently to automatically run pumps should a PLC failure occur. Floats will indicate and provide lead pump, lag pump, pump off, and high level control.

Sewage Grinder: A hydraulic powered grinder (Muffin Monster) as manufactured by JWC Environmental shall be provided. The installation of the grinder shall include a stainless steel frame and retrieval system mounted on the interior wall of the wet well at the invert of the influent line. All controls and hydraulic power supply will be installed complete as part of the grinder installation.

Junction Box: A NEMA 4 Electrical junction box shall be placed on or adjacent to the Wet Well for disconnecting the pump, at the direction of the ENGINEER, prior to installation.

Fasteners: All nuts and bolts used shall be "stainless steel".

Hoist: Pumps shall be removed by means of a 750 lb. removable hoist assembly. A stationary base, which accepts the portable hoist shall be permanently mounted on the top of the Wet Well.

Valve Pit: The Valve Pit shall be constructed of concrete cast in place or precast concrete sections covered by a concrete slab with an access opening as shown on the plans (3 ft. x 5 ft. min.) The minimum dimensions of the Valve Pit shall be 8 ft. wide x 8 ft. long x 7 ft. deep. A building shall be placed over the Valve Pit as shown on the plans. The building is to be insulated and the inside wall covered with V2 inch flake board. An aluminum access ladder shall be provided. The access opening is to be covered by grating mounted flush with the top of slab. An explosion proof light fixture shall be furnished in pit area. Ventilation will be provided by an electric fan with closable shuttered louvers with screens. The ventilation fan should be able to overturn the volume of air in the valve pit a minimum of 6 times an hour.

Building: A Building will be provided over the valve pit and will house all of the electronic/electrical components for the control of the pumps, monitoring system, and sewage grinder. The building shall be a minimum of 10’ x 10’ x 8’, insulated with the inside walls and ceiling covered with ½ inch flake board and heated with a model MUH-35 heater manufactured by QMARK. Ventilation will be provided for the attic area and shuttered louvers with screens. A 110 volt GFCI duplex outlet and lighting for the work area shall also be included. A GE #C746G470 W/175 WMV with photocell and switch inside the building shall be installed to provide light to the wet well area. **The building exterior materials will be approved by the City with aesthetics to coordinate with the development.**

Access Drive/Walk Way: A paved asphalt access drive shall be provided with a minimum pavement section of 6 inches of ODOT #304 aggregate and 1 ½ inches of ODOT 448 Type 2 and 1 ½ inches of ODOT 448 Type 1 asphaltic concrete. Pavement width shall be a minimum of 12 feet. A turn around area

(either circular area or a "T") for a full size pick up truck and auxiliary pump trailer is to be provided. Walk area from access drive to valve pit and wet well shall be provided and constructed from a minimum of 4 inch, 3000 psi concrete.

Control Panel: A control box shall be furnished consisting of a NEMA 12 enclosure, removable mounting panel supporting circuit breakers, pump alternator, and control circuits, and Uninterupted Power Supply (UPS). Hand-Off-OLC 3 position switches, elapsed time meters, and indicating lights shall be provided for each pump. Motor starters shall consist of overload relays and ALLEN-BRADLEY SMC Controllers. Provide an ALLEN-BRADLEY PLC using SLC-5/05 processor with EEPROM, Rack, Rack Power Supply, 16-Input Module, 8-Output Relay Module, 8-Input Analog Module, 4-Analog Output module as a minimum with the following inputs and outputs wired as a minimum:

Digital Inputs – 3-Phase Normal, UPS Input Power On, Station Intrusion, Wet Well High Level Float, Wet Well Low Level Float, PLC Selected for each pump, Pump On for each pump, Pump Failure/Overload for each pump, Pump Moisture Alarm for each pump, Pump Thermal for each pump, Sewage Grinder PLC/Auto Selected, Sewage Grinder On, Sewage Grinder Fault/Shutdown.

Digital Outputs – Pump Start/Stop for each pump, Sewage Grinder Start/Stop.

Analog Inputs – Wet Well Level, Flow. Bioxide tank level.

Analog Outputs – Future Use.
Pump Alternation shall be done with the PLC. PLC programming with documentation shall be provided by Telemetering Supplier and a copy on diskette given to City of Marysville. City of Marysville must approve panel drawing submittal before purchase.

Telemetering: by City designated integrator/programmer

a. One (1) – Radio system compatible with current City of Marysville radios or approved equal as determined by the Superintendent
b. One (1) Network Hub
c. One (1) Ethernet IP Camera
d. One (1) Allen-Bradley Panelview or Computer
e. One (1) Pump Panel PLC Program, Intellution Programming, both documented on diskettes to City.
f. One (1) - Fabricated Back Panel
g. One (1) - NEMA 4/12 enclosure
h. One (1) - Wooden Pole if required and Omni antenna
i. All-Related conduit, wire, cabling, and installation, and costs are the responsibility of the contractor. Panel shall be plugged into the Pump Panel UPS. Contractor must provide a Radio Path Study.

Emergency: A receptacle for an emergency generator is to be provided. The receptacle, mounted outside building, is to be **APPLETON AR20034 PARS – 200 AMP, 3W, 4P, STYLE Z, NO SUB**. A transfer switch is to be provided in the building. A 4 inch male quick connect pump by-pass shall be provided in the Wet Well and Valve Pit. Plumbing for the by-pass in the valve pit shall be to the outside of the building.

Pressure: A pressure gauge shall be provided on the force main in the Valve Pit at the location shown on the plans.

Flowmeter: **An ABB Magnetic Flow meter sized for the pumpstation is required**. Contact the Superintendent for current City of Marysville specification. **If the meter is contained in a pit below grade, the pit must be drained to eliminate submergence of the flowmeter.**

Vacuum Breaker: A vacuum breaker shall be provided in the Valve Pit, tapped onto the top of each force main between the pump and valve check. **The Vacuum Breaker must vent to the outside.**

Odor Control: A BIOXIDE feed system shall be designed by **Siemans-Milltronics Process** and installed as per the approved drawings. The bioxide systems shall follow the requirements listed in Standard Drawing SAS-24.

The odor control system shall contain the following:
-One (1) storage tank with approved **Siemans-Milltronics level indicator.**
-Spill/Storage tank failure containment system constructed of 3000 psi concrete
-Drainage from containment system shall be directed to wet well
-Concrete foundation
-Stainless Steel Control Panel
-All piping, valves, fittings, gages, and electronics necessary for complete operation.
-1,000 ml In-line graduated cylinder for pump calibration
-US Filter/Davis Process Chemical Feed Pumps
-Stainless Steel pipe support stand
-2" PVC fill lines with ball valve and quick connect coupling
-All miscellaneous piping, fittings, filters, etc. to complete the system.

SECTION VII
Site Work

7.1 EXCAVATION, BACKFILL AND EMBANKMENTS

Top Soil: All top soil shall be removed and stockpiled for future covering of the excavated or otherwise disturbed areas.

Protection: Excavation for structures shall be protected by bracing, sheeting, piling, or other approved means and shall be kept de-watered by suitable pumping equipment. The CONTRACTOR shall be responsible for protecting the excavation once it has reached grade, and excavation shall be adequately drained to prohibit saturation of the sub-grade. "Soft" sub-grade caused by inundation shall be de-watered and satisfactorily corrected with "french" drains or tile to the satisfaction of the ENGINEER, or: the "soft" material shall be removed to satisfactory bearing material and the area back filled with ODOT Item 613, LSM, or other material approved by the ENGINEER.

Unsuitable Bearing Materials: Unsuitable bearing materials encountered at finish grade shall, upon written notice by the ENGINEER, be removed or; if, in the opinion of the ENGINEER, other means of providing

the required bearing are indicated, he may require the CONTRACTOR in writing to drive piling, fill with Class "C" concrete, or accomplish other work to correct the situation.

Backfill and Embankment: The CONTRACTOR shall furnish and place acceptable material as backfill and embankment around the structures. Materials used may be obtained from the material excavated or from approved off-site borrow, if required. Waste excavation may be disposed of on the site, or on off-site areas when required. All backfill and embankment shall be placed so as to minimize subsequent settlement.

Top Soil Placement: Backfill and embankment shall be made to within approximately 3 inches of final grade, making reasonable allowance for settlement, except in agricultural crop land, where topsoil shall be replaced to a depth of 6" minimum. Top soil shall then be distributed over the area to the finished grade lives shown on the plans. Foreign material shall be removed from the top soil as it is placed and the surface raked evenly.

Granular Backfill: Granular backfill, where shown on the drawings, may be crushed stone or gravel compacted to the thickness shown. The granular material shall be deposited after the sub-grades have been leveled and cleared of all debris and immediately prior to the pouring of the concrete slabs.

Shape the sub-grade at all walls, floors and floor drains so that the required thickness of the concrete and granular backfill can be maintained. The granular material shall meet the requirements of Section 304 in the State of Ohio, Department of Transportation Construction and Material Specifications. Other well graded granular material may be approved by the ENGINEER.

7.2 GRADING, FERTILIZING, AND SEEDING

Description: The CONTRACTOR shall furnish all labor, equipment, and materials required to accomplish the fine grading, fertilizer, and seeding as specified herein.

If suitable topsoil is available as part of the material excavated, it shall be removed and stored separately and used to backfill the top 4 inches, 6 inches in Agricultural areas. After the backfill has been given a reasonable time to settle, it shall be graded off to the finished grade, then harrowed to a depth of 3 inches. All grass, weeds, roots, sticks, stones, etc. are to be removed and the soil carefully brought to the finished grade by raking. An application of not less than 1 pound per 100 s.f. of a 12-7-5 lawn or turf grade fertilizer shall be uniformly distributed and raked in. If there is no suitable topsoil available on any part of the work, or if there is a deficiency of suitable topsoil, the CONTRACTOR shall furnish and apply not less than 2 pounds per 100 s.f. of 12-7-5 lawn or turf grade fertilizer in the method above specified.
Immediately after the preparation and fertilization of the seed bed, the seed shall be thoroughly mixed and then evenly sown over the prepared areas at the rate of 3 pounds per 1,000 square foot. Seed shall be sown dry or hydraulically.

A. All areas to be seeded which are considered to be urban in character, and any area immediately in front of a residence, shall be seeded with the following mixture: (Percentages are by weight.)

35 percent Kentucky Bluegrass (Poa pratensis)

55 percent Creeping Red Fescue (Festuca rubra)

5 percent Red Top (Agrostis alba)

5 percent White Dutch Clover (Arifolium repens)

B. All areas in rights-of-way or in easements adjacent to rights-of-way and other than those mentioned above, shall be seeded with the following mixture:

100 percent Kentucky 31 Fescue (Festuca arundinacea var. Ky. 31)

The seed shall be carefully and uniformly sown by experienced and skilled workmen. Following the seeding, the surface shall be lightly raked and rolled with a light roller. Following the rolling, the area seeded shall be covered with 2 inches, loose measurement, of vegetative mulch, tied down or kept in place by other acceptable method.

All seeded areas shall be carefully looked after and tended by the CONTRACTOR, watering as necessary to secure a good turf. Settled areas shall be filled, graded, and re-seeded.

Seeding Time: All fertilizing and seeding shall be done in the months between April and November**.** The CONTRACTOR shall maintain areas until seeding is complete.

Areas to be Seeded: All the embankments and disturbed areas within the project site, all roadway embankments, fills, and ditches not sodded, shall be seeded.

7.3 TEMPORARY SEEDING

The work shall consist of furnishing all labor, equipment, and materials for seeding the areas as directed by the ENGINEER, and for liming, fertilizing, preparing a seedbed, and mulching when required.

Seed Requirements: All seed shall be labeled or marked in accordance with Section 907.03 of the Revised Code of Ohio. All seed temporarily stored on the job shall be protected from dampness at all times.

Seeding: The variety of seed and rate of application shall be as specified. Unless specified otherwise, the temporary seeding operation may be performed at any time during the year.

Seeding shall be made before the close of each day's work on all areas as specified by the ENGINEER for Temporary Seeding. Seeding and fertilizer shall be covered to a depth of one (1) inch. A disk harrow, or other suitable equipment as approved by the ENGINEER, shall be used to cover seed and fertilizer.
Fertilizer shall be uniformly applied on all areas to be seeded at the rate of 30 pounds per acre of nitrogen; 30 pounds per acre of P205; and 30 pounds per acre of K20. (Example: This specification can be met by applying fertilizer having an analysis of 10-10-10 at the rate of 300 pounds per acre.)

Temporary Seeding Schedule

Dates	Seed Type	Seeding Rate (Bushels/Acre)	Minimum Germination	Minimum Purity
3/1 to 8/15	Oats*	3	80%	97.5%
8/16 to 11/1	Rye**	3	85%	97%

* Rye grass may be substituted for this time of year, if oats are in short supply.

** Rye grass or winter wheat may be substituted for this time of year, if rye is in short supply.

Areas to be Seeded: All the embankments and disturbed areas within the project site, all roadway embankments, fills, and ditches not sodded, shall be seeded.

7.4 EROSION AND SEDIMENTATION CONTROL

The CONTRACTOR shall provide all labor and material required to protect those disturbed areas of exposed soils requiring immediate vegetative stabilization (as determined by the ENGINEER), such as the watercourse channels and other earthen structures. The method of protection shall be dependent upon the time of year when construction of the above is completed. During favorable planting conditions, temporary seeding shall be planted immediately upon completion of construction. During unfavorable planting conditions, a protective layer of straw or hay mulch shall be spread over the exposed sub-soils with over seeding conducted later when favorable growing conditions develop. Erosion control fabric consisting of knitted yarn construction with interwoven strips of biodegradable paper, such as Hold/Gro as manufactured by Gulf States Paper, Tuscaloosa, Alabama, or equal, shall also be acceptable.

On large areas of disturbance near watercourse, which will be disturbed in excess of 30 days the CONTRACTOR shall provide a sedimentation trap by installing a continuous cut-off wall of straw bales between the construction area and the river or creek. The wire or plastic tied straw bales shall be laid on their side, set in a trench with a minimum projection above the ground surface of 10 inches, and anchored to the ground by driving two wooden or metal stakes through each bale. The straw bale wall shall be maintained until the site seeding is established, after which said wall shall be removed, the trench filled with topsoil, and the straw and sediment utilized as mulching and fill material on the site.

7.5 RIPRAP

Description: The CONTRACTOR shall provide all labor, material, and equipment necessary for construction and placement of riprap within the limits and at the elevation shown on the drawings or as directed by the ENGINEER.

Material: All riprap stone shall be of such quality that it will not disintegrate under action of air, water or conditions to be met in handling and placing. The material shall be hard, durable, clean and free from earth, clay, refuse, adherent coating and other foreign matter. Individual stones shall not exceed "one man size" and shall weigh between ten pounds and three hundred pounds.

Installation: The loose rock riprap shall be placed by skip, clamshell, by hand or other acceptable method and arranged, if necessary, by hand so as to provide a dense compact paving of a minimum thickness of

twelve inches. The spaces between the larger stones shall be filled with smaller pieces to form a dense compact rock blanket of fairly even surface. Some handwork will be required to properly seat and key the rock together, and to chink the voids left after the rough placement. If excessive fines exist in the rock as delivered, it must be dumped and re-handled to remove the excess therefrom. The CONTRACTOR shall maintain the slope paving until accepted by the OWNER. Any material displaced by slippage or any other cause shall be replaced to the lines and grades as shown or as directed by the ENGINEER at no additional cost to the OWNER.

SECTION VIII

Concrete Work

8.1 CONCRETE

MATERIALS

Portland Cement shall conform to the Specifications for "Portland Cement" Type 1 (A.S.T.M. C150) or the Specifications for "Air Entraining Portland Cement" Type IA (A.S.T.M. C175), unless otherwise noted.

All cement delivered to the job site shall be of the same brand, furnished by a manufacturer of good reputation, and shall be shipped in strong cloth or paper bags bearing the manufacturers name and brand. The cement shall be stored in suitable buildings to fully protect it from moisture and shall be segregated by lots so as to permit easy access for inspection and sampling. Sufficient quantity of cement shall be kept on hand at all times to allow time (12 days minimum) for testing before use.

Bulk cement, if specially authorized for use by the ENGINEER for site mixing, or cement used by truck mixers shall be delivered in sealed cars and shall be accompanied by a certificate of the manufacturer that it complies with these specifications.

Cement, which contains lumps or has partially hardened, shall be rejected.

All cement rejected by the ENGINEER shall be immediately removed from the site or from storage with other cement intended for use in the work.

Fine Aggregates.

A. General: Fine aggregates shall be composed of clean, hard, durable, uncoated particles of stone, well graded from coarse to fine, with coarse particles predominating.

B. Grading: Fine aggregates used in concrete shall conform to the following grading requirements:

Sieve Size (U.S. Standard)	Total Passing % by Weight
3/8 inch	100
No.4	95-100

No.16	50-75
No.50	15-30
No.100	3.5-10

Loss on decantation by weights not over 4%.

No individual size portion shall exceed 35%. The fineness modulus of any shipment of fine aggregate from any one source shall not vary more than 0.2 either way from that of the sample upon which acceptance was based.

C. Deleterious Substance: Fine aggregate shall be free from lumps of clay, injurious amounts of organic impurities, soft or flaky particles, loam, coal, or other deleterious substances.

D. Mortar Strength: Mortar specimens (1-3) when made with fine aggregate proposed for use shall have a flexural or compressive strength at 7 days of at least 100 percent of similar specimens made with standard Ottawa sand.

E. Storage: Fine aggregate shall be stored separately and in such manner as to avoid the inclusion of any foreign material. Fine aggregate shall be handled in such manner that the moisture content will be reasonably uniform for each day's run. If necessary, in order to obtain uniformity of moisture content, stockpiling of all materials will be required.

Coarse Aggregates

A. General: Coarse aggregates shall be crushed stone, gravel, or crushed slag. The maximum size of particles shall not exceed 1/8 of the narrowest dimension between forms of 2/3 of the minimum clear space between adjacent bars of reinforcing steel.

B. Grading: Coarse aggregates shall be well graded from the maximum to the minimum size, which shall be that, retained on a 1/4" screen. The ENGINEER prior to use shall approve gradation and quality of coarse aggregate. When maximum size is greater than 1 1/2", the aggregate shall be furnished and stored separately in two sizes and combined in batching to conform to the desired gradation.

C. Deleterious Materials: The maximum percentage of deleterious substances shall not exceed the following:

	% by Weight		
Test	**Limestone**	**Gravel**	**Slag**
1. Removed by decantation	1	1	1
2. Shale	1	1	1
3. Coal	1	1	1
4. Clay lumps	0.25	0.25	0.25
5. Soft Fragments	3	3	3
6. Other Local Deleterious Substance which will Readily Disintegrate	1	1	1
7. Total of 2 to 6 inclusive not more than	5	5	5

D. Physical Properties

1. Limestone: The broken stone shall consist of uncoated particles of clean, sound, durable, angular rock, of uniform quality and free from an excess of thin, flat, or shaly pieces.

2. Gravel: The gravel shall be composed of hard, durable particles of stone, thoroughly clean, and shall be free from frozen lumps, vegetable or other deleterious matter and an excess of soft, thin, or elongated pieces.

3. Slag: The broken slag shall be composed of air cooled blast furnace slag and shall be clean, sound, durable, reasonably uniforms in density and free from an excess of thin or elongated pieces. Weight per cubic foot of aggregate compacted shall be not less than 70 pounds.

E. Tests: Coarse aggregate shall be subjected to the Los Angeles Abrasion Test, A.S.T.M. C-131 and shall show a percentage, of wear of not more than 40%.

Where concrete is finished work will be exposed to aggressive soils or water, to alternate freezing and thawing, or to other, destructive agents, the coarse aggregate shall be subjected to the sodium sulfate soundness test (A.S.T.M. C-88). Coarse, aggregates showing a loss by weight in excess of 12% after five cycles, shall be further investigated (by freezing and, thawing concrete specimens containing the aggregate) before being approved for use.

The ENGINEER may use aggregate failing to pass any of all of these tests upon approval provided that convincing, evidence of their suitability for the use proposed (based upon not less than eight years of competent record of their behavior, in similar structures under comparable conditions of exposure) is furnished the ENGINEER.

F. Storage: Coarse aggregates shall be stored separately and in such a manner as to avoid inclusion of any foreign material.

Stockpiles of coarse aggregates shall be built up in horizontal layers not to exceed three feet in height to avoid segregation.

G. Sampling and Testing: Unless otherwise specified, the CONTRACTOR at his expense shall furnish all test samples of aggregates.

Aggregates shall be approved by the ENGINEER before purchase. The ENGINEER shall be given opportunity to inspect the source of aggregate material and shall be furnished with sieve analyses of the fine and coarse materials which are proposed to be furnished, these analyses to be made from samples selected under the ENGINEER'S supervision. In addition to the above, there shall be provided analyses in the field covering: (1) color test for organic matter, (2) decantation test of silt and (3) sieve analysis or in lieu thereof, there shall be furnished equipment and facilities for making these tests in the field.

All other tests as required shall be made at the expense of the CONTRACTOR by a qualified testing laboratory under supervision of the ENGINEER.

Water: Water used in mixing concrete shall be furnished at the CONTRACTOR'S expense and shall be clean and free from deleterious amounts of oil, acids, alkalis, or organic materials.

Air Entrainment: Air entraining cements shall conform to the Specifications for Air Entraining Portland Cement Type IA, A.S.T.M. C-175. The mixed concrete immediately prior to placing shall contain between 4.0% and 6.0% of entrained air as determined by the Volumetric Method in conformance with specifications for "Air Content of Freshly Mixed Concrete by Volumetric Method", A.S.T.M. C-173.

Additives for increasing, reducing or controlling the air content shall conform to specifications for admixtures A.S.T.M. C-260 or shall receive the approval of the ENGINEER prior to use. Such additives shall be compatible with the cement used and shall be used in strict accordance with the manufacturer's recommendations and under the initial supervision of a representative of the manufacturer.

Plasticity and Workability Control: There shall be added to the batch immediately before or during its mixing, a water reducing or densifier admixture. Such admixture shall be "Pozzolith Normal" as manufactured by the Master Builders Company, "Plasticrete" as manufactured by the Sika Chemical Corporation or equal. Such admixtures shall be used in strict compliance with the manufacturer's directions and shall be compatible with the cement used.

Approved additives for controlling the rate of hardening (retarded, or accelerated) will be required when, in the opinion of the ENGINEER, adverse working conditions, weather conditions, or special conditions will have an adverse effect on the finished structure. When used, such admixtures shall be used in strict compliance with the manufacturer's recommendations and under the initial supervision of a representative of the manufacturer.

PROPORTIONING AND MIXING

Measurement: Wherever practicable, materials shall be measured by weighing except that sacked cement need not be weighed, and water may be measured by volume. The weight of a sack of cement shall be taken as 94 pounds and the weight of one gallon of water as 8.33 pounds.

When measurement of aggregate by volume is permitted, the ENGINEER shall approve the method used.

Water shall be measured in an approved manner such as will insure the desired quantity in successive batches. Under no circumstances shall the quantity of water used in successive batches be left to the manual control of the operator, except by written approval of the ENGINEER. The free water contained in the fine and coarse aggregates shall be deducted from the permissible quantity of water to be added per bag of cement.

The accuracy of all measuring devices shall be such that all quantities can be measured to within one percent of the desired amount.

Weight and paste or liquid admixtures shall measure powdered admixtures by weight and volume, within a limit of 3 percent. When small quantities of admixtures are used in proportion to the cement, as in the case of air entraining admixtures, mechanical dispensing equipment is recommended.

Proportioning: In general, all concrete mixtures shall contain the minimum amount of water required by modern efficient methods of vibratory placement. Mixes shall be used that contain the largest practicable maximum size of well-graded coarse aggregate, consistent with bar spacing.

Unless otherwise noted on the plans or by special specification, all reinforced concrete shall be Class "C"; Class "B" shall be all non-reinforced concrete not designated on the plans as Class "C"; and Class "A" concrete shall be non-reinforced fill concrete so designated on the plans, all in accordance with the table below:

Class	Min Bags of Cement per Cubic Yard	Max Water Content per Bag of Cement	Minimum 7 Day Compressive Strength (PSI)	Minimum 28 Day Compressive Strength (PSI)	Use
C	6.5	5.5	2,900	4,000	All reinforced concrete unless specifically noted otherwise on plans
B (non-reinforced)	5.75	6.5	2,400	3,400	All concrete unless noted otherwise on plans
A	4	9.75	1,000	1,700	Fill concrete so noted on plans

Class	Fine Aggregate (lbs)	*Coarse Aggregate (lbs)	Total (lbs)	Fine Aggregate (lbs)	*Coarse Aggregate (lbs)	Total (lbs)
C						
Gravel	183	263	446	187	263	450
Stone	195	254	449	199	254	455
Slag	205	211	416	209	211	420
B						
Gravel	219	290	509	224	290	514
Stone	230	282	512	235	282	517
Slag	240	236	476	245	236	481
A						
Gravel	374	382	756	382	382	764

Stone	374	386	760	382	386	768
Slag	394	318	712	402	318	720

Weight in Lbs. of Surface Dry Aggregates per Bag of Cement
Natural Sand (Fineness Modules 2.6-2.9 Limestone Sand (Fineness Modules 2.6-2.9)

Weights listed above will theoretically produce proper yield with 5% air entrained concrete.

*Weights base on AASHO-M-43, Size 57 coarse aggregate gradation.

The ENGINEER to produce the desired strength or workability may vary the proportions of water and fine and coarse aggregate.

The weights specified in the above table are for aggregates of the following bulk specific gravity:

Natural Sand and Gravel	2.62
Limestone Sand	2.68
Limestone	2.65
Slag	2.30

If the specific gravity varies more than 0.02 from the above, adjustments shall be made.

Consistency: The quantity of water used shall be the minimum necessary to produce concrete of the strength and workability required by the ENGINEER. Consistency shall be measured by the slump test (A.S.T.M. C-143) and in general the slump shall not exceed that indicated in the table below:

Class	Max Slump (in)
Class C - Reinforced Walls, Columns, Slabs, and Beams	5
Blass B - Sidewalks, non-reinforced concrete, lightly reinforced mass concrete, or as designated on the drawings	4
Class A - Fill concrete so noted on drawings	4

Mixing: Unless otherwise specified under "Special Specifications" or called for on the plans, the CONTRACTOR has the option of accomplishing mixing by the use of modern efficient, mechanical equipment in good condition by any of the following methods:

A. Mixing at the forms in a satisfactory mixer and the mixed concrete transported to the forms by concrete bucket and crane, concrete buggy, wheelbarrows or other approved means.

B. Mixing at a central mixing plant in a stationary mixer and the mixed concrete transported to the point of delivery in a truck agitator or truck mixer operating at agitating speed or in non-agitating equipment approved by the ENGINEER.

C. Mixing by transit-truck mixer.

The location, type, capacity, length of haul and condition of the plant and associated equipment shall be subject to the approval of the ENGINEER. All batching, mixing and agitation equipment for Ready Mixed Concrete shall meet the requirements of A.S.T.M. C-94.

Mixers and agitators shall be operated within the limits of capacity and speed rotation designated by the manufacturer of the equipment.

When a stationary mixer is used for complete mixing of the concrete, the mixing time for mixers having capacities of 1 cu. yd. or less shall not be less than one minute. For mixers of larger capacities, this minimum shall be increased 15 seconds for each cubic yard or fraction thereof-additional capacity. Mixing time shall be measured from the time all cement and aggregates are in the drum. The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregate, all water shall be in the drum by the end of the first one-fourth of the specified time.

When the concrete is mixed in a truck mixer loaded to its rated capacity, the number of revolutions of the drum or blades at mixing speed shall not be less than 50 nor more than 100. If the volume of the batch is greater than the rated capacity, but not greater than that guaranteed by the manufacturer, the number of revolutions of the drum or blades at mixing speed shall not be less than 70 nor more than 100. All revolutions after 100 shall be at agitating speed. When a truck mixer is used for the complete mixing of the concrete, the mixing operation shall begin within 30 minutes after the cement has been intermingled with the aggregates. Concrete batches, which arrive too dry, and already contain the maximum allowable mixing water, or batches, which arrive too wet, will be rejected.

TRANSPORTATION AND PLACING

Before beginning a run of concrete, the condition of mixing and handling equipment, forms, which are to receive concrete and the steel reinforcement, shall receive the approval of the ENGINEER.

Concrete shall be handled from mixer to the place of final deposit as rapidly as possible by methods, which prevent the separation or loss of ingredients. It shall be deposited in the forms as neatly as practicable in its final position. The surface of concrete during placing shall be maintained as nearly level as practicable.

During and immediately after placing, concrete shall be thoroughly compacted by means of power driven vibrators, operating at a frequency of not less than 3,200 pulsation’s per minute, and other suitable tools to produce a concrete of maximum density.

Sufficient vibrators and other suitable tools shall be provided to accomplish the proper placement of the concrete to the satisfaction of the ENGINEER.

Special attention is hereby directed to the number of and efficiency of puddles and spaders. The CONTRACTOR shall provide men for this work in sufficient numbers to accomplish the proper compacting of the fresh concrete to the satisfaction of the ENGINEER.

The concrete shall be well compacted and thoroughly worked around the reinforcing steel and into all corners and angles of the forms and around all embedded structures. Where rodding and spading of

concrete is difficult, due to thin sections of inaccessible portions, the compacting shall be assisted by hammering the forms opposite the freshly deposited concrete so carried on as not to damage the form surface.

Concrete shall be deposited continuously until the unit of operation, as approved by the ENGINEER, is completed. Concrete shall not be placed in water unless written permission is obtained from the ENGINEER.

No re-tempering of concrete will be permitted.

Before depositing new concrete on or against old concrete, which has set, the forms shall be re-tightened; the surface of the set concrete shall be cleaned of all foreign matter and laitance and saturated with water. The old surface shall be flushed with neat cement grout or with a mortar composed of cement and sand in the same proportions as required for the concrete in contiguous portions of the work, deposited in a layer at least one inch thick and the new concrete shall be deposited thereon before the grout or mortar has reached its initial set.

Cold Weather: No concrete shall be placed when the surrounding atmospheric temperatures are below 32^{O} F, nor when the concrete is likely to be subjected to freezing temperature before final set has occurred without the consent of the ENGINEER, and then only under his direction and with suitable means provided for heating materials so that the temperature of the concrete when placed shall not be less than 50^{O} F. nor more than 80^{O} F. Concrete shall be maintained at a temperature of at least 50^{O} F. for at least 72 hours after placing by suitable protection and heating devices.

JOINTS

Construction Joints: Horizontal and vertical construction joints in the concrete shall be made only where shown on the plans or where approved by the ENGINEER. When construction joints are not shown on the plans, the ENGINEER shall approve the plans on which a day's work is to terminate before depositing of concrete begins. Such joints shall be perpendicular to the lines of principal stress and in regions of small shear and in general shall be so designed and located to least impair the strength and appearance of the structure. Joints in columns shall be made at the under side of beams or haunches. At least two hours shall elapse after depositing column concrete before placing concrete in beams or slabs. Construction joints in floors shall be located near the middle of span and shall be at right angles to the finished concrete surface.

Horizontal joints will not be permitted in girders, beams, or slabs. Slabs acting with beams and girders shall be deposited continuously with them unless otherwise shown on the plans or approved by the ENGINEER.

In order to allow for shrinkage, concrete shall not be placed against the second side of construction joints for at least 12 hours after that on the first side has been placed.

Construction joints in water-bearing walls shall be watertight and shall be made as follows:

A. Unless otherwise specified on the plans, horizontal joints shall be constructed by forming a keyway in the lower portion of the concrete before concrete has hardened. In general, keyways shall have an

area equal to approximately 1/3 the cross-section area of the joint, but shall be not less than 2" deep and 4" wide. In the keyway shall be placed #12 gauge galvanized steel water stops 5" wide or PVC whichever is shown on the drawings. These strips shall be embedded 2" in the concrete before it has hardened. Joints where steel strips come together shall be lapped at least 4"; PVC shall be bonded. Before placing upper concrete, lower concrete shall be treated as specified above for bonding new to old concrete.

B. Unless otherwise specified on the plans, vertical joints shall be made with 20 oz. copper or PVC water stops of a design approved by the ENGINEER and as shown on the drawings.

On all exposed faces, the lines of horizontal or vertical construction joints shall be made truly straight. For horizontal joints, a temporary straight edge shall be tacked on the inside of the form so that its bottom edge is on the line of the joints.

All beams, rectangular section columns, and exposed concrete corners shall be finished with beveled edges.

Expansion Joints: All expansion joints will be constructed where and as shown on the plans. Expansion joint material shall be securely held in place during placing and finishing of the concrete. Expansion Joint material shall be made of reflex rubber.

FORMS

Construction: The form material and the design of the forms shall be adapted to the structure and the kind of surface required. For all faces exposed to continuous view, the surfaces of the forms next to the concrete shall be plywood or steel. The forms shall be substantially built, secure to prevent movement or deflection during concreting, and tight to prevent leakage of mortar. They shall be sufficiently strong and braced to resist the pressures to which they are subjected during placing of concrete and remain in straight, true alignment. Temporary openings shall be provided in wall, pier, and column forms to permit cleaning and inspection.

Form ties shall be used of a type, which will insure a tight, impervious wall, free from holes. On exposed faces, wall ties shall be of a type, which break off about 1/4" back of the wall surfaces when forms are stripped and which can be neatly pointed. Wire ties will not be permitted on exposed work. The ENGINEER shall approve the design of form ties.

Removal: Forms shall be removed in such manner as will prevent injury to the concrete and insure the complete safety of the structure. Before the removal of forms, the concrete shall be carefully inspected. No exact time for the removal of forms can be specified because of the varying character of the work and other controlling conditions, but no forms shall be stuck without the consent of the ENGINEER. In no case shall the supporting forms or shoring be removed until the members have acquired sufficient strength to support safely their weight and the load thereon. Forms shall be thoroughly cleaned and oiled before being used again.

EMBEDDED ITEMS

All metal parts to be embedded in concrete shall be accurately and securely fastened in position as indicated

on the drawings or as approved by the ENGINEER before the concrete is placed. Such embedded items shall be thoroughly clean and free from rust, scale, oil or other foreign matter. Care shall be exercised during placing and compacting concrete that embedded items are not moved from their proper position.

FINISHING

Walls, Beams, Girders, and Columns: Concrete surfaces exposed to continuous view in the finished structure such as the inside of buildings and the outside of structures above grade, shall be poured against smooth, tight forms. If wood forms are used, they shall be either built of plywood or lined with plywood so placed as to make the fewest possible joints. Such necessary joints shall be inconspicuous, regular and shall conform to the lines of the structures. During pouring of concrete, the exposed faces shall be made smooth by thrusting a spade or suitable tool between the form and the concrete to force back the coarse aggregate from the exposed face. Face forms shall be removed as soon as practicable and all fins and projections shall be removed. Voids and damaged places shall immediately be saturated with water and filled with a mortar of the same composition as that in the concrete mixture and brought even with the surface by means of a wood float. The entire surface shall then be rubbed with a carborundum brick or other abrasive until even and smooth and of uniform appearance, as determined by the ENGINEER, without applying any cement or other coating. In cases where it is impracticable to remove forms before the concrete has fully hardened, the exposed faces may be brushed with a neat cement grout and immediately rubbed with the carborundum brick to a uniform appearance.

Faces not continuously exposed to view in the finished work such as the inside of water reservoirs of the outside of structures below grade shall be treated as for exposed faces except that they need not be rubbed and forms need not be lined with plywood. Inside faces of covered basins and clear wells: reservoirs, filters below and line and open tanks below flow lines shall be classed as unexposed.

Slabs and Floors: Surfaces not subject to wear and not in contact with liquids shall be screeded and smoothed with a wood float.

Surfaces in contact with liquids and other top surfaces subject to wear, shall be screeded smooth, and after drying, but before reaching a final set, shall be trawled to a smooth, dense finish with a steel trowel. Excess mixing water and over-trawling shall be avoided.

Floor Hardener: The surface of concrete stair treads and concrete floor slabs within buildings other than floors of liquid retaining basins; that is, all floors which will be subject to pedestrian or vehicular traffic in normal operation shall be treated to harden and dust proof the surface. This may be accomplished by the use of a liquid chemical concrete hardener, applied in three (3) applications in accordance with the manufacturer's directions. The ENGINEER shall approve use of other like materials for this purpose.

Footings: That portion of the upper surface of footings on which walls are to be built shall be left rough to insure proper bond with the superimposed concrete. The balance of the footer top surface shall be smoothed with a screed, but not float finished.

CURING

All concrete shall be thoroughly protected from rapid drying and must be adequately cured.

Provisions shall be made for maintaining concrete in a moist condition for a period of at least 7 days after the placement of the concrete. For concrete made with high early strength cement, moist curing shall be provided for at least the first three- (3) days.

The methods of curing used shall be approved by the ENGINEER and may include:
(a) continuous mechanical application of water,
(b) saturated cotton mats or burlap,
(c) saturated straw,
(d) heavy kraft paper or,
(e) an approved waterproof membrane.

On all slabs a preliminary curing period of at least 24 hours duration under saturated cotton mats or two layers of saturated burlap will be mandatory. At the expiration of this preliminary curing period, curing shall be continued by any of the methods and for the periods specified above.

TESTS ON CONCRETE

During the progress of the work, the CONTRACTOR under supervision of the ENGINEER shall prepare test specimens. Tests shall be made in accordance with the "Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field" (A.S.T.M. C-31). Each test shall be made on one laboratory control specimen and one field control specimen.

There shall be at least one test for each class of concrete places on any one-day and at least one test for each 250 cubic yards of concrete or fraction thereof in the job.

The standard age of test shall be 28 days, but 7-day tests may be used provided that the relation between the 7 and 28-day strengths of the concrete is established by test for the materials and proportions used.

In all cases where the average strength of the laboratory control cylinders shown by these tests for any portion of the structures falls below the minimum ultimate compressive strengths called for in Table l (a), the ENGINEER shall have the right to order, (l) a change in the mix or, (2) a change in the water content, or (3) additional cement at no additional cost to the OWNER for the remaining portion of the structure. In cases where the average strength of the cylinders cured on the job falls below the required strength, the ENGINEER shall have the right to require load tests made on the portions of the structure so affected or cores drilled and tested on portions where load tests are not feasible.

The cost of making test cylinders in the field and the testing of cylinders by a testing laboratory approved by the ENGINEER shall be borne by the CONTRACTOR.

8.2 GROUTING

Material: Grout shall be non-shrink, nonmetallic, non-staining, and capable of developing a minimum compressive strength of 9,000 pounds per square inch at 28 days, when tested in 2 inch cubes. Grout shall be free of any metal, plastic, gypsum, chemicals, and guaranteed not to shrink below its original placement volume at any time.

Installation

A. Surface Preparation: All areas to be grouted shall be clean, free of all oils, grease, laitance, loose particles and foreign materials. All concrete to be grouted shall be thoroughly wetted leaving no puddles prior to grouting.

B. Placement: Non-shrink grout shall be mixed and placed in strict accordance with the manufacturer's instructions. All voids and spaces shall be solidly filled, excess grout trimmed and the surface finished to match adjoining surfaces or as directed. A surface temperature of not less than 50 degrees Fahrenheit shall be maintained for seven consecutive days after placing the grout and the grout kept wetted for three consecutive days after placing.

C. Items to be Grouted:
   1. Equipment
   2. Box Outs
   3. Base Plates
   4. Leveling Plates
   5. Closing of opening in concrete work
   6. Railings
   7. As required by the ENGINEER

Manufacturers: Non-shrink grout shall be "Five - Star Grout" by U.S. Grout Corporation, "F-100" by Sauereisen Cement Company, "Sonogrout" by Sonneborn Building Products, or equal.

8.3 CONCRETE REINFORCING

Material:

A. Metal bars: A-11 metal bar reinforcement shall be deformed and shall conform to the requirements of ASTM A615, Grade 40 or Grade 60, "Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement" or to AST14 616, Grade 50, "Standard Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement."

B. Cold Drawn Wire: All cold drawn wire reinforcement shall conform to the requirements of ASTM A82, "Standard Specification for Cold-Drawn Steel Wire for Concrete Reinforcement."

C. Welded Wire Fabric: All welded wire fabric reinforcement shall conform to ASTM A185, "Standard Specification for Welded Steel Wire Fabric for Concrete Reinforcement."

D. Tests: Provide certified mill test reports when requested.

Approval Drawings: Shop drawings for all work in this section shall be presented to the ENGINEER to assure that the reinforcement conforms to the size, spacing and shape shown on the plans and as specified herein.

Design and Fabrication:

A. Design:

1. Design: All reinforced concrete members have been designed on the basis of the "Working Stress Design Method."

2. Substitutions: No changes in the size, spacing, or arrangement of any reinforcement shall be made, in any structure, without the written approval of the ENGINEER.

B. Fabrication:

1. Detailing: Approval drawings and fabrication of all reinforcement, unless otherwise noted, shall conform to the American Concrete Institute (ACI) 315, "Manual of Standard Practice for Detailing Reinforced Concrete Structures."

2. Splices: All splices shall be lap splices. Splice locations not shown on the plans shall be approved by the ENGINEER. The minimum lap, unless otherwise noted on the plans, shall be as follows:
   a. Metal bar reinforcement, 30 bar diameters but not less than 12 inches.
   b. Cold drawn wire reinforcement, 30 bar diameters but not less than 12 inches.
   c. Welded wire fabric, 6 inches.

Installations:

A. Handling: Care shall be exercised to avoid damage to reinforcement during loading, unloading, storage, and installation. The ENGINEER will inspect all reinforcement and any damaged material that cannot be satisfactorily repaired on the site shall be rejected and removed from the site. Rejected material shall be replaced with material acceptable to the ENGINEER.

B. Accessories: Provide and install all accessories in accordance with the recommendations of ACI 315. All metal accessories at points of exposure shall be galvanized or stainless steel. Reinforcement accessories for slabs on grade may be solid concrete brick.

C. Surface Condition: Reinforcement at the times concrete is placed shall be free from mud and oil and shall be reasonably free from rust, scale or coatings of any character which would tend to reduce or destroy the bond.

D. Placing: Reinforcement shall be accurately placed and adequately supported before concrete is placed, and shall be secured against displacement within permitted tolerances and spacing as outlined in Chapter 7 of ACI 318, "Building Code Requirements for Reinforced Concrete."

E. Concrete Protection: The minimum concrete cover, unless otherwise shown on the plans, shall be as follows:

1. Metal Bars and Cold Drawn Wire:
    a. Main reinforcing bars in all beams, columns, piers, pilasters, and walls, 2 inches.
    b. Reinforcing in slabs, other than foundation slabs, top and bottom exposed to earth or water, 2 inches.
    c. Reinforcing in slabs, other than foundation slabs, top and bottom, not exposed to earth or water, 1 inch.
    d. Reinforcing in bottom of footings and foundation slabs cast against and permanently exposed to earth, 3 inches.
    e. Reinforcing in top of all footings and foundation slabs, 2 inches.
    f. Beam stirrups and column ties, 111 inches.

2. Welded Wire Fabric: Same as above.

8.4 CLASS FS CONCRETE

The following class of rigid replacement concrete as indicated below shall be used as per O.D.O.T. Item 499:

Class FS - This mixture is fast-setting Portland cement concrete for accelerated setting and strength development. The minimum cement content shall be 900 pounds per cubic yard and the maximum water cement ratio shall be 0.40. The rigid replacement may be opened to traffic after four (4) hours provided test beams have attained a modulus of rupture of 400 psi.

The concrete shall be kept plastic by means of a set-retarding admixture until the surface has been textured. The set-retarding admixture shall be used in accordance with the manufacturer's recommendations and the Engineer's instructions. Calcium chloride shall then be added and mixed with each batch of concrete just prior to placement.

If Type II (94-97 percent purity) calcium chloride is used, the addition rate shall be 1.6 percent by weight of the cement. Type 1 (77-80 percent purity) calcium chloride may be used at a rate of 2.0 percent by weight of the cement. When calcium chloride in a water solution is used the water used shall be considered, as part of the concrete mixing water and appropriate adjustments shall be made for its inclusion in the total concrete mixture.

Other approved accelerating admixture may be used if approved by the ENGINEER and used at the rate recommended by the manufacturer provided it will produce the required strength in the allotted time.

Immediately after the curing compound has been applied, Class FS repairs shall be covered with polyethylene film and further covered with insulation board. The insulation board shall be Class F as specified in ASTM C-208. The insulation board shall be wrapped in plastic film to protect it from rain and shall be placed tight against the surrounding concrete and weighted down to protect the fresh concrete from the weather.

Proportioning and Aggregate Size: The proportioning of the concrete materials to meet the requirements of each class of rigid replacement concrete specified shall be the responsibility of the CONTRACTOR. The coarse aggregate may be any one of the following sizes: No. 57, No. 6, No. 67, or No. 8. When No. 8 size is used, the entrained air content shall be 8 percent + 2. Otherwise, the entrained air content shall be 6 percent + 2.

Approval of Mix Design: The O.D.O.T. Engineer shall approve the concrete mix design based on the CONTRACTOR'S submitted proportions and the foregoing information. Submittal by the CONTRACTOR shall be made in sufficient time to allow approval of materials and mix design prior to placing concrete.

8.5 LOW STRENGTH MORTAR-BACKFILL MATERIAL

Description:

This work shall consist of the placement of a flowable low strength mortar for backfill over conduits or at other locations specified on the plans. The work shall be in accordance with O.D.O.T. Items 613 and 499 unless otherwise specified herein.

Materials:

Materials shall be:

A. Cement - O.D.O.T. 701.01 or 704.04
B. Fly Ash - Source approved by Engineer
C. Fine aggregate shall be natural sand consisting of mineral aggregate particles. The gradation of the sand shall be as follows:

Sieve Size	% Passing
3/4"	100
No. 200	0-10

It is intended that the sand be fine enough to stay in suspension in the mixture to the extent required for proper flow. The Engineer reserves the right to reject the sand if a flowable mixture cannot be produced.

Mortar Mix Proportioning:

Initial trial mixture shall be as follows:

Material	Quantity of Dry Materials per Cubic Yard (lbs)	
	Under Pavement	Outside Pavement
Cement	100	50
Fly Ash	0	250
Sand (SSD*)	2420	2910
Water	210-300	500

*Saturated Surface Dry

These quantities of materials are expected to yield approximately one (1) cubic yard of mortar of the proper consistency. Adjustments of the proportions may be made providing the total absolute volume of the materials is maintained.

Trial Batch: To expedite consolidation of the mortar, it will be necessary for bleed water to appear on the surface immediately after the mortar is struck off. A delay in bleeding indicates there are too many fines in the mixture, so the fly ash quantity shall be reduced in increments of 50 lbs. until the mixture is bleeding freely. Approximately 60 lbs. of sand shall be added to replace each 50 lbs. of fly ash to maintain the original yield.

Fluidity of the mortar mix shall be measured by the Corps of Engineer's flow cone method according to CRD-C661. Prior to filling the flow cone with mortar the mixture shall be passed through a 1/4-inch screen. The time of efflux shall be approximately 12 seconds.

The CONTRACTOR, prior to full scale placement of the mortar, shall make one or more trial batches of mortar not less than one (1) cubic yard in volume hauled to the job site and shall cast one or more test samples equivalent to the approximate dimensions of the trench to be backfilled. The samples may be placed in another section of trench, not under a paved area, and approved by the Engineer or cast in a form. The time required to support pavement replacement should be determined from these tests.

The CONTRACTOR shall provide sufficient mixing capacity, mixers and/or transport vehicles to permit the mortar to be placed without interruption.

The CONTRACTOR shall place the flowable mortar by any reasonable means into the space to be filled. The mortar shall be brought up uniformly to the fill line shown on the plans or as directed by the Engineer.

The flowable mortar shall be immediately leveled and the CONTRACTOR shall drain or remove the bleed water as it appears on the surface.

SECTION IX
Miscellaneous

9.1 PAVEMENT, DRIVE AND WALK REPLACEMENT

The CONTRACTOR/OWNER shall provide all labor, tools, material and equipment to replace the pavement, drives and walks that have been damaged or disturbed during the course of the work, all as specified herein or as directed by the ENGINEER.

During the entire period of construction of the project all streets, drives and walks shall be kept in usable and safe condition for public use**.** Before final acceptance, and after trench settlement has been provided to the satisfaction of the ENGINEER, pavement, drives and walks designated by the ENGINEER shall be re-paved with the type of pavement replacement specified herein.

Where necessary to disturb the existing pavement, the pavement will be line cut and the edges of face of the old pavement or base shall be left vertical. Ragged edges shall be trimmed so as to provide a substantially straight-line juncture between old and new surfaces.

If the pavement becomes damaged or destroyed outside the limits of the trench, it shall be replaced as specified by the ENGINEER.

The pavement replacement shall be so placed as to conform in grade with the existing pavement, drives or sidewalks.

The type of pavement, drives and walks used for replacement shall be as shown on Standard Drawing STR-01, STR-04, STR-07, STR-08, & STR-09 in accordance with the latest Construction and Material Specifications, State of Ohio, Department of Transportation.

Cold mix shall be applied to all pavements disturbed during construction while the backfill is given a chance to settle or until final paving can be accomplished at the discretion of the ENGINEER. Afterwards, the cold mix shall be removed and the pavement replaced as specified.

9.2 GRANULAR BACKFILL

Trenches shall be backfilled with granular material where indicated on the plans or as directed by the ENGINEER.

Granular material may be gravel or crushed stone meeting the requirements of Section 304 (as approved by the ENGINEER) State of Ohio, Department of Transportation, Construction and Material Specifications, or other well graded granular material approved by the ENGINEER.

The material shall be placed in layers of approximately six- (6) inches in thickness and compacted to the satisfaction of the ENGINEER in accordance with State of Ohio, Construction and Material Specifications, Section 304.05. It may be compacted with water if satisfactory drainage is provided for the free water. If in pavement, driveway or berm, the top eight- (8) inches of granular material shall be suitable for temporary paving material. If in lawn, the top four- (4) inches shall be topsoil.

If the CONTRACTOR is required to excavate below pipe grade, such as in rock excavation or to obtain a stable foundation for the pipe, the granular material required to restore the grade shall be as herein specified, or as approved by the SANITARY ENGINEER.

9.3 PAINTING

General: The CONTRACTOR'S attention is directed to the Concrete Specifications and referenced to the "rubbing" requirements on exposed interior concrete surfaces. In lieu of this requirement, the CONTRACTOR may elect to paint all exposed interior concrete surfaces as specified herein. Prior to painting all fins and projections shall be removed and voids, damaged places and form tie holes filled with mortar of the same composition as the concrete mixture. Remove hardware, accessories, plates, lighting, fixtures, etc., prior to painting. Remove doors where necessary to paint this action shall be replaced.

Extent of the Work: It is the intent of this specification that all piping, equipment, doors, railings, structural steel, metal, wood, pre-cast concrete roof slabs, concrete block, which are exposed either on the interior or exterior of the structures shall be painted, unless noted otherwise.

Field painting of factory finished item will not be required.

No galvanized, brass, bronze, aluminum or stainless steel items shall be painted, unless noted otherwise.

All structural steel and ironwork shall receive a shop coat as specified herein or under its specific section.

Spraying will be permitted only with the approval of the ENGINEER.

The manufacturer shall in accordance with the practices and recommendations set the application of the protective coatings forth.

All wood, except redwood and pressure treated shall be primed with white lead and linseed oil before delivery to the building and stored in a dry place until set. Priming shall include back, sides, top and bottom of all portions inaccessible after setting. All field cuts of painted lumber shall be touched-up.

On all woodwork which are to receive a priming coat, the knots and sap and pitch streaks shall be treated before the priming coat is applied. Exposed nail holes shall be properly puttied and rubbed down after priming coat has been applied.

The CONTRACTOR shall paint all exposed pipes, valves, stands, stems, machinery bases and equipment furnished or set in place by him. Cast iron pipe shall receive three coats of paint of a nature such that the paint will dry and the factory coating will not "strike through." Where machinery or equipment is finish painted before delivery, in a manner satisfactory to the ENGINEER, field painting may be omitted at the express permission of the ENGINEER.

Storage: All materials shall be stored in a single place approved by the ENGINEER. Such storage area shall be kept clean and neat at all times. Keep area ventilated.

All clean and oily rags shall be kept in separate metal containers with tight fitting covers. At the completion of each day's work, all oily rags shall be gathered and stored in the approved container.

Protection and Cleaning: CONTRACTOR shall protect all existing areas from damage by equipment, materials, spattering, etc. Particular care shall be taken to prevent staining of concrete floors. All spattering, drippings, etc. shall be removed immediately.

All debris, wastes, empty cans, etc. shall be removed from the site. None shall be allowed to accumulate.

Workmanship and Base Preparation: Prior to painting, the CONTRACTOR shall correct all blemishes, remove all grease, dirt and rust, sand all glossy surfaces, remove all loose and peeling paint, feather edge all chips and peeled areas by sanding.

If any surface to be finished cannot be put in proper condition, the painting contractor shall notify the ENGINEER immediately in writing or assume full responsibility for failure to do so and shall correct any unsatisfactory area.

All surfaces where called for or required to be sandblasted, shall be cleaned by sandblasting to a near white metal in accordance with the Steel Structures Painting Council Specification SSPC-SP-10 with a surface profile of not more than 2 miles and painted as specified.

Application, drying time between coats, mixing, etc., shall be in strict accordance with the manufacturer's recommendations.

Materials: The CONTRACTOR may submit for approval "Ready Mixed" paints, manufactured by reputable firms. CONTRACTOR shall submit for approval a list of brands he intends to use.

Color Coding and Banding: All inside piping shall be painted and marked with the following color code, bands, or as approved by the ENGINEER. The following schedule shall be used as a guide only and the OWNER may, at his discretion, change any color or color combination.

Banding tape, where called for, shall be 2 1/4 inches wide, self-sticking as manufactured by the W.H. Brady Co., Milwaukee, Wisconsin, Seton Corp., New Haven, Connecticut or equal. Banding shall be spaced as directed by the ENGINEER, but not greater than 10 feet o.c.

PAINTING SCHEDULE

To establish a standard of quality, the products of Koppers Company, Newark, New Jersey are set forth in the table below, however, Prufcoat, Cleveland, Ohio; Tnemec, North Kansas City, Missouri; Tropical, Cleveland, Ohio; Mobile, Kankakee, Illinois; Porter, Louisville, Kentucky; Degraco, Rockford, Illinois; Sherwin-Williams, Cleveland, Ohio, or equal may be used.

Surface	**Number of Coats**	**Dry Mill Thickness Each Coat**	**Make and Type Koppers**
Concrete (See Section 3A)	1 Primer 2 Finish	2 2	Dampfoil Surface Emulsion Glamorglaze
Concrete Block, Only, Except Garage	1 Primer 2 Finish	2 2	Dampfoil Surface Emulsion Glamorglaze
Non-Submerged Ferrous 1 Shop Metals, Equiptment Metal Doors & Frames	1 Touch-up 1 Intermediate 1 Finish	2 2 2 2	#622 #622 Glamortex Glamortex
Submerged Equiptment & Ferrous Metals	1 Shop 1 Touch-up 2 Finish	2 2 10	#626 #626 Coal Tar Epoxy
Pipe, Except Exhaust System or Submerged	1 Shop 1 Touch-up 1 Finish		#621 #621 Glamortex
Pipe, Submerged	2 Finish	10	Bitumastic 300 (Coal Tar Epoxy)
Pipe Covering, Except Exhaust System	1 Primer 2 Finish	2 2	#622 Glamortex
Exhaust Pipe System	2 Finish	2	Hi-Heat Gray
Wood Ceiling, Except Garage			Stain as Directed
Siding			Prefinished
Exposed Wood, Other Than Prefinished and Garage	2 Coats		Stain as Directed

Banding: The following piping in the table below shall be painted and/or marked with the following color codes, bands, or as directed by the ENGINEER.

Cold Water (Potable)	Blue
Floor Drains	Black
Raw Sewage	Gray
Chemical	As Directed
Other	As Directed

Pipe Marking: All plant piping not color coded or banded shall be stencil marked with the function of the pipe.

Provide directional arrows for the flow on all pipes as and where directed.

All markings shall be placed between all bends and not more than 5'-0" c/c on straight runs or as directed

9.4 MISCELLANEOUS METAL

General: All steel shall be either open hearth or Bessemer process and shall meet the requirements of the Standard Specifications for Structural Steel for Bridges and Building, ASTM designation A36.

All cast iron used in connection with structural work shall meet the requirements of the Standard Specifications for Gray Iron Castings of the ASTM designation A48.

In general, all steelwork is to be fabricated to meet the requirements applicable to this work of the Standard Specifications of the American Institute of Steel Construction.

Aluminum alloys are specified herein under the different types of shapes required. All aluminum in contact with concrete or dissimilar metals shall be isolated from the same by coating the contact surfaces with bituminous material.

Steel and wrought iron shall be well formed to shape and size, with sharp lines or angles. Shearing and punching shall leave clean, true lines and surfaces. Weld or rivet permanent connections. Do not use screws or bolts where they can be avoided; where used, heads shall be countersunk, screwed up tight and threads nicked to prevent loosening. Curved work shall be evenly sprung.

Castings shall be sound and free from warp, holes and other defects that impair their strength of appearance. Exposed surfaces shall have a smooth finish and sharp, well-defined lines and arises. Machined joints, where required, shall be milled to a close fit. Provide necessary rabbets, lugs and brackets so that work can be assembled in neat and substantial manner.

Fastenings shall be concealed where practicable. Thickness of metal, and details of assembly and supports shall give ample strength and stiffness. Joints exposed to weather shall be formed to exclude water. Provide holes and connections for the work of other trades.

All ironwork, steel and aluminum work shall be of high grade and good workmanship.

Where no details are indicated, it is expected that the CONTRACTOR will submit details drawn in a workmanlike manner in accord with the spirit of the design, for approval. Measurements shall be taken on the job to insure proper fit.

Painting and Protective Coating: All ferrous metal shall be properly cleaned and given one shop coat of rust resisting paint. Anchors that are built into masonry or concrete shall be coated with asphalt paint unless specified to be galvanized. Where hot-dip galvanized or zinc-coated metal is required it shall not be shop primed unless specifically called for but all abraded places and welding shall be touched up with aluminum paint. Where hot-dip galvanizing or hot-zinc-coating is specified, it shall be done in accordance with the Standard Specifications of the American Hot-Dip Galvanizers Association.

All steelwork not specified to be hot-dip galvanized, is to receive a shop coat of paint, before shipment to the job. After setting, all exposed steelwork is to be given additional paint. All painting shall be as specified under "Painting".

Structural Steel and Aluminum Shapes: Provide all structural steel and aluminum as shown on the drawings or as required to complete all work. All fabricating details, anchors and connection bearing plates, etc., shall be standard unless otherwise noted. Shop and placing drawings shall be submitted to the ENGINEER for approval prior to fabrication.

Aluminum Stop Plates, and Guides: All aluminum stop plates, and guides shall be 5052-H36 or 6061-T6 alloy, of the sizes and shapes shown on the drawings.

Aluminum Grating: Floor grating shall be of rectangular pressure locked type properly supported by ample frames anchored into concrete. Grating shall be of such construction as to have a uniform load of 250# per square foot with a deflection of less than 1/160 of the span. Bearing bars shall not be less than 3/16" thick and a minimum of 1 1/4," in depth. All openings and edges shall be banded. All gratings shall be of aluminum.

Where aluminum gratings are used they shall be supported by aluminum angles securely anchored to the concrete. Where angle support extends across an opening the angle shall be supplemented with a 3" aluminum channel.

9.5 BRICK MASONRY

Grade and Type of Brick: The type, color and texture of the brick will be selected by the ENGINEER from samples submitted by the CONTRACTOR. No brick shall be ordered until samples have been approved.

All exterior brick shall be first quality, hard-burned, Grade A, conforming to ASTM Specification C216, Grade SW, Type FBX or FBS.

Interior brick shall be first quality, hard-burned, Grade A, conforming to ASTM Specification C62, Grade MW, unless noted otherwise.

Storage: The CONTRACTOR shall provide adequate and satisfactory "off ground" storage facilities and shall protect the brick from the weather. Cost of storage and protection shall be included in handling and placing costs.

Method of Laying and Bond. Prior to starting the masonry work the foundation or "bed" shall be checked for level and line. All openings shall be accurately located both in plan and elevation. All intersecting partitions or columns shall be located together with major openings for pipe and ventilators. Irregularities in line and grade shall be noted and corrected. Coursing, both vertical and horizontal, shall be determined from the above and the lead corners laid up accordingly. No exposed brick under 4" in length shall be used.

Masonry shall be isolated from concrete with a coat of Bitumastic paint or a layer of 15 lb. unperforated felt, and as shown on the drawings.

Brick shall be laid in a common bond with a header course every 6th course, unless noted otherwise. Brick shall be reinforced and tied with "truss-type" reinforcing every third course, for three consecutive courses above and below all openings. Reinforcing shall extend a minimum of 2'-0" beyond each side of the opening.

Brick shall be laid in a full-unfurrowed bed, shoved home to completely fill the head joint. Parge the face of all back-up masonry with mortar and fill all joints and voids with mortar so that all walls shall be of solid construction except for masonry cores, expansion joints or where shown otherwise.

All face brick laid in the wall shall be free from chipped corners or edges and shall be reasonably straight and true. Discolored or chipped bricks shall be removed from the wall.

Care shall be exercised during laying operations to protect the finished masonry and floors from mortar stains, drippings and chipping.

In warm weather masonry units tending to absorb moisture from the mortar too rapidly shall be thoroughly wetted before laying. During freezing weather all brick and mortar materials shall be protected from the elements and kept dry until laid. No frozen material will be permitted in the mortar. After laying, all masonry work shall be protected from freezing during cold weather not less than 48 hours. As walls are constructed, the open top and ends are to be protected at the close of each working day and kept dry by covering with tarpaulins weighted down and overhanging the walls by a minimum of 2'-0". No masonry work shall be accomplished during inclement weather without the ENGINEER'S approval of proposed protective methods. Any and all masonry damaged by the elements shall be replaced to the satisfaction of the ENGINEER.

Mortar: The mortar for all masonry shall be composed of one part Portland cement, one part lime putty and five parts of sand. The lime putty shall be made by properly slaking a good quality lime. The quick lime shall be slaked at least three days before using. Water proofing mortar material as manufactured by the Master Builders Company of Cleveland, Ohio, Grace Construction Products or equal, shall be added to the

mortar according to the manufacturer's directions. Suitable arrangements shall be made for accurate measuring and thorough mixing of the ingredients to insure uniformity. Measurement shall be by volume. With the approval of the ENGINEER specially processed hydrates conforming to Type S for Hydrated Lime for Masonry Purposes may be used in lieu of lime putty.

Portland Cement - ASTM C-150 or C-175 for air entraining cement.

Lime - either hydrated lime conforming to ASTM Specification C-207 Type S and must be at least 92 percent hydrated, or quicklime conforming to ASTM C-5. Quicklime putty mixture shall be allowed to slake for 72 hours before using.

Sand - clean, natural colored and conforming to ASTM Specification C-144.

Brick Facing: Brick facing of concrete walls shall be mechanically tied to the concrete with dovetail ties 2'-0" o/c every third course.

Provide 1/4" copper bleed tubes 2'-0" o/c at the base of all brick as shown on the drawings.

Where shown, the outer wythe of brick shall be isolated from the concrete with a solid sheet of closed cell polyethylene.

Expansion Joint: Provide a self-expanding cork strip between brick wall and concrete where and as shown on the drawings. Expansion strip shall be recessed ½" from face of the brick to provide reglet for caulk

Chases and Openings: All chases and opening for other trades and/o contractors shall be built in as shown or indicated on the drawings as work progresses.

Patching: Patching of existing walls and closing of openings shall be as shown. All brick shall be keyed to the existing or stepped every course with all surfaces flush with the existing surface and all joints kept on line.

Pointing: Clean and point at the end of each working day all exposed masonry work including nail holes.

Where and when shown, existing brick shall be pointed. All cracks shall be cleaned of all existing mortar for the full depth of the face brick. All disintegrated joints shall be cut out to the full depth of the disintegration, all other joints shall be cut out to a minimum depth of 1". All cut joints shall be brushed and washed (under pressure) clean prior pointing.

Joints greater than 1" shall be stage-pointed. All joints shall be pointed to the full depth of the cut, tooled to match existing. Joints shall be kept wet while pointing.

Mortar shall be as specified above.

Clean-up: On completion of the work all masonry must be carefully cleaned down, removing all large particles of mortar with a putty knife or chisel. If acid is required for the removal of mortar stains (see note below), it shall be muriatic (hydrochloric) and not stronger than one volume of the commercial acid to nine

volumes of water. Before the acid solution is applied, the surface should be thoroughly soaked with clear water, otherwise the mortar Stain may be drawn into the pores causing a permanent dulling of the rich natural masonry colors. The acid solution should be applied with a long-handled stiff fiber brush, with proper precautions as to covering of clothing, hands and arms to prevent burns. It should not be placed over an area greater then 15 to 20 square feet before the wall is again thoroughly washed down, or preferably hosed, with clear water immediately after cleaning. It is important to remove all trace of the acid before it attacks the mortar joint. All frames, trim, sills, or other installations adjacent to the masonry must be carefully protected against contact with the acid solution.

Note: Whenever possible, smooth, light colored units should be scrubbed with warm water and soap powder in lieu of acid cleaning.

Measurement: For final payment purposes the completed and accepted masonry work will be measured and the number of various brick units determined on a square foot of single wall basis (not including openings) as follows:

	2 1/4" X 8"
1/4" Joints	7
3/8" Joints	6.5

The above table indicates the number of units of various sizes and joints per square foot of single width of wall surfaces.

9.6 BLOCK MASONRY

Concrete Block: Concrete block shall be Grade A quality, thoroughly cured, and of the size shown on the plans, free from imperfections and of a physical quality satisfactory to the ENGINEER.

Concrete blocks shall be made from Portland Cement and the use of the following aggregates: Limestone sand or natural sand with gravel, crushed stone, or blast furnace slag. Blocks to be of the two or three core type, except as noted herein.

No overall dimension shall vary more than 3 percent over or under the specified dimension for any form of unit.

All units shall be sound and free from cracks or other defects that would interfere with the proper placing of the unit or impair the strength, permanence, or appearance of the structure. Corner block and fillets shall be provided as shown on the drawings.

The OWNER or his authorized representatives shall be accorded proper facilities to inspect and sample the units at the place of manufacture from the lots ready for delivery. At least ten days should be allowed for completion of the tests.

Physical Requirements: Hollow load bearing blocks shall meet the physical requirements set forth in the following table:

Minimum Face Shell Thickness, inches	Compressive Strength, Min PSI (Avg. Gross Area) (Average of 5 Units)	Compressive Strength, Min PSI (Average Gross Area) (Individual Unit)	Water Absorption Max, lb. per c.f. (Avg. of 5 Units)	Water Content Max Percent (Avg. of 5 Units)
1 1/4 or over: Grade A	1,000	800	15	40
Under 1 1/4 and over 3/4	1,000	800	15	40

Method of Laying: All concrete block shall be laid in the best, neat, and workmanlike manner with plumb, even wall surfaces. All courses shall be laid level and all joints completely filled with mortar. Exterior joints shall be tooled. Interior finish surface joints shall be struck smooth and even with the wall surface or tooled at the option of the OWNER. Exposed surfaces shall be free from broken, defective, or warped block. All exposed surfaces shall be kept clean and free from mortar splashes and discoloration.

In warm weather, all concrete block shall be wetted before laying. In freezing weather, all concrete block and mortar materials shall be protected from the elements and kept dry until laid. No frozen material will be permitted in the mortar.

Block shall be mechanically tied to concrete with approved wall ties placed in the concrete as shown on the drawings.

All openings shall be accurately located in both plan and elevation. All majors intersecting partitions, walls, or columns shall be located together with major openings for pipes or ventilators. Irregularities in line or grade shall be noted and corrected if possible. From the above, the coursing, both vertical and horizontal, shall be determined and the lead corners laid up accordingly. Masonry shall be isolated from concrete "bed" with a coat of bitumastic paint or a layer of 15 lb. unperforated felt.

Care shall be exercised during laying operations to protect the finished masonry and floors from mortar stains, drippings, and chipping.

After laying, all masonry work shall be protected from freezing during cold weather for not less than 48 hours. Provisions shall be made to protect newly finished work from rain or weather elements. No masonry work shall be accomplished during inclement weather without the ENGINEER'S approval of proposed protective methods. Any masonry damaged by the elements shall be replaced at no additional cost.

Point up around all doors, windows, openings, nail holes, and elsewhere as required or directed.

Pre-cast Concrete Lintels: Pre-cast concrete lintels shall be furnished as and where shown on the drawings. Lintels shall be of the sizes shown, and shall match adjacent block in composition and texture. Lintels shall have a full 8- inch bearing at each end and be reinforced as shown on the drawings.

Mortar: The mortar for all masonry shall be composed of one part Portland Cement, one part lime putty, and five parts of sand. The lime putty shall be made by properly slaking a good quality quicklime. The quicklime shall be slaked at least three days before using. Waterproofing mortar shall be added to the mortar according to the manufacturer's directions. Suitable arrangements shall be made for accurate measuring and thorough mixing of the ingredients to insure uniformity. Measurement shall be by volume. With approval, Lime for Masonry Purposes may be used in lieu of lime putty.

Portland Cement - ASTM C-150 or C-175 for air entraining cement.

Lime - either hydrated lime conforming to ASTM Specification C-207 and must be at least 92 percent hydrated, or quicklime conforming to ASTM C-5. Quicklime putty mixture shall be allowed to slake for 72 hours before using.

Sand - clean, natural colored sand conforming to ASTM Specification C-144.

Masonry Reinforcing: All masonry walls shall be reinforced every other course vertically or every 16 inch o.c., and every course for three (3) consecutive courses above and below openings and extend 2'-0" each side of opening. Reinforcing shall be Truss type as manufactured by Dur-o-wal National, Inc., Lox-All, or equal.

Expansion Joints: Provide 1/2 inch closed cell polyethylene strips or self-expanding cork where shown on the drawings. Expansion strip shall be recessed 1/2 inch from the face of the block to provide a reglet for caulking.

Patching. Patching of existing walls and closing of openings shall be as shown. All block shall be keyed to every existing course with all surfaces flush with the existing surface and all joints kept on line.

Clean-up: On completion of the work, all masonry must be carefully cleaned down, removing all large particles of mortar with a putty knife or chisel and stiff brush ready and accepted for surface finish specified.

9.7 VALVES

Gate Valves: All hand-operated gate valves, three inches (3") and larger shall be iron body, double disc, parallel seats, bronze mounted conforming to the latest standard specifications of the American Water Works Association, unless otherwise noted on the plans or by separate page included herein. All valves 2 1/2" and under, shall be all bronze, of approved manufacture and suitable for the service required. All valves shall have openings through the body of the same circular area as that of the pipe to which they are attached.

All gate valves equipped with hand wheels shall be outside screw and yoke type. All gate valves not equipped with hand wheels shall be of the inside screw type with non-rising stem unless otherwise noted.

All hand-operated gate valves shall open by turning counterclockwise. The direction of opening shall be indicated by an arrow on hand wheels and on operating nuts.

Valves shall have flanged, mechanical joint, hub, or screw connections as required by the layout, shown on the drawings or called for in the valve list.

All submerged valves shall be furnished with "O" ring packing.

All gate valves shall be designed for a working pressure of 150 lbs. per square inch unless otherwise noted on the plans or in the valve schedule. The CONTRACTOR shall make all valves tight under their working pressures after they have been placed and before placed in operation. Any defective parts shall be replaced.

Check Valves. Check valves on pump discharge lines of 3" diameter and larger shall be of the non-slamming, externally balanced type. The seat ring shall be of bronze and back faced. The gate shall be mounted in a bronze gate ring and shall be hung from a solid bronze or malleable iron hinge with a solid bronze or stainless steel pin, connected in such a manner as to prevent gate rotation. The gate and all internal working parts shall be removable through a top cover.

The valve body shall be of cast iron construction and shall contain a bronze or stainless steel seat ring securely fastened within the valve body. The valve disc will contain a resilient-replaceable seat held in place by a bronze or stainless steel follower.

The valve shall normally be closed and shall open when the system pressure exceeds the pump discharge pressure by 10 percent. The valve shall close slowly when the system pressure returns to normal. An oil chamber shall be furnished externally that will effectively permit the valve to operate without any hammering action. The chamber shall be so arranged that the closing speed will be adjustable to meet the service requirements.

The opening pressure setting shall be factory set but adjustable in the field by adjustment of the spring tension.

Valve Boxes: All valves outside structures shall be provided with valve boxes. Valve boxes shall be of standard, adjustable, heavy pattern, cast iron extension type, of such length as is required. Where valve boxes are installed in locations subject to traffic, they shall be supported so that no load can be transmitted from the valve box to the valve.

Floor Boxes: Floor boxes shall be designed for installation in concrete floors or slabs and be designed to support the extension stem and operating nut of the N.R.S. Valve.

Floor boxes shall be Clow Corp. No. F-5695, Mueller Co. or equal.

Operating Nuts: All operating nuts for all valves shall be 2" square.

Valve Wrenches: Valve wrench shall be of T-bar design and of sufficient strength and size to open and close valves properly. The quantity required shall be as specified in the Valve List.

Extension Stems: Extension stems shall be extra strong steel pipes or cold rolled steel and of sufficient strength and size to open and close valves properly.

Stem Guides: Stem guides shall be fully adjustable and made of high strength cast iron. Guide shall be bronze bushed where the extension stem passes through. Stem guides shall be Clow Corp. No. F-5660, Mueller Co. or equal.

Plug Valves: Valves shall be non-lubricated eccentric plug types. Valves shall be rated for 175 lb. W.O.G. and cast of semi-steel. Flanges shall meet A.S.A. Flange Specification. Valves shall have a full round port with an E.P.T. (Ethylene-Propylene Terpolyme) coated plug.

Lever operated type shall have one lever for each type. High head extension shall have operating nut; support brackets and tees wrench as specified. Provide floor stands and gear operators where indicated.

Valves shall Ballcentric type as manufactured by Homestead Valve Co., Dezurik Corp. or equal.

Sluice Gates: The frames shall be of the flange type with round or rectangular opening as shown in the valve schedule and shall have the back face machined for attaching to the wall thimble. The front face shall be machined for attaching of cast iron type guides or shall be provided with integrally cast guides to form grooves for slide tongues. Guides shall be of cast iron of the integral type as outlined above or shall be of the separate bolt on type attached with corrosion resistant fasteners. Guide grooves shall be machined on all contact faces.

The gate slide of disk shall be of one-piece construction, rectangular in shape with integral cast vertical and horizontal ribs. The slide shall be designed to operate under maximum specified seating or unseating head. Pads for side wedges and top and bottom wedges, where required, shall be integrally cast on the slide and machined to receive the adjustable wedges. All sluice gates shall be the rising stem type.

The seating surface shall be bronze. They should be mounted in dovetail slots and held in position without the use of fasteners. Seating face shall be machined.

Wall thimbles shall be of cast iron and of the depth specified or shown on the drawings.

All fasteners shall be of stainless steel and of ample section to safely withstand the force created by the operation.

All sluice gates shall be as manufactured by Armco, Rodney Hunt or equal.

Hydraulic Surge Relief Valve: The elbow sewage surge relief valve shall be of a 90-degree elbow configuration. Its function to minimize surges resulting from starting and stopping of pumps either normally or as the result of a power failure.

Air Release Valves: The CONTRACTOR shall furnish and install air release valves at locations as directed by the ENGINEER. The air release valves shall be installed as shown on the Automatic Air Release Valve Detail. The component parts of the air releases shall meet the following requirements as well as the requirements detailed in Standard Drawing SAS-14:

The valve will be the type that releases large amounts of air, gases, and vapor during the filling of the system and admits large amounts of air when the system drains to prevent vacuum damage to

pipeline and accessories. The valve must release accumulated air from the system while the system operates under pressure while making an air pocket separation between the liquid and the sealing mechanism. The air release orifice will be integral to the air and vacuum orifice. All components of the valve must be of corrosion resistant materials. The valve must operate at a minimum pressure of 3 psi and a maximum of 230 psi. All metal shall be stainless steel. Valves will be ARI D Series or approved equal.

City of Marysville

Sanitary Sewer Specifications

Appendix A

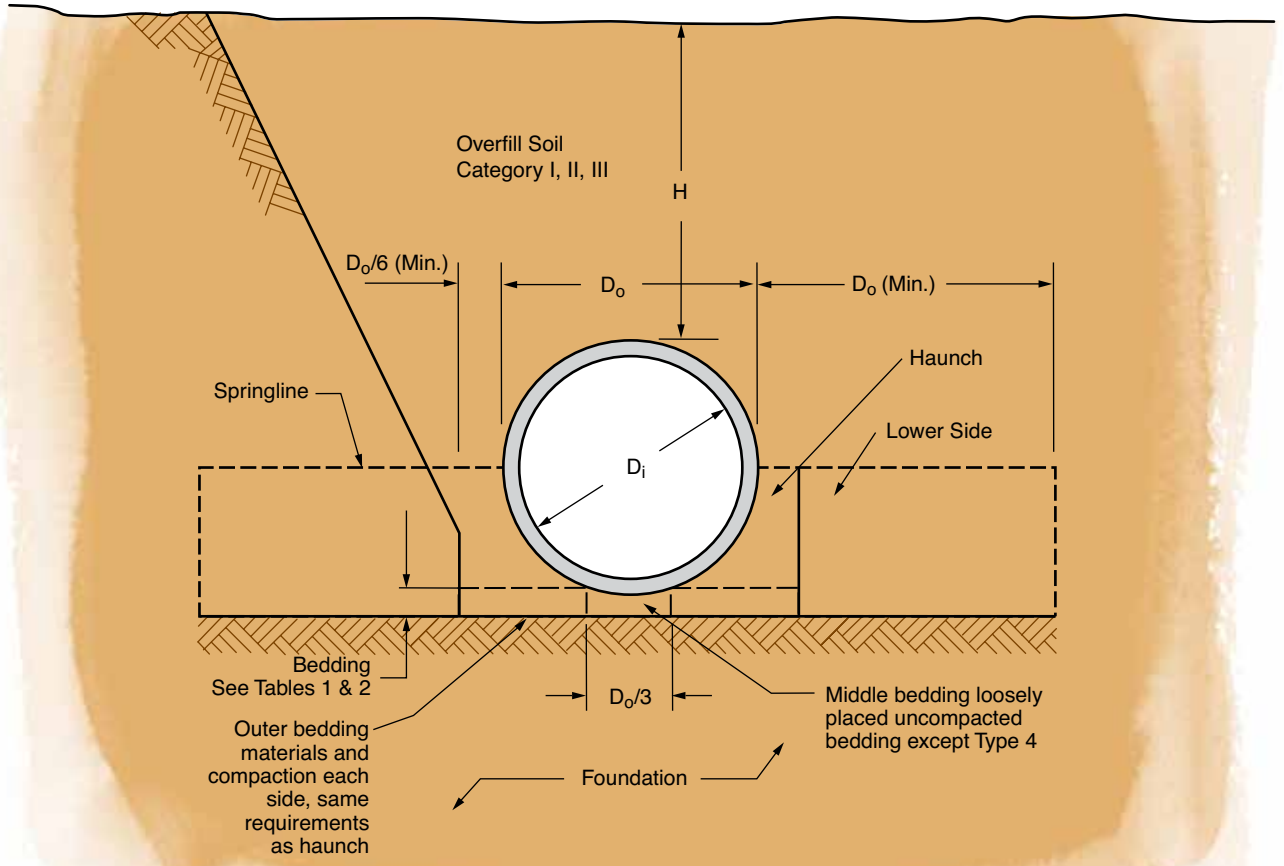
LRFD FILL HEIGHT TABLES

FOR CONCRETE PIPE

American
Concrete Pipe
Association

Standard Trench/Embankment Installation

Concrete pipe should be installed in accordance with the AASHTO LRFD Bridge Construction Specifications, Section 27 or ASTM C1479. Figure 1 shows the basic pipe and soil terminology.



There are four types of Standard Installations, each with its own soil and compaction requirements. Type 1 bedding provides the most support using highly compacted granular material, while Type 4 provides for less support allowing the use of silts and clay soils with little or no compaction. These four choices provide flexibility and versatility for the designer and contractor, as well as performance and economy for the owner that are not available with other types of pipe.

The soil and compaction requirements are provided in Table 1. Table 2 shows the equivalent soil designations per the Unified Soil Classification System (USCS) and AASHTO.

To facilitate your selection of the proper reinforced concrete pipe using the most beneficial Standard Installation for the conditions at the site, fill height tables are provided on the following pages. The required 0.01 inch crack D-Loads in units of lbs per linear foot per foot of diameter are provided numerically and the class of pipe per ASTM C76 (AASHTO M 170) meeting this requirement is designated by color of the cell.

Table 1: Standard Installation Soils and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	D_0/24 minimum, not less than 3" (75 mm) If rock foundation, use D_0/12 minimum, not less than 6" (150 mm)	95% Category I	90% Category I, 95% Category II, or 100% Category III
Type 2	D_0/24 minimum, not less than 3" (75 mm) If rock foundation, use D_0/12 minimum, not less than 6" (150 mm)	90% Category I or 95% Category II	85% Category I, 90% Category II, or 95% Category III
Type 3	D_0/24 minimum, not less than 3" (75 mm) If rock foundation, use D_0/12 minimum, not less than 6" (150 mm)	85% Category I, 90% Category II, or 95% Category III	85% Category I, 90% Category II, or 95% Category III
Type 4	No bedding required except if rock foundation, use D_0/12 minimum, not less than 6" (150 mm)	No compaction required, except if Category III, use 85%	No compaction required, except if Category III, use 85%

Reference: ASCE 15-98, "Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)", 1998.

Table 2: Equivalent USCS and AASHTO Soil Classifications for Standard Installation Soil Designations

Representative Soil Types			Percent Compaction	
SIDD	USCS	AASHTO	Standard Proctor	Modified Proctor
Gravelly Sand (Category I)	SW, SP, GW, GP	A1, A3	100 95 90 85 80 61	95 90 85 80 75 59
Sandy Silt (Category II)	GM, SM, ML, Also GC, SC with less than 20% passing #200 sieve	A2, A4	100 95 90 85 80 49	95 90 85 80 75 46
Silty Clay (Category III)	CL, MH, GC, SC	A5, A6	100 95 90 85 80 45	90 85 80 75 70 40
Not Allowed for Haunch or Bedding	CH	A7	100 95 90 45	90 85 80 40

Reference: ASCE 15-98, "Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)", 1998.

Table 3: Reinforced Pipe Classes for 0.01 inch Crack Per ASTM C 76 (lbs/ft/ft)

Class I	≤ 800
Class II	≤ 1000
Class III	≤ 1350
Class IV	≤ 2000
Class V	≤ 3000
Special Design	> 3000

NOTES:

1. Compaction and soil symbols – i.e. "95% Category I" refers to Category I soil material with a minimum Standard Proctor compaction of 95%. See Table 2 for equivalent Modified Proctor values.
2. Soil in the outer bedding, haunch, and lower side zones shall be compacted to at least the same compaction as the majority of soil in the overfill zone.

The following Fill Height Tables have been developed by the American Concrete Pipe Association (ACPA) using the indirect design method in accordance with Section 12.10.4.3 of the AASHTO LRFD Bridge Design Specification, 7th Edition, 2014.

Fill Height Tables are based on:

1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions
4. A Type 1 installation requires greater soil stiffness from the surrounding soils than the Type 2, 3, and 4 installations, and is thus harder to achieve. Therefore, field verification of soil properties and compaction levels should be performed.

D-Load (lb/ft/ft) for Type 1 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Fill Height in Feet														
Pipe Size (in)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12	1612	1399	888	695	633	620	635	661	544	603	662	721	780	839
15	1546	1344	856	673	614	602	617	644	532	589	646	704	761	818
18	1462	1307	836	660	604	593	608	634	526	583	639	696	752	809
21	1309	1281	823	653	598	588	604	630	525	581	637	693	749	805
24	1287	1262	814	648	595	587	603	629	527	583	638	694	750	805
27	1442	1264	815	653	599	591	608	634	530	586	642	697	753	809
30	1581	1272	819	660	605	598	615	640	535	591	646	702	758	814
33	1443	1222	798	651	599	596	615	641	541	597	653	709	765	821
36	1329	1187	780	643	595	595	616	643	547	603	660	716	772	829
42	1151	1099	745	627	587	591	613	641	553	609	665	721	778	834
48	1019	961	713	614	582	589	612	641	560	616	673	729	785	841
54	969	919	689	604	578	589	613	643	569	625	681	737	794	850
60	994	890	670	596	577	590	615	646	578	634	691	747	804	860
66	946	865	657	589	576	592	618	651	588	644	701	758	814	871
72	881	844	647	584	578	595	622	656	598	655	712	769	826	883
78	827	823	637	582	579	597	625	659	606	663	720	777	834	892
84	782	805	629	580	580	600	628	664	615	672	729	786	843	901
90	744	789	622	580	582	603	632	668	712	681	738	795	853	910
96	712	749	616	580	585	606	637	673	718	690	747	805	862	920
102	685	723	623	587	592	614	645	682	727	774	757	814	872	929
108	662	711	629	595	600	623	654	691	736	783	766	824	882	940
114	642	715	636	603	609	631	663	700	745	793	842	834	892	950
120	625	720	642	609	617	640	672	709	755	802	852	844	903	961
126	611	726	649	617	625	649	681	719	764	812	862	913	913	971
132	599	731	651	625	634	658	690	728	774	822	872	924	976	983
138	589	736	645	633	643	667	699	738	784	832	883	934	987	994
144	580	742	651	642	652	676	709	747	794	843	893	945	998	1052

Fill Height Tables are based on:

1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions
4. A Type 1 installation requires greater soil stiffness from the surrounding soils than the Type 2, 3, and 4 installations, and is thus harder to achieve. Therefore, field verification of soil properties and compaction levels should be performed.

D-Load (lb/ft/ft) for Type 1 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Fill Height in Feet														
Pipe Size (in)	15	16	17	18	19	20	21	22	23	24	25	26	27	28
12	898	957	1016	1075	1134	1194	1253	1312	1371	1430	1489	1548	1607	1666
15	876	933	990	1048	1105	1163	1220	1277	1335	1392	1449	1507	1564	1621
18	865	921	978	1034	1091	1147	1203	1260	1316	1373	1429	1485	1542	1598
21	861	917	973	1029	1084	1140	1196	1252	1308	1364	1420	1476	1532	1588
24	861	917	972	1028	1084	1139	1195	1251	1306	1362	1418	1474	1529	1585
27	864	920	975	1031	1087	1142	1198	1254	1309	1365	1421	1476	1532	1588
30	870	925	981	1037	1093	1148	1204	1260	1316	1372	1427	1483	1539	1595
33	877	933	989	1045	1101	1157	1213	1269	1325	1381	1437	1493	1549	1605
36	885	941	998	1054	1110	1167	1223	1279	1335	1392	1448	1504	1561	1617
42	890	946	1002	1058	1115	1171	1227	1283	1339	1395	1451	1508	1564	1620
48	897	953	1010	1066	1122	1178	1234	1290	1346	1403	1459	1515	1571	1627
54	906	963	1019	1075	1131	1188	1244	1300	1356	1413	1469	1525	1581	1638
60	917	973	1029	1086	1142	1199	1255	1312	1368	1425	1481	1538	1594	1650
66	928	985	1041	1098	1155	1211	1268	1325	1381	1438	1495	1552	1608	1665
72	940	997	1054	1111	1168	1225	1282	1339	1396	1453	1510	1567	1624	1681
78	949	1006	1063	1120	1177	1234	1291	1348	1405	1462	1519	1576	1633	1690
84	958	1015	1072	1129	1186	1244	1301	1358	1415	1472	1529	1587	1644	1701
90	967	1024	1082	1139	1196	1254	1311	1368	1425	1483	1540	1597	1655	1712
96	977	1034	1092	1149	1207	1264	1322	1379	1436	1494	1551	1609	1666	1723
102	987	1045	1102	1160	1217	1275	1333	1390	1448	1505	1563	1620	1678	1736
108	997	1055	1113	1171	1228	1286	1344	1402	1459	1517	1575	1633	1690	1748
114	1008	1066	1124	1182	1240	1298	1356	1413	1471	1529	1587	1645	1703	1761
120	1019	1077	1135	1193	1251	1309	1367	1426	1484	1542	1600	1658	1716	1774
126	1030	1088	1146	1205	1263	1321	1380	1438	1496	1555	1613	1671	1730	1788
132	1041	1100	1158	1217	1275	1334	1392	1451	1509	1568	1626	1685	1743	1802
138	1052	1111	1170	1229	1287	1346	1405	1464	1522	1581	1640	1698	1757	1816
144	1064	1123	1182	1241	1300	1359	1418	1477	1536	1595	1654	1712	1771	1830

Fill Height Tables are based on:

1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions
4. A Type 1 installation requires greater soil stiffness from the surrounding soils than the Type 2, 3, and 4 installations, and is thus harder to achieve. Therefore, field verification of soil properties and compaction levels should be performed.

D-Load (lb/ft/ft) for Type 1 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Fill Height in Feet														
Pipe Size (in)	29	30	31	32	33	34	35	36	37	38	39	40	41	42
12	1725	1784	1843	1902	1961	2020	2079	2139	2198	2257	2316	2375	2434	2493
15	1679	1736	1793	1851	1908	1965	2023	2080	2138	2195	2252	2310	2367	2424
18	1655	1711	1767	1824	1880	1937	1993	2049	2106	2162	2219	2275	2331	2388
21	1643	1699	1755	1811	1867	1923	1979	2035	2091	2147	2203	2258	2314	2370
24	1641	1696	1752	1808	1863	1919	1975	2030	2086	2142	2197	2253	2309	2365
27	1643	1699	1755	1810	1866	1922	1977	2033	2089	2144	2200	2256	2311	2367
30	1650	1706	1762	1818	1874	1929	1985	2041	2097	2152	2208	2264	2320	2376
33	1661	1717	1773	1829	1885	1941	1997	2053	2109	2165	2221	2277	2333	2389
36	1673	1730	1786	1842	1899	1955	2011	2067	2124	2180	2236	2293	2349	2405
42	1676	1732	1788	1845	1901	1957	2013	2069	2125	2181	2238	2294	2350	2406
48	1683	1740	1796	1852	1908	1964	2020	2077	2133	2189	2245	2301	2357	2414
54	1694	1750	1807	1863	1919	1975	2032	2088	2144	2200	2257	2313	2369	2426
60	1707	1763	1820	1876	1933	1989	2046	2102	2159	2215	2271	2328	2384	2441
66	1722	1778	1835	1892	1948	2005	2062	2119	2175	2232	2289	2345	2402	2459
72	1738	1795	1852	1909	1966	2023	2080	2137	2194	2251	2308	2365	2422	2479
78	1748	1805	1862	1919	1976	2033	2090	2147	2204	2261	2318	2375	2432	2489
84	1758	1815	1872	1929	1987	2044	2101	2158	2215	2272	2330	2387	2444	2501
90	1769	1826	1884	1941	1998	2056	2113	2170	2227	2285	2342	2399	2457	2514
96	1781	1838	1896	1953	2011	2068	2125	2183	2240	2298	2355	2413	2470	2527
102	1793	1851	1908	1966	2024	2081	2139	2196	2254	2311	2369	2427	2484	2542
108	1806	1864	1921	1979	2037	2095	2152	2210	2268	2326	2383	2441	2499	2557
114	1819	1877	1935	1993	2051	2109	2167	2224	2282	2340	2398	2456	2514	2572
120	1832	1891	1949	2007	2065	2123	2181	2239	2297	2355	2414	2472	2530	2588
126	1846	1905	1963	2021	2079	2138	2196	2254	2313	2371	2429	2488	2546	2604
132	1860	1919	1977	2036	2094	2153	2211	2270	2328	2387	2446	2504	2563	2621
138	1875	1933	1992	2051	2110	2168	2227	2286	2345	2403	2462	2521	2579	2638
144	1889	1948	2007	2066	2125	2184	2243	2302	2361	2420	2479	2538	2597	2656

Fill Height Tables are based on:

1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions
4. A Type 1 installation requires greater soil stiffness from the surrounding soils than the Type 2, 3, and 4 installations, and is thus harder to achieve. Therefore, field verification of soil properties and compaction levels should be performed.

D-Load (lb/ft/ft) for Type 1 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Fill Height in Feet												
Pipe Size (in)	43	44	45	46	47	48	49	50	51	52	53	54
12	2552	2611	2670	2729	2788	2847	2906	2965	3024	3084	3143	3202
15	2482	2539	2596	2654	2711	2768	2826	2883	2940	2998	3055	3112
18	2444	2501	2557	2614	2670	2726	2783	2839	2896	2952	3008	3065
21	2426	2482	2538	2594	2650	2706	2762	2817	2873	2929	2985	3041
24	2420	2476	2532	2587	2643	2699	2754	2810	2866	2921	2977	3033
27	2423	2478	2534	2590	2645	2701	2757	2812	2868	2924	2979	3035
30	2431	2487	2543	2599	2654	2710	2766	2822	2878	2933	2989	3045
33	2445	2501	2557	2613	2669	2725	2781	2837	2893	2949	3005	3061
36	2462	2518	2574	2631	2687	2743	2799	2856	2912	2968	3025	3081
42	2462	2518	2575	2631	2687	2743	2799	2855	2911	2968	3024	3080
48	2470	2526	2582	2638	2694	2750	2807	2863	2919	2975	3031	3087
54	2482	2538	2594	2651	2707	2763	2819	2876	2932	2988	3044	3101
60	2497	2554	2610	2667	2723	2780	2836	2892	2949	3005	3062	3118
66	2515	2572	2629	2686	2742	2799	2856	2912	2969	3026	3082	3139
72	2536	2593	2650	2707	2764	2821	2878	2935	2992	3049	3106	3163
78	2546	2603	2661	2718	2775	2832	2889	2946	3003	3060	3117	3174
84	2558	2615	2673	2730	2787	2844	2901	2958	3016	3073	3130	3187
90	2571	2628	2686	2743	2800	2858	2915	2972	3030	3087	3144	3201
96	2585	2642	2700	2757	2815	2872	2929	2987	3044	3102	3159	3217
102	2599	2657	2715	2772	2830	2887	2945	3002	3060	3118	3175	3233
108	2614	2672	2730	2788	2845	2903	2961	3019	3076	3134	3192	3250
114	2630	2688	2746	2804	2862	2920	2978	3035	3093	3151	3209	3267
120	2646	2704	2762	2820	2879	2937	2995	3053	3111	3169	3227	3285
126	2663	2721	2779	2838	2896	2954	3013	3071	3129	3187	3246	3304
132	2680	2738	2797	2855	2914	2972	3031	3089	3148	3206	3265	3323
138	2697	2756	2814	2873	2932	2991	3049	3108	3167	3226	3284	3343
144	2715	2774	2833	2892	2950	3009	3068	3127	3186	3245	3304	3363

Fill Height Tables are based on:
1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 2 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12	1492	1322	880	727	694	705	741	788	704	781	858	934	1011	1087
15	1434	1272	851	707	676	688	724	771	691	766	841	915	990	1065
18	1358	1240	834	697	668	680	717	763	688	761	835	909	983	1056
21	1220	1218	824	692	665	678	715	762	689	763	836	909	983	1056
24	1202	1203	818	690	665	680	717	764	694	768	841	915	988	1062
27	1344	1205	819	694	668	684	721	768	696	769	842	915	989	1062
30	1471	1213	823	701	674	690	727	773	699	772	845	919	992	1065
33	1347	1168	805	693	669	688	727	773	704	777	850	923	996	1069
36	1244	1137	789	687	665	687	728	775	710	783	856	929	1003	1076
42	1084	1059	759	673	659	685	726	773	715	788	861	933	1006	1079
48	966	935	732	663	655	684	726	774	722	795	867	940	1013	1085
54	923	899	712	655	654	685	728	777	731	803	876	948	1021	1094
60	948	875	696	650	654	688	731	781	740	813	885	958	1031	1103
66	906	855	687	646	655	691	736	787	750	823	896	969	1041	1114
72	850	837	679	643	658	696	741	793	761	834	907	980	1053	1126
78	802	820	672	642	660	697	744	796	768	841	913	986	1059	1131
84	763	805	665	641	661	700	747	799	775	848	920	993	1065	1138
90	730	791	660	641	664	703	750	803	863	855	927	999	1072	1144
96	703	756	655	642	666	706	754	807	867	862	934	1006	1078	1151
102	679	734	662	649	674	714	761	814	875	937	941	1013	1086	1158
108	660	723	668	657	681	721	769	822	882	945	949	1021	1093	1165
114	643	729	675	665	689	729	776	830	890	952	1016	1028	1100	1172
120	629	734	682	670	697	737	784	837	898	960	1024	1036	1108	1180
126	617	740	689	678	705	744	792	845	905	968	1032	1097	1115	1187
132	607	745	691	686	712	752	800	853	913	976	1039	1105	1171	1195
138	599	751	686	694	720	760	808	861	921	983	1047	1112	1178	1203
144	592	757	692	701	728	768	816	869	929	991	1055	1120	1186	1253

Fill Height Tables are based on:
1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 2 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
12	1164	1240	1317	1393	1470	1547	1623	1700	1776	1853	1929	2006	2083	2159
15	1139	1214	1289	1363	1438	1513	1587	1662	1737	1811	1886	1961	2035	2110
18	1130	1204	1278	1351	1425	1499	1573	1647	1720	1794	1868	1942	2015	2089
21	1130	1203	1277	1350	1424	1497	1570	1644	1717	1791	1864	1938	2011	2085
24	1135	1209	1282	1356	1429	1503	1576	1650	1723	1797	1870	1944	2017	2091
27	1135	1208	1282	1355	1428	1501	1574	1648	1721	1794	1867	1940	2014	2087
30	1138	1211	1284	1357	1430	1503	1576	1649	1722	1796	1869	1942	2015	2088
33	1143	1216	1289	1362	1435	1508	1581	1654	1727	1800	1874	1947	2020	2093
36	1149	1222	1295	1369	1442	1515	1588	1662	1735	1808	1881	1954	2028	2101
42	1152	1225	1298	1370	1443	1516	1589	1662	1735	1807	1880	1953	2026	2099
48	1158	1231	1303	1376	1449	1521	1594	1667	1739	1812	1885	1957	2030	2102
54	1166	1239	1311	1384	1457	1529	1602	1674	1747	1820	1892	1965	2037	2110
60	1176	1249	1321	1394	1467	1539	1612	1684	1757	1830	1902	1975	2048	2120
66	1187	1260	1332	1405	1478	1551	1623	1696	1769	1842	1914	1987	2060	2133
72	1199	1272	1345	1418	1490	1563	1636	1709	1782	1855	1928	2001	2074	2147
78	1204	1277	1350	1422	1495	1568	1640	1713	1786	1858	1931	2004	2076	2149
84	1210	1283	1355	1428	1500	1573	1645	1718	1790	1863	1935	2008	2080	2153
90	1216	1289	1361	1433	1506	1578	1650	1723	1795	1867	1940	2012	2084	2157
96	1223	1295	1367	1439	1512	1584	1656	1728	1800	1873	1945	2017	2089	2161
102	1230	1302	1374	1446	1518	1590	1662	1734	1806	1878	1950	2022	2094	2166
108	1237	1309	1381	1453	1524	1596	1668	1740	1812	1884	1956	2028	2100	2172
114	1244	1316	1388	1459	1531	1603	1675	1747	1819	1890	1962	2034	2106	2178
120	1251	1323	1395	1467	1538	1610	1682	1754	1825	1897	1969	2041	2112	2184
126	1259	1330	1402	1474	1545	1617	1689	1760	1832	1904	1975	2047	2119	2190
132	1266	1338	1410	1481	1553	1624	1696	1768	1839	1911	1982	2054	2125	2197
138	1274	1346	1417	1489	1560	1632	1703	1775	1846	1918	1989	2061	2132	2204
144	1282	1353	1425	1496	1568	1639	1711	1782	1854	1925	1996	2068	2139	2211

Fill Height Tables are based on:
1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 2 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Fill Height in Feet														
Pipe Size (in)	29	30	31	32	33	34	35	36	37	38	39	40	41	42
12	2236	2312	2389	2465	2542	2618	2695	2772	2848	2925	3001	3078	3154	3231
15	2185	2259	2334	2409	2483	2558	2633	2707	2782	2857	2931	3006	3081	3155
18	2163	2237	2310	2384	2458	2532	2605	2679	2753	2827	2900	2974	3048	3122
21	2158	2231	2305	2378	2452	2525	2599	2672	2745	2819	2892	2966	3039	3113
24	2164	2238	2311	2385	2458	2532	2605	2679	2752	2826	2899	2973	3046	3120
27	2160	2233	2306	2380	2453	2526	2599	2672	2746	2819	2892	2965	3038	3112
30	2161	2234	2307	2380	2453	2526	2599	2673	2746	2819	2892	2965	3038	3111
33	2166	2239	2312	2385	2458	2531	2605	2678	2751	2824	2897	2970	3043	3116
36	2174	2247	2320	2394	2467	2540	2613	2687	2760	2833	2906	2979	3053	3126
42	2172	2244	2317	2390	2463	2536	2609	2681	2754	2827	2900	2973	3046	3118
48	2175	2248	2320	2393	2466	2538	2611	2684	2756	2829	2902	2974	3047	3119
54	2183	2255	2328	2400	2473	2546	2618	2691	2763	2836	2908	2981	3054	3126
60	2193	2266	2338	2411	2483	2556	2629	2701	2774	2847	2919	2992	3065	3137
66	2205	2278	2351	2424	2496	2569	2642	2715	2787	2860	2933	3006	3078	3151
72	2220	2293	2365	2438	2511	2584	2657	2730	2803	2876	2949	3022	3095	3168
78	2222	2295	2367	2440	2513	2585	2658	2731	2803	2876	2949	3021	3094	3167
84	2225	2298	2370	2443	2515	2588	2660	2733	2805	2878	2950	3023	3095	3168
90	2229	2301	2374	2446	2518	2591	2663	2735	2808	2880	2952	3025	3097	3169
96	2233	2306	2378	2450	2522	2594	2667	2739	2811	2883	2955	3028	3100	3172
102	2238	2311	2383	2455	2527	2599	2671	2743	2815	2887	2959	3031	3103	3175
108	2244	2316	2388	2460	2532	2604	2676	2748	2819	2891	2963	3035	3107	3179
114	2250	2322	2393	2465	2537	2609	2681	2753	2824	2896	2968	3040	3112	3184
120	2256	2328	2399	2471	2543	2615	2686	2758	2830	2902	2973	3045	3117	3189
126	2262	2334	2405	2477	2549	2620	2692	2764	2835	2907	2979	3050	3122	3194
132	2269	2340	2412	2483	2555	2627	2698	2770	2841	2913	2985	3056	3128	3199
138	2275	2347	2418	2490	2562	2633	2705	2776	2848	2919	2991	3062	3134	3205
144	2282	2354	2425	2497	2568	2640	2711	2783	2854	2925	2997	3068	3140	3211

Fill Height Tables are based on:
1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 3 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Fill Height in Feet														
Pipe Size (in)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12	1518	1369	947	817	805	838	896	964	902	1000	1098	1196	1294	1392
15	1459	1318	916	794	783	815	872	939	880	975	1070	1165	1260	1355
18	1384	1285	897	781	772	804	860	926	870	963	1057	1150	1243	1337
21	1247	1263	886	775	767	799	855	921	867	959	1051	1144	1236	1329
24	1229	1248	879	772	765	798	854	920	868	960	1051	1143	1235	1327
27	1372	1251	881	778	770	804	860	925	872	963	1055	1147	1238	1330
30	1500	1260	887	786	777	812	868	933	878	970	1061	1153	1245	1337
33	1378	1218	871	780	775	813	871	936	886	978	1070	1162	1254	1345
36	1276	1189	857	776	774	815	875	941	895	987	1079	1172	1264	1356
42	1119	1113	829	765	770	815	875	942	903	995	1087	1179	1271	1363
48	1004	992	808	758	770	817	879	946	913	1005	1097	1189	1281	1373
54	963	958	791	753	771	822	884	953	926	1018	1109	1201	1293	1385
60	991	937	778	751	775	828	891	961	939	1031	1123	1216	1308	1400
66	952	920	772	751	779	835	900	970	954	1046	1138	1231	1323	1416
72	898	905	768	751	786	843	909	981	969	1062	1154	1247	1340	1433
78	853	890	762	752	790	847	913	985	977	1070	1162	1255	1348	1440
84	816	878	758	754	794	852	918	991	986	1079	1171	1263	1355	1448
90	786	866	755	756	798	857	924	996	1076	1088	1180	1272	1364	1456
96	760	833	753	759	803	862	930	1003	1083	1097	1189	1281	1373	1464
102	739	814	761	769	813	872	939	1012	1092	1174	1198	1290	1382	1473
108	722	805	770	778	822	882	949	1022	1102	1184	1208	1299	1391	1482
114	708	813	779	788	832	892	959	1032	1112	1194	1277	1309	1400	1492
120	696	821	788	796	842	902	969	1042	1121	1203	1287	1319	1410	1501
126	687	829	798	806	852	912	979	1052	1131	1213	1297	1382	1420	1511
132	679	837	802	816	863	922	989	1062	1141	1223	1307	1391	1477	1521
138	673	845	800	826	873	932	999	1072	1152	1233	1317	1401	1487	1531
144	669	853	808	837	883	943	1010	1082	1162	1244	1327	1411	1497	1583

Fill Height Tables are based on:
1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 3 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
12	1490	1588	1686	1784	1882	1980	2078	2176	2274	2372	2470	2568	2666	2764
15	1450	1545	1640	1735	1830	1925	2020	2115	2210	2305	2401	2496	2591	2686
18	1430	1523	1617	1710	1803	1897	1990	2083	2177	2270	2363	2457	2550	2643
21	1421	1513	1606	1698	1790	1883	1975	2068	2160	2252	2345	2437	2529	2622
24	1419	1511	1603	1695	1786	1878	1970	2062	2154	2246	2338	2430	2521	2613
27	1422	1514	1605	1697	1789	1880	1972	2064	2155	2247	2339	2431	2522	2614
30	1428	1520	1612	1704	1795	1887	1979	2071	2162	2254	2346	2437	2529	2621
33	1437	1529	1621	1713	1805	1897	1989	2081	2173	2265	2357	2449	2541	2633
36	1449	1541	1633	1726	1818	1910	2003	2095	2187	2280	2372	2464	2557	2649
42	1455	1547	1639	1731	1823	1915	2007	2098	2190	2282	2374	2466	2558	2650
48	1465	1556	1648	1740	1832	1924	2016	2108	2200	2291	2383	2475	2567	2659
54	1477	1569	1661	1753	1845	1937	2029	2121	2213	2305	2397	2489	2581	2673
60	1492	1584	1676	1768	1861	1953	2045	2137	2229	2321	2413	2506	2598	2690
66	1508	1601	1693	1786	1878	1970	2063	2155	2248	2340	2433	2525	2617	2710
72	1526	1619	1711	1804	1897	1990	2083	2175	2268	2361	2454	2547	2639	2732
78	1533	1625	1718	1810	1903	1995	2088	2180	2273	2365	2458	2550	2643	2735
84	1540	1632	1725	1817	1909	2001	2094	2186	2278	2370	2463	2555	2647	2740
90	1548	1640	1732	1824	1916	2008	2100	2192	2284	2377	2469	2561	2653	2745
96	1556	1648	1740	1832	1924	2016	2108	2199	2291	2383	2475	2567	2659	2751
102	1565	1657	1748	1840	1932	2024	2115	2207	2299	2390	2482	2574	2666	2757
108	1574	1666	1757	1849	1940	2032	2123	2215	2307	2398	2490	2581	2673	2764
114	1583	1675	1766	1857	1949	2040	2132	2223	2315	2406	2498	2589	2680	2772
120	1593	1684	1775	1866	1958	2049	2140	2232	2323	2414	2506	2597	2688	2780
126	1602	1693	1785	1876	1967	2058	2149	2241	2332	2423	2514	2605	2697	2788
132	1612	1703	1794	1885	1976	2067	2158	2250	2341	2432	2523	2614	2705	2796
138	1622	1713	1804	1895	1986	2077	2168	2259	2350	2441	2532	2623	2714	2805
144	1632	1722	1813	1904	1995	2086	2177	2268	2359	2450	2541	2632	2723	2814

Fill Height Tables are based on:
1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 3 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Fill Height in Feet							
Pipe Size (in)	29	30	31	32	33	34	35
12	2862	2960	3058	3156	3254	3352	3450
15	2781	2876	2971	3066	3161	3256	3351
18	2737	2830	2923	3017	3110	3203	3297
21	2714	2807	2899	2991	3084	3176	3268
24	2705	2797	2889	2981	3073	3165	3256
27	2706	2797	2889	2981	3072	3164	3256
30	2713	2804	2896	2988	3080	3171	3263
33	2725	2817	2909	3001	3093	3185	3277
36	2741	2833	2926	3018	3110	3203	3295
42	2742	2834	2926	3018	3110	3202	3294
48	2751	2843	2935	3026	3118	3210	3302
54	2765	2857	2948	3040	3132	3224	3316
60	2782	2874	2966	3058	3151	3243	3335
66	2802	2895	2987	3080	3172	3265	3357
72	2825	2918	3011	3103	3196	3289	3382
78	2828	2920	3013	3105	3198	3290	3383
84	2832	2924	3016	3109	3201	3293	3385
90	2837	2929	3021	3113	3205	3297	3389
96	2843	2934	3026	3118	3210	3302	3394
102	2849	2941	3032	3124	3216	3308	3399
108	2856	2947	3039	3131	3222	3314	3405
114	2863	2955	3046	3138	3229	3320	3412
120	2871	2962	3054	3145	3236	3328	3419
126	2879	2970	3061	3153	3244	3335	3426
132	2887	2979	3070	3161	3252	3343	3434
138	2896	2987	3078	3169	3260	3351	3442
144	2905	2996	3087	3178	3269	3360	3450

Fill Height Tables are based on:
1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 4 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12	1579	1481	1111	1032	1071	1154	1264	1383	1372	1521	1671	1820	1969	2119
15	1519	1426	1073	998	1036	1116	1221	1336	1326	1616	1612	1756	1899	2042
18	1443	1391	1050	978	1015	1093	1195	1307	1297	1580	1576	1715	1854	1994
21	1306	1366	1035	966	1002	1079	1179	1288	1279	1557	1552	1688	1825	1961
24	1288	1349	1025	959	994	1070	1168	1276	1267	1541	1535	1670	1804	1938
27	1431	1352	1025	960	993	1068	1165	1271	1259	1531	1524	1657	1790	1922
30	1560	1360	1029	965	995	1070	1166	1270	1254	1524	1517	1648	1780	1911
33	1437	1316	1010	955	988	1064	1160	1264	1252	1520	1512	1642	1773	1903
36	1336	1285	993	947	982	1060	1157	1260	1251	1518	1509	1639	1768	1898
42	1181	1211	966	935	976	1057	1153	1256	1252	1518	1508	1636	1764	1892
48	1068	1090	941	927	973	1056	1152	1255	1257	1522	1511	1638	1765	1892
54	1029	1058	925	921	973	1058	1154	1257	1264	1529	1516	1642	1768	1894
60	1059	1038	912	918	975	1062	1158	1261	1273	1538	1523	1649	1774	1899
66	1021	1022	906	917	978	1066	1163	1266	1282	1548	1532	1657	1781	1906
72	969	1008	902	917	984	1072	1169	1272	1292	1559	1541	1666	1790	1914
78	927	996	899	920	990	1079	1176	1280	1303	1570	1551	1675	1799	1923
84	893	986	898	925	997	1086	1184	1288	1315	1582	1562	1686	1810	1933
90	866	978	898	931	1004	1094	1192	1296	1408	1595	1574	1697	1820	1944
96	844	948	899	936	1012	1102	1201	1305	1417	1608	1585	1708	1831	1955
102	826	932	911	949	1024	1115	1214	1318	1429	1685	1597	1720	1843	1966
108	812	927	923	962	1037	1128	1226	1330	1441	1698	1609	1732	1855	1978
114	801	938	935	975	1050	1141	1239	1343	1454	1712	1682	1745	1867	1990
120	793	949	947	986	1063	1154	1252	1356	1467	1726	1694	1757	1879	2002
126	786	960	959	999	1076	1167	1265	1369	1480	1740	1707	1823	1892	2014
132	782	971	967	1013	1090	1180	1278	1382	1493	1754	1720	1836	1952	2027
138	779	982	968	1026	1103	1194	1292	1395	1506	1769	1733	1848	1965	2040
144	778	994	980	1039	1116	1207	1305	1409	1519	1783	1746	1861	1978	2095

Fill Height Tables are based on:
1. γs = 120 pcf
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 4 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet										
	15	16	17	18	19	20	21	22	23	24	25
12	2268	2417	2566	2716	2865	3014	3163	3313	3462	3611	3760
15	2185	2329	2472	2615	2759	2902	3045	3189	3332	3475	3618
18	2133	2272	2412	2551	2690	2830	2969	3108	3247	3387	3526
21	2098	2234	2370	2507	2643	2780	2916	3053	3189	3326	3462
24	2073	2207	2341	2476	2610	2744	2879	3013	3147	3282	3416
27	2055	2188	2320	2453	2586	2718	2851	2984	3116	3249	3382
30	2042	2174	2305	2436	2568	2699	2830	2962	3093	3225	3356
33	2033	2164	2294	2424	2554	2685	2815	2945	3075	3206	3336
36	2027	2156	2286	2415	2544	2674	2803	2932	3062	3191	3321
42	2020	2148	2276	2404	2532	2660	2788	2916	3044	3171	3299
48	2018	2145	2272	2399	2526	2653	2780	2907	3033	3160	3287
54	2020	2146	2273	2399	2525	2651	2777	2903	3029	3155	3281
60	2025	2150	2276	2401	2526	2652	2777	2903	3028	3153	3279
66	2031	2156	2281	2406	2531	2655	2780	2905	3030	3155	3280
72	2039	2163	2288	2412	2536	2661	2785	2909	3034	3158	3283
78	2047	2171	2295	2419	2543	2667	2791	2915	3039	3163	3287
84	2057	2181	2304	2428	2552	2675	2799	2923	3046	3170	3294
90	2067	2190	2314	2437	2561	2684	2807	2931	3054	3178	3301
96	2078	2201	2324	2447	2570	2693	2817	2940	3063	3186	3309
102	2089	2212	2335	2458	2581	2704	2826	2949	3072	3195	3318
108	2100	2223	2346	2469	2591	2714	2837	2959	3082	3205	3328
114	2112	2235	2357	2480	2602	2725	2848	2970	3093	3215	3338
120	2124	2247	2369	2491	2614	2736	2859	2981	3103	3226	3348
126	2137	2259	2381	2503	2626	2748	2870	2992	3115	3237	3359
132	2149	2271	2393	2515	2638	2760	2882	3004	3126	3248	3370
138	2162	2284	2406	2528	2650	2772	2894	3016	3138	3260	3382
144	2174	2296	2418	2540	2662	2784	2906	3028	3150	3272	3393

The preceding fill height tables are based on a concrete pipe installed in a positive projecting embankment installation with a soil unit weight of 120 lbs/ft^3 and HL-93 live load per the AASHTO LRFD Bridge Design specifications at the surface. Pipe outside diameters were based on a wall C thickness since the larger outside diameters would represent the highest soil overburden load on the pipe. The required classes of pipe do not account for construction loads or any other load induced on the pipe prior to its completed installation, or live load in excess of HL-93.

Dimensions of Circular Concrete Pipe - Metric Units

Designated Internal Diameter mm	Actual Internal Diameter mm	Wall B		Wall C	
		Minimum Wall Thickness mm	Average Weight kg/m	Minimum Wall Thickness mm	Average Weight kg/m
300	305	50	162	69	197
375	381	57	216	75	262
450	457	63	253	82	335
525	533	69	327	88	417
600	610	75	430	94	505
675	686	82	500	100	602
750	762	88	598	107	708
825	838	94	695	113	821
900	914	100	832	119	940
975	991	113	923	125	1090
1050	1067	117	1057	132	1207
1200	1219	125	1324	144	1504
1350	1372	138	1589	157	1829
1500	1524	150	1927	169	2192
1650	1676	163	2295	182	2582
1800	1829	175	2695	194	2998
1950	1981	188	3125	207	3457
2100	2134	200	3585	219	3943
2250	2286	213	4078	232	4460
2400	2438	225	4598	244	5009
2550	2591	238	5179	257	5595
2700	2743	250	5752	269	6202
3000	3048	279	6344	298	7521
3600	3658	330	8104	349	10,540

Dimensions of Circular Concrete Pipe - Imperial Units

Internal Diameter inches	Wall A		Wall B		Wall C	
	Minimum Wall Thickness inches	Average Weight pounds per foot	Minimum Wall Thickness inches	Average Weight pounds per foot	Minimum Wall Thickness inches	Average Weight pounds per foot
12	1-3/4	79	2	93	2-3/4	133
15	1-7/8	103	2-1/4	127	3	177
18	2	131	2-1/2	168	3-1/4	226
21	2-1/4	171	2-3/4	214	3-1/2	281
24	2-1/2	217	3	264	3-3/4	341
27	2-5/8	255	3-1/4	322	4	406
30	2-3/4	295	3-1/2	384	4-1/4	476
33	2-7/8	336	3-3/4	451	4-1/2	552
36	3	383	4	524	4-3/4	633
42	3-1/2	520	4-1/2	686	5-1/4	811
48	4	683	5	867	5-3/4	1011
54	4-1/2	864	5-1/2	1068	6-1/4	1232
60	5	1064	6	1295	6-3/4	1473
66	5-1/2	1287	6-1/2	1542	7-1/4	1735
72	6	1532	7	1811	7-3/4	2023
78	6-1/2	1797	7-1/2	2100	8-1/4	2329
84	7	2085	8	2409	8-3/4	2656
90	7-1/2	2395	8-1/2	2740	9-1/4	3004
96	8	2710	9	3090	9-3/4	3374
102	8-1/2	3078	9-1/2	3480	10-1/4	3765
108	9	3446	10	3865	10-3/4	4178
114	9-1/2	3840	10-1/2	4278	11-1/4	4611
120	10	4263	11	4716	11-3/4	5066
126	10-1/2	4690	11-1/2	5175	12-1/4	5542
132	11	5148	12	5655	12-3/4	6040
138	11-1/2	5627	12-1/2	6156	13-1/4	6558
144	12	6126	13	6679	13-3/4	7098
150	12-1/2	6647	13-1/2	7223	14-1/4	7659
156	13	7190	14	7789	14-3/4	8242
162	13-1/2	7754	14-1/2	8375	15-1/4	8846
168	14	8339	15	8983	15-3/4	9471
174	14-1/2	8945	15-1/2	9612	16-1/4	10,117
180	15	9572	16	10,263	16-3/4	10,785

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