ARTICLE III

WATER SYSTEMS

Section 301 General Requirements

301.1 All development shall be provided with an approved system of potable water in accordance with this Article.

301.2 All water main lines, extensions and appurtenances thereto shall be designed and constructed in accordance with the most current regulation of the Missouri Department of Natural Resources' rules, regulations, and Statutes of the State of Missouri.

301.3 In addition to the rules, regulations and state statutes as specified in Subsection 301.2 above, conformance with the following standards, specifications and design guidelines is required.

Section 302 Materials

302.1 **Water Distribution Line:** Water Distribution Line shall be PVC or ductile iron pipe meeting the following specifications:

1.1 PVC pipe shall be solid wall meeting the requirements of ASTM D2241, latest revision, with wall thickness SDR 21 (Class 200), as called for on the drawings. All pipe must bear the National Sanitation Foundation seal for potable water pipe. Pipe shall have an integral bell with a locked-in, solid cross section elastomeric gasket that meets the requirements of ASTM F477, latest revision. Provisions must be made for contraction and expansion at each rubber ring bell and spigot joint. Pipe shall be made from clean, virgin, NSF approved PVC material conforming to ASTM D1784, latest revision.

1.1.1 SDR 21 PVC pipe shall be suitable for use at maximum hydrostatic pressures of 200 PSI at 73EF.

1.1.2 Physical and Chemical Tests: Pipe shall meet the following physical and chemical test requirements. All physical and chemical tests shall be conducted at 73EF "3.6EF:

Test	ASTM Ref.	Requirements
Quick Burst Test	D1599	630 PSI applied in 60 to 70 sec.
Sustained Pressure Test	D1598	1000 hrs. @ 420 PSI
Acetone Immersion Test	D2152	No visible spalling or cracking after 20 minutes
Vise Test	--	No splitting or shattering when compressed 60% in 2 to 5 minutes

1.2 Ductile iron pipe shall be pressure class 350 and shall conform to the latest revision of ANSI A21.51 - (AWWA C151) Standard for Ductile Iron Pipe Centrifugally Cast in Metal Molds or Sand Lined Molds, for Water or Other Liquids. The pipe shall be standard asphaltic varnish coated on the outside. Pipe shall be cement mortar lined in conformance with ANSI A21.4-90 (AWWA C104) unless specified otherwise.

1.2.1 Joints for ductile iron pipe that is to be buried shall be push-on type consisting of a single neoprene gasket which are acceptable are "Tyton" as manufactured and licensed by the U.S. Pipe and Foundry Company' "Fastite" as manufactured and licensed by the American Cast Iron Pipe Company; and "Bell-Tite" as manufactured and licensed by James B. Clow and Son, Inc. All required joint materials including the neoprene gasket and the lubricant shall be furnished with the pipe.

1.3 Water Line Fittings: Fittings to be used with water distribution lines larger than 4 inches in diameter shall be either gray iron or ductile iron, and shall conform to the requirements of ANSI/AWWA C110/A21.10-93 or C153/A21.53-94. All mechanical joint fittings shall be pressure class 350 ductile iron. Fittings shall be standard asphaltic varnish coated on the outside. Fittings shall be cement mortar lined in conformance with ANSI A21.4-80 (AWWA C104). Fittings shall be mechanical joint or push-on joint and shall meet all applicable requirements of ANSI 21.11-85 (AWWA C111).

1.3.1 Fittings for water distribution lines four (4) inches in diameter and smaller shall be of the same material as that of the pipe.

302.2 **Water Service Line & Appurtenances:** Water service line shall be solvent weld PVC pipe, or copper tubing meeting the following specifications:

2.1 PVC pipe for water service lines shall be solvent weld PVC pressure pipe, Schedule 80, meeting the requirements of ASTM D1785, latest revision. All pipe shall bear the National Sanitation Foundation seal for potable

water pipe. Pipe shall be made from clean, virgin, NSF approved material conforming to ASTM D1784, latest revision. All connections shall be joined by primer and PVC solvent cement conforming to ASTM D2564, latest revision.

2.2 Copper tubing shall be Type K conforming to ASTM B88, latest revision.

2.3 Service Saddles: Shall be a hinged type suitable for installation on PVC pipe. The strap and body shall be 85-5-5-5 brass alloy conforming to ASTM-B-62 and AWWA C800. The gasket shall be of BunSD-N rubber to provide a leakproof installation. The tap shall be ¾" minimum with AWWA standard thread.

2.4 Corporation stops shall be designed and manufactured to conform to AWWA Standard C800-84, and shall be designed to withstand working pressures up to 250 PSI.

2.4.1 Inlet: Shall be AWWA standard thread.

2.4.2 Outlet: Shall be pack joint outlet.

2.5 Water Service Meters and Appurtenances:

2.5.1 Water Meters: Shall be purchased from the City.

2.5.2 Coppersetters: Shall be provided for each water service meter. Coppersetters shall have a brace eye for installation of a cross-brace. Coppersetters shall have pack joint inlet and outlet service line connections compatible for the size and type of water service line. An inverted key valve with padlock wings shall be provided at the meter inlet, and a dual angle check valve shall be provided at the meter outlet.

2.5.3 Meter Pits and Covers: Meter pits shall be ribbed and of Type 1, Grade 2 PVC conforming to ASTM D1784, latest revision. Pit shall be minimum 24" diameter by 30" deep. Flat meter pit covers of cast iron and of the size required to fit the meter pits shall be provided. Covers shall be stamped "Water Meter".

302.3 **Valves and Hydrants:**

3.1 Gate Valve and Box:

3.1.1 All gate valves shall be iron body, non-rising stem with O-ring gaskets. The valves shall be equipped with a two-inch square operating nut.

3.1.2 Gate valves shall conform to AWWA C500-93 (Metal Seated Gate Valves) or AWWA C509-94 (Resilient Seated Gate Valves) for design working water pressures of 200 psig for valves 12 inches NPS in diameter or smaller, and 150 psig for valves with diameter 16 inches NPS and larger.

3.1.3 Valve Boxes: Valve boxes shall be required for all buried valves, and shall be cast iron. The valve box shall have a round top with open base. A top cover will be provided, marked "water". The valve box shall be of the two-piece screw type with top piece capable of adjustment to final grade.

3.2 Fire Hydrants and Appurtenances:

3.2.1 Materials:

(a) Gate Valve and Box: Shall be located adjacent to each fire hydrant for isolation of the hydrant for repairs. Gate valves and boxes shall be as specified in Subsection 3.1, Gate Valve and Box.

(b) Fire Hydrants: Shall meet or exceed requirements set forth in AWWA Standard C502-94 or latest revision. Hydrants shall be dry barrel traffic model with break flange construction. Outlets shall be three-way and as required for the Fire Department's pumper and/or hose sizes and threads. Operating nut shall also be of the type in use by the City. Contractor shall be solely responsible for insuring compatibility of City's equipment and hydrants. Inlet shall be mechanical joint type and main valve size shall be 5¼ inch.

302.4 **Pipe Bedding Material:**

4.1 Granular Stone: Granular stone pipe bedding material shall be crushed limestone consisting of aggregate particles meeting the requirements of ASTM C-33, latest revision, gradation 67, 1-inch to No. 8 size as follows:

Sieve Size	Percent Passing
1"	100
¾"	90-100
3/8"	20-55
No. 4	0-10
No. 8	0-5

4.2 Sand: All sand used for bedding shall be clean, graded from fine to coarse, not lumpy or frozen, and free from slag, cinders, ashes, rubbish, or other material that, in the opinion of the Engineer, is objectionable or deleterious. It should not contain a total of more than 10 percent by weight, of loam and clay, and all material must be capable of being passed through a ¾-inch sieve. Not more than five percent shall remain on a No. 4 sieve.

302.5 **Steel Casing Pipe:** Steel pipe for casing at highway and railroad crossings shall conform to AWWA C209-91.

Section 303 Installation Procedures

303.1 **Trenching, Bedding, Backfilling, and Compacting:**

1.1 Trench Excavation :

1.1.1 Trench Depth: Trenches shall be cut as deep as necessary on either side of natural depressions, ditches, waterways, etc. to provide for not less than 36 inches of cover over the top of the pipe. Depth of cover shall be measured from the outside top of the pipe vertically to the original ground surface or pavement surface. Mounding over the trench to attain the specified cover shall not be permitted. Trenches shall be cut to prevent high spots that could lead to "air binding" of the water line. Trenches shall be excavated to four (4) inches below the bottom of the pipe to provide clearance for not less than four (4) inches of pipe bedding material. The maximum degree of deflection, either vertical or horizontal, shall not cause a pipe joint's annular clearance in the bell to be less than one-fourth (1/4) inch at its closest point. In case the trench be excavated at any place more than four (4) inches below grade, it shall be filled to the design grade with approved bedding material. Trench excavation shall, in all cases, be continuous from the ground surface to the established trench depth. Gutters and ditches shall be kept clear, or other satisfactory provisions shall be made to facilitate drainage. Ground adjacent to trench shall be graded to prevent water from flowing into the trench. Provisions shall be made for the continuous flow of all waterways, ditches, drains, or sewers encountered during construction. All ditches and waterways shall be restored to their original conditions as soon as possible.

1.1.2 Trench Width: The width of the trench, as dug, from the trench bottom to the top of the pipe, shall not exceed the outside diameter of the pipe bell or socket plus 12 inches, or 24 inches, whichever is greater. Trench width above the top of the pipe shall be as

required by field conditions to prevent sliding and caving of the excavation.

1.2 Sheeting, Shoring, or Bracing: Sheeting, shoring, or bracing shall be placed wherever necessary for the proper preserving of any excavation, embankment, or structure. Where the ground is of such a character or other conditions are such as to render it necessary, the sheeting shall be closely driven and to such depth below the lowest point of the final excavation as may be required. Shore up, protect, and insure from injury all buildings, retaining walls, piers and footings, storm sewers, sanitary sewers, gas lines, water lines, fences, curbs, trees, or other property liable to be injured during the process of the work. Sheeting, shoring, and bracing shall be provided, installed, and maintained to protect the excavation and insure open trench operations.

1.3 Placement of Bedding Material:

1.3.1 Granular Stone Pipe Bedding: Granular stone shall be placed in the trench and shaped to provide uniform support for the bottom quadrant of the pipe barrel. The bedding shall be not less than four (4) inches in thickness. Following placement of the pipe, the trench shall be filled with granular stone bedding material to a minimum compacted depth of six (6) inches above the pipe barrel.

1.3.2 Sand Pipe Bedding: Sand shall be shaped and placed similar to the granular stone specified above.

1.4 Backfilling:

1.4.1 Material used for backfilling of trenches shall be free from perishable matter and from other material liable to become unstable when saturated with water after having been compacted. No frozen material shall be used in backfill. Care shall be taken to prevent damage to the pipe and structures. Special precautions shall be taken in backfilling over pipes. No backfill shall be placed over any portion of pipes and/or joints not inspected by the City Engineer. The bedding material shall be brought to a depth of at least six inches over the top of the pipe bell, with this material carefully deposited in uniform layers not exceeding six inches in depth, and each layer carefully and solidly tamped with mechanical tampers in such a manner as to avoid damage to pipe or disturbing completed work. Unless noted otherwise on the drawings, backfilling for the remainder of the trench shall be previously excavated gravel, sand, or earth, and shall contain no stone over ten inches in its largest dimensions. Stones smaller than that size may be used in proportion not exceeding one part of stone and

three parts of earth in any place. This backfilling shall be deposited and spread in layers and solidly tamped. Except as specified for roadway crossings, trench backfill shall be compacted to 80 percent of the maximum density at optimum moisture. As the trenches are backfilled, remove all surplus material and regrade the surface, leaving it in good order. The trenches shall be filled to the ground surface elevation which previously existed.

303.2 **Installation:**

2.2 Pipe Installation:

2.2.1 General: Only workers competent at laying pipe shall be employed on this phase of the work, and complete suitable equipment necessary for the execution of same is required. Any incompetency observed must be removed, and where improper equipment or lack of same appears to be impairing the quality or speed of the work, such adjustment in same shall be made.

2.2.2 The pipe, fittings and valves shall be placed in the trench with care. Under no circumstances shall pipe or other materials be dropped or dumped into the trench. If plastic pipe is used, the pipe shall be snaked into the trench, either employing the natural snaking tendency of some plastic pipe or the pipe shall be laid from one side to the other on alternate lengths.

2.2.3 Pipe Cleaning During Laying Operations: The pipe, if furnished from the factory with dust covers over the ends, shall be examined carefully during laying operations to insure that such covers are not lost inside the pipe. At the termination of pipe laying, the open end of the pipeline shall be closed off by a suitable cover until laying operations are resumed. No pipe shall be placed in the trench unless it is intended to make the joint to the pipeline at that time.

2.2.4 Inspection of Materials During Construction: Any materials not meeting the specifications, or obviously faulty material, shall be rejected and removed from the job site.

2.2.5 Joining Pipe: In joining sections of pipe, the installer shall use good working practices. All pipe ends shall be cleaned thoroughly inside and out before application of lubricant. The recommendations of the manufacturer of the pipe shall be followed closely in joining this type of pipe. Care shall be taken in lowering pipe into the trench in order that a tensile stress is not created that would cause partial or complete separation of the joints. Concrete

thrust blocks shall be installed at all bends, tees, crosses, and reducers.

2.2.6 Breaks in Pipe and Joints: Breaks in the pipe or joints shall be repaired.

2.2.7 Bedding of Plastic Pipe: The Contractor shall bed the pipe in accordance with the requirements of Subsection 303.1, Trenching, Backfilling, and Compacting.

2.2.8 Allowance for Expansion: Expansion and contraction of PVC pipe is relatively great. Snake the pipe in the trench or allow in other ways for some expansion or contraction of the pipe.

2.2.9 Avoidance of Unnecessary Bends: Excessive bends in the alignment of the pipe will not be permitted. Where obviously required, sweep ells shall be used in making connections between two sections having differing alignment. Standard 90E elbows are not to be used, except in confined locations.

2.3 Anchorage of Bends, Tees, and Plugs: All tees, plugs, caps, and bends exceeding 22-1/2" shall be squarely anchored by suitable thrust concrete backing. Such concrete backing shall be so placed that the pipe or fitting joints will be accessible for repair. The concrete shall be of 1:3:5 mix and shall be placed between solid ground and the fitting to be anchored. The area of the bearing on the pipe and the ground in each instance shall be a minimum of four square feet.

2.4 Water Mains Near Sewers:

2.4.1 Horizontal Separation: A water main shall be laid at least ten feet horizontally from any existing or proposed drain or sewer line. Should local conditions prevent a lateral separation of ten feet, a water main may be laid closer than ten feet to a storm or sanitary sewer line, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer line and at such an elevation that the bottom of the water main is at least eighteen inches above the top of the sewer line. When it is impossible to obtain vertical or horizontal separation, the sewer line must be relaid and constructed equal to the water line pipe, and should be pressure-tested to assure water tightness before backfilling.

2.4.2 Vertical Separation: Where water mains must cross over sewers, storm drains, or sanitary sewers, the water main must be laid at such an elevation that the bottom of the water main is at least eighteen inches above the top of the sewer, and a full length of water main pipe must be centered over the sewer to be crossed so that the joints will be equally distant from the sewer and as remote there from as possible. This vertical separation must be maintained for that portion of the water main located within ten feet horizontally of any sewer or sewer line that it crosses, said ten feet to be measured as the normal distance from the water main to the sewer.

2.4.3 Unusual Conditions: Where it is necessary for the water main to pass under a sewer line, the water main must be laid with ductile iron pipe which must extend on each side of the crossing until the normal distance from the water main to the sewer is at least ten feet. In making such crossings, a full length of pipe must be centered over or under the sewer to be crossed so that the joints will be equally distant from the sewer and as remote there from as possible. The sewer line must also be constructed of cast iron pipe with mechanical, compression, or leaded joints until the normal distance from the sewer to the water main is at least ten feet. Where a water main must cross under a sanitary sewer, a vertical separation of at least 18 inches between the bottom of the sewer line and the top of the water main must be maintained with adequate support for the larger size sewer lines to prevent them from settling or their breaking the water main. Where these conditions cannot be met, the Missouri Department of Natural Resources shall be consulted as to the precautions to be taken to protect the public water supply.

2.4.4 No water pipe shall pass through or come into contact with any part of a sewer manhole.

2.5 Water Mains Near Other Utilities: Water mains shall be located at least 10 feet horizontally from any existing or proposed oil and gas lines, and buried electric lines. In cases where the specified separation of 10 feet cannot practically be maintained, the City may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the water line closer to existing or proposed utilities, provided that the water line is in a separate trench. Under no circumstances, however, shall a water line be installed closer than 12 inches to other existing or proposed utilities.

303.3 **Testing, Flushing, and Disinfecting:**

3.1 Testing: Installed water lines shall be hydrostatically tested. The test shall be conducted with all meter settings in place and the angle valve closed. Prior to conducting the test, the water line and fittings shall be backfilled. All air shall be expelled from the pipeline prior to the test by use of air release valves, hydrants, or taps. Taps shall be plugged after testing is completed. The test procedure shall be as specified below:

3.1.1 Test pressure shall be the design working pressure at the low point of the test section. Gauge readings of pressure shall be taken at low points of the test section to insure test pressures do not exceed the allowable pressure rating of the pipe. The test section shall be pressurized for 24 hours.

3.1.2 The pipeline shall be pressurized using a hand or motor-operated pump equipped with a shut-off valve, pressure relief valve, and a gauge located to read the line pressure when the pump valve is closed.

3.1.3 At the end of the 24-hour test period, water shall be pumped into the system to bring the pipeline back up to the test pressure. The volume of water required shall be measured with an approved meter or by pumping from a calibrated vessel. The pipe or installation shall not be accepted unless or until the leakage determined under pressure is less than 10 gallons per inch of pipe diameter per mile of pipe over the 24-hour period.

3.1.4 The following table presents the allowable leakage per foot of pipe per 24-hour period.

Allowable Leakage		Allowable Leakage	
Pipe Dia. Inches	Gal/Ft./24 Hrs.	Pipe Dia. Inches	Gal/Ft/24 Hrs.
1	0019	6	0114
2	0038	8	0152
3	0057	10	0189
4	0076	12	0227

3.1.5 Any test section not meeting the requirements of this specification shall be repaired and retested until the test requirements are satisfied. Defective pipe, valves, fittings, hydrants, or other appurtenances shall be removed and replaced.

3.1.6 The pressure test shall be performed in the presence of the City Engineer or his representative. A written report shall be made by the installer during the test showing the test section, test pressure, test results, and other pertinent data.

3.2 Flushing and Disinfecting: The completed water distribution system shall be flushed and disinfected in accordance with AWWA C651-86. The "Continuous-Feed Method" shall be utilized. This method is summarized below:

3.2.1 Calcium hypochlorite granules shall be placed in pipe sections during construction. Granules shall be placed at upstream end of the first section of pipe, at the upstream end of each branch main, and at 500 foot intervals. One-half ounce of calcium hypochlorite granules shall be placed at the locations specified. Calcium hypochlorite granules shall not be placed within solvent weld PVC pipe or in screwed joint steel pipe.

3.2.2 Prior to disinfection, the completed water line shall be filled and flushed. All air shall be expelled from the pipeline as described in paragraph 3.1 of this specification. The flushing velocity shall not be less than 2.5 feet per second (fps). The following table shows the approximate rates of flow required to produce a velocity of 2.5 fps in pipes of various diameters:

Pipe Diameter Inches	Approx. Flow Req'd to Produce 2.5 fps, GPM	Pipe Diameter Inches	Approx. Flow Req'd. to Produce 2.5 fps, GPM
1	10	6	230
2	30	8	390
3	65	10	620
4	105	12	890

3.2.3 Potable water from an approved source shall be introduced into the water line at a constant, measured rate. At a point no more than 10 feet downstream from the beginning of the new water line, water entering the line shall receive a dose of one percent chlorine/water solution, fed at a rate such that the water shall have not less than 25 mg/l free chlorine. Measure the chlorine concentration at regular intervals using appropriate chlorine test kits. The following table shows the gallons of one percent chlorine/water solution required per 100 feet of pipe to produce a 25 mg/l concentration in the pipeline:

Pipe Diameter Inches	Gallons of 1% Solution Req'd. per 100 Ft. of Pipe	Pipe Diameter Inches	Gallons of 1% Solution Req'd. per 100 Ft. of Pipe
1	0.01	6	0.38
2	0.05	8	0.65
3	0.11	10	1.02
4	0.18	12	1.46

3.2.4 Approximately one pound of liquid chlorine (100% available chlorine) is required for 12 gallons of water to produce a one percent solution. Approximately one pound of calcium hypochlorite (HTH) is required per 8 gallons of water to produce a one percent solution.

3.2.5 The chlorinated water shall be allowed to stand in the new water line for at least 24 hours, during which time all valves and hydrants shall be operated. At the end of the 24-hour period, water in all portions of the line shall have a residual of not less than 10 mg/l free chlorine. If a concentration less than 10 mg/l is found after the 24-hour period, the entire disinfection procedure shall be repeated by the Contractor at his expense.

3.2.6 Upon satisfactory completion of the disinfection procedure, the heavily chlorinated water shall be flushed from the system until the chlorine concentration throughout the entire system is no higher than one mg/l or the chlorine concentration of the water source.

3.2.7 After final flushing and filling of the system and prior to placing the system in service, the installer shall arrange with the Missouri Department of Natural Resources for collecting samples for required tests. If bacteriological test results are unsatisfactory, the entire disinfection procedure shall be repeated by the Contractor at his expense. The installer shall be available to assist the Missouri Department of Natural Resources in collecting samples if required.

303.4 **Roadway Surface Replacement:**

4.1 All roadway surfaces removed during water line construction shall be replaced with the same type of surface as existed prior to construction. The Contractor shall be responsible for determining the nature and thickness of all pavement and surfacings to be cut and replaced, including any base courses. Concrete pavement, asphaltic pavement, macadam pavements, crushed stone, and any type of roadway surface, whether public or private, which is cut or damaged during construction of the project shall be replaced to conform to the lines and grades of the original roadway surface, and shall be of a quality, thickness, and appearance equal to or better than that of the roadway as it existed prior to construction.

4.2 Existing paving shall be cut vertically and horizontally to straight lines. The trench shall be backfilled with granular stone material compacted to 95 percent of maximum density, to an elevation level with the existing riding surface of the roadway. This level shall be maintained by the Contractor until all secondary settling has occurred. Any crushed stone

required to maintain the trenches in a suitable condition for traffic during this period shall be furnished at the Contractor's expense. When the trench has been properly backfilled and has settled sufficiently to permit final repairs, roadway surfacing shall be applied according to this specification. At the time of final repairs, the Contractor shall remove sufficient material to allow placement of roadway surfacing to the thicknesses specified below.

4.2.1 Granular stone shall meet the gradation requirements specified in Subsection 302.4.

4.3 Asphaltic Concrete: Asphaltic concrete roadway surfaces of a thickness greater than 4 inches shall be replaced with a concrete base of 8 inches thickness and 2 inches of asphaltic concrete. Edges of the existing pavement at the trench shall be trimmed vertically to produce a neat even edge. The base surface and vertical edge shall be sprayed with a prime coat of Grade RC-250 liquid asphalt heated to no less than 130EF, at a rate of 0.15 gallons per square yard. This primer shall be applied only when the base and existing pavement are free of moisture. The asphaltic concrete shall be hot mixed in an approved plant and delivered to the work area in dump trucks at a minimum temperature of 275EF. The asphaltic concrete shall be placed and then rolled while hot with an approved five ton steel wheel roller to the same thickness as the existing pavement. In no case shall the total compacted thickness of a layer be less than two inches or greater than four inches. No traffic shall be permitted on the finished pavement until it has cooled to atmospheric temperature. Concrete used for base beneath asphalt shall have a minimum 28-day compressive strength 3000 psi.

4.4 Crushed Stone: Trenching along or across unpaved roadways, including county roads, and city streets, as well as dirt, or gravel shoulders of paved streets, roads, or highways, shall be backfilled in compliance with these specifications. The trench shall be backfilled to a level with the existing riding surface of the roadway. When the trench has been properly backfilled and has settled sufficiently to permit final repairs, the backfill shall be removed as necessary for crushed stone surfacing. The crushed stone shall be rolled and thoroughly compacted in layers to a minimum finished thickness of 6 inches.

4.5 Concrete: Concrete surfaces, including private drives, shall be replaced with concrete surfacing equal to the thickness of existing pavement, plus a minimum of 2 inches. Concrete shall have a minimum 28-day compressive strength of 3000 psi.

4.6 Chip and Seal Asphalt Paving: The area to be repaired shall be bladed to eliminate minor depressions and humps. Following the blading operation, the surface shall be thoroughly cleaned and swept to remove all mud, matted earth, dust, and other foreign material. A prime coat of liquid asphalt shall be applied at the rate of 0.30 gallons per square yard at a minimum temperature of 120EF for asphalt grade CRS-2. On the primed base, a course of aggregate shall be spread at the rate of twenty-five (25) pounds per square yard. This stone shall be roller compacted from sides to center with a steel wheeled roller weighing a minimum of five tons. Immediately following the compaction of the first course of asphalt and aggregate, a second course, identical to the first shall be applied. The finish surface shall be swept to remove any loose stones. No traffic shall be allowed on the finished surface until it has cooled to atmospheric temperature.

303.5 **Clean-up:**

5.1 After completion of any portion of work, the construction area shall be cleaned of all surplus material, earth, rubbish, etc. and left in as near the original state as possible. All ditches and drainage shall be restored to their original condition.

5.2 All grassed areas shall be seeded, fertilized, and mulched as required to restore the areas to a condition equal to that which existed prior to construction.

303.6 **Highway and Railroad Crossings:** Where designated on the approved design drawings, underground highway and railroad crossings shall be installed. Such installations shall be accomplished by tunneling, boring, or jacking methods. Each method shall provide for removal of earth and rock encountered during installation of the carrier and casing pipes. Where jacking or tunneling are utilized, the annular space between the casing and earth shall be pressure grouted with neat cement grout.

6.1 Highway crossings shall be made in strict compliance with Missouri Department of Transportation (MoDOT) requirements. No highway crossings shall be installed without the Contractor first obtaining all necessary permits from MoDOT.

6.2 Railroad crossings shall be made in strict compliance with railroad company requirements. No railroad crossings shall be made without the Contractor first obtaining all necessary permits from the railroad company.

6.3 The contractor shall insure that traffic interruptions are minimized during the underground excavation operations. After the operation is completed, the Contractor shall slide the water pipe in place. After the pipe is in place, the annular space between the casing and carrier pipe shall be backfilled with sand, pea gravel, or by spacers approved for use in bracing the carrier pipe against uplift. Once the carrier pipe has been fixed, the annular space at each end of the casing pipe shall be sealed with sand bags or approved casing seals.

303.7 **Stream Crossings:** Where designated on the approved design drawings, underground stream crossings shall be installed. Installation shall be by trenching or longitudinal boring methods.

7.1 Carrier pipe shall be of restrained joint SDR21 PVC pipe, Yellowmine with CertSD-Lok joints, as manufactured by Certainteed Corporation.

7.2 Casing pipe shall be SDR 21 PVC pipe as specified in Subsection 302.1.

7.3 Installation of stream crossings shall be as shown on the standard details. Where trenching is utilized to install stream crossings, backfilled stream banks shall be protected from erosion by placement of stone riprap.