LEGEND: **DRAFT 03/23/15**
Text to be *[deleted]* is in italics and bracketed.
Black bold text is added from 10 States Standards Chapter 30 2014.
Blue bold text is added from 10 CSR 20-8.020(9).
Red bold text is added from RSMO 644.026.1.(12).
Orange bold text is added for clarification.

Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 20—Clean Water Commission
Chapter 8—Design Guides

10 CSR 20-8.120 *[Design of]* Gravity Sewers

PURPOSE: The following criteria have been prepared as a guide for the design of ***gravity*** *sewers. This rule is to be used with rules 10 CSR 20-8.110 through 10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission in regard to adequacy of design, submission of plans, approval of plans, and approval of completed wastewater treatment facilities and collection systems. It is not reasonable or practical to include all aspects of design in these standards. The design engineer should obtain appropriate reference materials which include but are not limited to: copies of all ASTM International standards pertaining to sewers and appurtenances, design manuals such as Water Environment Federation's Manuals of Practice, and other sewer design manuals containing principles of accepted engineering practice. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from the [2004 edition of the] Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers' Recommended Standards for Wastewater Facilities and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear.*

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms "shall" and "must" are used, they are to mean a mandatory requirement insofar as approval by the Missouri Department of Natural Resources (department) is concerned, unless justification is presented for deviation from the requirements. Other terms, such as "should," "recommend," "preferred," and the like, indicate the preference of the department for consideration by the design engineer.

(A) Deviations. Deviations from these rules may be approved by the department when engineering justification satisfactory to the department is provided. Justification must substantially demonstrate in writing and through calculations that a variation(s) from the design rules will result in either at least equivalent or improved effectiveness. Deviations are subject to case-by-case review with individual project consideration.

(2) Applicability. This rule shall apply to all *[facilities with a design flow of one hundred thousand (100,000) gallons (378.5 m^3) per day or greater. This rule shall also apply to all facilities with a design flow of twenty-two thousand five hundred (22,500) gallons (85.2 m^3) per day or greater until such time as 10 CSR 20-8.020 is amended.]* **gravity sewers. This rule shall supersede when there is a conflict with 10 CSR 20-8.020.**

(3) Approval of Sewers. The department will approve plans for new systems, extensions to new areas, or replacement sanitary sewers only when designed upon the separate basis, *[in which]* **where** rain water from roofs, streets, and other areas and groundwater from foundation drains are excluded.

(4) Design Capacity and Design Flow.

(A) Sewer capacities shall be designed for the estimated ultimate tributary population, except *[in]* **when** considering parts of the system*[s]* that can be readily increased in capacity. Similarly, consideration must be given to the maximum anticipated capacity of institutions, industrial parks, etc. An economic analysis of alternatives must be included in the engineering report or facility plan where future relief sewers are planned.

1. The following factors must be considered in determining the required capacities of sanitary sewers:

A. Design peak hourly flow;
B. Additional maximum wastewater or waste flow from industrial plants;
C. Inflow and infiltration (I/I);
D. Topography of area;
E. Location of wastewater treatment facilities;
F. Depth of excavation; and
G. Pumping requirements.

2. The basis of design for all sewer projects shall be included in the engineering report or facility plan. More detailed computations may be required by the department for critical projects.

(B) Sewer flows shall be based on the design peak hourly flow in accordance with 10 CSR 20-8.110(4)(C)4. and must be designed to prevent or eliminate sanitary sewer overflows (SSOs).

(5) Details of Design and Construction.

(A) Minimum Size. Gravity sewers conveying raw wastewater shall be no less than eight inches (8") (20 cm) in diameter, except in circumstances where smaller diameter pipe can be justified.

(B) Depth. All sewers shall be sufficiently deep so as to receive wastewater from basements and shall be covered with at least thirty-six inches (36") (91 cm) of soil, other insulation, or material to prevent freezing and to protect them from superimposed loads. **Insulation shall be provided for sewers that cannot be placed at a depth sufficient to prevent freezing.**

(C) Buoyancy. Buoyancy of sewers shall be considered *[and]***.** *[f]***F**lotation of the pipe shall be prevented with appropriate construction where high groundwater conditions are anticipated.

(D) Slope.

1. **Recommended minimum slopes.** All sewers shall be designed and constructed to give mean velocities, when flowing full, of not less than two feet (2') per second (0.6 m/s)**, based on Manning's formula using an "n" value of 0.013**. The following are the

recommended minimum slopes *[which]* **that** should be provided for sewers forty-two inches (42") (107 cm) or less*[;]***.** *[h]***H**owever, slopes greater than these may be desirable for construction, to control sewer gases*[,]* or to maintain self-cleansing velocities at all rates of flow within the design limits:

Nominal Sewer Size	Minimum Slope in Feet Per 100 Feet (m/100 m)
6 inch (15 cm)	**0.60**
8 inch (20 cm)	0.40
10 inch (25 cm)	0.28
12 inch (30 cm)	0.22
14 inch (36 cm)	0.17
15 inch (38 cm)	0.15
16 inch (41 cm)	0.14
18 inch (46 cm)	0.12
21 inch (53 cm)	0.10
24 inch (61 cm)	0.08
27 inch (69 cm)	0.067
30 inch (76 cm)	0.058
33 inch (84 cm)	0.052
36 inch (91 cm)	0.046
39 inch (99 cm)	0.041
42 inch (107 cm)	0.037

A. Sewer sizes not included in the above table should be designed and constructed to give mean velocities, when flowing full, of not less than three feet (3') per second (0.9 m/s), based on Manning's formula using an "n" value of 0.013.

B. The minimum size of six-inch (6") (15 cm) pipe for schools, resorts, subdivisions located in rural areas, and similar establishments will be considered based on engineering justification and approved by the department on a case-by-case basis.

2. Minimum flow depths. Slopes *[which]* **that** are slightly less than the recommended minimum slopes may be permitted. Such decreased slopes may be considered where the depth of flow will be one-third (1/3) of the diameter or greater for design average flow. Whenever decreased slopes are selected, the design engineer must furnish *[with his/her engineering report or facility plan]* computations of the anticipated flow velocities of average daily and peak hourly flow rates **included in the summary of design**. The operating authority of the sewer system *[will]* **shall** give written assurance to the department that any additional sewer maintenance required by reduced slopes will be provided.

3. *[Minimize]* **Minimization of** solids deposition. The pipe diameter and slope shall be selected to obtain the greatest practical velocities **so as** to minimize settling problems.

Oversize sewers will not be approved to justify using flatter slopes. If the proposed slope is less than the minimum slope of the smallest pipe*[, which]* **that** can accommodate the design peak hourly flow, the actual depths and velocities at minimum, average, and design maximum day and peak hourly flow for each design section of the sewer shall be calculated by the design engineer and be included with the *[plans]* **summary of design**.

4. Slope between manholes. Sewers shall be laid with uniform slope between manholes.

5. High velocity protection. Where velocities greater than *[fifteen]* **ten** feet *[(15')]* **(10')** per second *[(4.6 m/s)]* **(3 m/s)** are attained, special provision shall be made to **avoid scour and** protect against displacement **caused** by erosion *[and]* **or** impact.

6. Steep slope protection. Sewers on twenty percent (20%) slope**s** or greater shall be anchored securely with concrete**,** *[anchors]* or equal, **anchors** spaced as follows:

A. Not over thirty-six feet (36') (11 m) center-to-center on grades **of** twenty percent (20%) *[and]* up to thirty-five percent (35%);

B. Not over twenty-four feet (24') (7.3 m) center-to-center on grades **of** thirty-five percent (35%) *[and]* up to fifty percent (50%); and

C. Not over sixteen feet (16') (4.9 m) center-to-center on grades **of** fifty percent (50%) *[and over]* **or greater**.

(E) Alignment.

1. Sewers twenty-four inches (24") (61 cm) or less shall be laid with straight alignment between manholes. Straight alignment shall be checked by either using a laser beam or lamping.

2. Curvilinear alignment of sewers larger than twenty-four inches (24") (61 cm) may be considered on a case-by-case basis provided compression joints are specified and ASTM or specific pipe manufacturers' maximum allowable pipe joint deflection limits are not exceeded. Curvilinear sewers shall be limited to simple curves *[which]* **that** start and end at manholes. When curvilinear sewers are proposed, the recommended minimum slopes indicated in paragraph (5)(D)1. of this rule *[must]* **shall** be increased accordingly to provide a minimum velocity of two feet (2') per second (0.6 m/s) when flowing full.

(F) Changes in Pipe Size.

1. When a smaller sewer joins a larger one, a manhole is required according to subparagraph (6)(A)1.B. of this rule. The invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to place the 0.8 depth point of both sewers at the same elevation.

2. Sewer extensions should be designed for projected flows. When the diameter of the receiving sewer is less than the diameter of the proposed extension at a manhole, the manhole shall be constructed with special consideration of an appropriate flow channel to minimize turbulence. The department may require a schedule for construction of future downstream sewer relief.

(G) Materials. Any generally accepted material for sewers will be given consideration, but the material selected should be adapted to local conditions, such as character of industrial wastes, possibility of septicity, soil characteristics, exceptionally heavy external loadings, abrasion, corrosion, *[and]* **or** similar problems.

1. All sewer pipe and joint materials shall conform to the appropriate ASTM specifications.
2. Suitable couplings complying with ASTM specifications shall be used for joining dissimilar materials. The leakage limitations on these joints shall be in accordance with *[paragraph (5)(I)4. or (5)(I)5.]* **subparagraph (5)(I)3.A. or (5)(I)3.B.** of this rule.
3. All sewers shall be designed to prevent damage from superimposed live, dead, and frost-induced loads. Proper allowance for loads on the sewer shall be made because of soil and potential groundwater conditions, as well as the width and depth of the trench. Where necessary, special bedding, haunching, initial backfill, concrete cradle, or other special construction shall be used to withstand anticipated *[potential]* superimposed loading or loss of trench wall stability. See ASTM D2321 or ASTM C12 *[when]* **as** appropriate.
4. For new pipe or joint materials for which ASTM standards have not been established, the design engineer shall provide complete material and installation specifications developed on the basis of criteria adequately documented and certified in writing by the *[pipe]* manufacturer to be satisfactory for the specific detailed plans for approval by the department.

(H) Installation.

1. Standards. Installation specifications shall contain appropriate requirements based on the criteria, standards, and requirements established by industry in its technical publications. Requirements shall be set forth in the specifications for the pipe and methods of bedding and backfilling *[thereof]* so as not to damage the pipe or its joints, impede cleaning operations, and future tapping, *[nor]* create excessive side fill pressures and ovalation of the pipe, nor seriously impair flow capacity.
2. Trenching.
   A. The width of the trench shall be ample to allow the pipe to be laid and jointed properly and to allow the bedding and haunching to be placed and compacted to adequately support the pipe. The trench sides shall be kept as nearly vertical as possible. When wider trenches are specified, appropriate bedding class and pipe strength shall be used.
   B. In unsupported and unstable soil, the size and stiffness of the pipe, stiffness of the embedment, **and** insitu soil*[,]* and depth of cover shall be considered in determining the minimum trench width necessary to adequately support the pipe.
   C. Ledge rock, boulders, and large stones shall be removed to provide a minimum clearance of four inches (4") (10 cm) below and on each side of all pipe(s).
   D. Dewatering. All water entering the excavations or other parts of the work shall be removed until all the work has been completed. No sanitary sewer that ultimately arrives at existing pumping stations or wastewater treatment facilities shall be used for the disposal of trench water.
3. Bedding, haunching, and initial backfill.
   A. Rigid pipe. Bedding Classes A, B, C, or crushed stone, as described in ASTM C12, shall be used and carefully compacted for all rigid pipe provided the proper

strength pipe is used with the specified bedding to support the anticipated load**,** based on the type of soil encountered and potential groundwater conditions.

B. Ductile iron pipe. Embedment materials for bedding and initial backfill, as described in ASTM A746 for Type 1 through Type 5 laying conditions, shall be used for ductile iron pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load based on the type of soil encountered and potential groundwater conditions.

C. Plastic pipe. Embedment materials for bedding, haunching, and initial backfill, Classes I, II, or III, as described in ASTM D2321, shall be used *[and carefully compacted for all flexible pipe]* provided the proper strength pipe is used with the specified bedding to support the anticipated load**,** based on the type of soil encountered and potential groundwater conditions. **The embedment materials shall be carefully compacted for all flexible pipe.**

D. Composite pipe. Except as described in ASTM D2680, the bedding, haunching, and initial backfill requirements for composite pipe shall be the same as for plastic pipe.

4. Final backfill.

A. Final backfill shall be of a suitable material removed from excavation except where other material is specified. Debris, frozen material, large clods, stones, organic matter, or other unstable materials shall not be used for final backfill within two feet (2') (0.6 m) of the top of the pipe.

B. Final backfill shall be placed in such a manner **so** as not to disturb the alignment of the pipe.

5. Deflection test.

A. Deflection tests shall be performed on all flexible pipe. The test shall be conducted after the final backfill has been in place at least thirty (30) days to permit stabilization of the soil-pipe system.

B. No pipe shall *[extend]* **exceed** a deflection of five percent (5%) **of the inside diameter**. If *[the]* deflection exceeds five percent (5%), the pipe shall be excavated. Replacement or correction shall be accomplished in accordance with requirements in the department-approved specifications.

C. The rigid ball or mandrel used for the deflection test shall have a diameter not less than ninety-five percent (95%) of the base inside diameter or average inside diameter of the pipe depending on which is specified in the ASTM specification, including the appendix, to which the pipe is manufactured. The test**s** shall be performed without mechanical pulling devices. A mandrel must have nine (9) or more odd number of flutes or points.

6. Video inspection. Video inspection of all new and rehabilitated sewers after installation is recommended.

(I) Joints and Infiltration.

1. Joints. The installation of joints and the materials used shall be included in the specifications. Sewer joints shall be designed to minimize infiltration and to prevent the

entrance of roots throughout the life of the system. **Portland cement mortar joints are not acceptable.**

2. Service connections. Service connections to the sewer main shall be watertight and **shall** not protrude into the sewer. If a saddle-type connection is used, it shall be a device designed to join with the types of pipe which are to be connected. All materials used to make service connections shall be compatible with each other and with the pipe materials to be joined and shall be corrosion proof.

3. Leakage tests. Leakage tests shall be specified **for all gravity sewers except polyvinyl chloride (PVC) pipe with a diameter of twenty-seven inches (27") (69 cm) or less**. This may include appropriate water or low pressure air testing. The testing **method(s)** *[selected]* **specified** should take into consideration the range in groundwater elevations during the test**ing** and **those** anticipated during the design life of the sewer.

[4.] **A.** Water (hydrostatic) test. The leakage exfiltration or infiltration shall not exceed one hundred (100) gallons per inch of pipe diameter per mile per day (*[0.38]* **0.093** m^3/cm of pipe diameter/km/day) for any section between manholes of the system. An exfiltration or infiltration test shall be performed with a minimum positive head of two feet (2') (0.6 m).

[5.] **B.** Air test. The air test shall, as a minimum, conform to the test procedure described in ASTM C828 for clay pipe, ASTM C924 for concrete pipe twenty-four inches (24") or less in diameter, ASTM C1103 for concrete pipe twenty-seven inches (27") or greater in diameter, and ASTM F1417 for plastic, composite, and ductile iron pipe. *[All]* **For** other materials**,** *[shall have]* test procedures **shall be** approved by the department.

[(J) Alternative Installation Methods (Trenchless Technologies). Trenchless technologies shall be evaluated by the department on a case-by-case basis.]

(J) Bore or Tunnel. The spacing of supports for carrier pipe through casings must maintain the grade, slope, and structural integrity of a pipe.

(6) Manholes.

(A) Location.

1. Manholes shall be installed—

A. At the end of each line;

B. At all changes in grade, size, or alignment;

C. At all sewer pipe intersections;

D. At distances not greater than four hundred feet (400') (120 m) for sewers **that are** fifteen inches (15") (38 cm) or less; and

E. At distances not greater than five hundred feet (500') (150 m) for sewers **that are** sixteen inches to thirty inches (16"–30") (46 cm–76 cm).

2. Spacing of manholes greater than five hundred feet (500') (150 m) may be approved by the department in cases where adequate cleaning equipment can justify such spacing.

3. Greater spacing may be permitted in larger sewers.

Comment [ETC1]: RSMO 644.026.01(12) - Require the prior submission of plans and specifications, or other data including the quantity and types of water contaminants, and inspect the construction of treatment facilities and sewer systems or any part thereof in connection with the issuance of such permits or approval as are required by sections 644.006 to 644.141, except that manholes and polyvinyl chloride (PVC) pipe used for gravity sewers and with a diameter no greater than twenty-seven inches shall not be required to be tested for leakage;

4. Cleanouts may be used only for special conditions and shall not be substituted for manholes nor installed at the end of laterals greater than one hundred fifty feet (150') (46 m) in length.

(B) Drop Type.

1. A drop pipe shall be provided for a sewer entering a manhole at an elevation of twenty-four inches (24") (61 cm) or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than twenty-four inches (24") (61 cm), the invert shall be filleted to prevent solids deposition.

2. Drop manholes should be constructed with **an** outside drop connection. Inside drop connections *[can be used]* **(**when **necessary)** *[the manhole diameter is sufficient to]* **shall be** secure**d** *[the drop pipe]* to the interior wall of the manhole and **shall** provide *[adequate]* access for cleaning.

3. When using precast manholes, drop connections must not enter the manhole at a joint.

4. Due to the unequal earth pressures that would result from the backfilling operation in the vicinity of the manhole, the entire outside drop connection shall be encased in concrete.

(C) Diameter.

1. Manhole. The minimum diameter of manholes shall be forty-two inches (42") (107 cm) on eight-inch (8") (20 cm) diameter gravity sewer lines and forty-eight inches (48") (122 cm) on all sewer lines larger than eight inches (8") (20 cm) in diameter. Larger diameter**s** *[manholes]* are *[necessary]* **required** for **manholes with** large diameter sewers **or multiple pipes connecting at the manhole** in order to maintain structural integrity.

2. Manhole frame and cover. A minimum access diameter of twenty-two inches (22") (56 cm) shall be provided.

3. Cleanout. Cleanouts shall be a minimum of eight inches (8") (20 cm) in diameter.

(D) Flow Channel.

1. The flow channel straight through a manhole should be made to conform as closely as possible in shape and slope to that of the connecting sewers*[, without]***. The channel walls should be formed or shaped to the full height of the crown of the outlet sewer in such a manner as to not** obstruct*[ing]* maintenance, inspection, or flow in the sewers. **Changes in direction of flow should generally not exceed ninety degrees (90°). Where a junction of two (2) or more lines occurs, a separate channel shall be constructed for each incoming line with the channels gradually merging together ahead of the outlet using uniform curves. In general, the invert of any branch sewer should be slightly higher than the invert of the main sewer to avoid slack-water areas where solids may accumulate.**

2. When curved flow channels are specified in manholes, including branch inlets, **the** minimum slopes indicated in paragraph (5)(D)1. of this rule should be increased to maintain acceptable velocities.

(E) Bench. A bench shall be provided on each side of any manhole channel when the pipe diameter(s) are less than the manhole diameter. The bench should be sloped no less than a one-half inch per foot (0.5 in/ft) (12.7 mm/m). No **sewer, service connection, or drop manhole** pipe shall discharge onto the surface of the bench.

(F) Watertightness.

1. Manholes shall be watertight. Manholes shall be of the precast concrete or poured-in-place concrete type. Precast manholes shall conform to the design and test methods specified in ASTM C478 and C497.
2. Manhole lift holes, grade adjustment rings, precast section joints, and any additional areas potentially subject to infiltration shall be sealed watertight **with non-shrinking mortar or other material approved by the department**.
3. Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or *[any]* **another** watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place.
4. Watertight manhole covers are to be used wherever the manhole tops may be flooded by street runoff or high water. Bolt-down cover assemblies may be needed on manholes subject to displacement by sewer surcharging. Locked manhole covers may be desirable in isolated easement locations or where vandalism may be a problem.

(G) Inspection and Testing. The specifications *[shall]* **should** include a requirement for **manhole** inspection and testing for watertightness or damage prior to placing into service.

1. Vacuum testing, if specified for concrete sewer manholes, shall conform to the test procedures in ASTM C1244 or the manufacturer's recommendation.
2. Exfiltration testing, if specified for concrete sewer manholes, shall conform to the test procedures in ASTM C969.

(H) Corrosion Protection for Manholes. Where corrosive conditions due to septicity or other causes are anticipated, corrosion protection on the interior of the manholes shall be provided.

(I) Electrical. Electrical equipment installed or used in manholes shall conform to 10 CSR 20-8.130(4)(C)5.

(7) Inverted Siphons. **Inverted siphons are used to convey wastewater by gravity under depressions.**

(A) Design. Inverted siphons shall have not less than two (2) barrels, with a minimum pipe size of six inches (6") (15 cm). **Design shall provide sufficient head and appropriate pipe sizes to secure velocities of at least three feet (3') per second (0.9 m/s) for design average flows. The inlet and outlet details shall be so arranged that the design average flow is diverted to one (1) barrel and so that either barrel may be removed from service for cleaning.**

(B) Cleaning and Maintenance. They shall be provided with necessary appurtenances for maintenance, convenient flushing, and cleaning equipment. The inlet and discharge structures shall have adequate clearances for cleaning equipment, inspection, and flushing. *[Design shall provide sufficient head and appropriate pipe sizes to secure velocities of at least three feet (3') per second (0.9 m/s) for design average flows. The inlet and outlet details shall be arranged so that the design average flow is diverted to one (1) barrel and so that either barrel may be cut out-of-service for cleaning.]* The vertical alignment should permit cleaning and maintenance.

(C) Leakage Testing. Inverted siphons must be tested according to the requirements of paragraph (5)(I)3. of this rule.

(8) Sewers in Relation to Streams.

(A) Location of Sewers in Streams.

1. Cover depth. The top of all sewers entering or crossing streams shall be at a sufficient depth below the natural bottom of the stream bed to protect the sewer line. *[In general, t]***T**he following cover requirements *[must]* **shall** be met:

A. One foot (1') (0.3 m) of cover is required where the sewer is located in rock;

B. Three feet (3') (0.9 m) of cover is required in other material. In major streams, more than three feet (3') (0.9 m) of cover may be required;

C. In paved stream channels, the top of the sewer line should be placed below the bottom of the channel pavement; and

D. Less cover *[will]* **may** be approved only if the proposed sewer crossing will not interfere with future modifications to the stream channel. Justification for requesting less cover shall be provided to the department.

2. Horizontal location. Sewers along streams shall be located *[sufficiently]* outside **of** the stream bed **and at a sufficient distance to provide for future possible stream widening and** to prevent pollution by siltation during construction and to minimize possible exposure due to erosion.

3. Structures. The sewer outfalls, headwalls, manholes, gate boxes, or other structures shall be located so they do not interfere with the free discharge of flood flows of the stream.

4. Alignment. Sewers crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible and shall be free from change in grade.

5. Sewer systems shall be designed to minimize the number of stream crossings.

(B) Construction.

1. Materials. Sewers entering or crossing streams shall be constructed of ductile-iron pipe with mechanical joints*[; otherwise, they shall be constructed so they will remain watertight and free from changes in alignment or grade]*. Material used to backfill the trench shall be stone, coarse aggregate, washed gravel, or other materials which will not readily erode, cause siltation, damage **the** pipe during placement, or corrode the pipe.

2. Siltation and erosion. Construction methods that will minimize siltation and erosion shall be employed. The design engineer shall include in the project specifications the method(s) to be employed in the construction of sewers in or near streams. Such methods shall provide adequate control of siltation and erosion by limiting unnecessary excavation, disturbing or uprooting trees and vegetation, dumping of soil or debris, or pumping silt-laden water into the stream. Specifications shall require that clean-up, grading, seeding, planting, or restoration of all work areas shall begin immediately. Exposed areas shall not remain unprotected for more than seven (7) days.

3. Alternative construction methods. When the alignment of a sewer crosses a stream, consideration shall be given to trenchless construction technologies as an alternative to open trench construction in accordance with section (11) of this rule.

(9) Aerial Crossings.

(A) Support shall be provided for all joints in pipes utilized for aerial crossings. The supports shall be designed to prevent frost heave, overturning, and settlement.
(B) Precautions against freezing, such as insulation and increased slope, shall be provided. Expansion jointing shall be provided between above-ground and below-ground sewers. Where buried sewers change to aerial sewers, special construction techniques shall be used to minimize frost heaving.
(C) For aerial stream crossings, the impact of flood waters and debris shall be considered. The bottom of the pipe should be placed no lower than the elevation of the fifty (50)-year flood.
(D) Aerial crossings shall be constructed of ductile-iron pipe with mechanical joints; otherwise, they shall be constructed so that they will remain watertight and free from changes in alignment or grade.

(10) Protection of Water Supplies.
(A) Cross Connections Prohibited. There shall be no physical connections between a public or private potable water supply system and a sewer*[,]* or appurtenance *[thereto]* which would permit the passage of any wastewater or polluted water into the potable supply. No water pipe shall pass through or come in contact with any part of a sewer manhole.
(B) Relation to Water Works Structures.
1. While no general statement can be made to cover all conditions, it is recognized that sewers shall meet the requirements of 10 CSR 23-3.010 with respect to minimum distances from public water supply wells or other water supply sources *[and]* **or** structures.
2. All existing water works units, such as basins, wells, or other treatment units, within two hundred feet (200') (60 m) of the proposed sewer shall be shown on the engineering plans.
3. Soil conditions in the vicinity of the proposed sewer within two hundred feet (200') (60 m) of water works units shall be determined and shown on the engineering plans.
(C) Relation to Water Mains.
1. Horizontal and vertical separation.
A. Sewer**s** *[mains]* shall be laid at least ten feet (10') (3*[.0]* m) horizontally from any existing or proposed water main. The distance*[s]* shall be measured edge-to-edge. In cases where it is not practical to maintain a ten-foot (10') (3*[.0]* m) separation, the department may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such a deviation may allow installation of the **gravity** sewer closer to a water main, provided that the water main is in a separate trench or on an undisturbed earth shelf located on one (1) side of the **gravity** sewer and at an elevation so the bottom of the water main is at least eighteen inches (18") (46 cm) above the top of the sewer.
B. If it is impossible to obtain proper horizontal and vertical separation as described above for sewers, the sewer must be constructed of slip-on or mechanical joint pipe or continuously encased and be pressure *[tested]* **rated** to **at least** one hundred fifty

pounds per square inch (150 psi) (1,034 kPa) **and pressure tested** to *[assure]* **ensure** watertightness.

C. Manholes should be located at least ten feet (10') (3*[.0]* m) horizontally from any existing or proposed water main.

2. Crossings.

A. Sewers crossing water mains shall be laid to provide a minimum vertical distance of eighteen inches (18") (46 cm) between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. The crossing shall be arranged so that the sewer joints will be equidistant and as far as possible from the water main joints. Where a water main crosses under a sewer, adequate structural support shall be provided for the sewer to maintain line and grade.

B. When it is impossible to obtain proper vertical separation as stipulated above, one (1) of the following methods *[must]* **shall** be specified:

(I) The sewer shall be designed and constructed equal to water pipe *[and shall be pressure tested to assure watertightness prior to backfilling]* **as described in subparagraph (10)(C)1.B of this rule**; or

(II) Either the water main or sewer line may be *[continuously]* encased *[or enclosed]* in a watertight carrier pipe which extends ten feet (10') (3*[.0]* m) on both sides of the crossing, measured perpendicular to the water main. The carrier pipe shall be of materials approved by the department for use in water main construction.

(11) Trenchless Technologies. Trenchless technologies shall be evaluated by the department on a case-by-case basis.

(A) New Pipe Installation. The following trenchless technologies may be used for installation of new wastewater collection system piping:

1. Impact molding, which is technique that launches a percussive soil displacement hammer (mole) from an excavation to displace soil and form a bore. The new pipe is drawn behind the mole or pulled into the bore using the hammer's reverse action. A pneumatically driven mole displaces the soil by the action of a percussive piston;

2. Pipe ramming, which is a simple technique using a pneumatic hammer to drive steel casings through the ground from one (1) pit to another; or

3. Microtunneling, which is a remotely controlled mechanical tunneling system where the soil is removed from the cutting head within the new pipeline, which is advanced by pipe jacking. The cutting head must have the appropriate cutting tools and crushing devices for the range of gravels, sands, silts, and clays that may be found at the collection system site.

(B) Replacement Pipe Installation. The following trenchless technologies may be used for replacement of wastewater collection system pipe:

1. Pipe bursting, which is a method of on-line replacement of fracturable pipe. An expanding device, either pneumatic or hydraulic, is introduced into the defective pipeline, shattering the pipe and drawing in the new pipe behind it. Insertion of

short lengths may be made from pits but this involves jointing of the pipeline within the pit;

2. Pipe splitting, which is similar in technique to pipe bursting but is used on non-fragmental pipes such as steel, ductile iron or polyethylene. The system uses specialized splitting heads designed to cut through the pipe wall and joints and expand the existing pipe into the surround ground; or

3. Pipe eating, which is an on-line microtunneled replacement technique. The existing defective pipeline is crushed (or eaten), by the tunneling machine and removed through the new pipeline. It is used predominantly on concrete sewer installations. This system allows for size replacement and upsizing.

(C) Pipe Lining. The following trenchless technologies may be used for lining of existing wastewater collection system pipe, which reduces the inside diameter of the pipe:

1. Cement mortar lining, which is the application of a cement mortar (typically about four millimeters (4 mm) thick) to the inside of a pipe to protect against corrosion;

2. Epoxy spray lining, which is a method of lining pipes with a thin lining of resin (typically about one millimeter (1 mm) thick) that is sprayed onto the interior surface of a cleaned collection system pipe to isolate the pipe from the wastewater and possibly reinforce the structural capabilities of the pipe;

3. Cured-in-place pipe, which is a method of lining existing pipe with a flexible tube impregnated with a resin that produces a pipe after the resin cures. The resin may be set by the use of heat or ultraviolet light; or

4. Sliplining, by which continuous or discreet pipes are inserted within existing pipes.

(D) A wastewater collection system using a trenchless technology must be designed, installed, and constructed in accordance with ASTM standards with reference to materials used and construction procedures.

(E) Pipe installed by a trenchless technology is subject to the testing requirements in paragraph (5)(I)3. of this rule.

AUTHORITY: section 644.026, RSMo 2000. Original rule filed Aug. 10, 1978, effective March 11, 1979. Amended: Filed May 17, 1994, effective Dec. 30, 1994. Amended: Filed June 28, 2011, effective Feb. 29, 2012.*

**Original authority 1972, amended 1973, 1987, 1993, 1995.*