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TRENCH EXCAVATION AND BACKFILL**PART 1 - GENERAL****1.01 SECTION INCLUDES**

- A. Trench Excavation for Pipe Systems
- B. Trench Foundation Stabilization
- C. Pipe Bedding and Backfill

1.02 DESCRIPTION OF WORK

- A. Excavate trench for pipe installation.
- B. Stabilize trench and install pipe bedding materials.
- C. Place backfill material in trench.

1.03 SUBMITTALS

Comply with Division 1 - General Provisions and Covenants, as well as the following:

- A. Gradation reports for bedding materials.
- B. Results of required testing.
- C. Dewatering plan.

1.04 SUBSTITUTIONS

Comply with Division 1 - General Provisions and Covenants.

1.05 DELIVERY, STORAGE, AND HANDLING

Comply with Division 1 - General Provisions and Covenants.

1.06 SCHEDULING AND CONFLICTS

Comply with Division 1 - General Provisions and Covenants.

1.07 SPECIAL REQUIREMENTS

None.

1.08 MEASUREMENT AND PAYMENT

A. General: The following items are incidental to the underground utility being installed and will not be paid for separately:

1. Standard trench excavation.
2. Removal and disposal of unsuitable backfill material encountered during standard trench excavation.
3. Removal of abandoned private utilities encountered during trench excavation.
4. Furnishing and placing granular bedding material.
5. Placing and compacting backfill material.
6. Dewatering.
7. Sheeting, shoring, and bracing.
8. Adjusting the moisture content of excavated backfill material to the range specified for placement and compaction.
9. Temporary support for existing water, sewer, gas, telephone, electric, and other utilities or services that cross the trench.

B. Rock Excavation:

1. **Measurement:** Measurement will be by cubic yards of rock removed.
2. **Payment:** Payment will be at the unit price per cubic yard for the quantity of rock removed.

C. Trench Foundation:

1. **Measurement:** Measurement will be in tons for the quantity of stabilization material required to replace material removed by over-excavation. Measurement will be based on the scale tickets for the material delivered and incorporated into the project. Trench foundation required to correct unauthorized over-excavation will not be measured.
2. **Payment:** Payment will be at the unit price per ton for the quantity of stabilization material furnished and placed.
3. **Includes:** Unit price includes, but is not limited to, removal and disposal of over-excavated material required to stabilize trench foundation; and furnishing, hauling, and placing stabilization material.

D. Replacement of Unsuitable Backfill Material:

1. **Measurement:** Measurement will be in cubic yards for the quantity of backfill material required to replace unsuitable backfill material removed during standard trench excavation. Measurement will be based on compacted material in place.
2. **Payment:** Payment will be at the unit price per cubic yard for the quantity of backfill material furnished.
3. **Includes:** Unit price includes, but is not limited to, furnishing, hauling, and placing backfill material.

1.08 MEASUREMENT AND PAYMENT (Continued)**E. Special Pipe Embedment or Encasement:**

1. **Measurement:** Measurement will be by the linear foot along the centerline of pipe for each type of special embedment or encasement.
2. **Payment:** Payment will be at the unit price per linear foot for each type of special pipe embedment or encasement.
3. **Includes:** Unit price includes, but is not limited to, furnishing and placing all required special pipe embedment or encasement materials.

F. Trench Compaction Testing: If the contract documents specify that the Contractor is responsible for trench compaction testing, measurement and payment will be as follows.

1. **Measurement:** Lump sum item; no measurement will be made.
2. **Payment:** Payment will be at the lump sum price for trench compaction testing.
3. **Includes:** Lump sum price includes, but is not limited to, all payments associated with retesting resulting from failure of initial tests.

PART 2 - PRODUCTS**2.01 MATERIALS EXCAVATED FROM A TRENCH**

- A. Standard Trench Excavation:** All materials encountered during trench excavation, except rock and over-excavation.
- 1. Suitable Backfill Material:** Class II, Class III, Class IVA, or Class IVB as defined in Section 3010, 2.02.
 - 2. Unsuitable Backfill Material:** Includes, but is not limited to, the following materials:
 - a. Soils not classified as suitable backfill material, as defined in Section 3010, 2.02.
 - b. Individual stones or concrete chunks larger than 6 inches and averaging more than one per each cubic foot of soil.
 - c. Frozen materials.
 - d. Stumps, logs, branches, and brush.
 - e. Trash, metal, or construction waste.
 - f. Soil in clumps or clods larger than 6 inches, and without sufficient fine materials to fill voids during placement.
 - g. Environmentally contaminated soils.
 - h. Materials removed as rock excavation or over-excavation.
 - 3. Topsoil:** Class V material. Comply with Section 3010, 2.03.
- B. Rock Excavation:** Boulders or sedimentary deposits that cannot be removed in trenches without continuous use of pneumatic tools or blasting.
- C. Over-excavation:** Excavation of unsuitable or unstable material in trenches below the pipe zone, comply with Figure 3010.101.

2.02 BEDDING MATERIAL**A. Class I Material:**

1. Crushed stone complying with the following gradation:

Sieve	Percent Passing
1 1/2"	100
1"	95 to 100
1/2"	25 to 60
No. 4	0 to 10
No. 8	0 to 5

2. The Engineer may allow the use of gravel or authorize a change in gradation subject to materials available locally at the time of construction.
3. The Engineer may authorize the use of crushed PCC for pipe sizes up to 12 inches.
4. Use aggregates having a percentage of wear, Grading A or B, not exceeding 50%, determined according to AASHTO T 96.

2.03 BACKFILL MATERIAL

- A. Class II Material:** Manufactured and non-manufactured open-graded (clean) or dense-graded (clean) processed aggregate, clean sand, or coarse-grained natural soils (clean) with little or no fines. Class II materials are further described in Table 3010.01.

Table 3010.01: Class II Materials

Type	Soil Group Symbol ASTM D 2487	Description	Percentage Passing Sieve Sizes		
			1 1/2 in.	No. 4	No. 200
Coarse-Grained Soils, clean	GW	Well-graded gravels and gravel-sand mixtures; little or no fines.	100%	< 50% of "Coarse Fraction"	< 5%
	GP	Poorly-graded gravels and gravel-sand mixtures; little or no fines.			
	SW	Well-graded sands and gravelly sands; little or no fines.		> 50% of "Coarse Fraction"	
	SP	Poorly-graded sands and gravelly sands; little or no fines.			
Coarse-Grained Soils, borderline clean to with fines	e.g. GW-GC, SP-SM	Sands and gravels that are borderline between clean and with fines.	100%	Varies	5% to 12%

B. Class III Material:

1. Natural coarse-grained soils with fines. Class III materials are further described in Table 3010.02.
2. Do not use where water condition in trench may cause instability.

Table 3010.02: Class III Material

Table	Soil Group Symbol ASTM D 2487	Description
Coarse-Grained Soils, with fines	GM	Silty gravels, gravel-sand-silt mixtures.
	GC	Clayey gravels, gravel-sand-clay mixtures.
	SM	Silty sands, sand-silt mixtures.
	SC	Clayey sands, sand-clay mixtures.

C. Class IVA Material:

1. Natural fine-grained inorganic soils. Class IVA materials are further described in Table 3010.03.
2. The Engineer will determine if material is not suitable for use as backfill material under deep fills, surface applied wheel loads, heavy vibratory compactors, tampers, or other conditions.
3. Do not use where water conditions in trench may cause instability.
4. Material is suitable for use in dry trench conditions only.

2.03 BACKFILL MATERIAL (Continued)**Table 3010.03: Class IVA Material**

Type	Soil Group Symbol ASTM D 2487	Description
Fine-Grained Soils (inorganic)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, silts with slight plasticity.
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clay, lean clay.

D. Class IVB Material:

1. Natural fine-grained inorganic (high elastic silts and plastic clays - fat clay) with a liquid limit greater than 50%. Class IVA materials are further described in Table 3010.04.
2. When approved by the Engineer, material may be used as final trench backfill in a dry trench.
3. Do not use in the pipe embedment zone.

Table 3010.04: Class IVB Material

Type	Soil Group Symbol ASTM D 2487	Description
Fine-Grained Soils (inorganic)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
	CH	Inorganic clays of high plasticity, fat clays.

2.04 TOPSOIL**A. Class V Material:**

1. Organic soils. Class V materials are further described in Table 3010.05.
2. Use only as topsoil outside of the pavement, unless otherwise specified or allowed by the Engineer.
3. Do not use in the pipe embedment zone.

Table 3010.05: Class V Material

Type	Soil Group Symbol ASTM D 2487	Description
Organic Soils (unsuitable for backfill)	OL	Organic silts and organic silty clays of low plasticity.
	OH	Organic clays of medium to high plasticity, organic silts.
Highly Organic (unsuitable for backfill)	PT	Peat and other high organic soils.

2.05 STABILIZATION (FOUNDATION) MATERIALS

- A. Clean 2 1/2 inch crushed stone with the following gradation:

Sieve	Percent Passing
2 1/2"	100
2"	90 to 100
1 1/2"	35 to 70
1"	0 to 20
1/2"	0 to 5

- B. The Engineer may authorize a change in gradation depending on materials available locally at time of construction.
- C. Crushed concrete may be used, if approved by the Engineer, if it is within $\pm 5\%$ of the gradation for each size of material.

2.06 SPECIAL PIPE EMBEDMENT AND ENCASEMENT MATERIAL

- A. Concrete Cradle, Arch, or Encasement:** Use Iowa DOT Class C concrete.
- B. Flowable Mortar:** Comply with Iowa DOT Article 2506.02.
- C. CLSM:**
1. Approximate quantities per cubic yard:
 - a. Cement: 50 pounds
 - b. Fly ash: 250 pounds
 - c. Fine aggregate: 2,910 pounds
 - d. Water: 60 gallons
 2. A compressive strength of at least 50 psi compressive strength at 28 calendar days can be expected.
 3. Comply with material requirements of Iowa DOT Article 2506.02.

PART 3 - EXECUTION**3.01 TRENCH EXCAVATION**

- A. Notify the Engineer prior to the start of excavation activities.
- B. Remove topsoil to a minimum depth of 12 inches and stockpile.
- C. Excavate trench to required elevations and dimensions. Comply with Figure 3010.101.
 - 1. Protect existing facilities, trees, and shrubs during trench excavation.
 - 2. Place excavated material away from trench.
 - 3. Grade spoil piles to drain. Do not allow spoil piles to obstruct drainage.
- D. Unsuitable Backfill Material:
 - 1. If unsuitable backfill material is encountered, notify the Engineer.
 - 2. Remove rock, rubbish, boulders, debris, and other unsuitable backfill materials at least 6 inches below and on each side of the pipe.
 - 3. Keep unsuitable backfill material separated from suitable backfill material and topsoil.
 - 4. Restore trench to design dimensions using bedding or stabilization material.

3.02 ROCK OR UNSTABLE SOILS IN TRENCH BOTTOM

- A. Notify the Engineer prior to over-excavation.
- B. The Engineer will determine the need for over-excavation and trench foundation stabilization prior to installation of pipes and structures.
- C. Comply with Figure 3010.101 for over-excavation of rock and wet or soft foundations.

3.03 TRENCH PROTECTION

- A. Install adequate trench protection (sheeting, shoring, and bracing) to prevent ground movement or damage to adjacent structures, pipelines, and utilities.
- B. Move trench boxes carefully to avoid disturbing pipe, bedding, or trench wall.

3.04 DEWATERING

- A. Maintain water levels below the bottom of trench excavation.
- B. Perform the dewatering operation according to the dewatering plan approved by the Engineer. The dewatering plan may be modified to meet actual field conditions, with approval of the Engineer.
- C. Ensure operation of the dewatering system does not damage adjoining structures and facilities. Cease dewatering operations and notify the Engineer if damage is observed.
- D. Discharged Water:
 - 1. Do not discharge water into sanitary sewers.
 - 2. Discharging water into storm sewers requires Engineer's approval.

3.04 DEWATERING (Continued)

3. Obtain permission of adjacent property owner prior to discharging water onto their property.
4. Maintain and control water discharge as necessary to prevent a safety hazard for vehicular and pedestrian traffic.
5. Direct water discharge away from electrical facilities or equipment.
6. Use dewatering equipment that will minimize disturbance from noise and fumes.
7. Protect discharge points from erosion. Provide sediment control for sediment contaminated water discharged directly from trench.

3.05 PIPE BEDDING AND BACKFILL

A. General: Comply with Figures 3010.101, 3010.102, 3010.103, 3010.104, and 3010.105, as appropriate.

1. Bedding and backfill used for pipe installation will depend on:
 - a. Type of installation (water main, sanitary sewer gravity main, sanitary sewer force main, or storm sewer).
 - b. Pipe material.
 - c. Depth of bury.
 - d. Pipe diameter.
2. After pipe installation, place remaining bedding material and immediately place backfill in trench.
3. Adjust the moisture content of excessively wet, but otherwise suitable, backfill material by spreading, turning, aerating, and otherwise working material as necessary to achieve required moisture range.
4. Adjust the moisture content of excessively dry, but otherwise suitable, backfill material by adding water, then turning, mixing, and otherwise blending the water uniformly throughout the material until the required moisture range is achieved.
5. Hydraulic compaction (flooding with water) is not allowed unless authorized by the Engineer.

B. Pipe Bedding:**1. Granular Material:**

- a. Class I granular bedding material is required for all gravity mains. Use when specified for pressure pipes.
- b. Comply with Figures 3010.101, 3010.102, 3010.103, 3010.104, and 3010.105.
- c. Place bedding material in the bottom of the trench in lifts no greater than 6 inches thick. Consolidate and moderately compact bedding material.
- d. Shape bedding material to evenly support pipe at the proper line and grade, with full contact under the bottom of the pipe. Excavate for pipe bells.
- e. Install pipe and system components.
- f. Place, consolidate, and moderately compact additional bedding material adjacent to the pipe to a depth equal to 1/6 the outside diameter of the pipe.

3.05 PIPE BEDDING AND BACKFILL (Continued)**2. Suitable Backfill Material:**

- a. Only use with pressure pipe. Comply with Figure 3010.104.
- b. Use suitable backfill material to shape trench bottom to evenly support pipe at the proper line and grade, with full contact under the bottom of the pipe. Excavate for pipe bells.

3. Special Pipe Embedment and Encasement Materials:**a. Concrete, Flowable Mortar, or CLSM:**

- 1) If specified in the contract documents, use concrete, flowable mortar, or CLSM in lieu of other bedding materials.
- 2) Secure pipe against displacement or flotation prior to placing concrete, flowable mortar, or CLSM.

b. Waterstop:

- 1) Place Class IVA clay backfill material, and compact to at least 90% of Standard Proctor Density. Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.
- 2) If trench stabilization material is required, extend waterstop through stabilization material to bottom of trench.

C. Haunch Support: Place from the top of the pipe bedding to the springline of the pipe.**1. Granular Material:**

- a. Place Class I material in lifts no greater than 6 inches thick.
- b. Consolidate and moderately compact by slicing with a shovel or using other approved techniques.

2. Suitable Backfill Material:

- a. Place in lifts no greater than 6 inches thick.
- b. For Class II backfill material, consolidate and moderately compact by slicing with a shovel or using other approved techniques.
- c. For Class III and Class IVA backfill materials, compact to at least 90% of Standard Proctor Density. Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.

3. Special Pipe Embedment and Encasement Materials:**a. Concrete, Flowable Mortar, or CLSM:**

- 1) If specified in the contract documents, use concrete, flowable mortar, or CLSM in lieu of other bedding materials.
- 2) Secure pipe against displacement or flotation prior to placing concrete, flowable mortar, or CLSM.

b. Waterstop: Place and compact Class IVA clay backfill material according to the suitable backfill material requirement above.**D. Primary and Secondary Backfill:****1. General:**

- a. For primary backfill, place from the springline of the pipe to the top of the pipe.
- b. For secondary backfill, place from the top of the pipe to 1 foot above the top of the pipe.

2. Granular Material:

- a. Place in lifts no greater than 6 inches thick.
- b. Compact to at least 65% relative density.

3.05 PIPE BEDDING AND BACKFILL (Continued)**3. Suitable Backfill Material:**

- a. Place in lifts no greater than 6 inches thick.
- b. For Class II backfill material, compact to at least 65% relative density.
- c. For Class III and Class IVA backfill materials, compact to at least 95% of Standard Proctor Density. Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.

4. Special Pipe Embedment and Encasement Materials:**a. Concrete, Flowable Mortar, or CLSM:**

- 1) If specified in the contract documents, use concrete, flowable mortar, or CLSM in lieu of other bedding materials.
- 2) Secure pipe against displacement or flotation prior to placing concrete, flowable mortar, or CLSM.

- b. Waterstop:** Place and compact Class IVA clay backfill material according to the suitable backfill material requirement above.

E. Final Trench Backfill:

1. Place suitable backfill material from 1 foot above the top of the pipe to the top of the trench.
 - a. Use no more than 8 inch thick lifts for backfill areas more than 3 feet below the bottom of pavement.
 - b. Use no more than 6 inch thick lifts for backfill areas less than or equal to 3 feet below the bottom of pavement.
2. Place backfill material after recording locations of connections and appurtenances or at the Engineer's direction.
3. Class I and Class II Backfill Material:
 - a. Compact to at least 65% relative density within right-of-way.
 - b. Compact to at least 50% relative density outside right-of-way.
4. Class III and Class IVA Backfill Material:
 - a. Compact to at least 95% of Standard Proctor Density within right-of-way.
 - b. Compact to at least 90% of Standard Proctor Density outside right-of-way.
 - c. Obtain required compaction within a soil moisture range of optimum moisture to 4% above optimum moisture content.
5. In areas to remain unpaved, terminate backfill material 8 inches below finished grade. Use topsoil for the final 8 inches above trench backfill material.
6. Terminate backfill material at subgrade elevation in areas to be paved.

3.06 TRENCH COMPACTION TESTING

A. General: When trench compaction testing is specified in the contract documents as the Contractor's responsibility, provide testing of trench backfill material using the services of an independent testing laboratory approved by the Engineer.

B. Soil Testing:**1. Cohesive Soils:**

- a. Determine moisture-density relationships by ASTM D 698 (Standard Proctor). Perform at least one test for each type of cohesive soil used.
- b. Determine in-place density and moisture content. Use ASTM D 1556 (sand-cone method) and ASTM D 2216 (laboratory moisture content), or use ASTM D 6938 (nuclear methods for density and moisture content).

3.06 TRENCH COMPACTION TESTING (Continued)**2. Cohesionless Soils:**

- a. Determine maximum and minimum index density and calculate relative density using ASTM D 4253 and ASTM D 4254.
- b. For Class I granular bedding material, determine gradation according to ASTM C 136.

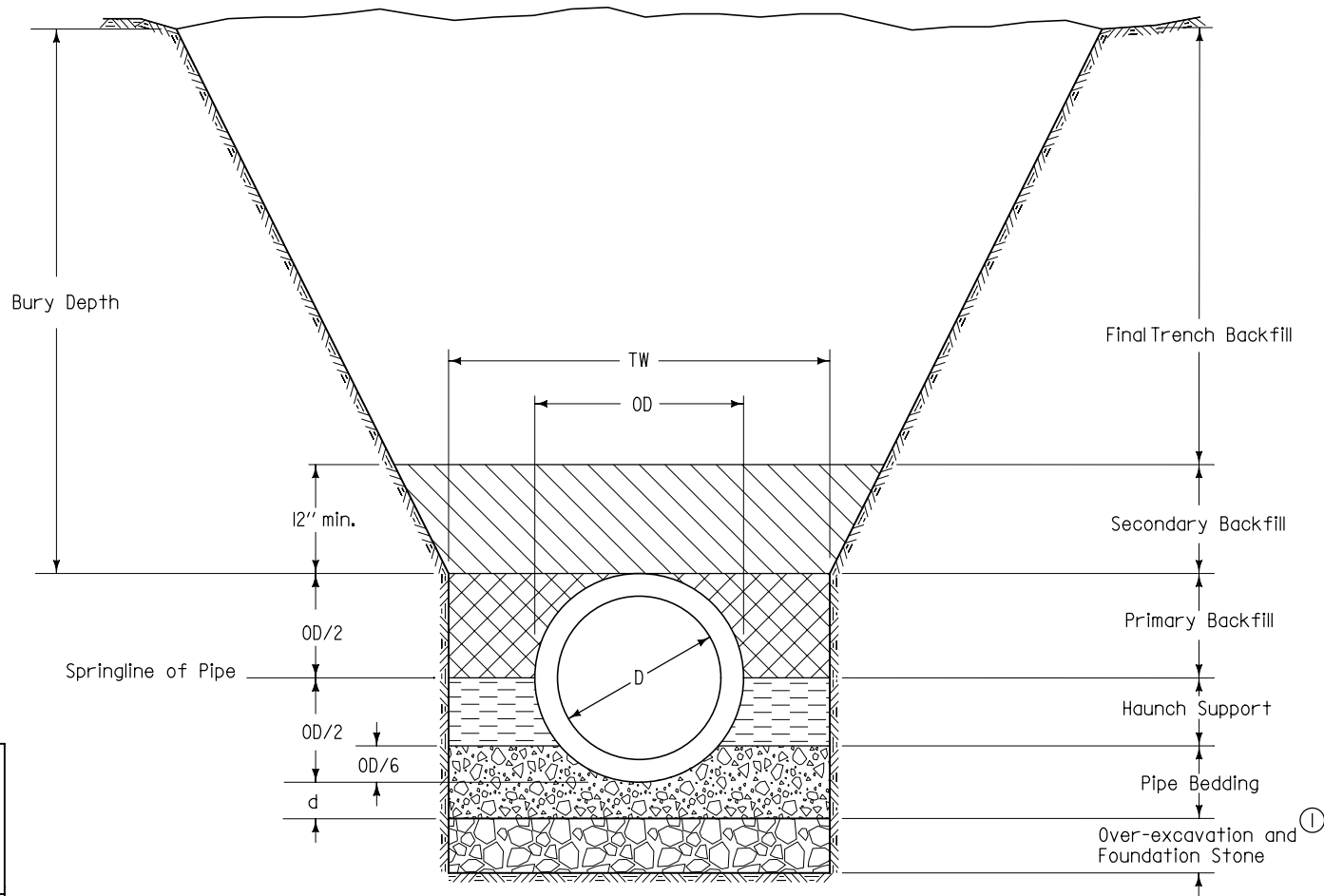
C. Field Testing:

- 1. Testing Frequency and Locations:** Perform testing of the final trench backfill, beginning at a depth of 2 feet above the top of the pipe, as follows:
 - a. Coordinate the timing of testing with the Engineer.
 - b. The Engineer will determine the location of testing.
 - c. For each 2 vertical feet of consolidated fill, provide tests at a maximum horizontal spacing of 200 feet and at all street crossings.
 - d. Additional testing may be required by the Engineer in the event of non-compliance or if conditions change.
 - e. If necessary, excavate to the depth and size as required by the Engineer to allow compaction tests. Place backfill material and recompact.
- 2. Test Failure and Retesting:** Rework, recompact, and retest as necessary until specified compaction and moisture content is achieved in all areas of the trench. In the event of failed tests, the Engineer may require retesting as deemed necessary.

END OF SECTION

Refer to the contract documents for specific material and placement requirements.

① Required only when specified in the contract documents or when directed by the Engineer.



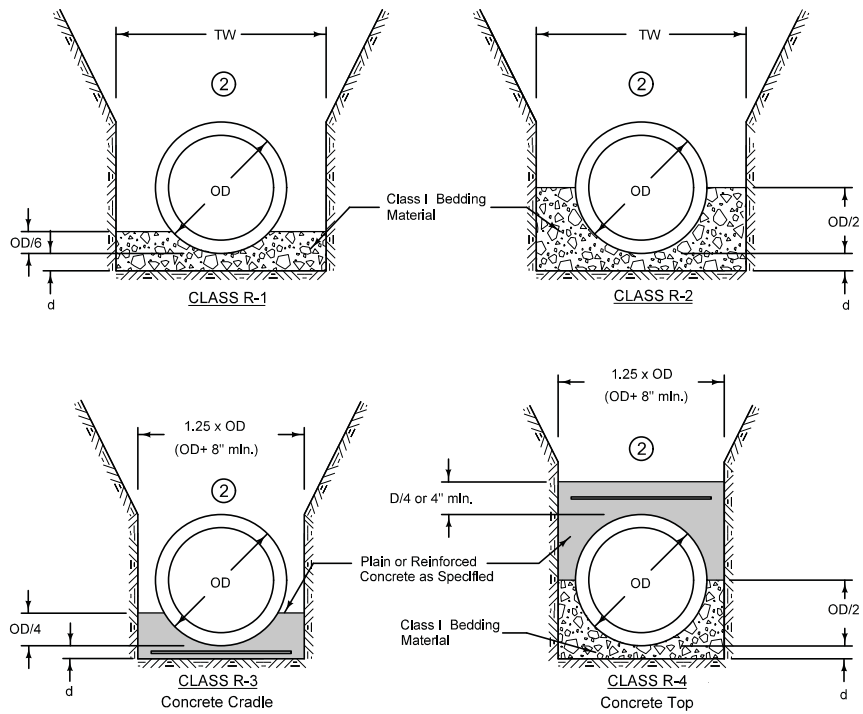
Key

- OD = Outside diameter of pipe
- D = Inside diameter of pipe
- TW = Trench width at top of pipe
- d = Depth of bedding material below pipe

FIGURE 3010.101 SHEET 1 OF 1

SUDAS	Iowa Department of Transportation	REVISION	
		NEW	04-21-09
FIGURE 3010.101	STANDARD ROAD PLAN	SW-101	
		SHEET 1 of 1	
REVISIONS: New. Replaces SUDAS Figure 3010.1.			
SUDAS DIRECTOR		DESIGN METHODS ENGINEER	
TRENCH BEDDING AND BACKFILL ZONES			

RCP AND VCP CIRCULAR PIPE BEDDING ①



Refer to sheet 2 for bury depth restrictions.

- ① Use Bedding Class R-1 or R-2 unless specified otherwise.
- ② Place remainder of bedding and backfill materials as specified in the contract documents.

Key

- OD = Outside diameter of pipe
- OS = Outside span of pipe
- TW = Trench width at top of pipe:
Min. = OD + 18 inches
Max. = 1.25 x OD + 12 inches OR
54 Inches (whichever is greater)
- d = Depth of bedding material below pipe:
OD/8 or OS/8, OR 4 inches
(whichever is greater)

REINFORCED CONCRETE ARCH AND ELLIPTICAL PIPE BEDDING

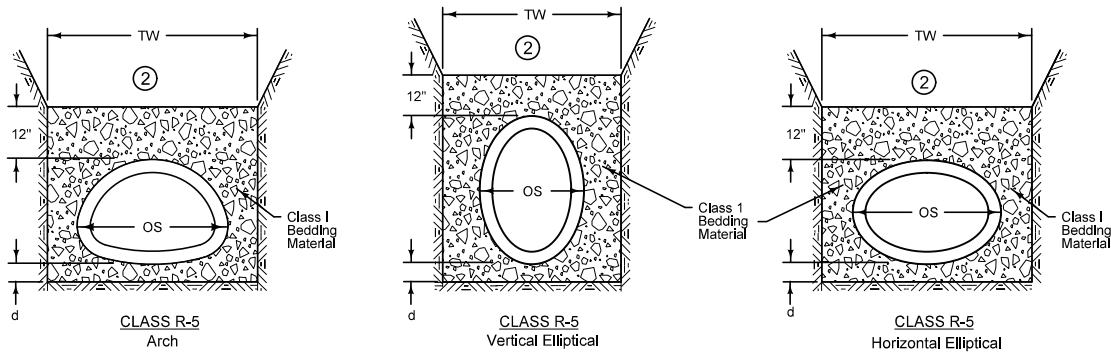


FIGURE 3010.102 SHEET 1 OF 2

SUDAS	IOWADOT	REVISION
		2 04-18-17
FIGURE 3010.102	STANDARD ROAD PLAN	SW-102
SHEET 1 of 2		
REVISIONS: Changed title to RCP AND VCP "CIRCULAR" BEDDING. Changed title on bedding Class R-4 from Concrete Arch to Concrete "Top".		
Paul D. Wigand SUDAS DIRECTOR		Brian Smith DESIGN METHODS ENGINEER
RIGID GRAVITY PIPE TRENCH BEDDING		

ALLOWABLE BURY DEPTH

CLASS III RCP

Pipe Diameter (in)	Class R-1 Bedding	Class R-2 Bedding	Class R-3 & R-4 Bedding		
			No Steel	As=0.4%	As=1.0%
12	7'	10'	15'	19'	27'
15	8'	10'	16'	19'	27'
18	8'	1 1'	16'	20'	40'
21	8'	1 1'	18'	26'	40'
24	8'	12'	23'	36'	40'
27	10'	15'	30'	40'	40'
30	1 1'	15'	29'	40'	40'
33	1 1'	15'	28'	40'	40'
36	1 1'	15'	27'	40'	40'
42	1 1'	15'	26'	38'	40'
48	1 1'	15'	26'	36'	40'
54	1 1'	15'	25'	34'	40'
60	1 1'	15'	25'	33'	40'
66	1 1'	15'	24'	32'	40'
72	1 1'	15'	24'	32'	40'

As = Area of Steel Reinforcing

CLASS IV RCP

Pipe Diameter (in)	Class R-1 Bedding	Class R-2 Bedding	Class R-3 & R-4 Bedding		
			No Steel	As=0.4%	As=1.0%
12	12'	15'	23'	28'	40'
15	12'	16'	23'	30'	40'
18	13'	16'	29'	40'	40'
21	13'	18'	40'	40'	40'
24	16'	23'	40'	40'	40'
27	19'	30'	40'	40'	40'
30	19'	29'	40'	40'	40'
33	19'	28'	40'	40'	40'
36	19'	28'	40'	40'	40'
42	18'	27'	40'	40'	40'
48	18'	26'	40'	40'	40'
54	18'	25'	40'	40'	40'
60	18'	25'	40'	40'	40'
66	18'	25'	40'	40'	40'
72	18'	24'	40'	40'	40'

As = Area of Steel Reinforcing

CLASS V RCP

Pipe Diameter (in)	Class R-1 Bedding	Class R-2 Bedding	Class R-3 & R-4 Bedding		
			No Steel	As=0.4%	As=1.0%
12	18'	23'	35'	40'	40'
15	19'	24'	40'	40'	40'
18	19'	30'	40'	40'	40'
21	25'	40'	40'	40'	40'
24	34'	40'	40'	40'	40'
27	40'	40'	40'	40'	40'
30	40'	40'	40'	40'	40'
33	40'	40'	40'	40'	40'
36	40'	40'	40'	40'	40'
42	37'	40'	40'	40'	40'
48	35'	40'	40'	40'	40'
54	33'	40'	40'	40'	40'
60	32'	40'	40'	40'	40'
66	31'	40'	40'	40'	40'
72	31'	40'	40'	40'	40'

As = Area of Steel Reinforcing

EXTRA STRENGTH VCP

CONCRETE ARCH PIPE

HORIZONTAL ELLIPTICAL RCP

VERTICAL ELLIPTICAL RCP

Pipe Dia. (in)	Bedding Class				
	R-1	R-2	R-3 & R-4		
			No Steel	As=0.4%	As=1.0%
6	25'	30'	30'	30'	30'
8	20'	26'	30'	30'	30'
10	18'	23'	30'	30'	30'
12	16'	20'	30'	30'	30'
15	15'	19'	28'	30'	30'
18	14'	18'	30'	30'	30'
21	15'	22'	30'	30'	30'
24	18'	28'	30'	30'	30'
27	20'	30'	30'	30'	30'
30	19'	29'	30'	30'	30'
33	20'	30'	30'	30'	30'
36	20'	30'	30'	30'	30'
39	19'	29'	30'	30'	30'
42	18'	26'	30'	30'	30'

As = Area of Steel Reinforcing

Pipe Size (inch by inch)	Equiv. Dia. (in)	Pipe Class	
		A-III	A-IV
18 x 1 1'	15	6'	1 1'
22 x 13	18	6'	1 1'
26 x 15	21	6'	13'
29 x 18	24	7'	15'
36 x 22	30	8'	15'
44 x 27	36	8'	14'
51 x 31	42	8'	15'
58 x 36	48	8'	15'
65 x 40	54	8'	15'
73 x 45	60	8'	14'
88 x 54	72	9'	14'

Based on Class R-5 bedding

Pipe Size (in x in)	Equiv. Dia. (in)	Pipe Class	
		HE-III	HE-IV
14 x 23	18	12'	22'
19 x 30	24	15'	29'
22 x 34	27	15'	28'
24 x 38	30	15'	27'
27 x 42	33	15'	27'
29 x 45	36	15'	26'
32 x 49	39	15'	26'
34 x 54	42	15'	25'
38 x 60	48	15'	25'
43 x 68	54	15'	24'
48 x 76	60	15'	24'
53 x 83	66	15'	24'
58 x 91	72	15'	24'
63 x 98	78	15'	23'
68 x 106	84	15'	23'

Based on Class R-5 bedding

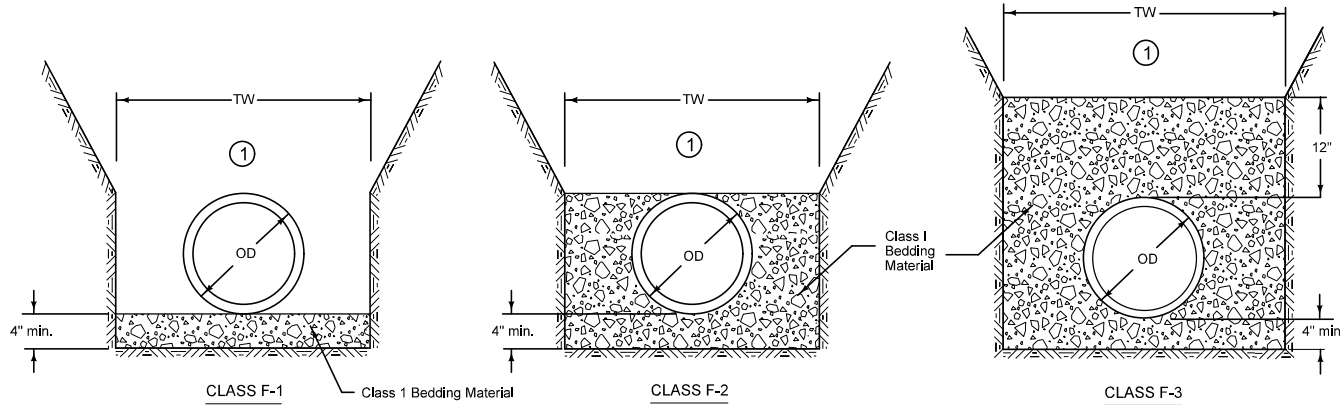
Pipe Size (in x in)	Equiv. Dia. (in)	Pipe Class			
		VE-III	VE-IV	VE-V	VE-VI
23 x 14	18	10'	15'	22'	33'
30 x 19	24	10'	16'	34'	40'
34 x 22	27	11'	20'	40'	40'
38 x 24	30	12'	23'	40'	40'
42 x 27	33	15'	30'	40'	40'
45 x 29	36	15'	29'	40'	40'
49 x 32	39	15'	29'	40'	40'
54 x 34	42	15'	28'	40'	40'
60 x 38	48	15'	27'	40'	40'
68 x 43	54	15'	27'	40'	40'
76 x 48	60	15'	26'	40'	40'
83 x 53	66	15'	25'	40'	40'
91 x 58	72	15'	25'	40'	40'
98 x 63	78	15'	25'	40'	40'
106 x 68	84	15'	24'	40'	40'

Based on Class R-5 bedding

FIGURE 3010.102 SHEET 2 OF 2

SUDAS	IOWADOT	REVISION
		2 04-18-17
FIGURE 3010.102	STANDARD ROAD PLAN	SW-102
SHEET 2 of 2		
REVISIONS: Changed title to RCP AND VCP "CIRCULAR" BEDDING. Changed title on bedding Class R-4 from Concrete Arch to Concrete "Top".		
Paul D. Wigand SUDAS DIRECTOR		Brian Smith DESIGN METHODS ENGINEER
RIGID GRAVITY PIPE TRENCH BEDDING		

BEDDING CLASSES



- ① Place remainder of bedding and backfill materials as specified in the contract documents.
- ② Minimum depth of bury 12 inches or as specified by the manufacturer.

ALLOWABLE BEDDING CLASSES

PIPE MATERIAL	STORM SEWER	SANITARY SEWER
Ductile Iron	F-1, F-2, F-3	F-1, F-2, F-3
HDPE	F-2, F-3	Not allowed
Polypropylene	F-2, F-3	F-3
PVC	F-2, F-3	F-3

Key

OD = Outside diameter of pipe
 TW = Trench width at top of pipe:
 Min. = OD+18 Inches OR 1.25xOD+12 Inches
 (whichever is greater)

ALLOWABLE BURY DEPTH ②

PVC PIPE

Pipe Diameter (in)	ASTM D 3034			ASTM F 679	ASTM F 949	ASTM F 1803	ASTM D 2680
	Solid Wall			Solid Wall SDR 35	Corrug. Exterior	Closed Profile	Composite (Truss Type)
	SDR 23.5	SDR 26	SDR 35				
8	30'	28'	24'	---	24'	---	32'
10	30'	28'	24'	---	24'	---	32'
12	30'	28'	24'	---	24'	---	32'
15	30'	28'	24'	---	24'	---	32'
18	---	---	---	24'	24'	---	---
21	---	---	---	24'	24'	24'	---
24	---	---	---	24'	24'	24'	---
27	---	---	---	24'	---	24'	---
30	---	---	---	24'	24'	24'	---
33	---	---	---	24'	---	---	---
36	---	---	---	24'	24'	24'	---
42	---	---	---	24'	---	24'	---
48	---	---	---	24'	---	24'	---
54	---	---	---	---	---	24'	---
60	---	---	---	---	---	24'	---

DUCTILE IRON, AWWA C151, CLASS 52

Pipe Diameter (in)	Class F-1 Bedding	Class F-2 Bedding	Class F-3 Bedding
4	40'	40'	40'
6	40'	40'	40'
8	40'	40'	40'
10	40'	40'	40'
12	37'	40'	40'
14	31'	40'	40'
16	28'	37'	40'
18	25'	34'	40'
20	23'	32'	40'
24	20'	29'	38'
30	18'	23'	31'
36	18'	22'	30'
42	17'	21'	29'
48	16'	19'	27'
54	16'	19'	27'

HDPE PIPE

Pipe Diameter (in)	AASHTO M 294
12	8'
15	9'
18	9'
24	9'
30	9'
36	9'
42	8'
48	8'
54	8'
60	8'

POLYPROPYLENE PIPE

Pipe Diameter (in)	ASTM F 2736	ASTM F 2764
12	24'	---
15	25'	---
18	22'	---
24	20'	---
30	22'	22'
36	---	21'
42	---	22'
48	---	23'
54	---	21'
60	---	21'

*Storm Sewer Only

FIGURE 3010.103 SHEET 1 OF 1

SUDAS IOWADOT	REVISION 2 10-18-16
	FIGURE 3010.103 STANDARD ROAD PLAN SW-103 SHEET 1 of 1

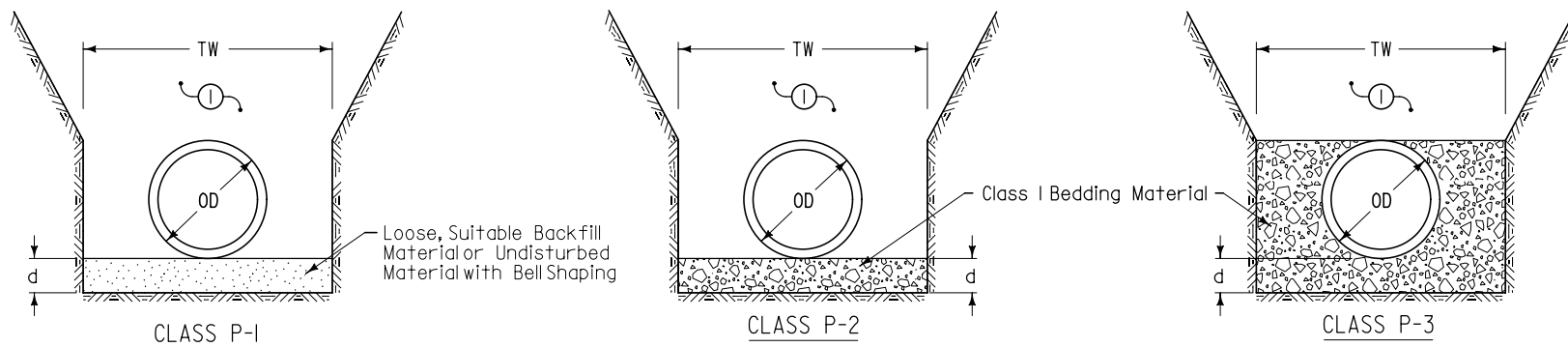
REVISIONS: Added polypropylene pipe for storm sewer applications.

Paul D. Wigand
 SUDAS DIRECTOR

Brian Smith
 DESIGN METHODS ENGINEER

**FLEXIBLE GRAVITY PIPE
TRENCH BEDDING**

BEDDING CLASSES



ALLOWABLE BURY DEPTH

DUCTILE IRON, AWWA C151, CLASS 52

Pipe Diameter (inches)	Class P-1 Bedding	Class P-2 Bedding	Class P-3 Bedding
4	40'	40'	40'
6	40'	40'	40'
8	40'	40'	40'
10	36'	40'	40'
12	31'	40'	40'
14	26'	40'	40'
16	23'	37'	40'
18	20'	34'	40'
20	18'	32'	40'
24	16'	29'	38'
30	13'	23'	31'
36	13'	22'	30'
42	13'	21'	29'
48	13'	19'	27'
54	13'	19'	27'

PVC, AWWA C900 & C905, DRI8

Pipe Diameter (inches)	Class P-1 Bedding	Class P-2 Bedding	Class P-3 Bedding
4	19'	23'	40'
6	19'	23'	40'
8	19'	23'	40'
10	19'	23'	40'
12	19'	23'	40'
14	19'	23'	40'
16	19'	23'	40'
18	19'	23'	40'
20	19'	23'	40'
24	19'	23'	40'

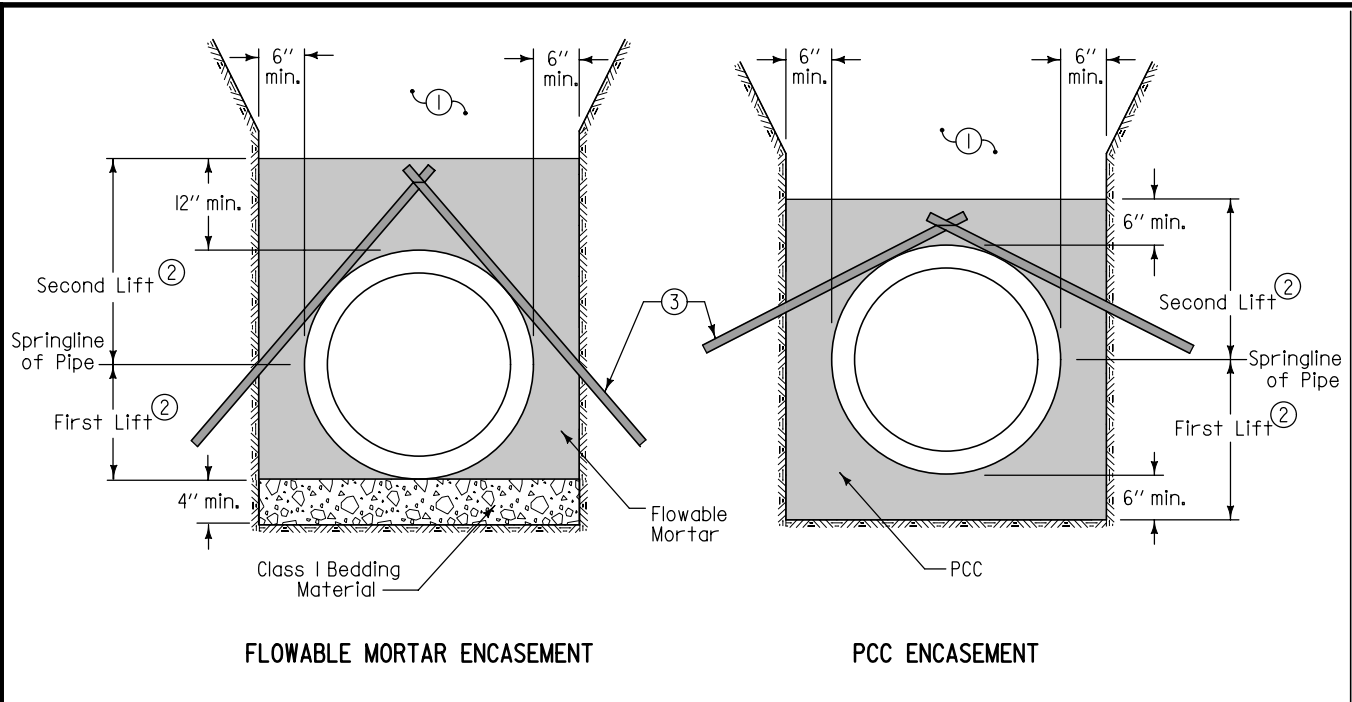
① Place remainder of bedding and backfill material as specified in the contract documents.

Key

- OD = Outside diameter of pipe
- TW = Trench width at top of pipe:
Min. = OD+18 inches OR 1.25xOD+12 inches
(whichever is greater)
- d = Depth of bedding material below pipe:
Min. = OD/8 OR 4 inches
(whichever is greater)

FIGURE 3010.104 SHEET 1 OF 1

		REVISION
		NEW 04-21-09
FIGURE 3010.104	STANDARD ROAD PLAN	SW-104
		SHEET 1 of 1
REVISIONS: New.		
SUDAS DIRECTOR		DESIGN METHODS ENGINEER
PRESSURE PIPE TRENCH BEDDING		



- ① Place remainder of bedding and backfill material as specified in the contract documents.
- ② Place encasement material in two lifts, or as required to prevent pipe flotation. Allow previous lift to reach initial set prior to placing subsequent lifts.
- ③ Restrain pipe as necessary to prevent flotation.
- ④ When specified in the contract documents, install waterstops at a nominal spacing of 800 feet or at locations as specified by the Engineer.

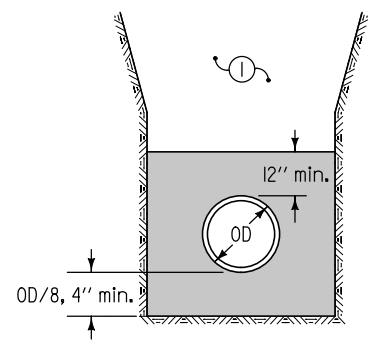
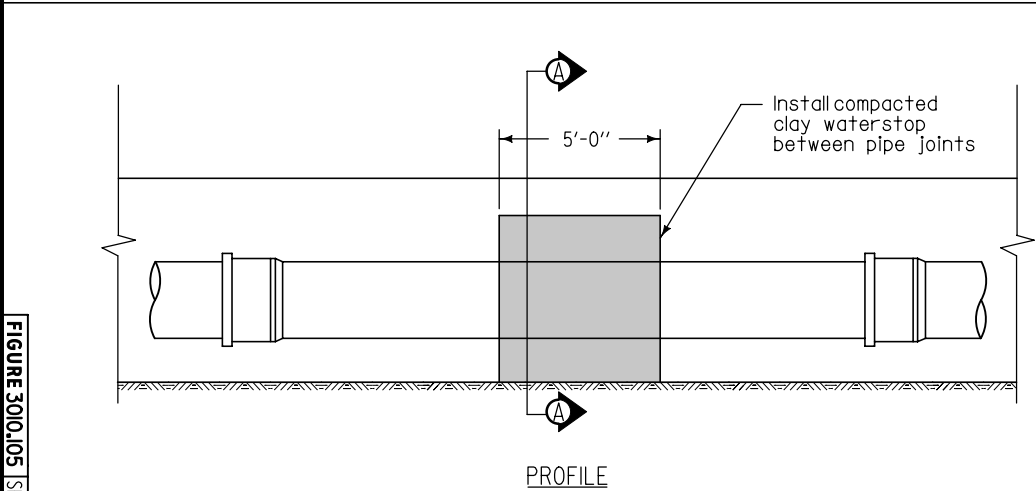


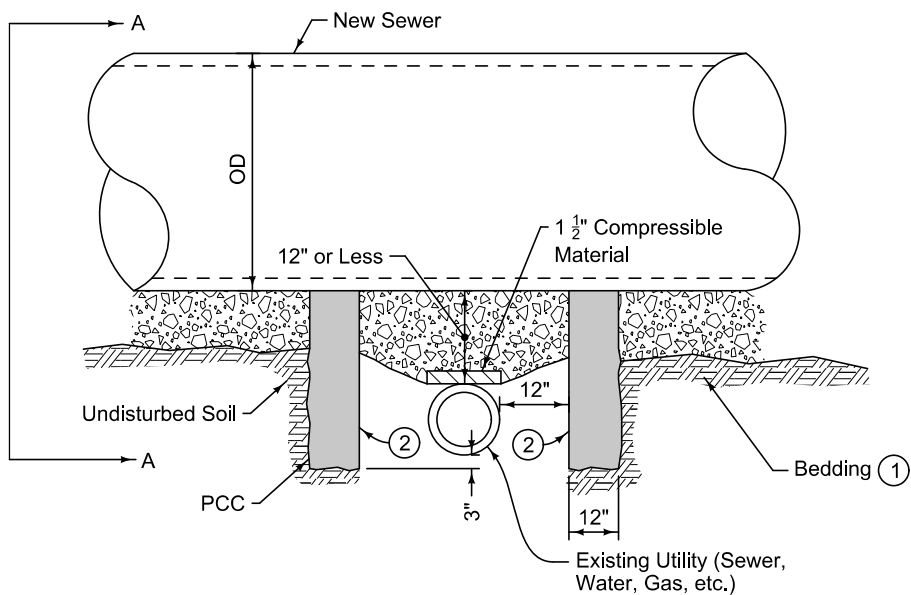
FIGURE 300.105 SHEET 1 OF 1

PROFILE

SECTION A-A

WATERSTOP FOR TRENCHES ④

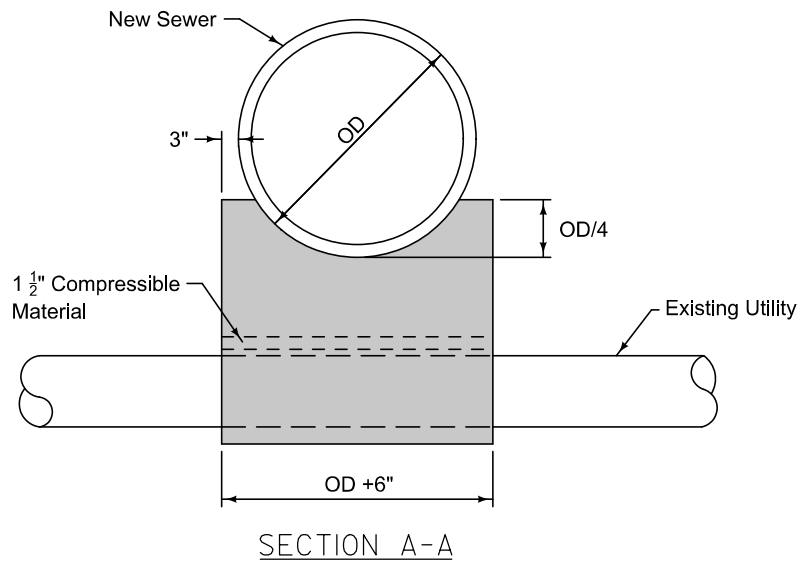
SUDAS	Iowa Department of Transportation	REVISION
		1 10-20-09
FIGURE 300.105	STANDARD ROAD PLAN	SW-105
		SHEET 1 of 1
REVISIONS: Added waterstop information from SUDAS Figure.		
SUDAS DIRECTOR		DESIGN METHODS ENGINEER
MISCELLANEOUS PIPE BEDDING		




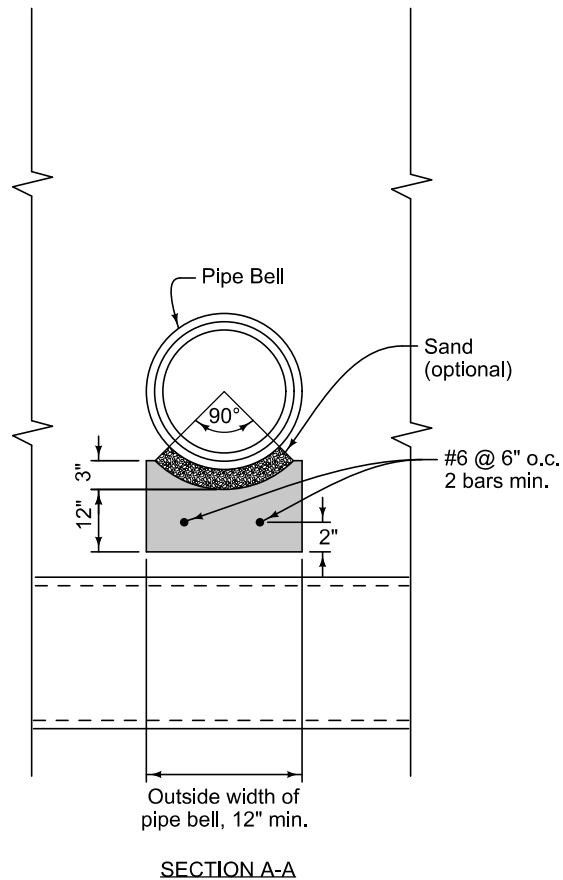
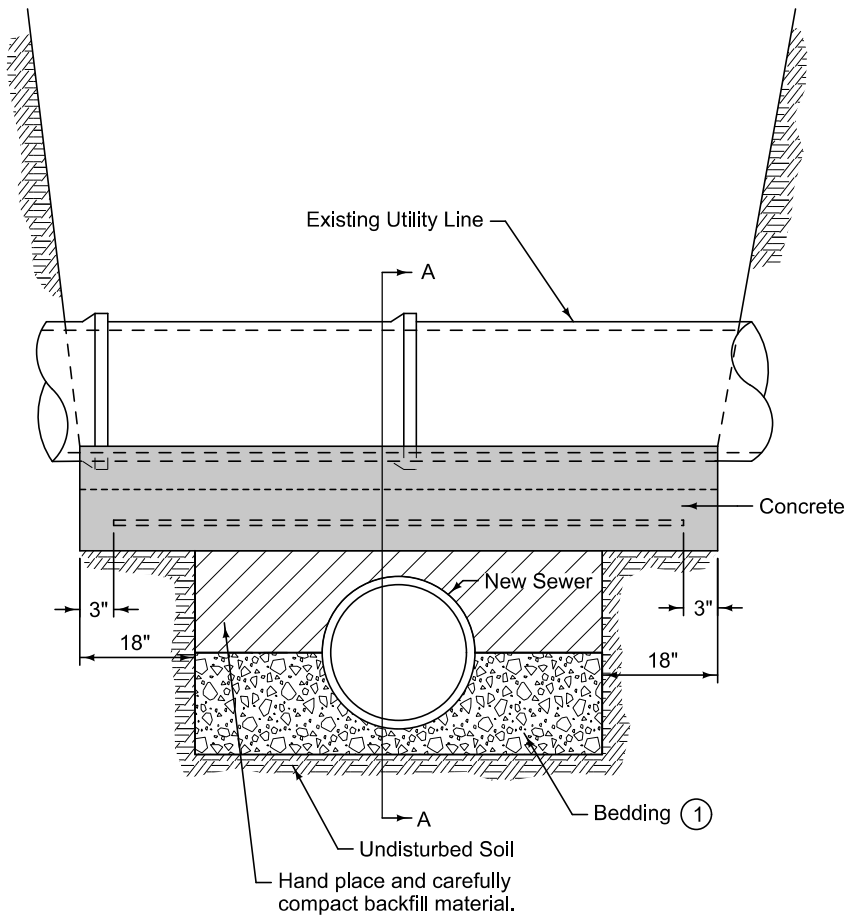
Install pipe support for all new sewers 12 inches in diameter or larger when clearance between bottom of new sewer and top of existing line is 12 inches or less.

- ① Comply with Figure 3010.101.
- ② Form interior surface of footings. Keep the 12 inch utility clear zone free of concrete.

OD = Outside pipe diameter



	REVISION
	1 10-21-14
	3010.901
SHEET 1 of 1	
SUDAS Standard Specifications	
SEWER PIPE SUPPORT OVER EXISTING UTILITY LINE	




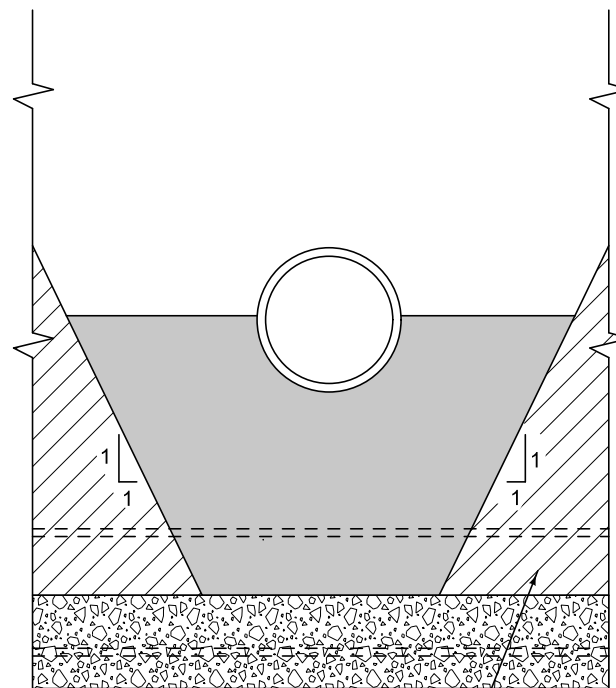
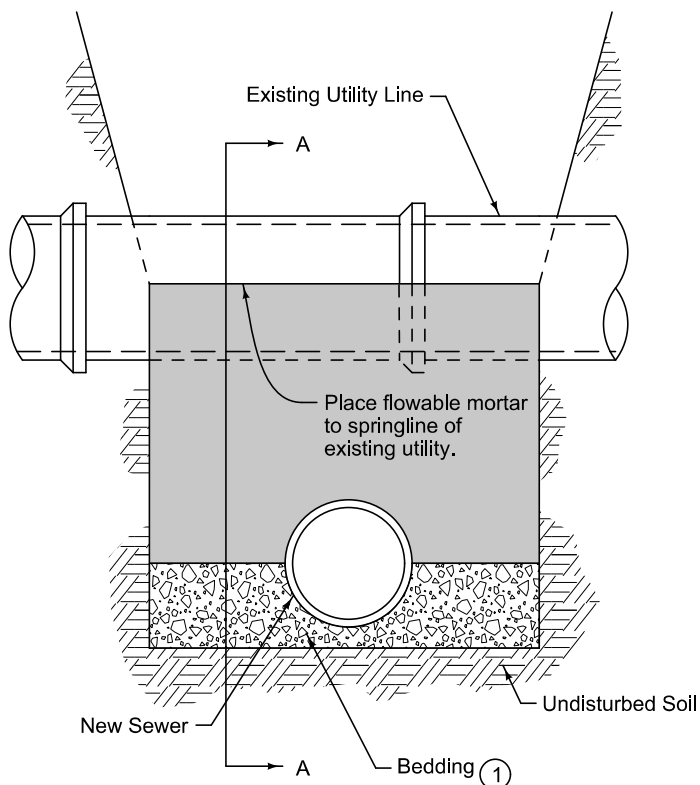
Use reinforced concrete beam utility line support when new sewer excavation is crossing under an existing utility line (sewer lines, water lines, gas lines, etc.) as directed by the Engineer.

Allow concrete to cure a minimum of 48 hours before placing backfill material.

Special design required for trench width greater than 7 feet or trench depth greater than 15 feet.

① Comply with Figure 3010.101.

	REVISION
	1 10-21-14
	3010.902
SHEET 1 of 1	
SUDAS Standard Specifications	
REINFORCED PCC BEAM UTILITY LINE SUPPORT	




Use flowable mortar utility line support when new utility excavation is crossing under an existing utility line (sewer lines, water lines, gas lines, etc.) as directed by the Engineer.

Allow flowable mortar fill to cure a minimum of 24 hours before placing backfill material.

Trim uncompacted backfill material away from slopes before pouring flowable mortar.

Side slopes of flowable mortar fill to be 1:1 or greater. See Section A-A

① Comply with Figure 3010.101

	REVISION 1 10-21-14
	SUDAS 3010.903
	SHEET 1 of 1
SUDAS Standard Specifications	
FLOWABLE MORTAR FILL UTILITY LINE SUPPORT	

TRENCHLESS CONSTRUCTION (BORING, JACKING, AND TUNNELING)**PART 1 - GENERAL****1.01 SECTION INCLUDES**

- A. Trenchless Installation of Carrier Pipe with Casing Pipe
- B. Trenchless Installation of Carrier Pipe without Casing Pipe

1.02 DESCRIPTION OF WORK

- A. Excavate launching and receiving pits.
- B. Install casing or carrier pipe by trenchless methods.
- C. Install carrier pipe inside casing pipe (if required).
- D. Place backfill material in excavations.

1.03 SUBMITTALS

Comply with Division 1 - General Provisions and Covenants, as well as the following:

- A. Proposed installation methods and equipment.
- B. Gradation reports for bedding materials if required.
- C. Shop drawings of casing spacers and proposed spacing.
- D. Dewatering plan (if required).

1.04 SUBSTITUTIONS

Comply with Division 1 - General Provisions and Covenants.

1.05 DELIVERY, STORAGE, AND HANDLING

Comply with Division 1 - General Provisions and Covenants.

1.06 SCHEDULING AND CONFLICTS

Comply with Division 1 - General Provisions and Covenants.

1.07 SPECIAL REQUIREMENTS

None.

1.08 MEASUREMENT AND PAYMENT

All items of work contained in this section are incidental to the underground utility pipe being installed and will not be paid for separately.

PART 2 - PRODUCTS**2.01 CARRIER PIPE****A. Carrier Pipe Installed within Casing Pipe:**

1. **Sanitary Sewer Gravity Main:** Comply with Section 4010, 2.01.
2. **Sanitary Sewer Force Main:**
 - a. **Restrained Joint Ductile Iron Pipe:** Comply with Section 4010, 2.02.
 - b. **Restrained Joint PVC Pipe:** Comply with Section 4010, 2.02.
3. **Storm Sewer:** Comply with Section 4020, 2.01.
4. **Culverts:** Comply with Section 4030, 2.01.
5. **Water Main:**
 - a. **Restrained Joint Ductile Iron Pipe:** Comply with Section 5010, 2.01.
 - b. **Restrained Joint PVC Pipe:** Comply with Section 5010, 2.01.

B. Carrier Pipe Installed without a Casing Pipe:

1. **Sanitary Sewer Gravity Main:**
 - a. **Reinforced Concrete Pipe:** Comply with Section 4010, 2.01.
 - b. **Vitrified Clay Pipe:** Comply with Section 4010, 2.01.
 - c. **Restrained Joint Ductile Iron Pipe:** Comply with Section 4010, 2.02.
 - d. **Restrained Joint PVC Pipe:** Comply with Section 4010, 2.02.
2. **Sanitary Sewer Force Main:**
 - a. **Restrained Joint Ductile Iron Pipe:** Comply with Section 4010, 2.02.
 - b. **Restrained Joint PVC Pipe:** Comply with Section 4010, 2.02.
3. **Storm Sewer and Culverts:**
 - a. **Reinforced Concrete Pipe:** Comply with Section 4020, 2.01.
 - b. **Reinforced Concrete Arch Pipe:** Comply with Section 4020, 2.01.
 - c. **Reinforced Concrete Elliptical Pipe:** Comply with Section 4020, 2.01.
 - d. **Reinforced Concrete Low Head Pressure Pipe:** Comply with Section 4020, 2.01.
4. **Water Main:**
 - a. **Restrained Joint Ductile Iron Pipe:** Comply with Section 5010, 2.01.
 - b. **Restrained Joint PVC Pipe:** Comply with Section 5010, 2.01.

2.02 CASING PIPE

A. Pipe: Use only new, steel pipe meeting the requirements of ASTM A 139, Grade B; ASTM A 252, Grade 2; or ASTM A 53, Grade B. Pipe may be welded or seamless. Wall thickness will be as specified in the contract documents.

B. Joints:

1. Comply with American Welding Society Code D1.1. Weld all joints with full penetrating weld. Welders must be qualified according to Iowa DOT Materials I.M. 560. Welds must comply with Iowa DOT Materials I.M. 558.
2. Upon approval of the Engineer, an interlocking casing pipe connection system may be used in lieu of field welding the sections of casing pipe.

2.02 CASING PIPE (Continued)

- C. Pipe Diameter:** Minimum inside diameter as specified in the contract documents. If diameter is not specified, use a minimum inside casing diameter of at least 4 inches greater than the largest outside diameter of the carrier pipe, including pipe bells.

2.03 CASING SPACERS

- A. Use manufactured casing spacers to position carrier pipe in casing. Do not use wood skids.
- B. Meet the following material requirements:
1. HDPE Band/Panel and Riser: ASTM D 638.
 2. Stainless Steel or Carbon Steel Band/Panel and Riser: Type 304 stainless steel according to ASTM A 240 or carbon steel according to ASTM A 36.
 - a. Liner: Elastomeric PVC per ASTM D 149.
 - b. Spacer Skid/Runner: Abrasion resistant polymer with a low coefficient of friction.
 - c. Fasteners: Type 304 (18-8) stainless steel per ASTM A 193.

2.04 BACKFILL FOR ABANDONED TUNNELS

- A. Use Iowa DOT Class C concrete, approximately 4 inch slump.
- B. Flowable mortar or CLSM according to Section 3010, 2.06.

2.05 BACKFILL MATERIAL

- A. Excavated Materials:** Comply with Section 3010 for classification of excavated materials. Use only suitable material for backfill material.
- B. Special Fill Materials:** For use where specified in the contract documents.
1. **PCC:** Use Iowa DOT Class C concrete, approximately 4 inch slump.
 2. **Flowable Mortar:** Comply with Iowa DOT Article 2506.02.
 3. **CLSM:** Comply with Section 3010, 2.06.

2.06 CASING END SEAL

- A. Manufactured:** Minimum 1/8 inch thick manufactured synthetic rubber casing end seal with stainless steel bands and fasteners.
- B. PCC:** Comply with Section 6010. Do not use PCC casing end seals with flexible carrier pipes.

PART 3 - EXECUTION**3.01 EXCAVATION**

- A. Notify the Engineer prior to the start of excavation activities.
- B. Remove topsoil to a minimum depth of 12 inches and stockpile.
- C. Excavate the minimum size pits necessary to safely and properly perform the work.
 - 1. Protect existing facilities, trees, and shrubs during excavation.
 - 2. Place excavated material away from trench.
 - 3. Grade and shape spoil piles to drain and protect adjacent areas from runoff. Do not allow spoil piles to obstruct drainage. Stabilize stockpiles with seeding and provide sediment control around stockpiles.
- D. Remove rock, rubbish, debris, and other materials not suitable for use as backfill.

3.02 SHEETING, SHORING, AND BRACING

Comply with Section 3010, 3.03.

3.03 DEWATERING

Comply with Section 3010, 3.04.

3.04 TRENCHLESS INSTALLATION

- A. **General:** Select a method of installation that is appropriate for the soil conditions anticipated and will 1) allow the pipe to be installed to the desired line and grade within the specified tolerances; 2) prevent heaving or settlement of the ground surface or damage to nearby facilities; and 3) prevent damage to the carrier pipe and any lining materials within the carrier pipe.
 - 1. **Installation Methods:**
 - a. **Auger Boring:** A method that utilizes a rotating cutting head to form the bore hole and a series of rotating augers inside a casing pipe to remove the spoil.
 - b. **Directional Drilling:** A method for installing pipe from a surface-launched drilling rig. A pilot bore is formed and then enlarged by back reaming and removing the spoil material. The pipe is then pulled in place.
 - c. **Open-ended Pipe Ramming:** A method that involves driving a steel casing pipe with a percussive hammer. The front end of the casing pipe is open-ended. Spoils are removed from the pipe.
 - d. **Pipe Jacking:** A method in which pipe is pushed into the ground with hydraulic jacks while soil is simultaneously excavated. Excavation is normally completed with a tunnel boring machine.
 - e. **Microtunneling:** A method of pipe jacking using a remote controlled tunnel boring machine.
 - f. **Utility Tunneling:** A method of forming large diameter tunnels. As excavation takes place at the front of the tunnel, a liner is constructed to temporarily support the tunnel. Upon completion of the tunnel, the pipe is pushed in place.
 - g. **Other:** Other methods may be allowed with the Engineer's approval.

3.04 TRENCHLESS INSTALLATION (Continued)**2. Line and Grade:**

- a. Install pipe at line and grade that will allow the carrier pipe to be installed at its true starting elevation and grade within the specified maximum alignment deviation of the pipe centerline.
- b. When no deviation tolerances are specified in the contract documents, apply the following maximum deviations to the carrier pipe.
 - 1) Gravity Pipe:
 - a) Horizontally: ± 1.0 foot per 100 feet;
 - b) Vertically: ± 0.2 feet up to 100 feet; an additional ± 0.1 foot per 100 feet thereafter. Backfall in pipe is not allowed.
 - 2) Pressurized Pipe:
 - a) Horizontally: ± 2.0 feet
 - b) Vertically: ± 1.0 foot. Maintain the minimum depth specified in the contract documents.
- c. Greater deviation or interference with other identified facilities may be cause for rejection.

3. Deviation from Line and Grade:

- a. Provided adequate clearance remains for proper installation of the carrier pipe, the Contractor will be allowed to correct deviations in grade of a casing pipe in order to achieve design grade of the carrier pipe by:
 - Pouring an invert in the casing pipe, or
 - Shimming the carrier pipe with casing spacers to a uniform grade.
- b. Installations deviating from the specified tolerances that cannot be adjusted to conform to the specified tolerances may be rejected by the Engineer. If non-conforming installation is not rejected, provide all additional fittings, manholes, or appurtenances needed to accommodate horizontal or vertical misalignment, at no additional cost to the Jurisdiction.
- c. Abandon rejected installation and place special fill materials, at no additional cost to the Jurisdiction. Replace abandoned installations, including all additional fittings, manholes, or appurtenances required to replace rejected installations.

B. Casing Pipe or Un-cased Carrier Pipe Installation:

1. Install pipe by approved methods.
2. Use a jacking collar, timbers, and other means as necessary to protect the driven end of the pipe from damage.
3. Do not exceed the compressive or tensile strength capacity of the pipe during pushing or pulling operations.
4. Fully support bore hole at all times to prevent collapse. Insert pipe as soil is removed, or support bore with drilling fluid.
5. Fully weld all casing pipe joints. Use an interlocking connection system when approved by the Engineer.
6. Fill space between the inside of the bore hole and the outside of the pipe with special fill material if the space is greater than 1 inch.

3.04 TRENCHLESS INSTALLATION (Continued)**C. Carrier Pipe Installation through Casing:**

1. Clean dirt and debris from the interior of the casing pipe after installation.
2. Install casing spacers on carrier pipe sections as necessary to support the pipe barrel according to the pipe manufacturer's recommendations subject to the following minimum requirements:
 - a. Install a spacer within 1 foot of each side of the carrier pipe joint and at a maximum spacing of 6 feet.
 - b. Do not allow the pipe to be supported by joint bells.
 - c. Lubricate casing spacers with drilling mud or flax soap. Do not use petroleum-based lubricants or oils.
3. Ensure that thrust loads will not damage carrier pipe joints. Provide thrust collars between joint shoulders of concrete pipe.
4. Provide timbers for sufficient cushioning between the end of the pipe pushed and the jacking equipment to prevent damage to the pipe. Do not allow the steel jack face to thrust against the unprotected pipe end.
5. Position jacks so the resulting force is applied evenly to the entire end of the pipe.
6. Assemble pipe joints in the jacking pit before pushing the carrier pipe into the casing.
7. Close the end of the casing pipe around the carrier pipe with a casing end seal.
8. When specified in the contract documents, fill the annular space between the carrier and casing pipe with flowable mortar or CLSM.

3.05 PIT RESTORATION

- A. Remove installation equipment and unused materials from the launching and receiving pits.
- B. When the carrier pipe extends beyond the limits of trenchless installation and into the bore pit, place bedding and backfill material according to Section 3010, 3.05.
- C. Place suitable backfill material in the pit. Apply the testing requirements of Section 3010, 3.06.
- D. Restore the site to original condition or better.

END OF SECTION