REVISIONS TO THE 2008 PIPELINE DESIGN MANUAL

MARCH 2015

REGULATION

SUMMARY OF REVISION
TO THE 2008 PIPELINE DESIGN MANUAL

PART ONE – WATER DESIGN GUIDELINES

Section 4 - Selection of Pipe Material.

- Revisions for Maryland Transit Administration (MTA) Rail Lines requirements.

Section 7. – Allowable Fittings.

- Revisions for not allowing tapping to PCCP water pipelines.

Section 9 - Connections to Existing or Proposed Water Pipelines.

- Revisions for Maryland Transit Administration (MTA) Rail Lines requirements for to call out Internal Acoustic fiber optic (AFO) Cables in most of the existing PCCP water pipeline.
- Revision requiring more than one connection to our Transmission Mains 36-inch and larger PCCP

Section 23. – Blowoff Connections..

- Revisions for new requirement from Maryland Department of the Environment (MDE).

PART TWO – SEWER DESIGN GUIDELINES

Section 3 - Selection of Pipe Material (Gravity Sewer).

- Revisions for Maryland Transit Administration (MTA) Rail Lines requirements.

PART THREE – COMMON DESIGN GUIDELINES

Section 2 – Pipeline Crossing and Clearances

- Revisions for existing PCCP width requirements.

Section 3 – Pipeline Crossing and Clearances

- Revisions for Maryland Transit Administration (MTA) Rail Lines requirements and new requirement from Maryland Department of the Environment (MDE)

Section 25 – Tunnels

- Revisions for Maryland Transit Administration (MTA) Rail Lines requirements.

Section 26 – Tunnel Design Criteria

- Revisions for Maryland Transit Administration (MTA) Rail Lines requirements.

Section 28 – Corrosion Control

- Revisions for Maryland Transit Administration (MTA) Rail Lines requirements.

4. Selection of Pipe Material.

a. General.

1) Allowable water pipe material for routine projects in accordance with the Specifications are as follows:

   a) Water Pipelines:

      (1) DIP or PVC for pipelines 12-inch diameter and smaller.

      (2) DIP for pipelines larger than 12-inch diameter.

   b) Water services:

      (1) Copper tubing for water house services 2-inch diameter and smaller.

      (2) DIP for 4-inches to 12-inch diameter.

2) In the General Notes indicate the minimum pipe class designation.

   a) On the profiles when required, indicate the change in pipe class designation and give stations to show the limits of pipe class designation.

3) For special projects, when pipe diameters exceed 54-inch or for special applications, the WSSC may require a special pipe material, such as steel.

b. Determining Pipeline Cover.

1) Determine the maximum pipeline cover using the largest differential between the profile grade or ground line shown on profile and the pipe crown.

c. Selection of Pipe Class and Wall Thickness.

1) Copper tubing. The copper tubing indicated in the Specifications is suitable for normal WSSC water system pressures and earth cover.

2) DIP in accordance with AWWA C151. The design for DIP shall be based on the allowable cover over the pipeline and the following:

   a) Class of DIP, in accordance with AWWA C151 as specified as Special Pipe Classes.

      (1) In the General Notes on the drawings, indicate the minimum class of pipe for DIP required for the project.

      (2) On the profile indicate by pipeline stations any changes to the class of pipe.

      (3) Minimum class 54 for all pipe size. For determining actual class of pipe higher than the minimum class 54, see the following:

         (a) Class of pipe (i.e. wall thickness) is indicated in Standard Detail W/6.0 and differs for various depths of cover. Use Standard Detail W/6.0 for determining allowable earth cover over DIP. Standard Detail W/6.0 assumes that bedding and backfill are in accordance with the Specifications and the classes of pipe are adequate for all operating pressures in the WSSC's water distribution system. For depth of cover greater than Standard Detail W/6.0, see "Depth of Cover for DIP Greater Than WSSC Requirements" in this section.

(b) Larger than 48-inch diameter may not be manufactured in accordance with the Specifications. Verify with the pipe manufacturers that the material specified can be produced. Example: Larger size DIP may be available in Pressure Class instead of Class of Pipe. The pipeline design must be reviewed for allowable working pressure and cover over the pipe, and Special Provisions for Pressure Class must be added to the Specifications, see requirements under Part Three, Section 6, (Modifications to Specifications and Standard Details).

(c) Pipelines with welded-on connections see Part One, Section 7 (Allowable Fittings).

(d) Flanged pipe, minimum class 54, in accordance with AWWA C115.

(e) Pipelines designed within MSHA right of way, see Wall Thickness of DIP for Special Applications, in this section.

(3) Pipeline crossing under a railroad, verify with the railroad authority the requirements for crossing its property or right of way.

(a) When crossing under Maryland Transit Administration (MTA) Rail Lines, see Part Three, Section 3 (Pipeline Crossings and Clearances).

(5) Pipelines within tunnels and casing pipes see Part One, Section 17 (Tunnels or Casing Pipes) and Part Three, Section 26 (Tunnels Design Criteria)

3) <u>PVC</u> pipe in accordance with AWWA C900. The design for PVC pipe shall be based on the operating pressure and cover over the pipeline.

a) <u>PVC</u> for design of water pipelines must be approved by WSSC as an alternate pipeline material.

b) <u>Pipe dimension ratio for PVC AWWA C900.</u>

(1) For 4-inch through 12-inch diameter:

(b) Use only AWWA C900 DR14 Pipe Dimension Ratio (DR).

(c) Maximum operating pressure is one hundred sixty (160) psi.

c) <u>Allowable cover for PVC Pipe AWWA C900</u>.

(1) For allowable cover over PVC pipe use Standard Detail W/6.1. Allowable cover differs for varying DRs and trench backfill. Standard Detail W/6.1 assumes bedding and backfill are in accordance with the Specifications.

d) Design limitations.

(1) PVC pipe has a strict limitation on joint deflections; see Part One, Section 12 (Allowable Joint Deflections).

(2) PVC pipe do not be used for fire hydrant lead piping and for water house connections 3-inch and larger.

e) Information required on the Drawings.

(1) In the General Notes on the drawings, indicate the pipe dimension ratio of DR 14 for PVC Pipe.

(2) If granular material bedding is required due to the depth of cover, see "Allowable cover for PVC (AWWA C900)" in this section. Show on the profile by pipeline stations the required limits of granular material bedding and provide a note for borrow aggregate within the pipe embedment zone for Standard Detail M/8.1a.

(3) PVC water mains require a tracer wire on top of the PVC pipe, in accordance with the Specifications.

(a) The tracer wire shall be connected to all valves, fittings and fire hydrants, see Standard Details W/2.2, W/8.0 and W/8.1.

(b) If connecting a PVC water main to an existing CIP or DIP water main, provide a note on the drawings to connect to the existing pipe with a MJ Solid Sleeve. Connect the tracer wire to the MJ Solid Sleeve in a way similar to gate valves, see Standard Detail W/2.2.

(4) PVC Insulating Spool, if the operating pressure, pipe dimension ratio and allowable cover are within the limits allowed. Include a note on the drawings that the Contractor has the option of using the PVC insulating spool vs. the insulating flange. Include a reference to Standard Detail C/3.2a and indicate the required PVC dimension ratio (DR).

d. Depth of Cover for DIP Greater Than WSSC Requirements.

1) For depths of cover greater than shown in Standard Detail W/6.0, or for other special conditions, the wall thickness for DIP must be calculated in accordance with the method in AWWA Standard C150/ANSI A.21.50. Use the assumption of Laying Condition Type 1 for pipe sizes 24-inch and smaller and Laying Condition Type 3 for pipe sizes larger than 24-inch.

2) Based on the calculated thickness, select a class of pipe. The thickness of the selected class must be equal to, or greater than, the calculated thickness.

e. Wall Thickness of DIP for Special Applications.

1) Wall thickness criteria for DIP for the following special applications are not covered in the Standard Details and additional consideration/calculations are required in the following situations:

a) Pipe on supports or hangers, e.g. bridge crossings.

b) Shallow cover, less than two and one half (2-1/2) feet.

c) Vehicular or equipment loading greater than AASHTO H-20 or HS-20 loads configuration.

d) Operating pressures greater than those found in the WSSC's water distribution system.

c) Surges exceeding allowances given in the Specifications and under Part One, Section 5 (Total Internal and Transient Pressures).

d) Certain vacuum conditions, see Part One, Section 6 (Buckling Design).

e) When the pipeline crosses under a railroad, verify with the Railroad Authority, the requirements for crossing its property or right of way.

h) When pipelines are to be designed within MSHA right of way for highways, design the pipeline as follows:

(1) MSHA definition for types of highways (from MSHA Utility Policy, dated March 1998). Contact the MSHA for current guidelines.

(a) Expressways are divided highways, with full control of access, on which all crossroads are grade separations and all entrance and exit maneuvers are via interchange ramps. Expressways are primarily designed for high speed, long distance travel with unrestricted movement of traffic and no direct access to abutting properties.

(b) Controlled Access Highways are a higher class of highway and usually incorporate access control. Controlled access designations severely restrict the use of highway right of way for any purpose other than its primary function. Controlled access limits are denoted on MSHA drawings and plats by the words "Right of Way of Through Highway".

(2) Requirements stated below are only for pipelines within MSHA's right of ways and are only general guidelines. Verify additional requirements with MSHA.

(3) Pipelines passing through MSHA's highways.

(a) All pipelines crossings must be in a sleeve, tunnel or have the class of DIP increased to the next higher class of pipe.

(4) Longitudinal occupancy by pipelines within MSHA's right of way for highways.

(a) Expressways. No longitudinal occupancy by new pipelines is permitted.

(b) Controlled Access Highways. Longitudinal occupancy is permitted by special exemption. During the design, obtain written exemption from MSHA.

(c) Roadways other than Expressways and Controlled Access Highways. Longitudinal occupancy is permitted; see MSHA Utility Policy, dated March 1998.

i) When pipelines are to be designed near or within Maryland Transit Administration (MTA) Rail Lines, see Part Three, Section 3 (Pipeline Crossings and Clearances) and Part Three, Section 26 (Tunnels Design Criteria).

7. Allowable Fittings.

a. General Requirements.

1) The fittings listed in this section are generally the allowable fittings for the design of DIP and PVC pipe. For steel pipe and fittings, see Part One, Sections 2 (Pipe Material and Fittings) and 3 (Pipe and Fitting Joints).

b. Design Considerations.

1) DIP.

a) Allowable fittings can be either AWWA C110 (full size fittings) or AWWA C153 (compact fittings). The lay lengths are different between the two AWWA standards. Determine if space requirements will limit the design to either AWWA C110 or C153 fittings.

b) Compact fittings in accordance with AWWA C153. The lay lengths for these fittings are in accordance with AWWA C153, which only provides a minimum lay length for each fitting. Use the minimum lay length of the fitting, as specified in AWWA C153 and provide a means to adjust to the manufacturer's lay length in the design.

c) Fittings for 54-inch DIP.

(1) Lay lengths for these fittings are in accordance with AWWA C153, which only provides a minimum lay length for each fitting. Use the minimum lay length of the fitting, as specified in AWWA C153 and provide a means to adjust to the manufacturer's lay length in the design.

(2) Mechanical joints are not available on fittings for 54-inch DIP, see Part One, Section 3 (Pipe Material and Fittings). Therefore, connections to field cut restrained joint 54-inch DIP can not be accomplished with a mechanical joint solid sleeve. Special attention will be required for the design in order to avoid the need for connecting to field-cut 54-inch restrained joint DIP pipe or provide some other means for closures (field welding of the retainers is not permitted).

d) ANSI B/16.1, Class 250 Flanges on Fittings.

(1) Specify ANSI B16.1, Class 250 flanged fittings when they will be connected to a Class 250 Gate Valve, see requirements under Part One, Section 19 (Pipeline Valves). During the design, if possible try to use a transition short piece of DIP (ANSI B16.1, Class 250 flat face flange by AWWA C110 flange).

(2) ANSI B16.1, Class 250 flanged fittings may not be available. Verify availability with the manufacturer during the design. ANSI B16.1, Class 250 requirements for lay lengths, which are different than AWWA C110 requirements. The design must incorporate the lay length that will allow all manufacturers to supply the fittings.

2) PVC Pipe.

a) Allowable fittings for PVC pipelines.

(1) Injection-molded fittings in accordance with AWWA C907 for sizes 4-inch through 8-inch.

(2) Fabricated fittings in accordance with AWWA C900, Class 200 or AWWA C905, Class 235.

(3) Ductile Iron fittings as specified in this section.

b) For design, use Ductile Iron Fitting.

c. Type of Fittings.

1) **Bends.**

a) Minimize the use of bends and attempt to align the pipeline by deflecting pipe joints, see Part One, Section 12 (Allowable Joint Deflections). Deflecting the joints on bends is not permitted, see Part One, Section 14 (Joint Deflection at Fittings), unless thrust restraint design calculations for the bend for additional joint deflections are submitted in accordance with Part Three, Section 27 (Thrust Restraint Design For Buried Piping).

b) Allowable bends.

(1) For Ductile Iron Fittings, $1/4^{th.}$ or 90°, $1/8^{th.}$ or 45°, $1/16^{th.}$ or 22-1/2° and $1/32^{nd.}$ or 11-1/4°. Use of $1/4^{th.}$ or 90° bends in the horizontal plane only upon approval. Use of $1/4^{th.}$ or 90° bends is not permitted in the vertical plane.

(2) For PVC bends, design using ductile iron fittings. PVC fittings may not be available.

c) Bends can be used in the horizontal or vertical plane.

(1) Horizontal plane bends are referred to as horizontal bends (HB).

(2) Vertical plane bends are referred to as Upper Vertical Bend (UVB), where the thrust force is transferred upward to top of pipe and Lower Vertical Bend (LVB), where the thrust force is transferred downward to invert of pipe.

d) Thrust blocking for bends greater than 16-inch in diameter is not covered by the Standard Details and requires special design, see Part Three, Section 27 (Thrust Restraint Design For Buried Piping).

e) Bends designed to be rotated in both the horizontal and vertical plane require special pipe restraint, see Part One, Sections 13 (Rotation of Fittings), 14 (Joint Deflections at Fittings) and 15 (Deflections of Pipe Joints) and Part Three, Section 27 (Thrust Restraint Design For Buried Piping).

2) **Tees.**

a) The connecting branch pipe must be perpendicular or ninety (90°) degrees to the mainline pipe. No joint deflections are allowed at the branch connection of the tee.

b) For PVC tees, design using ductile iron fittings. PVC fittings may not be available.

c) If the mainline DIP is 24-inch or larger and it is noted on the drawings, a welded-on connection 8-inch and smaller may be designed in lieu of a tee, see Welded-on Connections, in this section.

d) Use a TS&V when connecting to an existing main having more than ten (10) domestic services that would be placed out of service during the installation of a tee. Exceptions may be granted, if no other alignments are feasible.

e) Thrust blocking for branch sizes larger than 16-inch diameter is not covered by Standard Details and requires special thrust restraint design, see Part Three, Section 27 (Thrust Restraint Design For Buried Piping).

f) Tees designed to be rotated greater than five (5°) degrees in the vertical plane may require special pipe restraint, see Part Three, Section 27 (Thrust Restraint Design For Buried Piping) and Design Requirements for Pipeline Valves under Part One, Section 18 (Pipeline Valves).

3) **Cross.**

a) The alignment requires two connecting pipelines to cross the main pipeline perpendicular to each other.

b) For PVC cross, design using ductile iron fittings. PVC fittings may not be available.

c) Welded-on connections and TS&V cannot be used in lieu of crosses, unless the connections are spaced far enough apart. See requirements for Welded-on Connections and TS&V, in this section.

d) The branch connections of the cross must be extended for a distance on both sides of the cross, see Table "28" (Length of Straight Pipe Required in Front of Valves) in Part Three, Section 27 (Thrust Restraint Design For Buried Piping).

(1) If the branch connections are not extended for the distance noted above, use two (2) tees.

(a) Example: If one side of the cross is not extended, the cross will act similar to a tee and will require thrust blocking. When the pipeline is extended in the future, removing the blocking behind the tee, a total water system shutdown would be required due to removal of the blocking and the plug.

(b) If the design requires connections on both sides of the pipeline and a cross cannot be used, provide a minimum of ten (10) feet spacing between the centerline tees.

e) If the alignment from the cross requires using one or more reducers on one or both sides of the cross, special pipe restraints are needed for any unbalanced forces due to the reducer, see Part Three, Section 27 (Thrust Restraint Design For Buried Piping).

4) **Tapping, Sleeve and Valve (TS&V).**

a) Design TS&V for only DIP, CIP and PVC pipe. Indicate on the drawings the type of existing pipe to be tapped. This information is provided from the as-built drawings and/or WSSC's contract files.

b) When designing a connection to an existing CIP water pipeline, research the original contract documents, or verify with WSSC to determine the type and outside diameter of the existing pipeline.

(1) Older CIP (Pit Cast Iron Pipe and Centrifugally Cast Iron Pipe) that was manufactured prior to and into the 1950's can have an outside diameter (OD) that is equal to or greater than the OD of CIP or DIP produced from the 1960's to the present.

(2) As-built drawings and contract files can be checked to ascertain the existing pipe class or wall thickness, so that a compatible tapping sleeve and gasket can be identified and incorporated into the contract documents.

(3) If the class or thickness of the pipeline cannot be determined or if a suitable tapping sleeve and gasket combination cannot be identified, the design must provide for one of the following:

(a) Test pits will be required on the existing pipeline for determining the pipe OD.

(b) Design the connection using a tee, in lieu of a TS&V.

(c) Also, require the contractor to test pit for determining the pipe OD and provide the suitable tapping sleeve.

c) When the connection to the existing pipe is 12-inch and larger DIP or CIP and the connecting pipe is 6-inch and larger, design the connection to the existing pipeline using a TS&V. Exceptions will be reviewed by WSSC.

d) Use a TS&V when connecting to an existing main, having more than ten (10) domestic services that would be placed out of service during the installation of a tee. Exceptions may be granted by the WSSC, if no other alignments are feasible.

e) Pipeline being tapped may be the same size as the branch pipe, unless the proposed main is larger than 14-inch, see the requirements for valve sizing in Part One, Section 19 (Pipeline Valves).

f) Design the location of the tapping sleeve on DIP or CIP, so that the centerline of the connecting pipeline is a minimum of five (5) feet from the face of any existing bell joints.

g) Design no more than one TS&V on the same existing nominal pipe length.

h) Verify that adequate space is available to avoid conflict between existing utilities and the tapping machine. Check with the tapping machine manufacturers for space requirements.

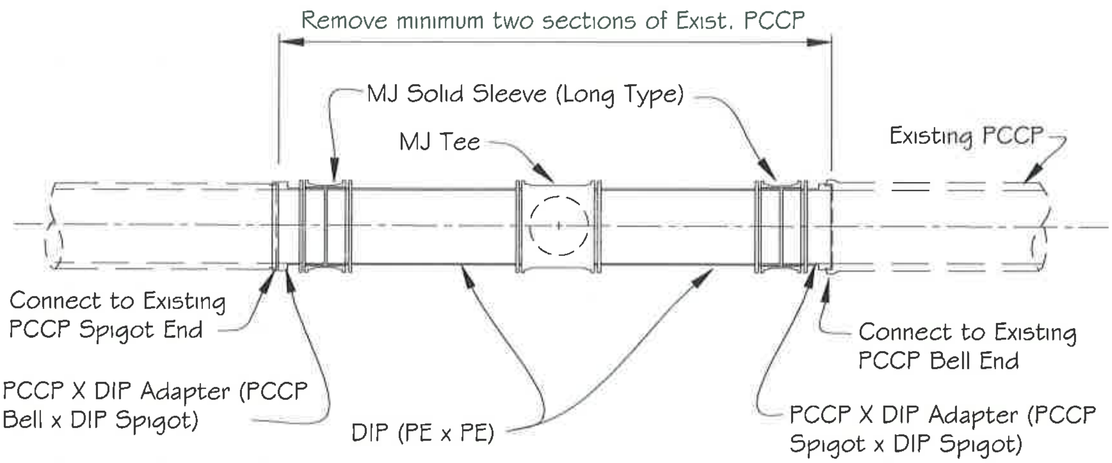
i) Restrain or block the TS&V's in the same manner as a tee.

j) For additional requirements, see Tees in this section.

5) **Tapping Assembly and Valve (TA&V).**

a) Tapping Assembly and Valve (TA&V) is not allowed for connecting to existing PCCP water mains.

b) For connecting to existing PCCP water mains, see Sketch “A”.



SKETCH "A"

Connecting to Prestressed Concrete Cylinder Pipe Using a Tee

c) Show the manufacturer's name and job number for the existing PCCP pipeline on the drawings for example, Lockjoint # PE-00-00. This information can be obtained from WSSC.

6) Welded-on Connections.

a) Welded-on connections may be used in lieu of tees on DIP for blowoffs, air valves and branch connections, if the mainline pipe is 24-inch diameter or larger and the welded-on connection is a minimum of 3-inch diameter up to a maximum of 8-inch in diameter. For additional requirements, see Tees, in this section.

b) In accordance with the Specifications, there are two types of Welded-on Connections:

(1) Welded-on Bosses.

(a) This type of outlet has the socket welded onto the mainline pipe. When a flanged valve is required to connect to the flanged welded-on boss, a short piece of flanged by flanged DIP will be required.

(2) Welded-on Outlets.

(a) This type of outlet has a short length of DIP welded onto the mainline pipe.

c) In accordance with the Specifications, welded-on connections require a minimum Class 54 DIP for the mainline pipe. Restrain or block the welded-on connections in the same manner as a tee.

d) Provide a note on the plan and profile indicating the location of the welded-on connection and type of outlet joint connection.

e) Pipe joints for welded-on connections shall be as follows:

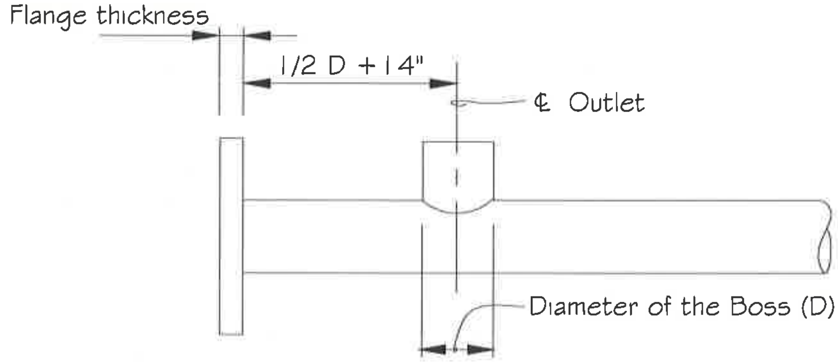
(1) Flanged as specified in AWWA C-110 or ANSI B16.1 Class 250, when in a vault.

(2) Mechanical joint or push-on restrained joint bell, when buried.

f) Locate welded-on connections on the mainline pipe as follows:

(1) Welded-on Connections on Flanged Pipe.

(a) The centerline of the outlet must be a minimum of one-half (1/2) the outlet diameter plus 14-inch from the inside edge of the flange, see Sketch "B".

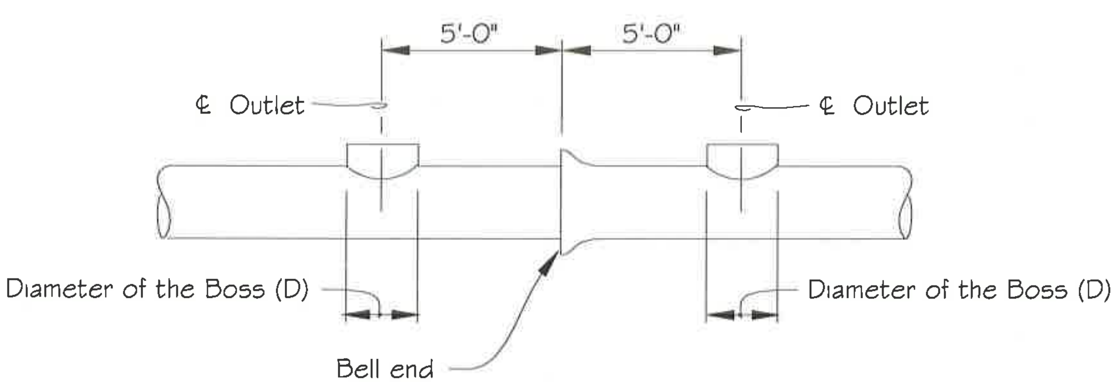


SKETCH "B"

Location of Welded-on Connection, Flanged Pipe

(2) Welded-on Connections on pipe other than flanged pipe.

(a) The centerline of the outlet must be a minimum of five (5) feet from the bell face of the mainline pipe, see Sketch "C".



SKETCH "C"

Location of Welded-on Connection,
Pipe Other Than Flanged Pipe

7) **Plugs and Caps.**

a) Plugs and caps are to be used at the end of pipelines and branch connections. The Contractor has the option to use either a plug or cap.

b) On the drawings specify a cap.

c) Thrust blocking for plugs and caps larger than 16-inch diameter is not covered by the Standard Details and requires special thrust restraint design; see Part Three, Section 27 (Thrust Restraint Design for Buried Piping).

8) **Wyes.**

a) Wyes are not permitted for use on water pipelines, except when the design requires flanged end fittings inside structures.

9) **Reducers.**

a) Required when downsizing the pipeline; may require special thrust restraint for unbalanced forces, see Part Three, Section 27 (Thrust Restraint Design for Buried Piping).

b) Avoid using reducers on short runs of pipe if the cost of downsizing the pipeline, which includes pipe restraints for reducer, house connection taps with saddles, a reducer, etc., exceeds the cost of the larger diameter pipeline.

c) When reducing the pipe size on 16-inch and larger pipelines, the profile must be examined to determine if the reducer will create a high point at the large end of the reducer. If so, use an eccentric reducer, matching the top elevations of both size pipelines at the reducer.

10) **Adapters.**

a) When connecting to or extending PCCP pipelines, a PCCP by DIP adapter is required, see Specifications for requirements of PCCP adapter.

b) Typically, the DIP end of the adapter will require a flanged end, see Standard Details C/3.3 and C/3.4, and Part Three, Section 28 (Corrosion Control). When a PVC spool piece is used the DIP end of the adapter will require a mechanical joint bell, see Standard Detail C/3.3a and Part Two, Section 3 (Pipe and Fitting Joints).

c) Design the connection between PCCP and DIP to account for unbalanced thrusts. For requirements see Unbalanced Thrusts at Connections to Existing Water Pipelines under Part Three, Section 27 (Thrust Restraint Design for Buried Piping).

11) **Solid Sleeves and Mechanical Couplings.**

a) Generally, mechanical joint solid sleeves are used for direct burial conditions and mechanical couplings are used in vaults and structures.

b) Type of DI mechanical joint solid sleeves is as follows:

(1) <u>Mechanical Joint, Long Type</u>

(a) Use this type of sleeve only for single closures between the ends of the pipeline.

(b) Typically this type of sleeve requires a spacer piece, see Standard detail W/11.0, for long type solid sleeves.

(2) Mechanical Joint, Short Type can be use as follows:

(a) Use two closures between the ends of the pipeline (which eliminates the need for a spacer piece), see Standard detail W/11.0.

(b) This type of sleeve may be an acceptable alternative to using a restrained mechanical coupling in a vault, in accordance with Standard Detail B/3.0, except the joints must be restrained with a wedge action restraining gland, see Standard Detail W/2.4 for an example.

(c) When using this fitting on situations other than those described above, approval will be required.

(d) Some manufacturers may not supply short type solid sleeves. The Designer must verify the availability of this fitting during the design.

(3) Solid Sleeve for 54-inch DIP.

(a) This type of sleeve is not available. During the design phase determine and verify the type of sleeve/coupling that will be required. See "Design Considerations" in this section for information on 54-inch diameter fittings.

d) Types of mechanical couplings.

(1) Mechanical Couplings.

(a) Mechanical Couplings are used for connecting pipelines in vaults and structures where the pipelines have the same OD.

(b) Direct burial of mechanical couplings requires approval and special exterior coatings, see Part Three, Section 28 (Corrosion Control).

(c) Mechanical coupling may require restraint; see Standard Detail B/3.0.

(d) When the design requires a mechanical coupling to be connected next to a flanged gate valve, provide a flanged spool piece a minimum of 12-inches long between the flanged end of the valve and the flanged end of the assembly for harnessing the coupling, see Standard Detail B/3.0.

(2) Transition Couplings.

(a) Transition Couplings are use for connecting pipelines with different OD's. Verify OD's of the connecting pipes before specifying this type of coupling, or provide requirements in the contract documents for the contractor to verify the OD's.

(b) For connecting to Existing Asbestos Cement Pipe (ACP), see Standard Detail W/11.1.

(c) Transition Couplings may be used for direct burial with approval and require special exterior coatings, see Part Three, Section 28 (Corrosion Control).

(3) Insulating Couplings.

(a) Insulating Couplings provide electrical isolation for metallic pipelines; see Part Three, Section 28 (Corrosion Control).
(b) Direct burial of insulating couplings requires WSSC approval and special exterior coatings, see Part Three, Section 28 (Corrosion Control).

(c) Use of insulating couplings requires special insulating thrust restraint if used on a restrained length of pipe.

12) **Offsets.**

a) Offsets may be used in lieu of two bends when approved.

b) The allowable offset diameter and offset distance "D" dimension are as follows:

(1) Offsets are limited to sizes 12-inches and smaller diameter fitting size (diameter of pipe).

(2) Offset distance "D" dimension can only be 6, 12 or 18-inches.

c) Provide special thrust restraint for the offset, see Part Three, Section 27 (Thrust Restraint Design for Buried Piping).

13) **Other Fittings.**

a) The allowable fittings listed in this section are the only fittings approved for design. Fitting manufacturers can produce non-AWWA standard fittings (AWWA C110, C153, C900, C905 and C907) which are not approved by WSSC. These fittings may be used in the design only with WSSC approval and require special provisions to the Specifications.

9. Connections to Existing or Proposed Water Pipelines.

a. Design of Connections to Existing Pipelines.

1) Limitation to connections to Existing Pipelines.

a) Water Mains (12-inch and smaller) cannot connect to PCCP Transmission Mains 36-inch and larger, except in the following conditions; If the connection is to existing PCCP water main and the proposed service connection is looped to another water main that is not depended on existing PCCP water main.

2) Determine the pipe material and the alignment of the existing pipeline.

a) Information that are available and items that are required to be developed.

(1) WSSC "as-built" contract drawings are intended to show only the control reference ties to the horizontal appurtenances of the pipeline alignment, the type of pipe material used, and the Contractor's name. As-builts do not always show changes to the original design alignment (horizontal or vertical) that may have been made during the construction of the pipeline. The Designer must investigate using other methods described below and determine if any changes have been made to the original design of the existing pipeline, and adjust the design accordingly.

(2) Field surveys must follow the requirements set by WSSC. Perform all surveys required to design the alignment. Any survey information that is provided by WSSC from previous contracts, etc., must be verified, as WSSC will not be responsible for this information.

(3) Test pits are typically needed when the design requires the vertical and horizontal alignment to be accurately located. Perform test pits on the existing alignment so that the horizontal and vertical position can be accurately determined.

(4) WSSC construction files may be requested by the Designer. The type of information that may be available in the contract files includes:

(a) WSSC Construction Inspector's field reports/notes.

(b) WSSC/Contractor written correspondence.

(c) Contractor's shop drawings, including lay schedules for PCCP, etc.

3) Connecting to existing pipelines other than DIP, CIP or PVC.

a) Prestressed Concrete Cylinder Pipe (PCCP). Any connections between existing PCCP and new DIP will require special design including: Adapter (PCCP to DIP) see Part One, Section 7 (Allowable Fittings), Insulated Joint (typically flanged type) see Part One, Section 3 (Pipe and Fitting Joints), possible cathodic protection and special coatings see Part Three, Section 28 (Corrosion Control), and possible thrust restraint see Part Three, Section 27 (Thrust Restraint for Buried Piping). Verify the following for PCCP connections:

(1) WSSC has installed Internal Acoustic fiber optic (AFO) Cables in most of the existing PCCP water pipelines. This cable is designed to monitor the existing condition of the PCCP

pipeline.

(a) Prior to connecting to existing PCCP pipelines, first verify with WSSC as to whether the pipeline has AFO Cables. If pipeline has AFO Cables, the cables must be removed and replaced by an approved WSSC contractor responsible for installing and monitoring the cable at no cost to WSSC.

(2) Perform test pits to verify the actual horizontal/vertical alignment of the existing PCCP pipeline, location of the existing joint, and to determine if the existing joint is beveled or straight.

(3) If the existing PCCP has restrained joints, indicate this on the drawings and design the proposed connection to account for the restrained thrust.

b) Steel Pipe, Asbestos Cement Pipe (ACP), old pit-cast CIP with oversize OD's. When the existing pipe material is not DIP, CIP or PCCP provide a detailed design and specifications on how the connection will be constructed.

(1) When connecting to existing ACP, design the connection to remove only a short section of existing ACP pipe. Existing ACP section removed during the connection will remain in the trench, see Specifications.

4) Tapping existing pipelines requires test pits when certain physical features may prevent proper tapping of the existing pipe and when necessary to determine the alignment of the existing pipeline and the location of the existing pipe joints. For information on positioning a TS&V on DIP, CIP or PVC, see Part One, Section 7 (Allowable Fittings).

(1) Tapping PCCP water mains is not allowed; see Part One, Section 7 (Allowable Fittings).

b. Revising Designed Connections During Construction.

1) Connecting to an existing pipeline 12-inch and smaller in diameter. The vertical and horizontal alignment can usually be changed or revised during construction of the pipelines with little difficulty due to the amount of allowable joint deflection, which provides greater alignment flexibility.

2) Connecting to an existing pipeline 16-inch and larger in diameter. The vertical and horizontal alignment may require additional fittings, appurtenances and etc., to adjust alignment location during construction.

(a) If the vertical alignment requires revisions, the new alignment may create additional high or low points. In this case, additional blow-off connections or air release valves may be required.

(b) If the vertical and horizontal alignment both require revisions, the new alignment may result in pipeline joints having deflections exceeding the allowable, which would require additional bends and thrust restraints to be added.

(c) If the alignment requires changes during construction, the Designer will be responsible for the additional cost as determined by the WSSC.

c. Connection to Proposed or Future Pipelines.

1) Connecting to a pipeline to be built under another contract.

a) Coordinate design with connecting contracts.

b) When the pipeline under design will be extended, design the future alignment approximately two-hundred (200) feet from the end of the cap or plug, see requirements under Length of Profile, Part One, Section 11 (Vertical Alignment – Profiles).

c) If the new pipeline will depend on the construction of another pipeline for the supply of water, include a "Dependency Note" on the drawings. Indicate in the note that the new pipeline cannot be placed in service until another contract is in service; provide contract numbers of the depending pipeline.

d. Labeling Existing Pipelines on the Drawings.

1) Existing pipeline material (DIP, CIP, PVC, PCCP, ACP, steel, etc.), thickness class, type, grade, etc. For PCCP, indicate the manufacturer's name and job number for the existing PCCP pipeline.

2) Existing WSSC contract number.

3) Special pipe corrosion protection, coatings, wrappings, joint bonding, etc.

4) Special thrust restraint, existing special thrust blocking and/or existing restrained joint types, locations and lengths, including valves restrained to tees.

e. Special Items.

1) Special items to be considered during the design of connections to existing pipelines include thrust pipe restraints, see Part Three, Section 27 (Thrust Restraint Design for Buried Piping) and pipe corrosion protection, see Part Three, Section 28 (Corrosion Control).

2) When shutdown of the existing water system is determined to be impossible, line stops can be designed to temporarily shut down the existing water pipeline. See Specifications for requirements and Part One, Section 22 (Specialty Valves). Special thrust pipe restraints will be required to restrain the line stop, see Part Three, Section 27 (Thrust Restraint Design for Buried Piping).

23. Blowoff Connections.

a. Design Requirements for Blowoff Connections.

1) Blowoff connections are required for the following water pipeline sizes:

   a). For 16-inch and larger pipelines, see Type "A" and Type "B" Blowoffs under Types of Blowoffs, in this section.

   b). For 6-inch and smaller pipelines, see Type "C" Blowoff under Types of Blowoffs, in this section.

2) Locate all blowoffs for pipelines 16-inch and larger, including fire hydrants designed as blowoffs, as close as possible to an existing/proposed sanitary sewer manhole to allow for the disposal of the chlorinated water into the sanitary sewer.

3) Under no circumstances shall discharge water from the blowoff piping pass directly to a storm drain pipe or sanitary sewer pipe and/or any type of storm drain or sanitary sewer structure (inlet, manhole, etc.).

4) For blowoff manhole requirements for minimum and maximum depths, see the guidelines in Part Two, Section 18 (Manhole Depth Design).

5) For information on setting the manhole frame and cover, see Part One, Section 16 (Design of Structures).

6) Verify that the location of blowoff manholes and valves as shown on the Standard Details is suitable for the proposed design. If the location is not suitable, provide notes and dimensions on the drawings for modifying the Standard Details to show the location of the manhole off the mainline pipe, see Part Three, Section 6, (Modifications to Specifications and Standard Details).

b. Types of Blowoff Connections.

1) Type "A" blowoffs are designed so that a hose or a pump can be connected to the blowoff and can be discharged directly into a sanitary sewer manhole. This design provides versatility for the collection and disposal of the discharged chlorinated water.

   a) For 16-inch to 30-inch diameter water pipelines there are two options for draining the pipeline.

      (1) If the mainline pipeline is located within a roadway, design the blowoff to be a fire hydrant. For design requirements for fire hydrant settings and spacing, see Part One, Section 24 (Fire Hydrants). Verify that the fire hydrant will fully function to the Fire Marshall's standards, and design the connection as a Type "A" blowoff. When fire hydrants are designed as blowoffs, they serve a dual purpose and offer economy in design.

      (2) In all other areas, design Type "A" blowoffs, as shown in Standard Detail W/3.0. This connection consists of a 6-inch branch from the mainline pipeline which drains into a blowoff manhole, allowing the water level in the pipeline to be drained by gravity to the invert elevation of the 6-inch connection at the mainline pipeline.

   b) For 36-inch and larger diameter water pipelines, design Type "A" blowoffs, as shown in

Standard Detail W/3.02. This connection consists of a 6-inch branch that is rotated down forty-five (45°) degrees at the mainline pipeline, which then drains into the blowoff manhole, allowing the water level in the pipeline to be drained completely.

2) Type "B" blowoffs are designed to discharge directly into a stream or channel, when the stream or channel has the capacity to handle the volume of discharged water without causing any downstream flooding, erosion, or damage and there are no environmental restrictions prohibiting the discharge of the chlorinated water. Contact MDE for permit restrictions, before incorporating a Type "B" blowoff into the design.

a) For 16-inch to 30-inch diameter water pipelines designed using Type "B" blowoffs, see Standard Detail W/3.04. This connection consists of a 6-inch branch connection from the main, which discharges directly into a stream or channel. This type of blowoff will not allow the pipeline to be drained completely by gravity; it only allows the pipeline to drain down to the elevation of the discharge point at the endwall.

b) For 36-inch and larger diameter water pipelines designed using Type "B" blowoffs, see Standard Details W/3.03 and W/3.04. This connection consists of a 6-inch branch that is rotated down forty-five (45°) degrees at the mainline pipeline, and drains either into a manhole or to an endwall. This type of blowoff will allow the water level in the pipeline to be drained completely when it is drained into the manhole. This design includes a Type "A" connection for greater versatility when dewatering and chlorinating.

c) When a Type "B" blowoff cannot be provided either due to environmental restrictions or stream or channel limitations, design the blowoff as a Type "A" blowoff.

3). Type "C" blowoffs are designed for 6-inch and smaller pipelines that are not looped or connected to another pipeline (dead end mains). This connection is designed for flushing smaller diameter pipelines and consists of a 4-inch connection with a 2-1/2" fire hose connection; see Standard Details W/3.07 and W/3.08.

a) Design the connection a maximum 15 feet from the cap or plug on the mainline pipeline.

b) Located the blow-off setting (2-1/2" fire hose connection) in a non-traffic area and not in sidewalks or driveways.

c. Blowoff Connection to the Mainline Pipeline.

1) Blowoff connections for pipelines 20-inch and smaller, use a tee connection.

2) Blowoff connections for pipelines 24-inch and larger, design the connection as a welded-on connection. Center the welded-on connection on a twenty (20) foot length of pipe, with both ends of the pipe section having the same elevation. In some cases, the welded-on connection can be designed so that the blowoff connection is closer to the end of the twenty (20) foot length of pipe, see requirements for welded-on connections in Part One, Section 7 (Allowable Fittings).

d. Drawing Requirements for Blowoffs.

1) On plan drawings, show the blowoff piping, the pipeline stations of the mainline pipeline, and reference the Standard Detail number.

3. Selection of Pipe Material (Gravity Sewers).

a. General.

1) The Section discusses pipe material for gravity sewers and SHCs, for force mains, see Part Two, Section 24 (Force Mains) and for pressure sewer systems, see Part Two, Section 25 (Grinder Pump, Pressure Sewer Systems).

2) When pipelines are to be designed near or within Maryland Transit Administration (MTA) Rail Lines, see Part Three, Section 3 (Pipeline Crossings and Clearances) and Part Three, Section 26 (Tunnels Design Criteria).

3) The amount of allowable cover is determined using the highest profile grade/ground line shown on the profile.

4) Do not change the type or class of pipeline material between manhole sections.

5) Indicate in the General Notes the following:

   a) Size and type of the gravity sewer pipeline.

   b) For RCP, DIP or PVC AWWA C900/C905, indicate the pipe class designation on the profile defining the limits of pipe class designation and the limits of each type of pipe material.

   c) For DIP and fittings, specify polyethylene encasement, see Part One, Section 2 (Pipe Materials and Fittings) and special interior lining in accordance with the Specifications.

   d) For PVC AWWA C900 with ductile iron fittings, specify polyethylene encasement, see Part One, Section 2 (Pipe Materials and Fittings) and special interior lining following the Specifications.

6) When designing RCP, use Wall C dimensions for determining pipe OD.

7) When DIP or PVC AWWA C900/C905 is required, verify the pipe diameter and capacity.

   a) DIP or PVC AWWA C900/C905 is not available in the same pipe sizes as RCP and PVC sewer pipe.

b. Selection of Pipe Material.

1) Sewer House Connections (SHC), 4-inch or 6-inch diameter.

   a) Polyvinyl Chloride Pipe (PVC) meeting ASTM D3034, SDR 35 or SDR 26.

2) Mainline Gravity Sewers.

   a) Polyvinyl Chloride Pipe (PVC), 8-inch through 15-inch diameter, meeting ASTM D3034, SDR 35 and 18-inch through 27-inch diameter meeting ASTM F679, thickness T-1.

   b) Polyvinyl Chloride Pipe (PVC AWWA C900), 12-inch and smaller diameter, meeting AWWA C900. Use PVC AWWA C900 for the following conditions:

(1) For sewer pipelines on steep slopes, see Part Two, Section 16 (Pipe Slope and Manhole Distance) and Standard Detail S/3.03.

(2) For sewer pipelines when the cover is over twenty-two (22) feet, see requirements on Standard Detail W/6.1.

(3) When horizontal and vertical separation between the water and sewer pipelines as stated in Part Three, Section 3 (Pipeline Crossing and Clearances) cannot be obtained.

c) Polyvinyl Chloride Pipe (PVC AWWA C905), larger than 12-inch in diameter, see Part One, Section 4 (Selection of Pipe Material) and AWWA C905. Use PVC AWWA C905 for the following conditions:

(1) For sewer pipelines on steep slopes, see Part Two, Section 15 (Pipe Slope and Manhole Distance) and Standard Detail S/3.03, except special designs and details must be provided; see Part Three, Section 6 (Modifications to Specifications and Standard Details).

(2) When horizontal and vertical separation between the water and sewer pipelines as stated in Part Three, Section 3 (Pipeline Crossing and Clearances) cannot be obtained.

d) Closed Profile Polyvinyl Chloride Pipe (PVC), 21-inch through 48-inch diameter, meeting ASTM F1803.

e) Open Profile Polyvinyl Chloride Pipe (PVC), 18-inch through 30-inch diameter, meeting ASTM F794.

f) Reinforced Concrete Pipe (RCP), 21-inch and larger, meeting ASTM C76. Use RCP for the following conditions:

(1) Stream crossings of sewer pipelines; see Part Two, Section 8 (Vertical Alignment (Profiles).

(2) Horizontal alignment requires the sewer pipeline to have a curved alignment, see Part Two, Section 6 (Curved Horizontal Alignment).

g) Ductile Iron Pipe (DIP), see Part One, Section 4 (Selection of Pipe Material).

(1) For sewer pipelines on steep slopes, see Part Two, Section 15 (Pipe Slope and Manhole Distance) and Standard Detail S/3.03, except special designs and details must be provided; see Part Three, Section 6 (Modifications to Specifications and Standard Details).

(2) When horizontal and vertical separation between the water and sewer pipelines as stated in Part Three, Section 3 (Pipeline Crossing and Clearances) cannot be obtained.

(3) Stream crossings of sewer pipelines; see Part Two, Section 8 (Vertical Alignment (Profiles).

(4) For sewer pipelines when the cover is over twenty-two (22) feet.

h) <u>Special Materials</u>.

(1) For special projects or conditions, the use of pipe manufactured to industry standards other than those listed in the Specifications can be specified, examples are:

(a) Flow under highly surcharged conditions or groundwater levels are excessive, reinforced concrete low-head pressure pipe might be considered.

(b) Areas where hydrogen sulfide may create corrosion problems, such as downstream from a pumping station or pressure sewer discharge, might require investigation of polyethylene-lined or fiberglass-lined DIP, T-Lock RCP, RCP with extra "sacrificial" concrete or other special protective linings.

c. Selection of Pipe Class and Wall Thickness.

1) Polyvinyl Chloride Pipe (PVC).

a) PVC sewer pipe meeting ASTM D3034, ASTM F679, ASTM F1083 or ASTM F794 as specified in the Specifications.

b) For backfill requirements see the Specifications and Standard Detail M/8.1c.

c) Maximum cover over the pipe in accordance with Standard Detail M/8.1c is twenty two (22) feet, based on procedures for flexible pipe in Uni-Bell's Handbook of PVC Pipe.

2) Polyvinyl Chloride Pipe (PVC AWWA C900 or C905).

a) Selection of pipe class/wall thickness for PVC AWWA C900 or C905 sewer pipelines is the same procedure as indicated for PVC water pipelines; see Part One, Section 4 (Selection of Pipe Materials).

b) Maximum cover over the pipe will depend on bedding and backfill requirements see Standard Detail W/6.1 for Dimension Ratio (DR) and allowable cover.

3) Ductile Iron Pipe (DIP). Selection of pipe class/wall thickness for DIP sewer pipelines is the same procedure as indicated for DIP water pipelines; see Part One, Section 4 (Selection of Pipe Materials).

4) Reinforced Concrete Pipe (RCP).

a) RCP meeting ASTM C76.

b) For the class of pipe for various depths of cover, see Standard Detail S/8.0.

c) For special conditions that differ from the conditions/criteria in the Specifications and Standard Details (for example, trench width exceeding the standard, depth of cover exceeding the standard, etc.) special analysis/calculations must be performed to arrive at the appropriate combination of pipe class/bedding. Generally, the design calculations follow the procedures in the American Concrete Pipe Association's Concrete Pipe Handbook and Concrete Pipe Design Manual.

2. Rights of Way and Construction Strips.

a. General.

1) When a water or sewer pipeline(s) extends into property that is not publicly owned, show the limits of the right of way and construction strip on the drawings, see the requirements listed in this section and in Appendix "D" (WSSC Survey and Right of Way Criteria). WSSC will review the widths of both the right of way and the construction strip for maintenance and constructability due to the depth and/or soil conditions and make any necessary changes to the widths.

2) After determining the limits of the right of way and construction strips and receiving concurrence from WSSC, prepare the right of way documents.

b. Existing Pipeline Width Requirements.

1) The existing widths of rights-of-way shown / provided for existing large diameter pipelines (30-inch and larger) may be inadequate from public safety, operation and maintenance perspectives. The most serious risks are posed in situations where occupied spaces are built within short distances of large diameter Pre-Stressed Concreter Cylinder Pipe (PCCP). Future design should take this into consideration. WSSC will provide available information and discuss potential design considerations upon request.

c. Proposed Pipeline Width Requirements.

1) For right of way and construction strip minimum width requirements for water and sewer pipelines, see Tables "20" and "21". WSSC may require an increase in the width of the right of way and/or construction strip, greater than those indicated in Tables "20" and "21".

2) Consider the construction and maintenance requirements when determining the required widths for the construction strip(s) and the right of way.

   a) Construction strip(s). Take into account the topography along the alignment, when determining the area necessary to construct the pipeline (i.e., steep side slopes which may require the contractor to bench an area to be able to construct the alignment, deep excavations, etc.). If additional area is required to construct the pipeline due to stockpiling material along the alignment, consider the following items: storing the pipe along the trench; stockpiling stone, gravel and/or select backfill, and excavated trench material; contractor's access along the alignment; trench width and equipment area; and the area along the trench for other construction equipment (i.e., front-end loader, etc.).

   b) Right(s) of way. Take into account when determining the width of the right of way, the area required to facilitate future maintenance, excavation, and repairs. Additional access points along the alignment may be required to facilitate the mobility of equipment and personnel.

      1) Provide sufficient right of way to minimize the potential for personal injury to the public and/or significant property damage caused by water or sewer pipeline breaks.

TABLE "20"

Right of Way and Construction Strip Minimum Width Requirements for Water Pipelines

Pipeline Diameter	Width of Right of Way	Total Width of Construction Strips
14-inch and smaller	20 feet	15 feet
16-inch to 24-inch	25 feet	20 feet
30-inch	30 feet	20 feet
36-inch to 42-inch	40 feet	To be determined by WSSC
48-inch to 66-inch	60 feet	To be determined by WSSC
72-inch and larger	75 feet	To be determined by WSSC

TABLE "21"

Right of Way and Construction Strip Minimum Width Requirements for Sewer Pipelines

Pipeline Diameter	Width of Right of Way	Total Width of Construction Strips
Smaller than 15-inch	20 feet	20 feet
15-inch to 24-inch	45 feet	20 feet
30-inch to 36-inch	50 feet	To be determined by WSSC
42-inch and larger	55 feet	To be determined by WSSC

(For Right of Way widths for deep sewers, see information below)

c). Right of Way for Deep Sewers.

1) For requirements for Deep Sewers, see Part Two, Section 8 (Vertical Alignment (Profile).

2) For determining width of right of way for sewer pipelines over twenty-two (22) feet of cover, use the following:

(a) For sewers 12-inch and smaller with depth greater than twenty (22) feet, multiply two (2) feet of right of way width by each foot of cover pipeline depth. If Deep Sewer is sharing the right of way with another pipeline, see additional in this section.

Example: For a 12-inch diameter sewer pipeline with twenty (23) feet of cover:
2 (feet of right of way) times 23 (feet of cover) equals 46 feet.
Total ROW width shall be 46 feet width.

(b) For sewers 15-inch and larger, with depth greater than 22 feet, multiply one (1) foot of right of way width from the edge of the right of way to the centerline of the deep sewer for each foot of cover pipeline depth. Also, see requirements for Location of Pipelines Within Rights of Way and Construction Strips in this section

Example: For a 15-inch diameter sewer pipeline with twenty (23) feet of cover:
1 (feet of right of way) times 23 (feet of cover) equals 23 feet for both pipelines (new sewer and future relief sewer).
Offset the sewer for future relief sewer, add minimum of 10 feet separation
Total ROW width shall be 56 feet width.

d. Location of Pipelines Within Rights of Way and Construction Strips.

1) One (1) pipeline within the right of way. Typically, locate one pipeline in the center of the right of way and equally divide construction strip on both sides of the right of way, except for the following:

a) Water pipelines 48-inch to 66-inch, provide a minimum of twenty (25) feet from the OD of the pipeline to the right of way line, for total minimum width of the right of way, see Table "20".

b) Water pipelines 72-inch and larger, provide a minimum of thirty (30) feet from the OD of the pipeline to the right of way line, for total minimum width of the right of way, see Table "20".

c) Sewer pipelines 15-inch and larger, offset the sewer within the right of way for future relief sewer, see Part Three, Section 3 (Pipeline Crossings and Clearances) Minimum Spacing Requirements Between Two (2) Pipelines in this section. If depth of cover is less than twenty (20) feet, provide a minimum distance of fifteen (15) feet from the right of way line to the centerline of the pipeline, for total minimum width of right of way, see Table "21". If depth of cover is twenty (20) feet or more, see Right of Way for Deep Sewers in this section.

2) Two (2) pipelines within the same right of way and parallel to each other.

a) Existing Right of Way. Research the recorded documents for existing rights of way, to see if another pipeline can occupy the existing right of way.

1) If the recorded documents state that it is for one pipeline, prepare a new right of way document for the proposed pipeline.

2) If the recorded documents state that it is for one or more pipelines, then see if the spacing of the proposed and existing pipelines are within the requirement for Minimum Spacing Requirements Between Two (2) Pipelines in this section. If the existing right of way is not large enough to suit the required spacing, prepare a new right of way document for the additional right of way required.

b) Proposed Right of Way. If the design requires two pipelines to occupy the same right of way, the proposed right of way documents must include in the description the right to have more than one pipeline occupy the right of way.

c) Minimum separation requirements between two pipelines parallel to each other. Refer to Part Three, Section 3 (Pipeline Crossings and Clearances).

d) Additional spacing requirements between two pipelines parallel to each other.

(1) If the soil boring logs show that rock will be encountered during the construction, determine if the distances stated above will be safe for blasting the trench if one (1) of the pipelines is existing.

(2) If one (1) of the pipelines is existing and the area over the existing pipeline will be used for the construction of the new pipeline, evaluate the impact of the construction over the existing pipeline. Construction over an existing pipeline should not add any additional pipe loading, which includes heavy construction equipment (exceeding AASHTO H20 loading), trench spoils, etc., unless calculations are submitted showing that the existing pipeline will not be jeopardized due to the additional pipe loading. Information may have to be added to the contract limiting the types of activities, types of construction equipment, etc., permitted in the area above the existing pipe.

(3) When one of the new pipelines is 15-inch or larger and parallel to an existing pipeline, provide a minimum working area of twenty five (25) feet on the opposite side of the new pipeline. (Combination of both the right of way and construction strip).

e. Right of Way for Water Pipeline Appurtenances.

1) Fire hydrants: provide a minimum twelve (12) foot wide of the right of way, six (6) feet on each side of the fire hydrant and extended six (6) feet behind the fire hydrant and no construction strip is necessary.

2) Meters (box, vaults, etc.) and structures: provide a right of way a minimum of ten (10) feet on each side of the outside edge of the vault wall, meter box, pipeline, (i.e., bypass line), etc.

f. Construction Strips.

1) Typically, the construction strip is equally divided on both sides of the right of way. The location, type and size of the pipeline may require the construction strips to vary in size and location.

2) When one side of the right of way cannot be used for construction, i.e., stream location, steep slopes, etc., provide the total width of the construction strip on the side that can be used for construction.

3) When the proposed pipeline is parallel to an existing pipeline, provide the construction strip adjacent to the new pipeline right of way.

4) State in the right of way documents whether the contractor has the right to cut trees within the construction strip. The need to cut trees in the construction strip will be determined after the design review stage.

g. Access Points Along the Right of Way.

1) Provide adequate access along the pipeline right of way. Access points are to allow for entry to the right of way so that traversing of private property will not be required. The exact distance between the access points can be varied slightly to be cost effective.

2) For 48-inch and larger water pipelines, design access points along the right of way every six-hundred (600) feet, unless otherwise directed by WSSC.

h. Property of the Maryland National Capital Park and Planning Commission (MNCPPC).

1) In most cases, MNCPPC requires permits for the construction of pipelines within park property. Show the total working area required to construct the pipeline(s) on the drawings. Include both the width of the right of way and construction strips in the total working area. Indicate the total working area on the drawings as "WORK LIMITS". Verify with MNCPPC for requirements within their property.

i. Potomac Electric Power Company (PEPCO).

1) In some cases, PEPCO owns a utility right of way through a road right of way. This may require WSSC to obtain a right of way from PEPCO within a road right of way.

2) No structures (manholes, vaults, etc.) are permitted within a PEPCO right of way, unless approved by PEPCO.

3) Design pipeline crossings of PEPCO rights of way at ninety (90°) ± degrees and indicate the distances to PEPCO towers, etc. to reference the location.

4) Verify PEPCO requirements within its right of way.

3. Pipeline Crossings and Clearances.

a. General.

1) When determining pipeline clearances, measure the distance between pipelines or utilities, from the outside diameter (OD) or edge of each pipe or utility unless otherwise noted.

2) Water and Sewer Pipelines.

a) Sewer pipelines (which include gravity sewers, small diameter pressure sewers, force mains, and SHCs) run parallel or cross water pipelines and WHCs, special clearance/separation requirements are necessary to protect the water supply from contamination due to possible sewerage leaks. See Vertical Separation for Water Pipelines Crossing Sewer Pipelines, Horizontal Separation Between Water and Sewer Pipelines and Horizontal Separation Between WHCs and SHCs in this section.

b) For other requirements see this section.

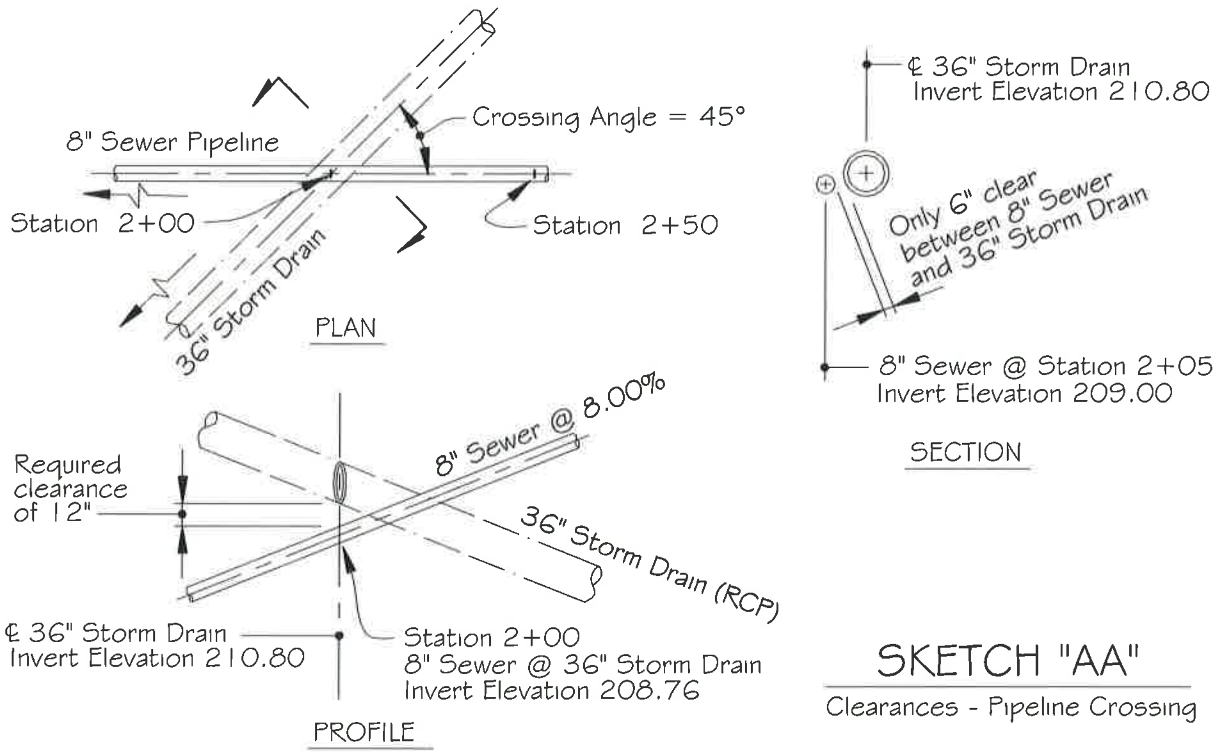
3) Tunnels Crossings.

a) For crossing and clearances requirements for tunnels, see Part Three, Section 26, Tunnel Design Criteria

b. Vertical Clearances for Pipeline or Utility Crossings.

1) Provide minimum one and half (1'-6") feet vertical clearance between water and sewer pipeline and when water and sewer pipelines are crossing other utilities provide minimum one (1'-0") feet vertical clearance.

2) When two (2) pipelines or utilities cross each other and are not perpendicular ninety (90°) degrees check the plotting of the entire pipeline or utility crossing in the vertical plane. In the profile, when the crossing is not perpendicular, the total length of the crossing may be greater than one (1) pipe diameter. The vertical clearance requirements may be several feet from the centerline of the two (2) pipelines or utilities. Sketch "AA" is an example of two pipelines, in which the required pipeline clearances are satisfied at the centerline of the two crossings, but the entire pipeline crossing does not meet the required pipe clearances, see the Sketch "A-A" Clearances - Pipeline Crossings.



SKETCH "AA"

Clearances - Pipeline Crossing

Example.

8-inch sewer at station 2+00 crosses a 36-inch storm drain at an angle of 45°. At the centerline of the two pipelines, the design shows that the two pipelines have a 12-inch clearance, but at station 2+05 the two pipelines have only 6-inch of clearance. This is due to the slope of the two pipelines, see "Section" of Sketch "AA".

To have the required pipe clearance at the centerline of the two pipelines, the clearance at station 2+00 will need to be at least two (2) feet so that the centerline crossing will have the required one (1) foot clearance over the entire pipeline crossing, see Sketch "AA".

3) The minimum vertical clearance for other jurisdiction's utilities, is governed by that utility (i.e., Colonial Pipeline requires a minimum of two (2) feet of vertical clearance).

c. Horizontal Separation With Other Utilities/Structures.

1) Provide a minimum of five (5) feet horizontal separation between water/sewer pipelines and other utilities and structures (manholes, inlets, vaults, poles, etc.).

2) Provide the following minimum separation when a water/sewer pipeline is parallel or adjacent to existing or proposed buildings or dwellings:

a) Water Pipelines.

(1) For water pipelines 12-inch and smaller in diameter, provide a minimum separation from a building or dwelling the greater of the following: fifteen (15) feet horizontal separation or 1:1 slope from the bottom of the foundation of the existing or proposed building or dwelling to the bottom edge of the pipeline trench.

(2) For water pipelines larger than 12-inch diameter, the minimum separation from a building or dwelling is to be determined based on the following factors: maintain a minimum horizontal separation of twenty-five (25) feet and being outside WSSC existing or proposed right of way. Also, see requirements under Part Three, Section 2 (Right of Way and Construction Strips) Existing Pipeline Width Requirements.

b) Sewer Pipelines.

(1) For sewer pipelines 12-inch and smaller in diameter, provide a minimum separation from a building or dwelling the greater of the following: fifteen (15) feet horizontal separation or 1:1 slope from the bottom of the foundation of the existing or proposed building or dwelling to the bottom edge of the pipeline trench.

(2) For sewer pipelines larger than 12-inch diameter, the minimum separation from a building or dwelling is to be determined based on the following factors: maintain a minimum horizontal separation of twenty-five (25) feet and being outside WSSC existing or proposed right of way.

3) Minimum separation requirements between existing and proposed or relocated water pipelines, where the existing water line is to remain in service.

a) For water pipelines 14-inch and smaller in diameter, provide a minimum of ten (10) feet separation centerline to centerline of the two pipelines.

b) For water pipelines 16-inch to 24-inch in diameter, provide a minimum of ten (10) feet separation OD to OD of the two pipelines.

c) For water pipelines 30-inch and larger in diameter, provide a minimum of twenty (20) feet separation OD to OD of the two pipelines.

d) Horizontal separation between the existing and proposed water pipelines may have to be increased when the pipeline is within the zone of influence of existing concrete blocking. To determine if there is adequate passive soil resistance, see Passive Soil Pressure for Concrete Thrust Blocks in Part Three, Section 27 (Thrust Restraint Design for Buried Piping).

4) Minimum separation requirements between existing and relocated sewer pipelines where the existing sewer is to remain in service until the relocation is complete.

a) For sewer pipelines smaller than 14-inch diameter, provide a minimum of ten (10) feet separation, centerline to centerline of the two pipelines.

b) For sewer pipelines 14-inch to 24-inch diameter, provide a minimum of ten (10) feet separation, OD to OD of the two pipelines.

c) For sewer pipelines larger than 24-inch diameter, see requirements below for minimum separation requirements between relief sewers and original sewer pipelines.

5) Minimum separation requirements between relief sewers and original sewer pipelines.

a) If both pipelines are 36-inch and smaller diameter, provide a minimum of twenty (20) feet separation, centerline to centerline of the two pipelines.

b) If one or both pipelines are larger than 36-inch diameter, provide a minimum of twenty five (25) feet separation, *centerline to centerline* of the two pipelines.

6) Minimum separation requirements between an existing or new sewer and a new force main.

a) If both pipelines are 12-inch and smaller diameter, provide a minimum of ten (10) feet separation, centerline to centerline of the two pipelines.

b) If either pipeline is larger than 12-inch diameter, provide a minimum of ten (10) feet separation, OD to OD of the two pipelines.

7) Horizontal Separation Between Sewer and Water Pipelines.

a) When a sewer is parallel to a water pipeline, provide ten (10) feet minimum horizontal separation, see Standard Detail M/18.0.

b) Where sewers and water pipelines are less than ten (10) feet apart horizontally, design the bottom of the water pipeline with a minimum of eighteen (18) inches vertical clearance above the top of the sewer pipeline, see Standard Detail M/18.0.

c) If it is impossible to obtain the horizontal separation between the water and sewer pipelines as stated above, see Alternatives – When Water and Sewer Clearances Cannot Be Met, in this section.

d. Crossing Under Existing Pipelines and Utilities.

1) When crossing under an existing critical pipeline or other utility with a new pipeline(s), special precautions and provisions are necessary in the design to avoid damage and minimize future settlement of the existing utility. Consider the following pipelines and utilities as critical:

a) All sizes of Prestressed Concrete Cylinder Pipes (PCCP), both water and sewer.

b) All ductile iron water and sewer pipelines larger than 24-inch diameter.

c) All non-PVC sewer pipes equal to and larger than 18-inch diameter.

d) Any other critical utility identified on a case by case basis such as electrical ductbanks, etc.

2) The necessary precautions and provisions to be considered in the design of new pipelines crossing under existing utilities are as follows:

a) Supporting the existing pipe or utility across the proposed trench. This is accomplished by limiting the proposed pipe trench width so that the existing pipe is self-supporting or specially designing a support. New water and sewer pipelines that are installed according to the Specifications will be built using standard trench widths indicated in Standard Detail M/8.0.

(1) Generally, it is the responsibility of the contractor to provide support as necessary when trenching under existing utilities. This provision is included in the Specifications, therefore, special design typically is not required.

(2) If there is considerable interest in protecting the existing pipeline or utility which may be undermined by a wide trench, etc., and if directed by the WSSC. Provide a design for the support of the excavation and the utility as part of the contract documents; see Part Three, Section 18 (Temporary Construction Support Criteria).

b) Restoring a firm foundation and bedding. Restore a firm foundation and bedding for the existing utility to minimize future settlement and maintain the structural strength of the pipe.

(1) When the design calls for crossing under the critical pipelines listed in 1) a) through c) above, provide a note on the drawings, both plan and profile, referring to Standard Detail M/8.3. This detail calls for replacing disturbed earth under and to 1'-0" above the existing pipeline with compacted structural fill.

(2) For special crossing situations, such as 1) d) above, provide the special design and details for backfilling under the utility.

e. Vertical Separation For Gravity and Pressure Sewer Pipelines Crossing Water Pipelines.

1) When the sewer is below the water, provide minimum one and half (1'-6") feet vertical clearance.

2) When the sewer is above the water, provide minimum v one and half (1'-6") feet vertical clearance and design the new pipeline with one full eighteen (18) to twenty (20) foot nominal pipe length centered at the crossing. If the design requires pipe bedding for the new pipes, provide a compacted well graded material such as special borrow material, in accordance with the Specifications, for a minimum of ten (10) feet on each side of the crossing.

3) If it is impossible to obtain the vertical separation between the water and sewer pipelines as stated above, see Alternative – When Water and Sewer Clearances Cannot Be Met, in this section.

f. Horizontal Separation Between SHC and WHC.

1) Separate Trench, provide ten (10) feet minimum horizontal separation between gravity SHC and WHC when they are designed in a separate trench.

2) Common or Combined Trench, when the WHC and SHC are designed in a common or combined trench sees Standard Detail M/18.0 for the horizontal and vertical clearances and the following:

a) If a ductile iron WHC and a SHC are less than ten (10) feet apart horizontally, design the bottom of WHC with a minimum of eighteen (18) inches vertical clearance above the top of the SHC and a minimum of eighteen (18) inches horizontal separation.

b) If a copper pipe WHC and a SHC are less than ten (10) feet apart horizontally, design the bottom of WHC with a minimum of twelve (12) inches vertical clearance above the top of the SHC and a minimum of eighteen (18) inches horizontal separation.

3) Provide ten (10) feet minimum horizontal separation between Pressure Sewer House Connection (PSHC) and WHC when designed in a separate trench. Do not design PSHC's and WHC's in a common or combined trench. Where PSHC and WHC are less than ten (10) feet apart horizontally, design the bottom of WHC with a minimum of eighteen (18) inches vertical clearance above the top of the PSHC.

g. Alternatives - When Water and Sewer Clearances Cannot Be Met.

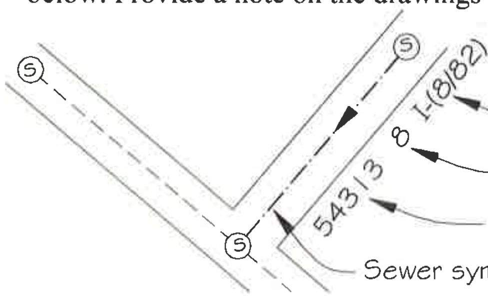
1) If it is impossible to obtain the vertical and horizontal separations between water and sewer pipelines as stipulated in "Vertical Separation For Gravity and Pressure Sewer Pipelines Crossing Water Pipelines" and "Horizontal Separation Between Sewer and Water Pipelines" in this section, then specify one or more of the following alternative methods for the section of the pipeline which is less than the required clearance.

2) Prior to specifying these alternatives, consider re-aligning the pipeline to meet the required vertical and horizontal separations between water and sewer pipelines, unless it is more cost effective to use the alternative methods.

3) Alternative Methods.

a) Slip lined sewer pipelines. Nothing additional is required if the existing or proposed sewer pipeline are slip lined with an approved continuous liner such as the following.

(1) Slip line existing sewer pipeline. Review the Sewer 200-foot reference sheets to determine if the existing sewer in question has been lined. See example of 200-foot reference sheet below. Provide a note on the drawings indicating that the existing sewer has been lined.



(2) Slip lined water pipeline. The allowable water pipeline liner is a steel pipe liner with welded joints.

b) Pipe bell joint leak clamps. Provide pipe bell joint leak clamps on either the water or sewer pipeline. Provide special provisions to the Specifications, see Part Three, Section 6 (Modifications to Specifications and Standard Details). Indicate the limits of the bell clamps, which should include the section of the pipeline where there is less than the required clearance on the drawings.

c) Concrete encasement of existing sewer pipelines. Provide concrete encasement on the existing sewer pipeline joints, at least one (1) foot minimum on both sides of the joint and in accordance with Standard Detail M/9.0. (Do not encase in concrete PVC sewer pipelines) For the allowable sewer pipeline materials which can be encased in concrete, see Part Three, Section 13 (Concrete Encasement, Arches and Cradles). Nothing additional is required if the existing sewer pipeline is already encased in concrete. Provide a note on drawings indicating the limits of the existing concrete encasement.

d) Tunnel or casing pipe. If either/both the existing/proposed water or sewer pipelines are within a tunnel or casing pipe as indicated below, nothing additional is required. Provide a note on the drawings stating that the existing pipeline is within a tunnel or casing pipe.

(1) The water pipeline or pressure sewer is to be within a continuous welded joint steel casing pipe, in accordance with Standard Details M/17.1 or M/17.7.

(2) The gravity sewer pipeline is to be within a tunnel or casing pipe that is filled with concrete, in accordance with Standard Detail M/17.0.

e) Special pipe materials. If the water or sewer pipeline is one of the following pipe materials, nothing additional is required: Steel Pipe with welded joints, Prestressed Concrete Cylinder Pipe with continuous welded joints, High Density Polyethylene Pipe (HDPE) with butt fusion joints or solvent welded PVC pipe. Provide note on the drawings indicating the type of material.

f) Upgrade the sewer pipe material. If the existing or proposed sewer pipeline material is one of those used for water pipelines, see Part One, Section 2 (Pipe Materials and Fittings), nothing additional is required.

g) Replace the sewer pipeline. At the pipe crossings, replace the existing sewer pipeline, if the existing pipe material is either of PVC AWWA C900/905 pipe or ductile iron pipe, with a nominal full length (18 to 20 foot) centered at the crossing. For parallel installation, replace the existing sewer pipeline with an upgraded sewer pipe material, as specified in this section.

h. Working in the Vicinity of Existing 36-inch and Larger Water Mains.

These notes are to be added to construction plans used for paving and grading above WSSC facilities when there will be less than 3'-0" of cover over the top of the pipe(s) during construction.

SPECIAL CONSTRUCTION REQUIREMENTS FOR WORK PERFORMED IN THE VICINITY OF THE EXISTING (fill in type, size of pipe)

1. Construction vehicles generating a load greater than an AASHTO H20 and vibratory compaction equipment are not permitted within 10 feet clear of the existing __" water or sewer main(s).

2. The Contractor shall submit construction vehicle specifications for all vehicles to be used closer than 10 feet clear of existing __" water or sewer main(s) to the WSSC Relocations Unit for WSSC approval prior to commencing work over the mains.

3. Stockpiling of soil or other material is not permitted within 10 feet clear of the mains.

4. The contractor shall locate and stake out the existing __" water or sewer mains and maintain the markers during construction. Unless otherwise approved by WSSC Relocations Unit, construction vehicles are not permitted within 10 feet clear of the __" water or sewer mains at any time when less than 3'-0" of cover exists over the mains during construction. The Contractor is responsible for identifying areas where less than 3'-0" of soil cover will exist over the mains during his construction operations.

5. All backfill and compaction over the __" water or sewer mains with less than 3'-0" of soil cover must be performed manually and/or with vehicles positioned a minimum of 10 feet clear of the main(s) until 3'-0" of cover is achieved. If necessary, temporary fill shall be placed over the existing mains to allow WSSC approved vehicle traffic to cross over the pipeline.

6. All exposed rocks, broken pavement, curbing and other unyielding debris having any

dimension greater than three inches shall be removed from above the main(s) prior to placing and compacting fill, subgrade materials or paving over the main.

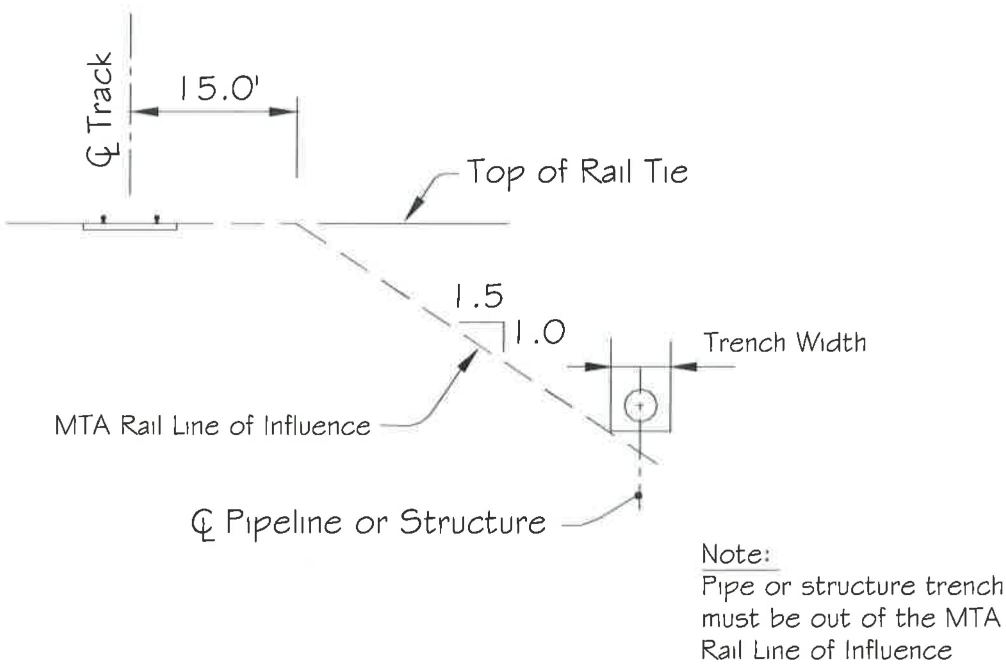
7. The contractor shall notify the WSSC Construction Inspector ______ at telephone number _____ at least ___ days in advance of any grading or paving in the vicinity of the existing __" water or sewer main(s). All grading and paving over the mains shall be coordinated and performed under the supervision of the WSSC Construction Inspector.

8. The contractor shall use special care while performing work in the vicinity of the existing __" water or sewer main where less than 3'-0" of soil cover exists and strictly adhere to these special construction requirements. The Contractor is responsible for any damage and/or replacement required as result of his work over the mains.

i. Working Within Maryland Transit Administration (MTA) Rail Lines.

1) Locations of water and sewer pipelines (which include water mains and gravity sewers, small diameter pressure sewers, force mains SHCs, and WHCs, manholes, vaults, valves and fire hydrants) shall not be located with the MTA Rail Line of Influence, see Sketch "UU".

2) When within the MTA Rail Line of Influence install the water and sewer pipelines in a casing pipe, see Casing Pipe Lengths, Section 26 (Tunnel Design Criteria).



SKETCH "UU"

MTA Light Rail Zone of Influence

25. Tunnels.

a. General.

1) This section discusses the typical situations which require the use of a tunnel for the installation of a water or sewer pipeline.

2) Use of tunnels. Due to higher construction costs for a tunnel, the first choice of water and sewer pipeline construction is to use the cut and cover method, for additional design guidance see Part Three, Section 19, (Geotechnical Considerations for Pipeline Alignments). However, under certain circumstances and in areas where the requirements of other jurisdictional authorities apply, tunnel construction will be required. If a water or pressure sewer tunnel is required, use a small diameter casing pipe with casing pipe spacers whenever possible, see Standard Details M/17.6 and M/17.7. Microtunneling can be considered in many cases where tunneling is desired or required.

3) Tunnel design and submittal requirements, see Part Three, Section 26 (Tunnel Design Criteria) and Section 20 (Geotechnical and Corrosion Submittals).

b. Conditions and Requirements for Tunnels.

1) Railroad crossing - Consolidated Rail Corporation (Conrail). Refer to the latest edition of the "Specifications for Pipeline Occupancy of Consolidated Rail Corporation Property" (Publication CE-8) for the design of tunnels crossing a Conrail right of way. Consider the requirements stated under Publication CE-8 and the following:

   a) Provide on the plans, a specified method of installation, size and material for both the casing and carrier pipes. No alternatives will be allowed.

   b) Design the casing pipe not less than five and one-half (5-1/2) feet from the base of the rail to top of the casing pipe at the closest point, except under sidings or industry tracks the distance may be four and one-half (4-1/2) feet, with approval from Conrail.

   c) Pipelines to be abandoned are to be removed or filled with grout, compacted sand or other methods approved by Conrail.

   d) Design the carrier pipe as either DIP, class 56 or RCP, class V, wall C, ASTM C 76. Steel pipe cannot be used as sewage carrier pipe.

   e) Extend vent pipes not less than four (4) feet above ground surface.

   f) Locate the face of all pits a minimum of twenty-five (25) feet from the centerline of the adjacent track, measured at right angles to the tracks.

2) Railroad crossing - CSX Transportation, Inc. Refer to the latest edition of "Application for Encroachments Upon the Right of Way of CSX Transportation, Inc", to design tunnels crossing CSX property. Consider the requirements stated under Application for Encroachments Upon the Right of Way of CSX Transportation, Inc and the following:

   a) Casing pipe may be omitted for non-pressure sewer crossing where the pipe strength is capable of withstanding railway loading.

b) Design mechanical or welded type joints for carrier pipe operating under pressure.

c) Carrier pipe can be either Polyethylene or PVC, if all three of the following requirements are met: 1) pipeline is used for non-flammable substances, 2) working pressure is less than 100 psi, and 3) pipeline is encased in a larger steel casing pipe.

3) Railroad crossing - Amtrak. Refer to the latest edition of the "Requirements & Specifications for Pipeline Occupancy of National Railroad Passenger Corporation" (Publication Eng. 1604) for the design of tunnels crossing Amtrak property. Consider the requirements stated under Publication Eng. 1604 and the following:

a) Provide a tunneling shield for all liner plate installations 60-inch and larger. Design the shield to conform to and not to exceed the outside dimensions of the liner plate tunnel by more than one (1") inch at any point on the periphery. Due to this requirement to use tunneling shields for all liner plate installations, it will generally be more economical to use a jack and bore casing pipe installation.

b) Specify only four (4) flange liner plate or RCP, class V, wall C, ASTM C76 for the casing pipe. Smooth wall RCP bells with a nominal diameter of over 54-inch will not be permitted. Do not design liner plate tunnels for water pipelines.

c) Design the carrier pipe as either DIP, class 56 or RCP, class V, wall C, ASTM C 76.

d) Do not exceed the outside diameter of the casing pipe by more than one half (1/2") inch, during the over-cutting by the head of the auger in the boring method.

e) Block both ends of the casing pipe for carrier pipe of non-flammable substances in such a way as to prevent the entrance of foreign material, but allowing leakage to pass in the event that a carrier pipe breaks.

f) The use of explosives will not be permitted.

4) Rail Line crossing Maryland Transit Administration (MTA) Rail Lines.

a) For requirements, see Part 3, Section 3 (Pipelines Crossings and Clearance).

5) Maryland State Highway Administration (MSHA) crossings.

a) Refer to the latest edition of "Policy on the Accommodation of Utilities on State Highway Rights of Way" published by Maryland State Highway Administration. Provide the option of using jack and bore casing pipes and steel liner plates for tunnel construction.

b) Design the carrier pipes within a tunnel for the external loads as if they were not in a tunnel.

6) Other road crossings.

a) Crossing any access, secondary or primary roadway where traffic flow cannot be interrupted as determined by the jurisdictional authority.

b) For the design of tunnel construction method options and carrier pipe, see MSHA crossings.

7) Right of way crossings.

a) Crossing the right of way of any county, municipality or utility upon which there exists pavement or other features that may not be disturbed.

b) If the crossing is short requiring only several lengths of pipes, then the economical tunneling method is to jack and bore a small diameter casing pipe and use casing pipe spacers as the support for the carrier pipe inside the casing, see Standard Details M/17.6 and M/17.7.

8) Crossing environmentally sensitive or hazardous waste contaminated areas.

a) Tunneling may be required when crossing environmentally sensitive or hazardous waste contaminated areas whereby the disturbance to the critical upper soil layer is mandated to be minimized or avoided. Evaluate alternate pipeline alignments to determine the most cost effective and acceptable method for crossing or avoiding these areas.

b) In general, the tunnel methods to be used in these areas are the jack and bore casing pipe installation or the earth balanced micro tunneling method.

26. Tunnel Design Criteria.

a. General.

1) This section presents soft ground tunnel design criteria only. The criteria for rock tunnels are to be determined on a project specific basis, subject to WSSC approval.

2) The primary objectives of tunnel design must satisfy the following requirements: stability of tunnel openings, protection of adjacent or overlying structures and ability of the tunnel to perform over the intended life.

3) The criteria presented in this section are generally applicable to soft ground tunnel design. If conditions are encountered which are not covered in this section, the relevant design criteria are to be established in conjunction with WSSC.

4) The term "tunnel" as used in this section, micro tunneling and bore, open cut casing installation and jack casing installations.

b. Tunnel Use.

1) Whenever possible and agreed by the affected land owner, the primary choice of WSSC for constructing water and/or sewer pipelines is the cut and cover method. When the conditions stated in "Conditions and Requirements for Tunnels", under Part Three, Section 25 (Tunnels) requires the water and/or sewer pipeline to be in a tunnel, design the tunnel following the criteria in this section.

2) Also, verify with the affected landowner and/or appropriate jurisdictional authority as to whether or not a tunnel crossing is required.

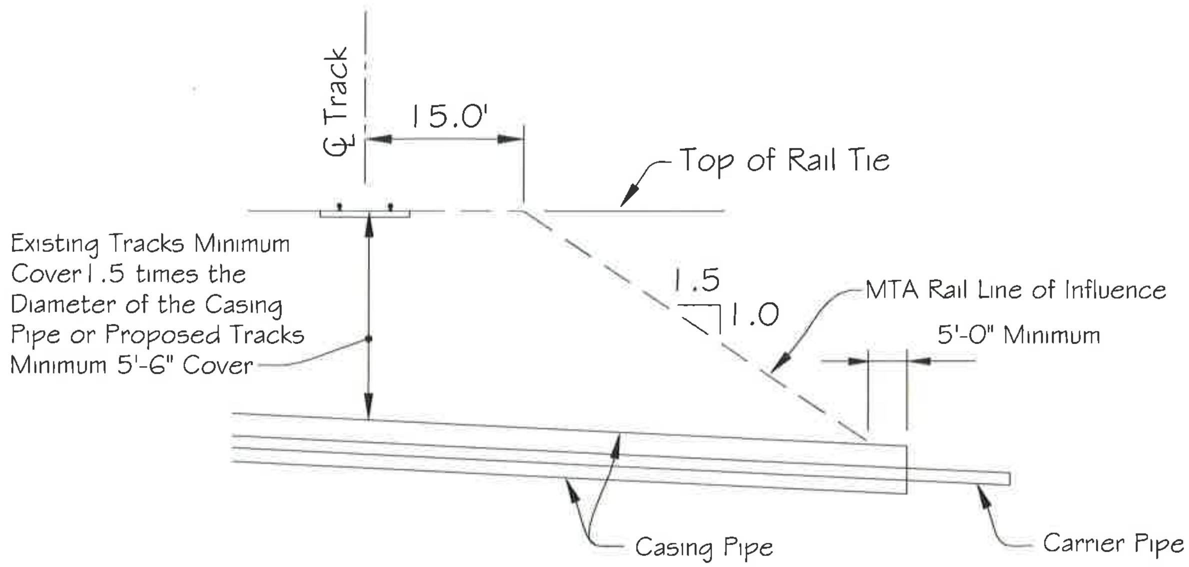
c. Tunnel Casing Length.

1) Maryland Transit Administration (MTA) Rail Lines.

a) Tunnels crossing a MTA Rail Lines, the angle of the crossing is to be based on the economics of the practical alternatives. The crossing is to be located as near perpendicular to the rail line alignment as practical.

b) Minimum length of a tunnel crossing a MTA rail lines is to be as follows:

(1) At a location were top of the tunnel crosses MTA Rail Line of Influence plus a minimum five (5) feet, see Sketch "VV".



SKETCH "VV"

Profile of Tunnel Crossing MTA Light Rail

2) Other Railroad or roadway. For tunnels crossing a railroad or roadway, the angle of the crossing is to be based on the economics of the practical alternatives. The crossing is to be located as near perpendicular to the railroad or roadway alignment as practical and the minimum length of tunnel casing is to be the width of the railroad right of way.

3) State highways. Minimum casing length of a tunnel crossing a state highway is to be as follows:

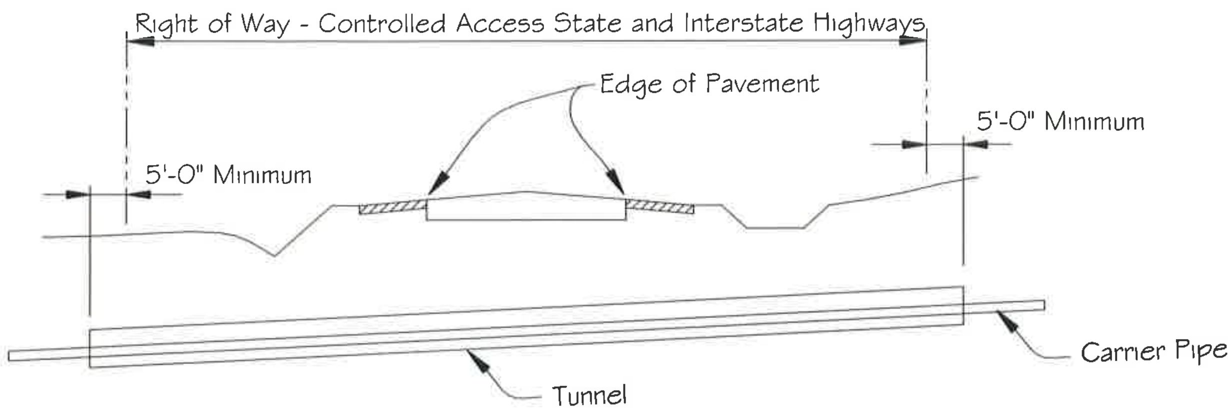
a) The width of the right of way plus five (5) feet for controlled access state highways and interstate highways, see Sketch "FF".

b) On other state highways:

(1) The width of the highway (from shoulder to shoulder or paved ditch to paved ditch) plus a horizontal distance measured out from the edges of both shoulders or paved ditches and equal to the elevation difference between the bottom of the pipe and the roadway surface (for shoulder to shoulder case) or the ground surface beside the ditch (for ditch to ditch case) plus five (5) feet.

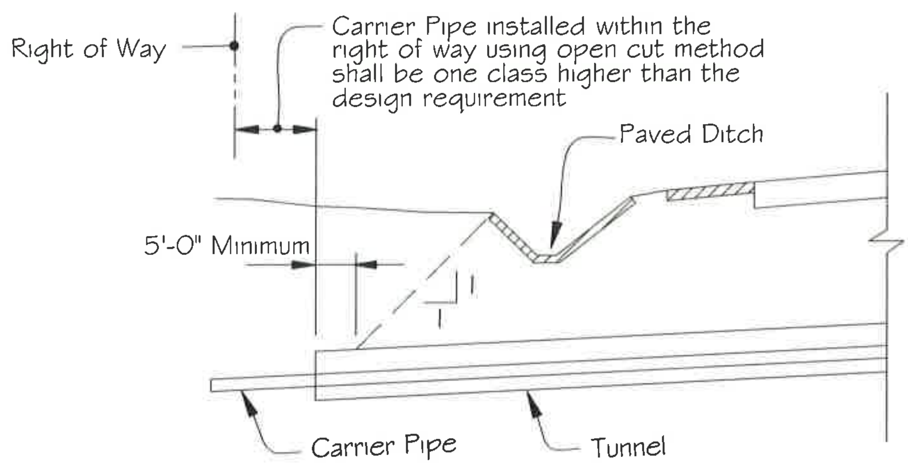
(2) If the width of the highway (from shoulder to shoulder or from paved ditch to paved ditch) is much narrower than the width of right of way, the contractor may be given the option of mixed construction using tunneling and open cut excavation within the right of way for carrier pipe installation. For the remaining part of the right of way, open cut method design the carrier pipe with one (1) class higher than the design requirement, see Sketch "GG".

c) All tunnels. Extend the length of the tunnel casing beyond the limits of planned future expansion of the surface structure. This distance will be the width of the estimated pressure influence zone outside the planned structure area. As an approximation, the pressure influence zone may be bounded by a forty five (45°) degree line extended outward from the edges of the loading area.



SKETCH "FF"

Profile of Tunnel Crossing MSHA Controlled Access and Interstate Highway



SKETCH "GG"

Profile of Tunnel Crossing MSHA Highway other than Controlled Access and Interstate Highway

d. Tunnel Casing Diameter.

1) Tunnel diameter requirements using pipe sleeves, liner plates and casing pipes will vary based on the carrier pipe diameter and the carrier pipe type and contents as follows:

a) Tunnel sizes for gravity sewers to be in accordance to Standard Detail M/17.0.

b) Tunnel sizes for water pipelines and pressure sewers to be in accordance to Standard Detail M/17.6. In certain ground conditions or in special cases, it may be necessary to use a liner plate or other larger diameter tunnel for a water pipeline or a pressure sewer. See Standard Detail M/17.1 for the tunnel diameters.

c) Tunnel diameters for carrier pipe diameters not included in the Standard Details are to be based on ease of installation and maintenance as well as economic considerations, for review and approval by WSSC.

e. Minimum Soil Cover.

1) The minimum soil cover above the tunnel is to be the greater of four and one half (4-1/2) feet, one and one half (1.5) times the outside diameter of the tunnel or the depth requested by the jurisdictional authority.

f. Soft Ground Tunneling Methods.

1) Bore and jack. A method of installing a casing by means of cutting, hand mining or boring an opening in the soil while simultaneously forcing the pipe through the opening with hydraulic jacks. Design the tunnel using steel pipe or reinforced concrete pipe for the casing; see Specifications for casing pipe requirements. The method is limited to a maximum diameter casing pipe of 60" and the maximum tunnel length is limited to two hundred (200) feet.

2) Excavation with liner plate support. Use only for tunnels 48-inch or larger diameter, see the Specifications for the requirements for liner plate, gravel packing, grout and concrete.

3) Microtunneling. A method of installing a casing pipe by jacking the casing pipe behind a remotely controlled, steerable, guided Microtunnel Boring Machine (MTBM) which fully supports the excavated face with either slurry or earth pressure balance at all times. Design the tunnel using steel pipe for the casing; see specifications for casing pipe requirements. Alternate casing materials require approval by the Commission.

g. Clearances with Surrounding Existing Installations.

1) Vertical clearance. Maintain a minimum of two (2) foot clearance between tunnel and other utility lines. The actual location and elevation of the existing utilities over or under the tunnel alignment are to be determined prior to design.

2) Horizontal clearance. For tunnels 72-inch and smaller diameter, maintain (15) feet horizontal clearance between the outside of surrounding surface or subsurface structures/utilities and the outside diameter of the tunnel and tunnels greater than 72-inch diameter, determine the horizontal clearance subject to WSSC approval, typically the horizontal clearance will be greater than (15) feet.

3) Ends of tunnel. The ends of a tunnel are not to be located in steep slopes, streams or drainage ditches. Steep slope is defined as being 3:1 and higher than ten (10) feet from the toe to the top of slope. Extend the ends of a tunnel at least fifteen (15) feet beyond the toe of a steep slope.

h. Tunnel Soil Investigation Submittals and Tunnel Geotechnical Report.

1) A tunnel soil investigation is required for all proposed tunnels. A well-planned and detailed tunnel soil investigation is of great importance to the successful design and construction of a tunnel. The investigation is to be planned by a registered professional geotechnical engineer experienced in tunnel design and meet the minimum requirements of Appendix "F", Soil Investigation for Soft Ground Tunnel Projects. Conduct all fieldwork under the continuous inspection of a person experienced in subsurface explorations. Conform to Appendix "F" for all

submittals for the tunnel soil investigation.

2) Preliminary tunnel submittal to contain a natural scale profile of the proposed tunnel (1" = 10'- 0" horizontal and vertical) and tunnel soil investigation submittals are specified in Appendix "F".

3) Tunnel geotechnical report.

a) In general, when a proposed tunnel is greater than 72-inch diameter or a tunnel project appears to be complex such as tunneling in soft clay or loose sand and silt under the water table, a tunnel geotechnical report may be requested to supplement the tunnel soil investigation submittals.

b) The necessity of a tunnel geotechnical report for a particular project will be decided by WSSC after the initial review of the preliminary submittal.

c) If a tunnel geotechnical report is requested by WSSC, bind the report in a suitable cover, signed and sealed by a registered professional geotechnical engineer, including the following minimum information. All pages are to be marked draft until the report is acceptable to WSSC.

(1) All submittals required under Appendix "F" for the tunnel soil investigation.

(2) Description of the site, field program and laboratory testing program.

(3) Area geology and subsoil conditions.

(4) Recommended design groundwater level.

(5) Present estimated subsurface profiles and groundwater levels along the tunnel alignment.

(6) Discuss any special dewatering problems as well as unfavorable soil conditions for tunneling. Propose possible methods of handling these tunnel construction problems including the limitations and advantages of each.

(7) Estimation of design pressure due to dead and live loads for the tunnel liner plates.

(8) Estimation of surface settlements for the ground above and adjacent to the tunnel when it is requested by WSSC.

(9) Evaluation of the face stability for tunneling. This should be discussed in tunneling terms in accordance with Behavior of Ground at Heading, in this section.

(10) Recommend the soil parameters as discussed in this section, including but not limited to parameters such as unit weight, friction angle, cohesion or undrained shear strength and effective grain diameter for use in the tunnel access shaft and jacking pit designs.

i. Soil Parameters.

1) Cohesionless soil. Due to the difficulty of obtaining relatively undisturbed samples, the in-situ properties of cohesionless soils are seldom determined in the laboratory. For complex projects where the effort is warranted, commonly accepted field testing methods shall be used. For most

projects, the soil parameters may be determined on the basis of local experience or empirical correlation with SPT blow counts and effective grain diameter (D_{10}). Some typical empirical correlations are included in Table "25".

2) Cohesive soil. Soil parameters such as unit weight, coefficient of permeability and shear strength of cohesive soils may be determined by laboratory testing on undisturbed samples. For a complex project, emphasis on the method of determination shall also be placed on field testing.

j. Behavior of Ground at Heading.

1) Definitions.

a) Firm ground. Heading can be advanced without initial support.

b) Raveling ground. Chunks or flakes of material begin to drop out of the arch or walls sometime after the ground has been exposed. "Fast raveling" begins within a few minutes, otherwise the ground is "slow raveling".

c) Running ground. Granular materials without cohesion are unstable at a slope greater than their angle of repose. When exposed at steeper slopes they run like granulated sugar or dune sand until the slope flattens to the angle of repose.

d) Cohesive running ground. Material with sufficient cohesion to stand for a brief period of raveling before it breaks down and runs.

e) Flowing ground. A mixture of soil and water flows into the tunnel like a viscous fluid. The material can enter the tunnel from the invert as well as from the face, crown, and walls, and can flow for great distances, completely filling the tunnel in some cases.

2) Ground behavior and face stability in various soil conditions.

a) Plastic clay. For plastic clays at depths not less than approximately two tunnel diameters, the stability of the tunnel face may be evaluated by the following ratio: (Ratio should not exceed six (6) in order to maintain face stability.)

$$(P_z - P_a) \div S_u$$

Where:

P_z = total vertical pressure at depth z of center of tunnel, (psf)

P_a = air pressure above atmospheric, (psf)

S_u = undrained shear strength of clay, (psf)

b) Silty sands.

(1) Soils with a unified classification of SP-SM, SW-SM or SM are included in this group. Coarse silt of ML classification may also have similar behavior. The permeability of these soils is commonly moderate to low, in the range of 10^{-3} to 10^{-5} cm/sec.

(2) Above water table.

(a) The ground behavior may be estimated from the ratio of overburden pressure to unconfined compressive strength if the materials have sufficient cohesion or cementation to permit sampling and testing to define the unconfined compressive strength.

(b) Firm ground. When the overburden pressure at tunnel depth is in the range of about 1/10 to 1/6 the unconfined strength or less, the ground is likely to be firm.

(c) Slow raveling. Likely to occur when this ratio is in the range of 1/5 to 1/4.

(d) Fast raveling. When the overburden pressure is in the range of 1/3 to 1/2 the unconfined strength, the behavior is likely to be fast raveling or worse.

(e) Estimate of ground behavior based on D_{10} size. When the soil has too little cohesive strength or cementation to be cored and strength tested, an estimate of ground behavior may be based on effective grain diameter (D_{10}) as shown in Figure "D". The figure is drawn for the case of dense soils (N>30) above the water table assuming relatively uniform gradation (C_u less than 6), and grain shape and packing typical of materials which have experienced moderate transport and working by water. Loose sand (N<10) or sand with very rounded particles would likely exhibit a behavior one to two classes poorer. Soils with very angular particles, significant cementation or relict bonding, or an unusual history such as previous deep burial and compaction, may exhibit behavior one or two classes better.

(3) Below water table.

(a) The ground behavior depends upon the external water head, the nature of the fine contents, relative density, soil stratification, rate of excavation advance and other factors.

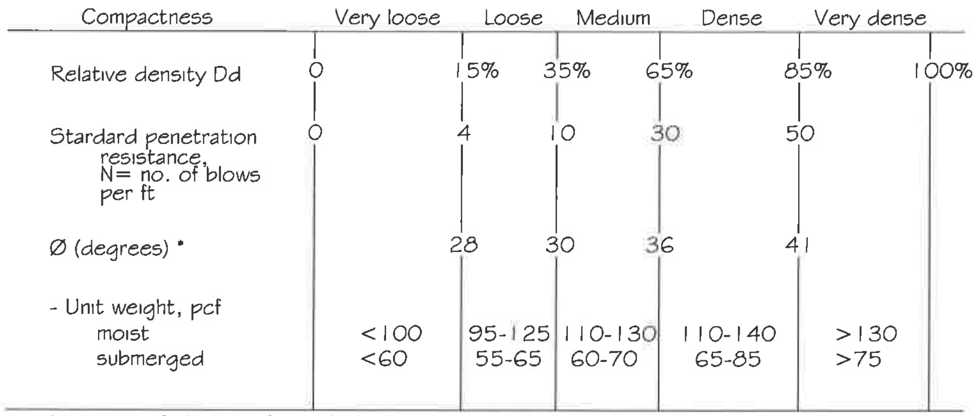
(b) When compressed air is used to control excavation stability, the tunneling system should have the capability of balancing the full external water head at the level of the excavation invert. This is necessary for times when the excavation is stopped. When tunneling with compressed air in clean sands, it is necessary to balance the external water pressure at the level of the lower portion of the tunnel face to prevent excessive water seepage into the invert. If the pressure is balanced at invert level, then at the crown the air pressure is greater than the water pressure, resulting in air losses and drying of sand in the crown. A balance point commonly around the lower 1/4 point of the face is usually selected as a compromise.

(c) The estimated bands shown in Figure "E", are intended to represent reasonable lower limits of required air pressure for stability of a tunnel face advancing at a steady rate in the range of thirty two (32) feet per day or more, assuming good construction practice and good ground control.

c) Clean sand and gravel.

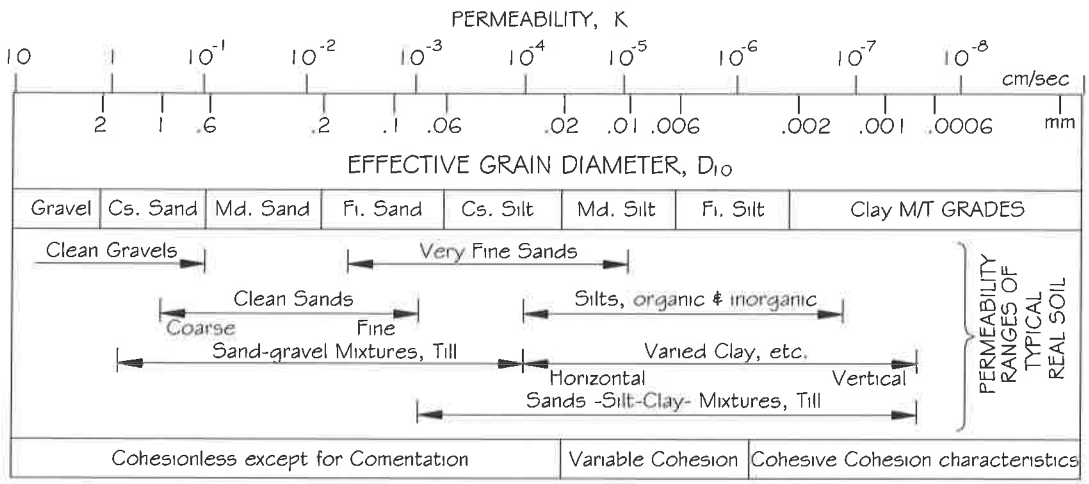
1) Above the water table. These soils must be assumed to act as running ground unless the soil investigation shows a significant cementation or a very dense and angular interlocked grain structure in the deposit. For the later case, a raveling ground may be assumed.

2) Below the water table. These soils must be assumed to act as flowing ground. Some form of ground water control such as dewatering or the use of compressed air must be considered. The internal air pressure must approximately balance the external water head.



* increase 5 degrees for soils containing less than 5% fine sand or silt.

COHESIONLESS SOIL PROPERTIES AND N VALUES (TENG. 1962)

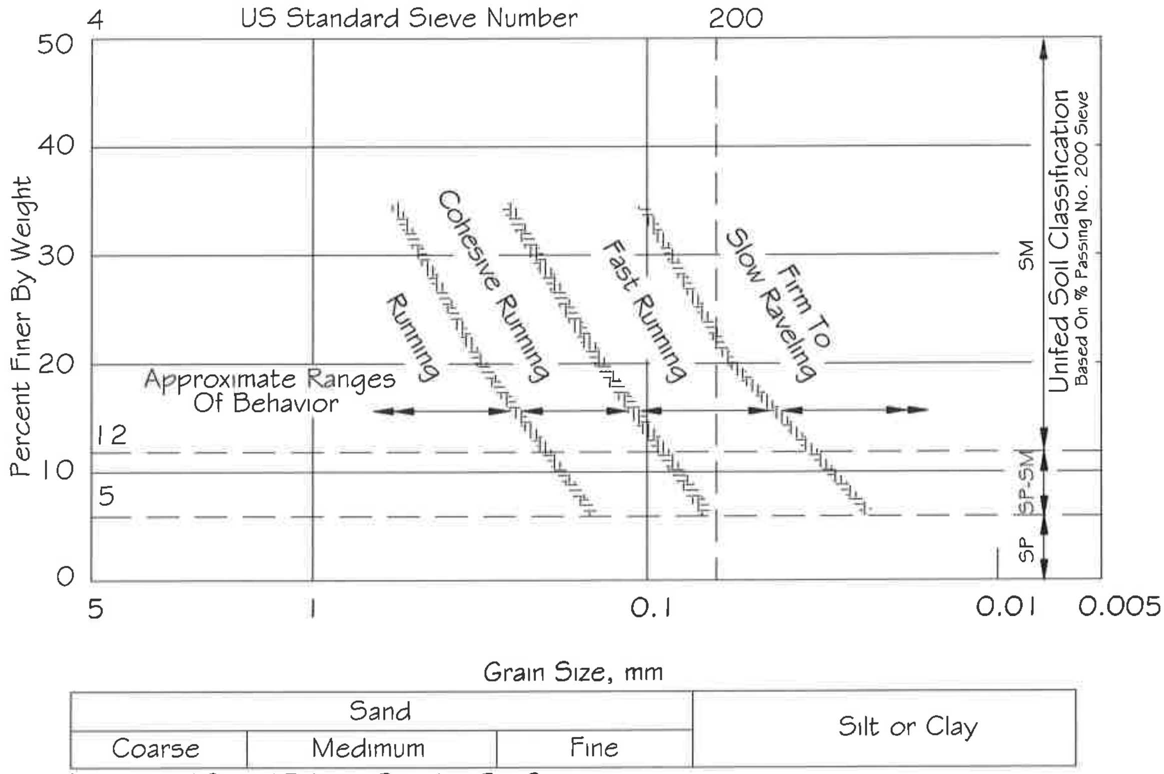


COEFFICIENT OF PERMEABILITY AND D_{10} SIZE

(BICKEL & KUESEL, 1982)

TABLE "25"

Empirical Correlation of Soils



Anticicipated Ground Behavior Based on D_{10} Size
Dense Soil N>30, Above Water Table
(HEUR AND VIRGENS, 1987)

FIGURE "D"

Anticicipated Ground Behavior Based on D_{10} Size.

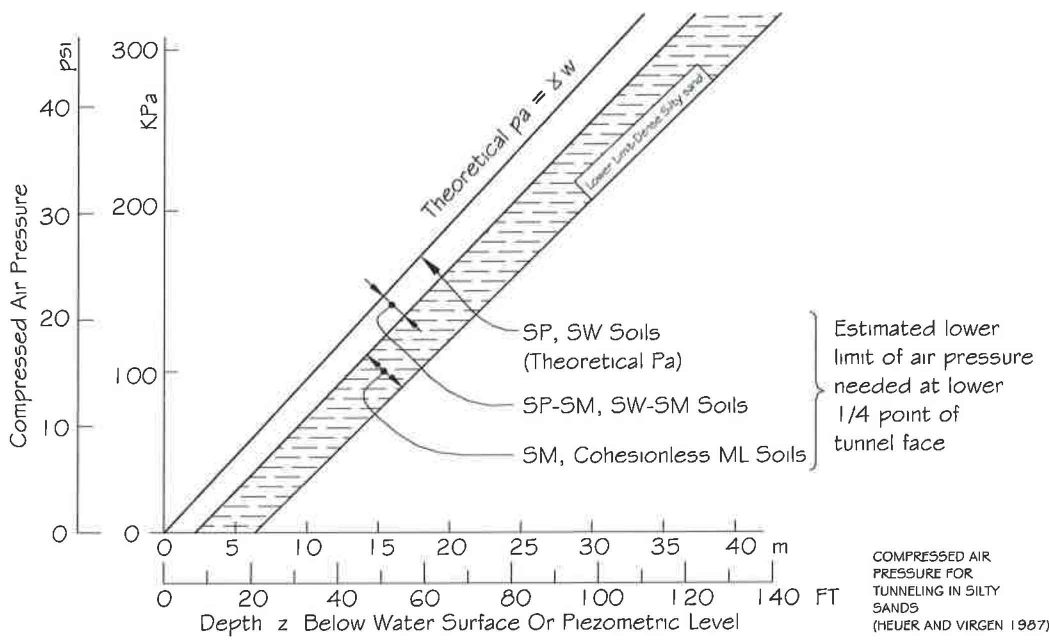


FIGURE "E"

Compressed Air Pressure for Tunneling in Silty Sands

k. Surface Settlement Estimation.

1) Perform surface settlement estimation if it is requested by WSSC after the initial review of the preliminary tunnel submittal, which includes the submitted plan and the soil investigation results. In general, surface settlement analysis may be requested if the soil borings indicate that the tunneling operation will be mainly in soft clay or loose sand and silt under the water table. Settlement analysis may also be requested for tunnel diameters greater than 72-inch in any soil condition or for a proposed tunnel alignment where sensitive structures will be closer than fifteen (15) feet in horizontal direction from the center of the tunnel. Either one of the following methods may be used for the analysis.

a) Semi-empirical method. The surface settlement trough over a single tunnel may be represented with an error function. The pertinent properties of the error function and its relationship to the dimensions of the tunnel are shown in Figures "F" and "G". Using these figures, the width of the settlement trough is expressed as a multiple of i. The maximum settlement, δ_{max}, above the center of the tunnel may then be estimated from the i value and the volume of the trough as follows:

$$\delta_{max} = V \div 2.5\, i$$

The volume of the trough, V, in clay may be expressed as:

$$V = 3\,(S_u \div E)\ \ EXP\,(OF - 1) \qquad (\text{For } OF > 1)$$

Where:

$OF = (P_z - P_a) \div S_u$

P_a = air pressure above atmospheric on the tunnel face (psf)

P_z = overburden pressure (psf)

S_u = undrained shear strength (psf)

E = deformation modulus (psf)

(Note: Usual range of $(S_u \div E)$ is between 0.002 and 0.005)

The volume of lost ground in sand over a single tunnel is usually estimated from past experience with similar methods of tunnel construction.

b) Theoretical analysis. A finite element method which simulates tunneling operation and load deformation characteristics of the soils may be used to estimate the soil deformation and surface settlements. The selection of deformation modulus for the soil in the analysis shall be based on local experience, actual field measurements or the estimation from SPT values in accordance with NAVFAC, Soil Mechanics Design Manual, 7.01.

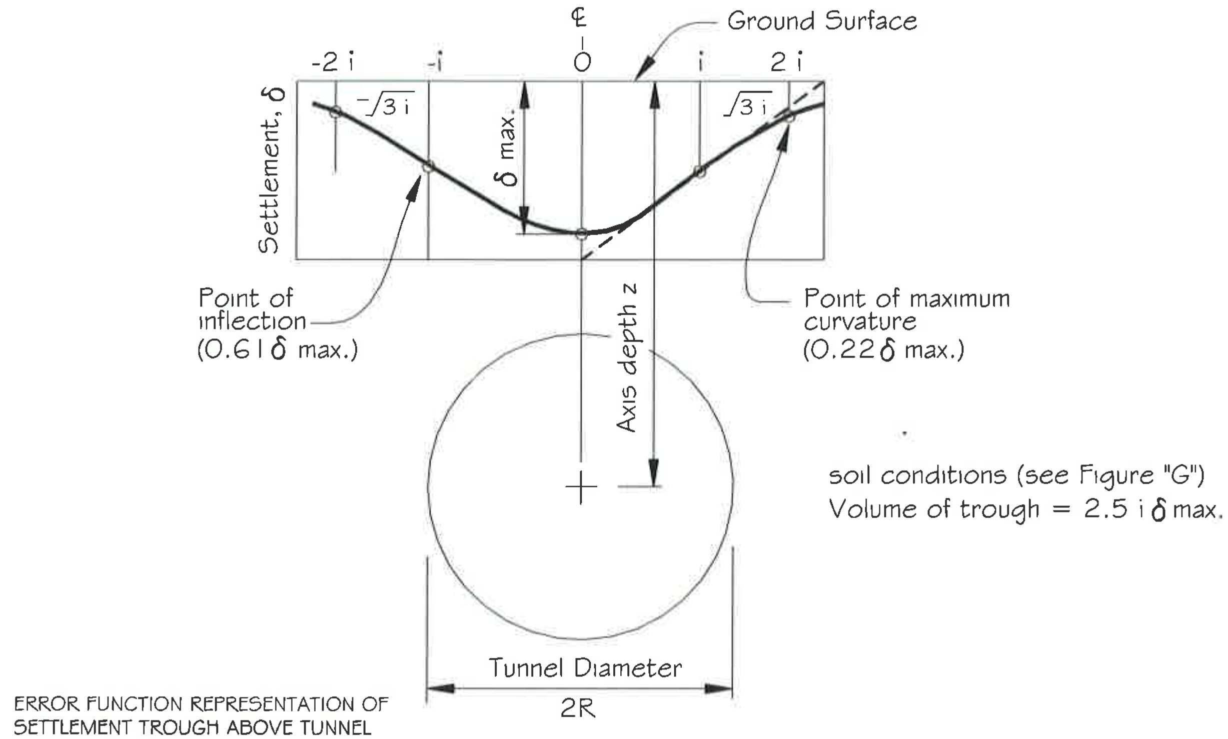


FIGURE "F"

Error Function Representation of Settlement Trough Above Tunnel

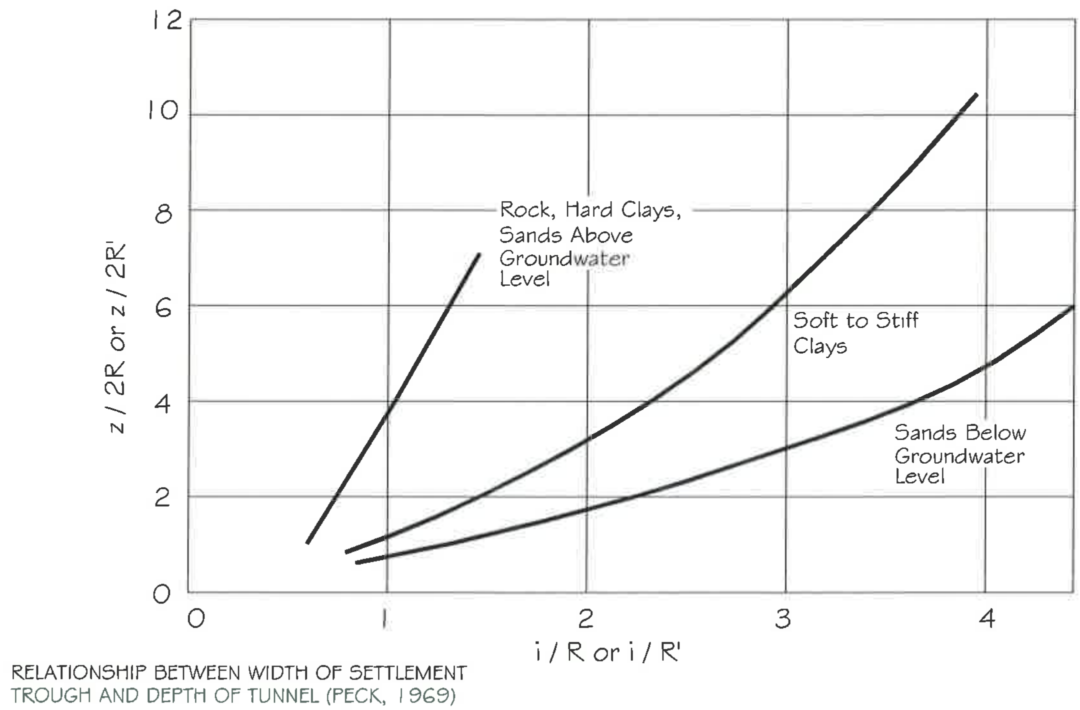
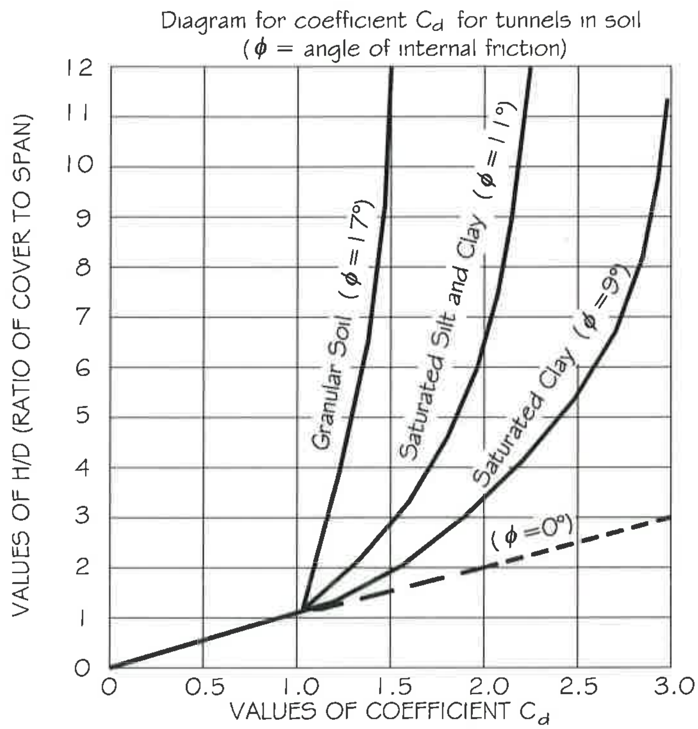


FIGURE "G"

Relationship Between Width of Settlement Trough and Depth of Tunnel



COEFFICIENT OF PRESSURE FOR TUNNEL DESIGN (WINTERORN & FANG, 1975)

FIGURE "H"

Coefficient of Pressure for Tunnel Design

(b) Live load. The value of P_l for both highway and railway loadings can be taken from Table "26", which includes both static and dynamic loading.

TABLE "26"

Value of P_l

Height of Cover (feet)	Highway H20 (psf)	Height of Cover (feet)	Railway E-80 (psf)
1	1800	2	3800
2	800	5	2400
3	600	8	1600
4	400	10	1100
5	250	12	800
6	200	15	600
7	175	20	300
8	100	30	100

The affect of live load less than 100 psf may be disregarded.

(c) Ground water pressure.

$$P_w = \Gamma_w \, [h_w - (C_d \; D)]$$

Where:

Γ_w = unit weight of water (pcf)

h_w = height of water surface above the top of the tunnel liner (ft)

I. Tunnel Design.

1) Design external pressures.

a) External pressures acting on a circular tunnel which may be constructed with either liner plates or a casing pipe may be computed approximately with the following procedures.

(1) If grouting is used to fill the voids between the tunnel liner and the soil and grouting pressure is greater than the computed external pressures, use grouting pressure for design of the tunnel.

(2) In general the external pressure due to earth load, ground water, and live load can be computed by the following formula:

$$P = P_d + P_w + P_l$$

Where:

P = external pressure on the tunnel liner (psf)
P_d = vertical pressure at the level of the top of the tunnel liner due to the soil load (psf)
P_w = water pressure in excess of that considered in the saturated soil load (psf)
P_l = vertical pressure at the level of the top of the tunnel liner due to live loads (psf)

(a) Earth load.

$$P_d = C_d \; W \; D$$

Where:

C_d = coefficient of pressure for tunnel liner, (H is height of cover in feet in Figure "H").
W = total unit weight of soil (pcf) (Saturated unit weight for soil below water table.)
D = horizontal diameter of tunnel (ft)

The charts for earth loads on jacked or tunneled installations published in the Concrete Pipe Design Manual by American Concrete Pipe Association (ACPA) can also be used for this purpose. However, the loading obtained from the charts shall be divided by "D" above and furthermore the cohesion term from the charts shall be neglected in the design.

This excess water pressure will be included only if h_w is greater than (C_d D). When h_w is less than (C_d D), the water pressure is included in the evaluation of P_d when the saturated unit weight of soil is used.

2) Design of tunnel liner plate.

a) Consider the following criteria in the design of tunnel liner plates:

(1) Joint strength. Liner plates must be sufficient to withstand the thrust developed from the pressure determined in Tunnel Design, Design External Pressures, in this Section. The thrust may be calculated as follows:

$$T = PD \div 2$$

Where:

T = thrust (lb/ft)
P = pressure (lb/ft^2)
D = diameter (ft)

The ultimate joint strength of the plate should be at least three times (safety factor of 3) the thrust value. Values of the ultimate joint strength of steel liner plates can be obtained from the manufacturer's literature.

(2) Minimum stiffness for installation. The liner plate ring shall have enough rigidity to resist the unbalanced loadings of normal construction such as grouting pressure, local slough-ins and miscellaneous concentrated loads. The values given here for minimum stiffness are only recommended minimums. Actual job conditions may require higher values of effective stiffness. Minimum eight (8) gauge liner plate shall be used for tunnels not grouted shut.

$$\text{Minimum Stiffness} = (E\ I) \div D^2 = 111 \text{ minimum}$$

Where:

D = diameter in inches
E = modulus of elasticity of steel (29×10^6 psi)
I = centroidal movement of inertia of the liner plate section (in^4/in); value of the centroidal movement of inertia can be obtained from the manufacturer's literature

(3) Buckling strength. Design for buckling is accomplished by limiting the ring compression thrust, T, to the buckling stress multiplied by the effective cross section area of the liner plates divided by the factor safety:

$$T = (f_c\ A) \div FS$$

Where:

T = thrust per lineal foot
A = effective cross section area of liner plate (in^2/ft), (from manufacturer's literature; equal to 2 actual area)
FS = factor of safety is 2 for buckling
f_c = buckling stress (psi)

Buckling stress is determined from the following formula, and shall not exceed the specified yield strength (f_y = 28,000 psi) of liner plates.

For diameters less than:

$$(r \div k)\,[(24\,E) \div f_u)]^{1/2}$$

$$f_c = f_u - [f_u^2 \div (48\,E)]\ \ [(k\ D) \div r]^2 \quad \text{(psi)}$$

For diameters greater than:

$$(r \div k)\,[(24\,E) \div f_u)]^{1/2}$$

$$f_c = (12\ E) \div [(k\ D) \div r]^2 \quad \text{(psi)}$$

Where:

- f_u = minimum specified tensile strength of steel, psi
- k = soil stiffness factor, which will be 0.22 for soils where friction angle >15E and 0.44 where friction angle <15E
- D = pipe diameter (in)
- r = effective radius of gyration of section (in) (from manufacturer's literature; equal to 0.75 of actual radius of gyration).
- E = modulus of elasticity of steel (29 x 10^6 psi)

(4) Deflection. Over size the structure to provide for a normal deflection where the tunnel clearances are important. Good construction methods shall result in deflections of not more than three (3%) percent of the normal diameter.

3) Design of steel casing pipe.

a) Consider the following criteria in the design of steel casing pipe. However, under no circumstances shall the wall thickness and the yield strength of the casing pipe be less than 3/8" and 35,000 psi respectively.

(1) Deflection.

$$\triangle x = D_l\,\left((K\ W_L\ r^3) \div [(E\ I) + (0.061\ E'\ r^3)]\right)$$

Where:

- $\triangle x$ = horizontal deflection of pipe (in)
- D_l = deflection lag factor (use 1.5)
- K = bedding constant (0.1)
- W_L = load per unit length of pipe (lb/linear in of pipe); this can be calculated using P, see Tunnel Design, Design External Pressures, in this Section and is equal to PD/12
- r = radius of pipe (in)
- E = modulus of elasticity of steel (29 $\times 10^6$ psi)
- I = transverse moment of inertia per unit length of pipe wall (in^3) (equal to $t^3/12$ where t is the wall thickness of the pipe)
- E' = modulus of soil reaction (lb/in^2)

The deflection $\triangle x$ shall be less than three (3%) percent of the pipe diameter.

(2) Buckling pressure. The allowable buckling pressure may be determined as follows:

$$q_a = (1 \div FS)\left(32\ R_w\ B'\ E'\ [(E\ I) \div D^3]\right)^{1/2}$$

Where:

q_a = allowable buckling pressure (psi)
FS = design factor
= 2.5 for $(h/D) \geq 2$
= 3.0 for $(h/D) < 2$
h = height of ground surface above top of pipe (in)
D = diameter of pipe (in)
R_w = water buoyancy factor
= $1 - 0.33 \times (h_w \div h),\ 0 \leq h_w \leq h$
h_w = height of water surface above top of pipe (in)
B' = empirical coefficient of elastic support (dimensionless)
= $1 \div (1 + 4e^{(-0.065H)})$
H = height of fill above pipe (ft)
e = 2.7183 (constant)
E, I & E' are as defined previously, herein

The external pressure P computed in Design External Pressures in this section shall be equal to or less than $144 \times q_a$.

(3) Jacking force. Design the pipe to withstand the axial stress induced by the jacking operation. The required jacking force may be estimated from the total area of exterior surface of the pipe and the unit friction between the soil and the pipe. The unit friction may be evaluated from the external pressure determined from Tunnel Design, Design External Pressure, in this section, and the pipe weight or it may be estimated from past experience.

4) Design of RCP casing.

a) Consider the following criteria in the design of the RCP casing: The casing pipe to meet the requirements of ASTM C 76 minimum class IV and for casing pipes crossing under a railroad, meet the requirements of ASTM C 76 Class V with type C wall.

(1) Selection of pipe strength. The required pipe strength for the external pressure may be determined as follows:

$$D_{0.01} = (P \div L_f)\ FS$$

Where:

$D_{0.01}$ = 0.01 inch crack D-load (psf)
P = external pressure P computed in Tunnel Design, Design External Pressure, in this section (psf)
L_f = load factor (use 1.9)
FS = factor of safety (use 1.0 for 0.01 inch crack)

(2) Jacking force. Design the pipe to withstand the axial stress induced by the jacking operation. The same approach as described in Tunnel Design, Design of Steel Casing Pipe, in this section, can be used for estimation of the jacking force.

5) Design of carrier pipe inside the tunnel for the total soil prism load. For railroad crossings, it is further required that the highest class of pipe, DIP Class 56 be used.

m. Access Shaft and Jacking Pit.

1) As indicated in the Specifications, the design and construction of the access shaft and jacking pit are the responsibility of the contractor. The following information is presented only for reference.

a) Access shaft.

(1) Locate the access shafts at the low end of the tunnel and a receiving pit at the another end for a short tunnel. The surface area around the shaft needs to be large enough to contain all necessary services and working space such as space for trucks removing muck, space for storage of tunnel lining materials, etc.

(2) Earth pressures.

(a) In earth pressure calculations, use the total unit weight of soil for the shafts above the water table. For shafts below the water table use the submerged unit weight of soil and add the hydrostatic pressure due to groundwater.

(b) Surcharge load accounting for the sloping ground surface, adjacent fill, equipment or structures is to be considered in the analysis. In the case where no detailed information is available, assume a minimum of three hundred sixty (360) psf of uniform surface loading beside the shaft.

[1] <u>Shaft in sand</u>. For a vertical cylindrical shaft, the earth pressure surrounding the shaft may be determined in accordance with the method on pp. 7.1-201 of NAVFAC, 1986, Soil Mechanics Design Manual, 7.01.

For a rectangular or square shape braced excavation the earth pressure on the walls may be calculated following the procedures on pp. 7.2-100 of NAVFAC, 1986, Foundation and Earth Structures Design Manual.

[2] <u>Shaft in clay</u>. For a cylindrical shaft in soft clay, the earth pressure surrounding the shaft may be evaluated in accordance with the method on pp. 234 of Proctor, R. V. and White, T. L., 1977, Earth Tunneling with Steel Supports, Commercial Shearing, Inc., Youngstown.

The procedure presented on page 7.2-100 NAVFAC, 1986, Foundation and Earth Structures Design Manual, may be used to evaluate the earth pressure for a rectangular or square shape braced excavation.

2) <u>Jacking pit</u>. Provide a jacking pit at the lower end of the tunnel when using the bore and jack method. The earth pressure on the jacking pit walls due to the excavation may be calculated similar to the access shaft. Design a reaction backstop suitable to resist the jacking force required to install the casing pipe.

n. Dewatering.

1) There are several efficient methods of dewatering that may be considered, such as pumping from well points or pumping from deep wells. Required pump capacity may be sized from the estimated coefficient of permeability of the soils. Without previous in-situ test data, the soil permeability may be preliminarily estimated from effective grain diameter (D_{10}). Pump size shall then be adjusted as required during construction.

2) Well points and deep well pumping are only workable if the percentage of soil particles smaller than 0.05 mm (millimeter) is not more than ten (10) to fifteen (15%) percent. Dewatering by pumping from deep well points can cause varying amounts of settlement. Carefully consider the settlement of ground due to loss of water before using these methods.

3) Compressed air methodology may sometimes be used as an alternative to dewatering when ground water draw down is expected to cause excessive settlement.

o. Casing Seal, Permanent/Temporary Bulkhead or Tunnel Access Manhole.

1) Casing end seals are used at each end of a small diameter water and pressure sewer casing which uses casing spacers as shown in Standard Details M/17.6 and M/17.7.

2) Provide permanent bulkheads on both ends of large diameter water and pressure sewer tunnels installed according to Standard Detail M/17.1 when the tunnel invert is less than or equal to twenty (20) feet. Provide the design for a permanent brick or concrete bulkhead on the plans.

3) Provide tunnel access manholes at both ends of large diameter water and pressure sewer tunnels installed according to Standard Detail M/17.1 when the tunnel invert is greater than twenty (20) feet. Provide tunnel access manholes according to Standard Detail M/17.5.

4) For gravity sewer tunnels installed according to Standard Detail M/17.0 that are to be grouted shut, the specifications requires the contractor to provide temporary bulkheads to facilitate grouting the annular space between the carrier pipe and the casing.

p. Carrier Pipe Tie-Downs.

1) When the annular space between a carrier pipe and casing pipe or tunnel is not grouted shut, such as the case for water pipelines and pressure sewers, provide permanent tie-down assemblies. All types of tie-downs are included in the Standard Details and depend on the material type and size of the tunnel or casing pipe as follow:

a) Refer to Standard Detail M/17.2 for hold down assembly for bore and jack steel casing pipes, Standard Detail M/17.3 for hold down assembly for steel liner plate and Standard Detail M/17.4 for hold down assembly for RCP casing pipes.

b) Refer to Standard Details M/17.6 and M/17.7 for casing spacers for supporting carrier pipes in small diameter casings installed according to Standard Detail M/17.6.

c) For sewer tunnels where the annular space between carrier pipe and the casing or tunnel is to be filled with concrete or grout, temporary supports to prevent pipe flotation are provided in accordance with Standard Detail M/17.0.

q. Ground Movement Monitoring.

1) Specify the locations of critical structures, surface or subsurface installations to be monitored other than those generally specified for roadway and railroad crossings in the Specifications. Take a minimum of three movement measurements on any critical structures during tunnel construction as follows:

a) Tunnel face is ten (10) feet before passing the structure.

b) Tunnel face is passing the structure.

c) Tunnel face is ten (10) feet beyond the structure.

2) Unless a more stringent criteria is required for a specific structure, the maximum allowable settlements or heaves are included in the Specifications.

3) Surface settlement markers and subsurface settlement indicators should be installed prior to the tunnel construction. Surface settlement markers can take the form of paint on a concrete surface, pk nail on the paved areas and a wood hub in unpaved areas. Details of subsurface settlement indicators are shown on Standard Detail M/7.0.

r. Codes.

1) Codes, standards, regulations, and recommended practices.

a) The American Society for Testing and Material Standards (ASTM).

b) Regulations of the Maryland Department of Transportation, State Highway Administration (MSHA).

c) Applicable regulations of affected Railroad Authorities.

d) Standard Details.

e) Occupational Safety and Health Administration (OSHA) 29 CFR 1926.

f) American National Standards Institute (ANSI) A10.16-1995 (R2001), Safety Requirements for Construction of Tunnel Shafts and Caissons.

g) American Concrete Institute (ACI) and American Institute of Steel Construction (AISC) Manuals.

h) The BOCA Basic Building Code with Montgomery County and Prince George's County Amendments.

i) Regulations of the State of Maryland.

j) Applicable Regulations of the Federal Government.

k) American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications.

l) American Railway Engineering Association (AREA) Design Manual.

m) NACE International Recommended Practices.

s. References.

a) Proctor, R. V. and White, T. L., 1977, Earth Tunneling with Steel Supports, Commercial Shearing, Inc., Youngstown.

b) Peck, R. B. et.al., November 1969, Some Design Considerations in the Selection of Underground Support Systems, Department of Civil Engineering, University of Illinois, Urbana.

c) Peck, R. B., 1969, Deep Excavations and Tunneling in Soft Ground, State of the Art Volume, 7th International Conference on Soil Mechanics and Foundation Engineering, Mexico City, pages 225 to 290.

d) Commercial Pantex Sika, Inc., Soft Ground Tunneling Catalog.

e) Warren Consolidated Industries, Inc., Tunnel Liner Plates Catalog.

f) Golder Associates and James F. Maclaren Ltd., 1976, Tunneling Technology: An Appraisal of the State of the Art for Application to Transit Systems.

g) Bickel, J. O. and Kuesel, T. R., 1982, Tunnel Engineering Handbook, Van Nostrand Reinhold Co.

h) NAVFAC, 1986, Soil Mechanics Design Manual 7.01.

i) NAVFAC, 1986, Foundation and Earth Structures Design Manual 7.02.

j) NAVFAC, 1982, Soil Dynamics, Deep Stabilization and Special Geotechnical Construction Design Manual 7.3.

k) Heuer, R.E. and Virgens, D.L., 1987, Anticipated Behavior of Silty Sands in Tunneling, Proceedings Volume 1, Rapid Excavation and Tunneling Conference, New Orleans, Louisiana, June 14-18, pages 221-237.

l) Winterkorn, H.F. and Fang, H.Y., 1975, Foundation Engineering Handbook, Van Nostrand Reinhold Company.

m) TENG, W.C. 1962, Foundation Design, Prentice Hall, Inc., Englewood Cliffs, N.Y.

n) Spangler, M.G. & Handy, R.L., 1982, Soil Engineering, Harper & Row Publishers, N.Y.

28. Corrosion Control.

a. Abbreviation.

NACE National Association of Corrosion Engineers (NACE International)

b. General.

1) This section includes the specific corrosion control design requirements for buried ductile iron pipe and general guidance on the type of corrosion control to be provided for other ferrous metal pipelines. The topics addressed include when corrosion control is necessary, design and submittal procedures, and site evaluation criteria for selecting the type of corrosion control required.

2) Future/proposed extension of WMATA Metrorail lines and Maryland Transit Administration (MTA) Rail Lines, see Table "32" (Stray Current Analysis).

3) All ferrous metal pipelines, particularly ductile iron and steel are to be evaluated to determine what corrosion control measures will be required. The specific pipe sizes, materials, and conditions which are to be evaluated for corrosion control include:

a) All sizes of Ductile Iron Pipe (DIP). Corrosion control is required for all buried DIP as follows:

(1) DIP smaller than 16-inch. Generally, polyethylene encasement will be used on all pipes in this size range and can be expected to provide adequate corrosion control except when stray currents are encountered or anticipated. Follow the procedures and guidelines in this section to evaluate the pipeline for sources of stray currents. Determine the type of material of the existing pipe that is being connected to in order that protection can be provided against galvanic corrosion between dissimilar pipe metals. Also, determine if the existing pipe has some form of corrosion control. Based on stray current and existing pipe analyses, protection beyond that provided by polyethylene encasement may be required, such as coating DIP or selecting coated steel pipe or a non-metallic pipe material.

(2) 16-inch and larger DIP. Ductile iron water pipelines 16-inch and larger at a minimum will require polyethylene encasement. Complete evaluation is required to determine the corrosion control requirements as outlined in this section.

b) All sizes of exposed (non-buried) DIP. Provide paint or coating material to protect the pipe from the environmental effects to which it is exposed such as road salts, submersion, etc. The analysis and design guidelines for exposed DIP are not included in this section.

c) All sizes of steel pipe. Corrosion control is required for all exposed and buried steel pipe. This includes pipe coatings, cathodic protection, electrical isolation and a cathodic protection monitoring system. The analysis and design guidelines for steel pipe are not included in this section.

4) Corrosion design qualifications. A Corrosion Engineer, a NACE Certified Senior Corrosion Technologist or a NACE Certified CP or Corrosion Specialist is required to oversee all work required under this section of the Pipeline Design Manual.

5) Test station numbering. If the design requires corrosion monitoring test stations, WSSC will provide the test station numbering. Existing test stations are numbered and recorded on control cards on file at WSSC. Show on drawings the location and number of the existing test stations.

c. Corrosion Design Procedure and Submittal Requirements.

1) The corrosion control design procedure consists of up to three (3) submittal stages. A detailed description of the submittal requirements is included below. For convenience, the submittals for stages one and two are standard forms, a checklist and a documentation form contained at the end of this section. The third submittal consists of the corrosion design drawings and specifications, which are required, only if more stringent corrosion control measures prove to be necessary. A summary of the three specific submittal stages is as follows:

a) First submittal. For all ductile iron pipe sizes, submit the completed Corrosion Survey Checklist including preliminary plans showing the pipeline alignment and proposed soil boring locations as required in Appendix "E" (Subsurface Investigation Requirements for Water and Sewer Design and Construction). Detailed instructions for completing the Checklist are included at the end of this section. Perform the Existing Pipe Analysis as indicated in this section and include the results from Chart "D" on the Checklist in the space provided.

b) Second submittal.

(1) DIP smaller than 16-inch. If there are no sources of stray currents or any additional corrosion considerations from the checklist, then submit plans with corrosion control provisions if connecting to existing pipe according to Chart "D". If there are stray current sources complete the Stray Current Analysis and submit the results along with the completed Corrosion Documentation Form "B".

(2) DIP 16-inch and larger. Perform the Stray Current Analysis and Soil Condition Analysis and submit the results along with the completed Corrosion Documentation Form "B", including the recommended corrosion control measures.

c) Third submittal. DIP 16-inch and larger and DIP smaller than 16-inch with stray current submit plans and specifications, including the corrosion control design, if required.

d. Soil Condition Analysis.

1) A Soil Condition Analysis is required for all 16-inch and larger water pipelines.

2) Obtain soil samples along the alignment in accordance with Appendix "E" (Subsurface Investigation Requirements for Water and Sewer Design and Construction). Perform laboratory or field tests (in situ, where appropriate) for pH, chloride content, redox potential, soil description, and soil resistivity on soil samples taken at the pipeline depth. Intervals of the soil samples should not exceed one thousand (1000) feet, unless the pipeline alignment is less than two thousand (2000) feet in length, then the intervals should not exceed seven hundred (700) feet. A minimum of two (2) soil samples is required for each pipeline alignment.

2) Consideration must also be given to the possible exposure to roadway deicing salt. If the pipeline is located next/parallel to and below the bottom of a roadway ditch, follow the recommendations in Chart "D", under Stray Current Analysis, Moderate Exposure for the corrosion control requirements.

4) Decision Process.

(1) Obtain laboratory or field results from soil sample tests. Using the Analysis Type and Analysis Range columns in Table "30" determine Points that will apply to each Analysis Type and total them to get the "Overall Corrosivity Rating" from Table "31" for the condition of the pipeline trench.

(2) Match Overall Corrosivity Rating Total Points from Table "31" with Chart "C" and obtain a preliminary determination of the corrosion control requirements.

TABLE "30"

Soil Condition Analysis

ANALYSIS TYPE	ANALYSIS RANGE	POINTS	ANALYSIS TYPE	ANALYSIS RANGE	POINTS
PH	0 – 2	5	Soil Description	Clay (Blue-Gray)	10
	2 – 4	3		Clay/Stone	5
	4 – 8.5	0		Clay	3
	> 8.5	3		Silt	2
Chloride Content	> 1000 ppm	10		Clean Sand	0
	500 – 1000 ppm	6		---	--
	200 – 500 ppm	4	Soil Resistivity	< 1,000 ohm-cm	10
	50 – 200 ppm	2		1,000 – 1,500 ohm-cm	8
	0 – 50 ppm	0		1,500 – 2,500 ohm-cm	6
Redox Potential	Negative	5		2,500 – 5,000 ohm-cm	4
	0 – 100 mV	4		5,000 – 10,000 ohm-cm	2
				> 10,000 ohm-cm	0
	> 100 mV	0		---	--

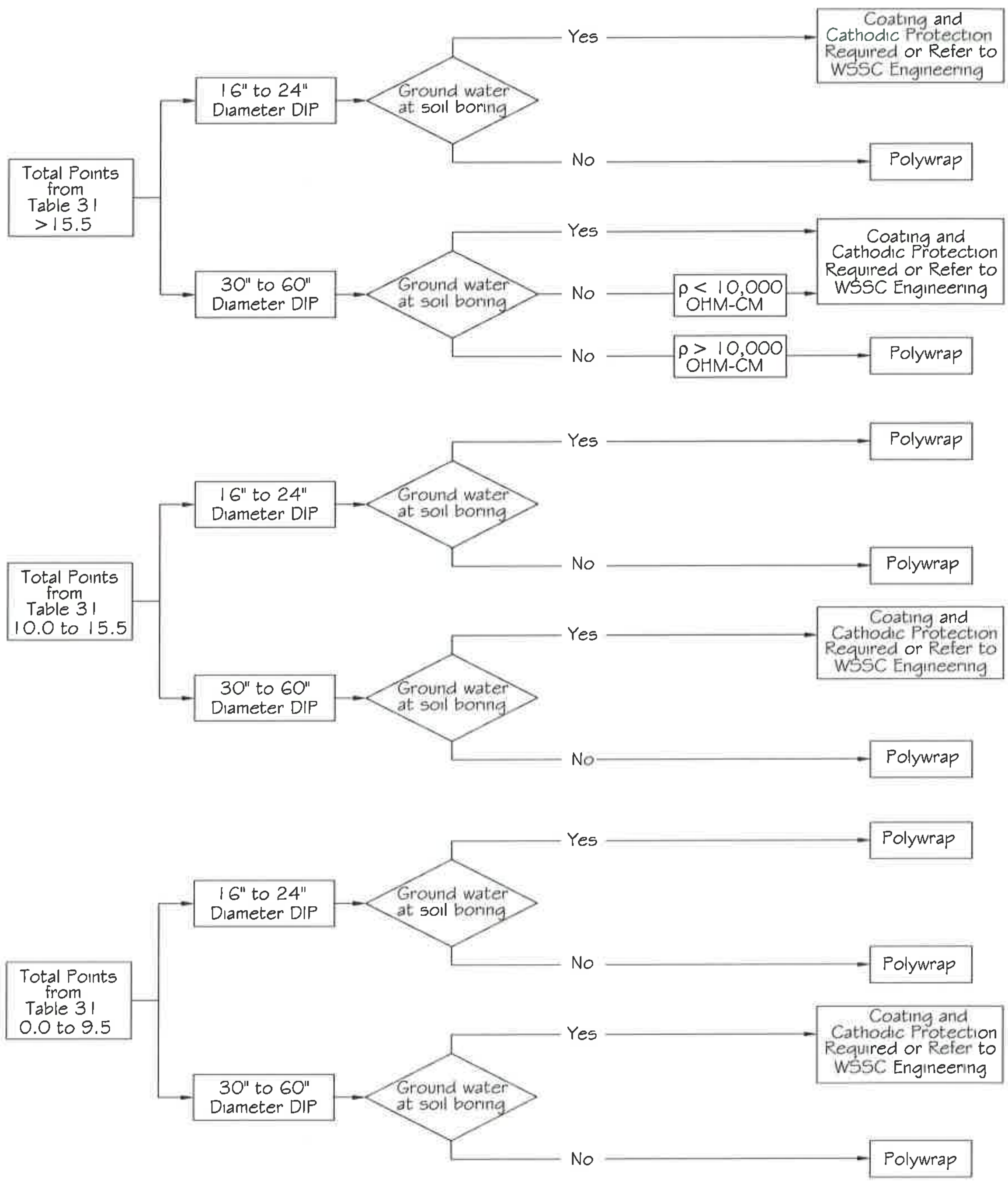
TABLE "31"

Overall Corrosivity Rating

SOIL CORROSIVITY	TOTAL POINTS
Severe	> 15.5
Appreciable	10.0 – 15.5
Moderate	5.0 – 9.5
Mild	0 – 4.5

5) Not included in Table "30" and "31" are conditions for stray current exposure, road salt run-off and foreign pipeline crossing.

6) Table "30" and "31" are adapted from Table 20.1 "Assessment of Overall Soil Corrosivity to Steel", C.P. Dillon *Corrosion Control in the Chemical Process Industries*. Materials Technology Institute of the Chemical Process Industries, 1994.



NOTES:

1. "Polywrap" means polyethylene encasement in accordance with WSSC specifications.
2. "Coating" means a bonded high performance coating.

CHART "C"

Flowchart - Overall Soil Corrosivity Rating Points for DIP

e. Stray Current Analysis.

1) A Stray Current Analysis is required for all sizes of water pipelines.

2) First, identify the source of stray currents. Examples of stray current sources are listed below:

a) Impressed current cathodic protection systems which may be located along natural gas and petroleum products pipelines, at bulk storage facilities with ground level or buried tanks, at gas stations with buried steel storage tanks, along buried pipe-type oil filled high voltage cables, along buried telephone cables, and at public or private housing complexes with on-site gas distribution systems (including military bases).

b) Electrified rail systems, such as at-grade WMATA Metrorail lines, subway WMATA Metrorail lines and Maryland Transit Administration (MTA).

c) Welding shops and other industrial facilities.

3) Testing for Stray Current.

a) When there is an existing stray current source within two thousand (2000) feet of water pipeline, use a recording type instrument for detecting possible stray current influence. A Corrosion Engineer, a NACE Certified Senior Corrosion Technologist or a NACE Certified CP or Corrosion Specialist is to oversee the stray current testing.

b) No testing is required if there are no stray current sources identified within two thousand (2000) feet or if the ductile iron pipeline will be within two hundred (200) feet of WMATA Metrorail lines. When within 200 feet of WMATA Metrorail lines, take protective measures in accordance with "Severe Exposure" in Table "32".

4) Decision Process.

a) Make a site visit and determine the presence of possible stray current sources and perform testing as required to verify and quantify stray current in the vicinity of the pipeline.

b) Using Table "32" determine the level of exposure to stray currents and go to Chart "D", to determine what, if any, corrosion control measures are needed.

5) For the purpose of this analysis, *ground bed* refers to impressed current cathodic protection anodes, and *foreign* refers to another buried utility pipe or cable, including an existing WSSC pipeline. Foreign pipe that is not of concern includes non-metallic materials such as PVC and prestressed concrete cylinder pipe that typically does not have impressed current cathodic protection.

TABLE "32"

Stray Current Analysis

Exposure Level to Stray Currents	Pre-Construction Survey and Test Results
SEVERE EXPOSURE	• Continual stray current that results in more than 50 mV potential variation (any source). • WMATA Metrorail lines or Maryland Transit Administration (MTA), that are within 200 feet of the pipeline. • Future/proposed extension of WMATA Metrorail lines or Maryland Transit Administration (MTA), within 500 feet of the pipeline. • Cathodically protected foreign buried pipes or cables that cross or come within 100 feet of the pipeline and have a ground bed within 2000 feet.
MODERATE EXPOSURE	• Moderate or sporadic stray current that results in 50 mVor less potential variation (any source). • WMATA Metrorail lines or Maryland Transit Administration (MTA), that are between 200 to 500 feet of the pipeline. • Cathodically protected foreign buried pipes or cables that are within 100 to 500 feet of the pipeline and have a ground bed within 2000 feet or that cross the pipeline and have a ground bed over 2000 feet away.
NO EXPOSURE	• No stray current detected during testing. • WMATA Metrorail lines or Maryland Transit Administration (MTA), beyond 500 feet away from the pipeline. • Cathodically protected foreign utility buried pipes and cables are more than 500 feet away from the pipeline.

f. Existing Pipe Analysis.

1) An Existing Pipe Analysis is required for all sizes of water pipelines. Determine what corrosion control measures will be required at the connection between the existing and new pipeline(s).

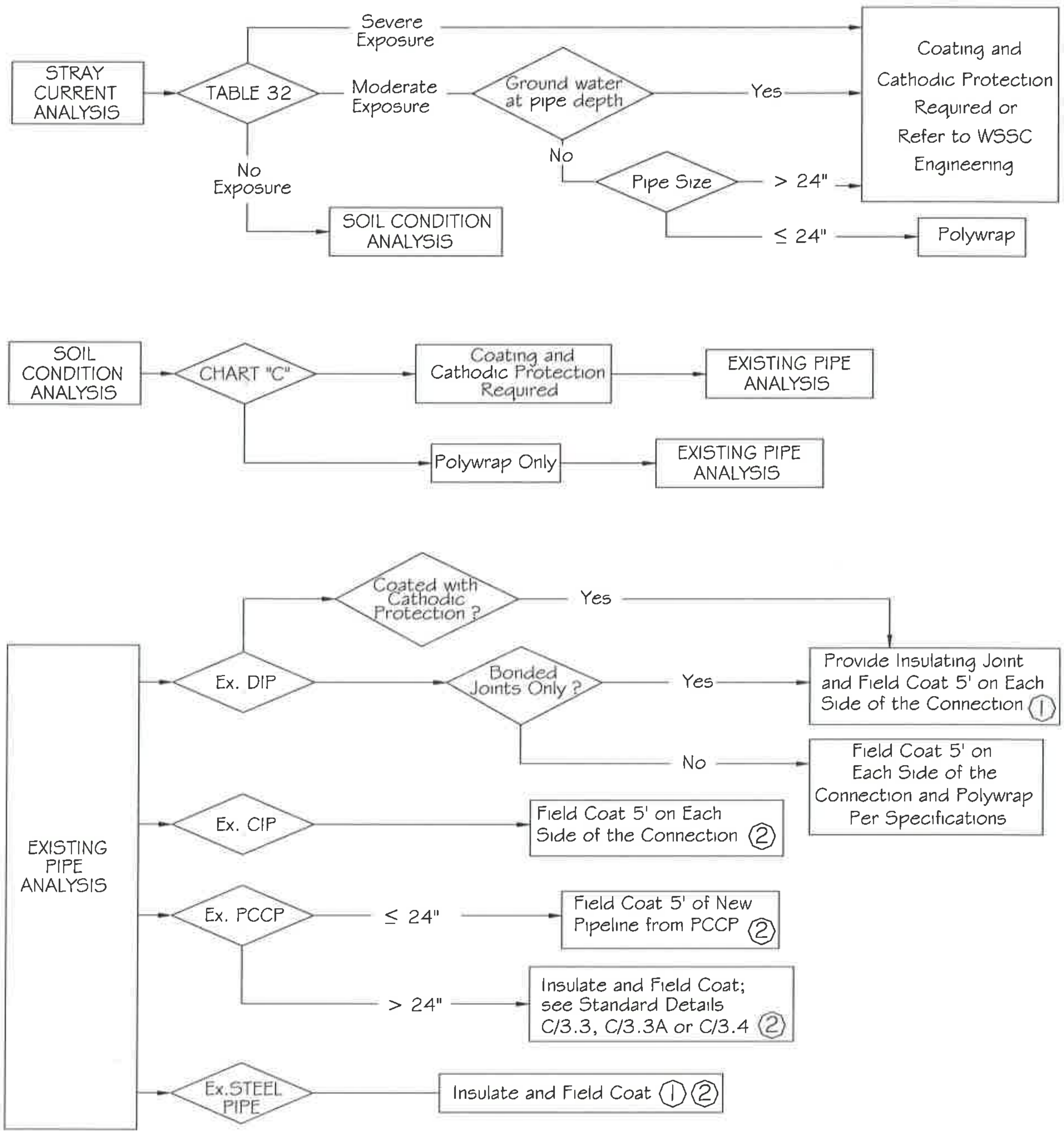
2) Determine if any corrosion control measures were used on the existing pipe to which the new pipe will be connected.

3) Identify the existing pipeline material (ductile iron, cast iron, prestressed concrete cylinder, steel, etc.).

4) Decision Process.

a) Using Chart "D" and the type of existing pipe material, determine what corrosion control measures are required.

b) If Stray Current Analysis indicates Moderate or Severe Exposure these results shall supersede the results of the Soil Condition Analysis and Existing Pipe Analysis.



① If existing pipe has a bonded coating (epoxy, coal tar enamel, polyethylene back tape, etc.), over lap field coating onto existing pipe coating a minimum of 6".

② When polywrap is used on new pipe, overlap it onto the field coating.

CHART "D"

Corrosion Control Decision Tree For New Ductile Iron Pipelines

g. Corrosion Survey Checklist.

1) The information below includes instructions on how to complete the Corrosion Survey Checklist and describes the items on the checklist in greater detail. Select an alignment that avoids areas where special corrosion control measures are likely to be required. Note the results of the investigation of these issues on the Corrosion Survey Checklist and include the completed checklist with the **first submittal**.

a) Complete the existing pipe analysis for all connecting pipe sizes, to include type of pipe material, sizes, pipeline type, existing corrosion control, if any, and corrosion control required from Chart "D".

b) Identify the sources of stray currents, including buried utilities or transportation facilities in the vicinity (crossing, parallel or within two thousand (2000) feet) of the pipeline alignment that may be a source of stray current. Potential stray current sources are listed below.

(1) Washington Metropolitan Area Transit Authority (WMATA) DC transit lines and Maryland Transit Administration (MTA), especially surface routes.

(2) Petroleum Product or Natural Gas pipelines with impressed current cathodic protection systems.

(3) Direct Burial or Pipe Type communication or power cables with impressed current cathodic protection systems.

(4) Overhead mounted high voltage electrical lines that are in a parallel right of way.

(5) Service stations with impressed current cathodic protection systems for buried fuel tanks and pipes.

c) Indicate on the checklist, if the pipeline will be exposed to any of the following corrosive conditions which will impact the corrosion rate of a metallic pipeline and influence the selection of pipe coatings or the need for cathodic protection or alternative materials.

(1) Deicing salt exposure, typically encountered when the pipeline is located beneath a roadway stormwater drainage ditch, infiltration trench, etc.

(2) Relocation of pipelines in older areas where the streets have cinders that may have been dumped before the streets were paved.

(3) Exposure to chemical or animal waste runoff from nearby farms.

(4) Wetlands and sites containing significant deposits of organic soils, such as peat.

(5) Pipe exposed to continuously wet or submerged environments.

(6) Cyclic wetting and drying due to a fluctuating groundwater table.

(7) Soil type generally corrosive to buried metals, as indicated in the United States Department of Agriculture Soil Conservation Services Soil Surveys for Prince George's County and Montgomery County, such as acid sulfate soils.

(8) History of pipe leaks or breaks in the vicinity.

(9) Proximity of highly break or leak sensitive land use features, such as alignments directly adjacent to large structures or within dams.

(10) Size and importance of the pipeline. Water pipelines 16-inch and greater are typically candidates for more stringent corrosion control measures. For all water pipelines 16-inch and greater, perform the soil and groundwater testing indicated at the bottom of the checklist and submit the results with the **second submittal**.

(11) If the pipeline will be connected to an existing pipeline or another pipeline which was or will be constructed with dissimilar metal that may create conditions for a galvanic corrosion cell, identify the type and size of the existing pipe and the original WSSC contract number. For prestressed concrete cylinder pipe, also identify the manufacturer's project number and if the pipe is embedded cylinder type (SP-12) or lined cylinder type (SP-5). Also, identify the type of corrosion control on the existing pipeline, if any.

h. FORM "B" Corrosion Documentation.

1) Following the completion of any required Soil Condition Analysis, Stray Current Analysis and Existing Pipe Analysis complete the Corrosion Documentation, Form "B" and submit it with the **second submittal**.

2) Determine what type of corrosion control is required and indicate the type at the bottom of Form "B".

CORROSION SURVEY CHECKLIST

PROJECT NAME ______________________ CONTRACT NO.: ____________________________

PREPARER (Please print): _________________________ TITLE: _______________________

SIGNATURE OF PREPARER: _______________________ DATE: _______________________

a) Existing Pipe Analysis: (all pipe sizes).

Size(s) _______

Connecting to:
- ____ CIP
- ____ DIP
- ____ PCCP
- ____ Steel
- ____ Other

Pipeline Type:
- ____ Water Pipeline
- ____ Force Main
- ____ Other _______________

Existing Pipe Corrosion Control:
- ____ none
- ____ Bonded Joints
- ____ Coated: Type: _______________
- ____ Cathodic Protection: Type: ____ Galvanic Anodes
  ____ Impressed Current

Note: Provide any additional supporting information on a separate sheet of paper.

Corrosion Control Required (from Chart "D"): ____

b) Identify Sources of Stray Currents (crossing, parallel or within 2000 feet).

(1) Yes [] No [] WMATA DC transit lines and Maryland Transit Administration (MTA), especially surface routes.
(2) Yes [] No [] Petroleum or Product or Natural Gas pipelines with impressed current cathodic protection systems.
(3) Yes [] No [] Direct Burial or Pipe Type communication or power cables with impressed current cathodic protection systems.
(4) Yes [] No [] Overhead high voltage electrical lines that are in a parallel right of way.
(5) Yes [] No [] Service stations with impressed current cathodic protection systems.

c) Additional Corrosion Considerations.

(1) Yes [] No [] Exposure to deicing salts.
(2) Yes [] No [] Relocation in older streets.
(3) Yes [] No [] Exposure to chemical or animal waste runoff from nearby farms.
(4) Yes [] No [] Wetlands and sites containing significant deposits of organic soils, such as peat.
(5) Yes [] No [] Pipe exposed to continuously wet or submerged environments.
(6) Yes [] No [] Cyclic wetting and drying due to a fluctuating groundwater table.
(7) Yes [] No [] Soil type generally corrosive to buried metals (i.e., acid sulfate soils).
(8) Yes [] No [] History of pipe leaks or breaks in the vicinity.
(9) Yes [] No [] Proximity to highly break or leak sensitive areas (dams, buildings, bridges, etc.).
(10) Yes [] No [] Size and importance of the proposed pipeline. Water pipelines 16-inch or larger? If yes, perform the soil and groundwater testing indicated below and include the results with the second submittal.
(11) Yes [] No [] Connecting to dissimilar pipe materials? If yes, indicate type(s) of pipe _______ and type of corrosion control on the existing pipe, if any. ______________________

d) Field Soil And Groundwater Testing Requirements for All Ductile Iron Pipelines 16-inch and Larger. (See Appendix "E" for Specific Testing Requirements; submit with <u>second submittal</u>).

(1) Redox potential (ASTM D 1498) of <u>soil</u> at the proposed pipe depth.
(2) Water soluble chloride content (ASTM D 512) of <u>soil</u> at the proposed pipe depth. Chloride ion extraction using accepted industry methodology prior to testing.
(3) Carbon Dioxide (CO_2) content (ASTM D 513) of <u>groundwater</u>, if present.

FORM "B"
Corrosion Documentation

Date________________

1. Job Description:

Contract Number ______________________ Location: ____________________________

County ______________________ Map Book Page: __________ Map Book Grid: ________

Type of Job: ______ New Pipeline. ______ Relocation. ______ Other: ______________

New Pipe: Size(s): _____ Type of Pipeline

___ DIP ___ Water Pipeline

___ Steel ___ Force main

___ PCCP ___ Other ______________________

2. Site Evaluation:

a) Existing Pipe Analysis: (all pipe sizes).

Size(s) ________ Existing Pipe Corrosion Control:

Connecting to: ___ none

___ CIP ___ Bonded Joints

___ DIP ___ Coated: Type: ______________________

___ PCCP ___ Cathodic Protection: Type: _____ Anodes

___ Steel _____ Impressed Current

___ Other

Corrosion Control Required (from Chart "D"): ______________________________

b) Stray Current Analysis: (all pipe sizes).

___ Cathodically Protected Gas Lines or Natural Gas Pipelines:

___ Impressed Current.___ Magnesium Anode. ___ Proximity of Ground Beds (feet): ______

___ Electric: Direct Burial Cables. ____ Pipe-Type Cables ___ Overhead High Voltage. ___

___ Telephone.

___ WMATA Rail Line:

___ Parallel (feet): _____ ___ Crossing. ___ Subway. ___ At Grade.

___ Other: ____

c) Soil Condition Analysis: (16-inch and larger pipeline).

___ Soil Borings: Groundwater. ___ Clay soil. ___ Mixed Soil. ___

___ Soil Chemical Analysis:

pH. ____________________ Chlorides (ppm):________________

Sulfate (ppm) ________________ Resistivity (ohm-cm): ______________

Redox Potential (mv) __________ Others: ____________________

___ County Soil Survey – Risk of Corrosion:

___ Low. ___ Medium. ___ High.

___ Potential for Exposure to Road Salts.

___ Other: ____

3. Corrosion Control Requirements:

___ Liquid Epoxy Coating. ___ Bonded Joint(s). ___ Field Applied Mastic Coating.

___ Tape Coating. ___ Insulated Joint(s). ___ Polyethylene Encasement.

___ Cathodically Protect Pipe. ___ Install Test Station(s).

___ Other: ____

___ Remarks: ____