SPECIFICATIONS

FOR

PIPELINE OCCUPANCY

OF

NORFOLK SOUTHERN CORPORATION

PROPERTY

INDEX

APPENDIX

Specifications for Pipeline Occupancy of Norfolk Southern Property

1.0 GENERAL

1.1 Scope

A. This specification shall apply to the design and construction of pipelines carrying flammable or non-flammable substances. This specification shall also apply to tracks owned by others (sidings, industry tracks, etc.) over which NS operates its equipment.

B. It is to be clearly understood that NS owns its right-of-way for the primary purpose of operating a railroad. All occupancies shall therefore be designed and constructed so that rail operations and facilities are not interfered with, interrupted or endangered. In addition, the proposed facility shall be located to minimize encumbrance to the right-of-way so that the railroad will have unrestricted use of its property for current and future operations.

1.2 Definitions

A. NS	-	Norfolk Southern Corporation
B. Applicant	-	Individual, corporation or municipality desiring occupancy of NS property
C. Professional Engineer	-	Engineer licensed in the state where the facilities are to be constructed
D. Carrier Pipe	-	Pipe used to transport the product
E. Casing Pipe	-	Pipe through which the carrier pipe is installed
F. Sidings or industry tracks	-	Tracks located off NS's right-of-way, serving an industry

1.3 Application for Occupancy

A. Individuals, corporations, or municipalities desiring occupancy of NS property by pipeline occupations must agree, upon approval of the engineering and construction details by NS, to execute an appropriate NS occupational license and pay any required fees and/or rentals specified therein.

B. The application process and guidelines for a pipeline crossing occupancy can be found at www.nscorp.com, then follow links for "Customers", "Real Estate", "Wireline/Pipeline and Fiber Optics"

C. All applications shall be submitted through the web based application portal at https://ns.railprospermitting.com with a PDF copy of all design and construction plans, and a PDF copy of all specifications and engineering computations for the proposed occupancy. On extensive projects, only those plans involving work on, or affecting NS property and operations, shall be submitted. Included shall be a plan showing the extent of the total project upon which that portion of the work affecting NS is clearly defined.

D. All of the above plans, specifications and computations must be prepared by and bear the seal of a Professional Engineer licensed in the state the project is located.

1.4 Right of Entry

A. No entry upon NS property for the purpose of conducting surveys, field inspections, obtaining soils information or any other purposes associated with the design and construction for the proposed occupancy, will be permitted without a proper entry permit prepared by NS. The applicant must pay the associated fees and execute the entry permit.

B. It is to be clearly understood that the issuance of an entry permit does not constitute authority to proceed with any construction. Construction cannot begin until a formal agreement is executed by NS and the applicant receives permission to proceed with the work, from the designated construction monitoring agency of NS.

C. The application for a Right of Entry permit shall be obtained at www.nscorp.com, then follow links for Real Estate > NS Services > Access NS Property.

1.5 Site Inspection

A. For longitudinal occupancy of NS property, a site inspection along the proposed pipeline route may be required before final design plans are prepared. When a site inspection is required, the applicant and/or his engineer must meet with representatives of NS to view the entire length of the proposed occupancy.

B. Prior to the site inspection the applicant must submit the following information through the application portal:

(1) A plan view of the proposed route showing all tracks, both NS right-of-way lines and all other facilities located on the right-of-way. The distance from the proposed pipeline to the adjacent track and to the right-of-way lines must be shown.

(2) A complete "Pipe Data Sheet" (See Plate I)

(3) Typical cross sections along the proposed route. (See Plate V)

C. Site inspections for pipe crossings are not required unless, in the opinion of NS, the size and location of the facility warrant an inspection.

1.6 Information Required for Submission

1.6.1 Plans and Computations

A. Plans for proposed pipeline occupancies shall be submitted to and approved by NS prior to NS issuance of an agreement and start of construction.

B. Plans are to be prepared in 11" x 17" size and submitted in a PDF format. Failure of the applicant to comply with these requirements may be sufficient cause for rejection of the application.

C. Plans shall be drawn to scale, dimensioned with US Customary Units, and shall include the following (See Plates I to IX):

(1) Plan view of proposed pipeline in relation to all NS facilities and facilities immediately adjacent to

NS including, but not limited to, tracks, buildings, signals, pole lines, other utilities and all other facilities that may affect or influence the pipeline design and construction. (See Plate II)

(2) The location, in feet, of the pipe crossing from the nearest centerline of an NS bridge, giving the NS bridge number. If the above is not available, provide distance to the nearest highway grade crossing of the railroad and the DOT number posted at the highway grade crossing, if available.

(3) In all cases, the name of the State and County in which the proposed facilities are located must be shown. In States where Townships, Ranges and Sections are used, show the distance in feet to the nearest Section line and identify the Section number, Township and Range.

(4) The profile of the ground above the centerline of the pipe, from field survey, showing relationship of the pipeline and/or casing pipe to the ground levels, the tracks and other facilities, (See Plate III). For longitudinal occupations, the top of rail profile of the adjacent track shall be shown on the pipeline profile, (see Plate IV).

(5) All NS property lines indicated by dimensions, in feet, to the centerline of adjacent track, as well as the overall width of the NS right-of-way. If the pipeline is in a public highway, the limits of the dedicated highway right-of-way, as well as the limits of any paving, sidewalks etc., shall be defined, by dimensions in feet, from the centerline of the dedicated right-of-way,

(6) The angle of the crossing in relation to the centerline of the tracks(s). (See Plate II)

(7) On pipelines having valves, the distance in feet along the pipeline from the crossing to the nearest valves and/or control stations.

(8) A separate "Pipe Data Sheet" (See Plate I) shall be submitted on an 8 ½" x 11" sheet, for each crossing.

D. The plan shall be specific, on NS property and under tracks that are not on NS property, as to the:

(1) Method of installation. (See Section 5.1)

(2) Size and material of the casing pipe. (See Section 4.3)

(3) Size and material of the carrier pipe. (See Section 4.4)

These items **cannot** have an alternative and any application that is received that indicates options in any of the above items **will not be processed.**

E. Once the application has been approved by NS, no variance from the plans, specifications, method of installation, construction, etc., as approved in the occupancy document, will be considered or permitted without the payment to NS of additional fees for the re-processing of the application.

F. All plans and computations associated with the work under the agreement shall be prepared by, and bear the seal of, a licensed Professional Engineer in the state where the work will take place. If not so imprinted, the application will be given no further consideration. This requirement also applies to all data submitted by the applicant's contractor. Contractor's plans and computations that are not stamped will be returned and construction will not be permitted to proceed.

1.6.2 Specifications

A. Project specifications, for all work on and affecting the NS right-of-way, shall be included with the submission. All pertinent requirements of this document shall be included.

1.7 Notification to Proceed with Construction

A. After approval of the engineering plans and specifications and execution of the occupational agreement, the applicant will be notified of the appropriate NS representative that must be contacted prior to start of construction. The NS representative will coordinate all other construction aspects of the project that relate to NS, including but not limited to, construction monitoring, flagging, track work, and protection of signal cables.

2.0 GENERAL REQUIREMENTS

2.1 Use of a Casing Pipe

A. A casing pipe will be required for all pipeline crossings carrying liquid flammable or non-flammable substances under pressure.

B. For flammable and nonflammable gas pipelines the casing pipe may be omitted provided the carrier pipe meets the requirements provided in the AREMA Manual Chapter 1, Part 5, Section 5.2.3. NS may require use of a casing pipe at locations where increased risks from specific site conditions (track speed, traffic density, etc.) are present.

C. Pressure pipelines that do not cross under the track but are located within 30 feet of the centerline of any track or closer than 45 feet to nearest point of any bridge, building or other important structure, shall be encased.

D. The casing pipe shall be laid across the entire width of the right-of-way, except where a greater length is required to comply with Section 4.3.1.F. of this specification, even though such extension is beyond the right-of-way. For non-pressure sewer or drainage crossing, where a casing is used for carrier pipe installation purposes only, the casing need only to extend from the boring pit to the receiving pit.

2.2 Location of Pipeline on the Right-of-Way

A. Pipelines laid longitudinally on NS right-of-way shall be located as far as practicable from any tracks or other important structures and as close to the railroad property line as possible. Longitudinal pipelines must not be located in earth embankments or within ditches located on the right-of-way.

B. Pipelines shall be located, where practicable, to cross tracks at approximate right angles to the track, but preferably at not less than 45 degrees.

C. Pipelines shall not be placed within a culvert, under railroad bridges, nor closer than 50 feet to any portion of any railroad bridge, building, or other important structure, except in special cases, and then by special design, as approved by NS Engineering.

D. Pipelines shall not be located within 50 feet of a turnout (switch) when crossing the track. The limits of the turnout extend from the point of the switch to the last long timber.

E. Pipeline shall not be located within 50 feet of a control point area. The limits of the control point area are governed by the signal system regulating the control point.

F. Pipeline installations shall not be designed as an open cut installation where the pipeline is to be located within the limits of a grade crossing. If it is shown that no other method of installation is possible, the applicant will be responsible for reimbursing NS for all costs associated with the removal and reconstruction of the grade crossing.

G. Pipelines carrying liquefied petroleum gas shall, where practicable, cross the railroad where tracks are carried on embankment.

H. Longitudinal uncased gas pipelines must not be located within 30 feet of any track.

2.3 Depth of Installation

2.3.1 Pipelines Conveying Non-Flammable Substances

A. Casing/carrier pipes placed under NS track(s) shall be not less than 5 ½ feet from base of rail to top of pipe at its closest point, except that under sidings or industry tracks this distance may be 4 ½ feet as approved by NS. On other portions of the right-of-way, where the pipe is not directly beneath any track, the depth from ground surface will be 4 feet or from bottom of ditch to top of pipe shall not be less than 3 feet.

B. Pipelines laid longitudinally on NS right-of-way, 50 feet or less from centerline track, shall be buried not less than 4 feet from ground surface to top of pipe. Where the pipeline is laid more than 50 feet from centerline of track, the minimum cover shall be at least 3 feet.

2.3.2 Pipelines Conveying Flammable Substances

A. Casing pipes under NS track(s) shall be not less than 5 ½ feet from base of rail to top of pipe at its closest point, except that under sidings or industry tracks this distance may be 4 ½ feet as approved by NS. On other portions of the right-of-way, where the pipe is not directly beneath any track, the depth from ground surface will be 4 feet or from bottom of ditch to top of pipe shall not be less than 3 feet.

B. Uncased gas pipelines, under NS track(s), shall not be less than 10 feet from the base of rail to the top of the pipe at its closest point. At all other locations where crossing the right-of-way, the minimum ground cover must be 6 feet. Where it is not possible to obtain the above depths, use of a casing pipe will be required.

C. Pipelines laid longitudinally on NS's right-of-way, 50 feet or less from centerline track, shall be buried not less than 6 feet from ground surface to top of pipe. Where the pipeline is laid more than 50 feet from centerline of track, the minimum cover shall be at least 5 feet.

2.4 Pipelines Within Limits of a Dedicated Highway

A. Pipelines within the limits of a dedicated highway are subject to all the requirements of this specification and must be designed and installed in accordance with them.

B. The limits of the dedicated highway (right-of-way) must be clearly shown on the plans.

C. Construction cannot begin until an agreement has been executed between NS and the applicant and proper notification has been given to NS 's authorized representative. (See Section 1.7)

D. Pipelines shall maintain a minimum horizontal clearance of 4-feet, or if within 4-feet, a minimum vertical clearance of 10-feet from the base of any railroad signal apparatus.

2.5 Modification of Existing Facilities

A. Any replacement or modification of an existing carrier pipe and/or casing shall be considered as anew installation, subject to the requirements of this specification.

2.6 Abandoned Facilities

A. The owner of all abandoned pipe crossings and other occupancies shall notify NS in writing of the intention to abandon. The owner of pipe crossings and other occupancies shall submit to NS a request to abandon through the application portal and shall include its abandonment plans.

B. Abandoned pipelines shall be removed or completely filled with cement grout, compacted sand or other methods as approved by NS.

C. Abandoned manholes and other structures shall be removed to a minimum distance of 3 feet below finished grade and completely filled with cement grout or compacted sand.

D. Grouting Standards

2.7 Conflict of Specifications

A. Where laws or orders of public authority prescribe a higher degree of protection than specified herein, then the higher degree so prescribed shall be deemed a part of this specification.

2.8 Insulation

A. Pipelines and casings shall be suitably insulated from underground conduits carrying electric wires on NS property.

2.9 Corrosion Protection and Petroleum Leak Prevention

A. Pipelines on NS property that carry petroleum products or hazardous liquids shall be designed in accordance with current federal, state and/or local regulations that mandate leak detection automatic shutoff, leak monitoring, and sacrificial anodes and/or exterior coatings to minimize corrosion and prevent petroleum releases.

3.0 SOIL INVESTIGATION

3.1 General

A. Test borings or other soil investigations approved by NS shall be made to determine the nature of the underlying material for all pipe crossings 60 inches in diameter and larger under track(s). (See section 1.4 relative to procedures)

B. Test borings or other soil investigations, approved by NS, may be required when, in the judgement of NS, they are necessary to determine the adequacy of the design and construction of pipe crossings less than 60 inches in diameter and for other facilities located on the right-of-way.

3.2 Location

A. Borings shall be made on each side of the track(s), on the centerline of the pipe crossing, and as close to the track(s) as practicable. (See Section 1.4 relative to procedures)

B. Test boring logs shall be accompanied with a plan, drawn to scale, showing the location of the borings in relation to the track(s) and the proposed pipe.

3.3 Sampling

A. Test borings shall be conducted by a qualified firm using current methods approved by ASTM for soil sampling. Boring logs and soil data shall be accompanied by an analysis of the pertinent soil characteristics and their impact on the project as it relates to the railway by a certified Geologist or licensed Professional Engineer

3.4 Boring Logs

A. Test boring logs shall clearly indicate all of the following:

(1) Boring number as shown on the required boring location plan.

(2) Ground elevation at each boring using same datum as the pipeline construction plans.

(3) Engineering description of soils or rock encountered.

(4) Depth and percent recovery of all soil samples.

(5) Depth from surface for each change in strata.

(6) Blows for each 6 inches (152mm) of penetration for the standard penetration test described in ASTM D 1586. Blows for lesser penetrations should be recorded.

(7) Percent recovery and Rock Quality Designation (RQD) for all rock cores.

(8) Depth to ground water while sampling and when it has stabilized in the bore hole.

B. The location of the carrier pipe and/or casing pipe shall be superimposed on the boring logs before submission to NS.

C. All borings shall be sealed, for their full depth, with a 4-3-1 bentonite-cement-sand grout after accurate ground water readings have been taken and recorded.

D. Soil samples taken from auger vanes or return wash water are not acceptable.

3.5 Additional Information

A. When directed by NS, additional borings may be required for the purpose of taking undisturbed thin-wall piston samples or Dennison type samples for laboratory testing to determine the index and engineering properties of certain soil strata.

B. The geotechnical report shall access the risk of frac-out. Information required to evaluate such a risk includes but not limited to the following:

(1) Maximum allowable fluid pressure
(2) Minimum depth of bore
(3) Expected drilling fluid pressure
(4) Pressure exerted by overburden
(5) Potential for type of soil to have fissures

4.0 DESIGN REQUIREMENTS

4.1 Design Loads

4.1.1 General Requirements

A. All pipes, manholes and other facilities shall be designed for the external and internal loads to which they will be subjected.

B. To allow for placement of additional track(s) or shifting of the existing track(s), all proposed pipelines or structures shall be designed as if a railroad loading is directly above thefacility.

4.1.2 Earth Load

A. The dead load of the earth shall be considered as 120 pounds per cubic foot unless soil conditions warrant the use of a higher value.

4.1.3 Railroad Load (Live Load Impact)

A. The railroad live load used shall be a Cooper E-80 loading. This loading consists of 80-kip axle loads spaced 5 feet on centers.

B. An impact factor of 1.75 (multiply live load by the impact factor) shall be used for depth of cover up to 5 feet. Between 5 and 30 feet, the impact factor is reduced by 0.03 per foot of depth. Below a depth of 30 feet, the impact factor is one.

C. The values shown in Table shall be used for the vertical pressure on a buried structure for the various heights of cover.

Table 1

Live loads, including impact, for various heights of cover for a Cooper E-80 loading.

Height of Cover	Load
Feet	lb/sq ft
2	3800
3	3150
4	2850
5	2550
6	2250
7	1950
8	1700
9	1500
10	1300
12	1000
14	800
16	625
18	500
20	400
25	250
30	150

D. To determine the horizontal pressure caused by the railroad loading on a sheet pile wall or other structure adjacent to the track, the Boussinesq analysis shall be used. The load on the track shall be taken as a strip load with a width equal to the length of the ties, 8 ½ feet. The vertical surcharge, q (psf), caused by each axle, shall be uniform and equal to the axle load divided by the tie length and the axle spacing, 5 feet. For the E-80 loading results in;

$Q = 80{,}000 / (8.5 \times 5) = 1882$ psf. ($q = 356 / (2.591 \times 1.524) = 90.1$ kPa)

The horizontal pressure due the live load surcharge at any point on the wall or other structure is p_h and can be calculated by the following:

$p_h = (2q/\pi)(\beta - \sin\beta(\cos 2\alpha))$ (See PLATE IX)

E. The vertical and horizontal pressures given above shall be used unless an alternate design method is approved by NS. Proposals to use an alternate design method must include acceptable references and a statement explaining the justification for choosing the alternate method.

4.2 Design Assumptions

A. To design a casing pipe or an uncased carrier pipe for the external loads on NS's right-of-way, the following design assumptions shall be used, unless site conditions indicate more conservative values are required:

B. Flexible Pipe (Steel, DIP, CMP, Tunnel Liner Plate)

(1) Steel Pipe (Bored and jacked in place)
- Spangler's Iowa formula shall be used for design with:

(a) Deflection lag factor - $D_\vartheta = 1.5$
(b) Modulus of soil reaction - $E' = 1080$ psi
(c) Bedding constant - $Kb = 0.096$
(d) Soil loading constant - $K_{u'} = 0.13$
(e) Allowable deflection of pipe - 3% of pipe diameter

(2) Ductile Iron Pipe (Open Cut)
- ANSI Specification A 21.50 shall be used for design with:

(a) Pipe laying condition = type 3 (see Sec. 5.1.2 for backfill requirements on RR R/W)
(b) Earth load – ANSI A 51.50 prism method

(3) Corrugated Steel Pipe & Corrugated Structural Steel Plate Pipe (Open Cut)
- AREMA Chapter 1, Part 4, Sections 4.9 & 4.10 shall be used for design with:

(a) Soil stiffness factor - K = 0.33
(b) Railroad impact as per Section 4.1.3b. of this specification

(4) Tunnel Liner Plate (Tunneled)
- AREMA

(a) Soil stiffness factor - K = 0.33
(c) Railroad impact as per Section 4.1.3.b. of this specification.

4.3 Casing Pipe

4.3.1 General Requirements

A. Casing pipe shall be so constructed as to prevent leakage of any substance from the casing throughout its length, except at ends of casing where ends are left open, or through vent pipes when ends of casing are sealed. Casing shall be installed so as to prevent the formation of a waterway under the railroad, and with an even bearing throughout its length, and shall slope to one end (except for longitudinal occupancy).

B. The casing pipe and joints shall be of steel and of leakproof construction when the pipeline is carrying liquid flammable products or highly volatile substances under pressure.

C. The inside diameter of the casing pipe shall be such as to allow the carrier pipe to be removed subsequently without disturbing the casing or the roadbed. For steel pipe casings, the inside diameter of the casing pipe shall be at least 2 inches greater than the largest outside diameter of the carrier pipe joints or couplings, for carrier pipe less than 6 inches in diameter; at least 4 inches greater for carrier pipe 6 inches and over in diameter.

D. A maximum vertical deflection of the casing pipe of 3 percent of its diameter, plus ½ inch clearance shall be provided so that no loads from the roadbed, track, traffic or casing pipe itself are transmitted to the carrier pipe. When insulators are used on the carrier pipe, the inside diameter of the flexible casing pipe shall be at least 2 inches greater than the outside diameter of the carrier pipe for pipe less than 8 inches in diameter; at least 3 ¼ inches greater for pipe 8 inches to 16 inches, inclusive, in diameter and at least 4 ½ inches greater for pipe 18 inches and over in diameter.

E. The casing pipe diameter shall not be larger than is necessary to permit the insertion of the carrier pipe.

F. Casing pipe under railroad tracks and across NS's right-of-way shall extend the **greater** of the following distances, measured at right angle to centerline of track:

(1) Across the entire width of the NS right-of-way
(2) 3 feet beyond ditch line
(3) 2 feet beyond toe of slope
(4) A minimum distance of 30 feet from each side of centerline of outside track when casing is sealed at both ends.
(5) A minimum distance of 45 feet from centerline of outside track when casing is open at both ends.
(6) Beyond theoretical railroad embankment line. This line begins at a point, on existing grade, 14 feet horizontally from centerline track and extends downward on a 2 (H) to 1 (V) slope. (See Plate III) The 14 feet is measured from 19 inches below the base of the rail.

G. If additional tracks are constructed in the future, the casing shall be extended correspondingly at the applicant's expense.

4.3.2 Steel Pipe

A. Steel pipe may be installed by open cut, boring (HDD) or jacking.

B. Steel pipe shall have a specified minimum yield strength, SMYS, of at least 35,000 psi . The ASTM or API specification and grade for the pipe are to be shown on the Pipe Data Sheet (Plate I).

C. Joints between the sections of pipe shall be fully welded around the complete circumference of the pipe.

D. In situations where the applicant can demonstrate a situational need, interlocked joints (commonly known as "Permalok" joints) may be considered in place of fully welded joints. Submissions shall include an engineering analysis of the suitability of the proposed interlocked joint for railroad loading and jacking stresses in the given soil.

E. Steel casing pipe, with a minimum cover of 5 ½ ft., shall have a **minimum** wall thickness as shown in Table 2, unless computations indicate that a thicker wall is required.

Table 2

Pipe Diameter	Cathodically Protected	Uncoated and Unprotected
Nominal Pipe Size	Nominal Wall Thickness	Nominal Wall Thickness
Inches	Inches	Inches
10 and under	0.188	0.188
12 & 14	0.188	0.250
16	0.219	0.281
18	0.250	0.312
20 & 22	0.281	0.344
24	0.312	0.375
26	0.344	0.406
28	0.375	0.438
30	0.406	0.469
32	0.438	0.500
34 &36	0.469	0.532
38	0.500	0.562
40	0.531	0.594
42	0.562	0.625
44 & 46	0.594	0.657
48	0.625	0.688
50	0.656	0.719
52	0.688	0.750
54	0.719	0.781
56 & 58	0.750	0.812
60	0.781	0.844
62	0.812	0.875
64	0.844	0.906
66 & 68	0.875	0.938
70	0.906	0.969
72	0.938	1.000

F. Coated steel pipe that is bored or jacked into place shall conform to the wall thickness requirements for uncoated steel pipe since the coating may be damaged during installation.

G. Smooth wall steel pipes with a nominal diameter over 72 inches will require additional review.

4.3.3 Corrugated Steel Pipe and Corrugated Structural Steel Plate Pipe

A. Corrugated steel pipe and corrugated structural steel plate pipe may be used for a casing only when placed by the open cut method. Jacking or boring through the railroad embankment is not permitted.

B. Corrugated steel pipe and corrugated structural steel plate pipe may be used for a casing provided the pressure in the carrier pipe is less than 100 psi.

C. Pipe shall be bituminous coated and shall conform to the current American Railway Engineering and Maintenance-of-Way Association Specifications Chapter 1, Part 4.

D. Corrugated steel pipe shall have a minimum sheet thickness as shown in Table 4. Corrugated structural steel plate pipe shall have a minimum plate thickness of 8 gage, 0.168 in. If computations indicate that a greater thickness is required, the thicker sheet or plate shall be used.

Table 4

Pipe Diameter		Sheet Thickness
Inches	Gage	Inches
12 to 30	14	0.079
36	12	0.109
42 to 54	10	0.138
60 to 120	8	0.168

4.3.4 Steel Tunnel Liner Plates

A. Liner plates shall be installed by the tunneling method as detailed in Section 5.15 ofthis specification.

B. Tunnel liner plates shall be galvanized and bituminous coated and shall conform to current AREMA Specification Chapter 1, Part 4, Section 4.16. If the tunnel liner plates are used only to maintain a tunneled opening until the carrier pipe is installed, and the annular space between the carrier pipe and the tunnel liner is completely filled with cement grout within a reasonably short time after completion of the tunnel, then the tunnel liner plates need not be galvanized and coated.

C. Tunnel liner plates are to be a minimum of 12 gage and shall be fabricated from structural quality, hot-rolled, carbon-steel sheets or plates conforming to ASTM Specification A 569.

D. The following liner plate information must be shown on the Pipe Data Sheet (plateI):

(1) Number of flanges (2 or 4)

(2) Width of plate

(3) Type of plate (smooth or corrugated)

4.3.5 Concrete Encasement

A. At locations where the installation is by open cut and a casing pipe is required but cannot be installed due to elbows or other obstructions, concrete encasement may be used when approved by NS.

B. The concrete encasement must provide a minimum cover of 6 inches of concrete around the pipe. A 6 x 6 – W 2.9 x W 2.9 (152 x 152 MW 18.7 x MW 18.7) welded wire fabric shall be placed in the concrete on all sides.

4.4 Carrier Pipe

4.4.1 General Requirements

A. The pipe shall be laid with sufficient slack so that it is not in tension.

B. Steel pipe shall not be used to convey sewage, storm water or other liquids which could cause corrosion.

C. Carrier pipes which are not encased and are located on NS's right-of-way or under tracks which NS operates, shall be manufactured in accordance with the following specifications:

(1) Steel Pipe – The ASTM or API specification and grade for the pipe is to be shown on the Pipe Data Sheet. The specified minimum yield strength is to be at least 35,000 psi (241 MPa). For flammable substances see Sections 4.42 and 4.43 for additional requirements.

(2) Ductile Iron Pipe – ANSI A21.51/AWWA C151

(3) Corrugated Metal Pipe – AREMA Chapter 1, Part 4

D. Carrier pipes installed within a casing pipe shall be designed for the internal pressure to which it will be subjected.

E. Gravity flow carrier pipes, installed without a casing pipe, shall meet the requirements, of the particular pipe material, as given in Section 4.3 of this specification.

4.4.2 Pipelines Carrying Flammable Substances

A. Pipelines carrying oil, liquefied petroleum gas and other flammable liquid products shall be of steel and conform to the requirements of the current ANSI B 31.4 Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols, and other applicable ANSI codes, except that the maximum allowable stresses for design of steel pipe shall not exceed the following percentages of the specified minimum yield strength (multiplied by the longitudinal joint factor) of the pipe as defined in the above codes:

(1) The following percentages apply to hoop stress in steel pipe within a casing under railroad tracks, across NS right-of-way and longitudinally on NS right-of-way:

(a) Seventy-two percent on oil pipelines.

(b) Fifty percent for pipelines carrying condensate, natural gasoline, natural gas liquids, liquefied petroleum gas, and other liquid petroleum products.

(c) Sixty percent for installations on gas pipelines.

(2) The following percentages apply to hoop stress in steel pipe laid longitudinally on NS right-of- way without a casing:

(a) Sixty percent for oil pipelines.

(b) Forty percent for pipelines carrying condensate, natural gasoline, natural gas liquids, liquefied petroleum gas, and other liquid petroleum products.

(c) For gas pipelines see Section 4.4.3.b.

B. Computations, based on the above requirements and stamped by a P.E., shall be submitted with the application occupancy.

4.4.3 Uncased Pipelines Carrying Gas

A. Pipelines carrying flammable and nonflammable gas products shall be steel and shall conform to the requirements of the current ANSI B 31.8 Gas Transmission and Distribution Piping Systems, and other applicable ANSI codes.

B. The minimum wall thickness for uncased carrier pipe shall be in accordance with the values provided in AREMA, Chapter 1, Part 5, Section 5.2, Tables 5.2.3 (a through j).

C. A durable coating, which will resist abrasion (fusion bonded epoxy or other suitable material), shall be used to protect the uncased pipeline when the boring method of installation is used.

D. If NS determines there is the potential for damage to the uncased pipeline (foreign material in the subgrade, third party damage, etc.) special protection of the pipeline will be required. Special may include the use of a protection slab over the pipeline, increased depth of bury or other means.

4.5 Casing Pipe End Seals

A. Casings for carrier pipes of flammable and hazardous substances shall be suitably sealed to the outside of the carrier pipe. Details of the end seals shall be shown on the plans.

B. Casings for carrier pipes of non-flammable substances shall have both ends of the casing blocked up in such a way as to prevent the entrance of foreign material but allowing leakage to pass in the event of a carrier break.

C. The ends of a casing pipe may be left open when the ends are at or above ground surface and above high water level, provided drainage is affordable in such a manner that leakage will be conducted away from railroad tracks and structures.

4.6 Vents

A. Sealed casings for flammable substances shall be properly vented. Vent pipes shall be of sufficient diameter, but in no case less than two inches in diameter, and shall be attached near each end of the casing and project through the ground surface at right-of-way lines or not less than 45 feet, measured at right angles from centerline of nearest track.

B. Vent pipes shall extend not less than 4 feet above the ground surface. Top of vent pipe shall have a down-turned elbow, properly screened, or a relief valve. Vents in locations subject to high water shall

be extended above the maximum elevation of high water and shall be supported and protected in a manner approved by NS.

C. Vent pipes shall be at least 4 feet, vertically, from aerial electric wires or greater if required by national Electrical Safety Code (ANSI C2).

D. When the pipeline is in a public highway, street-type vents shall be installed.

4.7 Signs

A. All pipelines (except those in streets or access roads where it would not be practical to do so) shall be prominently marked at right-of-way lines (on both sides of track for crossings) by durable, weatherproof signs located over the centerline of the pipe. Signs shall show the following:

(1) Name and address of applicant

(2) Contents of pipe

(3) Pressure in pipe

(4) Emergency telephone number

B. For pipelines running longitudinally on NS property, signs shall be placed over the pipe (or offset and appropriately marked) at all changes in direction of the pipeline. Such signs should also be located so that when standing at one sign the next adjacent marker in either direction is visible. In no event shall they be placed more than 500 feet apart unless otherwise specified by NS.

C. The applicant must maintain all signs on NS right-of-way as long as the occupational agreement is in effect.

4.8 Warning Tape

A. All pressure pipelines installed on NS right-of-way by open cut shall have detectable underground warning tape placed a minimum distance of 18 inches directly above the pipeline with the tape placed not less than 12” below grade.

4.9 Shut-off Valves

A. Accessible emergency shut off valves shall be installed within effective distances each side of the railroad at locations selected by NS where hazard to life and property must be guarded against. No additional valves will be required where pipelines are provided with automatic control stations and within distances approved by NS.

4.10 Cathodic Protection

A. Cathodic protection shall be applied to all pipelines carrying flammable substances on NS’s right-of-way.

B. For crossings and at other locations where the pipeline must be placed within a casing, the casing is to have cathodic protection, or the wall thickness is to be increased to the requirements of Section 4.3.2 Table 2.

C. Uncased gas carrier pipes must be coated and cathodically protected to industry standards and test sites, for monitoring the pipeline, provided within 50 feet of the crossing.

D. Where casing and/or carrier pipes are cathodically protected by other than anodes, NS shall be notified and a suitable test made to ensure that other railroad structures and facilities are adequately protected from the cathodic current in accordance with the recommendation of current Reports of Correlating committee on Cathodic Protection, published by the National Association of Corrosion Engineers.

E. Where sacrificial anodes are used the locations shall be marked with durable signs.

4.11 Manholes

A. Manholes shall not be located on NS property where possible. At locations where this is not practical, including longitudinal occupancies, manholes shall be precast concrete sections conforming to ASTM Designation C 478, "Specification for Precast Concrete Manhole Sections".

B. The top of manholes located on NS property shall be flush with the top of ground and shall not be located with service or access roads.

C. The distance from centerline of adjacent track to centerline of proposed manhole shall be shown on the plans.

4.12 Box Culverts

A. Reinforced concrete box culverts shall conform to the requirements of the most recent edition of Norfolk Southern's Public Projects Manual, available here: http://www.nscorp.com/content/nscorp/en/transportation-terms/other-requirements/public-project-guidelines.html.

4.13 Drainage

A. Occupancies shall be designed, and their construction shall be accomplished, so that adequate and uninterrupted drainage NS right-of-way is maintained.

B. All pipes, ditches, spillways, overflows, and other structures carrying surface drainage on or to NS property and/or under NS track(s) shall be designed to carry the run-off from a one hundred (100) year storm. Computations indicating this design, prepared by a Professional Engineer, and suitable topographic plans, outlining the total drainage area, shall be submitted.

C. If the drainage is to discharge into an existing drainage channel on NS's right-of-way and/or through a drainage structure under NS track(s), the computations must include the hydraulic analysis of any existing ditch and/or structure.

D. When calculating the capacity of existing or proposed drainage structures, under NS track(s), the headwater at the structure shall not be greater than 1.5.

E. Pipe(s) used to carry surface drainage on NS right-of-way shall have a minimum diameter of 36 inches.

F. Detention ponds must not be placed on any part of NS's right-of-way. Also, the railroad embankment must not be used as any part of a detention pond structure.

G. Formal approval of the proposed design, by the appropriate governmental agency having jurisdiction, shall be submitted with the drainage computations.

4.14 Pipelines on Bridges

A. Pipelines of any types shall not be installed on any bridge carrying NS tracks.

B. New overhead pipe bridges shall not be constructed over NS's right-of-way where underground installation of the pipeline is possible. Where the applicant can show that no practicable alternative is available, this type of structure will be permitted provided the following conditions are met:

(1) The vertical clearance, distance from top of rail to bottom of structure, is shown and is a minimum of 23 feet, measured at a point 6 feet horizontally from centerline track.

(2) The support bents for the overhead structure are located off of NS's right-of-way or a minimum clear distance of 18 feet from centerline track, whichever distance is greater.

(3) Support bents within 25 feet of centerline track have pier protection in accordance with AREMA requirements.

(4) Complete structural plans and design computations for the structure and foundations, stamped by a Professional Engineer, are submitted with the application.

(5) A fence (with barbed wire) or other measures are provided which will prevent access to the bridge by unauthorized personnel or vandals.

C. Pipelines carrying flammable substances or non-flammable substances, which by their nature might cause damage if escaping on or near railroad facilities or personnel, shall not be installed on bridges over NS tracks. In special cases when it can be demonstrated to NS's satisfaction that such an installation is necessary and that no practicable alternative is available, NS may permit the installation and only by special design approved by NS.

D. When permitted, pipelines on bridges over NS tracks shall be so located as to minimize the possibility of damage from vehicles, railroad equipment, vandalism and other external causes. Leak protection extending across the NS right-of-way shall be provided as directed by NS (See Plate VII).

5.0 CONSTRUCTION REQUIREMENTS

5.1 Method of Installation

5.1.1 General Requirements

A. Bored, jacked or tunneled installations shall have a bore hole essentially the same as the outside diameter of the pipe plus the thickness of the protective coating.

B. The use of water or other liquids to facilitate casing emplacement and spoil removal is prohibited except when used in conjunction with Directional Boring Method "A" (see section 5.1.6).

C. If during installation an obstruction is encountered which prevents installation of the pipe in accordance with this specification, the pipe shall be abandoned in place and immediately filled with grout. A new installation procedure and revised plans must be submitted to, and approved by, NS before work can resume.

5.1.2 Track and Ground Monitoring

A. General track and ground monitoring requirements

(1) General requirement

a. Temporary lighting may also be required by the NS to identify tripping hazards to train crewmen and other NS personnel.

b. Any excavation, holes or trenches on the NS property shall be covered, guarded and/or protected. Handrails, fence, or other barrier methods must meet OSHA and FRA requirements.

(2) Track and ground monitoring are required as follows:

a. For crossings with pipe diameter and depth (below base of rail) as shown below in

b. For shoring within Zone 1 of any track, as shown below in PLATE VIII.

c. Additional monitoring may be required by the NS on a case by case basis.

(3) Monitoring schedule

a. Monitoring shall commence once any construction activity is within Zone 1. See PLATE VIII.

b. Monitoring shall continue through completion of installation and may be required after completion for a period of time determined by NS or its representative.

Table 5.1.2-1

Final Bore Hole, inches

Depth, feet (below base of rail)	1-5	6-12	12-24	24 - 42	42 - 54	54 - 60	>60
5	X	X	X	X	X	X	X
10	X	X	X	X	X	X	X
15		X	X	X	X	X	X
20			X	X	X	X	X
25				X	X	X	X
30					X	X	X
>30						X	X

X = Track Monitoring is required

B. Track Monitoring

(1) Track Deflection Limits

(2) Targets

a. Track monitoring shall not require track access other than to place the track monitoring targets.

b. Monitoring targets should be placed such that monitoring is possible when a train is present. However, monitoring during the passing of a train is not required as the train will temporarily deflect the track.

c. Adhesive backed reflective targets may be attached to the side of the rail temporarily. Targets should be removed once monitoring phase is complete.

(3) Monitoring Plan

(4) If the top of rail does deflect more than values listed below, all operations shall stop until the matter is resolved.

a. Track monitoring values for Class 3 through Class 4:
   1. Threshold value = 1/8 inch permanent vertical or horizontal deflection
   2. Installation Shutdown value = 1/4 inch permanent vertical or horizontal deflection

b. Track monitoring values for Class 1 through Class 2:
   1. Threshold value = 1/4 inch permanent vertical or horizontal deflection
   2. Installation Shutdown value = 1/2 inch permanent vertical or horizontal deflection

c. Provide established contingency plan, see Section D, in the event of ground loss and/or the rail deviates ¼ inch vertical or horizontal.

d. Establish a benchmark in the vicinity of the construction. Establish locations for shooting elevations on the top of rail at each area of construction.
   1. Example locations for shooting rail elevations would be at:
      - At the centerline of an under-track crossing.
      - At both outside edges of the crossing i.e. for a wide excavation.
      - At multiple locations from the crossing/excavation edge but no less than 10, 20, 30, 40 and 50 feet from the crossing.

e. Monitoring shall be continuous and recorded in a field logbook dedicated for this purpose. Copies of these field log entries can be made available to all concerned parties upon request at any time during construction.

C. Ground Monitoring

(1) Provide means for monitoring ground settlement. Submit monitoring plan for NS review.

(2) Ground monitoring points should be in alignment above the proposed construction activities.

D. Contingency Plans

(1) The Contractor shall supply Contingency Plan(s), which anticipate reaching the Threshold and Installation Shutdown values, for all construction activities which may result in horizontal and/or vertical track deflection.

   a. Track monitoring values for Class 3 through Class 4:
      1. Threshold value = 1/8 inch permanent vertical or horizontal deflection
      2. Installation Shutdown value = 1/4 inch permanent vertical or horizontal deflection
   b. Track monitoring values for Class 1 through Class 2:
      1. Threshold value = 1/4 inch permanent vertical or horizontal deflection
      2. Installation Shutdown value = 1/2 inch permanent vertical or horizontal deflection

(2) The Contingency Plans shall provide means and methods, with options if necessary.

(3) The Contractor should anticipate the need to implement each Contingency Plan with required materials, equipment and personnel.

   a. Once the Threshold value is met, the contractor shall determine the appropriate Contingency Plan(s) and immediately discuss this plan with, and receive approval confirmation from, the NS.

   b. Once the Installation Shutdown value is exceeded all project work shall stop and the chosen

Contingency Plan shall commence. NS may choose to allow and/or require the immediate implementation of specific approved Contingency Plans, submitted by the contractor, once the Installation Shutdown value is exceeded.

5.1.3 Open Cut

A. Open cut is a non-standard procedure that should be avoided whenever possible. The applicant must request a variance for open cut approval when making application for occupancy. Applicant should be aware that open cut applications and procedures have the potential to result in additional NS charges.

B. Installations beneath the track by open trench methods will be permitted only with the approval of the AVP Maintenance of Way & Structures.

C. Installations by open cut will not be permitted under mainline tracks, tracks carrying heavy tonnage or tracks carrying passenger trains. Also, open cut shall not be used within the limits of a highway/railroad grade crossing or its approaches, 25 feet either side of traveled way, where possible.

D. At locations where open cut is permitted, the trench is to be backfilled with crushed stone with a top size of the aggregate to be a maximum of 2 inches and to have no more than 5% passing the number 200 sieve. The gradation of the material is to be such that a dense stable mass is produced.

E. The backfill material shall be placed in loose 6 inch lifts and compacted to at least 95% of its maximum density with a moisture content that is no more than 1% greater than or 2% less than the optimum moisture as determined in accordance with current ASTM Designation D – 1557 (Modified Proctor). When the backfill, material is within 3 feet of the subgrade elevation (the interface of the ballast and the subsoil) a compaction of at least 98% will be required.

F. All backfilled pipes laid either perpendicular or parallel to the tracks must be designed so that the backfill material will be positively drained. This may require the placement of lateral drains on pipes laid longitudinally to the track and the installation of stub perforated pipes at the edge of the slopes.

G. Unless otherwise agreed upon, all work involving rail, ties and other track material will be performed by NS employees, at such times as are consistent with NS work schedules regarding the availability of said employees, and at the sole expense of the applicant.

5.1.4 Bore and Jack (Steel Pipe)

A. This method consists of pushing the pipe into the earth with a boring auger rotating within the pipe to remove the spoil.

B. The boring operation shall be progressed on a 24-hour basis without stoppage in Zone 1, 2, and 3 as indicated in Plate VIII (except for adding lengths of pipe) until the leading edge of the pipe has reached the receiving pit.

C. The front of the pipe shall be provided with mechanical arrangements or devices that will positively prevent the auger from leading the pipe so that no unsupported excavation is ahead of the pipe.

D. The auger and cutting head arrangement shall be removable from within the pipe in the event an obstruction is encountered. If the obstruction cannot be removed without excavation in advance of the pipe, procedures as outlined in Section 5.1.1c. must be implemented immediately.

E. The over-cut by the cutting head shall not exceed the outside diameter of the pipe by more than ½ inch. If voids should develop or if the bored hole diameter is greater than the outside diameter of the pipe (plus coating) by more than approximately 1 inch, grouting (see Section 5.2) or other methods approved

by NS, shall be employed to fill such voids.

F. The face of the cutting head shall be arranged to provide a reasonable obstruction to the free flow of soft or poor material.

G. Plans and description of the arrangement to be used shall be submitted to NS for approval and no work shall proceed until such approval is obtained.

H. Any method that employs simultaneous boring and jacking for pipes over 8 inches in diameter that does not have the above approved arrangement **will not be permitted.** For pipe 8 inches and less in diameter, augering or boring without this arrangement may be considered for use only as approved by NS.

5.1.5 Jacking (Steel Pipe)

A. This method consists of pushing sections of pipe into position with jacks placed against a backstop and excavation performed by hand from within the jacking shield at the head of the pipe. Ordinarily 36-inch pipe is the least size that should be used, since it is not practical to work within smaller diameter pipes.

B. Jacking shall be in accordance with the current American Railway Engineering Association Specifications, Chapter 1, Part 4 "Jacking Culvert Pipe Through Fills." This operation shall be conducted without hand-mining ahead of the pipe and without the use of any type of boring, auguring, or drilling equipment.

Bracing and backstops shall be so designed and jacks of sufficient rating used so that the jacking can be progressed on a 24-hour basis without stoppage in Zone 1, 2, and 3 as indicated Plate VIII.(except for adding lengths of pipe) until the leading edge of the pipe has reached the receiving pit.

C. Immediately upon completion of jacking operation, the installation shall be pressure grouted as per Section 5.2 of this specification.

5.1.6 Tunneling (Tunnel Liner Plate)

A. This method consists of placing rings of liner plate within the tail section of a tunneling shield or tunneling machine. A tunneling shield shall be used for all liner plate installations unless otherwise approved by NS.

B. The shield shall be of steel construction, designed to support a railroad track loading as specified in Section 4.1.3 of this specification, in addition to the other loadings imposed. The advancing face shall be provided with a hood, extending no less than 20 inches beyond the face and extending around no less than the upper 240 degrees of the total circumference. It shall be of sufficient length to permit the installation of at least one complete ring of liner plates within the shield before it is advanced for the installation of the next ring of liner plates. The shield shall conform to and not exceed the outside dimensions of the liner plate tunnel being placed by more than 1 inch at any point on the periphery unless otherwise approved by NS.

C. The shield shall be adequately braced and provided with necessary appurtenances for completely bulkheading the face with horizontal breast boards and arranged so that the excavation can be benched as may be necessary. Excavation shall not be advanced beyond the edge of the hood, except in rock.

D. Manufacturer's shop detail plans and manufacturer's computations showing the ability of the tunnel liner plates to resist the jacking stresses shall be submitted to NS for approval.

E. Unless otherwise approved by NS, the tunneling shall be conducted continuously, on a 24-hour basis,

until the tunnel liner extends at least beyond the theoretical railroad embankment line with no stoppage within Zone 1, 2, and 3 as indicated (See Plate VIII).

F. At any interruption of the tunneling operation, the heading shall be completely bulkheaded.

G. The liner plates shall have tapped grout holes for no smaller than 1 ½ inch pipe, spaced at approximately 3 feet around the circumference of the tunnel liner and 4 feet longitudinally.

H. Grouting behind the liner plates shall be in accordance with Section 5.2 of this specification.

5.1.7 Directional Boring / Horizontal Directional Drilling (Steel Pipe)

Method "A"

A. This method consists of setting up specialized drilling equipment on existing grade (launching and receiving pits are not required) and boring a small diameter pilot hole on the desired vertical and horizontal alignment, using a mechanical cutting head with a high pressure fluid (bentonite slurry) to remove the cuttings. The drill string is advanced with bentonite slurry pumped through the drill string to the cutting head and then forced back along the outside of the drill string, carrying the cuttings back to the surface for removal. When the cutting head reaches the far side of the crossing, it is removed and a reamer (with a diameter greater than the cutting head) is attached to the lead end of the drill string. The

pipeline is attached to the reamer and the pilot hole is then back reamed while the pipeline is pulled into place.

B. This method is used to place pipelines under rivers, wetlands and other obstructions which would be difficult to cross by conventional methods. The length of the bore is generally several hundred feet in length, with installations over a thousand feet possible.

C. Consideration will be given where the depth of cover is greater than 10 feet below the base of the rail, or the bore is in rock. Factors considered will be track usage, pipe size, contents of pipeline, soil conditions, etc.

D. The following preliminary information must be submitted with the request for consideration of this type of installation:

(1) A site plan of the area.
(2) A plan view and profile of the crossing
(3) A Pipe Data Sheet
(4) Appropriately spaced soil borings along the proposed pipeline route
(5) A construction procedure, including a general description of equipment to be used

If NS determines this method of installation is acceptable, final design plans and specifications are to be prepared and submitted for approval.

E. The project specifications must require the contractor to submit, to NS for approval, a complete construction procedure of the proposed boring operation. Included with the submission shall be the manufacture's catalog information describing the type of equipment to be used.

F. Maximum pipe size for HDD application shall be 36" in diameter.

G. Any over-cut by the cutting head should be minimized to match the pipe being installed. Any over-cut shall be no more than 2" larger than the installed pipeline. If voids should develop or if the bored

hole diameter is greater than the outside diameter of the pipe (plus coating) by more than approximately 1 inch, grouting (see Section 5.2) or other methods approved by NS, shall be employed to fill such voids. HDD can be progressed on a 24- hour basis without stoppage in Zone 1, 2, and 3 as indicated Plate VIII.

H. The applicant's engineer shall provide the project geotechnical analysis to the NS representative for review. Specify the maximum drilling fluid pressures so that applicant's engineer can ensure that frac-out does not occur. As a general rule of thumb, the fluid pressure must not exceed the uplift capacity of the soil (nominally 1 psi per foot of depth).

Reference National Utility Contractors Association (NUCA) "*Trenchless Construction and Rehabilitation Methods*" *(4th Edition) and* ASCE's *"Pipeline Design for Installation by Horizontal Directional Drilling" (4th Edition).* Per NUCA, "Important physical properties that need to be determined include strength, grain size, moisture content, plasticity characteristics, compressibility, and permeability of the deposits".

Further geotechnical analysis by the applicant may be required to verify that railroad tracks, property and facilities will not be affected by the proposed bore.

Method "B"

A. This method is used to place small diameter conduit for electric lines and other utilities. This method consists of using hydraulic jacking equipment to push a solid steel rod under the railroad from a launching pit to a receiving pit. At the receiving pit, a cone shaped "expander" is attached to the end of the rod and the conduit (casing pipe) is attached to the expander. The rod, expander and conduit are then pulled back from the launching pit until the full length of the conduit is inplace.

B. This method may be used to place steel conduit (casing pipe), up to and including 6 inches in diameter, under the railroad.

C. The project specifications must require the contractor to submit, to NS for approval, a complete construction procedure of the proposed boring operation. Included with the submission shall be the manufacture's catalog information describing the type of equipment to beused.

D. Maximum pipe size for HDD application shall be 36" in diameter.

E. Any over-cut by the cutting head should be minimized to match the pipe being installed. Any over-cut shall be no more than 2" larger than the installed pipeline. If voids should develop or if the bored hole diameter is greater than the outside diameter of the pipe (plus coating) by more than approximately 1 inch, grouting (see Section 5.2) or other methods approved by NS, shall be employed to fill such voids. HDD can be progressed on a 24- hour basis without stoppage in Zone 1, 2, and 3 as indicated Plate VIII.

F. The applicant's engineer shall provide the project geotechnical analysis to NS representative for review. Specify the maximum drilling fluid pressures so that applicant's engineer can ensure that frac-out does not occur. As a general rule of thumb, the fluid pressure must not exceed the uplift capacity of the soil (nominally 1 psi per foot of depth).

Reference National Utility Contractors Association (NUCA) "*Trenchless Construction and Rehabilitation Methods*" *(4th Edition) and* ASCE's *"Pipeline Design for Installation by Horizontal Directional Drilling" (4th Edition).* Per NUCA, "Important physical properties that need to be determined include strength, grain size, moisture content, plasticity characteristics, compressibility, and permeability of the deposits".

Further geotechnical analysis by the applicant may be required to verify that railroad tracks, property

and facilities will not be affected by the proposed bore.

5.1.8 Tunnel Boring Machines and Microtunneling

A. A tunnel boring machine (TBM), also known as a "mole", is a machine used to excavate tunnels with a circular cross section through a variety of soil and rock strata. May also be used called Microtunneling for smaller tunnels.

B. Use of TBM will be considered for installations of pipelines at least 20-feet below base of rail.

C. Plans must indicate locations and depth of boring and receiving pits and shoring details as required in Section 5.8, below.

D. The submission must include a detailed soil analysis and the details of the machine to be used, including the type of boring head, type of slurry to be used (if applicable), and type of guidance system.

5.1.9 Slip Lining

A. Slip-lining is the process of replacing an existing carrier pipe within an existing casing pipe.

B. The submission must demonstrate that the existing casing is constructed of a material described in section 4 of this specification, including appropriate wall thickness and joints.

C. The submission must demonstrate that the existing casing is of an adequate length to meet the requirements of section 4.3.1 of this Specification.

D. The submission must include documentation that clearly demonstrates that the casing has not deteriorated to a point where it no longer complies with items B and C, above. If necessary, the applicant may apply for a right-of-entry permit as outlined in Section 1.4 of this Specification in order to excavate the ends of the existing casing for a thorough inspection.

5.1.10 Cured In Place Pipe (CIPP)

A. CIPP is a trenchless rehabilitation method used to repair existing pipelines from existing access points.

B. CIPP will be considered for rehabilitation of existing non-pressurized sewer and storm drain only.

C. Submission must include details of proposed access to existing pipe on either side of the Railroad right-of-way, and a detailed assessment and analysis of the condition of the existing pipe.

D. Submission must include details of the proposed pipe bypass system to be used during construction.

(1) The submission must include documentation that clearly demonstrates that the casing has not deteriorated to a point where it no longer complies with items B and C, above. If necessary, the applicant may apply for a right-of-entry permit as outlined in Section 1.4 of this Specification in order to excavate the ends of the existing casing for a thorough inspection.

5.1.11 Pipe Bursting and Pipe Ramming

A. Pipe Bursting is a trenches method of replacing buried pipelines such as sewer, water, or natural gas pipes without the need for a traditional trenching by expanding the diameter of the current pipe to receive a new pipe.

B. Pipe Ramming uses pneumatic percussive blows to drive the pipe through the ground without the use of an auger.

C. Neither Pipe Bursting nor Pipe Ramming will be considered for installations beneath railroad track. Both methods may be considered at NS's discretion if the installation will not come closer than 25-feet to the centerline of any railroad track or closer than 50-feet to any other railroad structure.

5.2 Grouting

A. For jacked and tunneled installations, a uniform mixture of 1:6 (cement: sand) cement grout shall be placed under pressure through the grout holes to fill any voids which exist between the pipe or liner plate and the undisturbed earth.

B. Grouting shall start at the lowest hole in each grout panel and proceed upwards simultaneously on both sides of the pipe.

C. A threaded plug shall be installed in each grout hole as the grouting is completed at that hole.

D. When grouting tunnel liner plates, grouting shall be kept as close to the heading as possible, using grout stops behind the liner plates if necessary. Grouting shall proceed as directed by NS, but in no event shall more than 6 lineal feet (1.8 m) of tunnel be progressed beyond the grouting.

5.3 Soil Stabilization

A. Pressure grouting of the soils or freezing of the soils before jacking, boring, or tunneling may be required at the direction of NS to stabilize the soils, control water, prevent loss of material and prevent settlement or displacement of embankment. Grout shall be cement, chemical or other special injection material selected to accomplish the necessary stabilization.

B. The materials to be used and the method of injection shall be prepared by a Registered Professional Soils Engineer or by an experienced and qualified company specializing in this work and submitted for approval to NS before the start of work. Proof of experience and competency shall accompany the submission.

5.4 Dewatering

A. When water is known or expected to be encountered, pumps of sufficient capacity to handle the flow shall be maintained at the site, provided the contractor has received approval from NS to operate them. Pumps in operation shall be constantly attended on a 24-hour basis until, in the sole judgement of NS, the operation can be safely halted. When dewatering, close observation shall be maintained to detect any settlement or displacement of railroad embankment, tracks, and facilities.

5.5 Safety Requirements

All operations shall be conducted so as not to interfere with, interrupt, or endanger the operation of trains nor damage, destroy, or endanger the integrity of railroad facilities. All work on or near NS property shall be conducted in accordance with NS safety rules and regulations. The contractor shall secure and comply with the NS safety rules and shall give written acknowledgement to NS that they have been received, read, and understood by the contractor and its employees. Operations will be subject to NS monitoring at any and all times.

A. All cranes, lifts, or other equipment that will be operated in the vicinity of NS's electrification and power transmission facilities shall be electrically grounded as directed by NS.

B. At all times when the work is being progressed, a field supervisor for the work with no less than twelve (12) months experience in the operation of the equipment being used shall be present. If boring equipment or similar machines are being used, the machine operator also shall have no less than twelve (12) months experience in the operation of the equipment being used.

C. Whenever equipment or personnel are working closer than 15 feet from the centerline of an adjacent track, that track shall be considered as being obstructed. Insofar as possible, all operations shall be conducted no less than this distance. Operations closer than 15 feet from the centerline of a track shall be conducted only with the permission of, and as directed by, a duly qualified NS railroad employee or an authorized NS representative present at the site of the work.

D. Construction near switching areas may require lighting.

E. Crossing of tracks at grade by equipment and personnel is prohibited except by prior arrangement with and as directed by NS.

5.6 Blasting

A. Blasting will not be permitted.

5.7 Protection of Drainage Facilities

A. If, in the course of construction, it may be necessary to block a ditch, pipe or other drainage facility, temporary pipes, ditches or other drainage facilities shall be installed to maintain adequate drainage, as approved by NS. Upon completion of the work, the temporary facilities shall be removed, and the permanent facilities restored.

B. Soil erosion methods shall be used to protect railroad ditches and other drainage facilities during construction on and adjacent to NS right-of-way.

5.8 Support of Excavation Adjacent to Track

5.8.1 Launching and Receiving Pits

A. The location and dimensions of all pits or excavations shall be shown on the plans. The distance from centerline of adjacent track to face of pit or excavation shall be clearly labeled. Also, the elevation of the bottom of the pit or excavation must be shown on the profile.

B. The face of all pits shall be located a minimum of 25 feet from centerline of adjacent track, **measured at right angles to track**, unless otherwise approved by NS.

C. NS Typical Drawing No. 4 – Shoring Requirements shall govern the limits and type of required excavation support.

D. All plans and calculations for shoring shall be prepared, signed and sealed by a Registered Professional Engineer licensed in the state of the project. The Engineer will be responsible for the accuracy for all controlling dimensions as well as the selection of soil design values which will accurately reflect the actual field conditions.

E. The plans shall contain details of the shoring system showing sizes of all structural members, details of connection, *and* embedment depth. The plans shall include a plan view showing all the proposed excavations and distances from centerline of track to face of excavation. Plans shall show a section normal to the track showing the shoring location relative to the centerline of track and showing the height of sheeting and track elevation in relation to the bottom of excavation. The plans must be complete and accurately describe the nature of the work.

F. Shoring in Zone 1 or 2, AREMA recommended practice is to be used for design. No increase in temporary stresses is permitted. Refer to AREMA Load Section.

G. Design shall include 2 feet of spoils adjacent to the shoring and the first 1 foot below the dredge line is to be neglected for passive resistance

H. Shoring location in Zone 2 as shown on NS Typical Drawing No. 4 – Shoring Requirements shall be designed using interlocking sheeting. Soldier piles and lagging will be considered only when its use is specifically approved by NS. Consideration for the use of soldier piles and lagging will only be made if the required penetration of steel sheet piling cannot be obtained and when dry, stable material will be encountered.

I. All excavations with the limits shown on NS Typical Drawing No. 4 – Shoring Requirements shall be designed for railroad live load surcharge. All shoring designed for railroad live load surcharge shall be based on Cooper's E-80 live load. AREMA Chapter 8, Part 20, Section 3, Paragraph 2(b), refers to the Boussinesq equation as a method to determine lateral pressure values for railroad surcharge loading. NS Typical Drawing No. 5 – Shoring Design Guide – Lateral Pressures from Train Loads indicates the lateral pressures associated with various depths of excavation and distances from centerline of track as determine by the Boussinesq equation.

J. Calculations for the proposed shoring shall include deflection calculations. The maximum deflection for excavations within 18'-0" of the centerline of the nearest tack shall be 3/8". For all other cases, the max deflections shall not exceed ½".

K. Railings shall be constructed around all excavations on NS property. Walkways with railings shall be constructed over open excavations adjacent to the tracks located within the normal walkway. Refer to AREMA Section 15 for walkway and railing design criteria. Railings shall not be closer than 10'-0" horizontally from centerline of track. Railing shall be indicated on plans submitted for NS acceptance.

L. Approval of the excavation plan does not relieve the applicant of ultimate responsibility and liability for the excavation plan.

M. If the excavation pit design and shoring system will be submitted by the applicant's contractor, the applicant's contract specifications must require the applicant's contractor to obtain NS approval prior to beginning any excavation.

5.8.2 Parallel Trenching and Other Excavation

A. NS Typical Drawing No. 4 – Shoring Requirements shall govern the limits and type of excavation support.

B. The design and construction requirements for this construction shall be in accordance with the requirements of Section 5.8.1.

5.9 Inspection and Testing

A. For pipelines carrying flammable or hazardous materials, ANSI Codes, current at time of constructing the pipeline, shall govern the inspection and testing of the facility on NS property, except as follows:

(1) One hundred percent of all field welds shall be inspected by radiographic examinations, and such field welds shall be inspected for 100 percent of the circumference.

(2) The proof testing of the strength of carrier pipe shall be in accordance with ANSI requirements.

5.10 Reimbursement of Costs

A. All costs incurred by NS or its representative associated with the pipe installation (construction

monitoring, flagging, track work, protection of signal cables, etc.) shall be reimbursed by the applicant.

PUBLICATION STANDARDS SOURCES

ANSI	American National Standards Institute, Inc. 1899 L Street, NW, 11th Floor Washington, DC 20036 Tel: 202.293.8020
AREMA	American Railway Engineering Maintenance-of-Way Association 4501 Forbes Blvd., Suite 130 Lanham, MD 20706 Tel: 301.459.3200
ASTM	American Society for Testing and Materials 100 Barr Harbor Drive, PO Box C700 West Conshohocken, PA 19428 Tel: 610.832.9500
AWWA	American Water Works Association, Inc. 6666 West Quincy Avenue Denver, CO 80235 Tel: 303.794.7711 or 800.926.7337
NACE	National Association of Corrosion Engineers 15835 Park Ten Place Houston, TX 77084 Tel: 281.228.6200

NOTE: If other than ANSI, AREMA, ASTM, AWWA or NACE specifications are referred to for design, materials or workmanship on the plans and specifications for the work, then copies of the applicable sections of such other specifications referred to shall accompany the plans and specifications for the work.

Plate I - Pipe Data Sheet

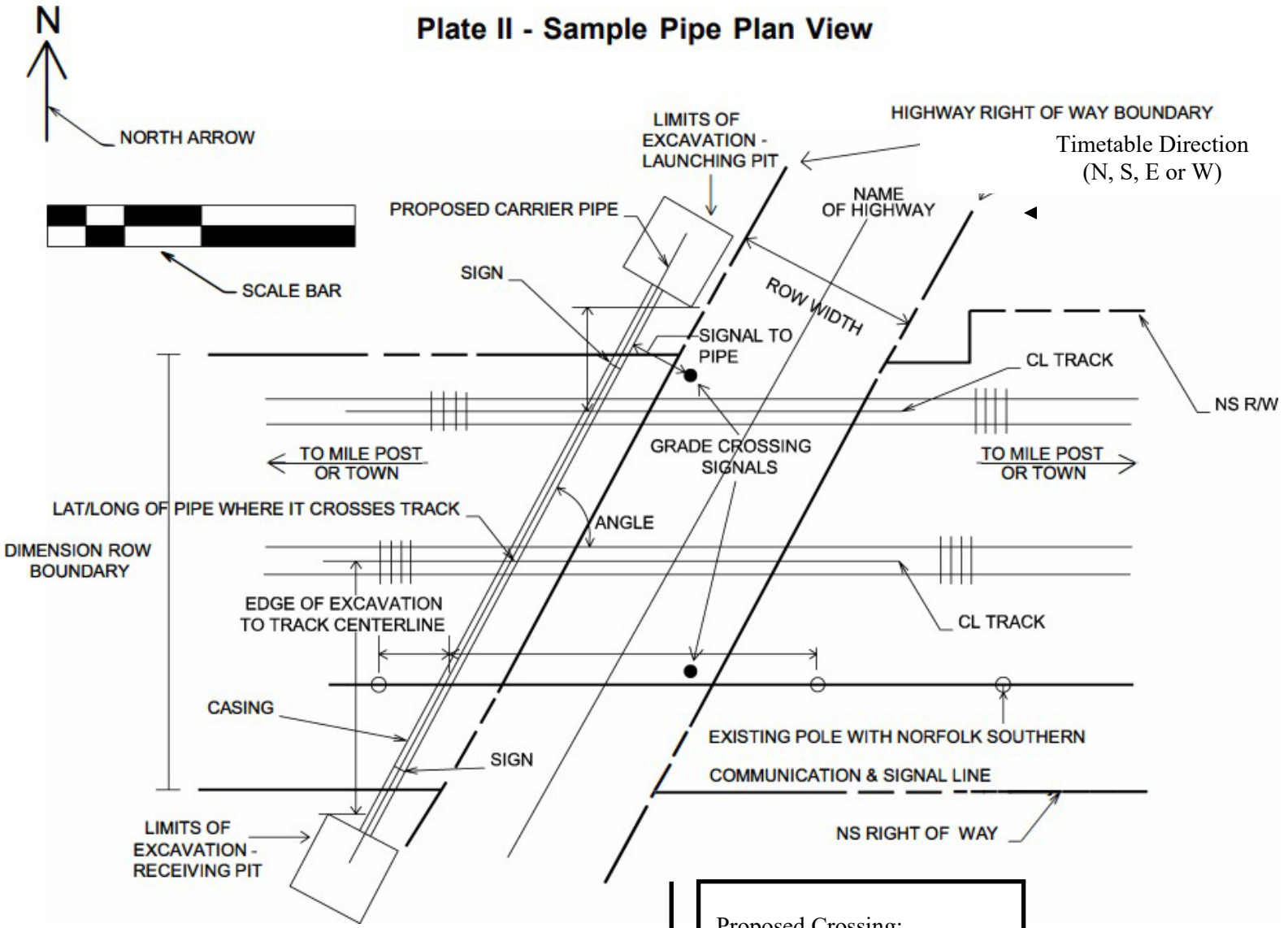
	CARRIER PIPE	CASING PIPE
CONTENTS TO BE HANDLED		
MAX. ALLOWABLE OPERATING PRESSURE		
NOMINAL SIZE OF PIPE		
OUTSIDE DIAMETER		
INSIDE DIAMETER		
WALL THICKNESS		
WEIGHT PER FOOT		
MATERIAL		
PROCESS OF MANUFACTURE		
SPECIFICATION		
GRADE OR CLASS (Specified Minimum Yield Strength)		
TEST PRESSURE		
TYPE OF JOINT		
TYPE OF COATING		
DETAILS OF CATHODIC PROTECTION		
DETAILS OF SEALS OR PROTECTION AT END OF CASING		
CHARACTER OF SUBSURFACE MATERIAL		
APPROXIMATE GROUND WATER LEVEL		
SOURCE OF INFORMATION ON SUBSURFACE CONDITIONS		

Proposed method of installation:

- ☐ Bore and jack (per Section 5.1.3 of NSCE-8)
- ☐ Jacking (per Section 5.1.4 of NSCE-8)
- ☐ Tunneling (with Tunnel Liner Plate) (per Section 5.1.5 of NSCE-8)
- ☐ Directional Bore/Horizontal Direction Drilling – Method A (per Section 5.1.6 of NSCE-8)
- ☐ Directional Bore/Horizontal Direction Drilling – Method B (per Section 5.1.6 of NSCE-8)
- ☐ Open Cut (per Section 5.1.2 of NSCE-8). *All installations directly under any track must be designed as a bored installation. Open cut installations will be considered on a case-by-case basis by Norfolk Southern's Division Superintendent at the time of installation.*
- ☐ Other (Specify):_____

Last Revised: 12/20/17

Plate II - Sample Pipe Plan View



Looking Direction should be
Increasing and Decreasing Milepost

Plate III - Sample Pipe Profile View

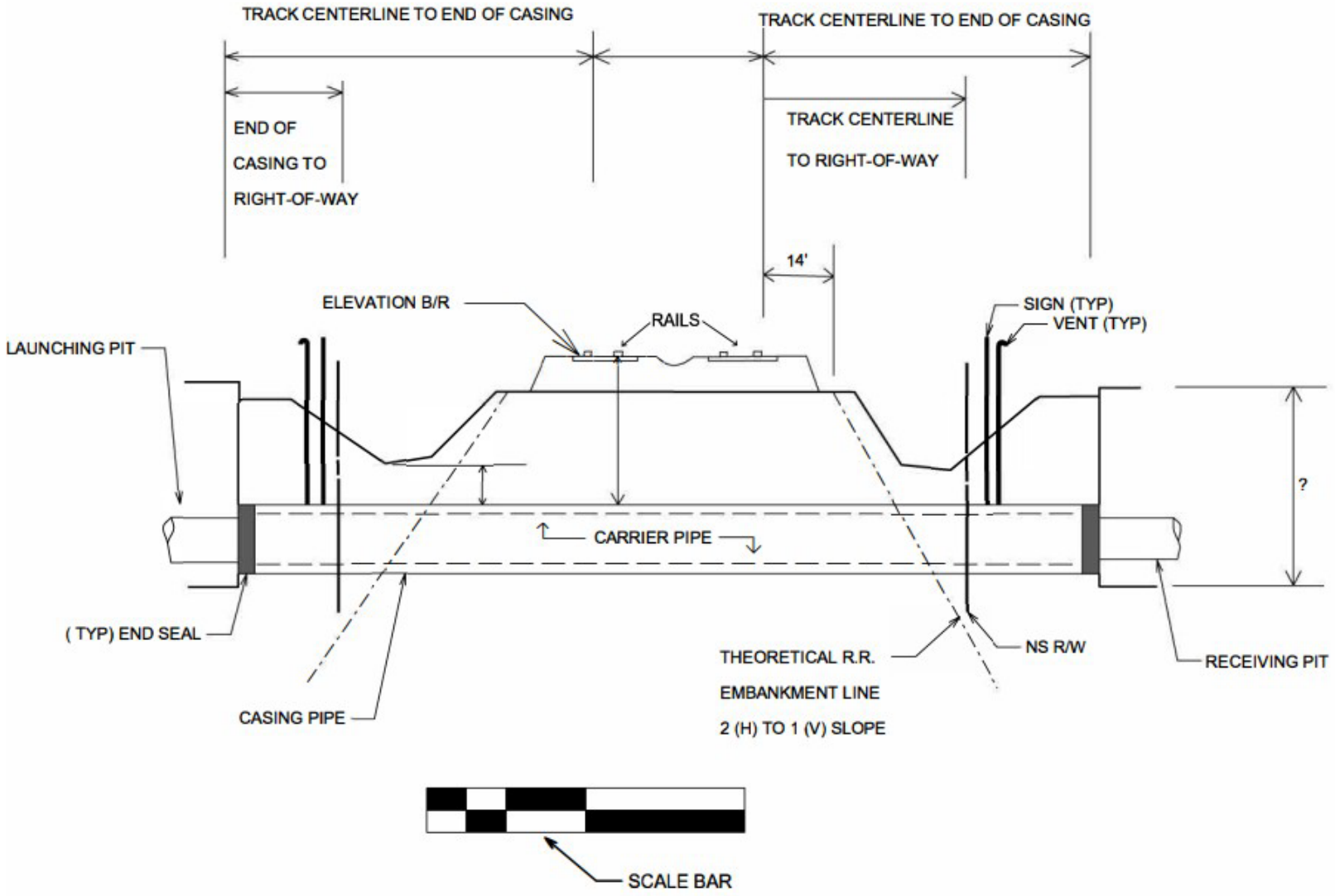
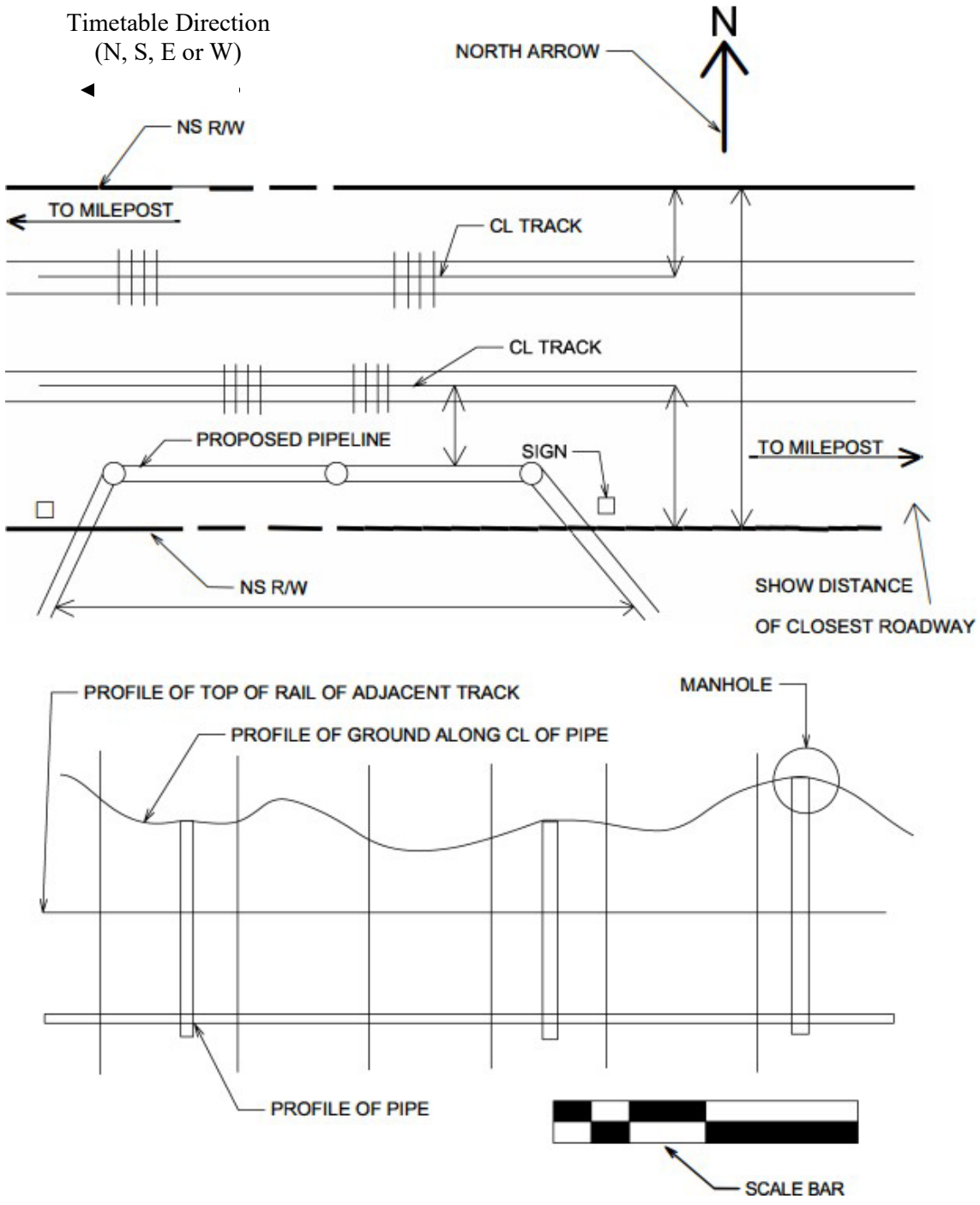
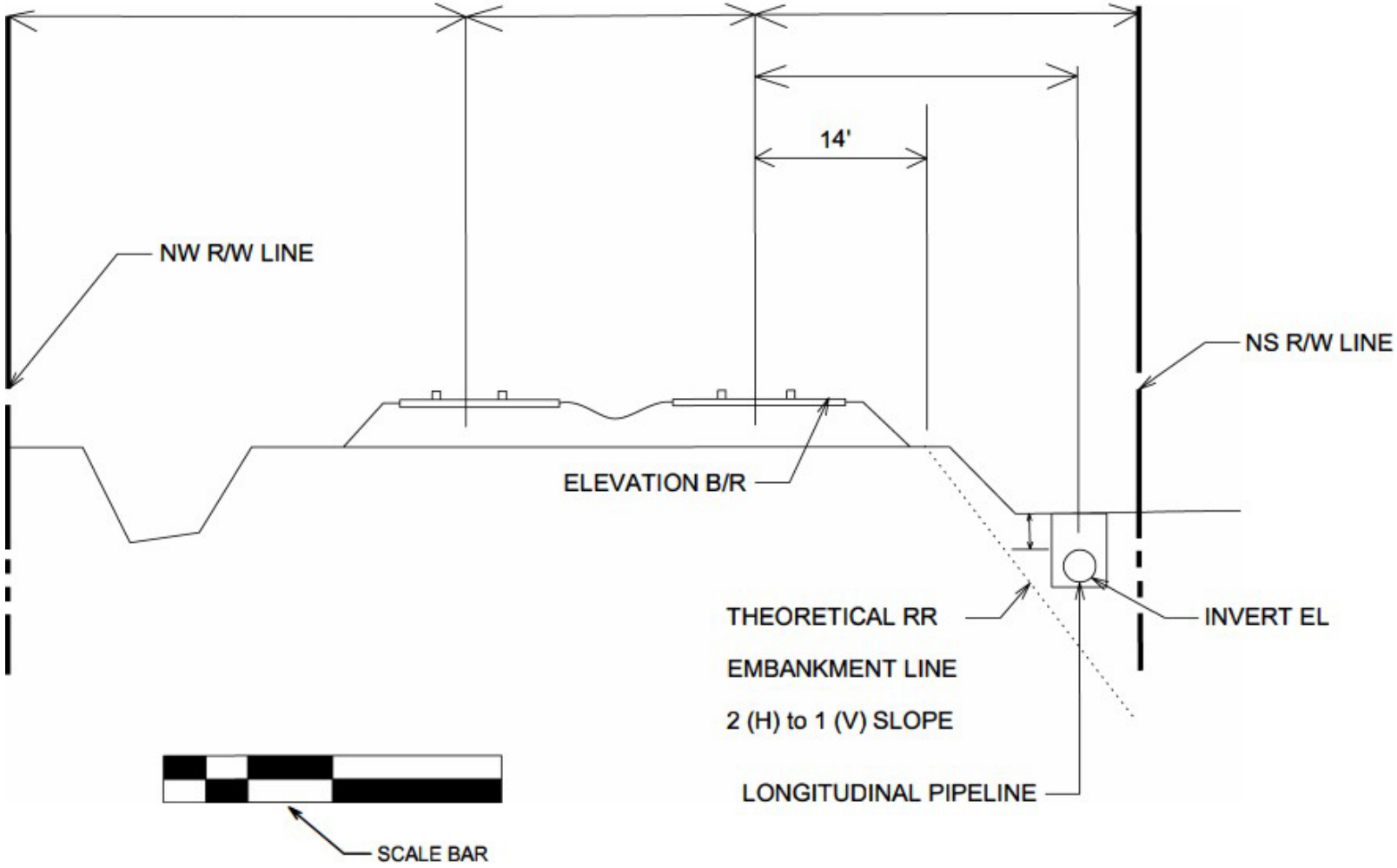


Plate IV - Sample Pipe Parallel Plan and Profile Views



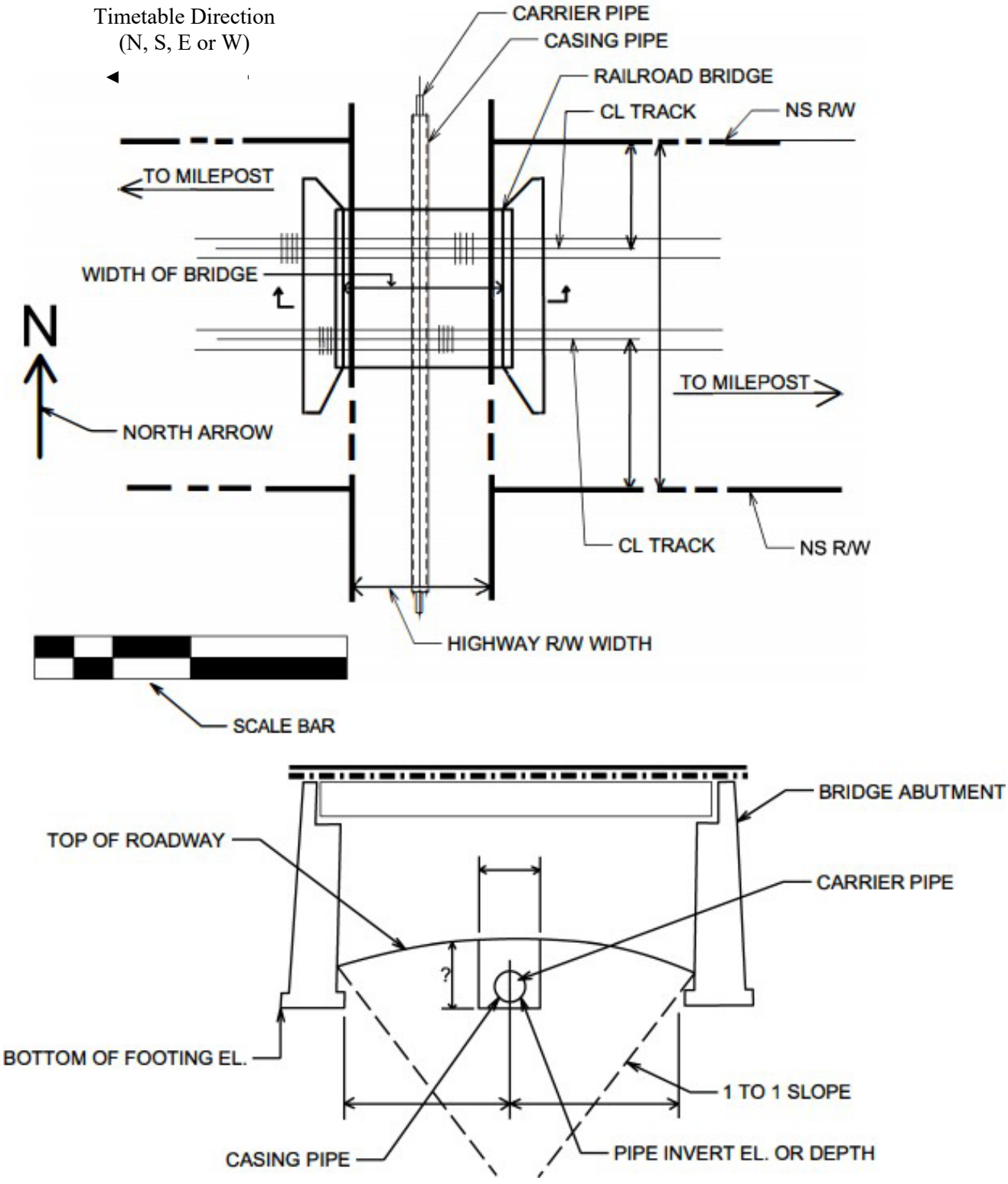
Looking Direction should be
Increasing and Decreasing Milepost

Plate V - Sample Pipe Parallel Section View



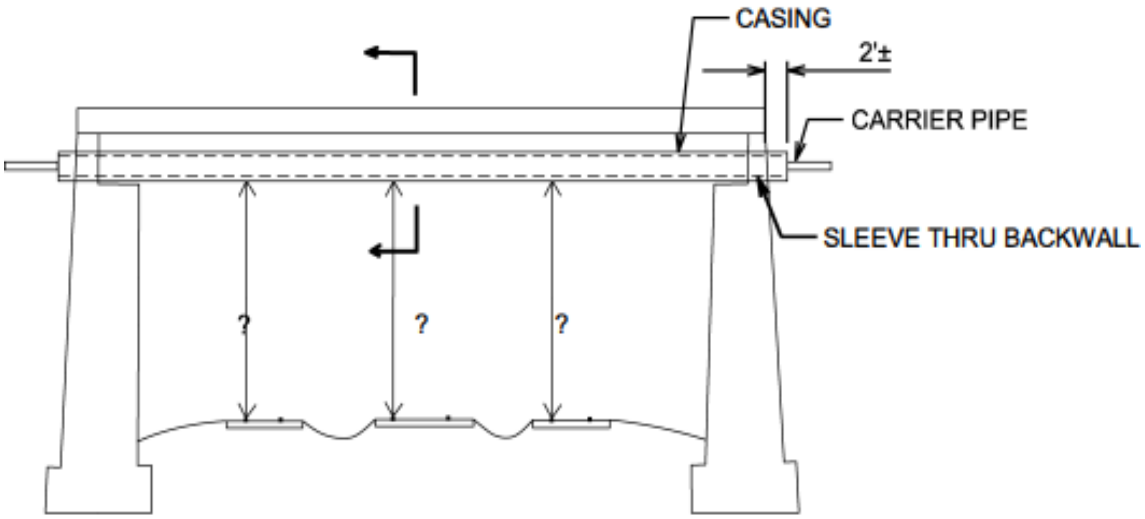
Looking Direction should be
Increasing and Decreasing Milepost

Plate VI - Sample Pipe Plan and Section Under Railway Bridge



Looking Direction should be
Increasing and Decreasing Milepost

PLATE VII - Sample Pipe Profile and Section Views Pipe in Highway Over Railway



Looking Direction should be
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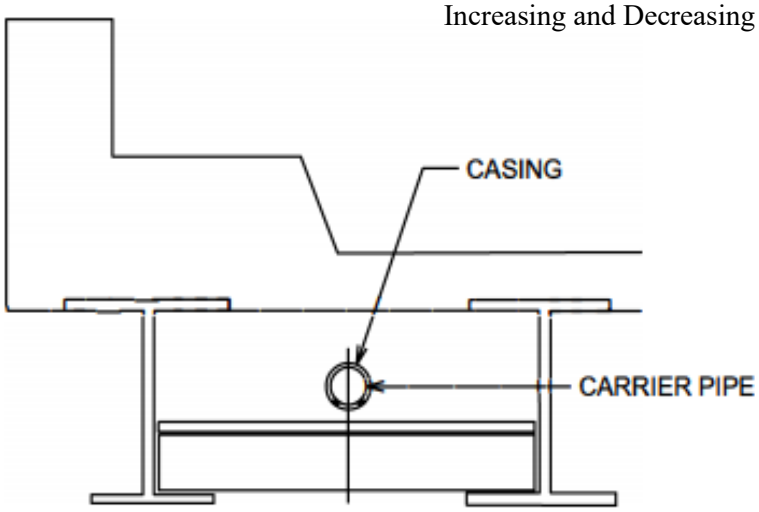


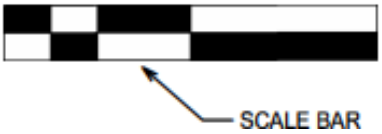
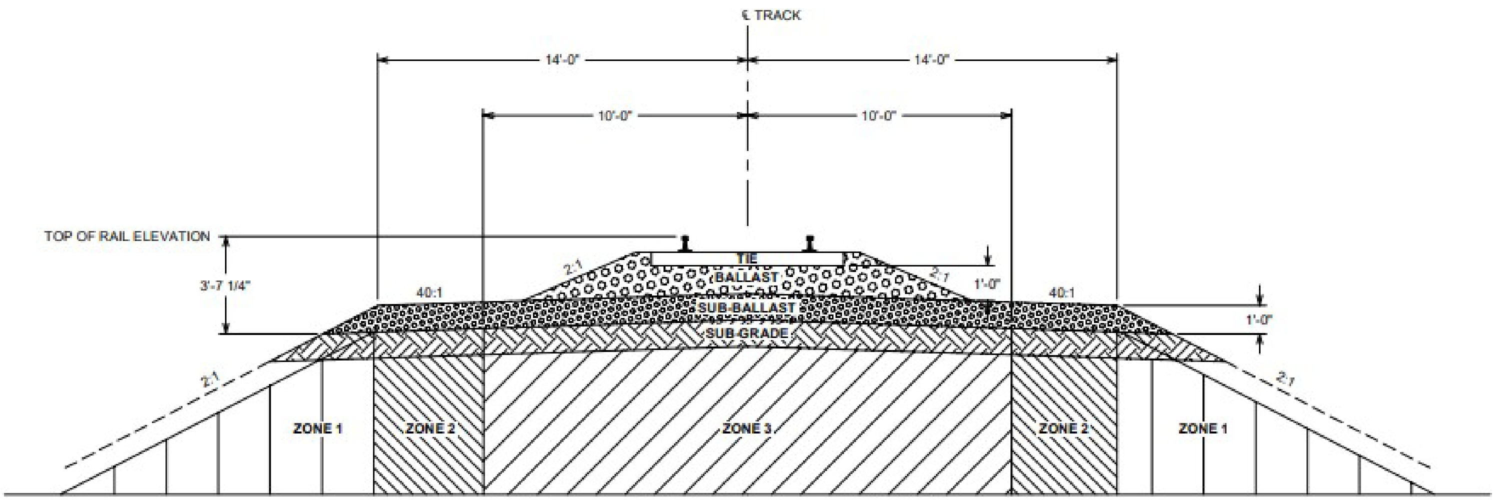


PLATE VIII - Railway Shoring Requirements



ROADBED PROFILE - SHORING REQUIREMENTS (NTS)

ZONE 1 EXCAVATION WITHIN ZONE 1 WILL REQUIRE SHORING FOR THE PROTECTION OF THE RAILROAD

ZONE 2 EXCAVATION WITHIN ZONE 2 WILL REQUIRE SHORING CONSISTING OF INTERLOCKING SHEETING FOR THE PROTECTION OF THE RAILROAD

ZONE 3 **NO EXCAVATIONS WILL BE ALLOWED IN ZONE 3**

NOTES:

1. EXCAVATIONS OUTSIDE OF ZONE 1 MAY REQUIRE SHORING FOR SAFETY. LATERAL PRESSURES DUE TO TRAIN LOADINGS DO NOT AFFECT SHORING DESIGN OUTSIDE OF ZONE 1.
2. REFER TO PUBLIC PROJECTS MANUAL APPENDIX H, SECTION H.1.6.A. (OVERHEAD BRIDGE) OR SECTION H.2.8.A (UNDERPASS BRIDGE) AND APPENDIX H FOR ADDITIONAL SHORING LOCATION REQUIREMENTS.

REVISIONS		
DATE	LTR.	DESCRIPTION
9/23/2013	1	REVISE ZONE 2 DIMENSION AND AREA
1/1/15	2	REVISED NOTE 2

NORFOLK SOUTHERN

PUBLIC PROJECTS MANUAL
TYPICAL DRAWINGS

SHORING DESIGN GUIDE
SHORING REQUIREMENTS

REF. NO.: SEC 1 - OHB - 5 - SHT 4

DATE: AUGUST 1, 2015 DRAWING NO.: 4

PLATE IX - Lateral Pressures for Sheeting Design

LATERAL PRESSURES FROM COOPERS E-80 TRAIN LOADS

THE BOUSSINESQ EQUATION FOR STRIP LOADS IS SHOWN IN THE AREMA MANUAL FOR RAILWAY ENGINEERING, CHAPTER 8, SECTION 20.3.2.2

BOUSSINESQ EQUATION:

$$PS = (2q/\pi) * (\beta - (SIN(\beta) * COS(2\alpha)))$$

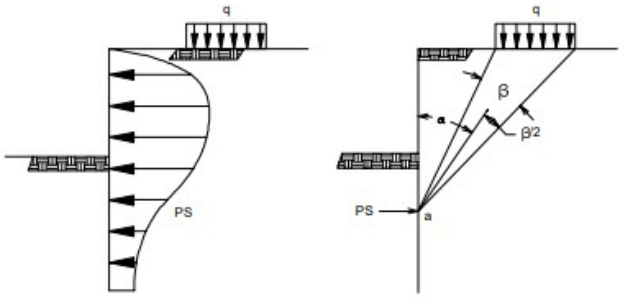
WHERE:

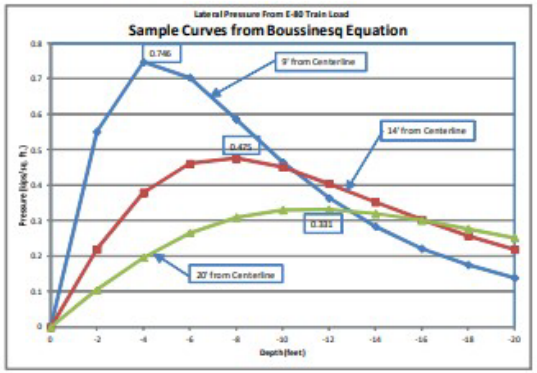
PS	=	ACTIVE PRESSURE FROM SURCHARGE LOADING
β	=	ATAN((CLT+TL/2) / HS) - ATAN((CLT-TL/2) / HS) IN RADIANS
α	=	β/2 + ATAN((CLT-TL/2) / HS) IN RADIANS
q	=	UNIFORM SURCHARGE LOAD FROM TRAINS = 80 KIPS/ (5) (TL)
CLT	=	DISTANCE FROM FACE OF RETAINING WALL TO CENTERLINE OF TRACK
TL	=	TIE LENGTH = 8.5' STANDARD
HS	=	DEPTH BELOW APPLIED SURCHARGE LOADING

Table 1 - Lateral Pressure from E-80 Train Loads
(From Boussinesq Equation)

"CLT" (Distance From Centerline of Track in Feet)	Depth (Feet) 0	-2	-4	-6	-8	-10	-12	-14	-16	-18	-20
8	0	0.7	**0.846**	0.732	0.576	0.439	0.333	0.253	0.195	0.152	0.12
9	0	0.55	**0.746**	0.703	0.585	0.464	0.363	0.283	0.221	0.175	0.139
10	0	0.44	0.65	**0.659**	0.579	0.478	0.385	0.307	0.245	0.196	0.158
11	0	0.36	0.565	**0.608**	0.561	0.482	0.99	0.326	0.265	0.215	0.176
12	0	0.301	0.492	**0.556**	0.536	0.477	0.406	0.339	0.281	0.232	0.192
14	0	0.218	0.378	0.46	**0.475**	0.45	0.404	0.352	0.302	0.257	0.218
16	0	0.165	0.297	0.38	**0.413**	**0.411**	0.386	0.35	0.311	0.272	0.236
18	0	0.13	0.239	0.315	0.357	**0.369**	**0.36**	0.338	0.309	0.278	0.247
20	0	0.104	0.196	0.265	0.309	0.329	**0.331**	0.319	0.3	0.276	0.251
23	0	0.078	0.15	0.208	0.25	0.276	**0.287**	**0.287**	0.279	0.265	0.247
26	0	0.061	0.118	0.166	0.205	0.232	0.248	**0.255**	**0.254**	0.247	0.237
29	0	0.049	0.095	0.136	0.17	0.196	0.214	0.224	**0.228**	**0.227**	0.222
32	0	0.04	0.078	0.113	0.143	0.167	0.185	0.197	0.205	**0.207**	**0.206**
35	0	0.034	0.066	0.095	0.122	0.144	0.161	0.174	0.183	0.188	**0.189**
39	0	0.027	0.053	0.078	0.1	0.119	0.135	0.148	0.158	0.164	**0.168**
43	0	0.022	0.044	0.064	0.083	0.1	0.115	0.127	0.137	0.144	**0.149**
47	0	0.019	0.037	0.054	0.07	0.085	0.098	0.11	0.119	0.127	**0.133**
51	0	0.016	0.031	0.046	0.06	0.073	0.085	0.095	0.104	0.112	**0.118**
55	0	0.014	0.027	0.04	0.052	0.063	0.074	0.084	0.092	0.099	**0.105**

All pressures shown are in kips per sq. ft.
Boxed values represent the maximum pressure ordinate for each value of "CLT".





NOTES:

1. TABLE 1 PROVIDES THE RESULTANT LATERAL PRESSURES FOR VARIOUS DEPTHS AND DISTANCES FROM THE CENTERLINE OF TRACK. THREE REPRESENTATIVE PRESSURE CURVES ARE ALSO SHOWN ON THE PROVIDED SAMPLE CURVES FROM BOUSSINESQ EQUATION.
2. FOR A SIMPLIFIED ENGINEERING ANALYSIS, THE RAILROAD LOADING SURCHARGE PRESSURE MAY BE ASSUMED RECTANGULAR WITH WIDTH (P) EQUAL TO 0.8 OF THE MAXIMUM PRESSURE ORDINATE AS GIVEN BY THE APPROPRIATE RAILROAD CURVE.
3. WORK THIS DRAWING WITH PUBLIC PROJECTS MANUAL APPENDIX H, SECTION H.I.6 (OVERHEAD BRIDGE) OR SECTION H.2.8 (UNDERPASS BRIDGE).

REVISIONS		
DATE	LTR.	DESCRIPTION

NORFOLK SOUTHERN

PUBLIC PROJECTS MANUAL
TYPICAL DRAWINGS

SHORING DESIGN GUIDE
LATERAL PRESSURES FROM
TRAIN LOADS

REF. NO.: SEC 3 - MISC 1

DATE: AUGUST 1, 2015 | DRAWING NO.: 5