

WVDOH Standards Committee Meeting

Wednesday, August 6, 2025

Meeting Location: 1900 Kanawha Blvd. E., Building 5, Room 820, Charleston, WV

Also meeting virtually via Google Meet. Email distribution includes instruction.

Old Business: Standards discussed at the June 2025 meeting are below.

ITEM	Champion
<p>4th time to Committee. Discussed in: February, April, June. Structure Directive (SD)</p> <ul style="list-style-type: none"> • <i>SD2090-Jointless Bridge Abutments</i> <ul style="list-style-type: none"> ○ Revision to entire SD. The SD now provides guidance on when integral abutments and semi-integral abutments can be used and DOH's design and detailing expectations. The SD also includes a new section discussing semi-integral abutment conversions. ○ Item tabled by champion until August. • <i>SD2110-Piers</i> <ul style="list-style-type: none"> ○ SD has been modified to add limits to the acceptable amount of reinforcing steel in pier caps, added requirements for second-order analysis on pier columns to avoid oversizing slender elements, and codify when more thorough investigation of pier configurations would be warranted. The SD also includes a new section discussing the expectations for evaluation of existing pier and foundation elements that may be subject to changes in loading due to various rehabilitation activities. ○ Item tabled by champion until August. 	B. Neeley
<p>2nd time to Committee. Discussed in: June. One proposed drawing to the WVDOH Standard Details Book – Volume 1.</p> <ul style="list-style-type: none"> • Standard Sheet PVT1-Concrete Pavement Joint Layout and Types. • The revision adds tie bolt assembly for both shoulders. 	V. Allison
<p>2nd time to Committee. Discussed in: June. The revision removes Chief Engineer and reinstates State Highway Engineer for the following:</p> <p>Design Directive (DD)</p> <ul style="list-style-type: none"> • <i>DD 104-Pre-Bid Meeting</i> • <i>DD 105-Specification, Standards, Manuals, and Material Procedure Approval Process</i> • <i>DD 106-Approval for Patented or Proprietary Products</i> • <i>DD 202-Field and Office Reviews for Initial Engineering Preliminary Engineering and Final Design</i> • <i>DD 205-Guidance for Preparation of Design Reports and Studies</i> • <i>DD 206-Guidance for Location and Design Approvals</i> • <i>DD 501-Drainage Manual</i> • <i>DD 503-Selection of Pipe Materials</i> • <i>DD 505-Ditch Linings</i> • <i>DD 600-Geometric Design Project Categories</i> 	J. Chapman

<ul style="list-style-type: none"> • <i>DD 605-Controlling Criteria and Design Expectation Policy</i> • <i>DD 641-Pavement Type Selection Guide</i> • <i>DD 644-Asphalt Pavement</i> • <i>DD 646-Pavement Design Guide</i> • <i>DD 647-Life-Cycle Costs Analysis for Pavement Design</i> • <i>DD 648- Alternate Design Alternate Bidding of Pavements</i> • <i>DD 664-Median Barrier Warrants</i> • <i>DD 681-Work Zone Safety and Mobility</i> • <i>DD 702-Signing and Sealing of Professional Work Title Sheet Signature Block</i> • <i>DD 706-Guidelines for Preparation of Project Plans, Specifications, and Estimates (PS&E) Submittals</i> • <i>DD 708-Guidelines for Development of the Incentive/Disincentive (I/D) Contract Provision</i> • <i>DD 710-Road User Delay Reduction Methods</i> • <i>DD 811-Accessibility Standard Curb Ramps and Sidewalks</i> • <i>DD 813-Bicycle/Pedestrian Accommodation</i> • <i>DD 816-Value Engineering</i> <p>Structure Directive (SD) <i>SD 1050-Additional Design Considerations</i></p>	
<p>2nd time to Committee. Discussed in: June. The revision builds upon the Chief Engineer/State Highway Engineer change and adds updates for outdated links. FHWA has also requested to revise 105 & 106.</p> <ul style="list-style-type: none"> • <i>DD-105-Specification, Standards, Manuals, and Material Procedure Approval Process</i> • <i>DD-106-Approval for Patented or Proprietary Products</i> • <i>DD-600-Geometric Design Project Categories</i> • <i>DD-647-Life-Cycle Costs Analysis for Pavement Design</i> • <i>DD-648-Alternate Design Alternate Bidding of Pavements</i> • <i>DD-681-Work Zone Safety and Mobility</i> • <i>DD 811-Accessibility Standard Curb Ramps and Sidewalks</i> • <i>DD 813-Bicycle/Pedestrian Accommodation</i> 	

New Business: None

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS

STRUCTURE DIRECTIVE 2090 JOINTLESS BRIDGE ABUTMENTS

May 4, 2022
First Edition

Fully integral and semi-integral abutments shall be used whenever possible to eliminate deck expansion joints. See Standard Details Volume III. Jointless bridge abutments serve to reduce maintenance and construction costs, improve aesthetics and long-term serviceability of a structure. Integral abutments are the preferred jointless bridge abutments and shall be used when the anticipated thermal movement is two (2) inches or less ~~and the skew is 30° or less. If the grade exceeds five percent (5%), the lower grade abutment for a single span bridge shall be fixed and for a multi-span configuration, the pier(s) or lower abutment shall be fixed.~~ Semi-integral abutments may be used for instances that are not appropriate for integral abutments. ~~Both types are assumed to be pinned and shall be designed in accordance with the following guidelines.~~ Steel diaphragms or cross frames at bearings are not required for superstructures with integral or semi-integral abutments. If required for construction stability, temporary bracing may be placed adjacent to the abutment and removed after the concrete has cured.

2090.1-CRITERIA FOR INTEGRAL ABUTMENTS

Integral abutments refer to short stub-type abutments connected rigidly to the bridge deck without joints. This rigid connection allows the abutment and the superstructure to act as a single structural unit. As a result, the bridge superstructure, abutment, and foundation piles are all subjected to cyclic loading.

2090.1.1-Approach Slabs: Approach slabs are encouraged for all integral abutments and are required for integral abutments having a total anticipated thermal movement exceeding ½ inch. Approach slabs shall be anchored to the abutment by reinforcing steel bars and detailed to accommodate appropriate thermal movements. Approach slabs shall be twenty (20) feet unless geometrically constrained. In such cases, the length of the approach slab should be maximized. Approach slabs shall be in accordance with SD 2140 and the most recent Standard Details Book, Volume III.

2090.1.2-Expanded Polystyrene (EPS): Integral abutments shall utilize a minimum six (6) inch thick expanded polystyrene material behind the abutment to reduce earth pressure forces generated by thermal movement. Refer to the most recent Standard Details Book, Volume III for expanded polystyrene detailing behind approach slabs. Omission of expanded polystyrene material shall require Project Manager's approval and supplemental structural and geotechnical design outside of the scope of this directive.

2090.1.3-Bridge Length: The maximum bridge length for which integral abutments are recommended shall be 400 feet and 600 feet for steel and concrete superstructures respectively.

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These bridge lengths are based on past experience with jointless bridges which did not show serious construction or maintenance problems.

When economically feasible, the use of integral abutments on bridges with lengths exceeding the limits specified herein should be investigated. Special design considerations and details may be necessary for integral abutments on bridge lengths exceeding those specified.

The ratio between the span lengths in the bridge shall be chosen such that no net negative beam reaction is produced at any limit state unless approved by the Project Manager. No net negative force shall be allowed on any pile at any limit state.

2090.1.4-Skew Angle: Earth pressure acts in a direction perpendicular to the abutments. For skewed bridges, the earth pressure forces on the abutments produce a torque that causes the bridge to twist in plan. This twisting can cause cracking at the ends of the deck. Limiting the skew angle reduces this effect. The maximum allowable skew angle is:

- A. 20° for integral abutments without approach slabs.
- B. 20° for multiple span structures with adjacent end spans greater than 140 feet.
- C. 30° for multiple span structures with adjacent end spans less than 140 feet.
- D. 30° for single span steel structures less than 140 feet or single span concrete structures between 140 feet and 90 feet.
- E. 45° for single span concrete structures less than 90 feet.

Integral abutments for simple span structures should be skewed at the same angle. Different skew angles are allowed for multiple span structures but shall not differ by more than 10°. Superstructures may be skewed greater than the above limits with the State Bridge Engineer's approval and supplementary calculations and detailing, as required, to limit transverse movement.

2090.1.5-Horizontal Alignment: Straight beams should be used with integral abutments. Curved superstructures utilizing straight beams may be used when centrifugal forces are considered in the integral abutment's design. Horizontally curved beams are discouraged but are allowed if they meet all the following criteria:

- A. Beams are concentric.
- B. Bearing lines are not skewed more than 10° from radial.
- C. The stiffnesses of all beams is similar in both planes.
- D. The span eccentricity does not exceed 2.5 percent of the span length.
- E. Crossframes or diaphragms are designed as primary members and installed at spacing not to exceed 25 feet for steel I-Beam superstructures.
- F. Appropriate centrifugal forces are considered in the integral abutment's design.

Integral abutments outside of the above limits may be used with the State Bridge Engineer's approval and supplementary calculations and detailing as required.

2090.1.6-Vertical Alignment: Integral abutments may be used on bridges with vertical curvature. The grade between the abutment and nearest fixed support should not exceed five percent (5%). Integral abutments on steeper slopes may be used with additional design considerations.

2090.1.7-Geometric Constraints: Integral abutments measured from the top of deck to bottom of pile cap shall not exceed ten (10) feet. A taller integral abutment may be allowed with supplementary calculations and thicker expanded polystyrene layer with the Project Manager's approval. The berm elevation should be approximately constant along the front face of the integral abutment to avoid uneven earth pressure during contraction of the bridge.

The height of the pile cap section shall be minimized to avoid developing high passive earth pressures or premature failure of the expanded polystyrene. The pile cap portion of the integral abutments shall be no less than three (3) feet by three (3) feet.

Wingwalls should be cantilevered and shall not extend more than six (6) feet from the edge of the abutment transversely nor extend more than twelve (12) feet longitudinally. Wingwalls shall have a minimum thickness of twelve (12) inches. The wingwalls may be tapered as needed for aesthetics and constructability. Cantilevered wingwalls shall be connected to the abutment using a one (1) foot chamfer. Refer to Figure 2090.A.

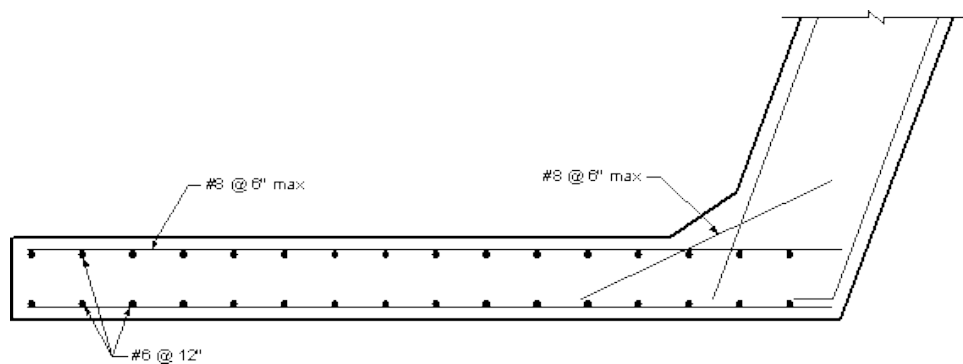


Figure 2090.A

Structurally isolated wingwalls may be used for instances that are not appropriate for cantilevered wingwalls. Appropriate preformed joint material shall be used between the integral abutment and structurally isolated wingwalls to allow unhindered thermal movement. The use of structurally isolated wingwalls with integral abutments requires approval from the Project Manager.

2090.1.8-Piling Constraints: Piles shall be a single row of steel H-Piles aligned so that the flanges are parallel to the direction of thermal movement. Piles shall be HP12 or HP14 sizes unless otherwise approved by the Project Manager. All piles shall be embedded into the pile cap a minimum of two (2) feet. Additional embedment may be necessary for integral abutments with large thermal movements. The distance from the side of any pile to the nearest edge of the abutment shall not be less than nine (9) inches. Pile spacing shall not exceed ten (10) feet unless approved by the Project Manager. Piling lengths of ten (10) feet minimum to fifteen (15) feet shall be predrilled to the top of rock. Piling lengths greater than fifteen (15) feet shall be predrilled a minimum of fifteen (15) feet. Pre-drilling shall be in accordance with Section 616 of the Specifications. Pile points are permitted but are not considered a substitute for pre-drilling integral abutment piling. Piling shall not be allowed under wingwalls.

It is good practice to position piles directly under bridge beams for load transfer. Where this is not practical, the distance between the centerline of any given beam to the centerline of the nearest pile should not exceed the effective shear depth (d_v) of the pile cap. If this requirement cannot be satisfied the pile cap shall be designed using the Strut-and-Tie Methodology. For adjacent box beam bridges the pile cap may be designed assuming superstructure forces are distributed uniformly across the abutment's width. A minimum of four (4) piles shall be used unless otherwise approved by the State Bridge Engineer. Piles shall be evenly spaced using the same pile size.

2090.1.9-Closure Pour: To reduce cracking in integral abutments, a closure pour consisting of the backwall, and an adjacent "X" feet minimum of deck shall not be placed until all other deck pours have been placed and cured. The distance "X" is equal to 0.5 feet + the effective slab length measured from the front face of the abutment.

2090.1.10-Scour and Drainage: Protective countermeasures are recommended around all integral abutments to avoid erosion. Protective countermeasures are required around all integral abutments for which any of the following criteria are satisfied:

- A. Water surface elevations from the design storm reaches the abutment.
- B. Water surface elevations from the check storm reaches the bottom of the beams.
- C. The toe of the abutment fill falls within ordinary high water.
- D. The abutment fill slope exceeds 4:1.
- E. Scuppers are present near the abutment or along the abutment's fill slope.

Design and check storms are defined within the West Virginia Department of Transportation, Division of Highways Drainage Manual. Integral abutments supporting bridges in scour prone areas shall be evaluated for structural stability after scour has occurred. The evaluation shall show the bridge does not incur damage that hinders its ability to be operational after the roadway fill has been re-established.

2090.2-DESIGN OF INTEGRAL ABUTMENTS

Integral abutments and piles shall be designed to resist all applicable force effects. Integral abutments are assumed to act as pinned connections. Flexural forces between the pile cap and closure pour shall be evaluated by modeling the frame action for integral abutments that do not meet the requirements of SD 2090.1.4 – SD 2090.1.8.

2090.2.1-Loads and Load Combinations

2090.2.1.1-Permanent Loads: All permanent loads on the abutment including beam dead load, wearing surface, approach slabs, abutment self-weight, attached wingwalls, down drag, etc. shall be considered. Permanent loads that are not transferred through the bridge beams, excluding those from cantilevered wingwalls, may be assumed to act uniformly across the abutment width. Self-weight of cantilevered wingwalls may be assumed to act as point loads at the ends of the abutment pile cap. Permanent loads carried by the approach slab should be applied to the abutment assuming the approach slab acts as a simple span beam between the abutment and sleeper slab.

2090.2.1.2- Live Loads: All live loads on the abutment including truck loads, lane loads, pedestrian loads and impact forces shall be considered. Impact forces may be omitted or reduced for the design of the piles in accordance with AASHTO LRFD Bridge Design Specifications.

For the design of the integral abutment and the piles, live loads are assumed equally distributed to all beams in the cross section due to the high rigidity of the abutment. Multiple presence factors shall be omitted for abutments carrying more than two (2) design lanes to avoid underestimation of pile forces on wide bridges where the length-to-depth ratio of the abutment beam is relatively high. The total live load on the abutment shall be determined assuming the largest number of traffic lanes that may be allowed as defined within AASHTO LRFD Bridge Design Specifications. For the design of integral abutments, the live load reaction of any beam may be computed as follows:

$$R_V = \frac{R_{BRG} N_L}{g_{INT} N_B}$$

Where:

R_V	=	Beam reaction for integral abutment design
R_{BRG}	=	Interior beam reaction from the beam design program
g_{INT}	=	Interior beam shear distribution factor from the beam design program
N_B	=	Number of beams in the cross section
N_L	=	Maximum number of traffic lanes allowed by the bridge clear width

Live load from the approach slab shall be considered and applied assuming the approach slab acts as a simple span beam between the abutment and sleeper slab. It is unlikely the position of the design vehicle that produces maximum beam reactions will concurrently produce significant live load on the approach slab therefore, in absence of more thorough analysis, only lane load needs be applied to the approach slab for integral abutment design.

Centrifugal forces shall be applied to integral abutments that lie within horizontal curves. The centrifugal forces may be applied as an increase in vertical live load from rotation of the superstructure as a rigid body.

Braking force shall be applied to the integral abutment for the design of the closure pour, backwall, and pile cap. Thermal movement controls the design of the piles therefore braking forces should not be considered in their design.

2090.2.1.3-Wind Loads: Wind uplift on the superstructure and transverse wing loads on the superstructure and on live load should be considered in the design of integral abutments for large multiple span bridges. The magnitude of wind forces on small bridges does not often control the design of integral abutments and may be omitted based on engineering judgement.

2090.2.1.4-Other Transverse Loads: The load combination for which water and ice loads are investigated does not often control the design of integral abutments and may be omitted based on engineering judgement.

2090.2.1.5-Thermal Movements: The integral abutment thermal movement due to uniform temperature change shall be computed as:

$$\Delta = \alpha \Delta t_{max} L$$

Where:

Δ	=	Thermal movement due to uniform temperature change
α	=	Coefficient of thermal expansion of the bridge material
Δt_{max}	=	Uniform temperature difference ($\Delta t_{max} = 115^{\circ}\text{F}$ for steel superstructure) ($\Delta t_{max} = 85^{\circ}\text{F}$ for concrete superstructure)
L	=	Distance from abutment centerline and point of fixity

The design thermal movement at the abutment shall be based on the difference in temperatures specified in SD 2012.1.6 and temperature at which the pile cap is made integral with the superstructure. The structural deck concrete shall be poured and allowed to cure between 45°F and 85°F therefore the design thermal deflection shall be calculated from a uniform temperature difference (Δt_{max}) of 115°F and 85°F for steel and concrete superstructures respectively.

The length between centerline of abutment bearing and nearest point of fixity (L) shall be used to compute the thermal deflection. The point of fixity shall be defined as the location on the bridge which does not move longitudinally during changes in temperature. Appropriate stiffnesses shall be considered in determining the point of fixity.

The distance to fixity (L) should be equal to half of the span length for simple spans with approximately constant width and height with integral abutments at both ends. For simple spans with differing widths or heights with integral abutments at both ends, the distance to fixity (L) for integral abutments may be estimated as:

$$L_{A1} = L_{BRIDGE} \left(\frac{W_{A2} H_{A2}}{W_{A1} H_{A1} + W_{A2} H_{A2}} \right) \geq 0.4 L_{BRIDGE}$$

$$L_{A2} = L_{BRIDGE} - L_{A1} \geq 0.4 L_{BRIDGE}$$

Where:

L_{A1}	=	Distance from Abutment 1 to the point of fixity
L_{A2}	=	Distance from Abutment 2 to the point of fixity
L_{BRIDGE}	=	Bridge length
W_{A1}	=	Abutment 1 width
H_{A1}	=	Abutment 1 average height
W_{A2}	=	Abutment 2 width
H_{A2}	=	Abutment 2 average height

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The distance to fixity (L) should be equal to the span length for simple spans with integral abutment at only one end. The distance to fixity (L) is defined as the distance from the abutment to the nearest fixed bearing for continuous structures where the fixed bearing is founded on a stiff substructure. For all other configurations the thermal movement for the subject integral abutment shall be calculated as:

$$\Delta_i = \frac{F}{k_i}$$

$$F = k_{eq} \Delta_{tmax}$$

$$\frac{1}{k_{eq}} = \sum_{i=1}^n \frac{1}{k_i}$$

Where:

Δ_i	=	Design deflection of the i-th abutment
F	=	Force required to deflect bridge the design movement (Δ_{tmax})
k_i	=	Spring stiffness of the i-th substructure unit
k_{eq}	=	Equivalent spring stiffness of springs in series
n	=	Number of substructure units
Δ_{tmax}	=	Uniform temperature difference

The spring stiffness of each substructure unit shall be determined with consideration of bearing movement, pier deflections, pile deflection, etc. as appropriate. For horizontally curved bridges the consideration of out of plane thermal deflection should be considered as needed. The pile flanges shall be oriented parallel to the assumed direction of thermal movement for horizontally curved bridges. See Figure 2090.B.

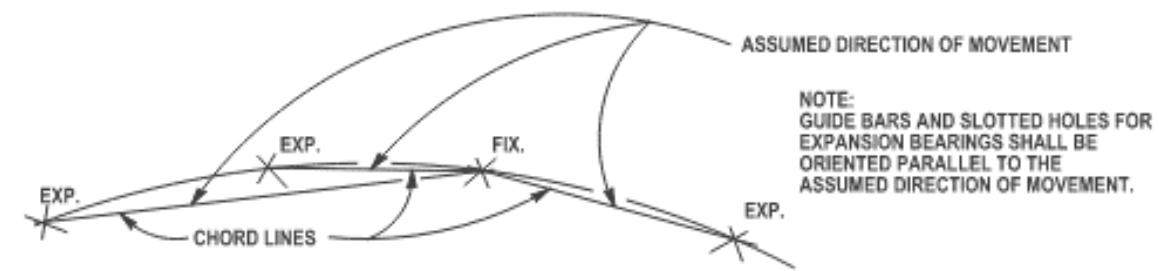


Figure 2090.B

2090.2.1.7-Other Loads: Secondary load effects from creep and shrinkage shall be considered. Other secondary loads may be evaluated at the engineer's discretion.

2090.2.2-Abutment Design: The components of the abutment are made up of the combined closure pour and backwall, pile cap, piles and wingwalls. Longitudinal forces shall be considered

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for design of the abutment for out of plan flexure and bi-axial bending. Passive earth pressure shall be computed in accordance with code requirements. Earth pressure forces may be reduced for integral abutments using expanded polystyrene but shall not be less than 40 PCF equivalent fluid pressure.

2090.2.2.1-Closure Pour: Reinforcing steel within the closure pour shall match standard deck details. Refer to Figure 2090.C.

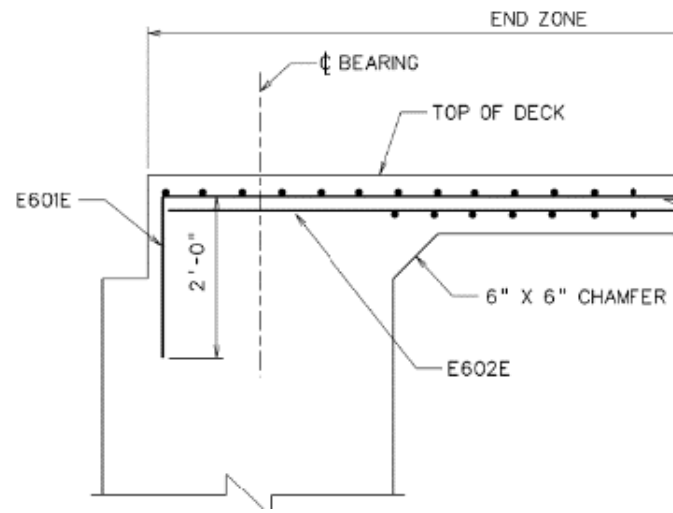


Figure 2090.C

2090.2.2.2-Backwall: The backwall shall be designed without consideration of strength from reinforcing steel in the closure pour. The backwall shall be designed as a horizontal beam resisting earth pressure and all other applicable horizontal forces. Refer to Figure 2090.D.

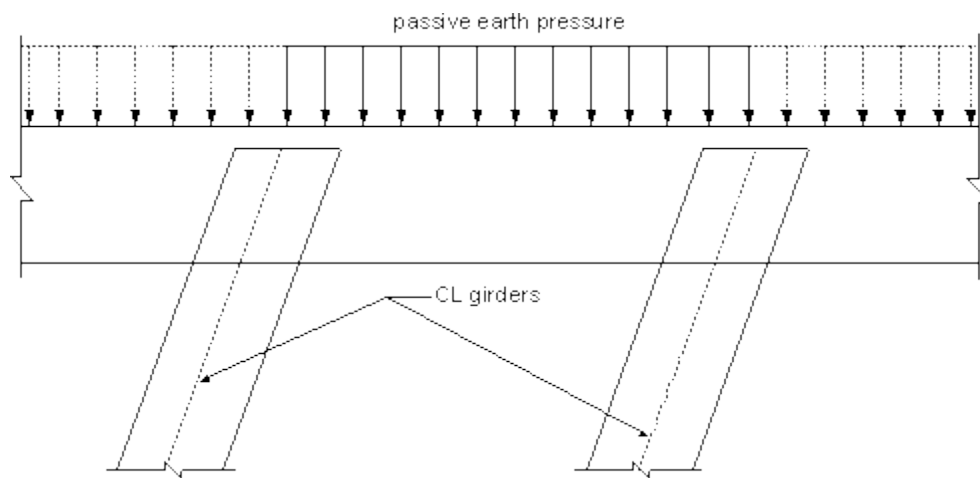


Figure 2090.D

It is best practice to use the same longitudinal reinforcing steel bar size in the front and back faces to avoid unintentional construction errors. The longitudinal reinforcing should be detailed for maximum flexure force effects unless significant cost saving can be realized. Longitudinal bars shall be contained within closed stirrups designed for appropriate shear effects.

Additional longitudinal reinforcing bars shall be placed through holes drilled or cast in the beam ends. The beam anchorage reinforcing steel shall be #8 bars at twelve (12) inches maximum spacing, placed 5½” from the front face of the abutment. A minimum of three (3) longitudinal bars are required to pass through the beam web unless otherwise approved by the Project Manager. Longitudinal bars should be detailed to lap or mechanically couple between beams for ease of placement.

Vertical reinforcing steel shall be approximately equally spaced across the width of the abutment except at beams where modifications may be necessary. The closure pour – pile cap interface shall be connected by fully developed vertical reinforcing steel. Flexure forces at the closure pour – pile cap interface shall be computed assuming frame action for integral abutments not meeting the requirements of SD 2090.1.7.

2090.2.2.3-Pile Cap: The pile cap shall be designed in accordance with AASHTO LRFD Bridge Design Specifications with consideration of both vertical and horizontal forces. Primary flexural reinforcing bars shall be of equal number and size in the top and bottom mat, shall be continuous along the cap’s length if possible, and be hooked at the pile caps ends. Secondary flexural reinforcing bars shall be of equal number and size in the front and back mats and shall be continuous along the cap’s length if possible. If required, splices in mats of reinforcing steel should be made near points of contraflexure. Shear stirrup size and spacing shall remain constant along the cap’s length unless significant savings can be realized. Shear stirrups shall enclose flexural reinforcement except where they conflict with the embedded piles in which case U-Shape stirrups shall be used. Punching shear of the pile through the cap without consideration of the backwall shall be investigated when the positioning of beam and piles requires Strut-and-Tie modeling as specified in SD 2090.1.

2090.2.2.4-Cantilevered Wingwalls: Cantilevered wingwalls shall be designed in accordance with AASHTO LRFD Bridge Design Specifications with consideration of both vertical and horizontal forces. Horizontal forces from earth pressure introduce torsion in rectangular wingwalls that shall be considered as part of their design.

Constant thickness rectangular cantilevered wingwalls are recommended for ease of construction. It is best practice to use the same bar size for horizontal tension reinforcing steel unless significant savings can be realized. Wingwalls should use the same reinforcing steel bar size throughout to avoid unintended construction errors if practical.

2090.2.2.5-Isolated Wingwalls: Isolated wingwalls may be used with integral abutments when cantilevered wingwalls are not practical. Preformed joints shall be used to allow free expansion of the integral abutment without contacting the isolated wingwalls. Foundations for isolated wingwalls shall also be isolated from the abutment foundation. Use of isolated wingwalls with integral abutments requires the Project Manager’s approval.

2090.2.3-Pile Design: Steel piles shall be designed in accordance with AASHTO LRFD Bridge Design Specifications with the P-Δ methodology using LPILE or similar software package. Steel pile design shall use resistance factors defined within AASHTO LRFD Bridge Design Specifications for driven piles. Steel piles subject to thermal movements less than ½” may be designed without consideration of the flexural forces introduced as part of the lateral analysis. Design of piles using lateral analysis shall follow the following steps:

STEP 1: Perform borings, field reconnaissance and computations to establish geotechnical parameters needed to complete lateral pile analysis. Modify geotechnical parameters as specified within AASHTO LRFD Bridge Design Specifications for closely spaced piles.

STEP 2: Select pile size based on available information. Use axial loads to estimate pile size if flexural forces are not yet available.

STEP 3: Create LPILE model assuming a fixed head condition. Apply shear and moments at the pile head to establish the deflected fixed head condition. Limit moment to the plastic moment of the pile. Run modeling.

STEP 4: Summarize flexural forces predicted from modeling. Document the first point of zero moment (L_{i1}), second points of zero moment (L_{i2}) and maximum moment between the two points (M_u) as shown within Figure 2090.E.

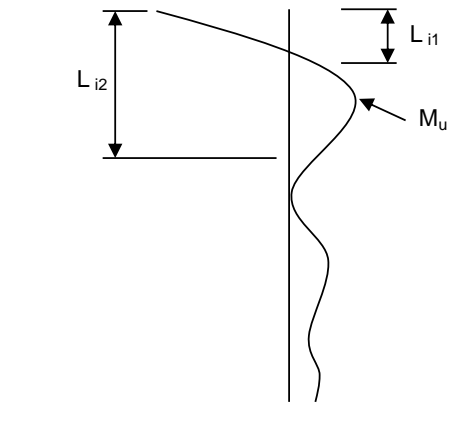


Figure 2090.E

STEP 5: Determine axial pile capacity with an unbraced length equal to the difference between the first and second points of zero deflection.

STEP 6: Design pile in accordance with AASHTO LRFD Bridge Design Specifications for axial and flexural force M_u . Return to Step 3 if pile does not have sufficient capacity.

2090.1-INTEGRAL ABUTMENTS

~~Approach slabs are required for all integral abutments having a total anticipated thermal movement exceeding 1/2 inch, or those conditions described in SD 2140. The approach slab shall be anchored to the abutment by reinforcing steel bars. The approach slab shall not be anchored to the wingwalls and to reduce friction, filter fabric shall be placed over the base course prior to placing the approach slab.~~

~~Provide expansion joints for utilities, sidewalks, concrete barriers, guardrail and other roadway features that pass over integral abutments onto the approach roadway.~~

~~Construct a Type H joint (Standard Detail Sheet PVT2) between the approach slab and pavement to accommodate thermal movement when using flexible approach pavement. Rigid approach pavements require a Type B joint (Standard Sheet PVT1) between the approach slab pavement for movements up to 1/4 inch and a Type J joint (Standard Sheet PVT5) for movements greater than 1/4 inch.~~

~~To reduce cracking in integral abutments, a closure pour consisting of the backwall and an adjacent "X" feet minimum of deck shall not be placed until all other deck pours have been placed. The distance "X" is equal to 0.5 feet + the effective slab length (distance between beam quarter points, in feet) measured from the front face of the abutment.~~

~~To reduce the effects of passive earth pressure, use loose (non-compacted) select material for backfilling when thermal movements at integral abutments exceed 1/2 inch. The design must provide for adequate drainage of the backfill.~~

~~Abutment diaphragms or cross frames are not required for superstructures with integral abutments. If required for construction stability, temporary bracing may be placed adjacent to the abutment and removed after the concrete has cured. Sufficient clearance between the abutment and temporary bracing shall be maintained to provide adequate room for the construction of the abutment backwall. Bearing stiffeners are required on steel superstructures.~~

~~The beam seat shall be sloped parallel to the beam grade for integral abutments.~~

~~Integral abutments shall be designed using a single row of piling. Wingwalls requiring more support than that available from the integral abutment shall be structurally isolated.~~

~~The following parameters apply to integral abutments:~~

- ~~A. Piling shall be a single row and aligned so that the flanges are parallel to the direction of thermal movement.~~
- ~~B. Piling shall be embedded into the abutment at least two (2.0) feet unless the analysis requires more.~~
- ~~C. The distance from the side of any pile to the nearest edge of the abutment shall be greater than nine (9) inches.~~
- ~~D. Piling lengths of ten (10) feet (minimum) to fifteen (15) feet shall be predrilled to the top of rock. Piling lengths greater than 15 FT shall be predrilled a minimum of fifteen (15) feet. Pre-drilling is in accordance with Section 616 of the Specifications. Pile points are permitted to facilitate pile driving but are not considered a substitute for pre-drilling integral abutment piling.~~
- ~~E. Wingwalls supported by the abutment shall be limited to six (6) feet for straight wings and twelve (12) feet for U-wings.~~

2090.3-CRITERIA FOR SEMI-INTEGRAL ABUTMENTS

Semi-integral abutments may be used for instances that are not appropriate for integral abutments and where foundation sites rule out the use of an abutment on a single row of piles.

2090.3.1-Approach Slabs: Approach slabs are required for all semi-integral abutments unless approved by the State Bridge Engineer. Approach slabs shall be anchored to the semi-integral abutment diaphragm by reinforcing steel bars and detailed to accommodate appropriate thermal movements. Approach slab geometry shall meet the requirements of SD 2090.1.1.

2090.3.2-Expanded Polystyrene (EPS): Expanded polystyrene for semi-integral abutments shall be in accordance with the requirements of SD 2090.1.2. Expanded polystyrene shall be placed along the full height of the diaphragm that thermally deflects. The thickness of the expanded polystyrene material behind the abutment shall be derived from engineering computations where thermal movements exceed 2 inches but shall not be less than twelve (12) inches.

2090.3.3-Skew Angle: Semi-integral abutments experience similar earth pressure and torsional effects as described in SD 2090.1.4. Semi-integral abutments may be used for skew angles up to 30° without supplementary analysis. Semi-integral abutments for structures should be skewed at the same angle. Different skew angles are allowed for multiple span structures but shall not differ by more than 10°. Superstructures may be skewed outside these limits with the Project Manager's approval and supplementary calculations and detailing, as required, to limit transverse movement.

2090.3.4-Horizontal Alignment: Semi-integral abutments are subject to the horizontal alignment requirements of SD 2090.1.5. Semi-integral abutments that do not meet those requirements may be used with the Project Manager's approval.

2090.3.5-Geometric Constraints: The pile cap portion of a semi-integral abutment shall be no less than three (3) feet by three (3) feet. Wingwalls shall meet the same geometric constraints as described in SD 2090.1.7.

2090.3.6-Foundations: Semi-integral abutments shall be supported by direct bearing on rock, steel piling, drilled caissons, or micropiles. Geotechnical information and design shall be used to establish the preferred foundation type.

2090.3.6.1-Piling Constraints: A minimum of two rows of steel H-Piles aligned so that the flanges are perpendicular to the direction of thermal movement shall be used. All piles shall be embedded into the pile cap a minimum of two (2) feet. The distance from the side of any pile to the nearest edge of the abutment shall not be less than nine (9) inches. Pile size, drilling, and driving criteria shall be at the discretion of the Geotechnical Engineer. The front row of piles may be tapered to resist longitudinal loads if necessary.

2090.3.6.2-Drilled Caisson Constraints: A single row of caissons shall be used and designed to resist applicable longitudinal loads. All caissons shall be embedded into the pile cap a minimum of twelve (12) inches. Caisson reinforcing steel shall be fully developed in accordance with AASHTO LRFD Bridge Design Specifications. The distance from the side of any caisson to the nearest edge of the abutment shall not be less than nine (9) inches. Drilled caissons shall be a minimum of three (3) feet in diameter unless otherwise approved by the Project Manager.

2090.3.6.3-Micropile Constraints: Micropiles should be investigated where access is limited or when longitudinal loads would require taper of conventional piling. Micropile foundations shall be designed and detailed in accordance with FHWA Micropile Design and Construction Guidelines.

2090.3.7-Abutment Seat: A full-length curb on the top of the semi-integral abutment stem shall be used to help retain backfill when the bearing height exceeds 1 ½ inches. Neoprene seals shall be used for waterproofing. Refer to Standard Details – Volume III.

2090.4-DESIGN OF SEMI-INTEGRAL ABUTMENTS

Semi-integral abutments and piles shall be designed to resist all applicable force effects in accordance with AASHTO LRFD Bridge Design Specifications. Semi-integral abutments shall be limited to 4 inches of thermal movement computed in accordance with SD 2090.2.1.5.

2090.5-SEMI-INTEGRAL ABUTMENT CONVERSION

The conversion of an existing non-integral abutment to a semi-integral abutment should be carefully considered in major rehabilitation projects. These considerations should include at a minimum the cost premium for the semi-integral abutment conversion, anticipated rehabilitated bridge service life and differences in maintenance costs. Project Manager approval is required for any semi-integral abutment conversion.

Applicable requirements of SD 2090.4 shall apply for all semi-integral abutment conversions unless otherwise approved. The engineer shall carefully consider the life cycle costs and risks of using semi-integral abutment conversions which fall outside the recommendations of SD 2090.4. All new works associated with the semi-integral abutment conversions shall be designed to resist all applicable force effects in accordance with AASHTO LRFD Bridge Design Specifications.

The preferred method of conversion involves full height removal of the backwall to bearing seat elevation and reconstruction in accordance with Standard Details – Volume III. When this method of construction poses challenges, partial height backwall removal may be considered. The condition of remaining segments of backwall shall be in good condition or rehabilitated as needed.

2090.2-SEMI-INTEGRAL ABUTMENTS

~~———— Semi-integral abutments may be used where foundation sites rule out the use of an abutment on a single row of piles, while retaining full integrity with the superstructure.~~

~~———— Consideration must be given to the following:~~

- ~~A. When full height U-shaped wingwalls are used, provisions shall be made to allow for thermal expansion of the superstructure without interference from the wingwalls.~~
- ~~B. The Designer must account for these items:~~
 - ~~1. Uplift resulting from the span arrangement.~~
 - ~~2. Buoyancy.~~
 - ~~3. Excessive grade; greater than five percent (5%).~~
 - ~~4. Potential roadway settlement.~~

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~~C. Seal between the abutment seat and cap to retain the backfill and for waterproofing. Add a full-length curb to the top of the semi-integral stem to help retain the backfill when the bearing height exceeds 1 ½ inches. See Standard Details—Volume III.~~

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS

STRUCTURE DIRECTIVE 2110

PIERS

May 4, 2022

First Edition

Piers are intermediate supports in a multi-span bridge system. All feasible pier types must be considered in the preliminary phases of a project. Refer to SD 1044 for a general description of various types of piers. The use of integral pier caps, steel bents, and prestressed pier components fall outside the scope of this directive. In such cases the Engineer shall coordinate with the Project Manager to establish geometric and design constraints.

~~Class B Concrete with a compressive strength of 3,000 PSI should be used for most piers. Class B Modified concrete with a compressive strength of 4,000 PSI may be used, if required for strength.~~

~~For the strength and extreme event limit states, the Designer shall use the strut and tie model for thick concrete elements as defined within AASHTO LRFD Bridge Design Specifications (e.g., footings, pile caps and pier caps). Use this method to determine internal force effects near supports and points of concentrated loads.~~

~~Moment redistribution shall be used where appropriate.~~

2110.1-PIER ~~CAPS~~ CAP GEOMETRY

All pier caps must be wide enough to accommodate the bridge bearings and jacking points. The edge of the bearing masonry plates must be a minimum of three (3) inches from the face of the pier cap. Instances of pier caps being wider than the column, necessitated by skewed bearings and dual bearings ~~such as those found on prestressed concrete beam superstructures~~ are acceptable.

~~Pier cap depths shall be determined by strength and clearance requirements. The minimum size is three (3) feet vertically by three 2.5(3) feet horizontally and must extend one (1) foot beyond the fascia beam bearings. Pier caps are usually haunched in the region beyond the face of the exterior column or stem. Any pier cap longer than four five (45) feet beyond the face must shall be haunched unless approved by the Project Manager. A haunch ratio between 2:1 haunch ratio is preferred and 4:1 shall be used unless approved by the Project Manager. The use of parabolic haunches or similar complex geometry should be avoided to reduce forming costs.~~ The ends of the pier caps may be either plane vertically or shaped (i.e., cylindrical to mirror the columns).

~~Minimum horizontal reinforcement shall be #5 bars spaced at twelve (12) inches. Rebar shall be placed to avoid anchor bolts.~~

~~Beam seats shall be stepped and finished level. The sloped stem option, per SD 2080, is preferred when steps exceed four (4) inches.~~

2110.2-PIER CAP DESIGN

Pier caps shall be designed to resist all applicable force effects in accordance with AASHTO LRFD Bridge Design Specifications. The Engineer shall use the strut and tie modeling for thick concrete elements as defined within AASHTO LRFD Bridge Design Specifications. Use this method to determine internal force effects near supports and points of concentrated loads.

Class B Concrete with a compressive strength of 3,000 PSI should be used for piers. If required for strength, Class B Modified concrete with a compressive strength of 4,000 PSI may be used.

Minimum horizontal reinforcement shall be #5 bars spaced at twelve (12) inches. Reinforcing steel shall be placed to avoid anchor bolts. Tension steel bars shall not be larger than #11 nor spaced closer than six (6) inches to limit concrete consolidation problems unless approved by the Project Manager. Tension steel bars may be bundled, or a second row of reinforcing steel placed six (6) inches below the top mat may be used to attain additional flexural capacity. The pier cap geometry should be re-evaluated if sufficient flexural capacity cannot be attained within these limits.

2110.23-PIER COLUMNS

The minimum longitudinal column diameter or stem thickness shall be three (3) feet ~~unless otherwise approved by the Project Manager~~. Column tapers or section changes shall not be used ~~unless a detailed study proves that they are cost efficient~~ cost savings can be demonstrated. Multi-column piers should be evaluated if the diameter of the stem thickness of a single-column pier exceeds eight (8) feet. ~~Generally, these forming costs are very high. Consider hollow shafts for piers should be evaluated for columns~~ in excess of one hundred (100) feet ~~in height or ten (10) feet in diameter~~.

Multi-column piers should generally not be used in a flood plain. Single circular column, T-type or wall type piers may be used in the flood plain with rounded ends and shall be oriented parallel to the stream flow. Crash walls shall be considered in accordance with AASHTO LRFD Bridge Design Specifications and AREMA requirements.

2110.4-PIER COLUMN DESIGN

Pier columns shall be designed to resist all applicable force effects in accordance with AASHTO LRFD Bridge Design Specifications. Torsional forces from non-symmetric longitudinal loads shall be considered on single-column pier shafts. A second-order nonlinear analysis (P-Δ analysis) is preferred over approximate methods of moment magnification. A second-order analysis shall be used for all columns with slenderness (KL/r) exceeding 50 unless otherwise approved by the Project Manager.

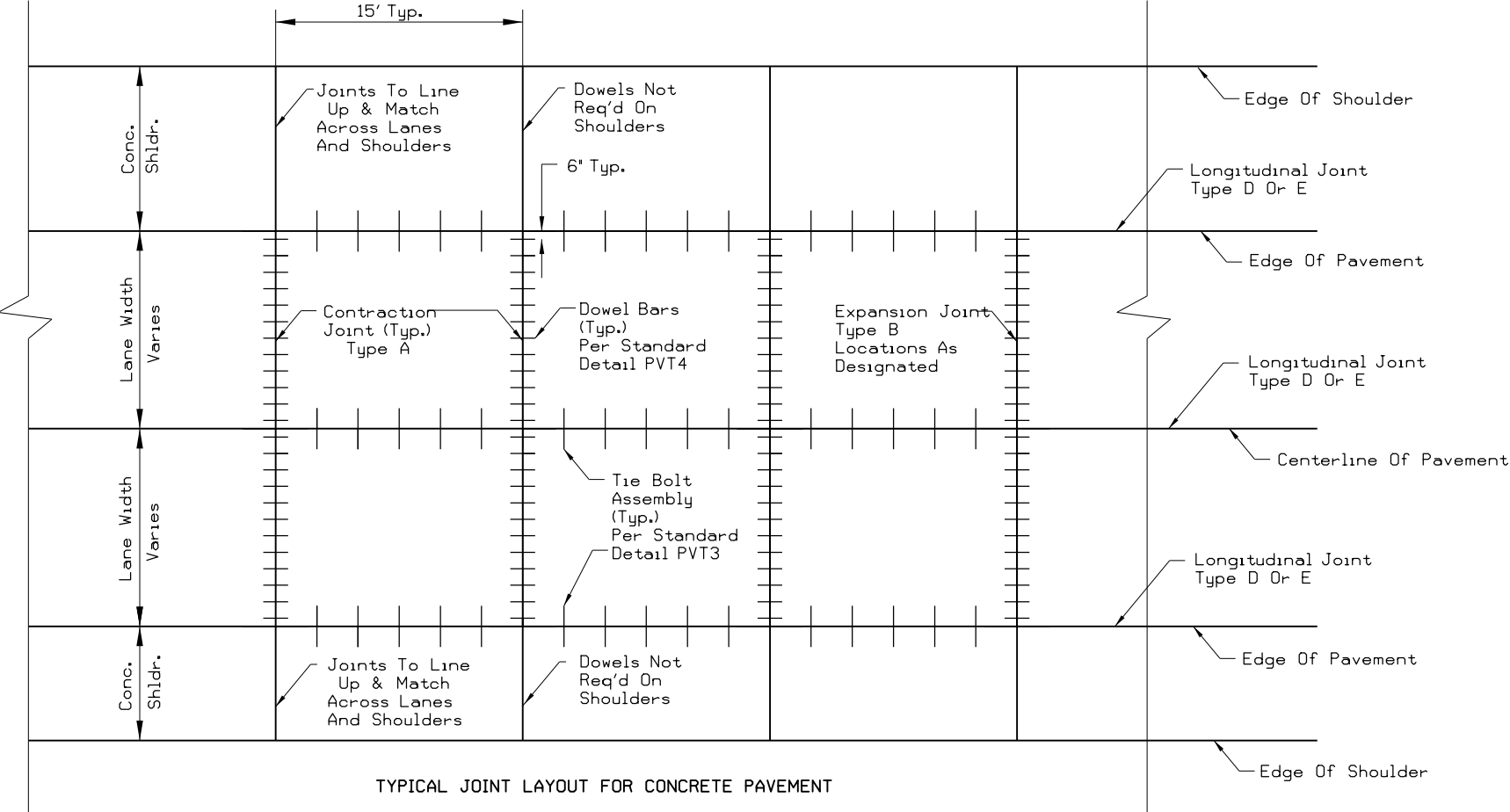
2110.35-PIER FOUNDATIONS

Pier foundations shall be located and designed as specified in SD 2120, Foundations.

2110.6-EVALUATION OF EXISTING PIERS

Major rehabilitation projects may involve repurposing or reusing existing piers. Where superstructure replacements, deck replacement or similar work are done the Engineer shall evaluate the increase in deadload on the pier and, if information is available, estimate the load carrying capacity of the existing foundations. Where insignificant increases in deadload are found and a field assessment shows no signs of distress, settlement and similar global issues the pier may be reused without the need for retrofitting. Where these increases are not insignificant, or the superstructure configuration allows for more traffic lanes than the existing condition, a more thorough evaluation may be necessary. All aspects of evaluation, repurposing and reuse of existing piers shall require approval from the Project Manager.

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TYPICAL JOINT LAYOUT FOR CONCRETE PAVEMENT

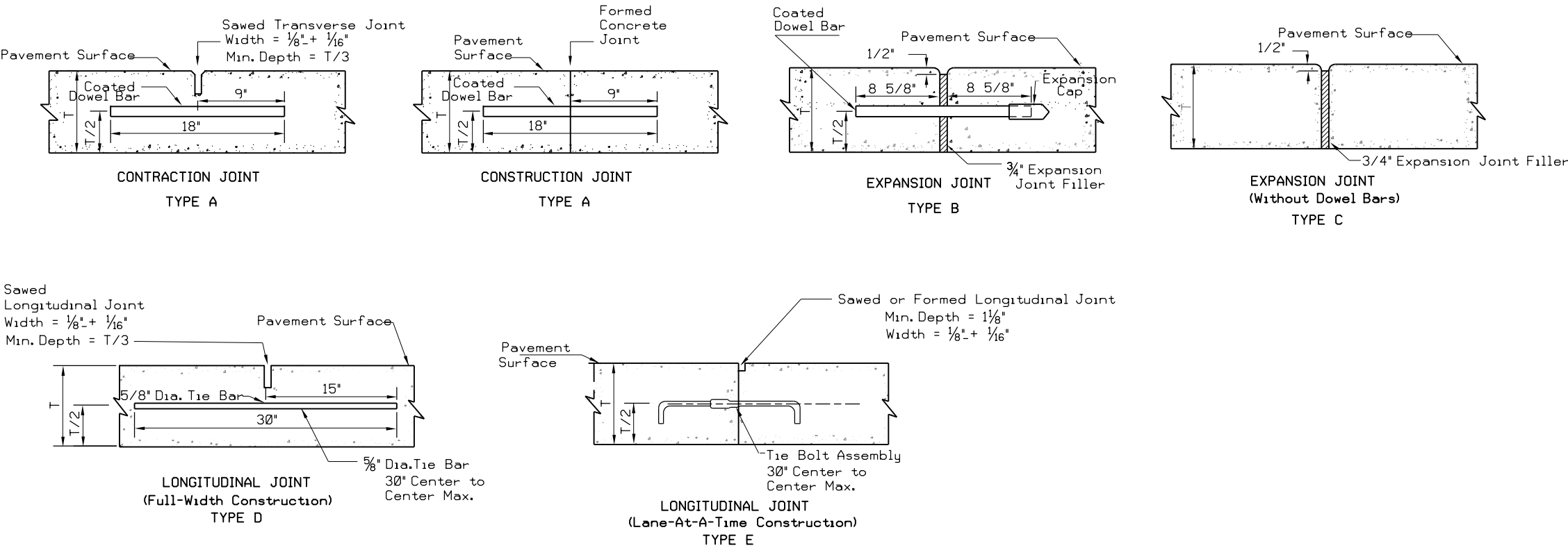
NOTES

For additional details and requirements concerning dowel bars and dowel baskets for Type A & B Joints, see Standard Sheet PVT4.

Type D Longitudinal Joint may be used as an alternate to Type E Longitudinal Joint for lanes or shoulders that are full width construction .

For additional details and requirements concerning Types E Joints, see Standard Sheet PVT3, Longitudinal Tie Bolt Assembly.

The Contractor shall submit for approval a Joint Layout Plan for all intersections on the project in general accordance with the "Street Jointing Criteria: Ten Rules Practice" as suggested by the Portland Cement Association (PCA), Skokie, Ill Illinois; the American Concrete Pavement Association's Joint Layout Guidelines; and the West Virginia Division Of Highways' Standard Specifications.



WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STANDARD DETAIL

PREPARED 7-1-99
REVISION DATE
11-22-2010

CONCRETE PAVEMENT
JOINT LAYOUT
AND TYPES

STANDARD SHEET PVT1

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 202
FIELD AND OFFICE REVIEWS FOR INITIAL ENGINEERING,
PRELIMINARY ENGINEERING AND FINAL DESIGN**

*September 6, 2023
Supersedes March 30, 2012*

Attached is the West Virginia Department of Transportation, Division of Highways, procedures for Field and Office Reviews during Initial Engineering, Preliminary Engineering and Final Design. These procedures shall be used on all applicable projects.

As a part of these procedures, in accordance with DD-200, *Project Development Process*, approvals required at the end of certain phases are indicated. These approvals must be obtained before the project proceeds to the next stage of development.

I. SCHEDULED REVIEWS

Projects developed by the West Virginia Department of Transportation (WVDOT), Division of Highways (DOH), shall generally consist of three phases of work. Each phase of work shall be accomplished utilizing a series of review submittals.

The following phases of development shall be utilized on all applicable projects:

PHASE I Initial Engineering

PHASE II Preliminary Engineering - This work generally includes environmental assessments, topographic surveys, geotechnical investigations, hydrologic analysis, hydraulic analysis, utility engineering, traffic studies, financial plans, revenue estimates, hazardous material assessments, general estimates of the types and quantities of materials. Other design activities are allowed for the purposes of defining project alternates or completing the NEPA alternatives analysis and review process as listed below under Preliminary Engineering.

PHASE III Final Design (According to 23 CFR 771.113)

Note: The designer is cautioned that no final design activities (regardless of funding source) shall proceed until one of the following three National Environmental Policy Act (NEPA) determinations have been completed:

- a. The action has been classified a PCE (Programmatic Categorical Exclusion)
- b. The action has been classified as a "Categorical Exclusion" (CE)
- c. A "Finding of No Significant Impact" (FONSI) has been approved
- d. A "Final Environmental Impact Statement" (FEIS) has been approved and available for the prescribed period of time and a "Record of Decision" (ROD) has been signed.

Initial Engineering:

End Product: Corridor Study / Design Report. See DD-205, *Guidance for Preparation of Design Reports and Studies* for more information.

Scheduled Reviews:

1. Field Review
2. Office Review

Preliminary Engineering:

End Product: Preliminary contract documents, completion of scheduled preliminary reviews shown below, preparation of review notes, and action on all comments agreed upon during the review. -Location and Design Approval shall be per DD-206, *Guidance for Location and Design Approvals*. Line and grade approval is to be obtained after environmental clearance is given.

Preliminary engineering will normally provide all the project information needed to satisfy environmental requirements; however, in certain cases more detailed design work may be needed to permit the full evaluation of environmental impacts and to permit the consideration of appropriate mitigation measures. This should not be construed as an authorization to proceed with final design activities for the entire project, but only for those aspects of the project necessary to consider specific environmental concerns. Written documentation should be prepared and retained in the project files to support any decision to proceed with final design activities needed to consider any specific environmental concerns. Such documentation should include identification of the specific environmental concern(s) and justification for those specific final design activities that need to be performed.

This documentation shall include a completed copy of the appropriate “Authorization for Detail Design Work Exceeding Preliminary Engineering”, attached to this Design Directive. Supporting information, reports, comments, and other appropriate documentation may also be included in the project file.

Other design activities are allowed for the purposes of defining project alternates or completing the NEPA alternatives analysis and review process. These activities include but are not limited to complying with other related environmental laws and regulation, environmental justice analyses, supporting agency coordination public involvement and permit application, development of environmental mitigation plans, development of typical sections, grading plans, geometric alignment including any clearances necessary, noise wall justification, temporary structure requirements, staged bridge construction requirements, bridge type/size/location studies, structural design, retaining wall design, noise wall design, design exceptions, guardrail length and layout, existing property lines and deed research, soil boring, cross sections, ditch designs, intersection design, interchange design, pavement design, storm or sanitary sewer design, culvert design identification of removal items quantity estimates, pavement details and preliminary traffic control plans.

Scheduled Reviews:

1. Preliminary Field Review/Span Arrangement (generally submitted simultaneously)
2. Value Engineering Review (if required per DD-816) to be conducted according to the currently approved Value Engineering Program
3. Slope Review

Final Design:

End Product: Final Contract Documents. See DD-706, *Guidelines for Preparation of Plans, Specifications, and Estimates (PS&E)* for more detailed instructions on the make-up of the *final contract documents*.

Scheduled Reviews:

1. Final Field Review
2. Combined Type, Size, and Location Review
3. Final Office Review
4. Bridge Rating Submission
5. Final Detail Bridge Plan Review

Scheduled Submittals:

1. PS&E Submission
2. Tracing Submission

Note:

1. An office review may be scheduled to supplement or replace any of the scheduled field reviews.
2. Additional reviews may be required when all the necessary data was not available at the scheduled review or whenever problems arising from the review are considered of sufficient importance to warrant another review.
3. Minor projects may not require all scheduled reviews be held. All projects should have a minimum of one review.

II. SUBMITTAL DOCUMENTS FOR SCHEDULED REVIEWS

Certification checklists, of required submittal documents for each scheduled review, are included in this design directive. The designer shall submit a signed copy of the appropriate certification checklist with each scheduled review. The submittal will not be considered complete if the checklist is not included and initialed by an appropriate level of management. The absence of a completed certification checklist may be cause for rejection of the submittal. The checklist must be initialed on each line by an Office Manager or an appropriate management level representing the designer. The project manager shall not initial the checklist.

The certification checklist indicates the documents required to be submitted for each scheduled review. The required number of plans to be submitted for each scheduled review shall be per the "Plan Distribution Schedule" included in this design directive. The plans shall be submitted to the division responsible for project development.

Distribution of the plans shall be made by the division responsible for project

development. The responsible division shall distribute the plans to the appropriate "resource agencies" per Appendix A of this DD.

The plans submitted in accordance with the Plan Distribution Schedule shall be bound separately and labeled on the outside per the schedule.

III. COMMENTS ON SCHEDULED REVIEW DOCUMENTS

A. Notes

1. Following any review, the responsible Division shall prepare notes in the following form:
 - a. Date of Review:
 - b. Project Number:
 - c. Description of Project:
 - d. Participants:
 - West Virginia Department of Transportation, Division of Highways
 - Federal Highway Administration
 - Consultant
 - Other
 - e. Comments:
2. Distribution of the review notes will be made to the appropriate Divisions and agencies.
3. Federal Highway Administration concurrence in the notes will be obtained, where applicable.

B. Action on Comments

1. All comments mutually agreed upon during the review are to be complied with immediately.
2. The list of comments and action taken thereon shall be prepared in the following form:
 - a. Project Number:
 - b. (Field Review, Office Review, etc.)
 - c. Consultant:
 - d. Date:

Numbering of comments shall correspond to numbering at the *scheduled review*:

1. Comment: Show garage left of Station 0+00.
 1. Action: Garage has been shown on plans.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 205
GUIDANCE FOR PREPARATION OF DESIGN REPORTS AND STUDIES**

*January 3, 2024
Supersedes November 1, 2023*

This Design Directive will give guidance and instruction on how to prepare, distribute for comments, and begin the final approval process of Design Reports and Studies. This Design Directive will provide uniformity for development of these reports/studies throughout the Division of Highways, to include the various Districts within the Division.

10. General Purpose of Design Reports and Studies

Design Reports and Studies (hereinafter referred to as “Study”, or “Studies”) are engineering studies of several proposed alignments for a highway project. These Studies are produced for projects such as small bridge replacements, roadway realignments, intersection improvements, turning lane additions, new roadway alignments, etc. By nature, these Studies are considered Initial Engineering by Design Directive (DD) 200, *Project Development Process*. The completion of the Study with an approved alternative alignment is considered the end of Initial Engineering by that particular DD. If a choice of alignments is given, the report will recommend one alignment as the “Preferred Alternate”, otherwise the alignment shown in the Study will be considered the “Preferred Alternate”. For most projects, the “Location & Design (L & D) Approval” will be requested at this time. On some projects, additional environmental work may be required, and Location and Design Approval may be requested during the Preliminary Engineering phase (see DD-206, *Guidance for Location and Design Approvals* for more information concerning this approval process). This Design Directive will cover only the preparation, distribution, receipt of comments, and selection of the Preferred Alignment in the Design Study itself.

These Design Reports and Studies should be prepared in enough detail to adequately hold the Scope of Work meeting for each project. The Study should contain a minimum of items that are unknown at the time of scoping. It is anticipated that these Studies will be handed over to the Division’s Designer or a Consultant Designer (overseen by a Roadway and a Bridge Project Manager (if required) assigned by the Division) for completion of design.

20. Preparation of Design Studies

20.1 General:

DD-201, *Public Involvement Process* should be reviewed to determine if any of the stipulations contained therein apply to each and every Design Study project. Any public involvement must take place before L & D Approval is requested. Public involvement must be noted in the L & D Approval request.

20.2 Existing Information:

All existing facilities, such as roadways, streams, culverts, storm sewers, bridges, homes/businesses (to include any sewerage facilities required by that facility, such as septic systems, “shotgun sewers”, etc.), railroads, utilities (public and private), etc. are to be field investigated and placed on the Study base mapping. The Division’s and courthouse tax map/assessor’s records are to be researched for any existing roadway, structure, right-of-way plans, property lines/owners, and known environmental information (which can be obtained from the Environmental Services Section of the Engineering Division) which may contain preliminary information vital to the Study (and can further be used when the project is scoped and assigned to a Designer). See DD-301, *Right of Way Plan Development* for more information on the required existing information to be shown on the plan sheet for each alignment. A centerline with stationing is to be provided for all existing roadways, with horizontal curve data to include at minimum the existing radii and superelevation, vertical curve data to include at minimum K-values and lengths, sight distances, etc. Bearings may be obtained from any existing mapping held by the Division, or can be taken from a compass reading. Sight distance for existing intersections/driveways should be determined and placed on the plan sheets also. Existing rights-of-way are to be placed on the plan sheets for each alternative alignment.

20.3 Mapping:

As a minimum, statewide base mapping in 1” = 400’ scale, with 10’ contour intervals, is available from the Planning and Research Division. There are other sources of mapping available within the Division. The Administrative Section of the Engineering Division maintains records of all aerial photography that has been flown and is in the Division’s possession, as well as any mapping that has been produced from said photography. In the absence of any mapping the Division may possess, blow-ups of USGS 7 ½ minute topographic sheets may be used, although this is not recommended. Any mapping provided by the Division is to be field-checked by the preparer of the Study for accuracy and then updated, with any and all updates to be made to the base mapping by the Designer. If no existing mapping is available, then conventional surveys or aerial photography and subsequent field-edited mapping may be utilized.

20.4 Scale/Paper Size:

The reports/studies should be produced at a 1” = 100’ scale, or a larger scale for smaller studies, such as a bridge replacement with very little roadway work. The scale should be chosen with the type and size of the Study, and the desired paper size in mind. If the scale needs to be made larger to show any necessary details, then match marks are to be utilized wherever necessary, based on the existing roadway’s centerline. Paper sized 11”x17” folded to 8 ½”x 11” can be used if the preparer of the Study determines that a larger scale on one sheet will contain all of the information required.

20.5 Design Criteria:

All design criteria to be used, according to the projected traffic volumes and existing or proposed roadway classification, are to be given, preferably in table format. The roadway classification and projected traffic volumes can be

obtained from the Planning and Research Division. The latest approved issues of the AASHTO Green Book, Very Low-Volume Local Roads Guide, Design Directives, Drainage Manual, and the Roadside Design Guide are to be used to determine all necessary criteria. If any design criteria cannot be met, design exceptions are to be indicated, and enough preliminary information given so that the designer can complete the design exception report(s) required during future design stages as described in the latest edition of DD-605, *Controlling Criteria and Design Exception Policy*.

20.6 Content:

Reference is hereby made to the Design Report Submission Checklists contained in DD-202, *Field and Office Reviews for Initial Engineering, Preliminary Engineering and Final Design* for the information required in the Study. Depending on the type, size, and complexity of the Study, not all information required by the checklists will be necessary. Any other information that may be known about the Study area, such as visible high water marks, other information gleaned from field surveys and observations, discussions with the residents in the Study area, and at any required public meetings such as location of septic systems, wells, etc. should be included also. The checklists are required to be submitted with each Study submission. The Project Numbers will be shown on each and every Study.

20.6.1 Existing Facilities:

All existing facilities as described in Section 20.2 above are to be contained on each alternative's plan sheet. It is very important that all existing information be indicated on the Study plans and narratives, as estimates for possible home/business relocations and right-of-way purchases, will be made by the Right-Of-Way Division for the Study. Utilities should be located in the field by notifying Miss Utility of West Virginia before the field visit is made, so as much accurate utility information is shown in the Study as possible. It is to be noted that not all utilities subscribe to Miss Utility, so it is vital that other utilities in the area be investigated for their presence. A list of the affected utilities in the project area is to be included in the narrative (See Section 20.6.6 hereinafter in this Design Directive). The capital cost of all required utility relocations will be made by the Utilities Unit of the Right of Way Division. All existing features described here and above in Section 20.1 are to be shown as described by the Division's CADD Standards, available on the WVDOH website.

20.6.2 Proposed Roadway Facilities:

A plan sheet and a profile sheet are to be prepared for each alternative alignment. A centerline is to be shown with stationing, radius and proposed superelevation for each required horizontal curve. Grades and vertical curves with preliminary K-values are to be shown for each proposed alternative's profile. This information is to be given for the mainline and all side roads.

Proposed detour roads required, such as an upstream and a downstream detour for a small bridge replaced on its existing alignment, are to be shown, along with the design speed.

The proposed construction limits should be shown, as well as property line information, obtained from the assessor's tax maps. Existing rights-of-way information and proposed right-of-way limits are to be shown. No stations or offsets are required. The cost of the necessary rights-of-way for each alternative alignment will be obtained from the Right-Of-Way Division.

All work in streams and wetlands in the project area must be indicated. Channel changes are to be shown, as the permits required are more complex and will require more time and design effort to obtain. Natural stream design methods and principles are to be used as necessary when designing any channel change on any US Army Corps of Engineers' jurisdictional stream; however this is only to be indicated in the report, and no design effort put forth. Streams which will require a culvert crossing of the roadway(s) are to be shown also, with preliminary sizes given. Preliminary drainage calculations required to size these culverts are to be included with the Study.

A sheet showing all roadway(s) typical section(s) is to be included, with widths obtained from utilizing the roadway classification and traffic volumes, the AASHTO Green Book, the AASHTO Low-Volume Local Roads Guide, and the Division's Design Directives. The Study should reference all AASHTO publications and Design Directives that were used to develop the Study. This will include a typical section for all required side roads, not including driveways. Also, the typical section for any proposed temporary detour roads and bridges is to be included.

All proposed roadway information is to be shown as described by the Division's CADD Standards, available on the West Virginia Division of Transportation's website.

20.6.3 Proposed structures:

The intent of this Design Directive in relation to structures is to develop a "Pre-Span Arrangement" report for each structure to be included in the Study. See the Division's Structure Directives for more information on this matter. Not all of the requirements for a Span Arrangement submission are required; the necessary information will be indicated in this Section of this Design Directive.

The Bridge Designer's tasks for a Design Study are to provide the necessary bridge information, capital cost estimates, and sketches for the Study to be developed. The Bridge Designer must look at the existing conditions for the project site, such as roadway geometry (both horizontal and vertical), utilities, right-of-way, existing and adjacent structures, etc. Also, historical data such as the latest Bridge Inspection Report, existing bridge plans, etc., hydraulic opening, and the proposed roadway alignments should be reviewed to assist in the development of the Study. The Bridge Inspection Files are available from the Operations Division, Bridge Evaluation Section. The Bridge Designer will develop plans and profile sheets for each structure, and give a capital cost estimate (to

include any required Temporary Bridges). The bridge drawings are to be simple line drawings with minimal details, such as stationing, grades, horizontal and vertical curve data. The capital cost estimate is to be based on historical data for similar structures based on a cost per square foot of deck area (including parapets and sidewalks). This cost can be obtained from discussions with any of the Bridge Engineers employed by the Division, or from the Designer's own engineering judgment.

The Bridge Designer is to meet with the Division's assigned Bridge Project Manager to discuss the feasible structural systems and span arrangements that will be included in the Study. The purpose of the meeting will be to eliminate or add additional alternates for further consideration on the Study. The Division's Bridge Project Manager will make the final decision on which alternates are to be carried through and studied in the Span Arrangement.

At this meeting the following information is to be available for use by the Bridge Designers and the Division's Bridge Project Manager: preliminary horizontal and vertical alignments and geometry, site plan for each structure alternate with both plan and profile sheets for each alternate, discussions on why structure options were chosen or rejected, superstructure types being considered, and a capital cost estimate for each alternative. No girder analysis is required in the Study.

As a matter of course, there will always be "No-Build" alternate given in the Study. At times, the preparer of the Study will be asked to include an alternate that is rehabilitation of the existing structure. In this case, unit costs can to be obtained from the yearly Unit Bid Price Report, which is available on the Division's website, from discussions with any of the Bridge Engineers employed by the Division, or from the preparer's own engineering judgment.

All proposed structure information is to be shown according to the Division's CADD Standards, available on the WVDOT website.

20.6.4 Hydraulics:

Hydraulics of any stream impacted by the proposed Study are a very important factor to consider when deciding on a new location for any structure, whether it is a bridge, large culvert, such as a box culvert or very large diameter pipe, or a channel change.

Enough preliminary hydraulic observations and computations are to be made to, at minimum, to determine the low chord elevation of any proposed structure, and the Q_{100} backwater elevation of the existing structure. Field surveys may be required to determine the stream channel bottom's topography and Manning's "n" values. Also, Flood Insurance Rate Maps should be consulted to see what Flood Zone the Study area is in. The regulatory Base Flood Elevation (BFE) should be shown on the plan and profile for each alternate, and the source cited in the Study. Many published Flood Insurance Studies and maps are available from the Technical Section of the Engineering Division. Further, the US Army Corps of Engineers and/or the local Flood Plain Coordinator should be contacted to determine if a detailed hydraulic study has already been performed in the area. Both tailwater and backwater effects are to be

considered, as well as preliminary scour depths for piers in the stream channel. A zero backwater increase is to be striven for. If this cannot be achieved, then easements will have to be acquired to cover the proposed backwater increase possibly involving the purchase of homes/businesses, and at minimum a Conditional Letter of Map Revision will have to be filed with the Federal Emergency Management Authority during final design activities.

The hydraulic aspects of altered streams, whether the work is as simple as locating piers in the stream, floodway or flood fringe, placing embankment in these areas, or a complete channel change become paramount when the new facility will result in water surface elevations very close to any published flood elevation. If there are no published flood elevations in the Study area, then a preliminary HEC-RAS analysis on all affected streams is to be performed and submitted as part of the Study.

20.6.5 Environmental overview:

A preliminary environmental overview is required. This work will require a representative from the Environmental Services Section of the Technical Support Division to examine the project site in enough detail to establish any environmental constraints which would affect the location of alternative alignments in the report, and be of sufficient detail to show in the Study as known constraints to the design. It is preferred that the environmental process be completed for a typical small bridge replacement study. But, studies over larger streams and rivers may require extensive agency coordination and environmental approval, especially federally endangered mussel species are encountered with the preliminary surveys. However, there should be enough surface observations and literature investigations performed to be reasonably sure that there are no major environmental constraints associated with the project.

Wetland involvement, cultural resource considerations for any structure (to include existing railroad facilities and roadway bridges), permit requirements, known endangered species, known hazardous waste/storage tank sites, etc. should be identified so there are no hidden items that come up when the project enters the Preliminary Engineering phase.

It is desired that the environmental process be completed for projects which fall under the Programmatic Categorical Exclusion process to have this document completed and approved at the time the L & D request is made.

20.6.6 Narrative requirements:

The narrative to accompany each report shall describe the existing facilities, to include traffic data for the present day as well as vehicles per day projected 20 years from the anticipated opening year of the facility to traffic, deficiencies in the existing horizontal/vertical alignments, sight distance obstructions, condition of the existing facilities (to include all roadways, shoulders, drainage facilities, and other structures, such as bridges), etc. The history of the section of roadway in question, such as construction year, any major reconstructions or rehabilitations performed,

is to be described. Some of this information can be obtained from the Straight-Line Diagrams and Roadway Inventory Logs maintained by the Planning and Research Division. These diagrams should be obtained and made a part of the project file in any case.

A conceptual Maintenance of Traffic scheme is to be described. At minimum, cases from the latest adopted issue of the Manual on Uniform Traffic Control Devices shall be cited. More complex Maintenance of Traffic schemes may require a more detailed plan. It is not the intent of this Design Directive to show detailed schemes in plan view, rather to describe in words a phasing of construction for the project, and therefore a required Maintenance of Traffic scheme. The length in miles of any detour assuming the facility will be closed is to be indicated. The proposed detour route must be examined for adequate roadway/shoulder widths for the character and amount of traffic which will be utilizing it, as well as the structural capacity/ratings/postings of all bridges along the route.

The proposed work for each alignment is to be described, listing the physical characteristics of each alignment (curvature, grades, length). Capital costs, such as construction costs, right-of-way costs to include home/business relocation costs and utility relocation costs, temporary roadway/bridge are to be indicated for each alignment. Also, each alignment's advantages and disadvantages shall be described. Bridge renovation costs are required if the existing bridge is potentially eligible for inclusion on the National Register of Historic Places.

The preliminary structure information, with the exception of the plan and profile sheets, described in Section 20.6.3 above is to be included as part of the narrative. The Sufficiency Rating for all existing structures is to be shown.

All utilities affected by the project are to be shown on the plan sheets and listed as a part of this narrative.

All accesses to be affected by each alternative are to be identified and taken into account in the capital cost estimates. If a property is to be landlocked, it shall be indicated as such on the plan sheet for that alternative.

A geotechnical overview shall be presented. This will consist of any known data from Natural Resource Conservation Service mapping, knowledge of the geology of the area (possibly from an adjacent project or one in the vicinity), on-hand literature searches such as bridge inspection reports or original bridge plans, etc.

The environmental overview described in Section 20.6.4 shall be made a part of the narrative.

A table listing all capital costs associated with that particular alternative, such as temporary roadway/structure costs, permanent roadway/structure costs, right-of-way costs, utility relocation costs, structure rehabilitation costs (if required), etc., is to be included with each alternative.

At the end of the report narrative, a Summary Table is to be given, with information for each alternative shown, including engineering costs, construction costs, detour length, and advantages/disadvantages of each alternative alignment, advantages/disadvantages of each structure

arrangement, etc. From this information, a Preferred Alternate is then chosen, and indicated. This will be the alignment that L & D Approval is requested on. When there is disagreement among the involved parties the Division's Project Manager or Designer will build a consensus among the parties to choose the Preferred Alternate, provided there are major anticipated environmental constraints.

The typical sections sheet(s) will follow the narrative section of the Study, followed by plan and profile sheets showing the existing situation, followed by plan and profile sheets for each and every alternative alignment. At the very end of the Study, photographs of the existing site showing the project area, including the bridge/roadway to be improved or replaced, nearby homes/businesses that may be impacted, streams impacted. Finally, a copy of all pertinent information from the most current Bridge Inspection File, the approved Programmatic Categorical Exclusion or the completed Environmental Services Section approval form (See DD-206 for this form), the completed Design Study checklists, etc. shall be included at the end of the Study.

30. Distribution of Design Studies for Comments

30.1 Distribution of preliminary report:

Reference is hereby made to DD-202, *Field and Office Reviews for Initial Engineering, Preliminary Engineering and Final Design*. The Study should be distributed to all entities shown under the Design Report Field Review column.

After each entity's receipt of the Study, at least 2 weeks should be allotted for review and comment. The transmittal memo is to state the date that comments are due. If no comments have been received by the due date in the transmittal memo, it will be assumed that the entity has no comments and the process will continue. It is highly recommended that each entity receiving a Study review and comment at each submission. For example, comments which would apply to the Field Review should be made at that submission, and not at the Office Review.

30.2 Distribution of final report:

Reference is hereby made to the Distribution List given in DD-202, *Field and Office Reviews for Initial Engineering, Preliminary Engineering and Final Design*. The study should be distributed again to all entities indicated in the Design Report Office Review column. At this time, a request should be made to the Utilities Unit of the Right of Way Division, for preliminary utility relocation cost estimates, and to the Right-of-Way Division with a request for preliminary estimates of the cost of property acquisitions.

Again, it is recommended that at least 2 weeks be given for review, as described above in Section 30.1. The Office Review portion of the study is the last review before a request for L & D Approval is made.

30.3 Documentation of comments:

All comments received are to be fully documented and made a part of the project file, as stipulated in DD-202.

40. Location and Design (L & D) Request and Approval:

Once a “Preferred Alternate” is chosen from the Study, an L & D approval request is made to gain the State Highway Engineer’s ~~Applicable Chief Engineer~~ approval. This process is described in DD-206, *Guidance for Location and Design Approvals* and shall be followed for all Design Reports for approval of the Preferred Alternate. Again, when there is disagreement among the involved parties the Division’s Project Manager or Designer will build a consensus among the parties to choose the Preferred Alternate. For most projects, the “Location & Design (L & D) Approval” will be requested at the end of the Initial Engineering Phase. On some projects, additional environmental work may be required, and Location and Design Approval may be requested during the Preliminary Engineering phase.

50. Scope of Work notes:

The Scope of Work notes will be developed by the preparer of the Study based on the approved Preferred Alternate from the Study. These notes should be adequate for a complete description of all design work to be performed to make a complete set of Contract Plans. See DD-706, *Guidelines for Preparation of Project Plans, Specifications, and Estimate Submittals*, for more information concerning what constitutes a complete set of Contract Plans.

60. Preliminary Engineering estimate:

The Preliminary Engineering Estimate will also be developed by the preparer of the Study. This Estimate is the estimate of man-hours of time expected to be required to develop the complete set of Contract Plans for the Preferred Alignment, which will be advertised for bids. See DD-706 for more information concerning what constitutes a complete set of Contract Plans.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 206
GUIDANCE FOR LOCATION AND DESIGN APPROVALS**

November 1, 2023

Supersedes June 18, 2014

This Design Directive will give guidance and instruction on how to obtain Location and Design (L & D) Approval for Design Reports and Studies produced by the Planning Division; the Engineering Division: In-House Design, Initial Engineering, and Consultant Review Sections; and all the Districts within the Division of Highways.

Use of this Design Directive will provide a means to standardize the process required to gain these L & D Approvals throughout all development units of the Division of Highways.

10. General

Design Reports and Studies (hereinafter referred to as “Study”, or “Studies”) are engineering studies of several proposed alignments for a highway project. These Studies are produced for projects such as bridge replacements, roadway realignments, intersection improvements, turning lane additions, new roadway alignments, etc. By nature, these Studies are considered Initial Engineering by Design Directive (DD) 200, *Project Development Process*. The completion of the Study with an approved alternative alignment is considered the end of Initial Engineering by that particular DD. If a choice of alignments is given, the report will recommend one alignment as the “Preferred Alternate”, otherwise the alignment shown in the Study will be considered the “Preferred Alternate”.

However, in those cases where there is no prudent, feasible or practicable alternative that would avoid adverse impacts to, the taking of, or the constructive use of: US Government property; those environmental resources covered by process requirements of certain federal laws (Section 404 of the Clean Water Act, Section 4(f) of the Transportation Act, Section 6(f) of the Land and Water Conservation Act, Section 106 of the National Historic Preservation Act, Endangered Species Act); or individual US Army corps of Engineers’ Section 404 permit thresholds; a number of comparative alternatives may need to be carried further into the Project Development Process, or refined at a later date, to document that there is no prudent, feasible, or practicable alternative to the impacts. Projects such as these may require a more rigorous initial engineering analysis or some revisiting of the Study in later stages of the process in order to comply with the unique process requirements of the federal regulations mentioned above.

For most projects, “Location & Design (L & D) Approval” will be requested when the Design Report is completed. Projects that require additional environmental work may request L & D Approval during the Preliminary Engineering phase. This Design Directive will cover only the approval process for L & D requests for any study. Refer to DD-205, *Guidance for Preparation of Design Reports and Studies*, for more information concerning the preparation of the Studies themselves.

20. Process of Approval of Location and Design (L & D) Requests

20.1 Environmental Requirements:

A preliminary environmental overview is required. This work will require a representative from the Environmental Section of the Technical Support Division to examine the project site in enough detail to establish any environmental constraints which would affect the location of alternative alignments in the report, and be of sufficient detail to show in the Study as known constraints to the design. The environmental process does not have to be completed fully. However, there should be enough surface observation and literature investigations performed to determine that there are no major environmental constraints associated with the project, such as wetland involvement, cultural resources considerations (to include existing railroad and roadway facilities and bridges), permit requirements, utility relocations, known endangered species, known hazardous waste/storage tank sites, etc. so there are no major constraints that come up when the project enters the Preliminary Engineering phase that would require the project to go through the process of developing and approving a Design Study again, thus delaying the project or requiring a change in the preferred alignment.

It is desired that the environmental process be completed for projects which fall under the Categorical Exclusion process to have this document completed and approved at the time the L & D Approval request is made.

A form has been developed that is attached to and made a part of this Design Directive for completion by the responsible Environmental Project Managers assigned to the project by the Environmental Section of the Technical Support Division, indicating that the environmental constraints for each project have been evaluated.

20.2 Selection of the Preferred Alignment:

Once the draft Study has been completed and sent through the required distribution and comment periods as described in DD-202, *Field and Office Reviews for Initial Engineering, Preliminary Engineering and Final Design*, an alignment is then selected from the alternates given in the report. See DD-205, *Guidance for Preparation of Design Reports and Studies* for information on how to complete a Design Study. The decision on the Preferred Alternate is usually made by the Division using the information provided in the final approved Study. It should be noted that DD-201, *Public Involvement Process* should be reviewed to determine if any of the stipulations contained therein apply to each and every Study. Any public involvement must take place before L & D Approval is requested. When there is disagreement among the involved parties the Project Manager or Designer will build a consensus among the parties to choose the Preferred Alternate.

20.3 Preparation of the L & D Approval Request:

After all required reviews described in DD-202, to which reference is hereby made, are completed, a Preferred Alternate is then chosen. The Preferred Alternate is the end result of the Study process. This is the alignment for the L & D Approval request to be made on.

The request will be made in memo form (see attached sample memo, which is for example only, and is to be modified as needed for each individual Study) from the Director of the Engineering Division for Central Office Studies, and from the District Engineer for District produced Studies, to the State Highway Engineer of Development ~~Chief Engineer of Development~~ outlining the choice of the Preferred Alternate. This memo should describe the justification for the choice, discussing estimated capital costs, environmental affects, utility relocations, major hydraulic requirements and residential/commercial effects, permit requirements, etc. Also, the attached Environmental Requirements approval form, completed for each alternate required to be carried forward, or the completed and approved Categorical Exclusion is to be included, as well as a copy of the approved Design Study itself showing the Preferred Alternate.

If the package is NOT approved, then the Study will have to be reinvestigated and the process repeated. Again, it is not necessary to have full environmental clearance to make an L & D request on most projects, but enough environmental work should be performed to assure that there are no major issues or circumstances as described in 20.1 above concerning federal regulatory agencies or major constraints that may be uncovered during Preliminary and Final Design that may delay the project or require a change in the Preferred Alternate. However, it is desirable that the environmental process be complete for projects which fall under the Categorical Exclusion process, having the environmental document completed and approved at the time the L & D Approval request.

The approved memo shall go into the Project Manager's on-hand files (as well as the Structure Manager's on-hand files, if required), a copy placed in Engineering Division's master files, copies sent to all parties involved in the review and selection of the Preferred Alternate, and a copy sent to the Programming Division.

30. Sample L & D Approval Request Memorandum (to be modified as required for each individual Study) and Environmental Checklist

MEMORANDUM

TO: HD

FROM: DDR (*Project Manager*) **OR** DDI (*Designer*) **OR** (*District xx - Designer*)
through the *Director of the Engineering Division (for Central Office projects)*
OR the *District Engineer (for District projects)*

SUBJECT: State Project xxxxxxxxxx
Federal Project xxxxxxxxxx
(Project Name)
(County)

Enclosed is the design report for the subject project, a summary of the recent public meeting on this project (if applicable), comment sheets from local public officials (if applicable), the completed Environmental Requirements Checklists, and a copy of the Study showing all xxx alternates for this project, with Construction Cost Estimates, a Scope of Work narrative, and Preliminary Engineering Estimates.

In compliance with Section 23, Code of Federal Register (CFR), Part 771, Environmental Impact and Related Procedures, the Division is considering (or “has considered” if the Environmental Document is completed and approved) the social, economic and environmental effects of this project and has determined that the preferred alternative is not likely to result in adverse impacts to environmental resources.

From an engineering and financial point of view, we recommend that Alternative xx be approved for the subject project; however, there has been strong support from local citizens for Alternate xx. Alternate xx is an acceptable alternate technically, but it will cost \$xxxxxxxx more than Alternate xx. We request approval on the Preferred Alternate to advance to plan development.

Enclosure

GLB:ss

Approved: _____ Disapproved: _____
Date: _____ (Reason for Disapproval)

cc: DDR(*Roadway Project Manager, Structure Project Manager (if necessary)*), DDE (*Environmental Project Manager*), DD(MF), (*Also copy to all parties who reviewed and commented*), D-xx (*and any other District people who reviewed and commented*), CP

Environmental Requirements Checklist

(Note: Complete this form for each alternative required to be carried forward)

Project Name: _____

Project Numbers: _____

Environmental and Cultural/Natural Resources Reviewers:

Archaeology: _____

Historic Resources: _____

Streams/Wetlands: _____

Endangered Species: _____

Alternative # and description _____

Archaeology:	No Effect	No Adverse Effect	Adverse Effect
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

If adverse effects describe: _____

Historic resources:	No Effect	No Adverse Effect	Adverse Effect
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

If adverse effects describe: _____

Streams/Wetlands:	No Effect	No Adverse Effect	Adverse Effect
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

If adverse effects describe: _____

Endangered Species:	No Effect	No Adverse Effect	Adverse Effect
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

If adverse effects describe: _____

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

DESIGN DIRECTIVE 501

DRAINAGE MANUAL

September 6, 2023

Supersedes December 15, 2008

The West Virginia Department of Highways Drainage Manual, latest edition with approved Addendums, is to be used for design of facilities for the Division of Highways. Any exceptions are to be approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 503
SELECTION OF PIPE MATERIALS**

*January 4, 2024
Supersedes September 6, 2023*

This design directive is to provide guidance on the selection of appropriate pipe materials in terms of service life, hydraulic efficiency, and structural capacity. The design process includes consideration of the factors shown in Section 1 through Section 5 below. Life cycle cost and safety shall take priority over initial cost. Small Corrugated metal pipe and pipe-arches may only be used for low volume roads with shallow cover heights. Galvanized structural plate pipe or pipe-arches installed with concrete paved inverts may only be used with the approval of the Director of the Engineering Division and the State Highway Engineer-Applicable Chief Engineer.

SECTION 1: ROADWAY CLASSIFICATION

The following table summarizes acceptable conduit materials based on the design classification, fill height, and service life requirement of the roadway that the pipe is to be placed under. Design classification is site specific rather than project specific and refers to the roadway that is directly over or supported by fill over the culvert. WVDOH items numbers are listed in parenthesis.

**Table 503-1
Allowable Pipe Materials**

DESIGN CRITERIA	ALLOWABLE CONDUIT MATERIALS
Highways with an ADT \geq 6,000 or Height of cover \geq 10 ft. 75 year design life	<ul style="list-style-type: none"> • Cast in Place or Precast Reinforced Concrete Box (604070) • Cast in Place (620003) or Precast Reinforced Concrete Arch (620001) • Reinforced Concrete Pipe (604037) and Elliptical Reinforced Concrete Pipe (604041) • High Density Polyethylene Pipe (solid wall (604056), profile wall (604050), or steel-reinforced (604051), installed in Type F trench • Polyvinyl Chloride Pipe (profile wall), installed in type F trench (604052) • Polypropylene Pipe (604045), (type F trench required for ADT \geq 12,000)
Highways with an ADT < 6,000 40 year design life	All of the above <ul style="list-style-type: none"> • High Density Polyethylene Pipe (solid wall (604056), profile wall (604050), or steel-reinforced (604051) • Polyvinyl Chloride Pipe (profile wall) (604052) • Polypropylene Pipe (profile wall) (604045)
Highways with an ADT < 400 and Height of Cover < 5 ft. 20 year design life	All of the above <ul style="list-style-type: none"> • Aluminized Steel, Type 2 Corrugated Metal Pipe, up to 24" (604076) • Aluminized Steel, Type 2 Corrugated Metal Pipe-Arch up to 128" x 83" (604077) • Aluminum Structural Plate Box Culvert (604074)

Unless otherwise specified, all pipes shall be installed in accordance with Standard Specification 604.

SECTION 2: HYDRAULICS

Hydraulic design of culverts is addressed in the WVDOT Drainage Manual.

SECTION 3: STRUCTURE

Refer to DD-502, *Maximum and Minimum Fill Height Tables for Drainage Pipe*, for maximum cover and minimum cover for all pipes. The maximum values in DD-502 are conservative. The designer may exceed the limits set in DD-502 if the pipe is designed in accordance with AASHTO LRFD Section 12, BURIED STRUCTURES AND TUNNEL LINERS.

SECTION 4: CORROSION

Plastic pipe materials are acceptable in most environmental conditions without soil and water testing.

Concrete pipe will require soil and water testing for resistivity and sulfate concentration. A resistivity of less than 1,000 ohm-cm is an indication of the presence of chlorides. Sulfate content data are required for the use of concrete pipe.

Sulfate concentration is also a durability concern for concrete. Type II cement is designed to resist sulfate attack. Therefore, Type II cement shall be used for precast concrete pipe. Reducing the water/cement ratio reduces permeability and is the single most important factor in increasing concrete resistance to sulfate attack. Increasing the cement content also improves sulfate resistance. Precast concrete pipe and box culverts are typically produced using 658 pounds (7 bags) of cement per cubic yard of concrete with a water cement ratio of 0.44 or less. Only a minor adjustment in the water cement ratio is required to meet the severe Sulfate condition. For very severe conditions the water cement ratio shall be reduced to 0.35. The following table illustrates the actions required for a given sulfate concentration. Cement content and water/cement ratio shall be included in the plans when severe and very severe sulfate conditions are encountered.

Table 503-2
Sulfate Concentration for Reinforced Concrete Pipe

Conditions			Requirements		
Relative Degree of Sulfate Attack	% Water-Soluble Sulfate in Soil Samples	PPM Sulfate in Water Samples	Cement Content		Maximum Water/Cement Ratio
			(bags/cy)	(lbs/cy)	
Negligible	0.00 - <0.10	0 - <150	5	470	0.53
Positive	0.10 - <0.20	150 - <1,500	5	470	0.53
Severe	0.20 - 2.00	1,500 - 10,000	5.5	517	0.4
Very Severe	>2.00	>10,000	7	658	0.35

Metal pipes and structures are allowed as stated in Table 503-1. The pH of the water and soil must be between 5 and 9.

SECTION 5: ABRASION

The designer shall assess the abrasion potential for proposed culvert installations. Consider the slope of the stream and the size of the stream bed material. Determine the size of the streambed

material in accordance with DD-409. Calculate the velocity of the flow in the channel upstream of the proposed culvert and in the proposed culvert to determine if the abrasive material in the streambed could be transported at a sufficient velocity to cause damage to the invert of the conduit. A 2-year storm (Q_2) shall be used to determine the velocity for abrasion potential. When flow velocities are greater than 25 feet per second, 6000 psi concrete and abrasion resistant aggregate are required.

There is a potential for higher than normal abrasion during construction due to runoff from disturbed areas that have not yet been vegetated or paved. For new construction projects, sediment traps shall be placed upstream of culverts to prevent large sediment from entering the culvert.

Three sided structures do not require invert protection, however, the potential for scour at the footings shall be addressed and documented. It may be less expensive to provide a concrete slab below the streambed between the footings instead of extending the footings to rock.

The following chart is to be used to select the appropriate invert protection for culverts. Use the velocity of the 2-year storm flow in the pipe or in the channel upstream of the pipe, whichever is greater.

Table 503-3
Invert Protection Chart for Abrasive Flows

CULVERT MATERIAL	2-Year (Q_2) Storm Design Velocity			
	0 to 5 ft/sec	5 to 10 ft/sec	10 to 25 ft/sec	Greater than 25 ft/sec
Aluminized Steel Type 2	None	None	Concrete Paved invert	Concrete Paved invert
Aluminum Alloy	None	None	Add one gage	Add two gages
Plastic (PVC or HDPE or PP)	None	None	None	None
Reinforced Concrete Pipe	None	None	Aggregate with LA Abrasion loss of less than 30%	6000 psi concrete Aggregate with LA Abrasion loss of less than 30%

SECTION 6: ALTERNATE MATERIALS

When using this directive, more than one material may be found to satisfy the project requirements. The designer should include economical designs that meet the requirements stated above. Allowable alternates must be listed in the pipe quantity table included in the plans.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

DESIGN DIRECTIVE 505

DITCH LININGS

September 6, 2023

Supersedes July 10, 2020

Designer shall use the sheer stress analysis method to design ditch linings. The sheer stress analysis method is found in the West Virginia Division of Highways Drainage Manual, Latest Edition, with approved Addendums. This method shall be used for selection of ditch linings for new and rebuilt ditches designed for the West Virginia Division of Highways. Any exceptions shall be approved by the Deputy State Highway Engineer - ~~Chief Engineer~~ of Development.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 605
CONTROLLING CRITERIA AND DESIGN EXCEPTION POLICY**

September 6, 2023

Supersedes May 4, 2022

Attached for your use is the Division of Highways (DOH) Controlling Criteria and Design Exception Policy. It shall be used on all applicable projects.

1.0 CONTROLLING CRITERIA

All new construction or reconstruction projects on the National Highway System (NHS) shall be designed in accordance with the AASHTO criteria, such as criteria found in the most current approved editions of AASHTO's "A Policy on Geometric Design of Highway and Streets" (Green Book) and the Roadside Design Guide. All RRR projects shall be designed in accordance with the current Construction Project on Existing Roads (CPER) guidance. Those criteria related to design speed, lane and shoulder widths, design loading structural capacity, horizontal curve radius, maximum grade, stopping sight distance, cross slope, superelevation rate, and vertical clearance are the controlling criteria that require formal design exceptions when not met. Stopping sight distance (SSD) applies to horizontal alignments and vertical alignments except for sag vertical curves.

Of the 10 controlling criteria, only design loading structural capacity and design speed apply to all NHS facility types. The remaining eight criteria are applicable only to "high-speed" NHS roadways, defined as Interstate highways, other freeways, and roadways with a design speed greater than or equal to 50 mph (80 km/h). However, any of the remaining eight criteria that are not met on projects that do not require a formal design exception for these criteria shall be documented to the project file, with any mitigation strategies indicated in the report. The following chart is included for clarity.

Application of Controlling Criteria

All NHS Roadways:	Interstate highways, other freeways, and roadways with design speed \geq 50 mph:
Design Speed	Design Speed
Design Loading Structural Capacity	Design Loading Structural Capacity
	Lane Width
	Shoulder Width
	Horizontal Curve Radius
	Superelevation Rate
	Maximum Grade
	Stopping Sight Distance
	Cross Slope
	Vertical Clearance

According to the Stewardship & Oversight Agreement, the WVDOH is responsible for preparation and approval of all design exceptions, including those on the NHS. For Full Oversight and other non-Delegated projects, a copy of the design exception should be forwarded to the FHWA for acceptance.

A formal design exception is not required and should not be submitted unless the existing/proposed value for any of the “10 Controlling Criteria” fails when compared to the design values for any of these criteria.

2.0 DESIGN EXCEPTIONS

All efforts should be made to adhere to the specified criteria. However, under unusual conditions, it may be necessary to use values that are less than the minimum values that have been established. If lesser values are proposed for use, a Design Exception Justification Report shall be developed and approved. A copy of the approved design exception shall be included in the project file.

As stated previously, design exceptions shall only be submitted when one or more of the “10 Controlling Criteria” design values is violated by the existing/proposed values. Design exceptions are not required and shall not be submitted on projects defined as CPER project types. The designer should refer to DD-600 “Project Categories” for guidance in determining which project types are classified as CPER maintenance projects and not defined as an alteration project.

Design criteria that are not satisfied and are not one of the “10 Controlling Criteria” shall not be documented and submitted as a formal design exception. These criteria exceptions shall be documented in the project files only.

3.0 DESIGN EXCEPTION JUSTIFICATION REPORT

The following information, which affects the design values selected, must be considered and documented as a part of the design exception request: (1) the existing roadway characteristics, the minimum design criteria values, specific design criteria that will not be met, the proposed design values, and the criteria source (controlling design directive or AASHTO section) must be identified; and (2) a narrative documenting that the acceptance of the design exceptions is prudent, cost-effective and will not compromise the safety of the traveling public. This narrative will discuss the following items:

1. The effect of the variance from the design criteria on the safety and operation of the facility and other impacts such as right-of-way, community, environmental, cost, and usability by all modes of transportation; and safety mitigating measures considered and provided;
2. The compatibility of the design and operation with adjacent sections of roadway;
3. Amount and character of traffic using the facility;
4. Accident history (type, location, severity, etc.);
5. Alternatives considered;
6. Comparative cost of full design criteria versus lower design criteria being proposed, or other practical alternatives;
7. The long-term effect of the reduced design criteria versus full design criteria (effect of capacity reduction);

8. Difficulty in obtaining full design criteria (cost, right of way involvement, delay, environmental impacts, etc.);
9. Level of Service for full design criteria versus reduced design criteria; and,
10. Any other design criteria that is not being met, i.e., cumulative effect of more than one standard that is being reduced.

This documentation is essential for each design exception requested. The level of analysis should be commensurate with the complexity of the project.

Design speed and design loading structural capacity are fundamental criteria in the design of a project. Exceptions to these criteria should be extremely rare and the documentation will provide the following additional information.

Design Speed exceptions:

- Length of section with reduced design speed compared to overall length of project,
- Measures used in transitions to adjacent sections with higher or lower design or operating speeds.

Design Loading Structural Capacity exceptions:

- Verification of safe load-carrying capacity (load rating) for all State unrestricted legal loads or routine permit loads, and in the case of bridges and tunnels on the Interstate, all Federal legal loads.

Design values chosen or being considered, which are exceptions to the appropriate minimum design criteria values, shall be approved as early as possible in the design process prior to considerable detailed design work being accomplished. The appropriate Depute State Highway Engineer ~~Chief Engineer~~ overseeing the plan development, will approve those exceptions necessary on projects. The DOH is responsible for the preparation and approval of all design exceptions.

During the design process, a continuing review of exceptions shall be made, and any additions or modifications documented and placed in the project files. Approved design exceptions will be shown on the title sheet and a copy saved to the “project file”. Design exceptions on all projects must be approved prior to submission of the PS&E package to Contract Administration Division.

SHEET 1 OF ____

DESIGN EXCEPTION JUSTIFICATION REPORT**PROJECT DATA**

State Project No. _____ Date: _____

Federal Project No: _____ County: _____

Project Name: _____

Project Description: _____

WVDOH Representative: _____

FHWA Representative: _____

HIGHWAY ROUTE DATA

AASHTO Functional Classification

1. ☐ Urban ☐ Rural

2. ☐ Arterial ☐ Collector ☐ Local Road

3. ☐ Freeway ☐ Divided/Arterial ☐ Two-Lane Arterial

4. ☐ Interstate

TERRAIN TYPE

☐ Level ☐ Rolling ☐ Mountainous

TRAFFIC DATA

Current Year: _____ Design Year: _____

ADT: _____ ADT: _____

DHV: _____ DHV: _____

SPEED LIMIT: _____ ☐ POSTED/ ☐ REGULATORY

ACCIDENT DATA

Accident Rate: _____

Base Accident Rate (Statewide Average): _____

Nature of Area: _____

DISTRICT DESIGN PROJECTS

DESIGN CRITERIA DATA (Document Only Exceptions)

<u>10 Controlling Criteria</u>	<u>Existing Condition</u>	<u>Minimum Design Criteria</u>	<u>Proposed Value</u>	<u>Criteria Source</u>
1. Design Speed	_____	_____	_____	_____
2. Lane Width	_____	_____	_____	_____
3. Shoulder Width	_____	_____	_____	_____
4. Stopping Sight Distance	_____	_____	_____	_____
5. Horizontal Curve Radius	_____	_____	_____	_____
6. Maximum Grade	_____	_____	_____	_____
7. Cross-Slope	_____	_____	_____	_____
8. Superelevation	_____	_____	_____	_____
9. Vertical Clearance	_____	_____	_____	_____
10. Design Loading Structural Capacity	_____	_____	_____	_____

APPROVAL SIGNATURES

RECOMMENDED:

1. _____
Responsible Charge Engineer

2. _____
District Engineer/Director or
Engineer of Record

APPROVED:

~~Deputy State Highway Chief~~ Engineer –
(Project Development Oversight)

Federal Highway Administration
(Full Oversight and non-Delegated Projects Only)

SHEET _____ **OF** _____

NARRATIVE DISCUSSION OF DESIGN EXCEPTION(S):

[illegible]

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 641
PAVEMENT TYPE SELECTION GUIDE**

*November 1, 2023
Supersedes June 18, 2014*

Attached is the West Virginia Department of Transportation, Division of Highways policy on pavement type selection. A pavement type selection will be performed on all projects requiring pavement in accordance with this document.

10. INTRODUCTION

Pavement type selection is a combination of engineering and economic analysis, which provides data to assist the engineer or manager in choosing a cost-effective pavement. The engineering analysis consists of a pavement structural design procedure with consideration of other factors that may influence the selection of a pavement. Pavement type selection has not evolved to an exact science, and there is no absolute or indisputable mathematical solution for all selections. The 1993 *AASHTO Guide for the Design of Pavement Structures* and 1998 *Supplemental* allows for "other factors," both principal and secondary, which need to be considered along with the engineering and economic data to select the pavement type that best fits the needs and conditions of the project. The principal factors, as defined in DD-646, *Pavement Design Guide*, have a major influence on the pavement type selection process. The secondary factors described in Section 40 of this design directive will be used when a clear choice is not indicated by the principal factors.

This Guide outlines the process for pavement type selection for new and reconstructed pavement structures as well as rehabilitation projects. It provides guidance in the design approach for the cost comparison, life cycle cost, and the use of design parameters. It also discusses principal and secondary factors to be utilized in making a pavement type selection. This Guide is provided in compliance with Title 23 Code of Federal Regulations. The latest edition of the *West Virginia DOT, Division of Highways, Pavement Design Manual* is to be used to obtain technical data needed in the analysis.

20. DETERMINATION OF A PAVEMENT SEGMENT

This selection process shall define what pavement type should be built on each pavement segment. A pavement segment shall not be limited by project length but should consider the entire highway system and how that system is to be maintained. A pavement segment may be comprised of multiple paving projects (Figure 1).

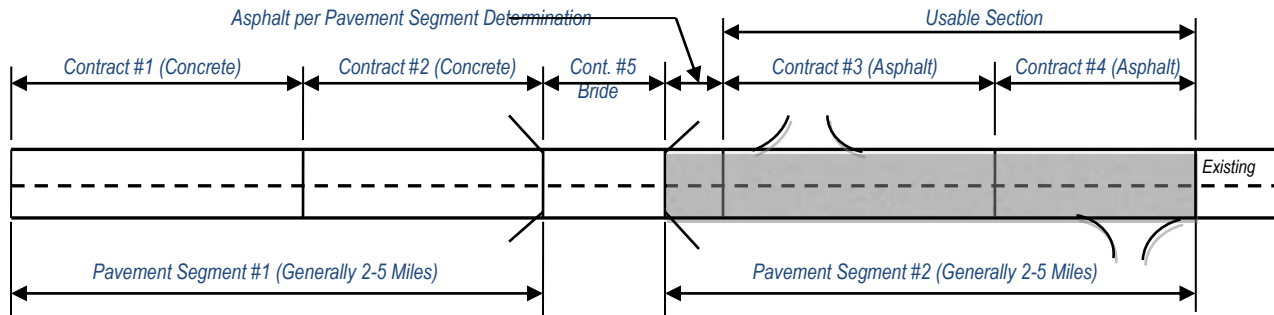


Figure 1. Illustration of *contracts* within *pavement segments*

The following criteria should be considered when determining a pavement segment:

- A. Pavement segment length should generally equal a reasonable rehabilitation or resurfacing project length, normally two to five miles, but could vary depending on the termini chosen.
- B. Distinction should be made between rural and urban pavement segments due to increased future user costs during rehabilitation projects in urban segments.
- C. Pavement segments should have logical termini such as bridges, interchanges, intersections, or locations where traffic lanes are added or dropped. Bridges should be given the most consideration as logical termini.
- D. Determination of pavement segments should be limited to the segments in the area of the project being bid. Pavement segments should not be chosen for an entire highway corridor prior to final design of the construction contracts.
- E. Consider all future maintenance activities required on the segment.
- F. The design parameters, such as traffic and geology, should remain relatively constant.

The straight-line diagrams maintained by the Program Planning and Administration Division should be consulted. These diagrams contain a wealth of West Virginia roadway information such as construction year, surface type, and intersection/interchange/bridge locations, which can be used by the designer to determine the termini of pavement segments. Also, the Pavement Management Section of the Operations Division is to be consulted for all data concerning the pertinent pavement segments. The designer may discover that a pavement segment was previously determined for the project area which can be evaluated and recommended as a proposed project pavement segment.

The designer shall submit a pavement segment to the Deputy State Highway Engineer-Chief Engineer of Development by memorandum for approval. This memo shall be retained in the project file.

30. PAVEMENT TYPE SELECTION METHOD

Selection of pavement type shall be performed using method A or B below. If no pavement exists in the pavement segment at the time of construction, then follow method A.

- A. Design the pavement alternates according to DD-646, *Pavement Design Guide*.
 1. If there are other engineering considerations such as slow-moving, heavy loads, grades, or stop conditions which would dictate a specific pavement type

then the pavement type may be selected independently of the Alternate Design Alternate Bidding (ADAB) process. Other factors to consider in this situation are proper asphalt pavement types and binder grades as called for in DD-644, *Asphalt Pavement*, or cement content and reinforcement for concrete pavement.

2. Perform the Life Cycle Cost Analyses (LCCA) per DD-647, *Life-Cycle Cost Analysis for Pavement Design*.
 - a. If the difference in the Net Present Value (NPV) of the LCCA is generally over 20% between the lowest two pavement alternates then the pavement alternate with the lowest NPV can be selected. The 20% difference shall be calculated by multiplying the lowest pavement alternate's NPV by 0.2.
 - b. The ADAB method of bidding as described by DD-648, *Alternate Design Alternate Bidding of Pavements* will generally be considered; however, if the NPV of the LCCA is less than 20%, then the ADAB method shall be recommended to the Deputy State Highway Engineer-Chief Engineer of Development for use on the project.

If the ADAB process is used, then all of the pavement type alternates may be used in the bidding process.

- B. When a pavement type has been selected within a pavement segment, a review of the previous selections for that *pavement segment* will be conducted. Issues to consider are:
 1. Length of pavement segment
 2. Length of previously constructed pavement as well as the remaining length to be constructed and the respective construction schedules
 3. Length of current project
 4. Changes in design parameters such as traffic data, availability of constructed sub-grade values, etc.
 5. Review of performance based on the Pavement Management System (PMS) which may be obtained from Operations Division
 6. Length of time traffic has used previously constructed contract

The Deputy State Highway Engineer-Chief Engineer of Development shall have the right to approve and/or change the above criteria to better match market conditions on a project by project basis.

The designer shall submit to the Deputy State Highway Engineer-Chief Engineer of Development the following information:

1. The previously approved pavement segment determination
2. The pavement cost percentage of the contract being bid
3. The LCCA
4. The bidding process
5. The pavement type recommended if the ADAB process is not being considered
6. Plus the engineering justification for the pavement type recommended

The ~~Deputy State Highway Engineer--Chief Engineer~~ of Development will then approve the bidding process or the pavement type and pavement section to be used for the contract being bid.

40. SECONDARY FACTORS.

These factors generally have a lesser influence on pavement type selection and will only be considered when there are no overriding characteristics or one alternate is not clearly superior.

1. Performance of Similar Pavements

Recommendations of experienced Division of Highways personnel concerning pavement performance in the field under similar traffic and geological conditions should be obtained. The Pavement Management Systems section of the Operations Division should be consulted also.

2. Adjacent Existing Pavements

It is beneficial to use similar pavement types for long pavement sections because maintenance operations could be assembled for only one pavement type.

3. Conservation of Materials

Material shortages usually increase material costs.

4. Availability of Local Materials and Contractors

An effort should be made to use local materials and contractors.

5. Traffic Safety

Traffic Safety is to be a consideration on all projects.

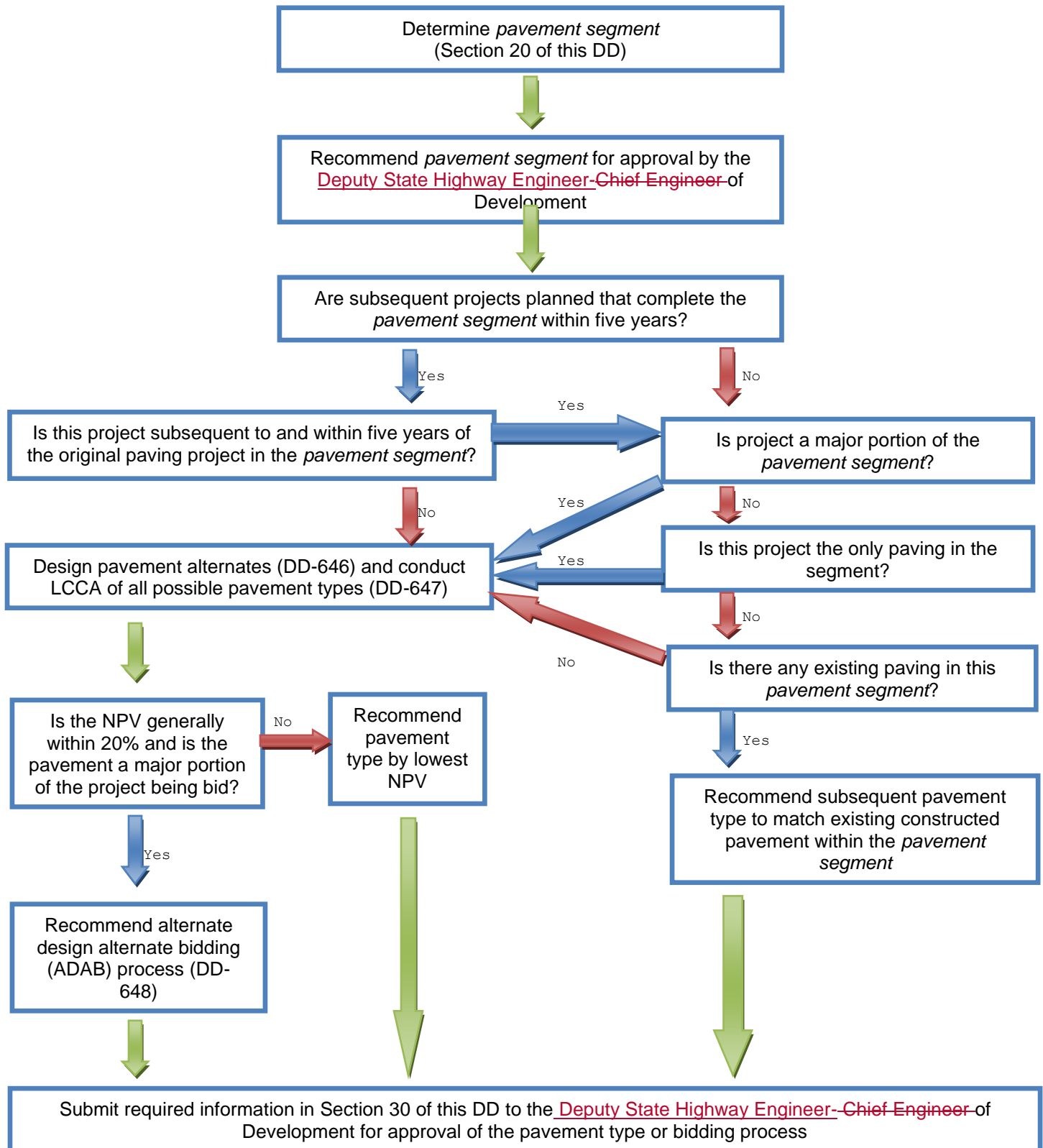
6. Incorporation of Technology

A work plan will be developed and the project evaluated over a performance period if the Division desires to field test a new material, concept, or technology.

50. PROJECTS SUBSEQUENT TO ADAB PROJECTS

On projects that are subsequent to an ADAB project and in the same pavement segment, the pavement type shall match the pavement type in the previously awarded ADAB project and a new pavement design is not warranted. However, if an extended period of time (beyond five years) has passed since the ADAB project was built and/or the design parameters have changed, the project manager should re-evaluate the design to ensure the adequacy of the original pavement design.

Pavement Type Selection Flowchart



**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

DESIGN DIRECTIVE 644

ASPHALT PAVEMENT

July 6, 2022

Supersedes February 23, 2017

This Design Directive (DD) provides guidance on selecting asphalt pavement mix design methods and types of asphalt pavement. It also provides descriptions of situations that require polymer-modified asphalts, and methods for calculating quantities and types of materials that are to be used.

TYPES OF ASPHALT MIX DESIGNS

Marshall Asphalt Mix Design: Bruce Marshall developed the “Marshall” method of asphalt mix design in the late 1930’s for the Mississippi Highway Department. This method has been used by the WVDOT since the 1970’s.

Superpave Asphalt Mix Design: “Superpave” stands for Superior Performing Asphalt Pavements. It represents an improved system for specifying the components of asphalt concrete, asphalt mixture design and analysis, and asphalt pavement performance prediction. The Strategic Highway Research Program (SHRP) developed the Superpave asphalt pavement mix design method in the early 1990’s.

ASPHALT PAVEMENT MIX DESIGN TYPE SELECTION

Superpave asphalt mixture types are to be used for the following type projects:

1. New construction of multilane divided highways where the mainline pavement is asphalt pavement.
2. Overlay or 3R type projects on existing multilane divided highways where the asphalt pavement overlay is 3 inches or more.
3. Overlay type projects on existing National Highway System (NHS) highways where the asphalt pavement overlay is 3 inches or more.
4. Projects on other highways were approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development or Operations.

Marshall asphalt mixture types are permitted on all other projects.

SPECIFICATION SELECTION CRITERIA

There are three specifications available when identifying the asphalt requirement for projects. Specifications Sections 401, 402 and 410 shall be used based on project criteria.

- Section 401 is the standard asphalt pavement specification, covering most roadways.
- Section 402 is utilized for roadways needing polish resistant aggregates to promote skid resistance.
- Section 410, “Percent Within Limits”, is a specification for use when there is a need for performance related results. This Specification uses mathematical models to quantify

relationships between quality characteristics and product performance. These characteristics include mat density, asphalt content, bond strength and others, with samples taken directly from the roadway. Acceptance according to Section 410 (PWL) shall be limited to the top two layers of the pavement, scratch and P&L do not count as a pavement layers. Other materials below the top two layers shall be accepted in accordance with section 401.

Section 410 (PWL) of the Specification shall be used on the following project types:

1. New Construction where the mainline is asphalt pavement.
2. Overlay projects on existing multilane divided highways.
3. Overlay projects on any National Highway System (NHS) routes, as found on the Divisions website using the latest version of the “Annual Roadway Inventory Statistics”
4. Projects on other highways were approved by the Deputy State Highway Engineer~~Chief Engineer~~ of Development or Operations.

Additionally, a project must meet the following specific requirements for the use of Section 410:

1. Projects exceeds 5,000 tons in either of the top two asphalt layers (scratch and P&L do not count as layers)
2. The overall width of asphalt equals or exceeds 20 feet in width
3. Project paving is continuous for a minimum of 1500 feet
4. Posted speeds equal to or greater than 35 mph

The Specifications in Section 401 and 402 shall be used for all other projects.

DETERMINATION OF EQUIVALENT SINGLE AXLE LOAD (ESAL)

The “ESAL Calculator” program shall be used to calculate the 20-year projected design ESALs for all projects unless one of the following applies.

1. The “ESAL Calculator” program produces a value exceeding 10,000,000.
2. When a traffic study has been performed. (i.e. When traffic movements or traffic counts are provided by the Traffic Modeling and Analysis Unit of the Planning Division.)
3. On roadway realignment projects that exceed 1000 feet of relocated roadway.
4. When there is an expected development in the area that may change or alter the nature or character of the expected traffic. (i.e. Shopping centers, schools, etc.)
5. The project is on the CRTS (Coal and Resource Transportation System).

The ESAL Calculator program can be obtained from the West Virginia Department of Transportation's Engineering Publications and Manuals website at <https://transportation.wv.gov/highways/engineering/Pages/Manuals.aspx>, then under the “Paving” heading choose “ESAL Calculator”.

When the ESAL Calculator program cannot be used to calculate the ESALs, then the ESALs or the percentage of traffic in each of the 13 classes shall be obtained from the Traffic Monitoring Unit of the Performance Management Group. The Traffic Monitoring Unit can be emailed at TMATrafficMonitoring@wv.gov. The designer is cautioned that the development of appropriate data to establish accurate ESAL estimates should be requested prior to the Design Study Office Review (if there is one) or prior to the Preliminary Field Review (if there was not a design study.)

SURFACE PREPARATIONS

Milling is used to remove surface distresses, create a better bond for an overlay, restore cross slope, and maintain vertical geometric properties, such as bridge clearance, guardrail height, and grade with gutter area. Milling shall be the preferred method of correcting deviations to the road surface prior to resurfacing.

When milling is specified by the contract, the thickness of milling specified by the Designer shall be at least ¼" into the layer just below the layer(s) being removed. The intent is to mill off entire layers, and not leave any partial layers.

Section 415 of the Specifications, *Milling of Asphalt Pavement Surfaces*, contains three types of milling: Standard Milling, Fine Milling, and Micromilling. These are differentiated primarily by the carbide tooth spacing, typically 15, 8, and 5 mm respectively, resulting in finer textured surfaces. These milling types specify the final surface texture prior to any overlay. The following describes the conditions in which the designer should use each type of milling:

- **Standard Milling:** Used as the default milling of asphalt pavement. It is intended to be used when the Division plans to remove existing asphalt pavement to correct deviations less than 1 inch, without a high level of profile and slope control.
- **Fine Milling:** Used when the Division intends to overlay the milled surface with a 2 inch or less asphalt course. It shall also be used when the contract contains pay items from Section 410 of the Specifications, *Asphalt Base and Wearing Courses, Percent Within Limits (PWL)*. It is intended be used when control of the profile and slope of the milled surface is important. Fine milling shall only be used if there is a minimum of 5,000 SY of fine milling.
- **Micro Milling:** Used for smoothness correction, skid correction, bump and/or grade corrections on existing or newly paved surfaces. This milling is typically less than an inch. It is not intended to be used when additional asphalt will be placed on the milled surface.

If fine milling is needed and multiple milling passes are necessary, standard milling shall be used to cut down to one inch above the final prepared surface. The designer shall document in the plans the estimated thickness of each type of milling.

ASPHALT MATERIAL (TACK COAT)

Asphalt Material (Tack Coat) (Section 408) shall be specified for placement on all existing pavement prior to placing asphalt pavement. If the designer can anticipate phased construction where part of the base or intermediate course will be open to traffic prior to final lift placement additional Asphalt Material should be included.

SCRATCH

Scratch Course is normally used in rehabilitation or resurfacing projects that do not contain a milling item. Scratch should be used to correct rutting and other deviations up to about one inch when the milling operation will cause an unnecessary disruption to the traveling public. If milling is performed on the project, Scratch Course shall not be used.

Scratch Course can be placed over the entire project or to the limits established by the designer. If the Scratch Course is not to be placed over the full width of the project, it shall be specified full lane width increments. Although Scratch Course can be placed over the entire project, it is not a constant thickness layer. The term "Scratch Course" comes from the method of placement of this item. The paving equipment is set to drag on or "scratch" the high areas of the

existing pavement, only depositing material in the low areas; thereby creating a smooth surface on which to place the next layer of asphalt pavement.

Scratch course may be specified as a 9.5 mm or a 4.75 mm mix. Scratch Course shall be shown on the plan typical sections as a line without a thickness or application rate. Scratch Course is not included in the structural design of the pavement.

Scratch Course shall not be used on new construction.

PATCH AND LEVEL

Patching and Leveling is to be placed at various locations throughout the project to remove irregularities in the existing pavement, such as dips, or to raise the outside edge of the existing pavement to provide a uniform template prior to placing a base or wearing course. Patching and Leveling shall not be specified as a continuous layer or course to be placed over the full width and length of the project.

Patching and Leveling shall be used only in resurfacing or rehabilitation projects, not in the construction of new pavements. It shall be specified when the deviations in the existing pavement are 1 inch or greater in depth.

Patching and Leveling shall be shown on the plan typical sections as a layer with thickness specified as "variable - 2" maximum lift thickness. No application rate shall be shown. Patching and Leveling thickness is not included in the structural design of the pavement.

PERFORMANCE GRADED (PG) BINDER TYPE SELECTION

Binder Selection will be based on the design ESAL estimate for all projects.

Binder	ESALs
PG64S-22	<20 million
PG64H-22	20 million – 30 million
PG64E-22 (Polymer Modified Binder)	See below

While rare, for colder areas of the state, a lower binder grade of PG 58S-28 may be appropriate. If unsure, the designer can contact the Asphalt Group of Materials Control, Soils, and Testing Division at DOHasphalt@wv.gov.

When using anything other than PG64S-22, the binder grade shall be provided on both the general notes sheet and the typical section sheet(s) showing the pavement details.

PG 64S-22 binder may be used in asphalt placed below the top two lifts in any pavement section. Scratch course and patching and leveling are not identified as lifts.

Polymer Modified Asphalts (PMA) or Non Standard Grade: The binder PG 64E-22, which is a polymer-modified binder, is required to be used in the following cases:

1. For the surface lift on roadways facilitating access to industrial parks, warehouses, production facilities, etc.
2. High Performance Thin Overlay (HPTO) asphalt pavement in accordance with Special Provision 496. Since PG 64E-22 is required by the Special Provision a plan note is not required.

A binder grade associated with a higher ESAL count may be used at the discretion of the responsible engineer on projects where the pavement exhibits severe rutting or shoving problems due to heavy traffic conditions, such as:

1. Intersections with very heavy truck traffic
2. Truck climbing lanes and ramps

PMA's have shown great success as being a long-term solution to severe rutting problems. Due to the additional cost of a PMA, it shouldn't be used on any project without first repairing base failures and removing excessively rutted pavement. PMA shall generally be used only in the skid surface mix (preferably a 12.5 mm mix) but may also be used in the underlying courses depending on the severity of the traffic conditions. Always use the preferred thickness from the Superpave asphalt pavement recommended lift thickness tables as a minimum thickness when using PMA. Any mix design to be used as a scratch course shall not be specified to use PMA.

PMA Pavement quantities shall be used in increments of 400 tons due to minimum requirements necessary for ordering of material.

PG 64S-22 binder should be used in asphalt placed below the top two lifts in any pavement section. Scratch course and patching and leveling are not identified as lifts.

PAVEMENT STRUCTURE

Bottom Courses: When developing the overall pavement thickness, it is recommended the designer use 25 mm mix as the bottom lifts. When a 25mm mix is to be used on a section 410(PWL) project, acceptance of the 25mm layer(s) shall be in accordance with section 401.

Where Marshall is permitted, a Marshall Type 2 Base Course shall be specified instead of a Type 1 Base when the total base course thickness is less than or equal to 3.25 inches.

Intermediate Courses: On new construction or multi-lift projects a Superpave 19mm or Marshall Type 2 base mixture shall be utilized below the surface course to promote smoothness in the final pavement.

Surface Courses: The wearing course is a single constant thickness layer to be placed over the entire pavement surface. The wearing course is the riding surface on which traffic travels. A Superpave 4.75 mm, 9.5mm, or 12.5mm or Marshall Type 1 or Type 3 Wearing mixture is the mix type to be used as the surface course. PMA can also be used if traffic warrants. A Marshall Type 4 Wearing is intended for use in heavy truck traffic situations, note that a wearing 4 is a visually coarse mixture.

Section 402 shall be used for the surface course on projects with a current ADT of 3000 or more vehicles per day. Only Superpave 9.5mm and 12.5mm mixtures and Marshall Type 1 and Type 4 wearing mixtures shall be specified as a skid resistant mix.

A 4.75 mm mix shall only be used for pavement preservation applications or as a surface course over an intermediate course in multi-lift applications. High performance thin overlays may be used for pavement preservation on roads with ADT of 3000 or more vehicles per day.

SUPERPAVE MIX TYPE RECOMMENDATIONS

The following table provides a list of Mix Type recommendations for the designer to use when preparing pavement lift thicknesses for the typical section. Pavement designs provide an overall thickness of asphalt pavement and the designer is generally left to make the decision on bottom, intermediate, and surface course thickness. The designer should use recommendations found in the Pavement Structure section, as well as minimum and maximum thicknesses from the table.

Recommended Lift Thickness for Superpave Asphalt Pavement			
Mix Type (mm)	Minimum (inches)	Maximum (inches)	Preferred^{Note 1} (inches)
4.75	5/8	1.0	5/8
9.5	1.5	2.0	1.5
12.5	1.5	2.5	2.0
19	2.25	3.5	2.5
25	3.0	4.0	3.5

Note 1: Minimum Thickness with Polymer Modified Binders

MARSHALL MIX TYPE RECOMMENDATIONS

- A. Marshall Bottom and Intermediate Courses (Base Courses):** It is recommended that in multi-lift pavements when Type 1 Base Course is used, an intermediate course (the top lift of base course) be a Type 2 to improve the smoothness of the finished pavement. This would eliminate the use of a Scratch Course prior to placing the surface course.

Recommended Lift Thickness (inches) for Marshall Base Courses			
Mix Type	Minimum	Maximum	Preferred
2	2.0	3.0	2.0
1	3.25	5.0	4.0

- B. Marshall Wearing Courses:** The wearing course is a single lift constant thickness course to be placed over the entire pavement surface.

Recommended Lift Thickness (inches) for Marshall Wearing Courses			
Mix Type	Minimum	Maximum	Preferred
3	0.5	0.75	5/8
1	1.0*	1.5*	1.0*
4	2.0	2.0	2.0

* 1½ inch thickness on resurfacing projects where the Wearing Course is the only asphalt pavement material being placed exclusive of Patching & Leveling and Scratch Courses.

PLAN REQUIREMENT

Projects will show the 20-year projected design ESALs on both the general notes sheet and the typical section sheet(s) showing the pavement details. This includes new construction, reconstruction, AND resurfacing projects (including ALL bridge replacement projects regardless of the length of pavement placed). The design ESALs shall be shown for the mainline and all other affected roadways where more than 500 feet of pavement is being placed.

The aggregate used in asphalt mixtures can be either primarily stone and gravel, or slag. The aggregate used is up to the contractor, and typically depends on what the contractor has readily available that also meets mix requirements. Mixes with the two aggregate types have different densities; as such, estimated weight quantities will be different for mixes with each aggregate type. Alternates for these two shall be listed in the plans, and the contractor will bid appropriately.

The following is an example of how to list alternate asphalt pavement items in plans:
BB1 401001-042 SUPERPAVE ASPHALT BASE CRSE, SG, TY 25, TN
BB2 401001-043 SUPERPAVE ASPHALT BASE CRSE, S, TY 25, TN

PLAN REQUIREMENTS WHEN USING MARSHALL MIX DESIGN

In addition to the requirements listed above, projects using Marshall asphalt pavement, including District-designed projects, will designate the use of “Medium Marshall Mix Design” or “Heavy Marshall Mix Design” as well as the design ESALs on both the general notes sheet and the typical section sheet(s) showing the pavement details. The designer should note that the terms “Medium” and “Heavy” refer to Equivalent Single Axle Loads (ESALs), and not to the quality of the asphalt pavement. After determining the ESALs, the mix design type shall be determined from the following criteria.

Medium Marshall Mix Design: This design is intended for use on local service roads or rural resurfacing projects with a 20-year projected design ESALs of less than 3,000,000.

Heavy Marshall Mix Design: This design is intended for use on new construction projects and on projects with a 20-year projected design ESALs of equal to or greater than 3,000,000.

QUANTITY ESTIMATING

Asphalt Pavement: The quantity for asphalt pavement shall be estimated at 1.98 ton/cy for stone and gravel mixes, 1.89 ton/cy for slag mixes and 2.10 ton/cy for steel slag mixes.

Patching And Leveling: The quantity for Patching and Leveling Course shall be estimated by multiplying the nominal depth of the irregularity to be repaired plus $\frac{3}{4}$ inch by the irregularity’s surface area. Then the conversion rates of 1.98 ton/cy for stone and gravel mixes, 1.89 ton/cy for slag mixes and 2.10 ton/cy for steel slag mixes will be utilized.

Scratch Course: The quantity for Scratch Course shall be estimated at a thickness of one-half inch (0.028 ton/sy) for the entire area to be covered with Scratch Course. If the Specification allows, Scratch Course may alternatively be estimated by the square yard. Scratch Course shall not be used if there is Milling on the project, or if there are more than two lifts of asphalt being placed.

Asphalt Material (Tack Coat): The quantity for Asphalt Material (Tack Coat) shall be estimated using the undiluted rates as indicated in Table 408.11 in the Specifications. No application rate will be shown on the typical sections.

Smoothness: If a project meets the requirements of Section 720.6 of the Specifications, smoothness testing shall be requested by the designer through the Request Form available at MCS&T’s Tool Box at <https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx>. If the test results are available, the results shall be included the PS&E submittal. If not available, then the request for testing shall be included in the PS&E submittal. If the results arrive before letting, then the results shall be included in an amendment. If too late for an amendment, then the results shall be provided to the District Construction Engineer.

SPECIAL SITUATIONS

General: The Specifications have been written to account for the majority of the situations that would occur during construction. However, there are always special situations that require the designers' attention.

Specification requirements shall only be altered after careful consideration and when, in the opinion of the designer, there is no practical way for the work to be performed in accordance with the Specifications and a project specific special provision shall be developed as outlined in DD-105.

Compaction: The specification density requirement in the of the Specifications shall not be modified when asphalt pavement is placed at normal paving widths. It is possible that asphalt pavement will be placed in certain areas of the project where densities of this magnitude cannot be obtained. These areas usually have an irregular shape, which will not allow the proper use of compaction equipment. Listed below is a situation where the density specification may be modified by plan note and the plan note to be used.

Situation	Plan Note
Concrete pavement repair ^{Note3}	Compaction testing shall be in accordance with the Lot-by-Lot method and the rollerpass method shall not be used for acceptance testing for compaction. The engineer may reduce the target density requirement if the contractor has made every reasonable effort at obtaining the required density.

Note3: If the proper density is not obtained during placement, traffic will continue to compact the asphalt pavement in the pavement repair area, causing additional settlement. This will be very noticeable because the surrounding overlay will be placed on the existing concrete pavement, which is rigid and will not settle.

When overlaying Portland Cement Concrete Pavement (PCCP) the concrete is sometimes in need of repair. Whether this is an initial overlay or a subsequent overlay, the designer shall examine the extent of the needed PCCP repairs and evaluate whether to repair with Patch and Level, to perform proper concrete pavement repairs, or to remove the PCCP through rubblization or another process prior to the asphalt overlay. The use of Patch and Level is restricted to those projects with a few shallow repairs when the cost of mobilization for concrete repairs is high. PCCP removal should be considered only when the existing pavement is extremely distressed. In addition to compaction, consideration shall be given to smoothness, temporary traffic control, and long term impacts to the traveling public.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 646
PAVEMENT DESIGN GUIDE**

November 1, 2023

Supersedes April 23, 2015

A pavement design will be completed for all projects requiring pavement (excepting certain Resurfacing, Restoration, and Rehabilitation projects), in accordance with the Division of Highways' Design Directive 641, *Pavement Type Selection Guide*.

This Design Directive (DD) provides a means to standardize the process to design and evaluate pavement designs throughout all development units of the West Virginia Division of Highways (WVDOT).

10. INTRODUCTION

Pavement design is a combination of engineering and economic analyses, which provides data to assist in choosing a cost-effective pavement structure and thickness. The engineering analysis consists of a pavement structural design procedure with consideration of "other factors" which may influence the thickness of the pavement section. The 1993 AASHTO *Guide for the Design of Pavement Structures* and 1998 *Supplemental* allows for these "other factors", both principal and secondary, which will be considered along with the engineering and economic data to select the pavement section for the project. The principal factors have a major influence on the thickness of the pavement section. The secondary factors will be used to evaluate the designed thickness.

This Guide outlines the process for pavement design for new or reconstructed pavement structures and rehabilitation projects. It provides guidance in the design approach for the cost comparison, the use of design parameters and discusses principal factors to be utilized in making a selection of a pavement type for design. This guide is provided in compliance with Title 23, Code of Federal Regulations Part 626. The following list provides other sources of information related to this DD:

- *West Virginia Division of Highways Pavement Design Manual*, 1997
- *AASHTO Mechanistic-Empirical Pavement Design Guide*, 2000 (and associated software)
- Westergaard Equations (for design of concrete slabs)
- Asphalt Pavement Alliance *PerRoad* software

The *designer* may also use engineering judgment based on past performance of other pavements in the project area, provided the pavements are of the same type, the geotechnical data, traffic characteristics, etc. are similar. Coordination with the Pavement Management System Section in the Operations Division is essential to gather information on past performances of differing types of pavement and rehabilitations in the different geological regions of the State.

If the criteria listed below are true then consider an *analysis period* of 50 years or more along with the design of a “perpetual pavement” or a “long-life pavement”. Additionally, the *Mechanistic-Empirical Pavement Design Guide* (M-E PDG) software should be used to verify the results of the *DARWin* analysis when the following situations are true:

- ESAL values are greater than 30,000,000.00
- *DARWin* software indicates that an asphalt pavement is greater than 13 inches
- When Plain Jointed Portland Cement Concrete Pavement (PCC) is 10 inches or thicker.

NOTE: The *M-E PDG* is not yet approved by AASHTO; however, it may be used if the designer is both familiar with it and can obtain the required material property values.

The *PerRoad* software from the Asphalt Pavement Alliance gives the thickness of an asphalt pavement known as a “Perpetual Pavement”, which is a pavement with a structural performance period greater than 50 years. Ride-ability overlays still must be considered with a perpetual pavement. These overlays are “mill and fill” overlays where the thickness milled out is replaced with an identical thickness of asphalt. PCC pavements with a structural performance period more than 50 years are known as “long-life pavements” and thicknesses are given by the Westergaard Equations. While the thicknesses are given by these equations, PCC pavements designed by this method must have full-depth, tied PCC shoulders for lateral support, as the equations assume that the edge of the PCC pavement has adequate lateral support so the slabs do not spread apart. These PCC pavements also require ride-ability rehabilitation techniques to be performed throughout the 50-year lifespan of the pavement.

In general, a minimum 40-year *analysis period* shall be used unless the conditions for a “perpetual pavement” or “long-life pavement” are met. In this case, an analysis period of at least 50 years will be considered. The conditions for the use of a 50-year analysis period are listed in paragraph four of “Section 10” of this DD.

20. PAVEMENT DESIGNS

Pavement designs shall be required for all pavement types with LCCA when more than one type of pavement is to be considered in the pavement type selection procedure. See DD-641, *Pavement Type Selection Guide*, for the criteria to be used for this determination.

An LCCA is not required on projects where pavement replacement or reconstruction is less than 1,000 feet on a single roadway segment or less than 500 feet of each bridge approach roadway. In these cases, the pavement design process can be based on engineering judgment; however, *pavement designs* shall be *required* on all other project types, with the exception of rehabilitation projects. The project manager shall give due consideration to selected *pavement segments*, considering in-kind replacement, adjacent pavement type and condition, past pavement performances as described in “Section 10” above, and future improvements when exercising judgment during the design process.

The asphalt overlay thickness for rehabilitation projects is to be based on historic practices utilized by the West Virginia Division of Highways, engineering judgment supported by a field review of the existing pavement and the past performance of asphalt overlays on similar projects, or if necessary a pavement design in accordance with this DD.

1. PRINCIPAL FACTORS

“Principal factors” are those which can have a major influence on the design. Some of these factors are included in the basic design procedures as they influence the structural requirements of the pavement design or sub-grade or the embankment treatments. In such cases, they are assigned an economic value for comparative purposes. The following discussion documents Division policies and practices for principal factors not considered in basic design procedures.

a. Traffic

Shifts occur in the economic activity of manufacturing and service industries throughout the state. These activities should be considered as factors affecting the proposed alternative and required method for construction of the selection. In urban areas or on roadways with heavy traffic, the need to minimize disruptions may be a major consideration.

b. Soils Characteristics

The design is to give full consideration to any unusual soils characteristics. Subsurface exploration is an essential part of the design process which includes investigation, sampling and testing, identification of materials types and the distribution of soils materials throughout the project. Based on past experience, the characteristics of the roadbed soils have been found to have a major influence on pavement performance.

c. Recycling

It is the Division's policy to promote recycling of existing roadway materials. The current edition of the *West Virginia Division of Highways Standard Specifications, Roads and Bridges* allows recycled materials to be incorporated in the pavement section.

30. RESPONSIBILITIES AND SELECTION PROCEDURES

The project manager will perform the design analysis utilizing appropriate software for all pavement alternates, when applicable. The analysis period shall be the same for each type of pavement with pavement rehabilitation strategies developed to give an equivalent performance.

The project manager will document the “principal factors” as they relate or apply to the project. Weighing the factors and any related costs along with the costs of alternates from the LCCA, a pavement design and bidding method will be submitted to the Deputy State Highway Engineer-Chief Engineer of Development for approval. Refer to DD-647, *Life-Cycle Cost Analysis for Pavement Design*, for more information concerning LCCA.

40. SAFETY

All projects, whether new construction, reconstruction or rehabilitation, will have skid resistant properties suitable for the needs of traffic. Refer to DD-644, *Asphalt Pavement*, for related criteria.

50. GENERAL TYPES

Consider the following types of pavement alternates:

A. Rigid

The pavement will be jointed Portland Cement Concrete (PCC) as required by the design parameters, current design policy, or as selected by use of DD-641, *Pavement Type Selection Guide*. Joint spacing shall be in accordance with details set forth in the current edition of the *WVDOT/DOH Standard Details, Volume 1*.

B. Flexible

Flexible pavement will be asphalt. *Applications* and asphalt *mix types* shall be in accordance with DD-644, *Asphalt Pavement*.

C. Base Courses

Base course(s) will be specified as per DD-643, *Use of Aggregates and Filter Fabric*.

D. Shoulders

Joint spacing on PCC shoulders shall match the spacing of the mainline pavement. For both PCC and asphalt pavements, the paved shoulder thickness shall match the mainline pavement section for:

- Urban arterials
- Projects with an ADT of 6,000 and truck traffic of 15% or greater
- Projects with an ADT greater than 15,000

60. PERFORMANCE PERIOD - NEW PAVEMENTS

Performance periods for new pavements will be selected based on past design practices, experiences, and a review of pavement data.

The WVDOT's current historical data regarding the initial performance period of original asphalt pavements indicates an average of 18 years to the first rehabilitation. This may be extended by as much as 4 years if one of the following is true:

- The initially constructed asphalt pavement utilized a polymer binder in at least the top 4 inches of the asphalt mix.
- A rut-resistant base (such as a Superpave 19 mm, 25 mm, 37.5 mm mix, or a combination of these) was used to the elevation of the bottom of the surface course and the surface course utilized has a polymer binder.

The WVDOT's current historical data indicates an average initial performance period of 22 years for original PCC pavements.

70. PERFORMANCE PERIOD - REHABILITATION

Rehabilitation projects are to be based on performance periods as described below. These performance periods vary by rehabilitation techniques (asphalt overlays vs. Concrete Pavement Restoration (CPR)) as well as original pavement types (asphalt vs. PCC).

Performance periods of subsequent asphalt overlays over asphalt pavements vary from 8 to 12 years (based on WVDOH historic data), which may be extended by up to 4 years when a polymer binder is used in at least the top 4 inches of the final pavement thickness.

Performance periods of subsequent rehabilitations over PCC pavements range between 10 and 14 years for Concrete Pavement Restoration techniques (based on national experience), and 6-10 years for asphalt overlays (based on WVDOH historic data), which may be extended by up to 4 years when a polymer binder is used for the entire thickness of the asphalt overlay mix. An additional four years should not be anticipated with minimal thickness polymer wearing course overlays.

The designer is cautioned to investigate all available historical data regarding past pavement performance, including overlays, when determining pavement rehabilitation schemes for the LCCA of newly constructed pavements. This is also true when considering rehabilitation schemes for existing pavements. The Pavement Management Systems Section of Operations Division is to be consulted for guidance in this matter.

80. TRAFFIC DATA

Traffic factors for growth rates, equivalent single axle loads (ESAL), and directional distribution percentage are to be obtained from the Traffic Modeling and Analysis Unit of the Planning Division.

90. ROADBED SWELLING AND FROST HEAVE

Recommended values from Table 1 of this DD are to be used unless project-specific information is available and approved by the Deputy State Highway Engineer-~~Chief Engineer~~ of Development.

100. SERVICEABILITY

Recommended values from Table 1 of this DD are to be used unless project-specific information is available and approved by the Deputy State Highway Engineer-~~Chief Engineer~~ of Development.

110. MATERIALS PROPERTIES

Effective roadbed soil resilient modulus data are to be obtained from Materials Control, Soil and Testing Division. Soil samples are normally obtained during the design phase; however, if a paving project is to be bid after the grading has been completed and enough time is available to perform in-place testing of the sub-grade, the Designer should request the Materials Control, Soils, and Testing Division to re-test the sub-grade prior to designing the final pavement section.

Recommended values from Table 1 of this DD are to be used unless project-specific information is available and approved by the Deputy State Highway Engineer-~~Chief Engineer~~ of Development.

120. PAVEMENT STRUCTURAL CHARACTERISTICS

Recommended values from Table 1 of this DD are to be used unless project-specific information is available and approved by the Deputy State Highway Engineer- Chief Engineer of Development.

130. PAVEMENT THICKNESS

The final pavement thickness will be based on the structural analysis. The minimum layer thickness will be consistent with standard construction methods and/or material requirements. For all pavement types, the total design thickness shall be rounded up to the nearest half-inch. Refer to DD-644, *Asphalt Pavement*, for information on pavement layer thickness criteria for asphalt pavements.

140. REHABILITATION PROJECTS

The Division recognizes that there are a variety of rehabilitation methods and strategies available to restore pavements. As all factors that influence pavement performance and life expectancy have not been quantified, the latest information and recommendations from the Pavement Management System Section of Operations Division should be considered in the selection type and process outlined herein.

The asphalt overlay thickness for overlay types of rehabilitation projects is to be based on historic practices utilized by the West Virginia Division of Highways, engineering judgment supported by a field review of the existing pavement and the past performance of asphalt overlays on similar projects, or if necessary a pavement design in accordance with this DD.

In situations where the use of an asphalt overlay as the rehabilitation method is questionable, the following process can be used to select the rehabilitation method best suited to the project:

A. Project Evaluation

The type of pavement rehabilitation to be considered begins with an evaluation of pavement distress, smoothness or ride-ability and consideration of general conditions within the proposed project area. For asphalt pavement, distress evaluations are based on the amount of rutting, longitudinal cracks, transverse cracks, alligator cracks, and smoothness. For concrete pavements, the distress will be measured on the basis of the amount of faulting, longitudinal cracking, transverse cracking, pumping, joint deterioration and smoothness. This information will normally be available from pavement management inventories collected by the Pavement Management Section of Operations Division. Project conditions will be gathered based on a field review by the project manager.

B. Project Analysis

Upon completion of evaluations, alternative solutions will be considered for the project. The following alternates considered by the designer may vary with the type of pavement being overlaid, the amount of distress and smoothness values. The alternates will be analyzed as to their constructability, performance period, initial agency costs, and life cycle costs. The performance periods may be chosen by the designer from the ranges given below, considering input from other

Division and District personnel, and the Pavement Management Section of Operations Division will consider the vertical clearances, traffic control, and construction conflicts.

NOTE: Full and partial depth patching are normally considered maintenance and occur prior to rehabilitation. Maintenance performed at a separate time and under a separate contract is not included in rehabilitation; however, full and partial patching performed in conjunction with an overlay *is* included in the LCCA and the rehabilitation project.

1. Original PCC Pavements

a. All Phases of Rehabilitation

i. Concrete Pavement Restoration Techniques

A performance period of up to 14 years may be considered when Concrete Pavement Rehabilitation (CPR) techniques are selected. These techniques may be as follows:

- a) Joint and crack repair (full and partial depth) for spalling or faulting joints
- b) Diamond grinding for IRI improvement

More information for the designer concerning joint repair and diamond grinding can be obtained at the Federal Highway Administration's website at the following address: <http://www.fhwa.dot.gov/pavement/guid.cfm>. This page conveys links to technical guidance papers for all types of pavements, rehabilitation techniques and materials, among other pertinent information.

If reconstruction is determined to be the preferred design after a thorough field evaluation of the existing pavement and consultation with the Pavement Management System Section, then the required initial performance period shall be as described in "Section 70" of this DD for the type of pavement selected.

ii. Superpave and Marshall Mix Designs

If reconstruction is determined to be the preferred design after a thorough field evaluation of the existing pavement and consultation with the Pavement Management System Section, then the required initial performance period shall be as described in "Section 70" of this DD for the type of pavement selected.

iii. Concrete Overlays

The service life of a concrete overlay is up to the designer and can range from 10-40 years and is designed to provide the selected extended performance. The overlay can be either bonded or unbounded depending on the pavement condition and desired service life. More information for the designer can be obtained from the

following web address: <http://www.fhwa.dot.gov/pavement/concrete>

iv. Asphalt Pavement on Rubblized PCC pavement

Asphalt pavement on rubblized PCC pavements should be designed as new, full-depth pavements. It is critical to properly assess the conditions under the concrete slabs and the uniformity of the rubblized layer to ensure the desired performance of the asphalt pavement.

2. Original Asphalt Pavements

a. All Phases of Rehabilitation

i. Superpave and Marshall Mix Designs

The asphalt overlay thickness for these types of rehabilitation projects is to be based on historic practices utilized by the West Virginia Division of Highways engineering judgment supported by a field review of the existing pavement and the past performance of asphalt overlays on similar projects, or if necessary a pavement design in accordance with this DD.

An 8 to 12 year performance period is appropriate and may be extended up to 4 years if the top 4 inches of the final pavement thickness (after the overlay is applied) has a polymer binder in the asphalt mix(s), or a large stone rut-resistant base (such as a Superpave 19 mm, 25 mm, 37.5 mm mix, or a combination of these) was used to the elevation where the surface course was applied.

If reconstruction is determined to be the preferred design after a thorough field evaluation of the existing pavement and consultation with the Pavement Management System Section, then the required initial performance period shall be as described in “Section 70” of this DD for the type of pavement selected.

ii. Whitetopping (Overlaying with Concrete Pavement)

No “ultrathin” whitetopping will be permitted. Only unbonded whitetopping overlays with a 5-inch minimum thickness will be permitted.

Whitetopping overlays may be designed for a 10 to 20-year service life.

The following FHWA publication provides guidance and references for use of whitetopping on asphalt pavements: <http://www.fhwa.dot.gov/pavement/concrete>.

C. Project Design

The design strategy will be to bring the Present Serviceability Index up to near the initial value of 4.2. The design of overlays will be in accordance with methods previously outlined.

D. Project Implementation

Rehabilitation projects will be initiated on an annual program in accordance with pavement management data and the budget.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 664
MEDIAN BARRIER WARRANTS**

*September 6, 2023
Supersedes June 25, 2015*

Reference is directed to the most current and officially adopted version of the “Roadside Design Guide” (RDG) as developed by the AASHTO Task Force for Roadside Safety, published by the American Association of State Highway Transportation Officials, chapter on Median Barrier Warrants.

The Median Barrier Warrants for Freeways and Expressways, as shown in the RDG, consider only median widths and average daily traffic as warrants for median barriers. Other factors should be considered when making the decision on specifying a median barrier, such as but not limited to the following:

- a) Accident data, including crossover crash rates
- b) Cost
- c) Median Width
- d) Median Slopes
- e) Traffic Volumes
- f) Vehicle Types
- g) Horizontal and Vertical Geometry

The Median Barrier Warrants for Freeways and Expressways, as shown in the RDG, were developed for full access control highways. Use of median barriers on partially controlled access roadways is more complex and requires additional engineering analysis and judgment with respect to the following factors.

- i. Sight Distance at intersections
- ii. Number of intersections and driveways
- iii. Right of way constraints
- iv. Barrier terminals

Use of median barriers for conditions outside those specified in the RDG shall be approved by Deputy State Highway Engineer ~~Chief Engineer~~ of Development.

The following median barrier selection form should be used to aid in selection and documentation of final decision. The selection form is to be included in the PS&E package and included with request for approval.

Median Barrier Selection Criteria	
	Project:
	Date:
	By:
Description	Value or Narrative
Full and Partial Access Control	
ADT, % Trucks	
Accident Data	
Crossover Rate	
Median Width(s)	
Median Slopes	
Vehicle Classification	
Horizontal Geometry	
Vertical Geometry / Grades	
Median U-Turns	
Other Factors	
Partial Access Control	
Intersection Sight Distance	
Number of Intersections	
Number of Driveways	
Right of Way Constraints	
Barrier Terminals	
Other Factors	
Proposed Barrier / Justification	

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 702
SIGNING AND SEALING OF PROFESSIONAL WORK,
TITLE SHEET SIGNATURE BLOCK**

*April 7, 2025
Supersedes January 3, 2024*

The intent of this directive to establish the Division of Highways (Division) procedures regarding signing and sealing engineering documents. Any person signing and sealing engineering work shall be a registered professional engineer in the State of West Virginia and fully knowledgeable of the publications noted below.

The designer and the responsible charge engineer are both referred to the West Virginia State Board of Registration for Professional Engineers publications “WV Engineering Law Booklet – April 2020;” “WV Engineering Law (State Code – Chapter 30, article 13) – As of March 2015;” WV Engineering Law (State Rules – title 17, Series 1 – Examination, Licensure and Practice) – As of April 2020;” and “WV Engineering Law (State Rules – Title 7, Series 2 – Administrative Hearing Procedures) – As of July 2004.” These publications are available at <https://wvpebd.org/West-Virginia-Engineering-Law/West-Virginia-Engineering-Law>.

Engineering work for and by the Division will adhere to these laws and legislative rules regarding the practice of engineering and the signing and sealing of documents.

Responsible Charge

In State Code §30-13-3(g) responsible charge is defined as:

“Responsible charge” means direct control and personal supervision of engineering work.

Division Directors or District Engineer/Managers, when those individuals are a West Virginia Registered Professional Engineer, or their W. Va. Registered P.E. designee, shall be the responsible charge engineer for work performed in their division/district. In the event a Division Director or District Engineer/Manager is not a West Virginia Registered Professional Engineer, then the duty shall fall to the next lower ranking person who is a West Virginia Registered Professional Engineer in the Section/Unit/Group where the engineering work is occurring. Consultants shall sign and seal professional engineering work submitted to the Division.

As standard practice, the person(s) who will have responsible charge of the engineering work shall be identified in the early stages of the project. In the event the person(s) having responsible charge cannot sign and seal their work, such work may be sealed by another professional, but only after a thorough review of the work to verify that the work has been accomplished to the same extent that would have been exercised if the work had been done under the direct control and personal supervision of the professional affixing the seal.

Documents

Generally, the final original document shall be signed and sealed. Contract plans shall be signed and sealed at the PS&E submission.

State Code §30-13-16 states the following about the types of documents that require signature and signing:

Whenever presented to a client or any public or governmental agency, the seal, signature and date shall be placed on all specifications, reports, drawings, plans, design information and calculations in accordance with rules promulgated by the board. The seal and signature shall be used by registrants only when the work being stamped was under the registrant's complete direction and control.

Engineering work that has been produced over long periods by the Division, with no clear person(s) having responsible charge will not require signing and sealing. Examples include, but are not limited to, The Standard Specifications Roads and Bridges and supplements thereto and the Standard Details Volumes I thru III. Revisions to these documents will require signing and sealing.

Revisions

A revision of engineering work after documents have been signed and sealed is addressed in §7-1-7.3.c of the Legislative Rule:

Revisions shall be numbered, dated, initialed, and sealed by the registrant responsible for the revision.

Revisions to engineering work during the construction phase shall be signed and sealed when the revisions change the design or impact previous engineering work or calculations. The engineer in responsible charge of the revisions shall sign and seal the changes. That person shall have direct control and personal supervision of the work and be responsible for engineering decisions regarding the change(s).

Value Engineering Change Proposals (VECP) and Practical Design Change Proposals (PDCP) are revisions to the plans. Such engineering revisions performed by the contractor or the contractor's agent require signing and sealing by the engineer responsible for the proposal.

It is highly recommended that the initial engineer in responsible charge be consulted for any significant change in scope. Not doing so places additional risk on the registrant signing and sealing revisions.

Right of Way Plans

Right of Way Plans are considered an engineering representation of the existing, proposed, or acquired right of way, depending on the submission. Right of Way plans prepared by or for the Division shall be sealed by the engineer in responsible charge of the RW-3 or RW-4 submission, as appropriate.

Title Sheet Signature Block

The attached title sheet signature blocks shall be used for all right of way plans and construction plans regardless if the construction is performed under contract or Division of Highways' Forces. The professional engineer signature and seal block on the consultant title sheets will be applied by the consultant.

All signatures, as per the attachments, will be by Division of Highways' personnel.

Occasionally there may be exceptions which will be handled on a project-by-project basis when approved by the appropriate Deputy State Highway Engineer-Chief Engineer.

Attachments

CENTRAL OFFICE and DISTRICT PROJECTS (INTERNAL DESIGN)
FULL-SIZE CONSTRUCTION and R/W TITLE SHEET



SIGNED: _____
RESPONSIBLE CHARGE ENGINEER

DATE: _____

RECOMMENDED: _____
PROJECT ENGINEER

RECOMMENDED FOR APPROVAL: _____
STATE HIGHWAY ENGINEER ~~CHIEF ENGINEER~~

APPROVED: _____
COMMISSIONER OF HIGHWAYS

**CENTRAL OFFICE and DISTRICT PROJECTS (CONSULTANT DESIGN)
FULL-SIZE CONSTRUCTION and R/W TITLE SHEETS**

RECOMMENDED: _____
PROJECT MANAGER

RECOMMENDED FOR APPROVAL: _____
STATE HIGHWAY ENGINEER ~~CHIEF ENGINEER~~

APPROVED: _____
COMMISSIONER OF HIGHWAYS

CENTRAL OFFICE and DISTRICT PROJECTS (INTERNAL DESIGN)
8 1/2" X 11" TITLE SHEETS

WV DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
PLAN OF PROPOSED IMPROVEMENTS OF
STATE HIGHWAY

PROJECT NAME: _____ STATE PROJECT NO.: _____

FEDERAL PROJECT NO.: _____ COUNTY: _____

LENGTH (mi): _____ COORDINATES: x = _____ DEG. _____ MIN. y = _____ DEG. _____ MIN.

BEGIN TERMINI: _____ END TERMINI: _____

TYPE OF IMPROVEMENT: _____ EXISTING ADT: _____

"TRAFFIC CONTROL FOR STREETS AND HIGHWAY CONSTRUCTION AND MAINTENANCE
OPERATIONS DATED _____ SHALL APPLY TO THIS PROJECT."



SIGNED: _____
RESPONSIBLE CHARGE ENGINEER

DATE: _____

RECOMMENDED: _____
PROJECT ENGINEER

RECOMMENDED FOR APPROVAL: _____
STATE HIGHWAY ENGINEER ~~CHIEF ENGINEER~~

APPROVED: _____
COMMISSIONER OF HIGHWAYS

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 706
GUIDELINES FOR PREPARATION OF PROJECT PLANS,
SPECIFICATIONS, AND ESTIMATES (PS&E) SUBMITTALS**

*January 3, 2024
Supersedes February 19, 2016*

The following are guidelines for the preparation and assembling of PS&E (Plans, Specifications and Estimate) submittals for projects developed or processed by Divisions (including all Districts projects) under the State Highway Engineer-Applicable Chief Engineer. It should be noted that other Design Directives are referenced to and hereby considered a part of this DD that pertain to similar subject matter and are more precise than these guidelines. They are referenced for clearer understanding of the preparation of items required to be submitted.

A checklist for developing the PS&E submittal package is attached to and made a part of this Design Directive. This checklist shall be used for all projects.

I. DEFINITIONS

- A. Engineers Estimate.** The predicted project cost at the time of receipt of bids developed from a knowledge of the costs for materials, labor, and equipment required to perform the necessary items of work.
- B. Contract Plans.** The contract drawings which show the locations, character, and dimension of the prescribed work, including layouts, profiles, cross sections, and other details.
- C. Required Contract Provisions.** Those provisions required by law or regulation of the various jurisdictions involved in funding projects and administering contracts for construction projects.
- D. Special Provisions.** Specifications for specific items or details applicable to the individual project and which are not covered in the Standard or Supplemental Specifications.
- E. Pre-PS&E Submission.** A submission made to the FHWA on Full Oversight projects to allow for their informal review and comment. This submission will include the completed contract plans and any project-specific Special Provisions and is intended to make the subsequent official submission to the FHWA as complete as possible.
- F. Specifications.** The compilation of provisions and requirements for the performance of prescribed work.
- G. Standard Details.** Drawings approved for repetitive use showing details to be used where appropriate. Included are Revised Standard Details that are to be referenced by revision date as appropriate.
- H. Special Details.** Modifications to a Standard Detail drawing, or any detail drawing required to describe an item of work not covered by a Standard Detail drawing.
- I. Standard Specifications.** A book of Specifications approved for general application and repetitive use.

- J. Supplemental Specifications.** Approved additions and revisions to the Standard Specifications.
- K. Working Time Calendar.** A bar chart completed by the designer showing the estimated time required for a contractor to complete a construction contract. See DD-803, *Determination of Contract Completion Date*.

II. PLANS

- A. Contract Plans.** Contract Plans are instructions using drawings containing engineering data or details pertaining to geometrics, drainage, structures, soils and pavements, and other appurtenances. See DD-701, *Contract Plan Presentation*, for further information concerning the preparation of Contract Plans.
 - 1. Plans should not encompass material that is properly a part of the Standard or Supplemental Specifications, Special Provisions, or Standard Details.
 - 2. The original drawings should be on standard sheets conforming to modern, accepted drafting practices or aerial photograph base maps. (See DD-701)
 - 3. Straight-line plans may be used provided they give sufficient information to properly complete the project. (See DD-701)
- B. Right of Way Plans**
See DD-301, *Right of Way Plan Development*, for information on preparation of right of way plans.

III. SPECIFICATIONS

Specifications contain the written instructions for constructing highway projects, outlining in detail a description of the work, materials, construction methods, method of measurement, and the basis of payment for each item of work involved in the contract.

- A. Standard Specifications**
Since every construction project involves subjects or items that occur repeatedly, standard specifications setting forth provisions and requirements applicable to the construction of highway projects have been prepared.
- B. Supplemental Specifications**
 - 1. Supplemental Specifications are specifications developed subsequent to the publication of the Standard Specifications to cover new or additional construction items or substantial changes regarding items included in the Standard Specifications.
 - 2. Supplemental Specifications will be printed and bound from time to time depending upon when the Standard Specifications are updated.
- C. Special Provisions**
 - 1. Special Provisions are specifications for governing all matters applicable to the individual project and, therefore, are not covered in the Standard or Supplemental Specifications.
 - 2. Special Provisions should be held to a minimum and, as much as possible, applicable Standard or Supplemental Specifications should be utilized.

3. Commitments for environmental mitigation which are contained in the environmental documentation should be incorporated into the project as Special Provisions.
4. Special Provisions should be in printed, copied or other acceptably reproducible form. Each Special Provision to be utilized in the project is to be listed in the appropriate place on the PS&E Checklist.

IV. ESTIMATES

- A. The Engineer's Estimate shall be prepared and reviewed carefully to reflect as realistically and accurately as possible the expected costs of the work at the time of receipt of bids. (Also see DD-707, *Development of Engineer's Estimate*)
- B. Consistent and compatible procedures for the preparation, review, and updating of estimates shall be followed.
 1. The unit prices used for estimates, and corresponding actual unit bid prices when available, for the preceding 12 months should be reviewed to determine if changes in estimated unit prices are needed to reflect any trends that have occurred.
 2. The estimate should reflect prices that are realistic for the areas, times, and characteristics of the work to be done (regional adjustment and seasonal adjustment are especially important, as is size of the project).
 3. Incentive/disincentive or escalation clauses should be considered in determining the estimated unit costs since such clauses may affect the estimate considerably. (See DD-708, *Guidelines for Development of the Incentive/Disincentive Contract Provision*)
 4. Other factors that can affect the estimated cost of a project, such as labor rates, equipment rates, interest rates, time to complete, competition levels, and material shortages, should be considered and estimated costs adjusted as necessary.
 5. Bid price data bases should be current at the time of estimate preparation and at the time of advertisement.
- C. Estimates should include an item number, description of the item, estimated quantity, unit, and price for each proposed item of work.
- D. For accounting purposes, the Engineer's Estimate should identify separately:
 1. Municipal and Non-Municipal quantities are not to be shown, but are to be broken down by the contractor in accordance with DD-805, *Use of Corporation Lines*.
 2. State-by-state breakdown;
 3. Tabulations of items coded on the basis of the predominant Improvement and Construction Type Code. For applicable code numbers, see the most recent code numbers provided in the AASHTO Transport software, to be used when preparing the Engineer's Estimate.

- E. Engineering and Contingencies (E & C) will be shown for each category of work, and then summed.

V. REQUIRED CONTRACT PROVISIONS

- A. Federal, state, and local agencies have certain required contract provisions covering employment, records of materials and supplies, subletting or assigning the contract, safety, false statements, termination, nonsegregated facilities, and environmental requirements among others that are to be included in contracts for construction projects.
- B. Because requirements may change on short notice, required contract provisions should not be included in bound books of general specifications.

VI. PS&E CONTENT

PS&E assemblies should include:

- A. Complete sets of plans;
- B. Special Provisions;
- C. Engineer's Estimate;
- D. Right-of-Way Certificate and Status of Utilities Report from the Right of Way Division;
- E. Approved agreements with railroads, utilities, and municipalities, if not previously submitted;
- F. Applicable permits;
- G. For projects which include outside funding, written documentation from the outside agency confirming the authorization to advertise. (i.e. other states, boards of education, private developers, etc.);
- H. The completed current PS&E Checklist as maintained by the Engineering Division and attached to and made a part of this DD; and
- I. Working time calendar.

VII. PS&E ASSEMBLY AND PROCESSING

The Project Manager or Designer shall assemble and submit the material listed in Section VI to the Contract Administration Division's PS&E Section for processing of the PS&E package.

The processing of the PS&E package will vary based on whether the project is Full FHWA Oversight or Delegated.

The steps to be followed and the estimated time required in working days for processing the PS&E package for each type of project are shown in the following tables:

PS&E ASSEMBLY AND PROCESSING

FULL FHWA OVERSIGHT FEDERAL-AID PROJECTS

	REQUIRED ACTIVITY	Estimated Number of Working Days
*a.	Completed contract plans and project specific Special Provisions are reviewed by the Project Manager or Designer. A “pre-PS&E” submission of completed contract plans and project specific Special Provisions will be made to the Federal Highway Administration (FHWA) at this time for their informal review and comment. The number of sets of plans and Special Provisions is to correspond with the number required for the “Half-Size PS&E Plans” submission in the Plan Distribution Schedule in DD-202.	20 days
*b.	The “pre-PS&E” comments from the FHWA are reviewed by the Project Manager or Designer. Any necessary revisions are made at this stage by the consultant and resubmitted to the Project Manager, or the revisions to the contract plans and project specific Special Provisions are made by the Designer if the project is In-House or District-designed.	
*c.	The PS&E Package is submitted to the Contract Administration Division’s PS&E Section for the preparation of the official submission of the proposal, plans, and estimates to FHWA for approval of authorization to advertise for receipt of bids. If construction cost is more than \$250,000.00, Equal Employment Opportunity Division reviews the project for possible DBE goal.	
*d.	Programming Division prepares and submits to FHWA all required financial data to complete the Funding Authorization Request.	
*e.	Contract Administration Division’s PS&E Section assembles the Contractor’s Bidding Proposal. The appropriate number of copies of bidding proposals and sets of plans are prepared.	
f.	The Contractor’s Bidding Proposal, Contract Plans, Right of Way Certificate, Signed Detailed Estimates, and Chart for Estimating Contract Time are formally submitted to the FHWA.	1 day
g.	FHWA reviews PS&E and gives written comments to Project Manager or Designer.	10 days
h.	Comments are reviewed by Project Manager or Designer. All responses to comments and necessary revisions are returned to FHWA for approval of PS&E.	10 days

i.	FHWA will authorize funding and give approval to Programming Division to advertise the project for the next available letting once the PS&E package is complete and ready to advertise.	2 days
j.	Programming Division contacts Contract Administration Division to advertise for receipt of bids for the next available letting.	2 days
**k.	An amendment for an advertised project: The Project Manager or Designer revises the plans, specifications, and detailed estimate of cost as required. These revisions are then given to Contract Administration Division's PS&E Section for the assembling of the amendment and the preparation the amendment directive that incorporates all proposal and plan revisions. These revisions must be submitted to Contract Administration Division's PS&E Section a minimum of 14 calendar days prior to the letting to allow for the preparation and submission of the amendment to FHWA for approval 12 calendar days prior to the advertised letting date. Amendment revisions must be printed and given to Contract Administration Division to mail to all contract plan holders a minimum of 7 calendar days prior to the advertised letting date.	14 days (Not included in the Total Time below)
**l.	Time between advertisement and letting (28 calendar days has been assumed to be 20 working days for the purpose of this table)	20 days (Minimum)

*, ** Performed simultaneously

TOTAL

65 DAYS

STATE FUNDED AND DELEGATED FEDERAL-AID PROJECTS

	REQUIRED ACTIVITY	Estimated Number of Working Days
*a.	Completed contract plans and project specific Special Provisions are reviewed by the Project Manager or Designer. Any necessary revisions are made at this stage.	15 days
*b.	PS&E package is submitted to Contract Administration Division's PS&E Section for advertising for receipt of bids. If construction cost is more than \$250,000.00, the project is reviewed by Equal Employment Opportunity Division for a possible DBE Goal (Federal Aid Projects Only).	
*c.	Programming Division reviews the project's financial data in this submission to ensure it is complete and in accordance with the Federal Aid Funding Requirements. For State Funded Projects the submission is reviewed to ensure it is in accordance with the State Funded Program Requirements.	
d.	When the Right of Way Certificate is available, the PS&E package and the Contractor's Bidding Proposal are assembled.	3 days
e.	Programming Division prepares and submits to FHWA all required financial data to complete the Funding Authorization Request, for an exempt Federal-Aid project.	2 days
f.	The advertising memo and signed BF-98 are prepared for Contract Administration to advertise for receipt of bids for the next available letting. The signed detailed estimate is given to the <u>Deputy State Highway Engineer/Development</u> Applicable Chief Engineer for final approval of cost.	1 day
g.	Programming Division verifies project cost to be in accordance with the funding request. The package is hand carried to the <u>Deputy State Highway Engineer/Development</u> Applicable Chief Engineer for approval to advertise for receipt of bids.	3 days
h.	When funding is approved by FHWA or the State itself, Programming Division contacts Contract Administration Division to advertise the project for receipt of bids in the next available letting once the PS&E package is complete and ready to advertise.	3 days

**i.	An amendment for an advertised project: The Project Manager or Designer revises the plans, specifications, and detailed estimate of cost as required. These revisions are then given to Contract Administration Division PS&E Section for the assembling of the amendment and the preparation the amendment directive that incorporates all proposal and plan revisions. These revisions must be submitted to Contract Administration Division's PS&E Section a minimum of 12 calendar days prior to the letting to allow for preparation and printing of the amendment. Amendment revisions must be printed and given to Contract Administration Division to mail to all contract plan holders a minimum of 7 calendar days prior to the advertised letting date.	12 days (Not included in the Total Time below)
**j.	Time between advertisement and letting (21 calendar days has been assumed to be 15 working days for the purpose of this table)	15 days (Minimum)

*, ** Performed simultaneously

TOTAL

42 DAYS

VIII. DATE OF PS&E SUBMISSION

Federal regulations [23 CFR 635.112(b)] require that all Federal-aid contracts be advertised for a minimum 3-week advertisement period prior to a scheduled letting and the contract documents are available for distribution at least 3 weeks prior to the letting.

The Division of Highways policy is to advertise Federal-aid projects at least 4 weeks, and preferably 5 weeks, prior to letting with contract documents available at least 4 weeks prior to the letting.

State law requires that State projects be advertised for a minimum 2-week advertisement period prior to a scheduled letting and the contract documents are available for distribution at least 2 weeks prior to the letting.

The Division of Highways policy is to advertise 100% State funded projects at least 3 weeks, and preferably 4 weeks, prior to the letting with contract documents available at least 2 weeks, and preferably 3 weeks, prior to the letting.

When pre-bid conferences are necessary, these time limits should be increased by 2 weeks to allow adequate time for review by interested contractors prior to the pre-bid meeting and to allow adequate time for issuance of amendments prior to the letting. See DD-104, *Pre-Bid Meetings* for more information concerning pre-bid conferences.

To conform with this policy, the Project Manager or Designer shall submit the material listed in Section VI to the Contract Administration Division's PS&E Section to allow adequate time for assembly and processing of the PS&E package as shown in Section VII and to allow adequate time for printing (3 working days).

The material listed in Section VI shall be submitted as indicated below:

- **Full FHWA Oversight Federal-aid Projects** - minimum 65 days prior to the letting.
- **Full FHWA Oversight Federal-aid Projects** - minimum 75 days prior to the letting (With pre-bid conference).
- **State Funded and Delegated Federal-aid Projects** - minimum 42 days prior to the letting.
- **State Funded and Delegated Federal-aid Projects** - minimum 52 days prior to the letting (With pre-bid conference).

All days are working days unless otherwise indicated.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 708
GUIDELINES FOR DEVELOPMENT OF THE
INCENTIVE/DISINCENTIVE (I/D) CONTRACT PROVISION**

*September 6, 2023
Supersedes October 1, 2003*

The above procedure is a guideline to follow for determining I/D payments and is subject to change during preparation of the I/D Special Provision. The designer preparing the special provision shall use this guideline to prepare a logical document that includes all assumptions and calculations that can be reproduced.

This material becomes the backup information to support the I/D Special Provision and becomes part of the project file maintained in the Engineering Division. For Federal-aid exempt projects, the Deputy State Highways Engineer-~~Chief Engineer~~ of Development will review and approve the time and amount calculation. On non-exempt Federal-aid projects, the time and amount calculations must be submitted to FHWA for review and approval.

An incentive/disincentive (I/D) contract provision used in a project is a method to compensate a contractor a fixed amount of money for each day identified critical work is completed ahead of schedule. Also, it assesses a deduction for each day the contractor overruns the time allotted for the completion of identified critical work.

An I/D provision is an effective method to motivate the contractor to complete projects or portions of a project faster than normal. Typically, their use should be limited to those projects whose construction will severely disrupt highway traffic resulting in significantly increased road user costs. These increased road user costs can be determined by the prediction of higher travel time and vehicle operating costs through the work zone or along a detour route. If an I/D provision is used, the minimum increase in road user costs should be approximately \$5,000 per day and ideally should be more than \$10,000 per day. This minimum increase in road user costs will usually occur on projects with four or more lanes, an average daily traffic (ADT) of 25,000 vehicles or more per day, and continuous lane closures during the 12 peak volume hours. The minimum increase in road user costs may also occur on projects that have a minimum ADT of 15,000 vehicles per day and require all traffic to be detoured due to the closure of the roadway or a bridge.

There may be other projects that warrant inclusion of an I/D provision in the contract which do not meet the requirements stated above. Examples of these projects would be projects whose construction would affect access to critical facilities such as schools, hospitals, or major businesses. This type of project would require special methods to calculate the I/D time and the I/D amount, which would vary with each project. These calculations will not be addressed in this directive. Should the designer encounter a project with these special conditions, the inclusion of an I/D provision will be determined by the Deputy State Highway Engineer-~~Chief Engineer~~ of Development and the Traffic Engineering Division.

During the preliminary field review on a project that involves a four-lane highway that has an ADT of 25,000 or more, a determination will be made by the Project Manager whether a continuous lane closure for the 12 peak hours will be required. This determination will be made by review of the interrelation of physically constructing the project and maintaining traffic. If the continuous lane closure appears to be unavoidable, the Project Manager shall make a recommendation for further

review by Traffic Engineering Division for a preliminary determination of road user costs. A recommendation to include an I/D provision in the contract will be made by Traffic Engineering Division to the ~~Deputy State Highway Engineer–Chief Engineer~~ of Development and, if applicable, to the Federal Highway Administration (FHWA) on non-exempt projects. If the recommendation for inclusion of an I/D provision is approved, then an I/D task force for the project shall be formed. This I/D task force will have the duty of writing the I/D Special Provision with all associated backup data. The task force will also review the plan development to assure that the critical work to which the I/D provision will be applied is clear and can be managed. The task force will be composed of representatives from Engineering Division (usually Project Manager), Contract Administration Division (Central Office or District Office), Traffic Engineering Division, and if applicable, FHWA.

The same procedure as above will be followed starting at the preliminary field review for projects on highways with an ADT of 15,000 or more that involve the closure of a bridge or road with a resulting one-lane detour or a detour of more than two miles in length, projects that complete a gap in the highway system, or projects which replace major bridges that are out of service.

The I/D task force will write the I/D Special Provision using the following as a general guide:

1. Definitions of Incentive Payment and Disincentive Assessment
 - a. When work is completed in fewer calendar days than are scheduled for traffic restricted operation, the contractor shall earn as an incentive a certain amount of money for each calendar day the work is completed ahead of the allowed number of calendar days.
 - b. When work is not completed within the scheduled number of calendar days for restricted traffic operation, the contractor shall be assessed as a disincentive a certain amount of money for each calendar day the work exceeds the scheduled number of calendar days. The disincentive assessment is separate from the contract liquidated damage clause; consequently, in addition to the disincentive assessment, the contractor is still governed by the Standard Specifications in regard to liquidated damages for completion of the project.
2. Determination of Incentive/Disincentive Time
 - a. A time analysis for each construction operation is developed by either Engineering Division following the guidelines in DD-803, Determination of Contract Completion Date.
 - b. Non-critical construction operations that do not have significant impact on traffic are eliminated and not considered in the I/D time calculation. Examples of such operations are guardrail installation, cleaning and painting of structure, removal of median crossovers, seeding and mulching, and installation and removal of traffic control devices.

The time estimated for the completion of critical operations is increased by 20% to allow for inclement weather. This working time is expressed in hours.
 - c. An aggressive pace of work is calculated by dividing the total working time in hours by a selected aggressive number of working hours, such as 10 working hours per day times five working days per week. The result is then multiplied by seven days per week.

- d. This is the total number of days the contractor is allowed to restrict traffic. The purpose of this computation is to convert the normal working time of an average contractor to the working time required by an above average contractor. Say this aggressive schedule is A1.
- e. An accelerated pace of work is calculated by dividing the total working time in hours by a selected accelerated number of working hours, such as 12, 14, or 16 working hours per day times 6 working days per week. The result is then multiplied by 7 days per week. Say this accelerated schedule is A2.
- f. A1 minus A2 is the maximum number of days the contractor can save by expediting the project. This is called the *possible time savings*.

3. Determination of Incentive/Disincentive Amount

- a. Daily road user costs are determined by using QUEWZ software with the guidelines in the *Interim Report QUEWZ - 85 (1982)* or by manual calculation using such data as traffic volumes, vehicle mix, length of closure, and additional time and operating costs due to increase in travel time and distance (if detour is involved). Actual hourly counts should be used as traffic volumes.

The total maximum incentive amount payable to the contractor will be 5% of the total contract amount. Under special circumstances, the total incentive amount may exceed the 5% cap as determined and approved during the I/D Special Provision development.

- b. There will be no maximum disincentive amount.
- c. The daily I/D amount is determined by dividing 5% of the total contract amount by the number of days the contractor can possibly save as calculated in the determination of I/D time discussed above.

The daily cost to the contractor to expedite completion of the project is the addition of (a) overtime payments and (b) rent for extra equipment.

- 1) Overtime payments by the contractor need to be estimated. An example is as follows:

Number of overtime hours per week per worker = total working hours per week under accelerated schedule minus total working hours per week under aggressive schedule = (12 hours per day times 6 days per week) - (10 hours per day times 5 days per week) = 22 hours per week

Assuming a crew of 8 workers, total number of overtime hours per week = 22 hours per week per worker times eight workers = 176 hours per week

Average hourly wage per worker (including fringe benefits) = \$30 per hour

Average hourly overtime wage per worker (including fringe benefits) = 1.5 times regular wage = \$45 per hour

Total cost of overtime to contractor per 6 working days per week = 176 hours per week times \$45 per hour = \$7,920 per 6 working days per week

Daily cost of overtime to contractor = \$7,920 per week, 6 working days per week = \$1,320 per day

2) Rent for Extra Equipment

Daily cost for renting equipment is estimated based on type and number of equipment needed. This daily rental rate is obtainable from local equipment rental companies.

4. Justification of the Daily Incentive Payment to the Contractor

- a. In order that the contract may be worthy of I/D provision, the daily road user costs should be greater than the daily cost to the contractor.
- b. In order for the contractor to be motivated to bid on the I/D contract and actively work to expedite completion of this project, the daily amount paid the contractor should be greater than the extra costs that are incurred to expedite.
- c. To justify the use of I/D provision, the daily road user costs should be greater than the daily incentive payment to the contractor.
- d. For the daily I/D amount to be justified:

Extra costs to contractor < Daily I/D payment < Daily road user costs

5. Additional I/D Checklist Items for Consideration in Preparing the Contract Special Provision

- a. Clearly define the beginning and ending dates for the critical work elements that are to be accomplished. The use of calendar days or specific completion date in the contract has proven most effective in controlling contract times.
- b. State the time the contractor is permitted to work, such as multiple shifts, weekends, holidays, etc., or conversely, when work should not be permitted. Describe what working operations the contractor may or may not perform during nighttime hours.
- c. Include the pay schedule for I/D.
 - 1) The pay schedule should relate money and time.
 - 2) Incentive payments should have a specified maximum time.
 - 3) Disincentive payments should be charged continuously until the critical elements have been completed.
- d. Address underruns and overruns. This may be accomplished by requiring a limited or extensive CPM as part of the contract. Whatever method is used, consideration should still be given to:
 - 1) Contractor time adjustments should be limited to only major work items.

- 2) The percent underrun or overrun should be substantial enough to warrant contract time changes.
 - 3) Values and formulas can be specified that advise the contractor of the relationship between underruns and time extensions or time deletions.
- e. Identify what work is considered preparation, fabrication, and cleanup that may be outside the critical time path for fully opening a project to traffic.
- f. Contracts involving bridge construction should take into account the time factor associated with shop drawing and erection procedure reviews and approvals. These two items can be an important factor in measuring and assessing contract time.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 710
ROAD USER DELAY REDUCTION METHODS**

September 6, 2023

Supersedes August 1, 2004

Attached are guidelines to aid the Project Manager in developing contract documents which minimize road user delays in high traffic volume areas.

These guidelines include methods that may be incorporated into the contract documents utilizing conventional bidding. There is also guidance on utilizing “Innovative Contracting” methods to provide Contractor incentives and thus reduce road user delays. Most of these methods are intended for use in the high traffic volume areas and will require the preparation of special provisions for the contract.

10 GENERAL:

The West Virginia Division of Highways routinely performs projects on its existing highway system. These projects involve activities which impact the existing movement of traffic. These impacts, no matter how small in nature, can cause delays to the road user. Projects on highways with large daily traffic volumes or highways which provide the only means of access to large facilities may cause road user delays resulting in significant costs to the public.

The Division of Highways is committed to evaluating the road user delay impacts on projects during contract plan development, and determining if special measures are warranted due to the existing traffic volumes or existing access issues. This directive provides guidance to designers on various methods to reduce road user delays on projects where existing traffic conditions warrant special considerations.

The methods to be considered are divided into two broad categories. The first category includes methods which can be incorporated into the contract documents or conducted during contract document development. The second category involves contracting method other than conventional bidding and award which may encourage a minimization of disruption to existing traffic movement.

20 CONVENTIONAL CONTRACTING:

The road user delay reduction methods described in this section pertain to contracts awarded to the lowest responsible bidder based on the total of the normal bid items. These methods are primarily tools used during contract development to plan and coordinate the work and contract provisions that will enhance traffic movement during construction.

20.1 Contract Document Development Phase: Described below are methods that have been successfully utilized on projects to minimize the impacts to the road user.

These methods involve steps the Project Manager may take during contract development that will facilitate the project execution during construction.

1. Consideration should be given to other Division of Highways projects in the same corridor. These may be projects that are under development or are already under construction. They may be central office or district projects.
2. Consideration should be given to combining projects to minimize the number of times the road users are affected.
3. Consideration of special events in an area which may result in a large temporary increase in traffic volumes.
4. Projects conducted by parties outside the Division of Highways which may have an additional impact on traffic movement. These may include highway projects by municipalities, construction by commercial or industrial developers, or large utility contracts.
5. Consideration should be given to corridor management traffic plans on high volume corridors where two or more projects are in close proximity to each other to allow the projects to be combined or bid within the same time frame to reduce the impact to motorists and even reduce the amount of traffic control that is required.

The Project Manager should consider all of the above items when developing both the schedule and the traffic control methods on projects in high traffic volume areas. Efforts should be made to coordinate with district and central office personnel concerning any known planned activities. The district utility supervisor should be consulted to determine if any utility permitting activities are underway in the area.

20.1.1 Local Coordination: Many traffic control delays can be minimized through coordination with local officials. This may involve meeting with local governmental officials, but may also involve coordinating with school administrators. Projects where peak traffic volumes are affected by large commercial or industrial installations may require coordination with private company administrators and adjusting daily project work schedules to accommodate large peak traffic volumes.

20.1.2 Public Information Activities: Projects involving high traffic volumes may require the Project Manager to hold public informational meetings to acclimate the general public to the potential delays. These advance meetings may also serve to allow some of the road users to adjust their driving routes thus effectively reducing the traffic volume during construction. Public informational activities also allow entities such as delivery companies and emergency entities to plan alternate routes thus reducing road user impacts.

20.2 Contract Provision Considerations: Projects in high traffic volume areas may be facilitated by the inclusion of certain requirements in the contract documents. These

contract provision methods serve in various ways to minimize the overall affect of the project activities on the road user.

20.2.1 Night Time Construction: One of the most effective means of reducing road user delays is to require project activities to be conducted by the Contractor during low traffic volume hours. These low volume hours will typically be during the night. Many projects such as HMA paving work are especially suited to this type of contract provision. Some projects may be aided by requiring night construction only during certain phases of the work. It is recommended that night time construction be used whenever possible on four lane highways with traffic volumes in excess of 25,000 ADT and on two-lane highways when traffic volumes are in excess of 15,000 ADT. When this type of construction is used the designer should consider the need for the use of Incentive/Disincentive contract provisions.

20.2.2 Motorist Services: On projects involving long lane closures in high traffic volume area the plans should include areas for motorists to pull-off without disrupting the remaining open lanes. This will minimize the affect of a disabled vehicle or accident in the work zone. The designer should consider the need for a Traffic Director per TED-604 and for a Roadside Assistance Service to be present during construction to aid in the resumption of traffic flow when an emergency situation occurs.

20.2.3 Incentive/Disincentive (I/D) Provisions: Many project schedules may be accelerated by the insertion of an I/D clause in the contract documents. The use of an I/D provision tends to motivate the Contractor and provides a means to compensate for the extra cost involved in accelerating the contract. This provision is many times used in combination with the other methods described in this design directive. The designer should refer to DD-708, *Guidelines for Development of the Incentive/Disincentive (I/D) Contract Provision*, for specific information on developing I/D payment amounts and provisions.

20.2.4 Public Information Activities: This activity differs from public information during design in that the focus of this contract provision is to provide up to date status information to the public concerning actual construction activities and progress. The Contractor may be required to provide advance warning of traffic pattern changes and to keep all local agencies informed concerning the project's schedule.

20.2.5 Partnering: Some projects that not only involve high traffic volumes but also involve coordination with a number of stakeholders, may warrant the use of a formal "Partnering" agreement in the contract provisions. This method provides a formal avenue for concerns and problems to be addressed by all parties. It may be particularly useful in urban areas where traffic patterns are being substantially altered by the project activities. A special provision for this process

is available from the State Specification Engineer for inclusion in the contract documents. The Project Manager must obtain approval from the Deputy State Highway Engineer ~~Chief Engineer~~ of Development for all projects and FHWA for non-exempt or concurrence projects prior to utilizing “Partnering” in the contract provisions.

20.2.6 Lane Restrictions: Some projects which involve high volumes of traffic on holidays, sporting events or other times when a high peak of traffic is likely to occur lane restrictions may be warranted. The designer may require that the contractor to open multiple lanes to traffic during these times in order minimize the disruption to traffic.

20.2.7 Blasting Restrictions: Projects that have blasting in close proximity to the traffic may require lane restriction. In order to not interrupt traffic during peak traffic time it is recommended that the blasting not be performed during peak traffic periods. It is also recommended that the designer require that the practical velocity of the blasting be reduced in the vicinity of the traffic in order not to cover the roadway with debris.

20.2.8 Interim Completion Dates: On projects where a high volume of traffic is involved and only part of the project effects the traffic the use of Interim Completion Dates may be warranted. When Interim Completion dates are used the amount used as the Liquidated Damages is the dollar amount calculated as the Road User Delay Cost. A special provision for this process is available from the State Specification Engineer for inclusion in the contract documents. The Project Manager must obtain approval from the Deputy State Highway Engineer ~~Chief Engineer~~ of Development for all projects and FHWA for non-exempt or concurrence projects prior to utilizing “Partnering” in the contract provisions.

30 INNOVATIVE CONTRACTING:

30.1 Introduction: As described in Section 10 above, there are two broad categories of road user delay reduction methods. Section 20 describes methods incorporated into projects that utilize conventional bidding techniques. This section describes alternative contracting methods which may be utilized by the Project Manager to encourage the Contractor to be innovative and expeditious on projects in high traffic volume areas.

Conventional bidding referred to in this directive is the process used normally by the WVDOH to award contracts. This process involves all prospective Contractors submitting unit prices for each item of work. The contract is then awarded to the lowest responsible bidder for the total of all items of work. The “Innovative Contracting” methods described in this section involves the Contractors submitting unit prices for the conventional items of work plus prices for a second component that involves time. The contract is then awarded to the lowest responsible bidder determined by the sum of the two components. “WV Code § 17-4-19 paragraph (e)” requires that the commissioner

award all construction contracts to the lowest responsible bidder. Therefore, any contract which utilizes an innovative contracting technique must reduce each component of the bid to a unit bid price and must require the awarding of the contract to the lowest responsible total bid. Therefore, the time component of the bid must be set-up in the contract documents in a manner that allows the Contractor to submit time units. These time units are then multiplied by unit costs of time to establish the low bidder as the sum of the total time cost plus total conventional bid item cost.

30.2 – Innovative Contracting Techniques: There are a number of innovative contracting techniques which may be utilized by the WVDOH to award a contract and encourage the completion of work in an expeditious manner. The currently accepted methods are described in this section; however the Project Manager must obtain approval per Section 30.3 of this directive prior to utilizing these techniques. Additional information concerning these techniques may be acquired from the Federal Highway Administration Contract Administration Core Curriculum Manual Section V.A. Non-traditional Contracting Practices for discussion on A+B bidding and Lane Rental.

30.2.1 – A+B Bidding: This method involves the combining of traditional cost (A) plus time cost (B) to determine the low bidder for purposes of awarding the contract. Under the A+B method each bid has two components.

- The “A” component is the total bid for all traditional bid items on the project.
- The “B” component is the total number of calendar days required to complete the project, as estimated by the bidder, multiplied by the road user cost per day, as established by the Project Manager in the contract documents.

The award of the contract is based on the lowest of the following formula:

$$(A) + (B \times \text{Road User Cost/Day})$$

The Project Manager shall consider the following requirements when utilizing the A+B method:

- Road User Cost/Day shall be determined by Traffic Engineering Division and approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development prior to inclusion in contract documents.
- A maximum allowable number of calendar days required to complete the project must be established by the Project Manager in the contract documents. This will set the maximum number of days that the contractor may bid but does not restrict the contractor from bidding a lower number of days.
- The formula for awarding the contract is not used to determine payment to the contractor. Payment is based on unit prices established in the “A” component of the bid.

- The contract completion date is established based on the number of calendar days in the “B” component of the bid as supplied by the successful bidder.
- The scope of work and conditions encountered in the field on the project must be well defined by the contract documents.
- A disincentive equal to the Road User Cost/Day is used to ensure the contractor meets the “B” component of the bid.

30.2.2 – Lane Rental: The lane rental method, like A+B bidding, involves the combining of traditional cost (A) plus time cost (B) to determine the low bidder for purposes of awarding the contract. The time portion of the bid consists of the total units of lane closure multiplied by the lane closure cost per unit, called lane rental cost. The units for the lane rental may be established based on the project requirements (i.e. minutes, hours, days, etc.). Different lane rental cost may be established in the lanes based on varying times of the day. For example, a lane may have one cost per hour between 6:00 am to 6:00 pm and a lower cost per hour between 6:00 pm to 6:00 am.

The lane rental cost for each lane and the maximum number of allowable lane rental units for each lane is established in the special provisions by the Project Manager. The Contractor then prepares the bid by combining the total unit cost for conventional bid items and the time component of each lane rental unit. The contract is awarded on the lowest bid from the following formula:

$$A + (B \times \text{LRC})$$

A = Total cost for conventional bid items

B = Number of Lane Rental Units

LRC = Lane Rental Cost / Unit

The following shall be considered by the Project Manager when Lane Rental is utilized on a project:

- Lane Rental Cost/Unit shall be determined by Traffic Engineering Division and approved by the Deputy State Highway Engineer ~~Chief Engineer~~ of Development prior to inclusion in contract documents.
- The number of allowable lane rental units for each lane shall be established based on the “B” component of the bid as supplied by the successful bidder.
- The formula for awarding the contract is not used to determine payment to the Contractor. Payment is based on unit prices established in the “A” component of the bid.

- Lane rental units utilized by the Contractor greater than those established in the bid shall be deducted from pay estimates at the lane rental cost per unit in the contract provisions.
- The Project Manager may choose to include provisions in the contract document that provide payments at the lane rental cost per unit rate, for lane rental units not utilized by the Contractor based on the bid number of units.
- The scope of work and field conditions of the project must be well defined by the contract documents.

30.2.3 – Warranties: This method of contracting requires the bidder to submit a conventional bid price which includes the cost of a warranty for the work for a specific period of time. The required period of the warranty shall be established by the Project Manager in the contract documents. The warranty shall be only for items which the Contractor has full control and not for long-term maintenance.

30.2.4 – Incentive/Disincentive (I/D)’s: I/D’s are a contracting method used to motivate the Contractor to complete the project ahead of a schedule. DD-708 provides the WVDOT’s guidelines for I/D clauses in contracts. I/D’s are used frequently in conjunction with the other contracting methods described in this directive.

30.3 – Approval of Innovative Contracting Techniques: All contracting techniques described in Section 30 of this directive require approval from the Deputy State Highway Engineer ~~Chief Engineer~~ of Development prior to being considered on projects. Non-exempt and concurrence projects require approval by FHWA.

A special provision must be prepared for any proposed “Innovative Contracting” method with all bidding parameters defined and reduced to a bid item. The special provision must include a Contractor’s proposal which provides time unit costs established by the WVDOT. The Contractor then submits a bid of time for each appropriate bid item. The low bid is then established as the sum of the total conventional bid item cost plus the total cost of the time bid items. As stated in Section 30.1 above the proposal must clearly establish the means to determine the “lowest responsible bidder” as the lowest total cost bid that is complete and regular. The special provision must be reviewed and approved by Legal Division, Contract Administration Division, Technical Support Division, Deputy State Highway Engineer ~~Chief Engineer~~ of Development and Federal Highway Administration.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

DESIGN DIRECTIVE 816

VALUE ENGINEERING

November 1, 2023

Supersedes August 2, 2013

This Design Directive defines the West Virginia Department of Transportation, Division of Highways policy on "Value Engineering".

PURPOSE:

This document provides information and guidance regarding the implementation of a Value Engineering Program within the Division of Highways of the West Virginia Department of Transportation. The policies described herein and the procedures set forth in the West Virginia Division of Highways "Value Engineering Manual" and "Construction Manual" are to be the references for Division employees who are involved in or affected by the Division's Value Engineering (VE) activities. The VE Manual is to be provided to Consultants at the time of the Scope of Work meeting on those projects-requiring a Value Engineering Analysis.

GENERAL POLICIES; SCHEDULING OF ANALYSIS:

A. VE Analysis Notification: The Project Manager and the Responsible Division shall notify the project team when a VE analysis is to be conducted on a project. The policies in the following sections shall be used to determine when a VE analysis is to be performed. When a VE analysis is to be conducted the Project Manager shall immediately notify the Programming Division in writing. The Programming Division shall then add a note in the tracking system indicating that a VE analysis is to be conducted.

B. Mandatory VE Reviews: It will be the policy of the West Virginia Department of Transportation, Division of Highways, to apply Value Engineering following the requirements in the latest federal transportation bill referred to as MAP-21 to all projects with the following criteria:

- **Projects on the National Highway System (NHS)** - All projects on the NHS, receiving federal assistance, with an estimated **total cost greater than \$50,000,000, shall undergo a VE analysis.**
- **Bridge Projects on the NHS** – All bridge projects on the NHS, receiving federal assistance, with an estimated **total cost greater than \$40,000,000, shall undergo a VE analysis.**

A project meeting the above criteria, to be delivered by the alternative project delivery / design-build method, shall not be required to have a value engineering analysis performed.

A "project" will be defined by the limits shown in the controlling environmental

document. The Total Project Cost includes all the cost associated with the environmental clearance, engineering, right of way, utilities, and construction phases of a project. All required VE analyses shall be performed, per the Division's Value Engineering Manual, prior to Final Design.

The Value Engineering Analysis, for a project, will normally be conducted at the 30% plan (Preliminary Field Review) stage.

C. Alternative Mandatory VE Reviews: When it is proposed to conduct a Mandatory VE Analysis utilizing alternative procedures, approval must be obtained from the "Deputy State Highway Engineer ~~Chief Engineer~~ of Development" and FHWA prior to conducting the analysis.

- 1. Representative Contract Section:** The Division may utilize a "Representative Contract Section" concept as a substitute for conducting a VE analysis for each design section of the entire project. The selected Representative Contract Section should contain elements that are generally representative of those that will be encountered throughout the entire project limits. The approved recommendations of the Value Engineering Analysis, on the Representative Contract Section, will be applied in the contract plan development of all subsequent design sections of the project.
- 2. Design Report VE Analysis:** The Division may also choose to conduct the required Value Engineering Analysis of a major project during the Design Study Report Preparation.

D. WVDOT Initiated Reviews: The WVDOT may choose to initiate a VE study on any project, regardless of cost, when it is felt that sufficient potential cost savings exist to justify the VE analysis costs. It is the intent of the Division of Highways to make periodic Value Engineering analyses of Standard Details; Standard Specifications; "allocation-type" projects; and Design, Traffic Engineering and Structural Directives on a cyclical basis. These analyses will, of necessity, have a lower priority than project analyses and, in the case of specifications, standards and directives will generally take place when they are being reissued.

E. Value Engineering Change Proposal (Initiated by Contractor): Value Engineering Change Proposals (VECP), initiated by the Contractor during the execution of a construction project, are an integral part of the WVDOT value engineering program. The Construction Manual by Contract Administration shall be referenced on the processing of VECP's.

GUIDANCE FOR VALUE ENGINEERING STUDIES:

Management oversight and the conduct of the Value Engineering Analysis will be in accordance with the elements and procedures spelled out in the AASHTO "Guidelines for Value Engineering", current edition and the WVDOT "Value Engineering Manual".

PRODUCTS OF THE ANALYSIS:

The product of the Value Engineering analysis shall be a written report to Management containing at least the following information:

1. Project number and description, including type and length of project, number of lanes; right of way and utility involvement; and generalized scope of work.
2. Stage of development of the project when the VE was performed.
3. Value Engineering team members and work locations; designer or project manager and other resource personnel who were consulted.
4. Specific items considered.
5. Items recommended and the reasons. Where appropriate, sketches or detail drawings are to be included.
6. Items rejected and the reasons.
7. Cost data with summary of anticipated costs and savings. Costs and savings are to consider capital costs and life-cycle costs.
8. Once the written report has been presented, the Team, or Team Chairperson, should be prepared to make an oral presentation to Management. If an oral presentation is requested the designer may be involved to critique or respond to the Value Engineering team recommendations.

APPROVAL OF RECOMMENDATIONS:

After completion of the written and oral reports, the project designer, or the project manager and consultant, will reply to each Value Engineering recommendation. The replies will be reviewed and comments prepared by the affected Division Directors. The results of the reviews will then be consolidated and the Deputy State Highway Engineer ~~Chief Engineer~~ of Development will make a final determination regarding each Value Engineering recommendation.

Upon the action of the Deputy State Highway Engineer ~~Chief Engineer~~ of Development, on each VE recommendation, a Final Value Engineering Report shall be prepared by the project designer or the project manager and submitted to the responsible division director for approval. This report will describe the disposition of each recommendation and attach the VE Report.

FILING OF COMPLETED VE REVIEWS:

The project designer or manager shall forward a copy of the approved Final Value Engineering Report to the "Value Engineering Coordinator" for filing and inclusion in Annual VE Report to FHWA. The Value Engineering Coordinator will maintain a file of all Final Value Engineering Reports, as described in Section 10.11 of the WVDOT "Value Engineering Manual".

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS

STRUCTURE DIRECTIVE 1050 ADDITIONAL DESIGN CONSIDERATIONS

*September 6, 2023
Supersedes May 4, 2022*

1050.1-CURVED BRIDGES

Bridge Designers are cautioned to design curved structures for all relevant forces as specified in the Governing Specifications, even if the girders are straight and the deck is curved.

For curved bridges, the use of straight steel girders or prestressed concrete beams satisfying the minimum and maximum deck overhang requirements shall be investigated. Investigation of curved bridges using straight steel girder or prestressed concrete beams may not be warranted when the central angle for any span exceeds 3.5 degrees as defined within AASHTO LRFD Bridge Design Specifications Chapter 4.

Slab bridges, cast-in-place and precast segmental bridges are other options for curved concrete bridges.

1050.2-AESTHETICS

The Bridge Designer shall determine and offer proposals of aesthetic treatment to the Bridge Project Manager in charge of the project.

For additional aesthetic requirements, see the AASHTO LRFD.

1050.3-APPROVAL OF VENDOR SUPPLIED PRODUCTS

All products designed and supplied by the Contractor or their Vendor shall be approved through DD 106, Proprietary Approval Process. These products include, but are not limited to culverts, proprietary retaining walls, bearings, expansion devices, inspection walkways, stay-in-place forms and any prefabricated item used on a structure other than those specifically designed and detailed in the contract plans.

If the product is not specified in the Standard Specifications, the Designer is responsible for writing a Special Provision to describe the product and the criteria it has to meet. This shall include directions to the Contractor as to the necessary information to submit for approval by the Engineer. The following is a partial list of items the Designer is to provide the Vendor: all applicable loads, critical dimensions, design method to be used (LRFD) and any additional information that may be required for the product to be designed and detailed.

Vendor submissions should include items such as design calculations, design method, detailed drawings, construction sequence, induced loads, etc. and shall be stamped by an Engineer registered in West Virginia.

When a proprietary item is proposed, the Designer shall justify the benefits of the product and show that no other alternate exists. Proprietary items may also be warranted when a new technology or product is being evaluated. The use of the proprietary item shall then be submitted for approval to the Bridge Project Manager. The Bridge Project Manager will then submit the request to the Deputy State Highway Engineer, Chief Engineer of Development, who will then forward it to the Federal Highway Administration (FHWA) for approval.

1050.4-PROTECTIVE FENCING

It shall be the policy of the WVDOT to evaluate the need for screening on bridges and overpasses when:

- A. A new structure is being designed;
- B. An existing structure is being renovated; and
- C. A pattern of accidents or public complaints indicates that there is a problem with objects or debris being thrown or dropped from an existing overpass or viaduct.

The intent of this section is to assist the designer in identifying those bridges where the probability of occurrence is high or where problems are known to exist and to assure that reasonable protective measures are taken at those locations. It will be the responsibility of the Bridge Designer to document the decision to, or not to install screening, the factors influencing the decision and the reasons for the type of screening chosen. This decision shall be included in the TS&L Report for review by the Bridge Project Manager.

Factors that shall be considered in the decision to install, or not to install, screening shall be as follows:

- A. Presence of a sidewalk;
- B. If no sidewalk, proximity to a school, playground or neighborhood that may generate a significant number of children who may play on or around the structure. In addition to protecting those below, the screening may prevent children from climbing on the railing and falling off the structure;
- C. The presence of a transportation facility such as a roadway, a railroad, or a navigable waterway below the overpass or bridge. In the case of a railroad, or navigable waterway, the frequency and sensitivity of the traffic passing under the structure shall be taken into account;
- D. Requirements of the entity or agency over which the structure passes, such as a railroad, the Corps of Engineers or the National Park Service;
- E. Effect on aesthetics or on maintenance, including inspection, snow removal or ice control or navigation lights, and the maintenance of the screening itself; and
- F. Effects on the safety of vehicles crossing the structure, especially where speeds are high.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 105
SPECIFICATION, STANDARDS, MANUALS, AND MATERIAL PROCEDURE
APPROVAL PROCESS**

August 6, 2023

Supersedes August 25, 2021

This Design Directive outlines the procedure that has been accepted by the Division for preparing and processing proposed Specifications and Special Provisions, Standards, Manuals, and Material Procedures for approval. The Publications Section of the Technical Support Division consists of three units: Specifications, Standards, and Manuals. The Materials Control, Soils, and Testing Division is the home division of the Materials Procedures.

10. Specifications

The general processing of Specifications and Special Provisions is administered through the Technical Support Division by the Specification Engineer.

Standard Specifications will be issued periodically as the need dictates. Supplemental Specifications to accompany the Standard Specifications are issued annually on January 1st and are effective on all projects let to contract thereafter. Each new Supplemental Specification replaces the previous one and incorporates changes from all previous supplemental specifications.

A searchable version of the Standard Specifications book and Supplemental Specifications is available from the Specifications webpage, located online at <http://transportation.wv.gov/highways/contractadmin/specifications/>

10.1 Procedure for Processing Specification Changes

Permanent specifications changes to the Standard Specifications or Supplemental Specifications should be submitted electronically to DOHSpecifications@wv.gov by the ‘champion’. The originating Division will prepare the specification changes in a format conforming to Design Directive 820. A brief overview of the item and background information with reason for the changes should accompany the request.

The Specifications Engineer will review all recommendations received and transmit to the Specifications Committee for action. The champion should attend all committee meetings pertaining to their respective specification. A proposed specification must be presented at two committee meetings before it can be recommended or rejected by the Specifications Committee.

10.2 Procedure for Processing Special Provisions for Individual Projects

There may be a need to use an innovative product or an experimental procedure to address unique demands of a project. Often, these items are not covered by existing

specifications, so they may require new or modified specifications to describe their material requirements, construction requirements and payment. Special Provisions (SPs) are written to address these situations.

Before drafting a SP, check with the Specifications Engineer (or ProjectWise folder: [Approved Project Specific Provisions \(PDF\)](#)) to determine if a SP already exists that meets the needs of the project.

SPs are processed as outlined above in 10.1. In general, the originating Division should submit proposed SP at least six months prior to their project's PS&E submission. This provides adequate time to process and resubmit any changes that may be requested by the committee.

When time does not permit this procedure, the following procedures should be followed:

- a. The originating Division will prepare the draft Special Provision in a format conforming to Design Directive 820, coordinating with the Technical Support Division, Specifications Engineer for review, comment, assignment of an appropriate section number and/or pay item number.
- b. The originating Division will secure the approval of the Applicable Deputy State Highway Engineer and the Federal Highway Administration as appropriate for that project. The approval of the Special Provision would only apply to the specific project. The submission for approval shall follow Design Directive 202 and may only encompass the PS&E package for advertising the project.

There are Project Specific Special Provisions that require management approval prior to their use on projects. These are listed in ProjectWise subfolder title "Requires Management Approval". The Project Manager shall provide justification of why the SP is needed to the Appropriate Deputy State Highway Engineer for approval.

10.3 Specifications Committee

The Specifications Committee review and recommend actions to proposed Specifications and Special Provisions. The committee meets on call by the Specifications Engineer with regular meetings scheduled every other month and follow the Open Government Meeting Act. Details of this act are available at: <https://ethics.wv.gov/openmeetings/Pages/default.aspx>.

The Specifications Committee consists of voting and non-voting members who provide expertise to review and recommend action of the proposed Specifications and Special Provisions. The committee requests comments on the provisions in the meeting agenda; and review/discuss them during the meeting. The committee meeting agenda will designate the items that are up for approval and dependent upon comments/discussion/changes the Specifications Engineer has the right to call for a vote on the final version.

The voting members consist of one representative from each of the following Divisions:

- Contract Administration Division
- Engineering Division
- Materials Control, Soil and Testing Division
- Operations Division
- Traffic Engineering Division

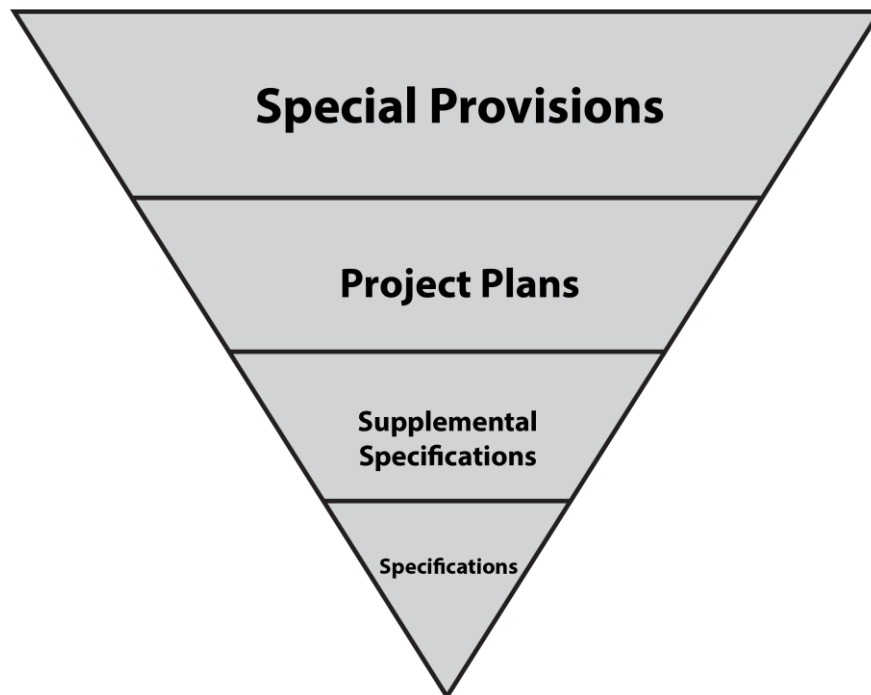
A quorum of 3 voting members must exist for the meeting to be valid. A majority of the present voting members is required to pass the proposed item. The Specifications Engineer

shall have the authority to cast the deciding vote when a tie occurs. All approved specification changes will be sent to FHWA for comment and concurrence.

The non-voting members consist of one or more representatives from the following agencies: Federal Highway Administration, Contractors Association of West Virginia, ACEC – WV, Asphalt Pavement Association of West Virginia, American Concrete Pavement Association, Builders Supply Association of West Virginia, various vendors, and anyone from the Division or Industry that has knowledge of the specifications being discussed.

10.4 Coordination of Specifications, Special Provisions, and Project Plans

The Specifications, Supplemental Specifications, Special Provisions, and project plans are essential parts of the Contract; and a requirement occurring in one is as binding as though occurring in all. In case of discrepancy, Supplemental Specifications will govern over Specifications; Plans will govern over Specifications and Supplemental Specifications; Special Provisions will govern over Specifications, Supplemental Specifications, and Plans as prescribed in Section 105.4 of the Standard Specifications. Below is a graphic display of the hierarchy of contract documents; where the items shown above, govern over items below it.



Project plans or plan notes should not be used to change specifications. The procedure outlined in this Design Directive should be utilized when this is necessary.

20. Standards and Manuals

The general processing of Standards and Manuals is administered through the Technical Support Division by the Standards Unit Leader and the Manual Unit Leader.

Standards and Manuals will be issued periodically as the need dictates. Each revised edition supersedes the previous one and incorporates changes from all previous editions.

These publications are available in electronic format on the Division of Highways' Engineering Division Publications webpage, located online at <https://transportation.wv.gov/highways/engineering/Pages/publications.aspx>.

20.1 Procedure for Processing Standards or Manuals Changes

Proposed changes to any of the Division of Highways' Standards or Manuals should be submitted electronically to the Technical Support Division's Standards or Manuals Unit Leader, as appropriate. The originating Division will prepare the document changes in a format conforming to that particular document. A brief overview of the document and background information with reasons for the changes should accompany the request.

The Standards or Manuals Unit Leader will review all recommendations received and transmit them to the Standards Committee (formally known as Technical Publications Committee) or Manuals Committee for action. A proposed standard or manual or revisions to an existing document must be presented at two committee meetings before it can be recommended or rejected by the Standards or Manuals Committee, unless considered by the committee to be a minor change.

20.2 Standards Committee and Manuals Committee

The Standards or Manuals Committee will review and recommend actions to proposed standards, manuals, or revisions to existing documents. The committee meets on call by the appropriate Unit Leader with regular Standards Committee meetings scheduled every other month (and as needed) and follow the Open Government Meeting Act. Details of this act are available at: <https://ethics.wv.gov/openmeetings/Pages/default.aspx>.

The Standards and Manuals Committee consists of voting and non-voting members who provide expertise to review and recommend action of the proposed standard or manual. The committee requests comments on the standard or manual in the meeting agenda; and reviews/discusses them during the meeting. The committee meeting agenda will designate the items that are up for approval and dependent upon comments/discussion/changes the presiding unit leader has the right to call for a vote on the final version.

The voting members consist of one representative from each of the following Divisions:

- Contract Administration Division
- Engineering Division
- Materials Control, Soil and Testing Division
- Operations Division
- Traffic Engineering Division

A quorum of 3 voting members must exist for the meeting to be valid. A majority of the present voting members is required to pass the proposed item.

The presiding unit leader shall have the authority to cast the deciding vote when a tie occurs.

The non-voting members consist of one or more representatives from the following agencies: Federal Highway Administration, Contractors Association of West Virginia, ACEC – WV, Asphalt Pavement Association of West Virginia, American Concrete Pavement Association, Builders Supply Association of West Virginia, various vendors, and anyone from the Division or Industry that has knowledge of the publications being discussed.

30. Material Procedures

The Material Procedures (MP) are updated on a four (4) year cycle unless the need dictates otherwise, as determined by the Materials Control Engineer who is the Chairperson of this committee. This person is referred to as “Chairperson” throughout the rest of this section. The MP Committee shall be modeled after AASHTO’s Committee on Materials and Pavements (COMP); specifically, how this committee reconfirms various AASHTO procedures and processes. The Chairperson is the default Champion for the updating of these MPs, though the Chairperson may assign a Champion for a particular MP or accept a volunteer Champion.

A new MP may also be submitted by a Champion to the Committee.

30.1 Material Procedures Committee

The Material Procedures Committee consists of voting and non-voting members who provide expertise to review and recommend action on the proposed additions or changes.

The Material Procedures Committee meets on call by the Chairperson with regular meetings usually scheduled on a four (4) to eight (8) week basis.

A quorum of 3 voting members must exist for the meeting to be valid. A majority of present voting members at any meeting shall be required for approval. The Chairperson shall have the authority to cast the deciding vote when a tie occurs.

The voting members consist of one (1) representatives from the following:

- Contract Administration Division
- Materials Control, Soil and Testing Division
- Operations Division
- Technical Support Division
- Traffic Engineering Division

The non-voting members consist of one or more representatives from the following agencies: Federal Highway Administration, Contractors Association of West Virginia, ACEC – WV, Asphalt Pavement Association of West Virginia, American Concrete Pavement Association, Builders Supply Association of West Virginia, Various Venders, and anyone from the Division or Industry that has knowledge of the MP being discussed.

30.2 Procedure for Adding a New MP

All proposals are to be submitted by the Champion to the Chairperson. The purpose for the change to policy and/or reason(s) for the new MP should accompany the request. These items should be submitted within seven (7) calendar days prior to the next meeting to be

considered at the meeting. The Champion, or a knowledgeable proxy must be present for all meetings pertaining to their respective MP or the MP will be pushed back to the next meeting that the Champion or proxy can be present. This requirement can be waived at the discretion of the Chairperson.

A proposed MP must be presented at two (2) Committee Meetings before it can be recommended or rejected by the Committee.

If a proposed MP is designated as minor or inconsequential in its intent, only one (1) Committee Meeting will be required for a vote of recommendation or rejection. Any voting member, or the FHWA representative may veto this designation as minor or inconsequential.

30.3 Procedure for Changing an Existing MP

A proposed MP change must be presented by the Champion at Two (2) Committee meetings before the MP can be recommended or rejected by the Committee. All Committee members should receive a copy of the MPs for review prior to the meeting. These comments should be returned to the Chairperson prior to the Committee meeting to give the Champion time to review them.

If a proposed MP change is designated as minor or inconsequential in its intent, only one (1) Committee meeting will be required for a vote of recommendation or rejection. Any voting member, or the FHWA representative may veto this designation as minor or inconsequential.

30.4 Procedure for Submission of Recommended Approvals

Pending the recommendation for approval from the committee, the Chairperson will forward the Provisional MP through the chain of command to FHWA.

A minor or inconsequential MP will not require the approval of FHWA, but will be forwarded through the chain of command at the DOH for approval. The FHWA representative for the MP Committee Meeting shall be given a chance to veto the minor or inconsequential status of the MP.

Upon receiving comment and approval by FHWA (if applicable), the updated or new MP will be published on the MCS&T webpage and be distributed to District Materials Supervisors and other interested parties.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 106
APPROVAL FOR PATENTED OR PROPRIETARY PRODUCTS**

*January 6, 2024
Supersedes September 6, 2023*

This document provides general information and guidance regarding how to obtain approval to use a patented or proprietary product on Federal-Aid construction projects let to bid by the West Virginia Department of Transportation, Division of Highways. It is to be a reference for DOH employees in disciplines such as design, construction, traffic engineering, utilities, right of way, and environmental.

10. INTRODUCTION

(Note: most of the following has been quoted directly from the FHWA website).

The FHWA regulation in [23 CFR 635.411, "Material or Product Selection"](#) prohibits the expenditure of Federal-aid funds on a Federal-aid highway project "for any premium or royalty on any patented or proprietary material, specification, or process" (referred to hereafter as "proprietary product"), unless specific conditions are met. This regulation is intended to ensure competition in the selection of materials, products, and processes while also allowing the opportunity for innovation where there is a reasonable potential for improved performance.

20. DEFINITION OF PATENTED OR PROPRIETARY PRODUCTS

A Patented or Proprietary Product is a product, specification, or process identified in the plans or specifications as a "brand" or trade name (e.g. 3M, Corten). However, it may also be a product so narrowly specified that only a single provider can meet the specification. A proprietary product must meet one of the conditions listed under 23 CFR 635.411(a) or (c) for Federal funds to participate in its use on a Federal-aid highway construction project. For purposes of this guidance, any reference to "proprietary product" shall mean "patented or proprietary product."

30. POLICY

The following was taken from "CFR § 635.411 Subpart D - General Material Requirements. Material or product selection" and defines the Federal Highways Administration's policy regarding patented or proprietary materials. This will be considered the West Virginia Department of Transportation, Division of Highways' policy.

- a) Federal funds shall not participate, directly or indirectly, in payment for any premium or royalty on any patented or proprietary material, specification, or process specifically set forth in the plans and specifications for a project, unless:

- 1) Such patented or proprietary item is purchased or obtained through competitive bidding with equally suitable unpatented items (a minimum of three competing, equally suitable unpatented items should be listed in the plans as alternates if possible – see Item 30 (b) below for more requirements); or
 - 2) The State transportation department certifies either that such patented or proprietary item is essential for synchronization with existing highway facilities, or that no equally suitable alternate exists; or
 - 3) Such patented or proprietary item is used for research or for a distinctive type of construction on relatively short sections of road for experimental purposes. If certification is for experimental purposes, then an Experimental Work Plan must be developed and submitted to FHWA. A sample Experimental Work Plan is available at the following FHWA web address: <http://www.fhwa.dot.gov/construction/contracts/pnpapprovals/samplewp.cfm>, and a sample Division of Highways' Work Plan is attached to this DD.
- b) When there is available for purchase more than one nonpatented, nonproprietary material, semifinished or finished article or product that will fulfill the requirements for an item of work of a project and these available materials or products are judged to be of satisfactory quality and equally acceptable on the basis of engineering analysis and the anticipated prices for the related item(s) of work are estimated to be approximately the same, the PS&E for the project shall either contain or include by reference the specifications for each such material or product that is considered acceptable for incorporation in the work. If the State transportation department wishes to substitute some other acceptable material or product for the material or product designated by the successful bidder or bid as the lowest alternate, and such substitution results in an increase in costs, there will not be Federal-aid participation in any increase in costs.
- c) A State transportation department may require a specific material or product when there are other acceptable materials and products, when such specific choice is approved by the Division Administrator as being in the public interest. When the Division Administrator's approval is not obtained, the item will be nonparticipating unless bidding procedures are used that establish the unit price of each acceptable alternative. In this case, Federal-aid participation will be based on the lowest price so established.
- d) Reference in specifications and on plans to single trade name materials will not be approved on Federal-aid contracts.
- e) In the case of a design-build project, the following requirements apply: Federal funds shall not participate, directly or indirectly, in payment for any premium or royalty on any patented or proprietary material, specification, or process specifically set forth in the Request for Proposals document unless the conditions of paragraph (a) of this section are applicable.
- f) State transportation departments (State DOTs) shall have the autonomy to determine culvert and storm sewer material types to be included in the construction of a project on a Federal-aid highway.

40. PROCEDURE

If the designer proposes the use of a proprietary or patented product on any Federal-Aid project, the designer must obtain the approval of the State Highway Engineer ~~Applicable Chief Engineer~~ to use the product. The following steps should be followed to gain approval:

- a) The certification will be in memo form, and be routed from the Director of the Division requesting the approval, to the State Highway Engineer ~~Applicable Chief Engineer~~, through the Deputy State Highway Engineer – Construction and Development ~~Deputy Commissioner of Highways~~. Examples of this certification memo are provided with this Design Directive.
- b) The certification must include the project information (State and Federal Project Numbers, Project Name, and County the project is in),
- c) A short description of the proprietary or patented item(s) being proposed,
- d) Whether the proprietary or patented product is project-specific, will be used in multiple projects, used in a specific region/District or Statewide, or will programmatic with a sunset date,
- e) A justification for the use of that item, to include a description of the unique need being addressed, why other available products are insufficient to meet the Division's needs, estimates or any additional costs associated with the proprietary or patented product, and any other pertinent information as may be required such as prior Division experience with the product,
- f) Any catalog cut sheets from the manufacturer describing technical, use, and safety data for the product,
- g) A certification statement with either of the following language, depending on whether the product is used because no equally suitable alternative for the item exists, or it is required for synchronization with existing facilities:

“I (name of certifying official), (position title), of the (Name of contracting agency), do hereby certify that in accordance with the requirements of 23 CFR 635.411(a)(2), that this patented or proprietary item is essential for synchronization with existing highway facilities”, or

“I (name of certifying official), (position title), of the (Name of contracting agency), do hereby certify that in accordance with the requirements of 23 CFR 635.411(a)(2), that that no equally suitable alternative exists for this patented or proprietary item.”

- h) Signature lines indicating Approval or Disapproval by the State Highway Engineer ~~Applicable Chief Engineer~~, and the date action was taken will be included at the bottom of the letter,
- i) The Federal Highway Administration will be included as a recipient on the distribution list for receiving approved certifications and will provide concurrence in the Division's approval.

It should be noted that if the product is being used as an Experimental Product, an

Experimental Work Plan as discussed under Section 30 “**POLICY**”, must be included with the certification. A sample Experimental Work Plan is included with this Design Directive.

All proprietary item certifications are to be placed on the AASHTO website at the following address: http://apel.transportation.org/all_certified_products.aspx. Other states that use this site are Arizona, Colorado, Connecticut, Maine, Maryland, Montana, New York, & Ohio.

Also, these approved certifications will be placed on the Division’s website in a Division Approved Source/Product Listing on the Materials Control, Soils, and Testing Division’s page.

50. DEFINITIONS

As used in this document:

Patented or Proprietary Product: A product, specification, or process identified in the plans or specifications as a "brand" or trade name (e.g. 3M, Corten). However, it may also be a product so narrowly specified that only a single provider can meet the specification. A proprietary product must meet one of the conditions listed under 23 CFR 635.411(a) or (c) for Federal funds to participate in its use on a Federal-aid highway construction project. See Question and Answer #B1. For purposes of this guidance, any reference to "proprietary product shall mean" patented or proprietary product.

Certification: As used in 23 CFR 635.411(a)(2), the written and signed statement of an appropriate contracting agency official certifying that a particular patented or proprietary product is either:

- a) Necessary for synchronization with existing facilities; or
- b) A unique product for which there is no equally suitable alternative.

Synchronization: As used in 23 CFR 635.411(a)(2), providing a product that matches specific current or desired characteristics of a project. Synchronization may be based on:

- a) Function (the proprietary product is necessary for the satisfactory operation of the existing facility),
- b) Aesthetics (the proprietary product is necessary to match the visual appearance of existing facilities),
- c) Logistics (the proprietary product is interchangeable with products in an agency's maintenance inventory), or any combination thereof.

In addition, it may be advisable to evaluate the following factors as they relate to synchronization:

- a) Lifecycle (the relative age of existing systems that will be expanded and the remaining projected life of the proposed proprietary element in relation to the remaining life of the existing elements),
- b) Size/extent of products and systems to be synchronized to/with, and the relative cost of the proprietary elements compared with replacing the elements requiring synchronization.

Experimental Product: As used in 23 CFR 635.411(a)(3), a patented or proprietary product used for research or for a distinctive type of construction on relatively short sections of road on an

experimental basis.

Public Interest Finding (PIF): As used in 23 CFR 635.411(c), an approval by the FHWA Division Administrator, based on a request from a contracting agency, that it is in the public interest to allow the contracting agency to require the use of a specific material or product even though other equally acceptable materials or products are available.

State Department of Transportation (State DOT): The relevant department of any State charged by its laws with the responsibility for highway construction; also State Transportation Agency (STA), the "State".

Contracting Agency: Any entity administering a contract using Federal aid highway funds. Includes State DOTs, Local Public Agencies (LPAs), and other agencies that may be administering such contracts.

Local Public Agencies (LPAs): Any State DOT sub-recipient of Federal-aid highway funds.

60. REFERENCES

The following references were used to develop this Design Directive and are provided for further information and guidance for the designer:

<http://www.gpo.gov/fdsys/pkg/CFR-2014-title23-vol1/xml/CFR-2014-title23-vol1-sec635-411.xml> - CFR Title 23, Section 635.411 – Material or product selection, Date: April 1, 2014.

<http://www.fhwa.dot.gov/programadmin/contracts/011106.cfm> - Guidance on Patented and Proprietary Product Approvals, Date: January 11, 2006.

<http://www.fhwa.dot.gov/programadmin/contracts/011106qa.cfm> - Questions and Answers Regarding Title 23 CFR 635.411 – Material or product selection, Date: April 11, 2013.

All proprietary item certifications are to be placed on the AASHTO website at the following address:
[missing link](#)

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 600
GEOMETRIC DESIGN PROJECT CATEGORIES**

September 6, 2023

Supersedes May 4, 2022

The purpose of the design directive is to provide guidance to designers on the selection of geometric design criteria for the category of projects based on American Association of State Highway and Transportation Officials (AASHTO) and Federal Highway Administration (FHWA) manuals and guidance.

1.0 INTRODUCTION

This directive shall be used by designers to evaluate the project category and apply proper geometric design criteria. Each project category defines the appropriate level of compliance to various levels of geometric criteria. Geometric criteria are defined by AASHTO's Policy on Geometric Design of Highways and Streets ("Green Book") as well as various other approved manuals developed by AASHTO. FHWA also provides guidance and direction for roads on the National Highway System (NHS). Designers will identify the category of the project early in plan development and address any deviations from the criteria with project notes or design exceptions.

Many manuals and documents provide information to designers when adjustments to published values are allowed. Policies are trending to provide more flexibility to rigid standardization allowing for designs to better fit to the environment around them. For many years the Green Book has provided rigid values to be used based on road classification and volumes. The newest version of the Green Book has expanded the definition of the roads from the traditional functional systems to include contextual setting of the roadway. Performance based practical designs are becoming featured to find better solutions for DOTs as funding becomes more critical to the decision making process. Flexibility and context sensitive solutions allow for designers to meet the purpose and need of the project within budgetary limits.

2.0 PROJECT CATEGORIES

Project categories are developed to direct the designer on the proper geometric design criteria that shall be followed for the type of project to be designed. The categories are based on the type of work to be done, whether the route is on the NHS, the functional system characteristics, traffic volumes and design speed. The criteria in the different manuals and guides are based on historical values, studies and engineering judgement. The values provide guidelines to expedite the decision making and documentation of design selections.

The categories used to develop design criteria are new construction, reconstruction and "construction on existing roads". These categories are further defined as project types in the Green Book. Each category uses a performance based practical design approach to the decision making used to develop design values. New construction projects are on new alignments that use strict adherence to values and criteria developed in manuals and guides. Reconstruction projects use the existing alignment but alter the road type. Construction on existing roads are projects on existing

alignments that would not be changing the roadway type and would be developed to address a specific need.

All categories shall be evaluated for their applicability as an alteration project. An alteration project is any project that meets the requirements or project description whereby Americans with Disabilities Act (ADA) facilities must be addressed. Any project defined as alteration must meet the Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right of Way (PROWAG) standards for curb ramp opening, slopes and widths. Refer to DD-811, *Accessibility Standards, Curb Ramps and Sidewalks*, for a list of projects defined as alteration.

Context and location of the roadway are fundamental items used to develop design values for flexible practical design. New construction can even be evaluated based on context of rural or urban environments. Formal design criteria can be used in rural areas due to fewer constraints than in urban, developed areas. Urban area constraints will influence the geometric design criteria and variations to criteria will need documented using performance factors based on function and context of the roadway.

2.1. New Construction: Projects that are developed in the New Construction category will use the design criteria in chapters 2 through 10 of the Green Book or other formal geometric design guidance. Generally, projects in this category shall apply “desirable” or other preferred values to geometric alignments and cross section elements. Functional and context classifications found in chapter 1 of the Green Book should be used to determine values for controlling criteria. There is flexibility allowed for these project categories, but the decisions shall be determined on performance based analysis and thoroughly documented.

2.2. Reconstruction: Projects developed under the Reconstruction category utilize existing alignments or minor changes but result in a change in roadway type. Changes in roadway type result in changes to cross sectional elements to address project needs or scope. These projects present problems when trying to adapt documented design criteria to new facilities due to existing context and constraints. These projects may not necessitate forecasting for future performance but should be part of a performance based approach to address facility needs. Green Book chapters 2 through 10 should be reviewed for geometric and cross-sectional guidance but facility context may drive decisions due to constraints within the corridor.

Projects such as intersection improvements, adding lanes and lane or shoulder widening would change the roadway type but would only cause minor changes to the existing alignment. These projects may not use the full criteria found in the Green Book due to nearby or corridor constraints.

Interstate reconstruction is a project type where variable design criteria may be applied. Cross slope information from the “A Policy on Design Standards – Interstate System” may be utilized to correct cross slopes. Criteria may be referenced from other guidance, such as correction of superelevation will use “Green Book” standards. In this case shoulder widths may be substandard to meet new construction criteria, but under the reconstruction category may not be widened since this would alter the roadway type.

2.3. Construction Projects on Existing Roads: Projects developed under the Construction Projects on Existing Roads (CPER) category are projects that have no or minor changes to the existing alignment and no changes to the roadway type. CPER project types are similar to what has historically been referred to as RRR (restoration, rehabilitation, resurfacing). These

projects use flexible criteria based on existing performance to address the facility needs or scope of the project. Projects may use Green Book design criteria, but other manuals may also be used for documenting design criteria of the project. The CPER category will encompass several other subcategories based on the requirements of the project. Projects within the category need to meet different thresholds of documentation and coordination. CPER projects may include resurfacing, slide correction, bridge deck replacements, safety upgrade and other preventive maintenance projects.

A subcategory of the CPER is a maintenance project. An example of a maintenance project is the common resurfacing project. These projects use the existing alignments and are not intended to alter the roadway type. These projects are developed to restore rideability and prolong the serviceability of the existing surface.

3.0 PROJECT CATEGORY EXAMPLES

The following are definitions and examples of work types for the project categories. The bulleted lists below are not all inclusive, especially for CPER. Any project meeting the criteria of Alteration Project must meet standards defined in PROWAG.

3.1. Alteration Project: An Alteration Project is project defined by “DOJ/FHWA Joint Technical Assistance on the ADA Title II Requirements to Provide Curb Ramps When Streets Roads or Highways are Altered Through Resurfacing”. Treatments that are considered alterations of the road surface are:

- Open-graded surface course
- Cape seals
- Mill and fill/Mill and overlay
- Hot in-place recycling
- Microsurfacing/Thin-lift overlay
- Addition of new layer of asphalt
- Asphalt and concrete rehabilitation and reconstruction
- New construction
- Widening of the existing pavement typical section
- Addition of turning lanes
- Pavement rubblization
- Installation of new drainage structures to improve existing drainage characteristic

Treatments that are NOT considered alteration projects are:

- Crack filling and sealing
- Surface sealing
- Chip, Slurry, and Fog seals
- Scrub sealing
- Joint crack seals
- Joint repairs
- Dowel bar retrofit
- Spot high-friction treatment
- Diamond grinding
- Pavement patching
- Shoulder repairs
- Pipe and inlet repairs
- Pulling and restoration of ditches
- Guardrail repair and installation
- Re-stripping

For additional information on alteration project definitions use the following link for guidance.

USDOT FHWA Civil Rights Website

<https://highways.dot.gov/civil-rights/programs/ada/departments-justicedepartment-transportation-joint-technical-assistance1>

https://www.fhwa.dot.gov/civilrights/programs/doj_fhwa_ta_glossary.cfm

3.2. New Construction: Defined as an Alteration Project, on new alignment meeting full compliance with design guidance. Guidance can be found in the latest adopted editions found in section *Policies, Manuals and Guidance*.

- New Interstate
- New Four Lane Divided Highway
- New Two Lane Highway

3.3. Reconstruction: Defined as an Alteration Project, on an existing alignment (or make only minor changes to the alignment) that alters the basic roadway type. Designers use standards approved in various design guidance criteria to make performance based practical design decisions that are documented. These concepts generally follow guidance provided in Green Book allowing for more flexibility based on surrounding system characteristics and context.

- Adding Lanes or a Median
- Adding Auxiliary Lanes
- Widening Lanes or Shoulders
- Intersection Improvements
- Bridge Replacement
- Sidewalk Construction
- Interstate Reconstruction

3.4. Construction Projects on Existing Roads: Defined as an Alteration Project, on an existing alignment (except for minor changes) that maintains the basic roadway type and uses practical engineering concepts to re-establish some portion of initial serviceability or Level of Service. Projects may not follow the formal DD-202 process, but quality assurance and control may be supplemented by Safety Reviews, ADA Exception Justification Reports and other documentation to support design decisions.

- Resurfacing, Restoration and Rehabilitation (RRR)
- NHS Resurfacing
- Guardrail Installation
- Bridge Deck Replacement

3.4.1. Construction Projects on Existing Roads (Preventive Maintenance): Defined as an alteration project, on an existing alignment (except for minor changes) that maintains the basic roadway type and uses practical engineering concepts to re-establish the rideability or corridor functionality.

- NHS Resurfacing
- Non-NHS resurfacing
- Slide Repair
- Bridge Deck Overlays
- Pipe Replacement
- Microsurfacing

3.4.2. Construction Projects on Existing Roads (Maintenance): Defined as a non-alteration project, on an existing alignment (except for minor changes) that maintains the basic roadway type and uses practical engineering concepts to extend the service life.

- Joint and Pavement Sealing
- Diamond Grinding
- Joint Repair and Dowel Bar Retrofit
- Pavement Patching
- Guardrail Repairs
- Pulling and Restoration of Ditches

- Restriping

4.0 POLICIES, MANUAL AND GUIDANCE

The following represents a list of approved policies and manuals for designers to document geometric design decisions.

- A Policy on Geometric Design of Highway and Streets, 2018, 7th Edition
- A Policy on Design Standards – Interstate System, May 2016
- Highway Safety Manual, 2014, 1st Edition
- Roadside Design Guide, 2011, 4th Edition
- Manual for Assessing Safety Hardware, 2016, 2nd Edition
- LRFD Bridge Design Specifications, 9th Edition
- LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 1st Edition
- Manual on Uniform Traffic Control Devices 2009, Revision 1 and 2
- Guidelines for Geometric Design of Low-Volume Roads, 2019, 2nd Edition
- WVDOT Design Directives
- WVDOT Structure Directives

Any errata, supplemental or new editions of the listed documents, formally adopted by FHWA on federal aid eligible projects. The use of AASHTO approved documents prior to FHWA adoption on non-NHS projects is acceptable.

5.0 DOCUMENTATION

The following shall provide a minimum of documentation requirements of the project category. The flexibility provided in the geometric design policy may necessitate additional documentation on performance based decisions. The documentation, if not based on published standards, shall thoroughly address design applicability in type, nature and context to function of the corridor or facility. The use of practical engineering concepts for CPER projects should be based on long held performance based decisions that meet system wide goals. When controlling criteria is being addressed by the scope of the project and appropriate limits cannot be obtained, variances shall be documented using DD-605 *Design Exception Policy*.

5.1. New Construction: The geometric design decisions shall be documented as reference to applicable manuals using tables, charts, or section reference. Design exception documents shall be used to identify nonstandard dimensions. The use of less than desirable values for any dimension not defined as a controlling criteria value, shall be submitted for approval by the appropriate Deputy State Highway Engineer-Chief Engineer.

5.2. Reconstruction: The geometric design decisions affecting roadway type shall be documented and referenced to the applicable manual using table, charts, or section reference. Design exceptions narrative should reflect performance based practical design decisions that identify the context of the surrounding area and improvements to the facility within funding constraints.

5.3. Construction Projects on Existing Roads: Projects designated as CPERs shall use flexible performance based solutions to address facility needs. Depending on facility

designation as an NHS route, the documentation will vary. Based on the type of work, the project may be documented using formal documentation, or decisions can be based on historical performance that meet the yearly fiscal or program monetary constraints. In all cases the designer shall analyze safety concerns, accident data and address ADA concerns when documenting project decisions.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 647
LIFE-CYCLE COSTS ANALYSIS FOR PAVEMENT DESIGN**

September 6, 2023

Supersedes June 15, 2010

This Design Directive (DD) gives guidance for the Division of Highways' (DOH) policy on Life-Cycle Cost Analysis (LCCA) for pavements.

This DD provides a means to standardize the process required to analyze and report the pavement design Life-Cycle Costs throughout all development units of the DOH. The general procedure for performing the LCCA is detailed herein. References for more in-depth LCCA analyses are also given.

10. General

The purpose of an LCCA for a particular pavement design within a defined *pavement segment* is to evaluate the overall long-term economic efficiencies of competing design alternates. Initial (construction) and discounted future (future rehabilitations, user, etc.) costs over the projected life of the pavement are added together to obtain a Net Present Value (NPV) for each *pavement type* selected. This process improves decisions concerning the utilization of limited funding for pavement in a construction project within a *pavement segment*.

20. Life-Cycle Cost Analysis (LCCA)

The WVDOH generally follows the LCCA methodology recommended in the FHWA Pavement Division's interim technical bulletin *Life-Cycle Cost Analysis in Pavement Design – in Search of Better Investment Decisions*, 1998. The publication number for this document is FHWA-SA-98-079 and is available electronically at <https://www.fhwa.dot.gov/pavement/lcca/lccafact/isdde.dot.gov/OLPFiles/FHWA/013017.pdf>. It contains standard procedures for estimating and comparing the long-term costs of *asphalt* and *Plain Jointed Portland Cement Concrete* (PCC) pavements over an analysis period under specified traffic and environmental conditions. The WVDOH uses an analysis period of at least 40 years for both the asphalt and PCC pavements. See *DD-641, Pavement Type Selection Guide*, for more information regarding pavement type selection parameters, and *DD-646, Pavement Design Guide*, for information concerning the design of the pavement structure itself.

The WVDOH generally follows the FHWA's recommendations for LCCA input data unless local data is available. Local input data includes, but is not limited to, traffic characterization, duration of construction, and construction costs. It is important to note that only differential costs are considered between alternates in the LCCA.

The Life Cycle Cost Analysis, if required per DD-641, will be performed on each *pavement segment* upon receipt of necessary soils data, existing pavement cores, and traffic data.

The base bid quantities for grading will be for the thicker pavement section. The *designer* may allow a lower profile grade but hold the cross-section to avoid additional earthwork. The

profile grade can be lowered by using a straight horizontal taper rate of 0.25%. This will occur at, but not be limited to, the ends of structures and at tie-ins to existing pavements. If the *designer does not allow* a lower profile grade, bid items for adjusting the grade must be added to the contract and included in the LCCA for that particular alternate; however, the contractor will not be permitted to raise the profile grade above that shown for the thickest pavement alternate. Costs common to each pavement alternate such as mobilization, signing/pavement marking, grading, drainage, rights-of-way, utility relocation, etc. are not included.

User delay costs are another important element in LCCA. Estimation of user delay costs follows the procedures in *Life-Cycle Cost Analysis in Pavement Design – In Search of Better Investment Decisions*, 1998. The user delay costs considered are the differential costs between competing alternates such as work zone costs including duration, setting traffic control, resetting traffic control for construction phasing, etc. User delay costs can differ by pavement type. The designer must carefully examine all facets of the planned work to accurately estimate user delay costs. Routine maintenance is not included in this analysis.

User costs are further divided into the *working day* and *non-working day* daily user costs. In most cases, the travel capacity of a construction zone on a *working day* is less than the capacity on a *non-working day*. For the purposes of this Directive, a *non-working day* is any day throughout the course of construction that traffic is not impeded in any way by lane/shoulder closures. User costs associated with *non-working days* are excluded from the analysis.

If the LCCA is performed on an entire pavement segment and the segment is not being fully constructed in one contract, then the result of the analysis will be pro-rated using the contract length divided by the entire *pavement segment* length. See DD-648, *Alternate Design Alternate Bidding of Pavements*, for more information on this matter.

30 Alternate Design Alternate Bid (ADAB)

The ADAB bid process is described in greater detail in DD-648.

40 Steps in LCCA

A standard procedure has been developed to perform the LCCA analysis. The *project manager* is responsible for the LCCA, using software that is specifically designed for use with *Life-Cycle Cost Analysis in Pavement Design – In Search of Better Investment Decisions*, 1998. The following steps are to be followed:

40.1 Project Selection

Criteria to be used for evaluating projects for inclusion in the LCCA process are described in DD-641.

40.2 Alternative Pavement Design Strategies

See DD-646 for selection of alternate design strategies and for information on the pavement design and rehabilitation process itself. The analysis period shall be at least 40 years.

The designer will develop reasonable design strategies for each alternative based on past pavement performance; that is, an initial pavement structure followed by a series of rehabilitations to cover the

analysis period. The analysis period will be the same for each alternative considered.

40.3 Estimate Agency Costs

Initial agency costs of the pavement section are the construction costs incurred by the WVDOT. These are official estimates prepared by the Division's *designer* or *project manager*. See the latest issue of DD-707, Development of Engineer's Estimate, for more information regarding the development of the official cost estimate.

Future agency costs are the costs incurred by the WVDOT to overlay, rehabilitate, or reconstruct the roadway in the 40 year (or longer) analysis period specified. All of these future costs must be considered in the LCCA for each pavement type considered for use.

40.4 Estimate User Costs

User costs are estimated according to the recommendations made in *Life-Cycle Cost Analysis in Pavement Design – In Search of Better Investment Decisions*, 1998. As stated above, only work zone user costs are estimated in the LCCA process. Estimation of user costs requires three steps: calculate the appropriate daily user costs, determine the duration of the construction activities and apply the daily user costs to the expected duration of the construction.

Data used for computation of LCCA user delay costs will be obtained from the Traffic Engineering Division and the Planning Division. The *designer* will be responsible for compiling all the required information from these sources and running the aforementioned program.

40.5 Compute Net Present Value (NPV)

In the broadest sense, LCCA is a form of economic analysis used to evaluate the long-term economic efficiency between investment options; therefore, the NPV of cash flow is calculated.

Economic analysis focuses on the relationships between costs, timings of costs, and discount rates employed. Once all costs and their timings have been developed, future costs must be discounted to the year of initial construction (the "base year") and added to the initial cost (the construction estimate cost) to determine the NPV for each LCCA alternate. Again, more information on the calculation and use of NPV is available in *Life-Cycle Cost Analysis in Pavement Design*, 1998. The designer is encouraged to consult this publication. Software designed from this publication will be used to determine the NPV of all cash flows.

Once completed, all LCCA's should be subjected to a sensitivity analysis. Sensitivity analysis is a technique used to determine the influence of major LCCA inputs, assumptions, projections, and estimates on the various LCCA results. In a sensitivity analysis, major input values are varied over a reasonable range of values, while all of the other variables remain constant. The input variables may then be ranked according to their effect on the results. This allows the designer to subjectively get a feel for the impact of the variability of individual inputs on overall LCCA results.

Sensitivity analyses, at a minimum, evaluate the influence of the discount rate on LCCA results. The discount rate accounts for the time value of money. It takes into account fluctuations in the inflation and interest rates to show the actual rate of increase in the value

of money over time. Using the discount rate allows the designer to use today's dollars in the LCCA. The higher the discount rate, the lower the present value of future cash flows. The discount rate to be utilized in all LCCA's will be the latest effective 30-year value of *real treasury interest rates* on *treasury notes* and *bonds* of *specified maturities* as given in the United States' Office of Management and Budget's *Circular A-94*, Appendix C. A table summarizing the past history of and giving the latest years' rate is available at <https://www.whitehouse.gov/wp-content/uploads/2023/12/CircularA-94AppendixC.pdf>~~<http://www.whitehouse.gov/omb/circulars/a094/dischist.pdf>~~.

If the *designer* finds that any LCCA is sensitive to a particular input, then the *designer* is to perform LCCA's utilizing a reasonable range of that input, and submit these results to the Deputy State Highway Engineer~~Chief Engineer~~ of Development in the package required by DD-641.

50. Comments

As projects utilizing LCCA are *let to construction*, their associated unit bid prices will be monitored to determine any trends in costs. Also, salvage values will not be considered in the LCCA's.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

DESIGN DIRECTIVE 648
ALTERNATE DESIGN AND ALTERNATE BIDDING OF PAVEMENTS
September 6, 2023
Supersedes June 15, 2010

This Design Directive (DD) gives guidance on the West Virginia Division of Highways' (WVDOH) policy on *alternate design and alternate bidding* (ADAB) of pavements.

Use of this DD provides a means to standardize the process required to utilize ADAB for pavements throughout all development units of the DOH; however, this DD does not detail the procedure for designing pavements and performing life-cycle cost analyses (LCCA), but references to publications written in detail concerning these subjects are given for the *designer's* use.

10. General

The objective of the ADAB process is to promote more cost-effective usage of highway construction funds. This is achieved by allowing contractors to select the *pavement type* constructed through the bidding process; consequently, increasing competition as well as making that competition more equitable. The Federal Highway Administration's (FHWA) Memorandum: *Clarification of FHWA Policy for Bidding Alternate Pavement Type on the National Highway System*, November 13, 2008, can be accessed at: <http://www.fhwa.dot.gov/pavement/081113.cfm>.

The ADAB process requires the WVDOH to consider future roadway rehabilitation, traffic control associated with that rehabilitation, and user delay costs. The process utilizes traditional *life-cycle cost analysis* (LCCA) concepts to model the cost of pavement section alternatives over a selected performance period. The selection process is then accomplished through an ADAB procedure, which essentially allows the bidder with the lowest *life-cycle costs* (LCC) to determine which pavement type will be constructed. See DD-647, *Life-Cycle Cost Analysis of Pavements*, for more information concerning LCCA.

To accomplish the ADAB process, the "A + B + C" bidding method is utilized for all bids submitted. Factor "A" is the contractor's bid, factor "B" is the time *in days* to construct the initial pavement, and factor "C" is the *net present value* (NPV) of all future rehabilitation costs, plus the NPV of *present* and *future* user costs for the pavement's analysis period. The lowest bidder is identified by adding "A + C".

The time factor "B" is not normally added to the contractor's bid. This factor may be used on projects that consist of total pavement reconstruction in order to capture the user costs associated with the initial construction. This *time factor* is usually zero (0) because most projects are on new alignments, and traffic is not impeded during the initial construction of a project.

If a particular project is not approved by the ~~Deputy State Highway Engineer-Chief Engineer~~ of Development or the FHWA's *Special Experimental Projects No. 14 – Alternative Contracting* (SEP-14) for the ADAB process, then the *designer* is to consider the following to recommend a *pavement type only* for approval:

- The LCCA
- *Secondary factors* as described in DD-641, *Pavement Type Selection Guide*, Section 40
- Sound engineering judgment

If the ADAB process is approved on any particular project, the *designer* may be required to submit a request to the FHWA headquarters, through the local office, to approve the use of ADAB on a project-by-project basis under the FHWA's SEP-14.

The following FHWA website contains additional information concerning SEP-14 submittals:

<https://www.fhwa.dot.gov/construction/cqit/sep14.cfm>www.fhwa.dot.gov/programadmin/contracts/sep-a.cfm

20. Criteria for Selection of Projects for the ADAB Procedure

Section 30 of DD-641 describes the criteria to be followed for selection of projects that will use the ADAB procedure for bidding of alternate pavement types.

30. Alternate Design and Alternate Bid (ADAB)

The ADAB bid model is accomplished by adding a factor "C" to each contractor's base bid factor "A". Factor "C" represents future rehabilitation and user delay costs for a particular pavement alternate. The implementation of ADAB, in general, may result in comparing multiple competing pavement structures with differing total thicknesses between the top of the sub-grade and the final pavement surface. A threshold of 20 percent in the difference of the NPV of the LCCA is a reasonable zone within which pavement types can compete.

In a contract in which the pavement is bid by the ADAB procedure, both the *asphalt* and the *jointed plain concrete* pavements shall be bid as a *pavement system* in square yards (sy). The *pavement system* is the entire pavement section, including fine grading, sub-grade, base and pavements. This approach allows an equal bidding process.

Note: The contract documents will include price adjustment factors for fuel, asphalt, and cement.

40. Steps in ADAB

A standard procedure has been developed to perform the ADAB analysis. This procedure has the following steps.

40.1 Project Selection

Criteria to be used for evaluating projects for inclusion in the ADAB process are described in DD-641, as mentioned in "Section 20" above.

40.2 Alternative Pavement Design Strategies

Refer to DD-641 for selection of alternate design strategies for the chosen analysis period, and DD-646, *Pavement Design Guide* for information regarding the pavement design process.

40.3 Estimate Agency Costs

Initial agency costs are the construction costs incurred by the WVDOT. These are official estimates prepared by the Division's *designer* or *project manager*. See the latest issue of DD-707, *Development of Engineer's Estimate*, for more information regarding the development of the official cost estimate.

Future agency costs are the costs incurred by the WVDOT to overlay, rehabilitate, or reconstruct the roadway in the 40 year (or longer) *analysis period* specified. All of these future costs must be considered in the LCCA for each pavement type considered for use.

40.4 Estimate User Delay Costs

See DD-647 for more information concerning computation of user delay costs.

40.5 Compute Net Present Value (NPV)

Refer to DD-647 for more information concerning computation of the NPV for each pavement alternate considered.

40.6 Analyze Results And Calculate Life-Cycle Cost Adjustment Factor "C"

After the total NPV for each alternate is computed, the results are then compared. If the difference in the total NPV between the lowest two alternates is greater than 20 percent, the alternate with the lower total NPV only is selected for bidding. The *designer* shall eliminate any pavement alternate that is considered, in the *designer's* judgment, to be impracticable for the project. Otherwise, alternate pavement designs will be included in the bidding documents and a *life-cycle cost* adjustment factor "C" will be included in the *schedule of prices* for each alternate.

The *life-cycle cost adjustment* factor, "C", is calculated as $C = \text{total NPV of the LCCA} - \text{construction cost}$. As part of the ADAB process, this "C" factor will be added to the contractors' bid. The lowest bidder identified by adding the "C" factor to the contractors' base bid "A" factor; thus, the lowest total is then selected.

If the LCCA is performed on an entire *pavement segment* and the *segment* is not being fully constructed in one contract, then the "C" factor will be pro-rated using the project length divided by the entire *pavement segment* length.

If the "C" factors are essentially equal (1% or less of the lowest cost initial *pavement section*) for all of the paving alternates considered, then "C" factors do not need to be added to the contractor's bids in order to determine the low bid.

Refer to "Section 30" of this DD for information on the handling of multiple pavement types in both the LCCA and bidding processes.

50. Comments

As Projects utilizing LCCA are *let* to construction, their associated unit bid prices are monitored to determine any trends in costs. Also, salvage values are not be considered in the LCCA's.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVES 681
WORK ZONE SAFETY AND MOBILITY**

January 3, 2024

Supersedes November 1, 2023

The West Virginia Division of Highways (WVDOT) is committed to providing a safe and efficient work zone environment. It is the Division's goal to minimize traffic delays to the traveling public, reduce work zone crashes and fatalities, and to promote a safe work place by improving mobility of the motorist and providing the utmost protection of the construction work force.

Compliance with this policy will benefit the traveling public, construction industry, and the business community by reducing work zone accidents, construction, and travel time.

The attached policy outlines procedures to be followed during all phases of development and construction or maintenance. It also assigns responsibilities for implementation to fulfill its requirements.

The requirements of this policy apply to all highway projects, regardless of the funding source.

Background

The Federal Highway Administration (FHWA) published the Final Rule on Work Zone Safety and Mobility, 23 CFR 630 Subpart J in September 2004. This rule, referred to as Work Zone Safety and Mobility, applies to State and local governments that receive Federal-aid highway funding. All transportation agencies are required to comply with the provisions of the Rule. This rule updates and broadens the former regulation, "Traffic in Highway and Street Work Zones," to address present and future work zone issues.

The final rule requires agencies to:

- Implement a policy that facilitates systematic consideration of work zone safety and mobility on all Federal-aid highway projects. Implementing the policy for non-Federal-aid highway projects is also encouraged.
- Develop procedures to assess and manage work zone impacts throughout the various stages of the project's development and construction. The agency must consider work zone impacts during project development, manage work zone impacts during construction, and assess work zone performance after implementation.
- Use work zone data to manage work zone impacts for specific projects and to improve the State processes and procedures.
- Ensure personnel are trained appropriately to the work zone job decisions for which they are responsible.
- Perform process reviews at intervals no greater than two years.

The final rule also requires each agency to identify significant projects as early as possible and provide Traffic Management Plans (TMP) with strategies in accordance with the complexity of the project. The Plans, Specifications and Estimate are required to include pay items for the TMP.

Additional information on the Final Rule on Work Zone Safety and Mobility is available at: http://www.ops.fhwa.dot.gov/wz/resources/final_rule.htm.

Classification of Projects

Significant Project

A significant project is one that, alone or in combination with other concurrent projects nearby is anticipated to cause sustained work zone impacts that are greater than what is considered tolerable based on this policy and/or engineering judgment. Work zone impacts refer to work zone-induced deviations from the normal range of transportation system safety and mobility. The extent of the work zone impacts may vary based on factors such as, functional classification, area type (urban, rural), traffic and travel characteristics, type of work being performed, time of day/night, and complexity of the project. These impacts may extend beyond the physical location of the work zone itself, and may occur on the roadway on which the work is being performed, as well as on other highway corridors and other modes of transportation.

The WVDOH shall identify upcoming projects that are expected to be significant. A significant project shall be identified at the Project Programming stage and re-evaluated periodically throughout to the project development and delivery process. For full oversight projects, the determination of significance should be made in cooperation with the FHWA. The State's work zone policy provisions, the project's characteristics, and the magnitude and extent of the anticipated work zone impacts should be considered when determining whether a project is significant or not.

All Interstate or Expressway projects that have an ADT greater than or equal to 25,000 or projects on other state highway routes that have an ADT greater than or equal to 15,000 and that occupy a location for more than three days with either intermittent or continuous lane closures will be considered significant. Exceptions for NHS significant projects may be granted from the FHWA. Exceptions on non-NHS significant projects may be granted from the ~~State Highway Engineer~~ Applicable Chief Engineer. Exceptions to these criteria will be granted based on ability to show that the specific project does not have sustained work zone impacts.

Project Levels

Depending on the complexity of the project, it will be assigned a classification of transportation management plan Level I, II or III, which determines the TMP requirements for the project. Any project identified as a significant project is a Level III project. Level II projects are those with a moderate level of construction activity with the primary traffic impact limited to the roadway containing the work zone. Level I projects are those with low complexity and may include simple construction projects, maintenance or utility work. Further information on these levels and the TMP requirements and recommendations associated with each is provided under "Plan Requirements" section of this policy.

Transportation Management Plans and Work Zone Management Strategies

The *Transportation Management Plan (TMP)* provides strategies to manage the work zone impacts of a project. At a minimum, the TMP includes a Temporary Traffic Control Plan (TTC). A Public Information (PI) component and a Transportation Operations (TO) component may also be included depending on the anticipated impacts. The overall success of a TMP must first be initiated early in the design process and developed throughout the design and delivery of the project.

The *Temporary Traffic Control plan (TTC)* describes Temporary Traffic Control measures to be used for facilitating the road user's passage through a work zone or an incident area. The TTC plan should be consistent with WVDOH policies, guidelines, and standards as described in this policy and in the "Manual on Temporary Traffic Control for Streets and Highways", 2006 Edition. TTC Strategies include:

- Control Strategies
- Traffic Control Devices
- Project Coordination, contracting and innovative construction strategies

The *Public Information (PI)* component of the TMP should include communication strategies that seek to inform all affected stakeholders about the project, the expected work zone impacts, and the changing conditions of the project. The scope of the PI component should be determined by the level of the project as set forth in this document. PI Strategies include:

- Public Awareness Strategies
- Motorist Information Strategies

The *Transportation Operations (TO)* component of the TMP should include the identification of strategies that will be used to mitigate impacts of the work zone on the operation and management of the transportation system within the impact area. TO Strategies include:

- Demand Management Strategies
- Corridor/Network Management Strategies
- Work Zone Management Strategies
- Traffic/Incident Management Strategies

Various work zone management strategies may be employed to minimize traffic delays, increase traveler and worker safety, and complete the work in a timely manner while maintaining access for businesses and residents. The strategies listed above are not meant to be all-inclusive, but to present a number of suggestions for consideration while developing TMPs. For a more extensive listing and general information on work zone management strategies refer to Appendix A of this directive.

The plans, specifications, and estimates shall include the TMP and appropriate individual pay items. Additional guidelines for development and implementation of TMPs can be found in the "TMP Guidelines" section of this policy.

Training

All WVDOH personnel will be trained in temporary traffic control design, deployment, operation, and maintenance consistent with the level of their responsibility. Individuals may gain

this training through either division provided courses or outside sources. The Development, Construction, and Operations Divisions shall each work with the Training Section of Personnel to develop training programs for Central Office and District Staff in their organization. Guidelines for who should be trained and suggested courses are included in Appendix B of this directive.

Stakeholders and Public Information

Highway improvements and the work zones to implement them are intended for the benefit of the traveling public. WV DOH personnel will work with appropriate stakeholders at every stage of projects to develop work zone strategies and keep them informed. Detailed information on stakeholders is included in Appendix C of this directive.

In addition to the work zone specific Public Information activities, the WVDOT provides general work zone information to the public through various outlets. These include, among other things, publication of a statewide work zone map and work zone driving safety tips, posting of current work zone locations and conditions to the internet, promotion of Work Zone Safety Awareness Week, and advertisement of work zone related messages via radio, television, and billboards. Through these efforts, WVDOT positively promotes work zone safety and mobility, as motorists gain access to information they need to plan their trips and become more work zone conscious.

Transportation Management Plan Guidelines

This section provides guidelines for developing and implementing project TMPs. These guidelines shall also be in compliance with the most recent version of The West Virginia Division of Highways Design Directives (DD). These plans will enhance our accountability and ensure that all options have been considered during the project development process as described in DD-200. These guidelines are to be used by Project Managers, Roadway and Bridge Designers, Traffic Engineers, Planning and Research Engineers, Maintenance Engineers, and all

Districts within the Division of Highways responsible for acquiring the information to develop Transportation Management Plans. The FHWA Area Engineer shall be involved in each step of the project's review process on full federal oversight projects. These guidelines require the evaluation of work zone traffic control and communication strategies during the project development process and during all phases of construction. All Temporary Traffic Control Plans shall be in compliance with the information published in the "Manual on Temporary Traffic Control for Streets and Highways, Latest Edition." Any deviations from the Manual shall be approved by the Traffic Engineering Division and noted in the plans and project file.

Initial Engineering – Identify potential work zone impacts using field observations, review of available crash data, and other relevant operational information. Determine preliminary work zone management strategies in conjunction with alternative project options and design schemes. Identify other coordination issues such as utilities, enforcement, and community impacts.

Relevant operational information should include but is not limited to, project definition (scope, project level of complexity, roadway and traffic characteristics, and TMP category), construction phasing/staging of equipment and materials, as well as temporary traffic control, public communications and transportation operations strategies.

Acquire traffic and crash data, develop a preliminary public information plan, and explore possible alternate/detour routes. A preliminary cost estimate for the projects transportation management plan shall be developed during this phase of the Project Development in accordance with DD-200 and DD-202.

Preliminary Engineering – Assess impacts of various work zone management alternatives. Consider design, construction, contracting and transportation management options. Select appropriate strategies. Develop TMP, including appropriate items in plans, specifications, and estimates for the project.

Public Information Meeting – Review the Preliminary TMP as incorporated by the Roadway Designer (includes Temporary Traffic Control Plan, Public Information Plan, and Transportation Operations Plan, as required) in accordance with DD-201.

Pre-Bid Conference – Complete the significant projects final TMP for review in accordance with DD-104 and include in pre-bid conference discussion.

Construction – Inspect the work zone during the first week of each phase of construction (Project Engineer, District Traffic Engineer, and Contractor) to ensure the compliance with the TMP and monitor safety and operation. Consult appropriate stakeholders to evaluate strategy performance and keep them informed. Review the TMP as needed to improve the work zone performance.

Any required changes to the TMP to enhance the work zone’s safety and mobility shall be approved by the Traffic Engineering Division. All such changes shall be documented and, if the project is a full federal oversight project, should be reviewed with an FHWA Area Engineer. An on-site review of the project’s work zone traffic control by the Project Engineer, District Traffic Engineer, Contractor, and a representative from the Traffic Engineering Division’s Safety, Planning, and Analysis Section shall be conducted within 48 hours of any fatal incident/crash within the work zone.

Report all fatal crashes that occur within the limits or that may be work zone related to the Traffic Safety, Planning & Analysis Section of the Traffic Engineering Division.

Transportation Management Plan Evaluation – For significant projects, a review of the effectiveness of the project’s TMP shall be completed during a Post Construction meeting and included with the Post Construction Report. A copy of the specific information on the effectiveness of the TMP will be forwarded to the Central Office Traffic Engineering Division’s Design and Operations Sections for review.

Roles and Responsibilities

The following guidance is provided to ensure that each member of the project development process understands their role and responsibilities in the development of the project’s TMP. Individuals noted below shall have direct responsibilities for the proper development of the TMP during the Plan Development Process.

Engineering Division

Shall ensure the proper design and presentation of all aspects of the TMP by providing the following detailed information in the plan development:

- Profile, alignment, superelevation and lane widths for all traffic lanes, turning lanes, lane shifts and detour routes not identified on existing roadways
- Earthwork/grading that must be completed prior to the next construction phase
- Utility work that can be completed within the project's guidelines for the TMP
- Identify all temporary pavement locations and temporary drainage items
- Illustrate the placement of all temporary signs, messages boards, electric arrows, devices, barriers, attenuators, temporary pavement markings and markers in the temporary traffic control plans for all construction phases (excluding temporary lane and shoulder closings) for Traffic Engineering Division's information and review.
- Identify and note all signal timing within the work zone and all detour routes
- Complete TMP cross sections
- Complete special design details and insert sheets
- Movement and staging of equipment and materials
- Need and placement of temporary bridge parapet and traffic barriers
- Need for the setting of beams over traffic
- Use of temporary bridges
- Need for demolition over traffic
- All temporary/permanent easements needed for construction are included in the plans
- Ensure that all utilities will not conflict with temporary traffic control and other safety devices for all phases of construction.

Traffic Engineering Division

Shall ensure the safety of the construction workers and the safe movement of traffic through the project's work zone by providing the Project Manager with the following recommendations, and verifying that the applicable information is included in the project's TMP:

- Lane width(s)
- Number of recommended traffic lane and turning lanes
- Provide existing pavement markings
- On-site and off-site detour routes
- Identify and provide all signal phasing within the work zone and all detour routes
- Requirements on the use of barriers, devices, and attenuators, etc
- Type and placement of all signs, message boards, electric arrows, etc
- Type and location of pavement markings and markers for each phase
- Time of day, weekend, and holiday restrictions
- Access to all businesses and private dwellings
- Transportation operations recommendations • Perform assessment of the Work Zone Traffic Impact
- Perform annual work zone review.

Programming Division

- Program project funding from Federal and State balances
- Coordinate schedules between adjacent or nearby projects to mitigate conflicts

Planning Division

- Collect and maintain traffic volume data as necessary for the project area
- Using information provided by the project manager, identify and report significant project
- Review appropriate PS&E items for level of anticipated TMP in projects.

Operations Division

- Monitor maintenance operations with ongoing projects and be compliant with the WVDOT Permitted Lane Closure Map to ensure statewide uniformity
- Coordinate district level maintenance projects with ongoing projects • Provide assistance to field maintenance organizations during emergencies.
- Ensure that appropriate staff are trained at the project level who has the primary responsibility, with sufficient authority, for implementing the TMP and other safety and mobility aspects of the project.

Office of Communications

Ensure that the transportation management plan is communicated to appropriate key stakeholders (motorists, police, businesses, schools, emergency service providers, residents, elected officials and media). Strategies will include:

- Developing a project-specific communications plan to keep key stakeholders informed about construction-related impacts before and during construction
- Communicating and promoting ways that users can avoid construction-related delays
- Developing an emergency communications plan which outlines steps to be taken during a major incident and includes emergency contact information
- Determine the need and types of community meetings needed to inform the public on the various aspects of the construction project
- Continuously update the WVDOT “projects under construction” webpage to alert motorists of such projects and available alternate routes.

District Engineers/Managers

Ensure the appropriate district staff shall implement the transportation management plan as set forth in this document. The key responsibilities include:

- Designate appropriate staff to review work zone traffic control during first week of each new phase of construction for all significant projects and identify areas of need for improvement
- Designate appropriate staff to monitor locations of projects and recommend change in TMP if needed due to proximity of projects
- Coordinate with other districts when lane closures or projects are affected by other lane closures or projects across district boundaries
- Ensure lane closures for all projects are in compliance with the Permitted Lane Closure Map

- Coordinate short-term maintenance activities with existing projects of a longer duration
- Designate appropriate staff to participate in work zone fatal crash accident reviews and gather any needed information from the accident in a timely fashion
- Ensure that appropriate staff are trained at the project level, and who has the primary responsibility, with sufficient authority, for implementing the TMP and other safety and mobility aspects of the project.

Contractor – Responsibilities of the contractor include:

- Designating a certified trained person at the project level who has the primary responsibility, with sufficient authority, for implementing the TMP and other safety and mobility aspects of the project
- Ensure that all contractor personnel are trained in traffic control to a level consistent with each of their responsibilities
- Advising the Project Engineer, as required, at least two working days before any work requiring a lane closure begins
- Working with the Project Engineer to ensure all lane closures are minimized
- Ensuring work zones are neat, orderly and effective for the safety of highway workers and motorists
- Minimizing delay and disruption experienced during construction
- Performing quality control of work zones to promote consistency and ensure compliance with contract documents, policies, and guidelines
- Recommend traffic control improvements to the Project Engineer to address field conditions pertaining to traffic flow, visibility, and worker and motorist safety.

Work Zone Fatal Crash Review -- A Fatal Crash Review Team may investigate all fatal traffic crashes that are work zone related. The team will be comprised of the following personnel: District Construction (or Maintenance) Engineer (or representative), Project (or Maintenance) Supervisor, Claims Investigator, District Safety Officer, District Traffic Engineer/Technician, and Traffic Engineering Division Representative. The team's responsibilities include to conduct a review of work zone, field documentation, any modifications made to the Traffic Control Plan, the crash report (if available), and develop any recommendations as appropriate.

Work Zone Review Team – The Work Zone Review Team will consist of representatives from Central Office, District, FHWA, and may consist of stakeholders. Responsibilities of the review team:

- Conduct annual reviews of work zone planning, design, implementation, management, and operation in multiple districts to ensure compliance with this policy
- Identify and document strengths and weaknesses observed during the review
- Communicate findings and recommendations to WVDOH management and personnel

Plan Requirements

This section provides guidance to Central Office and District Personnel for establishing a project's TMP requirements based on the project's level of complexity. These guidelines categorize a project into three types of transportation management. The project's level identifies the minimum TMP requirements and recommendations to be used by personnel responsible for the development and implementation for of a project. In general, the TMP shall consist of a temporary traffic control plan and as required, public information and a transportation operations plan. The specific project level requirements for plan content are listed below:

Level I

- Typical Projects: Minimum plan, Single Phase Construction, Maintenance projects, Utility and Work done under Permit
- Project Type: Simple Project – widening of pavement, adding turn lanes or entrances. Sequence consists of temporary lane closures and flagging operations with no shifting of traffic onto temporary pavement and with two-way traffic operation maintained at all times or at new construction locations with no existing traffic.
- Impact on Traffic: All lane closures and time restrictions will comply with the WVDOT Permitted Lane Closure Map
- Major Components:
- Temporary Traffic Control Plan – Major components will consist of General Notes, Typical Sections, and if needed, special details. (This information may be presented as in a narrative format with illustrations/sketches as necessary):
 - General Notes:
 - Identify the work zone location
 - Identify the length and width of the work zone
 - Identify the lanes affected by the project work
 - Note the hours the work zone will be active
 - Identify potential location(s), with the R/W, for construction equipment and material storage
 - Define the proposed traffic control by referencing the specific case(s) in the Manual on Temporary Traffic Control for Streets and Highways, Latest Edition
 - Note any entrances, intersections or pedestrian access points that will be affected by the work zone or by the traffic control devices
 - Typical Sections:
 - Illustrate lane configuration(s) in the work zone
 - Special Details:
 - Show schematically the placement of all traffic control devices
 - Place all traffic control devices and follow symbol conventions for identifying traffic control devices in accordance with the standards in the Manual on Temporary Traffic Control for Streets and Highways, Latest Edition, in the plans
 - Show all details, dimensions and explanatory notes required to execute the traffic control plan

- Public Information Plan – A public information plan is recommended for a roadway when the traffic volumes exceed the allowable ADT and the time of closure is established by the permitted lane closure maps. The public information plan shall provide the following information (this information may be presented in the project plans as part of the Temporary Traffic Control plan in a narrative format):
 - A process to notify the media, District Engineer and staff of scheduled work plans and traffic delays.
- Transportation Operations Plan – A Transportation Operations Plan is recommended when the work zone is greater than ½ mile in length and/or travel lane(s) are reduced. The transportation operations plan shall provide the following information (this information below is minimum requirements and should be presented in the project plans as part of the Temporary Traffic Control Plans in a narrative format):
 - A contact list of local emergency response agencies
 - A process to notify the District Engineer and staff, Traffic Engineering Division, and stakeholders of any incidents and expected traffic delays
 - Procedures to clear the incident and restore normal project traffic operations
 - Details of the process to review incidents for the purpose of modifying the Temporary Traffic Control Plan to reduce the frequency and severity of such incidents.
 - Submit a detour contingency plan, if approved by project manager/designer.

Level II

- Typical Projects: Moderate level of construction activity with the primary traffic impact limited to the roadway containing the work zone.
- Project Type: Moderately Complex Project – widening of pavement and bridges, additional thru lanes and pavement rehabilitation. Sequence consists of lane closures in one or both directions with shifting of traffic that may include temporary pavement or detours for the duration of the work.
- Impact on Traffic:
 - All lane closures and time restrictions will comply with the WVDOH Permitted Lane Closure Map.
- Major Components:
 - Temporary Traffic Control Plan – Major components shall consist of General Notes, Typical Sections, Detail Plans, and if needed, special details. Each component shall provide the following information per construction phase. This information shall be placed on a coordinated plan sheet. (This information may be presented as in a narrative format with illustrations/sketches as necessary):
 - Detail Plans which include all information listed under Level One Projects plus (this information shall be regarded as a minimum) :
 - Narrative describing the Sequence of Construction

- Type and location of all temporary signs for the work zone and all detour routes
 - Type and location of all temporary pavement markings
 - Type and location of all temporary pavement
 - Type and location of all temporary barrier
 - Type and location of all impact attenuator/end treatments
 - A list of calendar dates for Holidays and any special event(s) within project time frame
 - Identify potential location(s), with the R/W, for construction equipment and material storage
 - Define the proposed temporary traffic control plan by referencing the specific case(s) in the Manual on Temporary Traffic Control for Streets and Highways, Latest Edition.
 - Note any entrances, intersections or pedestrian access points that will be affected by the work zone or by the traffic control devices
- Typical Sections shall contain all the information listed for Level One Projects
 - Special Details/Cross Sections/ Profiles shall contain all the information listed for Category One Projects.
- Public Information Plan – A public information plan is recommended for a roadway when the traffic volumes exceed the allowable ADT and the time of closure is established by the permitted lane closure maps. The public information plan shall provide the following information (this information may be presented in the project plans as part of the Temporary Traffic Control plan in a narrative format):
 - All information listed under Level One Projects.
 - Transportation Operations Plan – A Transportation Operations Plan is recommended when the work zone is greater than ½ mile in length and/or reduced travel lane(s). The transportation operations plan shall provide the following information (this information below is minimum requirements and should be presented in the project plans as part of the Temporary Traffic Control Plans in a narrative format):
 - All information listed under Level One Projects.

Level III (Significant Projects)

These projects are anticipated to cause sustained work zone impacts greater than what is considered tolerable based on policy or engineering judgment. They should be identified early in the project development process in accordance to DD-200 and in cooperation with the FHWA.

- Typical Projects: Long duration construction or maintenance projects on Interstate and Expressway routes that have an ADT equal to or greater than 25,000 or on other state highway route that has an ADT equal to or greater than 15,000 that occupies a location for more than three days with either intermittent

or continuous lane closures. Also, this includes Interstates, Expressways, or other state highway route that may have multi-phase construction, high accident rates, full closures, or multiple work zones (two or more) within two miles of each other.

- Project Type: Complex Project – Multi-phase construction that as a minimum may add additional through lanes, bridge rehabilitation, interchange construction or reconstruction, pavement rehabilitation, reconstruction, and widening on high volumes of traffic as described above. Sequence consists of lane closures in one or both directions with traffic shifting several times and that may include temporary pavement or detours for the duration of the work. Impact of work zone on stakeholders extends beyond the work zone and affects alternate and/or detour routes.
- Impact on Traffic:
 - An assessment of the work zone impact will be completed using Quewz 98, Quickzone 1.0, or and operational-level traffic analysis software simulation program such as CORSIM.
 - Lane closure analysis will be performed and/or approved by the Traffic Engineering Design/Operations Section(s) at the request of the Project Manager/ Project Designer.
 - All lane closures and time restrictions will comply with the WVDOT Permitted Lane Closure Map
- Major Components:
- Temporary Traffic Control Plan – Major components shall consist of General Notes, Typical Sections, Detail Plans, and if needed, special details. Each component shall provide the following information per construction phase. This information shall be placed on a coordinated plan sheet. (This information shall be presented as in a narrative format with illustrations/sketches):
 - Detail Plans which include all information listed under Level Two Projects plus (this information shall be regarded as a minimum) :
 - A list identifying the location of reduced lane width(s)
 - Typical Sections shall contain all the information listed under Level Two Projects
 - Special Details/Cross Sections/ Profiles shall contain all the information listed under Level Two Projects.
- Public Information Plan – A public information plan is required for a roadway when the traffic volumes exceed the allowable ADT and the time of closure is established by the permitted lane closure maps. The public information plan shall provide the following information (this information may be presented in the project plans as part of the Temporary Traffic Control plan in a narrative format):
 - All information listed under Level One Projects.
- Transportation Operations Plan – A Transportation Operations Plan is required when the work zone is greater than ½ mile in length and/or results in reduced

travel lane(s). The transportation operations plan shall provide the following information (this information below is minimum requirements and should be presented in the project plans as part of the Temporary Traffic Control Plans in a narrative format):

- o All information listed under Level One Projects.

Operational Analysis

QUEWZ – 98 Program

The Division of Highways uses the computer program QUEWZ to determine the queues and user costs that are associated with work zone lane closures. Based on the type of lane closures, traffic volumes, time schedules, etc., the program will provide the user with the expected queue length and estimated user costs. The designer may use this program to ensure the proposed traffic control plan is still cost effective. The program user should review the user's manual to determine how to use the program. This analysis will be performed by the Traffic Engineering Division's Design Section.

Inputs

The user must provide the following inputs into the program:

1. lane closure configurations,
2. the schedule of work activities (e.g., work activity hours, lane constriction hours), and
3. the traffic volumes approaching the freeway segment.

The program provides default values for:

1. cost update factor,
2. percentage of trucks,
3. speeds and volumes at various points on a speed-volume curve,
4. capacity of a lane in the work zone,
5. maximum acceptable delay to motorist, and
6. critical length of queue.

To obtain meaningful results, the designer should consider revising the default values to meet the site location. For example, it should be noted that the program assumes that for queues longer than 20 minutes that some drivers will divert. To account for actual queues and the corresponding user costs, the designer may need to adjust the 20-minute time frame to meet the project situation. The designer should review the user's manual to determine if the default values are applicable to the location under consideration.

Outputs

QUEWZ has two output options - road user cost and lane closure schedule. The road user cost output option analyzes a specified lane closure configuration and schedule of work activities and provides estimates of traffic volumes, capacities, speeds, queue lengths, diverted traffic and additional road user costs for each hour affected by the lane closure. The lane closure schedule option summarizes the hours of the day when a given number of lanes can be closed without causing excessive queuing.

In addition to the values obtained from the program, supplemental user cost calculations may be required where changes are expected based on existing traffic patterns and volumes. Supplemental calculations for detours are typically required where an exit or entrance ramp within the construction zone (including those using crossovers) will be closed and where the designer judges that the QUEWZ program is not properly estimating the full amount of diverting mainline traffic.

Experience has shown that additional detour user cost calculations should be conducted for the following:

1. Where exit ramps are closed. Experience has shown that most or all of this traffic will divert from the mainline before the construction zone. Therefore, the exit ramp volumes should be deleted from the input mainline volumes before using QUEWZ and appropriate detour calculations performed.
2. Closed entrance ramps may or may not lead to changes in the input values for QUEWZ. Additional detour calculations will be required for any expected diversions.

Temporary Traffic Control Devices Final Rule

Background

The Federal Highway Administration (FHWA) published the Final Rule on Temporary Traffic Control Devices, 23 CFR 630 Subpart K in December 2007. This rule applies to State and local governments that receive Federal-aid highway funding. All transportation agencies are required to comply with the provisions of the Rule. This rule supplements the Work Zone Safety and Mobility Final Rule – Subpart J and applies to all Federal Aid highway projects to include highway construction, maintenance, and utility projects.

Requirements

- Use of positive protection devices to prevent intrusions.
- Exposure control measures to avoid or minimize exposure of workers and road users.
- A Uniformed Law Enforcement policy.
- Guidance for the safe entry and exit of work vehicles and equipment.
- Guidance for payment for traffic control features and operations
- Guidance to help maintain the quality and adequacy of the temporary traffic control devices for the duration of a project.

For additional information on the Final Rule on Temporary Traffic Control Devices – Subpart K, follow this link: <http://ops.fhwa.dot.gov/wz/resources/policy.htm>

The WVDOT is extending this requirement to all highway projects, regardless of the funding source.

These guidelines should be applied to all projects; with the exception to work related to emergency repairs.

Positive Separation Devices

As part of the development of a Traffic Control Plan (TCP), the need for and usefulness of

temporary traffic barrier protection should be evaluated throughout the project development process. In general, temporary traffic control barriers should only be installed if it is determined that the barrier offers the least hazard potential.

Installations and determination of Temporary Traffic Barriers are described per sections F.81 and F.82 and Figures 10 (Detail C) and 11 (Detail D) from the *West Virginia Division of Highways Temporary Traffic Control Manual – latest edition* and as described in Design Directive 685. These items can be found by the following links:
<https://transportation.wv.gov/highways/traffic/Documents/TemporaryTrafficControlManual2006.pdf>
<http://www.transportation.wv.gov/highways/engineering/Manuals/Traffic/TCM-06L.pdf>
<https://webapps.transportation.wv.gov/TWS/Engineering/2014DDManualMasterrev20250402.pdf>
<http://www.transportation.wv.gov/highways/engineering/DD/2006%20DD%20Manual%20MA%20S%20TER%2006112013.pdf>

In addition to the above, the following should be performed during design of the TCP:

Preliminary Plan: Frequently during preliminary design, the TCP has not been developed to the point where an adequate assessment of the use of temporary traffic barrier can be made; however, available data should be used to make an initial determination regarding whether temporary traffic barrier is warranted and whether exposure control measures should be considered.

Final Plan: During detailed design, as the TCP is developed further, an evaluation shall be performed to determine whether temporary traffic barrier is required and the most appropriate application of barrier (e.g., standard concrete traffic barrier, moveable concrete barrier, etc.). Factors to be considered in the evaluation include, but are not limited to, the following:

- Project scope and duration
- Anticipated travel speeds through work zone
- Traffic volumes
- Time of day (e.g., night work)
- Vehicle mix
- Pedestrian/bicycle exposure
- Type of work (as related to worker exposure and crash risks)
- Impacts on project cost and duration
- Distance between traffic and workers and the extent of worker exposure
- Escape paths available for workers to avoid a vehicle intrusion into the work space
- Work area restrictions (including impact on worker exposure)
- Consequences from/to road users resulting from roadway departure (e.g., severity of hazard, obstacle, or drop-off/slope)
- Potential hazard to workers and road users presented by device itself and during device placement and removal (e.g., clear zone, barrier end protection, barrier deflection distance)
- Geometrics that may increase crash risks (e.g., poor sight distance, sharp curves)
- Access to/from work space

Exposure Control Measures

The appropriate measures should be taken to limit the exposure of a worker to motorized traffic and exposure of motorists to work zone activities, while also providing adequate consideration to the potential impacts on mobility. A wide range of Temporary Traffic Control Strategies that may be appropriate for a individual project basis to limit these exposures can be found listed in the Appendices of this Design Directive.

Law Enforcement Implementation

The West Virginia Division of Highways has implemented a directive for the use of a Traffic Director as part of a highway project based the following criteria as described in Traffic Engineering Directive 604. This policy reads as follows:

A traffic director shall be a uniformed off-duty law enforcement official with a properly identified police vehicle that displays blue flashing lights. The intent of a traffic director is to enforce the posted speed limit and to increase safety for motorists and workers.

A traffic director shall be included within a traffic control plan when one or more of the conditions noted below exist in a work zone:

1. Nighttime paving operations, nighttime resurfacing operations, or nighttime pavement repair:
 - a. On any Interstate or Expressway facility with an ADT greater than 25,000, or
 - b. On any non-Expressway facility with an ADT greater than 15,000.
2. Pouring and curing of concrete, day or night, during the overlay of a bridge deck:
 - a. On any Interstate or Expressway facility, or
 - b. On any non-Expressway facility while maintaining two-way traffic with an ADT greater than 3,000, or
 - c. On any one-way non-Expressway facility.
3. Removing or setting of bridge beams:
 - a. Over any Interstate or Expressway facility, or
 - b. Over any non-Expressway facility with an ADT greater than 10,000.
4. Installation or removal of full span or half span sign structures:
 - a. On any Interstate or Expressway facility, or
 - b. On any multilane Non-Expressway facility.
 - c. A Traffic Director may be used under other circumstances, as approved by the Traffic Engineering Division.

<https://transportation.wv.gov/highways/traffic/Pages/TrafficEngineeringDirectives.aspx>
<http://www.transportation.wv.gov/highways/traffic/Pages/TrafficEngineeringDirectives.aspx>

Guidance for the Safe Entry and Exit of Work Vehicles and Equipment

The TTC plan should consider the need for a work area access plan. This is a constructability issue in which the designer addresses the question of how the contractor is to get materials and equipment into the work area safely. This is a particularly critical issue on high speed facilities (such as the Interstate) where barrier wall is used to protect median work areas. Some consideration may be given to the design and construction of temporary acceleration and deceleration lanes for the construction equipment. The following should be considered in the design, planning and operation of work zones.

1. Anticipate types of work zones likely to create ingress/egress problems. Examples are median work spaces requiring work vehicles to merge into/out of high-speed traffic and work activities that will generate frequent delivery of materials such as paving projects and the delivery of fill material.
2. Access into/out of the work space should be included in TCP. When operations require access and it is not addressed in the plan the project engineer must address the issue within the limits of their authority.
3. Adequate acceleration/deceleration space for work vehicles should be provided.
4. The location of access openings should provide good sight distance for oncoming traffic.
5. In extreme conditions lane closures may need to be considered.
6. Openings in barrier walls should be planned to ensure that ends are properly protected and that the walls do not create sight problems.
7. Ingress/egress condition may justify lowering the speed limit.
8. Warning signs (W21-10) are available for ingress/egress conditions and should be used when appropriate. Special warning signs may be necessary.
9. The use of Changeable Message Signs and/or Traffic Directors should be considered.
10. Vehicles entering/leaving a work space should use flashing amber lights for improved visibility by oncoming traffic.
11. Drivers and operators should be trained on safe operation and must be supervised and corrections made when unsafe actions occur.

Guidance for Payment for Traffic Control Features, Operations, and Guidelines for Maintaining the Quality of Temporary Traffic Control Devices

The guidance for the payment of operations and maintenance of the traffic control devices implemented for the use on a West Virginia highway construction project is listed under Section 636 of the latest adopted edition of *The West Virginia Division of Highways Standard Specifications for Roads and Bridges*, as amended by the latest adopted issue of the *West Virginia Division of Highways Supplemental Specifications*.

The guidelines set forth to maintain the quality and adequacy of temporary traffic control devices for the duration of a project will follow the latest adopted edition of *The West Virginia Division of Highways Standard Specifications for Roads and Bridges* as amended by the latest adopted issue of the *West Virginia Division of Highways Supplemental Specifications*, and supplemented with the latest edition of the *Quality Guidelines for Temporary Traffic Control Devices* issued by the American Traffic Safety Services Association (ATTSA). The application of the Standard Specifications and Quality Guidelines will help field personnel to evaluate the condition of devices and assure continued effectiveness.

References

1. The West Virginia Department of Transportation, Division of Highways, *Standard Specifications, Roads and Bridges, as amended by the supplemental specifications*.
2. The West Virginia Department of Transportation, Division of Highways, Engineering Division, *Design Directives*.
3. The West Virginia Department of Transportation, Division of Highways, Traffic Engineering Division, *Manual on Temporary Traffic Control for Streets and Highways, Latest Edition*.
4. The West Virginia Department of Transportation, Division of Highways, Traffic Engineering Division, *Traffic Engineering Directives*.
5. FHWA Final Rule Website
http://www.ops.fhwa.dot.gov/wz/resources/final_rule.htm
6. 23 CFR Section 630 (Final Rule Language)
http://www.ops.fhwa.dot.gov/wz/docs/wz_final_rule.pdf
7. FHWA Work Zone Mobility and Safety Web Site
<http://www.fhwa.dot.gov/workzones>
8. FHWA Safety Web Site <http://www.safety.fhwa.dot.gov>
9. WVDOH Permitted Lane Closure Map
<http://www.transportation.wv.gov/highways/traffic/Documents/permitted-lane-closure.pdf>

Appendix A

** - The strategies listed below are a minimum requirement for a TMP

Work Zone Management Strategies Temporary Traffic Control (TTC)		
Control Strategies	Traffic Control Devices	Project Coordination, Contracting, and Innovative Construction Strategies
<ul style="list-style-type: none"> • Construction phasing/staging • Full roadway closures • Lane shifts or closures <ul style="list-style-type: none"> Reduced lane widths to maintain number of lanes Lane closures to provide worker safety Reduced shoulder width to maintain number of lanes Shoulder closures to provide worker safety Lane shift to shoulder/median to maintain number of lanes • One-lane, two-way operation • Two-way traffic on one side of divided facility 	<ul style="list-style-type: none"> • Temporary signs <ul style="list-style-type: none"> Warning Regulatory Guide/information • Changeable message signs (CMS) • Arrow panels • Channelizing devices • Temporary pavement markings • Flaggers and uniformed traffic control officers • Temporary traffic signals • Temporary Lighting • Warning Lights 	<ul style="list-style-type: none"> • Project coordination <ul style="list-style-type: none"> Coordination with other projects Utilities coordination Right-of-way coordination Coordination with other transportation infrastructure • Contracting strategies <ul style="list-style-type: none"> Design-build A+B bidding Incentive/disincentive clauses Lane rental • Innovative construction techniques (precast members, rapid cure materials)

<ul style="list-style-type: none"> • Reversible lanes • Ramp closures/relocation • Night work • Weekend work • Work hour restrictions for peak travel • Pedestrian/bicycle access improvements • Business access improvements • Off-site detours/use of alternate routes 		
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Work Zone Management Strategies Public Information (PI)	
Public Awareness Strategies	Motorist Information Strategies
Press releases/media alerts	Changeable message signs (CMS)
Planned lane closure web site	Temporary motorist information signs
Project web site	Dynamic speed message sign
Public meetings/hearings	Freight travel information
Community task forces	Transportation Management Center (TMC)
Coordination with media/schools/businesses/emergency services	
Work zone safety highway signs	

Work Zone Management Strategies - Transportation Operations (TO)			
Demand Management Strategies	Corridor/Network Management Strategies	Work Zone Safety Management Strategies	Traffic/Incident Management and Enforcement Strategies
Shuttle services	Signal timing/coordination improvements	Speed limit reduction/variable speed limits	ITS for traffic monitoring/management
Ridesharing/carpooling			Transportation Management Center (TMC)
Park-and-ride promotion	Temporary traffic signals	Temporary traffic signals	Surveillance (ClosedCircuit Television (CCTV))
Variable work hours	Street/intersection improvements	Temporary traffic barrier	Mile-post markers
	Turn restrictions	Movable traffic barrier systems	Tow/freeway service patrol
	Parking restrictions	Crash-cushions	Total station units
	Truck/heavy vehicle restrictions	Temporary rumble strips	Photogrammetry
	Reversible lanes	Warning lights	Coordination with media
	Ramp closures	Automated Flagger Assistance Devices (AFADs)	Local detour routes
	Railroad crossings controls	Project task force/committee	Incident/emergency response plan
	Coordination with adjacent construction site(s)	Construction safety supervisors/inspectors	Dedicated (paid) police enforcement
		Road safety audits	Cooperative police enforcement
		TMP monitor/inspection team	Increased penalties for work zone violations
		Safety awards/incentives	
		Windshield surveys	

Appendix B

Stakeholders. Stakeholders are individuals, groups and organizations who have a “stake” in a particular highway improvement project. They may be immediately affected by the project because they must travel through the construction work zone. They may be more indirectly involved because of their position in the community or their job responsibilities are affected.

The traveling public is of course the important stakeholder. Motorists are most affected by highway improvement. They enjoy the new highway or the resurfaced highway once the project is completed and they are the ones inconvenienced when caught in the construction zone. They are by far, the largest and most important group a highway improvement project communication plan needs to target.

Major businesses in and around a project work zone are traffic generators. Employees going to and from work may travel through the zone daily. Deliveries to the businesses can create slower moving truck traffic and the timely arrival of some deliveries can be critical to some operations. Informing the businesses before construction starts not only builds good will, but enables them to inform employees and adjust delivery and transport schedules.

Other businesses located in the immediate area of a construction project may not be major employers, but may be traffic generators. The proprietors may be concerned about the construction project interfering or limiting customer access and the resulting loss of business. Being in the communication loop will reassure them and allow them to let their customers and employees know what to expect.

There are other stakeholders or stakeholder groups who may not be directly affected by highway improvement, but who should be considered when doing the construction project’s communication plan. The stakeholders may not be located near the work zone. They may not be traffic generators. As individuals, they may not even travel through the work zone or in anyway be inconvenienced. However, because of their position, they need to be informed. It may be as simple as sending them copies of news releases or composing a letter.

Local government officials, such as mayors, city managers, city council members, and county commissioners need to be informed in order to deflect complaints and feel part of the project.

Emergency services and law enforcement agencies have a ‘need to know’ about highway improvement in their service areas. Often it is a matter of sending news releases to law enforcement headquarters and emergency 911 operations centers.

Legislators at both the state and federal level often have an interest in highway projects in their respective districts. In some cases they have been involved with project funding or they have helped promote the need for projects. State legislators, using the legislative process, develop the state’s transportation budget. At the national level, members of congress help decide funding and national transportation policy. An informed legislator is much more likely to answer a constituent’s complaint about highway improvement in a positive tone.

Utility companies are another stakeholder that is often contacted during the design process if necessary. But keeping appropriate utility company personnel up to date on the highway improvement project will help promote the image for all parties.

Keep in mind that construction may create some special needs to contact specific individuals or organizations. The **postmaster** may need to reroute mail delivery due to a road closure or inability to access rural mail boxes. **Convention and visitor's bureaus** should have construction information to pass on to meeting planners. **Promoters and managers of special events** (local festivals, street fairs, county fairs, etc.), **entertainment venues and amusement parks** need to understand that construction could affect customer access. Look for opportunities to share construction information with **travel clubs**, such as the American Automobile Association.

Developing an all-inclusive list of stakeholders who have a need to know about any given highway improvement project is dependent on the type of construction, the extent of construction, the length of the construction zone and how long the construction is expected to take. When planning communication for a construction project, consider the construction zone's geography, business and residential environment in order to begin the development of a specific list of stakeholders who need information on the construction project. Remember, an informed group of stakeholders not only builds good will and lessens the complaints, but the stakeholders in turn become communicators to their constituents. Well planned and targeted communication will ensure a positive message is forwarded.

Appendix C

Proposed Work Zone Training Requirements				
Staff	Number of Individuals	Course	Time	Required
Design	150	NHI	3 days	Every 5 years
Construction	200	ATSSA	1 -1.5 days	Every 5 years
Maintenance	100	LTAP/T2	1 day	Every 5 years
Programming Planning	15	Peer to Peer	1 day	Every 5 years

Design staff shall be from Traffic Engineering Division, Engineering Division, District Design, District Traffic.

Construction staff shall be from Central Office and District level Construction Engineers, Construction Supervisors, Construction Inspectors, and Utilities Supervisors and Inspectors.

Maintenance staff shall be from Central Office and District level Maintenance Engineers, Maintenance Assistants from the County and Expressway Headquarters.

Programming Division and Planning Division staff shall be from the Central Office.

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 811
ACCESSIBILITY STANDARDS, CURB RAMPS AND SIDEWALKS**

January 3, 2024

Supersedes November 1, 2023

This Design Directive defines the West Virginia Department of Transportation, Division of Highways' policy concerning curbs and sidewalks, and further compliance with the Americans with Disabilities Act of 1990 (ADA) and the U.S. Department of Justice (DOJ) 2010 ADA Standards. Other references will be given to assist the Designer/Project Manager during the assessment of a project for ADA requirements, as well as details and criteria that are to be used when ADA requirements must be met.

Attached to and made a part of this Design Directive is an ADA Exceptions Justification Form. See Section 50 of this DD for more information.

The policies described herein will apply to all projects, whether designed at the District level, in the Central Office, or the Special Projects Section.

10. General

In compliance with the Americans with Disabilities Act of 1990 and the U.S. Department of Justice 2010 ADA Standards for Accessible Design, curb ramps as per DOH Standard Details shall be provided at all existing marked and unmarked crosswalks for which the Division of Highways has responsibility. Existing ADA features that are within the limits and scope of work of the project are to be checked for conformity with the DOJ 2010 ADA Standards for Accessible Design and are to be reconstructed if they do not comply. All curb ramps are to have Detectable Warnings installed. In addition, the existing condition of a sidewalk will not affect the decision of whether to add a curb ramp or not.

The following information is to be used to determine, for ADA applicability purposes, whether a project is considered a "Maintenance Project" under which curb ramps are NOT required to be incorporated into the project, or an "Alteration Project" under which curb ramps MUST be incorporated into the project. See the following web page for a more precise definition of some of the terms in the lists below: <https://highways.dot.gov/civil-rights/programs/ada/glossary-terms-dojfhwa-joint-technical-assistance-ada-title-ii>

www.fhwa.dot.gov/civilrights/programs/doj_fhwa_ta_glossary.cfm.

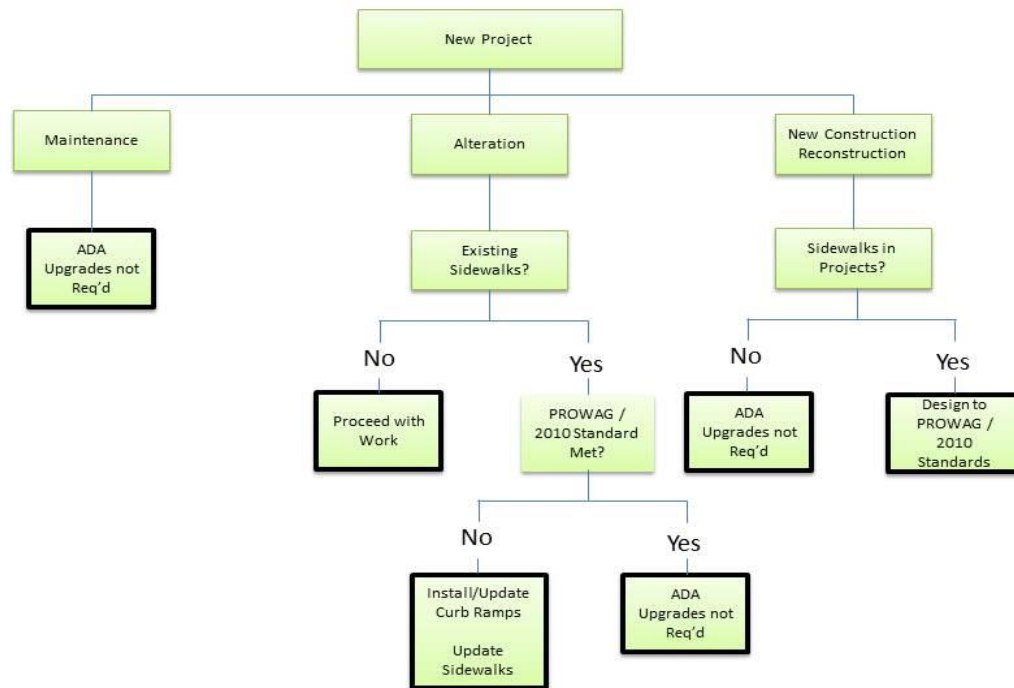
- A. Roadway Maintenance
 - 1. Crack filling and sealing
 - 2. Surface sealing
 - 3. Chip, Slurry, and Fog seals
 - 4. Scrub sealing
 - 5. Joint crack seals
 - 6. Joint repairs
 - 7. Dowel bar retrofit
 - 8. Spot high-friction treatment
 - 9. Diamond grinding

10. Pavement patching
 11. Shoulder repairs
 12. Pipe and inlet repairs
 13. Pulling and restoration of ditches
 14. Guardrail repair and installation
 15. Re-striping
- B. Roadway Alteration
1. Open-graded surface course
 2. Cape seals
 3. Mill and fill / Mill and overlay
 4. Hot in-place recycling
 5. Micro Surfacing / Thin-lift overlay
 6. Addition of new layer of asphalt
 7. Asphalt and concrete rehabilitation and reconstruction
 8. New construction
 9. Widening of the existing pavement typical section
 10. Addition of turning lanes
 11. Pavement rubblizing
 12. Installation of new drainage structures to improve existing drainage characteristics
- C. Bridge Maintenance
1. All painting of bridge members
 2. Scour Countermeasure Activities
 3. Expansion Joint Repairs and Replacement
 4. Concrete Crack Repairs
 5. Refurbishing or restoration of existing bridge bearings
 6. Deck drainage system repairs
 7. Seismic retrofit activities that do not include replacement of bearings or structural members
- D. Bridge Alteration
1. Bridge deck overlay projects
 2. Repairs to structural members for the purpose of restoring or enhancing structural capacity
 3. Strength repairs to substructure elements
 4. Bearing replacement
 5. Bridge deck replacement
 6. Superstructure replacement

Alteration projects administered by a municipality on WVDOT R/W, such as a streetscape, involve funds expended on a public right of way. The alteration requires the municipality and the WVDOT to meet full compliance with all federal laws and regulations during the development of plans and construction. As part of the development of plans for construction, where full design criteria for pedestrian access is not feasible, the designer (the municipality or their consultant) shall prepare an ADA Exception Justification Form, included in this DD, and submit with the plans for

review and approval to the WVDOT. All exceptions approved by the Division shall be filed as required for all projects.

ADA Requirements Flowchart



11/06/2014

20. Existing Sidewalks

Projects considered an alteration by the Department of Justice (DOJ) as described in Section 10 of this DD will require all curb ramps within the project limits to meet the requirements of the Americans with Disabilities Act (ADA). This will also require installing curbs ramps where presently a curb ramp does not exist to make the sidewalk ADA accessible. Detectable warning systems will be required on all existing curb ramps that otherwise meet the ADA criteria. Existing sidewalks shall be evaluated for ADA Compliance using the DOJ 2010 ADA Standards for Accessible Design. These Standards are available at:

www.ada.gov/regs2010/2010ADASTandards/2010ADASTandards.htm. The 2010 ADA Standards for Accessible Design consists of the U.S. DOJ TITLE 28 CFR Parts 35.151 from the Code of Federal Regulation combined with the 2004 ADA Accessibility Guidelines.

Within the project limits the evaluation of the sidewalks and any curb ramps which may exist within a project's limits is to be a field evaluation. An evaluation from remote sources such as Google Earth or the Division's pavement video records is not sufficient.

For sidewalks located outside of a municipality, the District/Division shall evaluate and fully document the entire sidewalk within the project limits for ADA Compliance. A cost estimate for the renovation and a copy of the ADA evaluation shall be forwarded for review to the District/Division ADA Coordinator. During project development, the District/Division shall consider incorporating side walk renovations into the project. If there is significant scope creep,

the District/Division may request, through the District ADA Coordinator, that sidewalk renovations not be incorporated into the project, and be included in the WVDOT ADA Transition Plan. The ADA Coordinator shall obtain approval for this request from the State Highway Engineer-Deputy Commissioner of Highways. Regardless of when the sidewalks are renovated, curb ramp work to make the sidewalk ADA compliant must be incorporated into the alteration project, or completed prior to the alteration project.

For sidewalks located on the WVDOT Right of Way within a municipality where the municipality is responsible for the sidewalk maintenance, the District/Division ADA Coordinator shall contact the municipality to inform them that the existing sidewalks need to be evaluated for ADA Compliance. Non-compliant sidewalks should be added to municipality's ADA Transition Plan. Regardless of sidewalk maintenance responsibility, curb ramp work must be incorporated into the project.

30. Curb Ramps on Resurfacing Projects in Urbanized Areas with Sidewalks

Alteration projects must include curb ramp installation if none previously existed where there is a pedestrian walkway with a prepared surface for pedestrian use within the scope of the project. Where a non-compliant curb exists within the pedestrian walkway, upgrading of the curb ramp to meet the Proposed Accessibility Guidelines for Pedestrian Facilities in the public Right-of-Way (PROWAG), dated July 26, 2011, is required.

When performing roadway activities at intersections and adjoining streets, the limits of resurfacing is to be the curb or gutter line of the street being altered.

The WVDOT recommends not paving to the end of the radius return on side street or alleys and impacting the existing curb ramps of the adjoining street. If flaring of the resurfacing project into an adjoining street is necessary, curb ramps shall be assessed for ADA compliance and addressed within the scope of the project.

Curb ramps are to be assessed for compliance with PROWAG, dated July 26, 2011, or constructed on resurfacing projects when:

- A. Limits of the resurfacing project encroach into the boundary of the curb ramp detail;
- B. Pedestrians may reasonably conclude that they would cross the resurfacing project from one curb ramp to another, even if the curb ramp is outside the limits of resurfacing;
- C. Construction activities expand beyond the original limits and encroach into the curb ramp area; and
- D. Curb ramps aren't present in sidewalks at signals, stop signs or yield signs (they must be constructed with the resurfacing project on each side of the pedestrian access route).

Additionally, when existing Type II (diagonal) curb ramps meet any of the above conditions, they must be assessed to determine if two separate ramps can be provided at the corner.

40. New Sidewalks and Replacement of Existing Sidewalks

The Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right of Way (PROWAG), dated July 26, 2011, should be considered as minimum criteria for the design of any new sidewalk or the replacement of an existing sidewalk. The complete PROWAG document is

available at the following web address: <https://www.access-board.gov/prowag/>~~<http://access-board.gov/>~~. Certain sections will be referenced for the designer in Section 40 of this DD.

Currently, PROWAG is still in the rule making process and the 2010 ADA Standards for Accessible Design is being enforced by the Department of Justice. Therefore, new sidewalks shall also be checked for compliance with the 2010 ADA Standards for Accessible Design. If sidewalks do not meet the requirements of the 2010 ADA Standards for Accessible Design an ADA Exception Justification Report (attached) shall be submitted to the District/Division ADA Coordinator for review and concurrence

50. Technical Guidance and References

2010 ADA Standards (Existing Sidewalks)

The 2010 ADA Standards are to be used to evaluate existing sidewalks for ADA compliance. If the existing sidewalk is to be replaced, The Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right of Way dated July 26, 2011 shall be used in the design of the new sidewalk.

A technical assistance “tool kit” which includes checklists and information on conducting assessments of existing facilities is available for use by Designers at the following web address: <http://www.ada.gov/pcatoolkit/toolkitmain.htm>. Chapter 6 of this resource provides the technical assistance, and Appendices 1 and 2 provide instructions and a survey form to use to analyze existing sidewalks.

- A. In short, the above-mentioned checklist includes the following items (this listing is NOT all-inclusive).
- B. Sidewalks shall be at least 3 ft. wide.
- C. The cross slope shall not exceed 2%.
- D. When sidewalks are less than 5 ft. in width, passing spaces with a minimum clear space of 5 ft. x 5 ft. shall be provided at intervals not to exceed 200'. Driveways, building entrances, and public sidewalk intersections may be used for passing spaces.
- E. Where an obstacle (example: utility pole or fire hydrant) is considered immovable, a minimum 32” of sidewalk width (excluding curb width from measurement) must be provided for the pedestrian. Reduction of sidewalk width from 36” (3’) due to an obstacle requires an ADA design exception. When developing sidewalk widths, the Roadside Design Guide (RDG) requirements of clear zone (RDG Section 3.1) and minimum lateral offset behind the curb (RDG Section 3.4.1) must also be considered.
- F. Curb ramps shall not exceed a running slope of 1:12 (maximum 1:10 is permitted at existing sites where it is not feasible to provide the 1:12 requirement due to space limitations and the rise is less than 6 inches).
- G. A level landing should be provided at the top of a perpendicular curb ramp.
- H. The transition from curb ramp to gutter should be flush; lips are not permitted.
- I. The foot of a curb ramp should be contained within the crosswalk markings.
- J. Gratings such as tree well covers, valve boxes with vent holes, manhole covers, etc. in the path of travel may not have an opening with a dimension of greater than ½” in any direction. Drainage inlets or any other item with openings greater than ½” in any dimension shall be located out of the path of travel.
- K. Drainage is to be provided upstream of the foot of the ramp to ensure flow depth is at

a minimum.

The Designer is cautioned to fully review the requirements contained in the Guide and consult the Checklist for complete information.

Accessibility Guidelines for Pedestrian Facilities in the Public Right of Way (PROWAG) (New Designs)

These standards shall be used in the design of all new sidewalks and the replacement of any existing sidewalks:

- A. The pedestrian access route shall have a minimum width of 4 ft. excluding the width of the curb.
- B. A level landing shall be provided at the top of a perpendicular curb ramp. The landing at the top of the curb ramp shall be a minimum 4 ft. wide when no obstructions exist at the backside of the landing and a minimum 5 ft. wide when obstructions exist such as a building, pole etc.
- C. All other requirements described for Existing Sidewalks above shall apply, noting that the list is NOT all-inclusive.

Additional guidance may be found at the following web site concerning Public Rights-of-Way Access from the United States Access Board (generally referring to facilities in public rights-of-way):

<https://www.access-board.gov/prowag/>~~<http://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way>~~. A manual entitled “Special Report: Accessible Public Rights-of-Way Planning and Design for Alterations”, dated August 2007, is available for technical assistance to the Designer, generally providing guidance for alterations of existing facilities at <https://www.access-board.gov/files/prowag/planning-and-design-for-alterations.pdf>~~<http://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/guidance-and-research/accessible-public-rights-of-way-planning-and-design-for-alterations>~~.

Technical guidance, including sample details, is available for the proposed DOJ rules at the address given heretofore in Section 20 of this Design Directive (the DOJ 2010 ADA Standards for Accessible Design (www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm).

Chapter 2 of this resource includes Scoping Requirements, while Chapter 4 “Accessible Routes”, include requirements and sample details for sidewalks and curb cuts.

Where a sidewalk which is being constructed or reconstructed along a State highway is carried around a radius, and ended, the surface of the sidewalk will smoothly meet the existing ground or adjacent sidewalk where conditions permit. If the sidewalk being constructed or reconstructed extends through the crosswalk on the intersecting street, curb cuts or ramps shall be provided.

The Checklists found in Design Directive 202, *Field and Office Reviews for Initial Engineering, Preliminary Engineering and Final Design* include lines for the Designer/Consultant Project Manager to initial for compliance when submittals are made.

60. ADA Exception Justification Report

If a requirement of the DOJ 2010 ADA Standards is deemed technically infeasible, the reasons for the exception must be fully documented and approved. Some reasons why an ADA requirement cannot be implemented include historical considerations, limited right-of-way, or problems with geometry (both horizontal and vertical). It is up to the Designer to determine feasibility. If an ADA exception is granted for technical infeasibility, the Designer should make every effort to mitigate the requirement. Specifically, Sections 201, 202, and 206 of the adopted DOJ 2010 ADA Standards discuss scoping, structural impracticality and technical Section 406 discusses Curb Ramps.

Attached to and made a part of this Design Directive is an ADA Exceptions Justification Form which is to be completed by the Designer/Project Manager for all projects which have exceptions to any ADA requirements. A copy of the proposed ADA Exception Report with the recommended signatures shall be mailed to the EEO Division ADA Coordinator to be forwarded to the ADA Board for approval. The completed Form is to be included in the Final Office Review and PS&E submittals.

West Virginia Division of Highways
EEO Division ADA Coordinator
1900 Kanawha Boulevard, East
Building 5, Room 618
Charleston, West Virginia 25305-0430

The District/Division ADA Coordinator shall maintain a copy of all approved ADA Exception Justification Reports and Sidewalk Evaluations for future reference.

AMERICANS WITH DISABILITIES ACT
EXCEPTIONS JUSTIFICATION REPORT

PROJECT DATA

State Project No. _____ Date: _____

Federal Project No: _____ County: _____

Project Name: _____

Project Description: _____

Special Project Sponsor
Name and Address: _____

WVDOH Representative: _____

FHWA Representative: _____

(Note: Project Description in above table should be the complete scope of the project: i.e. major or minor construction, urban or rural, reconstruction, rehabilitation, pavement overlay, etc. using the descriptions given in DD-803 as a guide)

HIGHWAY ROUTE DATAAASHTO Functional
Classification

1. ☐ Urban ☐ Rural
2. ☐ Arterial ☐ Collector ☐ Local Road
3. ☐ Freeway ☐ Divided/Arterial ☐ Two-Lane Arterial
4. ☐ Interstate
5. ☐ Other (i.e. school property)

TERRAIN TYPE
☐ Level ☐ Rolling ☐ Mountainous

ADA REQUIREMENTS (Document Only Exceptions)

	<u>ADA Requirements Triggered</u>	<u>Existing Condition</u>	<u>Design Criteria</u>	<u>Proposed Action</u>	<u>Criteria Source</u>
1.	Sidewalk	_____	_____	_____	_____
2.	Curb Ramps	_____	_____	_____	_____
3.	Detectable Warnings	_____	_____	_____	_____
4.	Accessible Signals	_____	_____	_____	_____
5.	Accessible Parking	_____	_____	_____	_____
6.	Van Accessible Spaces	_____	_____	_____	_____
7.	Path of Travel	_____	_____	_____	_____
8.	Bridge	_____	_____	_____	_____
9.	Other	_____	_____	_____	_____

(Note: references to the appropriate Section number of the 2010 ADA Standards for Accessible Design and proposed PROWAG Standards are to be used as the Design Criteria and the Criteria Source in the above table and in the Exception Report)

APPROVAL SIGNATURES**RECOMMENDED:**

1. _____
Consultant

2. _____
Project Engineer

3. _____
District/Division ADA Coordinator

APPROVED:

ADA Board Chairman

REVIEWED:

Federal Highway Administration

SHEET _____ **OF** _____

NARRATIVE DISCUSSION OF ADA EXCEPTION(S): Attach appropriate photos or other documentation as needed

[illegible]

**WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**

**DESIGN DIRECTIVE 813
BICYCLE/PEDESTRIAN ACCOMMODATION**

September 6, 2023

Supersedes September 30, 2013

The goal of the West Virginia Division of Highways (WVDOH) is to plan, design, construct, maintain and operate a safe, efficient, and economical highway system for all users of the system. While motor vehicle traffic is the major concern in performing this task, bicyclists and pedestrians must also be given proper consideration.

In order to integrate the needs of the motorized and non-motorized users of our highway system, the WVDOH, in cooperation with the Federal Highway Administration (FHWA), adopted “The Statewide Plan for Accommodation of Bicycle Transportation and Pedestrian Walkways” dated September 1997. Based on this document it is the policy of the WVDOH that during the design of all highway construction projects, consideration will be given, as outlined herein, for the incorporation of facilities for the accommodation of bicyclists and pedestrians.

The designer’s attention is directed to the following publication: “Guide For Development Of Bicycle Facilities 2012 (Fourth Edition)”, AASHTO (hereinafter referred to as the 2012 AASHTO Bicycle Guide) or most current edition. Many of the definitions in this Design Directive are summarized from this resource, and it is the source of any design standards not described here in detail. It is to be used as a reference supplementing this Design Directive.

DEFINITIONS

Bicycle Facilities: A general term denoting improvements and provisions made by public agencies to accommodate or encourage bicycling, including parking and storage facilities, and shared roadways not specifically defined for bicycle use. This includes new or improved lanes, paths, or shoulders for use by bicyclists as well as traffic control devices, shelters, and parking facilities for bicycles.

Bikeway: A generic term for any road, street, path, or way which in some manner is specifically designated for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes. **NOTE:** All public highways in West Virginia are open to bicycle traffic; however, on facilities such as Interstate Highways, bicycles are prohibited except in some very limited circumstances, such as when a fully controlled access highway is the only link between two separate bikeway segments.

Bicycle Boulevard: a local street or series of contiguous street segments that have been modified to function as a through street for bicyclists, while discouraging automobile through travel. Local access is maintained.

Bicycle Network: A system of bikeways designated by the jurisdiction having authority. This system may include bike lanes, bicycle routes, shared use paths, and other identifiable bicycle facilities.

Bicycle Lane: A portion of the roadway that has been designated for preferential or exclusive use by bicyclists by pavement markings. It is intended for one-way travel, usually in the same direction as the adjacent traffic lane, unless designed as a contra-flow lane.

Bicycle Route: A roadway or bikeway designated by the jurisdiction having authority, either with a unique route designation or with Bike Route signs, along which bicycle guide signs may provide directional and distance information. Signs that provide directional, distance, and destination information for bicyclists do not necessarily establish a bicycle route.

Category I Roadways: Any highway facility that is a partially controlled access facility or any highway facility that contains four (4) or more travel lanes with design speeds greater than 40 mph.

Category II Roadways: Any non-controlled highway facility or street not defined as being a Category I Roadway.

Pedestrian Walkway Facilities: A general term denoting improvements and provisions made by public agencies to accommodate or encourage walking. This includes new or improved lanes, paths or sidewalks.

Combined Facilities: A combined facility, for the purpose of this directive, is a facility designated for use by bicyclists and pedestrians.

Rural Areas: All parts of the highway system NOT within an urban area as described in “Urbanized Areas” below.

Shared Lane: A lane of a traveled way that is open to both bicycle and motor vehicle travel.

Shared Use Path: A bikeway physically separated from motor vehicle traffic by an open space or barrier and either within the highway right of way or within an independent right of way. Shared use paths may also be used by pedestrians, skaters, wheelchair users, joggers, and other non-motorized users. Most shared use paths are designed for two way travel.

Trails: Facilities that may be used by, but not limited to, non-motorized vehicles, horseback riders, cross-country skiers, and pedestrians.

Urbanized Areas: All parts of the highway system within an urban area as shown on The West Virginia Urban Area maps maintained by the Planning Division. These maps are located on the Division’s website at the following link:
<https://gis.transportation.wv.gov/ftp/Urban%20Area%20Maps/www.transportation.wv.gov/highways/programplanning/gti/GIS/MAPS/Pages/UrbanAreaMaps.aspx>.

BICYCLES

During the environmental review and/or planning process, the WVDOH will assess the need and potential for the development of bicycle facilities as a part of the project. The criteria

in the "Statewide Plan for Accommodation of Bicycle Transportation and Pedestrian Walkways", September 1997 will be considered. Reference is also made to the 2012 AASHTO Bicycle Guide or most current edition. It should be noted that the development of a bicycle facility may be combined with the development of a pedestrian walkway facility. The resulting combined facility would be designated for both bicycle and pedestrian use. The combined facility must meet the criteria for both bicycles and pedestrians while accounting for the required safe separation of these two transportation modes.

If it is determined that bicycle facilities are to be incorporated in the project, the environmental documents shall include recommendations as to the type of bicyclist(s), as well as the type of facility to be considered in the design process.

The designer shall use the following criteria when determining the need for bicycle facilities in new construction or reconstruction projects.

A. Urbanized Areas

- Bicycle facilities shall be established in all new construction or reconstruction projects that add a new highway or alter the functionality of an existing highway. Exceptions to this policy are described below.
- Bicycle facilities may not be required if one or more of the following conditions exist:
 - Bicycles are prohibited from using the roadway.
 - The cost of establishing a bikeway is greater than ten (10) percent of the estimated construction cost of the project.
 - Existing population conditions and other factors indicate an absence of need for bicycle facilities.
 - Development costs such as right-of-way, utility relocation, environmental mitigation, historical resource avoidance, and others may be considered when determining the need to establish a bicycle facility.

B. Rural Areas

- Designated bicycle facilities may be considered during the design phase of the project
- All new construction or reconstruction projects that add a new highway or alter the functionality of an existing highway, shall as a minimum, be designed as a Category II Roadway.
- The designer shall consider the continuity of bicycle facilities on highways where the classification of the highway changes from urban to rural in relatively short distances.

The final decision for inclusion of bicycle facilities in the project will be made during the design process utilizing the above criteria. If the designer proposes not to incorporate bicycle facilities in the proposed project, written approval must be obtained from the Deputy State Highway Engineer– Construction/Development or Operations, as applicable–~~Applicable Chief Engineer~~.

Bicycle facilities will be accommodated by one or more of the following methods:

- Designation of the project as a Bikeway or a Bicycle Route;
- Inclusion of a Bicycle Lane in the design of the project in urban areas; or

- Designation of or the inclusion of a Shared Use Path in the design of the project.

Sidewalks should not be designated for bicycle use. Bicyclists may be encouraged, with appropriate signing, to use short segments of sidewalks. One example of this would be a bridge structure that provides a safer environment to traverse the bridge. This would only be considered if the bridge sidewalk is wide enough to accommodate both pedestrians and bicyclists, in which case the criteria for a “Combined Facility” would be utilized (see the 2012 AASHTO Bicycle Guide or most current edition).

Design Bicyclist: To address the needs of bicyclists of various skill levels, the WVDOH shall use a classification of bicyclists. This system is a modification of the existing classification system used by AASHTO. This system is described as follows (taken from the 2012 AASHTO Bicycle Guide):

Experienced and Confident: This group includes bicyclists who are comfortable riding on most types of bicycle facilities, including roads without any special treatments for bicyclists. This group also includes utilitarian and recreational rider of many ages who are confident enough to ride on busy roads and navigate in traffic. Such bicyclists may deviate from the most direct route to travel in their preferred riding conditions. Experienced bicyclists may include commuters, long distance road bicyclists, racers, and those who participate in rides organized by bicycle clubs.

Most experienced riders are comfortable riding with vehicles on streets. Some prefer on-street bike lanes, paved shoulders, or shared use paths. They prefer a more direct route to their destination and avoid riding on sidewalks.

Casual and Less Confident: This group includes a majority of the population, and includes a wide range of people: (1) Those who ride frequently for multiple purposes; (2) those who enjoy bicycling occasionally but may only ride on paths or low-traffic and/or low-speed streets in favorable conditions; (3) those who ride for recreation, perhaps with children and; (4) those for whom the bicycle is a necessary mode of transportation.

Casual riders prefer shared use paths, bicycle boulevards, or bike lanes along low volume, low speed roads and streets. They may have difficulty gauging traffic and may be unfamiliar with the rules-of-the-road for bicyclists. They may use less direct routes to avoid heavy traffic volumes and are more likely to ride on sidewalks.

PEDESTRIANS

During the environmental review and/or planning process, the WVDOH will assess the need and potential for the development of pedestrian walkway facilities as a part of the project. The criteria in the "Statewide Plan for Accommodation of Bicycle Transportation and Pedestrian Walkways", September 1997 will be considered. Reference is also made to the following publication: “Guide for the Planning, Design, and Operation of Pedestrian Facilities, July 2004, AASHTO. It should be noted that the development of a pedestrian walkway facility may be combined with the development of a bicycle facility. The resulting combined facility would be designated for both pedestrian and bicycle use. The combined facility must meet the criteria for both bicycles and pedestrians while accounting for the required safe separation of these two

transportation modes.

If it is determined that pedestrian walkway facilities should be considered, the environmental documents would include recommendations as to the type of facility to be constructed. Facilities to be considered are sidewalks, shoulders and/or separate paths.

Any pedestrian accommodation on a project must be in accordance with DD-811 (Curb Ramps and Sidewalks) and be in accordance with the additional design standards noted below.

The designer shall use the following criteria when determining the need for pedestrian walkway facilities in new construction projects.

A. Urbanized Areas

- Pedestrian walkway facilities shall be established in all new construction or reconstruction projects that add a new highway or alter the functionality of an existing highway. Exceptions to this policy are described below.
- Pedestrian walkway facilities may not be required if one or more of the following conditions exist:
 - Pedestrians are prohibited by law from using the roadway.
 - The cost of establishing a pedestrian walkway is greater than ten (10) percent of the estimated construction cost of the project.
 - Existing population conditions and other factors indicate an absence of need for pedestrian walkway facilities. Development costs such as right-of-way, utility relocation, environmental mitigation, historical resource avoidance, and others may be considered when determining the need to establish a pedestrian walkway facility.

B. Rural Areas

- Designated pedestrian walkway facilities may be considered during the design phase of the project.
- All new construction or reconstruction projects that add a new highway or alter the functionality of an existing highway, shall as a minimum, be designed as a Category II Roadway.
- The designer shall consider the continuity of pedestrian walkway facilities on highways where the classification of the highway changes from urban to rural in relatively short distances.

On bridge construction projects, a sidewalk shall be designed as a part of the bridge if sufficient pedestrian activity exists and there is not a suitable pedestrian crossing reasonably close to the bridge. In the case of bridge replacement projects, a sidewalk shall be designed as a part of the bridge if the existing structure had a sidewalk or if sufficient pedestrian activity exists and there is not a suitable pedestrian crossing reasonably close to the bridge.

DESIGN STANDARDS

The following design standards have been developed for bicycle and pedestrian accommodation. These lists are not considered to be all-inclusive. The designer should consult the 2012 AASHTO Bicycle Guide (or most current edition) for further guidance, especially for design guidance for Shared Use Paths. The “Proposed Accessibility Guidelines for Pedestrian

Facilities in the Public Right of Way” (PROWAG), dated July 26, 2011, should be considered as minimum criteria for the design of any new or the replacement of any existing pedestrian facility.

A. General (Applicable to Pedestrian and Bicycle)

- The designer is cautioned to review sight distances carefully due to extra height of barriers as a design exception could be necessary for the extra height where a normal height barrier would not have needed one.
- All paved shoulders to accommodate both pedestrians and bicycles
- All structures shall have a combination of railings, fences or barriers with a minimum height of 42” for pedestrians and bicycles. A 48” railing shall be considered for the following conditions:
 - Where bicycle speeds are likely to be high (such as on a downgrade)
 - Where a bicycle could impact a barrier at a 25 degree angle or greater (such as in a curve)
 - Where significant bicycle traffic is anticipated
 - Where a bicycle falling over the rail could be catastrophic, such as a high drop off or into traffic.
- Drainage grates for bicycle routes shall be of a bicycle safe design.
- Reference is made to DD-645, Rumble Strips, to bicycle mitigation methods for rumble strips.

B. Category I Roadways

- Bicycle accommodations are to be designed for one way operation
- Bicycles to be encouraged to utilize right shoulder (with signing)
- Bicycles to be encouraged to use exit and entrance ramps shoulders (with signing)
- Minimum 5’-0” width of right shoulder (non-structure)* without rumble strip
- Minimum 6’-0” width of right shoulder (bridge structure)* without rumble strip
- Bridge expansion joints must be bicycle safe on the right shoulder (no exposed finger dams)

***NOTE:** The values for shoulder width shown in DD-601 shall supersede the values shown above if the values in DD-601 are greater.

C. Category II Roadways

- Bicycle accommodations are to be designed for one way operation
- When the ADT is greater than 1000 vpd, shoulders may be paved if bicycle and/or pedestrian walkway facilities are to be considered
- When the ADT is less than 1000 vpd, paved shoulder widths of 2’-0” should be considered; however, paved shoulder widths of 4’-0” or greater are encouraged. For pedestrian facilities, in absence of paved shoulders, a stabilized shoulder of 2’-0” minimum or 4’-0” preferred widths should be encouraged.
- All structures shall have a minimum shoulder width similar to the approach roadway shoulder width, but does not have to exceed 5’-0”
- Bridge expansion joints for bicycle facilities
 - If shoulder is 5’-0” or greater, no exposed finger dams on the right

shoulder

- If shoulder is less than 5'-0", no exposed finger dams on full roadway
- On curbed sections of roadways on bicycle routes, width of right lane shall be 14'-0", including the gutter pan.
- Structures without sidewalk shall have minimum shoulder widths of 4'-0"
- Structures with sidewalks shall have 4' minimum sidewalk widths and right lane/shoulder combined width of 14'-0" (12'-0" lane/2'-0" shoulder)

D. Shared Use Paths

- Designed for 2 way operation
- Minimum Travel Width - 10' with 2'-0" graded shoulders
- Reduced width of 8' in very rare circumstances or for short distances due to physical constraints.
- Structure railing/fence/barrier must be at least 5'-0" from the edge of shoulder of parallel roadway or separated by a combination of railings, fence or barrier with a height as described above.
- Superelevation 2% (no crown)

WVDOH Manuals Committee Meeting

Wednesday, August 6, 2025

Meeting Location: 1900 Kanawha Blvd. E., Building 5, Room 820, Charleston, WV

Also meeting virtually via Google Meet. Email distribution includes instruction.

Old Business:

ITEM	Champion
2nd time to Committee. Discussed in: June. <i>Construction Manual</i> <ul style="list-style-type: none">○ This is an update to <i>Section 402-Asphalt Skid Resistant Pavement</i>. The revision removes language from 402.2-Records and Daily Reports.	J. Cummings

New Business:

ITEM	Champion
1st time to Committee. <i>Drainage Manual – Chapter 8: Culverts</i> <ul style="list-style-type: none">○ This is an update to Chapter 8 Culverts. The revision adds clarification to several subsections and makes grammatical and format changes throughout the chapter.	D. Holmes

Next Meeting: The next meeting is on:

- **Wednesday, October 1., 2025.**
- **Deadline for submissions September 2, 2025.**

Adjournment:

SECTION 402 ASPHALT SKID-RESISTANT PAVEMENT

402.1-GENERAL

Section 401 covers many topics that are applicable to the construction of HMA skid-resistant pavements. Section 401.1 covers general topics including aggregate and binder materials, quality control, Job Mix Formulas, maintenance of traffic, preconstruction conferences, and safety considerations. Sections 401.2, 401.3, and 401.4, respectively, present a significant number of topics and inspection guidelines that are associated with HMA production and hauling, laydown and compaction, and troubleshooting equipment and mat problems. The following sections present information specific to the construction of HMA skid-resistant pavements.

402.1.1-Description of Work The HMA skid resistant pavement is an HMA wearing course that has skid resistant properties. The Contract Plans will designate the limits of this work. The wearing course will be constructed in accordance with the guidelines presented in Section 401 of this Manual. The following sections clarify the exceptions and additions to Section 401. The Project Inspector is responsible for ensuring that the Contractor performs the work in conformance with the Contract Plans and Specifications.

402.1.2-Aggregate and Asphalt Binder Materials The Primary difference between the HMA discussed in Section 401 and the HMA skid-resistant wearing course is that the skid-resistant wearing course is that the skid-resistant wearing course contains a coarse aggregate blend that is polish resistant. Acceptable types of in Section 402 of the Specifications and will be designated in the contract specifications. During the work, verify that the correct materials are being used.

402.2-RECORDS AND DAILY REPORTS

~~The Project Engineer/Supervisor shall request the performance of skid resistance and smoothness tests when required by the contract specifications.~~ See Section 401.5 for additional information on records and Daily Work Reports for skid-resistant pavements. See Specification section 720 for more information on requirements for smoothness testing. ~~See MP 721.10.01 for more information on the requirements for skid testing.~~

402.3-MEASUREMENT FOR PAYMENT

See Section 401.6 for applicable guidance on measuring quantities for payment for HMA skid-resistant pavements.

SECTION BREAK

NEW BUSINESS ITEMS



Chapter 8 Culverts

West Virginia
Department of Transportation
Division of Highways
Drainage Manual

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CHAPTER 8 CULVERTS

8.1 INTRODUCTION

Culverts are defined as hydraulic structures designed to convey surface water runoff under a highway embankment. This chapter outlines the policies, criteria, and guidelines for the hydraulic design of highway culverts. The information presented should enable the designer to select, plan, and design conventional highway culverts. This chapter does not cover all aspects of culvert design. The reference list at the end includes publications by the FHWA that should be consulted for additional information regarding specialized aspects of culvert design. Hydraulic Design Series 5 (HDS-5) is the primary FHWA reference for culvert design.

8.2 GENERAL DESIGN POLICY

The designer shall use the following general policies as a guide to select, plan, and design culverts placed beneath highways:

- Culverts shall be hydraulically designed.
- Culverts located in floodplains mapped by the Federal Emergency Management Agency shall satisfy the requirements of the National Flood Insurance Program.
- Culverts shall be designed to consider construction and maintenance costs, risk of failure, risk of property damage, traffic safety, and environmental considerations.
- Culverts shall be designed to be structurally stable and hydraulically efficient.
- The detail of documentation for each culvert site shall be commensurate with the risk and importance of the structure.

8.3 DESIGN CRITERIA

Culverts shall be designed with the following minimum design criteria to integrate hydraulics, economics, safety, environmental considerations, and maintenance.

8.3.1 STRUCTURE TYPE SELECTION

The choice between a culvert and a bridge at a given site shall be based on the following criteria:

Culverts are used:

- Where more economical than a bridge
- Where debris and ice are not significant
- Where bridges are not required to reduce backwater impacts
- Where environmentally acceptable

CHAPTER 8 CULVERTS

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- Culverts shall be designed to consider construction and maintenance costs, risk of failure, risk of property damage, traffic safety, and environmental considerations.
- Culverts shall be designed to be structurally stable and hydraulically efficient.
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8.2 GENERAL DESIGN POLICY

The designer shall use the following general policies as a guide to select, plan and design culverts placed beneath roadways and highways:

- Culverts shall be hydraulically designed;
- Culverts shall be located to present a minimum hazard to the public and the environment;
- Culverts shall be designed to be structurally stable and hydraulically efficient;
- Culverts shall be designed to consider construction and maintenance costs, risk of failure, risk of property damage, traffic safety and environmental considerations;
- The detail of documentation for each culvert site shall be commensurate with the risk and importance of the structure;
- Culverts located in floodplains mapped by the Federal Emergency Management Agency shall satisfy the requirements of the National Flood Insurance Program.

8.3 DESIGN CRITERIA

Culverts shall be designed with the following minimum design criteria to integrate hydraulics, economics, safety, environmental considerations, and maintenance.

8.3.1 STRUCTURE TYPE SELECTION

The choice between a culvert and a bridge at a given site shall be based on the following criteria:

- Where floodway encroachments are not critical
- Where overtopping potential and damage due to overtopping is low

Bridges are used:

- Where culverts cannot be used
- Where it is more economical than a culvert
- To avoid floodway encroachments
- To satisfy land use requirements
- To reduce environmental impacts caused by a culvert.
- To accommodate ice and large debris

8.3.2 LOCATION, ALIGNMENT AND GRADE

Culverts shall be in the existing channel to avoid major stream relocations beyond the roadway construction limits and to reduce environmental impacts. Where stream channel relocation is necessary, it shall be done without causing abrupt transitions of the stream at either end of the culvert. Consider the temporary diversion of the stream and constructability when locating a culvert.

Culverts shall be aligned with the direction of flow and with the natural grade of the stream. Improper selection of the alignment and grade can decrease hydraulic performance and increase sediment deposition, debris, and scour.

On steep terrain, long culverts under high fills should be designed to follow existing stream alignments with both horizontal and vertical bends. This will reduce trench excavation and possibly reduce outlet velocity.

8.3.3 MINIMUM SIZE

The minimum size of a culvert shall be determined based on the peak discharge of the design flow from the contributing drainage basin. Culverts in perennial streams shall span the bankfull channel if possible. In some instances, culverts may be oversized to limit upstream inundation due to headwater. Culverts may be sized to accommodate debris and to avoid maintenance problems due to sediment accumulation and clogging. Buoyancy issues should also be evaluated where they may be a concern. Table 8-1 denotes the minimum culvert diameter according to the type of roadway.

Driveway conduit is not classified as a culvert. For residential access it shall be a minimum of 15 inches in diameter for the case of single property access and 18 inches for single or multiple property access with more than 1 acre of contributory drainage area. For commercial or industrial

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Driveway conduit is not classified as a culvert. For residential access it shall be a minimum of 15 inches in diameter for the case of single property access and 18 inches for single or multiple property access with more than 1 acre of contributory drainage area. For commercial or industrial access it shall be a minimum of 18 inches. The placement of the driveway conduit shall not alter the natural water course. Driveways which cross a stream or natural water course have no allowable minimum size and shall be hydraulically designed. This criterion is presented in Section 6.3.11.

Storm drain conduit, which is also not classified as a culvert, shall be a minimum of 18 inches in diameter underneath of multi-lane or two-lane highways and a minimum of 24 inches in diameter when crossing multi-lane highways. The multi-lane crossing criteria is subject to the rule that conduit size shall not decrease in the downstream direction. This criterion is presented in Section 5.2.6.

8.3.3 MINIMUM SIZE

The minimum size of a culvert shall be determined based on the peak discharge of the design flood from the contributing drainage basin. In some instances culverts may be oversized to limit upstream inundation due to headwater. Culverts shall be sized to accommodate debris and avoid maintenance problems. The minimum culvert diameters based on the roadway classification shall be as shown in Table 8-1. It should be noted that storm drain and median drain pipes, which are not classified as culverts, should be at least 18 inches in diameter and inlet drain pipes should be at least 12 inches in diameter.

access it shall be a minimum of 18 inches. The placement of the driveway conduit shall not alter the natural water course. Driveways which cross a stream or natural water course have no allowable minimum size and shall be hydraulically designed. This criterion is presented in Section 6.3.11.

Storm drain conduit, which is also not classified as a culvert, shall be a minimum of 18 inches in diameter underneath of multi-lane or two-lane highways and a minimum of 24 inches in diameter when crossing multi-lane highways. The multi-lane crossing criteria is subject to the rule that conduit size shall not decrease in the downstream direction. This criterion is presented in Section 5.2.6.

Table 8-1
Minimum Culvert Diameter

Multi-lane Highways	24 inches
Two-lane Highways	18 inches

8.3.4 STORM FREQUENCY

Highway culverts shall be designed for the storm criteria shown in Table 4-2 and shall be evaluated based on the check storm criteria in Section 4.3.2 of Chapter 4.

Temporary culverts used to maintain drainage during construction should be sized based on the expected duration of the project and shall be designed for a storm recurrence interval of no less than the 2-year event.

8.3.5 HYDROLOGY

A constant peak discharge shall be assumed for most culvert designs to size the structure conservatively. Culverts shall be designed for the peak flow calculated at the inlet end of the culvert. The design peak flow shall be determined by the methods outlined in Chapter 4, Section 4.4. Hydrograph and storage routing methods are generally not used for designing culverts unless unusual circumstances exist.

8.3.6 MAXIMUM ALLOWABLE HEADWATER

Allowable headwater is the depth of water that can be ponded at the upstream end of the culvert during the design storm event. It will be based on the following requirements:

- Non-damaging to upstream property
- Below the roadway subgrade
- HW/D no greater than 1.2

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A constant peak discharge shall be assumed for most culvert designs in order to size the structure conservatively. Culverts shall be designed for the peak flow calculated at the inlet end of the culvert. The design peak flow shall be determined by the methods outlined in Chapter 4.

Hydrograph and storage routing methods shall not be used for designing culverts unless unusual circumstances exist. An example would be the use of a smaller culvert for the purposes of inducing flow detention (increased headwater) behind it.

8.3.6 MAXIMUM ALLOWABLE HEADWATER

Allowable headwater is the depth of water that can be ponded at the upstream end of the culvert during the design storm event. It will be based on the following requirements:

- Non-damaging to upstream property
- Below the roadway subgrade
- HW/D no greater than 1.2
- Equal to the elevation where flow diverts around the culvert.
- For replacement culverts, no greater than the existing condition
- In compliance with FEMA and local floodplain regulations

A reduction in the HW/D ratio from 1.5 in the 2007 manual to the present 1.2 infers proper sizing of a culvert for the bankfull channel which reduces future maintenance and allows better aquatic organism passage. Culverts in perennial streams shall span the bankfull channel if possible.

Major culvert installations where the headwater may affect insurable structures, developable property, or that are located within a FEMA designated flood zone may need to be analyzed using a backwater analysis program with the Engineering Division’s approval.

8.3.6 MAXIMUM ALLOWABLE HEADWATER

Allowable headwater is the depth of water that can be ponded at the upstream end of the culvert during the design storm event. It will be based on the following requirements:

- Non-damaging to upstream property
- Below the roadway subgrade
- HW/D no greater than 1.5
- Equal to the elevation where flow diverts around the culvert
- For replacement culverts, no greater than the existing condition
- In compliance with FEMA and local floodplain regulations

Culverts shall be evaluated based on the check storm criteria in Section 4.3.2 of Chapter 4. Major culvert installations where the headwater may affect insurable structures, developable property, or that are located within a FEMA designated flood zone may need to be analyzed using a backwater analysis program with the Division’s approval.

- Equal to the elevation where flow diverts around the culvert.
- For replacement culverts, no greater than the existing condition
- In compliance with FEMA and local floodplain regulations

A reduction in the HW/D ratio from 1.5 in the 2007 manual to the present 1.2 infers proper sizing of a culvert for the bankfull channel which reduces future maintenance and allows better aquatic organism passage. Culverts in perennial streams shall span the bankfull channel if possible.

Major culvert installations where the headwater may affect insurable structures, developable property, or that are located within a FEMA designated flood zone may need to be analyzed using a backwater analysis program with the Engineering Division's approval.

8.3.7 TAILWATER RELATIONSHIP

Tailwater is defined as the depth of water downstream of the culvert. It is measured from the outlet invert and is an important factor in determining the culvert capacity and headwater elevation under outlet control conditions. Tailwater may be caused by the hydraulic resistance (roughness) of the downstream channel or by obstructions such as a low water crossing, another culvert, or a reservoir. Tailwater in a tributary may also be controlled by backwater from a larger stream. For culverts operating in outlet control, tailwater depths shall be determined for a range of discharges. Depths are obtained from normal depth calculations, back water calculations for a receiving stream, or flood insurance study data.

The tailwater for a culvert located near the confluence with another stream or large water body shall be determined by a joint probability analysis (See Table 5-10 Section 5.3.6.5 of Chapter 5) or by a hydrograph analysis. If the design storm events occur concurrently (statistically dependent with coincident peaks), the high-water elevation that has the same frequency as the receiving stream or water body shall be used. If the events are statistically independent, the joint probability of the flood magnitudes shall be evaluated and a likely combination resulting in a greater tailwater depth shall be used. A hydrograph model at the confluence would account for the timing of the peak flow from each watershed to the confluence. Refer to Section 8.4.10 for more details regarding tailwater conditions.

8.3.8 END TREATMENTS (INLET OR OUTLET)

End treatments for culverts larger than 36 inches shall consist of headwalls or wingwalls at both ends as shown in the WVDOH Standard Drainage Details. Metal end sections or safety end sections for larger pipes may be used if approved by the engineer.

End treatments shall be located outside of the clear zone on high-speed roads to eliminate the possible hazard to an out-of-control vehicle. For culverts that are skewed to the roadway, headwalls shall be placed perpendicular to the culvert rather than parallel to the roadway. End

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Tailwater is defined as the depth of water downstream of the culvert. It is measured from the outlet invert and is an important factor in determining the culvert capacity and headwater elevation under outlet control conditions. Tailwater may be caused by the hydraulic resistance (roughness) of the downstream channel or by obstructions such as a low-water crossing, another culvert, or a reservoir. Tailwater in a tributary may also be controlled by backwater from a larger stream. For culverts operating in outlet control, tailwater depths shall be determined for a range of discharges. These are obtained from normal depth calculations, back water calculations for a receiving stream or flood insurance study data.

The tailwater relationship for a culvert located near the confluence with another channel or large water body shall be determined by a joint probability analysis (See Table 5-10 Section 5.3.6.5 of Chapter 5, Storm Drainage Systems). If the design storm events occur concurrently (statistically dependent with coincident peaks), the high water elevation that has the same frequency as the receiving channel or water body shall be used. If the events are statistically independent, the joint probability of the flood magnitudes shall be evaluated and a likely combination resulting in a greater tailwater depth shall be used. Refer to Section 8.4.10 for more details.

treatments on all culverts shall consider buoyancy protection. Refer to Section 8.4.12 for more details regarding end treatments.

8.3.9 MAXIMUM OUTLET VELOCITY AND SCOUR PROTECTION

The maximum velocity at the culvert outlet shall be determined by evaluating a range of discharges up to the design discharge. The need for scour protection shall be based on the maximum outlet velocity. Protection shall be provided by creating a stable discharge area that reduces the velocity to the pre culvert installation velocity. In other words, the culvert outlet velocity should be equal to or less than the velocity in the outlet channel before the installation. Allowable velocities of the stream bed material (Table 8-4) shall be used as a guide to determine the need for scour protection.

Outlet scour protection may consist of channel stabilization with rock lining or an equivalent material. On the plans, rock lining shall be designated as “Dumped Rock Gutter”, or “Select Embankment” as shown in the Standard Details. The use of rock-lined scour basins and energy dissipators shall be based on site-specific conditions and designed in accordance with the guidelines of HEC-14, published by the FHWA.

8.3.10 MINIMUM VELOCITY

The minimum velocity in the culvert shall be adequate to prevent sedimentation at low flow rates. Culverts shall be designed for a minimum velocity of 2 feet per second when the culvert is flowing at a depth equal to 15% of the diameter of the culvert.

8.3.11 DEBRIS CONTROL

Culverts at locations where excessive sedimentation and debris problems are expected (such as in steep streams that transport heavy bed load) shall be designed to accommodate debris or proper provisions shall be made for debris maintenance. Access to the culvert for maintenance, personnel, and equipment shall be provided. Debris control shall be designed using the guidelines of HEC-9, published by the FHWA.

8.3.12 PIPE MATERIAL SELECTION

Culvert material selection shall be based on Design Directive-503 (DD-503), Selection of Pipe Materials, published by the West Virginia Division of Highways.

Culvert material, gage, and corrugation shall be specified based on Design Directive-502 (DD-502), Maximum and Minimum Fill Height Tables for Drainage Pipe, published by the West Virginia Division of Highways.

8.3.13 MULTIPLE BARRELS

Multiple barrel culverts should generally be avoided. They refer to the use of more than one pipe of the same diameter with the same invert elevations. Multiple barrel culverts in an active stream natural channel will clog with debris and sediment. The clogging will cause flooding that could damage the highway, adjacent property, and endanger motorists. Where debris and sediment transport are a concern, a single cell culvert is recommended. If a special circumstance exists where multiple barrel culverts are considered, stream stability, fish passage, and sediment transport should be evaluated.

Locations where multiple barrel culverts are troublesome include:

- Where the approach flow is supercritical with high velocity. Such locations shall require a single barrel or special inlet treatment to avoid hydraulic jump effects.
- Where fish passage is required (see Section 8.4.15), except where special treatment is provided to ensure adequate low flow, such as lowering one barrel (becoming multiple cell culverts see Section 8.4.15).
- Where a meander bend is present immediately upstream

8.3.14 ENVIRONMENTAL CONSIDERATIONS

Culvert locations shall be selected to minimize impacts to the streams and wetlands whenever practical. Consideration shall be given to constructing culverts in the “dry” by using a temporary diversion channel. Aquatic life movement shall be accommodated when required by law or may be considered when it is beneficial as mitigation for stream impacts (see Section 8.4.17). If multiple barrels are used, special treatment shall be provided to ensure adequate low flow, such as lowering one barrel (becoming multiple cell culverts see Section 8.4.15).

8.4 DESIGN CONCEPTS AND GUIDELINES

8.4.1 CULVERT TYPES

Culverts are constructed of materials such as reinforced concrete, corrugated steel, polyvinyl chloride, polypropylene, and high-density polyethylene plastic. Common culvert shapes include circular, box, elliptical, arch, and pipe arch. The material and shape are selected based on factors such as roadway profile, channel characteristics, hydraulic performance, strength, construction methods, and corrosion and abrasion resistance.

Conventional culverts with uniform barrel cross-sections throughout their length are considered in this chapter. Culvert inlets and outlets may consist of the culvert barrel projecting from the roadway fill, mitered to the embankment slope, or with end treatments such as headwalls, wing-walls with apron slabs, or standard end sections of concrete or metal.

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8.3.13 *MULTIPLE BARRELS*

When considering multiple barrel culverts, stream stability and sediment transport must be evaluated. Where debris and sediment transport are a concerns, a single cell culvert is recommended.

Multiple barrel culverts shall be avoided:

- Where the approach flow is supercritical with high velocity. Such locations shall require a single barrel or special inlet treatment to avoid hydraulic jump effects;
- Where fish passage is required, except where special treatment is provided to ensure adequate low flow, such as lowering one barrel (see Section 8.4.15);
- Where a high potential exists for debris problems and clogging of the culvert;
- Where a meander bend is present immediately upstream.

8.4.2 CULVERT HYDRAULICS

An exact theoretical analysis of culvert hydraulics is extremely complex because the flow is usually non-uniform with regions of both gradually varying and rapidly varying flow. An exact analysis involves determining change in flow type for various flows and tailwater elevations, backwater and drawdown calculations, energy and momentum balance, application of hydraulic model studies, and determination of hydraulic jump locations.

8.4.3 CONTROL SECTION AND MINIMUM PERFORMANCE

The procedures in HDS-5 were developed to simplify culvert hydraulic calculations and systematically analyze culvert flow based on a “control section”. A control section is a location where there is a unique relationship between the flow rate and the upstream water surface elevation. Many different flow conditions exist over time but at a given time the flow is either governed by the inlet geometry (inlet control) or a combination of the inlet geometry, the culvert barrel characteristics, and the tailwater elevation (outlet control). Control may oscillate from inlet to outlet; however, the design method is based on a “minimum performance”. This means while the culvert may operate more efficiently at times (i.e., more flow for a given headwater level), it will never operate at a lower level of performance than the calculated minimum.

The HDS-5 design method uses equations, charts, and nomographs that were developed from numerous hydraulic laboratory tests and theoretical calculations. Due to the error introduced in the test data because of scatter, it should be assumed that culvert sizes calculated with this method are accurate to within plus or minus 10 percent, (HDS-5, Sept 2001, Chapter III, Section A, 3rd paragraph, page 23) in terms of head.

8.4.4 INLET AND OUTLET CONTROL

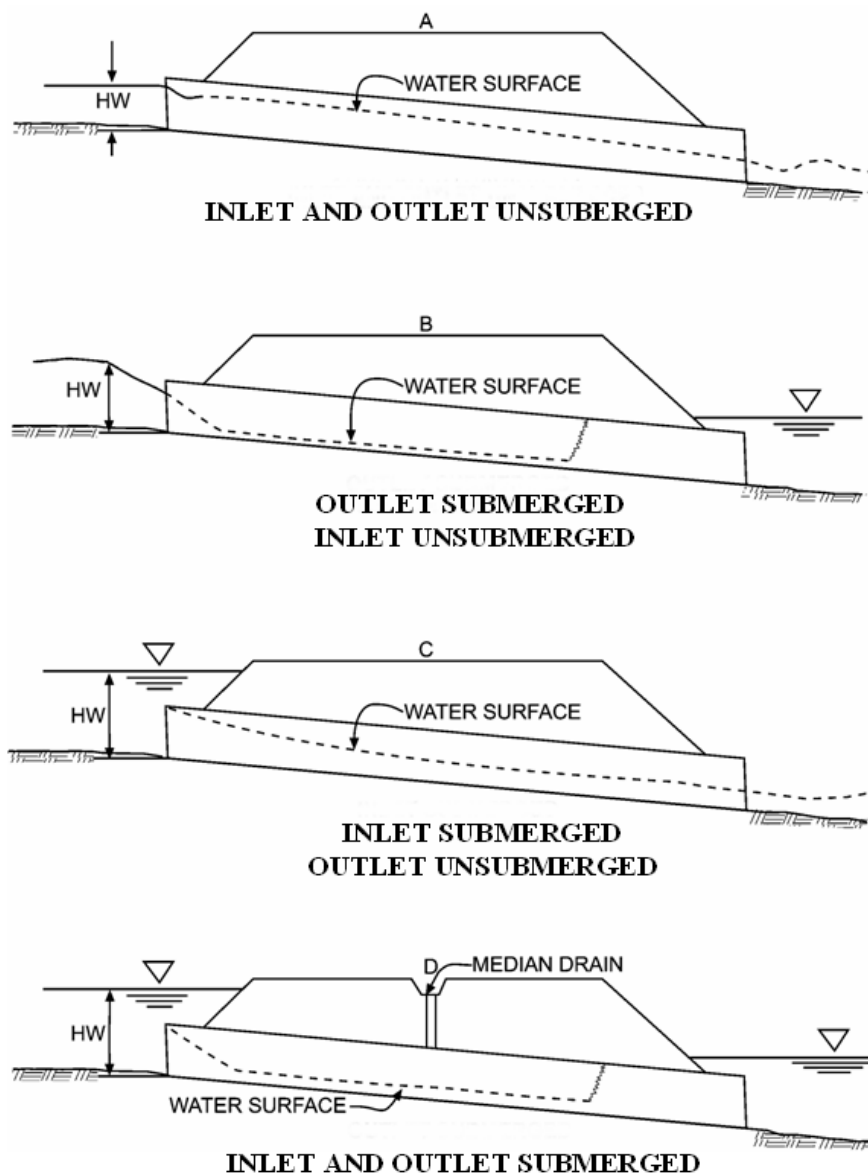
A culvert flowing in inlet control has shallow, high-velocity, supercritical flow with the control section located at the upstream end of the barrel. Inlet control is influenced by the headwater depth and inlet area, edge configuration, and shape. Figure 8-1 shows several examples of inlet control flow with either a submerged or unsubmerged inlet. The submerged inlet operates essentially as an orifice and an un-submerged inlet operates as a weir.

The inlet edge configuration is a major factor of inlet control performance, and it can be modified to improve performance. Modified inlets with beveled edges can reduce the flow contraction. This may decrease the headwater for a given barrel size or allow a smaller pipe for a given headwater.

A culvert flowing in outlet control will have a deep, low velocity, subcritical flow with the control section located at the downstream end of the culvert. The factors influencing outlet control are barrel roughness, tailwater elevation, headwater, edge configuration, barrel area, shape, length,

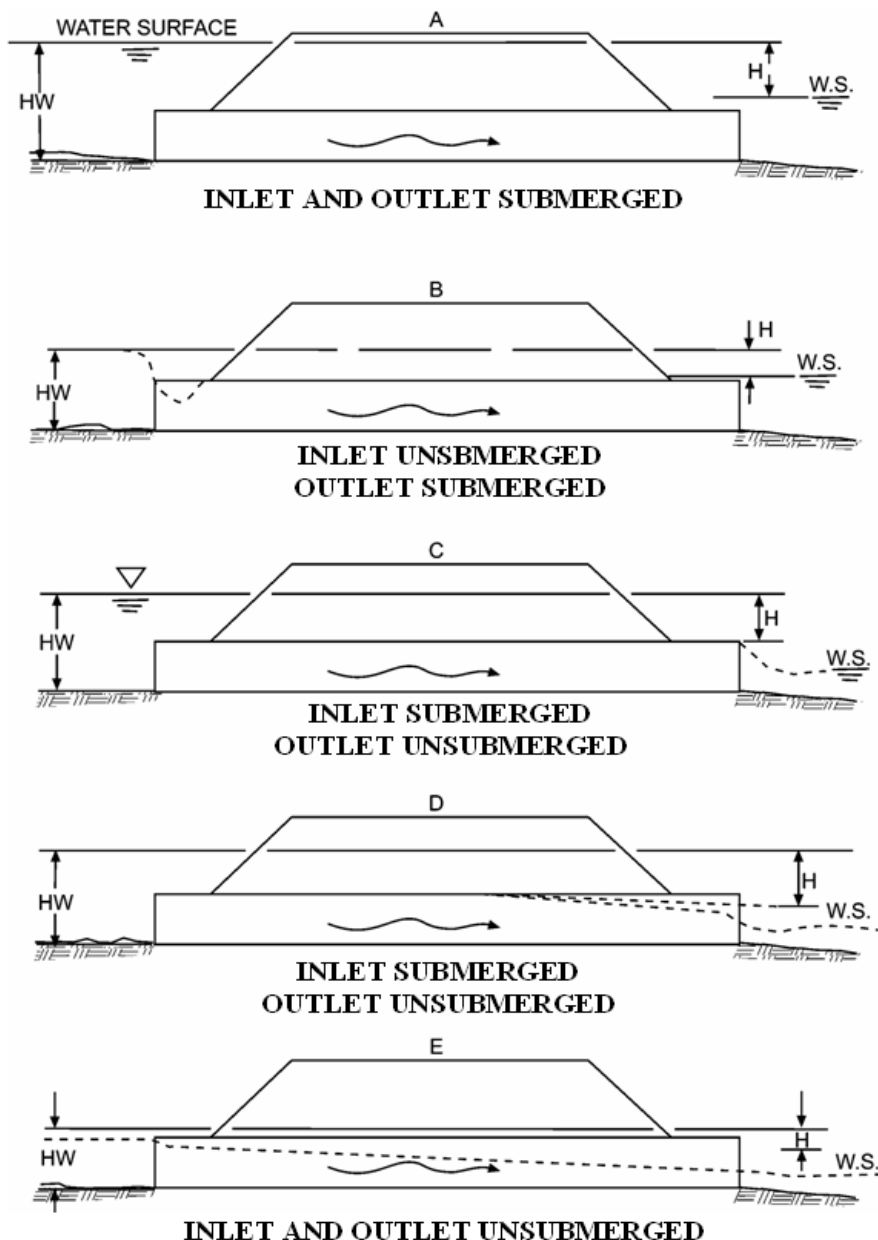
and slope. The greater depth of the tailwater or downstream channel, whichever is greater, is the control at the outlet. Figure 8-2 shows several examples of outlet control flow.

Figure 8-1
Types of Inlet Control



Source: *Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005*

Figure 8-2
Types of Outlet Control



Source: *Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005*

8.4.5 INLET AND OUTLET CONTROL EQUATIONS

The two conditions of inlet control depend upon whether the inlet end of the culvert is submerged by the upstream headwater. If the inlet is not submerged, the inlet performs as a weir. If the inlet is submerged, the inlet performs as an orifice.

The unsubmerged and submerged inlet control headwater design equations are provided below. Note that there are two forms of the unsubmerged equation. Form (1) is based on the specific head at the critical depth adjusted with two correction factors. Form (2) is an exponential equation similar in form to a weir equation. Form (1) is preferable from a theoretical standpoint, but Form (2) is easier to apply and is the only documented equation for some of the inlet control nomographs. A constant slope value of 2 percent was used for the development of the nomographs. This is due to the small effect of the slope and the conservatively high resultant headwater value for sites with slopes exceeding 2 percent.

UNSUBMERGED

$$\text{Form (1)} \quad \frac{HW_i}{D} = \frac{H_c}{D} + K \left[\frac{K_u Q}{AD^{0.5}} \right]^M - 0.5S$$

Note: For mitered inlets, the slope correction factor is **+0.7S instead of -0.5S** as shown in the equation below.

Note: For mitered inlets the slope correction factor is **+0.7S² instead of -0.5S²** as shown in the equation below.

The following equations are applicable up to $\frac{Q}{AD^{0.5}} = 3.5$

$$\text{Form (1)} \quad \frac{HW_i}{D} = \frac{H_c}{D} + K \left[\frac{K_u Q}{AD^{0.5}} \right]^M + 0.7S$$

$$\text{Form (2)} \quad \frac{HW_i}{D} = K \left[\frac{K_u Q}{AD^{0.5}} \right]^M$$

SUBMERGED

$$\frac{HW_i}{D} = c \left[\frac{K_u Q}{AD^{0.5}} \right]^2 + Y - 0.5S$$

The above equation applies above about $\frac{Q}{AD^{0.5}} = 4.0$

HW_i = Headwater depth above inlet control section invert (ft)

D = Interior height of culvert barrel (ft)

H_c = Specific head at critical depth (d_c + V_c²/2g) (ft)

Q = Discharge (ft³/s)

A = Cross-sectional area of the barrel (ft²)

K, M, c, Y Constants from Table 8-2

$K_u = 1.0$ for English units

$S = \text{Culvert barrel slope (ft/ft)} = 0.02$

Outlet control flow conditions are calculated based on energy balance. In its most basic form, the head loss H_L (total energy required to pass flow through a culvert with the barrel flowing full throughout its length) is made up of three major parts: an entrance loss (H_e), the friction loss through the culvert (H_f), and the exit loss (H_o).

$$H_L = H_e + H_f + H_o$$

The culvert barrel velocity is calculated as: $V = \frac{Q}{A}$

$V = \text{average velocity in the culvert barrel (ft/s)}$

$Q = \text{flow rate (ft}^3/\text{s)}$

$A = \text{full cross-sectional area of flow (ft}^2\text{)}$

The velocity head is expressed as: $H_v = \frac{V^2}{2g}$

$g = \text{acceleration due to gravity (32.2 ft/s}^2\text{)}$

The entrance loss (H_e) is expressed as a coefficient times the velocity head:

$$H_e = K_e \left(\frac{V^2}{2g} \right)$$

Table 8-2
Constants for Inlet Control Design Equations

CONDUIT	CHART	INLET EDGE TYPE	UNSUBMERGED		SUBMERGED	
			K	M	C	Y
CORRUGATED METAL PIPE	Chart 8-1	HEADWALL	0.0078	2.00	0.0379	0.69
		MITERED TO SLOPE	0.0210	1.33	0.0463	0.75
		PROJECTING	0.0340	1.50	0.0553	0.54
CONCRETE PIPE	Chart 8-4	SQUARE EDGE WITH HEADWALL	0.0098	2.00	0.0398	0.67
		GROOVE END WITH HEADWALL	0.0018	2.00	0.0292	0.74
		GROOVE END PROJECTING	0.0045	2.00	0.0317	0.69
HIGH DENSITY POLYETHYLENE PLASTIC PIPE	Chart 8-6	HEADWALL	0.0078	2.00	0.0379	0.69
		MITERED TO SLOPE	0.0210	1.33	0.0463	0.75
		PROJECTING	0.0340	1.50	0.0553	0.54
CONCRETE BOX CULVERTS	Chart 8-14	30° TO 75° WINGWALL FLARE	0.026	1.00	0.0347	0.81
		90° AND 15° WINGWALL FLARE	0.061	0.75	0.0400	0.80
		0° FLARE OR SIDE EXTENSION	0.061	0.75	0.0423	0.82
CORRUGATED METAL PIPE ARCH STANDARD SIZES	Chart 8-19	90° HEADWALL	0.0083	2.0	0.0379	0.69
		MITERED TO SLOPE	0.0300	1.0	0.0463	0.75
		PROJECTING	0.0340	1.5	0.0496	0.57
STRUCTURAL PLATE CORR. METAL PIPE ARCH 18 INCH CORNER RADIUS	Chart 8-21	90° HEADWALL	0.0083	2.0	0.0379	0.69
		MITERED TO SLOPE	0.0300	1.0	0.0463	0.75
		PROJECTING	0.0340	1.5	0.0496	0.57
HORIZONTAL ELLIPTICAL CONCRETE PIPE	Chart 8-32	SQUARE EDGE WITH HEADWALL	0.0100	2.0	0.0398	0.67
		GROOVE END WITH HEADWALL	0.0018	2.5	0.0292	0.74
		GROOVE END PROJECTING	0.0045	2.0	0.0317	0.69

Table 8-3
Entrance Loss Coefficients K_e

Outlet Control, Full or Partly Full Entrance Head Loss

$$H_e = K_e \left[\frac{V^2}{2g} \right]$$

<u>Type of Structure and Design of Entrance</u>	<u>Coefficient K_e</u>
• <u>Pipe, Concrete</u>	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius = D/12)	0.2
Mitered to conform to fill slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
• <u>Pipe, or Pipe-Arch, Corrugated Metal</u>	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
• <u>Box, Reinforced Concrete</u>	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of D/12 or B/12	
or beveled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of D/12 or beveled top edge	0.2
Wingwall at 10° to 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

*Note: "End Sections conforming to fill slope," made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections, incorporating a closed taper in their design have a superior hydraulic performance. These latter sections can be designed using the information given for the beveled inlet.

Source: *Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005*

The friction loss in the barrel (H_f) can be expressed as:

$$H_f = \left[\frac{29n^2 L}{R^{1.33}} \right] \frac{V^2}{2g}$$

n = Manning's Roughness Coefficient

L = Length of the culvert barrel (ft)

R = Hydraulic radius of the full culvert barrel = A / P (ft)

A = Cross-sectional area of the barrel (ft²)

P = Perimeter of the barrel (ft)

V = Velocity in the full barrel (ft/s)

Refer to Table 1-2 of Section 1.4 for Manning's Roughness Values for pipes.

The exit loss (H_o) for sudden expansion such as an endwall is:

$$H_o = 1.0 \left[\frac{V^2}{2g} - \frac{V_d^2}{2g} \right]$$

V_d = channel velocity downstream of the culvert (ft/s)

Since the downstream velocity is usually neglected, the exit loss becomes equal to the full flow velocity head in the culvert barrel.

$$H_o = H_v = \frac{V^2}{2g}$$

Inserting the above relationships for entrance loss, friction loss, and exit loss into energy or head loss equation, the following equation for total head loss is obtained:

$$H_L = \left[1 + k_e + \frac{29 n^2 L}{R^{1.33}} \right] \frac{V^2}{2g}$$

The outlet control headwater design equation:

$$HW_o = H_L + h_o - LS_o$$

Minor losses such as bend losses (H_b), junction losses (H_j), and losses at grates (H_g) should be included in energy or head loss equation if appropriate. See Chapter 5 section 5.3.6.8 for information on minor losses.

8.4.5.1 KEY PARAMETERS FOR CULVERT FLOW

Specific Energy

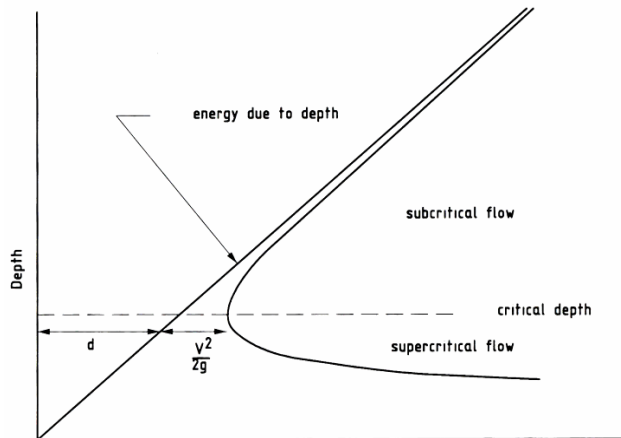
Specific energy (E) is the energy or head relative to the channel bottom. For a mild sloped channel with uniform flow (velocity and depth remain constant) the specific energy is defined as the depth plus the velocity head. If you look at the graph for depth vs. specific energy there is one depth at which the specific energy is at a minimum. This depth is the critical depth for the amount of flow or discharge.

$$E = \frac{V^2}{2g} + d$$

$$Q = VA \quad \text{or} \quad V = \frac{Q}{A}$$

The continuity equation transforms the specific energy equation in terms of depth, flow, and flow area.

$$E = \frac{Q^2}{2gA^2} + d \quad \text{(see Section 8.4.5 and this entire section for term explanations)}$$



It is important to define and distinguish between three important flow depths and how they pertain to a hydraulic pipe design.

Normal Depth

Normal depth is defined as the depth of uniform, steady flow under a constant discharge. In a uniform flow regime, the losses due to boundary friction are balanced by the force of gravity in the direction of the flow. In other words, friction and gravity forces in the direction of flow are equal but act in opposite directions. This creates a hydraulic condition where the discharge, cross-sectional area and velocity are constant throughout the length of the channel or pipe. The slope of the pipe invert, the slope of the water surface, and the slope of the energy grade line are equal and parallel to each other in this hydraulic condition.

Normal depth is a function of discharge, size of channel, shape of channel, slope of channel, and frictional resistance to flow. It can be calculated using the familiar Manning's Equation.

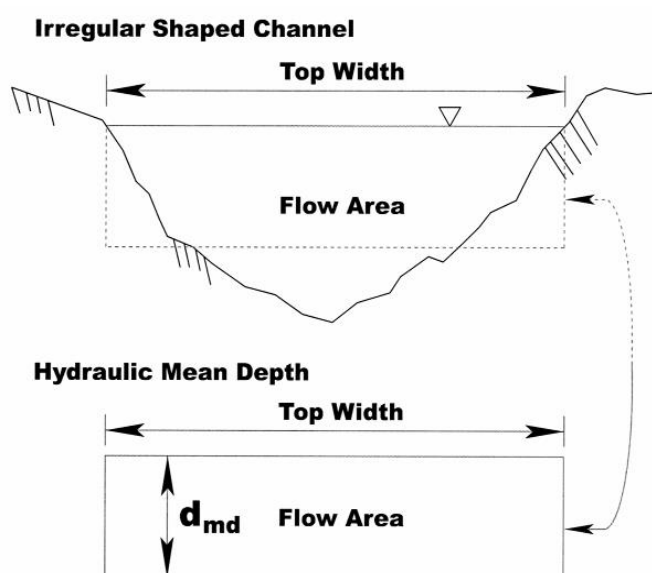
$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

$$Q = VA = \frac{1.486}{n} AR^{2/3} S^{1/2}$$

Hydraulic Mean Depth

The hydraulic mean depth is defined as the area of the flow cross section divided by the water surface top width. It is a method of characterizing an irregular shaped channel in terms of a rectangular shaped channel.

$$d_{md} = \frac{A}{T}$$



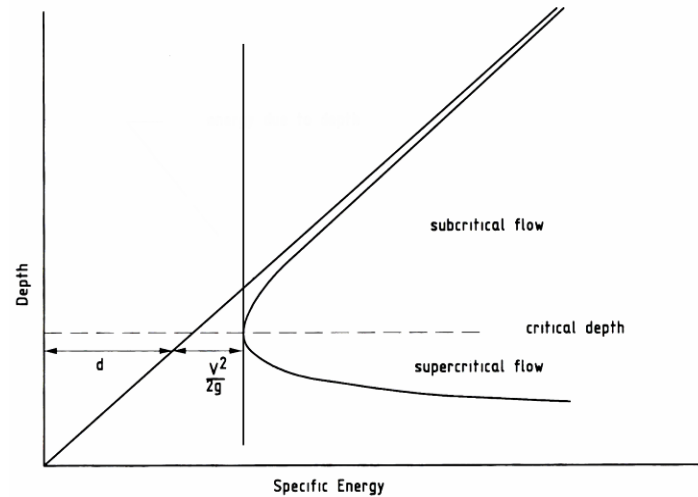
Critical Depth

The critical depth is defined as the depth at the point of minimum specific energy for a constant discharge. In most cases the occurrence of critical flow determines the location of the control point within that flow. The equation for determining critical depth is reached by taking the 1st derivative of the energy equation with respect to depth and setting it equal to zero (finding the point of zero slope with respect to the y axis).

$$E = \frac{Q^2}{2gA^2} + d$$

$$E = \frac{Q^2}{2g} \frac{1}{A^2} + d$$

$$\frac{dE}{dd} = \frac{Q^2}{2g} \frac{-2}{A^3} \frac{dA}{dd} + 1$$



If we take small enough slices of our channel, the change in area with respect to the change in depth is equal to the water surface top width:

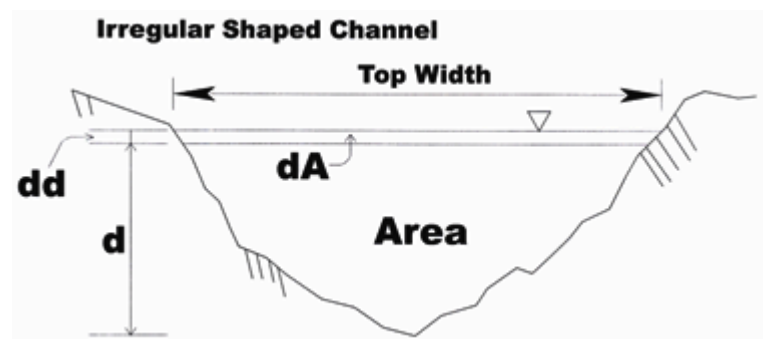
$$\frac{dA}{dd} = T$$

$$\frac{dE}{dd} = 1 - \frac{Q^2}{g} \frac{T}{A^3}$$

$$-\frac{Q^2}{g} \frac{T}{A^3} = -1$$

$$\frac{Q^2}{g} = \frac{A^3}{T}$$

Depth of flow determines the flow area (A) and the flow top width (T). To solve for critical depth, find the flow (Q) and its corresponding depth (d) that create the equality for this equation.



This equation applies to all sizes and shapes of pipe and is the source for the critical depth charts in this chapter. The calculation for determining the critical depth curves end at 94% of the

diameter for the case of circular pipes since this depth gives the maximum amount of discharge. The depth yielding the maximum amount of discharge will vary for arch pipes due to the many differences in cross sectional geometry. The same limit was used for the calculation of the critical depth curves for arch pipes to preserve consistency. Determining the critical depth beyond this 94% limit shall be taken from a “sketched” continuation of the calculated curve up to the diameter or rise of the pipe.

Critical Slope

Each culvert flow rate has a critical slope that corresponds to the critical depth.

$$S_C = \frac{14.56 n^2 d_{md}^{\frac{4}{3}}}{R^3}$$

The value of the critical slope can be compared against the slope of the culvert invert to determine the state of flow (see Chapter 5 Section 5.3.6.9). If S_c is greater than the slope of the culvert invert, then the flow is subcritical, and the control section is the outlet. If S_c is equal to the slope of the culvert invert, then the flow is critical inside of the culvert, and the control section is at the inlet.

Froude Number

When the flow is at critical depth, the specific energy is at a minimum and the Froude Number is equal to one. A detailed discussion of the Froude Number is provided in Chapter 5, Section 5.3.6.9. The derivation is provided here.

$$\frac{Q^2}{g} = \frac{A^3}{T} \quad Q = V A \quad \frac{V^2 A^2}{g} = \frac{A^3}{T}$$

$$\frac{V^2}{g} = d_{md}$$

The Froude Number: $\frac{V^2}{g d_{md}} = 1$ or $\frac{V}{\sqrt{g d_{md}}} = 1$

8.4.5.2 HIGH DENSITY POLYETHYLENE PLASTIC PIPE

The inlet and outlet control equations and their corresponding nomographs do not address the subject of designing a culvert using High density polyethylene plastic pipe (HDPE). This type has a smooth interior with a corrugated exterior. It was determined in the development of design

directive 503 (Design of Alternate Pipe Materials) that HDPE should be treated as a corrugated metal pipe in an inlet control situation. The constants K and M in an unsubmerged situation and c and Y in a submerged situation for circular corrugated metal pipe shall apply for HDPE in determining inlet control. This application shall be used for the headwall, mitered to slope, and projecting inlet edge description.

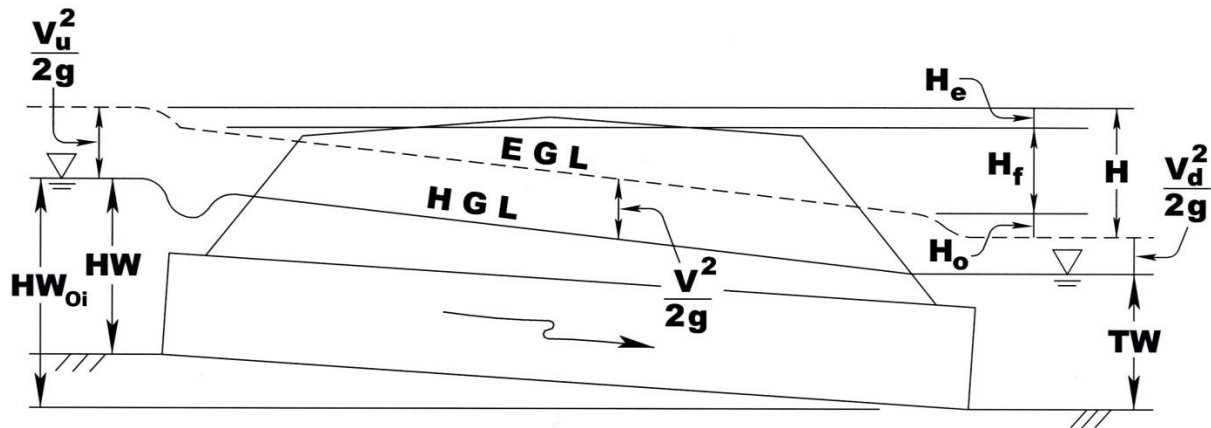
In an outlet control situation, the entrance loss coefficient K_e shall be the same as that for a concrete pipe. This application shall be valid for projecting from fill and headwall and wingwalls for a square or cut end, mitered to conform to fill slope, and an end section conforming to fill slope.

The roughness of the interior of the pipe varies with the type of backfill. When the non-compacted cementitious material, referred to as controlled low-strength material (see DOH specification 219) is used as backfill (type F trench see WVDOH Typical Sections and Related Details) the interior of the pipe remains smooth and the Manning's roughness coefficient is 0.013. When any other type of backfill is used the exterior corrugations tend to protrude into the interior and the roughness coefficient is 0.015. Since the nomographs for total head loss (H_L) use different roughness coefficients, only the equations on the nomographs can be used to determine total head loss for HDPEPP pipe in determining an outlet control headwater.

8.4.6 FULL FLOW ENERGY AND HYDRAULIC GRADE LINES

Figure 8–3 shows the energy grade line (EGL) and the hydraulic grade line (HGL) for full flow in a culvert barrel. The EGL represents the total energy at any point along the culvert barrel. The HGL is the water surface and the depth to which water would rise in vertical tubes connected to the sides of the barrel. The headwater (HW) and tailwater (TW) conditions as well as the entrance (H_e), friction (H_f), and exit (H_o) losses are also shown. HW is the depth from the inlet invert to the hydraulic grade line and HW_{oi} is the headwater depth above the outlet invert. V_u is the approach velocity and V_d is the downstream velocity.

Figure 8-3
Full Flow Energy and Hydraulic Grade Lines



8.4.7 ROADWAY OVERTOPPING

Roadway overtopping begins when the headwater rises to the elevation of the roadway. The overtopping will usually occur at the low point of a sag vertical curve resulting in flow that is equivalent to flow over a broad-crested weir. This overtopping flow is calculated using the weir equation:

$$Q = k C_d L H_w^{1.5}$$

Q = Overtopping flow rate (ft^3/s)

C_d = Overtopping discharge coefficient (weir coefficient)

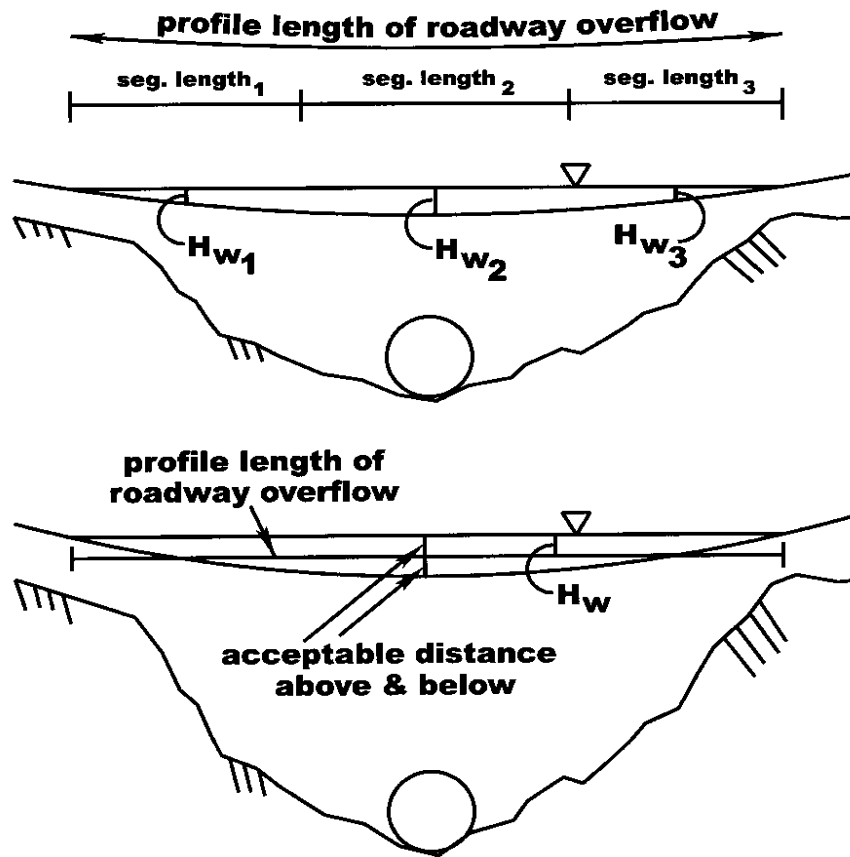
k = over-embankment flow adjustment factor

L = Profile length of the roadway overflow (ft)

H_w = Headwater depth measured above the roadway (ft)

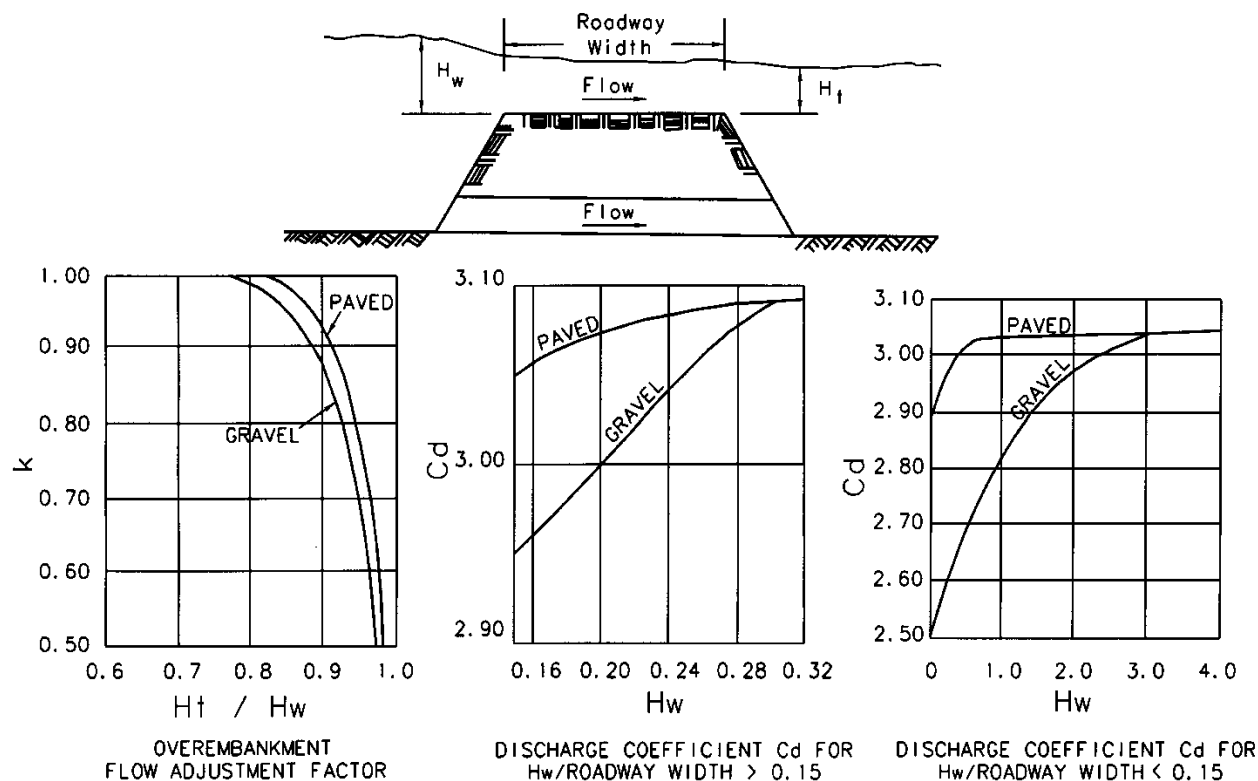
The length of overflow and the headwater depth along the roadway are difficult to determine when the overflow is defined by a sag vertical curve. The sag vertical curve can be broken into a series of horizontal segments and the flow over each segment is calculated for a given headwater using the weir equation (Figure 8–4). The given headwater is determined at the elevation along the vertical curve in the center of the horizontal segment. The overtopping flow rates for each segment are then added together, resulting in the total flow over the roadway.

Figure 8-4
Roadway Overtopping



The sag vertical curve can also be adequately represented by a single horizontal line with an acceptable variation above and below the line. The length of the overflow can be taken as this segment length or it can be based on the roadway profile. In effect, this method utilizes an average depth of the upstream pool above the roadway for the overflow calculation. Values of the weir coefficient (C_d in English Units) can be found in Figure 8-5 (Chart 60B from HDS-5). The roadway overflow plus the culvert flow must equal the design flow. A trial-and-error process are necessary to determine the amount of total flow passing through the culvert and the amount of flow over the roadway. Programs such as HY-8 are recommended when evaluating roadway overtopping.

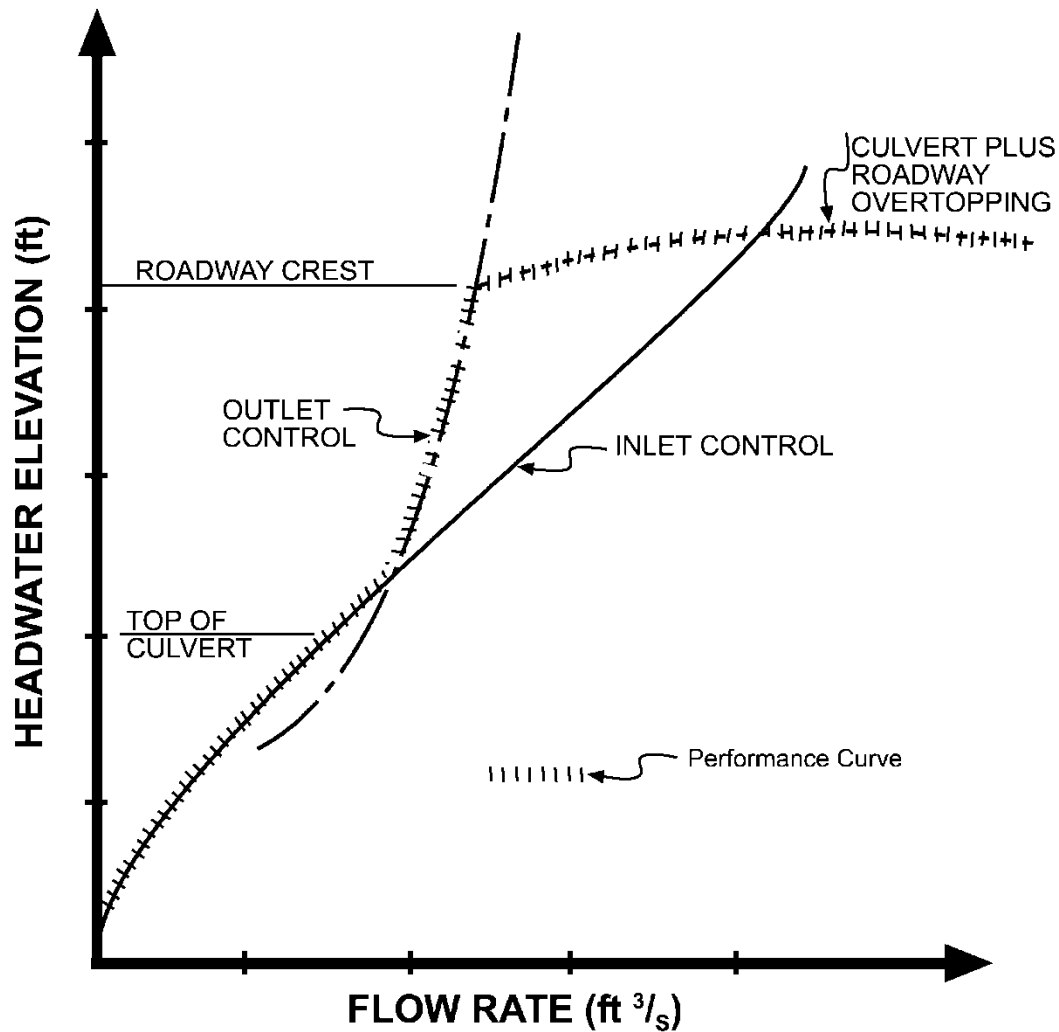
Figure 8-5
Roadway Overtopping / Discharge Coefficient



8.4.8 PERFORMANCE CURVES

Performance curves are plots of flow rate versus headwater depth or headwater elevation. Since the control section can exist at the inlet, outlet, or the throat of the culvert, a performance curve is possible for each control section including roadway overtopping. The overall performance curve is made up of the controlling portions of the individual curves for each control section. It can be used to determine the headwater depth or elevation for any flow rate, or to examine the performance of the culvert over a range of flow rates. Figure 8-6 depicts a typical culvert performance curve.

Figure 8-6
Overall Culvert Performance Curve



Source: *Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005*

An overall performance curve can be developed as follows:

1. Select a range of flows falling above and below the design discharge and calculate the corresponding inlet and outlet control headwater elevations.
2. Plot and combine the inlet and outlet control performance curves to define a single curve for the culvert.
3. For culvert headwaters that overtop the roadway crest elevation, use the weir equation (see Section 8.4.7) to calculate flow rates over the roadway.
4. Add the culvert flow and the roadway overtopping flow at the corresponding headwater elevations to obtain the overall performance curve.

8.4.9 ALLOWABLE HEADWATER

The economic design of culverts requires that consideration be given to the following effects:

- Hydraulic uplift or buoyancy, which is especially significant in permeable soils, and/or pipes with no headwalls. The possibility of uplift is increased when the culvert entrance becomes blocked with debris.
- Exfiltration in pipes due to pressure
- Erosion of the embankment due to falling headwater.
- Danger to fills due to seepage especially in hillside locations.
- Debris protection
- Maintenance
- Damage to upstream and downstream property
- Hazards to life
- Public image
- Acquisition of land affected by headwater. Areas inundated beyond levels of former flooding may need to be acquired.
- Possible future development of the land upstream

Allowable headwater depth criteria are provided in Section 8.3.6. The check storm should be evaluated in accordance with Section 4.3.2 (see Chapter 4).

The area upstream of a culvert where ponding might occur can impact the design of the culvert. If the upstream ponding area is limited, the allowable headwater may need to be reduced. Conversely, if the upstream area has a large storage capacity, the allowable headwater elevation could be increased thus reducing the required culvert size. In the latter case, the Division of Highways shall acquire the right to pond water on the affected area to prevent future development and maintain the area for ponding. This will require the purchase of right of way, permanent ponding easement, or permanent drainage easement. The delineation of the ponding area will require mapping with at least 2-foot interval contours.

8.4.10 TAILWATER CONDITIONS

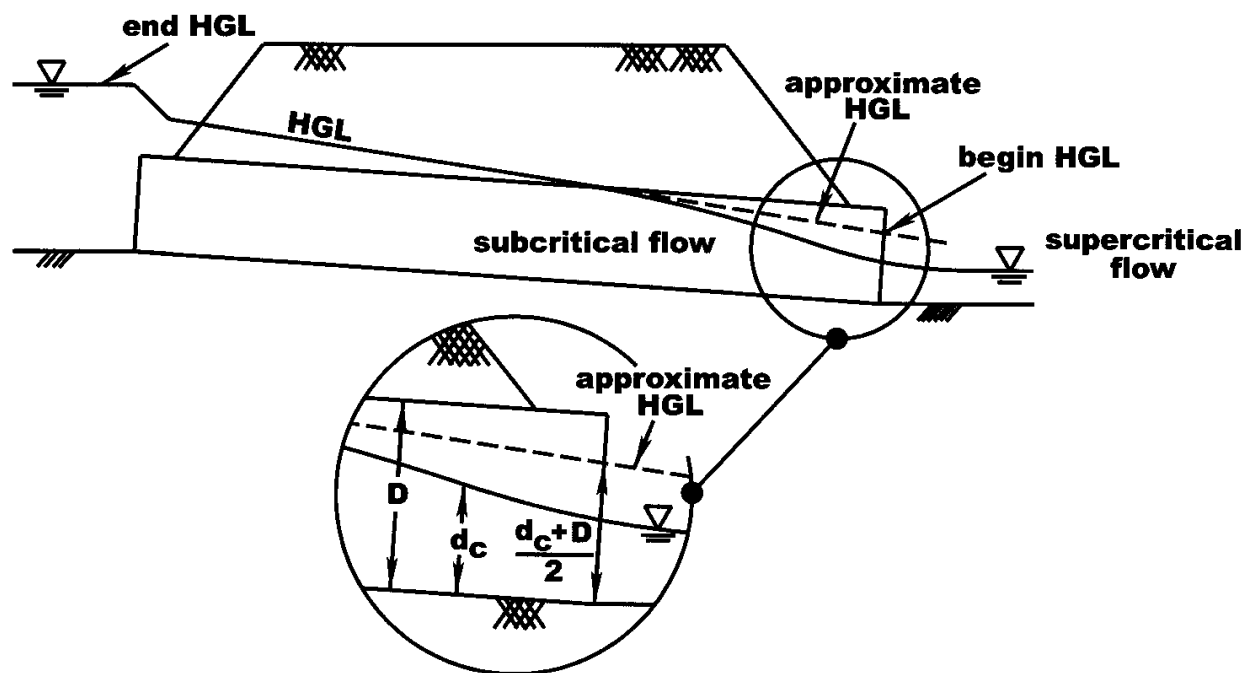
The tailwater elevation above the outlet invert at the design flow rate may be obtained from backwater calculations, normal depth calculations, or from field observations. A field inspection and a review of flood insurance studies should be made to check the effect of downstream controls on tailwater conditions at the outlet. Backwater computations from a downstream control point can be tedious and may require additional survey of the area. Normal depth computations

utilize Manning's Equation and the geometric properties of the outlet channel to determine a tailwater elevation, (assuming the channel is reasonably uniform in cross section) slope, and roughness. Once this elevation is determined, it is compared to the critical depth of flow for the culvert.

The critical depth of flow is a computable occurrence in the flow regime. Where this depth occurs, it influences the tailwater condition for a culvert. In the case of a hydraulic drop, flow changes from a subcritical state (slow, deep flow) to a supercritical state (shallow, fast flow). The depth of flow must pass through the critical depth to make this change in flow state.

In the case of the culvert flowing full at the outlet (as in Figure 8–3), the tailwater elevation is simple to determine. In the case of the culvert flowing partly full at the outlet, the tailwater is determined by comparing the observed or computed tailwater (from backwater or normal depth methods) with the critical depth. Based on numerous backwater calculations by the FHWA, it was determined that for partly-full flow, a downstream extension of the full-flow hydraulic grade line pierces the vertical plane of the culvert outlet at a point halfway between critical depth (d_c) and the top of the barrel (culvert diameter, D). This means the change in the flow state occurs within the culvert and the tailwater elevation at the culvert outlet is $(d_c + D)/2$ above the outlet invert (Figure 8–7). This is the value used to set the beginning of the hydraulic grade line at the outlet for the calculation of headwater in an outlet control situation.

Figure 8-7
Hydraulic Grade Line Approximation



If the observed or computed tailwater elevation exceeds $(d_c + D)/2$, then it is used to set the beginning of hydraulic grade line. The headwater elevation (or end of the hydraulic grade line)

is then determined by adding the exit loss, the head due to friction losses through the culvert barrel, the head due to entrance losses, and subtracting the change in the invert elevation (slope of culvert x length of the culvert) to $(d_c + D)/2$ or the tailwater, whichever is greater (see Section 8.5).

This approximate method by the FHWA works best when the barrel flows full over at least part of its length. When the barrel is partly full over its entire length, the method becomes increasingly inaccurate as the headwater falls further below the crown of the culvert. Adequate results are obtained down to a headwater of $0.75D$. For lower headwater, backwater calculations are required to obtain accurate headwater elevations. Programs such as HEC-2 or HEC-RAS should be utilized.

8.4.11 CULVERT SLOPE

The culvert length and longitudinal slope should be based on existing site conditions and topography. The flow characteristics of the existing channel at the proposed culvert should be examined to properly position the culvert vertically. The culvert invert should be as near as possible to the existing channel bottom and follow the existing stream bed alignment as close as is practical.

Where extremely steep grades are encountered, vertical breaks in grade can be introduced to reduce outlet velocities and minimize outlet protection requirements. The use of grade breaks in culverts should be coordinated with the WVDOH Engineering Division.

8.4.12 END TREATMENTS

Design of the inlet and outlet is a very important aspect of the overall design of a culvert. End treatments such as headwalls, wingwalls, end sections, and improved inlets can increase hydraulic efficiency, prevent buoyancy effects, and reduce erosion. Culvert outlets are also important because of the potential for erosion caused by the increased flow velocity through the culvert. Other types of end treatments include scour protection with rock lining and energy dissipators.

8.4.12.1 HEADWALLS OR WINGWALLS

Safety of the road user is an important consideration in the design and location of drainage structures. It is important to locate the headwall, wingwall, or end section outside the clear zone on high-speed roads to eliminate the possible hazard to an errant vehicle. Where end treatments must be within the clear zone, they should be designed or modified to be traversable or present a minimal obstruction to an errant vehicle where debris is not a concern. The end section can be made traversable by using sloped grates or safety slope end sections. If a major drainage feature cannot effectively be redesigned or relocated, shield it using a suitable traffic barrier. Refer to the AASHTO Roadside Design Guide for further information on traffic safety issues

associated with drainage features. See Section 8.3.8 for guidelines on where to use headwalls, wingwalls or other end sections.

Wingwalls retain the roadway embankment and improve the hydraulic efficiency by reducing the inlet and outlet loss coefficients. Cut-off walls at the entrance or outlet of a culvert are used to prevent piping and subsequent undermining along the culvert barrel.

8.4.12.2 IMPROVED CULVERT INLETS

Improved inlets are refinements to the geometry of the culvert entrance to increase the hydraulic performance. These types of inlets should be considered for exceptionally long culverts operating under inlet control or when an existing culvert operating under inlet control is lengthened and hydraulic performance needs to be increased. There are three types of improved inlets:

- Beveled-Edge
- Side-Tapered
- Slope-Tapered

The bevel-edged inlet acts to decrease the flow contraction at the inlet and generally increases the culvert capacity by 5 to 20 percent depending on the type of entrance edge, wingwalls, and depth of headwater.

The side-tapered inlet has an enlarged face area with tapered sidewalls that transition to the culvert barrel. This type of inlet provides an increase in flow capacity of 25 to 40 percent over that of a conventional culvert with a square edged inlet.

The slope-tapered inlet incorporates a steeper slope or fall in the enclosed entrance portion of the culvert. The increase in capacity with this inlet depends on the amount of fall available, but up to a 100 percent increase in capacity can be achieved over a conventional culvert with a square edged inlet.

The designer should refer to HDS-5 for detailed guidance on the design of improved inlets.

8.4.12.3 SCOUR PROTECTION AND ENERGY DISSIPATORS

A pre-formed basin lined with rock is called a scour basin. The geometry of a rock lined scour basin can be determined using the Energy Dissipator Module of HY-8, which is based on the methods presented in HEC-14 published by the FHWA.

High velocity culverts or culverts where a hydraulic jump cannot be avoided at the outlet may require an energy dissipator device to reduce the velocity. Energy dissipators work on the principle of inducing a hydraulic jump, controlling it within a stilling basin, and transitioning the reduced velocity flow to the downstream channel. HEC-14 presents a variety of energy dissipator

designs including the CSU basin, USBR impact basin, SAF stilling basin, rock lined scour basin, and the VPI tumbling flow dissipator. The need for maintenance is an important consideration for such energy dissipators. The design should be based on HEC-14.

The following guide should be used for selecting the most appropriate outlet protection. It is based on a comparison of the pre-existing stream velocity, culvert outlet velocity, and the maximum allowable velocity for the soil. The allowable velocities of the channel bed material are listed in Table 8-4. V_o is the culvert outlet velocity in feet/second.

- If $V_o <$ allowable streambed material velocity, no protection is needed.
- If $V_o >$ allowable streambed material velocity, use dumped rock gutter or select embankment.
 - If $V_o > 15$ fps, use rock lined basin or energy dissipator
- If $V_o > 20$ fps, use tied concrete block mattress, rock lined basin, or energy dissipator.

Table 8-4

Allowable Velocities of Streambed Material

SOIL TEXTURE	ALLOWABLE VELOCITIES (ft/sec)
Fine sand and sandy loam (A-3)	2.5
Silt soils (A-4, A-5, A-6)	3.0
Silt or clayey gravel and sand (A-2)	3.5
Clayey soils (A-6, A-7)	4.0
Clay, fine gravel	5.0
Cobbles	5.5
Shale	6.0

8.4.13 SEDIMENT/BEDLOAD

A major concern with culverts involves the adverse effects of sediment and bedload deposition. Excessive deposition can partially block the culvert inlet, the barrel itself, or the outlet and reduce the flow carrying capacity of the culvert. This can also result in a potential flood hazard or develop into a costly maintenance problem.

Culvert locations where potential sediment problems are anticipated require a sediment transport analysis. Whether sediment will be deposited or be scoured will depend on the ability of the upstream channel and the culvert to transport sediment under varying hydraulic conditions. There are four types of methods to evaluate sediment deposition and scour in a culvert: statistical, simplistic, complex, and tractive shear. A description of these methods can be found in the 2005 AASHTO Model Drainage Manual, Chapter 9, Appendix C. These methods

estimate the rate of sediment deposition versus the rate of scour or clean out under varying hydraulic conditions. This estimate predicts the potential for problems caused by sediment.

In most cases, a simplistic method of assessment will be adequate unless there are extenuating circumstances that dictate a more complex study. The simple method is based on extreme conditions, and it assumes the culvert barrel will fill more than the stream bed if the culvert were not present. The existing channel flow line is assumed to be the limit of deposition except for aggrading channels. This method results in a ratio that describes the sediment movement. This ratio is the sediment transport ratio and is determined by the following equation:

$$R_G = \left(\frac{V_1}{V_2} \right)^3 \left(\frac{n_1}{n_2} \right)^4 \left(\frac{y_2}{y_1} \right)^{\frac{5}{3}}$$

$V_{1,2}$ = Average velocity in uniform flow (ft/s)

$n_{1,2}$ = Manning's roughness value

$y_{1,2}$ = Average depth of uniform flow (ft)

In this expression the subscript 1 refers to the reach upstream of the culvert and the subscript 2 refers to a location within the culvert. If this ratio is greater than 1 the deposition will occur in the vicinity of section 2. If this ratio is much greater than 1 expect nearly all the sediment carried by the stream to be deposited in the vicinity of section 2. Since V_2 is within the culvert and an average velocity is taken throughout the length of the culvert. The location of section 2 can be taken at any point within the culvert.

In some instances, environmental considerations may require countersinking one or more culvert barrels. The purpose of countersinking a culvert is to allow the pipe barrel to fill with streambed material up to the profile of the streambed that existed prior to the culvert's installation. This is done to accommodate the passage of fish and other stream biota (see Section 8.4.17). Sediment transport calculations will be required to ensure that the desired depth of streambed material will be maintained in the culvert. Baffles may be required to hold the streambed material in the culvert during the design flow.

8.4.14 DEBRIS

Debris is defined as any natural or manmade material in the stream that has the potential to block the culvert opening and prevent it from performing its function. Debris potential at a site is dependent on the land use in the contributing watershed and the floodplain characteristics upstream of the culvert. A field reconnaissance of the upstream watershed **may be** conducted with particular attention given to the presence of shrubs and trees on eroded banks, stream susceptibility to flash floods and storage of manmade debris in the floodplain.

Accumulation of debris at a culvert's inlet or within the barrel **could** cause failure. The result **would** be increased headwater depths, flooding which can cause damage to upstream property, and possible roadway overtopping. **Possible accumulation of debris can be reduced by avoiding skewed culverts and providing a well-designed inlet.**

When a high potential for debris accumulation exists, the culvert entrance should be designed using HEC 9 published by the FHWA. Protection should be provided where experience or field observations indicate that the natural water course will transport a heavy volume of controllable debris. Debris protection design **may** be submitted as a part of the culvert design.

The type of debris protection will depend on the location. Debris interceptors can be placed at the entrance to the culvert or upstream of the culvert. Upstream interceptors come in the form of debris racks, floating drift booms, and debris basins. Culvert entrance interceptors include debris risers and cribs. Normally debris protection will not be considered necessary for culverts that carry runoff from natural watersheds, but it **may** be provided in areas where debris is a known problem. Example problem areas are where timbering or strip-mining operations exist upstream, locations in mountainous or steep regions where the culvert is under high fill, and where clean out access is limited. Maintenance access must be provided to the debris control device to allow for cleaning.

8.4.15 MULTIPLE CELL CULVERTS

Traditional culverts are sized to carry a low-frequency design discharge and are usually accompanied by channel modification that results in localized channel instability. The more common high-frequency events will flow with high-velocity, shallow flow through the culvert which can hinder fish passage. Traditional culverts on roadway embankments also block the floodplain and result in high-velocity flow concentration through the culvert, which can scour the outlet channel and cause “perching” of the culvert. Perched culverts can also impede fish passage.

Multiple cell culverts improve channel stability as well as facilitate fish passage. They should not be confused with adjacent multiple-barrel culverts. Multiple cell culverts consist of one cell which spans the bankfull channel (conveys the channel forming discharge) and one or more cells positioned in the floodplain to convey overbank flow. This arrangement reduces the flow concentration through the culvert, which reduces channel scour. The entire arrangement of cells shall follow the requirements of Section 8.3.6.

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8.4.14 DEBRIS

Debris is defined as any natural or manmade material in the stream that has the potential to block the culvert opening and prevent it from performing its function. Debris potential at a site is dependent on the land use in the contributing watershed and the floodplain characteristics upstream of the culvert. A field reconnaissance of the upstream watershed should be conducted with particular attention given to the presence of shrubs and trees on eroded banks, stream susceptibility to flash floods and storage of manmade debris in the floodplain.

Accumulation of debris at a culvert's inlet or within the barrel can cause failure. The result will be increased headwater depths and flooding which can cause damage to upstream property and possible roadway overtopping. Accumulation can be reduced by avoiding skewed culverts and providing a smooth and well-designed inlet.

When a high potential for debris accumulation exists, the culvert entrance protection should be designed using the Federal Highway Administration's Hydraulic Engineering Circular No. 9, "Debris-Control Structures". Protection should be provided where experience or field observations indicate that the watercourse will transport a heavy volume of controllable debris. Debris protection design should be submitted as a part of the culvert design.

The type of debris protection will depend on the individual location. Debris interceptors can be placed at the entrance to the culvert or upstream of the culvert. Upstream interceptors come in the form of debris racks, floating drift booms and debris basins. Culvert entrance interceptors include debris risers and debris cribs. Normally debris protection will not be considered necessary for culverts that carry runoff from natural watersheds but it should be provided in areas where debris is a known problem. Problem areas could be where timbering or strip mining operations exist upstream, locations in mountainous or steep regions where the culvert is under high fill and where clean out access is limited. Maintenance access must be provided to allow for clean out of the debris control device.

8.4.15 MULTIPLE CELL CULVERTS

Traditional culverts are sized to carry a low-frequency design discharge and are usually accompanied by channel modification that results in localized channel instability. The more common high-frequency events will flow with high-velocity, shallow flow through the culvert which can hinder fish passage. Traditional culverts on roadway embankments also block the floodplain and result in high-velocity flow concentration through the culvert, which can scour the outlet channel and cause “perching” of the culvert. Perched culverts can also impede fish passage.

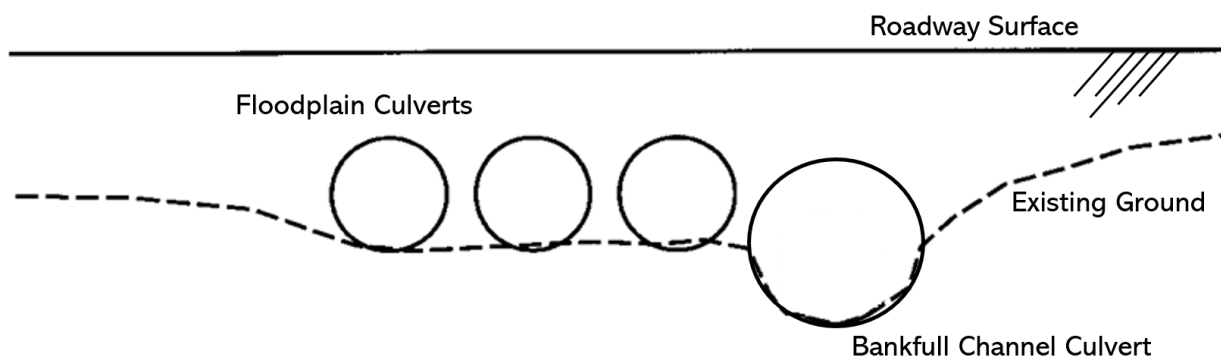
Multiple cell culverts improve channel stability as well as facilitate fish passage. They should not be confused with adjacent multiple-barrel culverts. Multiple cell culverts consist of one cell which spans the bankfull channel (conveys the channel forming discharge) and one or more cells positioned in the floodplain to convey overbank flow. This arrangement reduces the flow concentration through the culvert, which reduces channel scour. The entire arrangement of cells shall follow the requirements of Section 8.3.6.

8.4.15 MULTIPLE CELL CULVERTS

Traditional culverts are sized to carry a low-frequency design discharge and are usually accompanied by channel modification that results in localized channel instability. The more common high-frequency events will flow with high-velocity, shallow flow through the culvert which can hinder fish passage. Traditional culverts on roadway embankments also block the floodplain and result in high-velocity flow concentration through the culvert, which can scour the outlet channel and cause “perching” of the culvert. Perched culverts can also impede fish passage.

Multiple cell culverts were developed to improve channel stability as well as facilitate fish passage. They should not be confused with traditional multiple-barrel culverts. Multiple cell culverts consist of one or more cells placed in the channel to convey flows up to the dominant discharge (or channel forming discharge) and one or more cells positioned in the floodplain to convey overbank flow up to the design discharge without increasing the water surface elevation of the 100-year discharge. The width of the channel culvert or total width of the channel culverts shall be equal to the bankfull width of the channel. This arrangement reduces the flow concentration through the culvert, which reduces channel scour.

Figure 8-8
Multiple Cell Culverts



The designer is cautioned that multiple cell culverts are not appropriate for all streams. A stream stability assessment should be conducted to determine if they are appropriate. Multiple cell culverts should be considered only on stable streams that have active floodplains. A bridge is more appropriate for an unstable stream or a stream with no floodplain.

Scour protection of the floodplain cell outlets should be considered to prevent head cuts or erosion.

8.4.16 COMPUTATIONAL METHODS

Culverts can be designed using the design charts and nomographs from HDS-5 or with various programs. The FHWA HY-8 culvert analysis program is based on the methods presented in HDS-5. The results of computer applications should be spot-checked for accuracy using the design charts or equations.

8.4.17 ACCOMMODATING AQUATIC LIFE MOVEMENTS

Culverts have been determined to be barriers to passage of aquatic organisms in three ways:

- A high drop-off at the downstream end of the culvert keeps fish from entering. With a few exceptions, culverts are generally installed so that the invert of the pipe matches the bottom of the stream elevation. The high drop-off condition develops over time because of two possible causes. First, the streambed elevation downstream of the culvert has been lowered due to erosion after the culvert was installed. Second, the water velocities are high enough to cause a scour hole at the outlet end of the culvert.
- Steep, smooth culverts have flow that is too shallow and too swift for fish to swim through.
- Long culverts exceed the endurance limit of the fish by not providing pools for fish to rest in.

Research and regulation began in the 1970's. Most of the research in the U.S. has been focused along the northern Pacific coast, but efforts are increasing in the northeast and mid-Atlantic regions.

Legal basis

USACE Section 404 National Permit General Conditions, part C. 4. – Aquatic Life Movements:

“No activity may substantially disrupt the necessary life-cycle movements of those species of aquatic life indigenous to the waterbody, including those species that normally migrate through the area, unless the activity's primary purpose is to impound water. Culverts placed in streams must be installed to maintain low flow conditions.”

West Virginia 401 Water Quality Certifications Special Conditions for Nationwide 14 Linear Transportation Projects states that:

“The culvert barrel must be properly countersunk at the outlet.”

Reference is also made to “Appendix A for recommendations on proper culvert installation.”

These recommendations are from Oregon and Washington, and they have not been widely accepted or implemented in West Virginia.

Proposed Design Methods and Policy

The WVDOH has established a goal to accommodate aquatic life movements (ALM) where it is beneficial, practical, and feasible. In working toward this goal over the last few years, WVDOH has installed few experimental culverts which have yielded mixed results. The following design method and policy is proposed to implement ALM on a limited basis.

Step 1: Determine the culvert size based on WVDOH Drainage Manual to ensure that hydraulic design requirements are met. Remember to consider FEMA requirements if the stream crossing is in a mapped flood zone.

Step 2: Collect field data at the site to determine whether ALM is applicable.

- List aquatic organisms present at site. Note State and Federal Rare, Threatened and Endangered (RTE) species in conjunction with the Environmental Section of the Engineering Division's environmental document for the project.
- Consider whether the stream is perennial, intermittent, or ephemeral.
- Determine whether the stream is listed as a mussel stream.
- Determine whether the stream is a trout stream or an intermittent tributary of a trout stream.
- Measure bankfull width, bankfull maximum depth, and channel slope.

Step 3: Based on the data collected in step 2, determine whether ALM is appropriate.

- If the stream supports aquatic life, then ALM should be considered. Regulation of this issue is still developing. Building a stream crossing to accommodate ALM may be required, or it may be considered as mitigation of stream impacts.
- If ALM is not appropriate, then size the stream crossing based on the hydraulic culvert design performed in step 1.

Step 4: Determine whether the stream crossing should have an open bottom structure such as a bridge, 3-sided structure, or a closed cell culvert with natural stream bed material. Based on WVDOH calculations and current practice of other agencies, a stream slope of 5% is the upper limit for closed cell culverts with natural stream bed material. If the channel slope is less than 5%, follow steps 5 through 10 for closed cell culvert design. If the channel slope is greater than 5%, follow steps 11 through 14 for open bottom structure design.

Culverts

Step 5: Set the culvert width equal to the bankfull channel width. Investigate which structure types will be appropriate for this width.

Step 6: Determine what measures will be needed to ensure that the culvert will have adequate substrate and structure to allow ALM. Some culverts may be set at a low elevation and be expected fill in naturally over time. Others will require streambed material placement inside the culvert.

Step 7: For culverts that require streambed material placement inside the culvert, determine the size and thickness of the material to fill the bottom of the culvert. Based on current information:

$$D_{50} = 15.6dS$$

D_{50} = the median size of well graded stream bed material (ft)

d = bankfull maximum depth (ft)

S = channel slope (ft/ft)

The thickness of the stream bed material should be approximately $2D_{50}$.

Step 8: Determine the culvert height based on stream bed material thickness and bankfull maximum depth.

Step 9: Determine which structure sizes and types are acceptable based on fill heights and hydraulic requirements in step 1.

Step 10: Complete final design of culvert.

Bridges and three-sided structures

Step 11: Set the structure width equal to or greater than the bankfull channel width. Investigate which structure types will be appropriate for this width.

Step 12: Perform bridge scour analysis.

Step 13: Obtain core borings.

Step 14: Design the structure and foundations.

All stream crossings

Step 15: Prepare drawings and quantity tables for the permit applications.

8.5 CULVERT DESIGN PROCEDURE

The following is a step-by-step procedure to determine the minimum size of a culvert. While it is possible to follow the design method without an understanding of culvert hydraulics, it is not recommended as it can result in an inadequate and possibly unsafe structure. Therefore, the designer is advised to become familiar with the detailed procedures here. More information is provided in HDS-5.

Step 1: Assemble site data and culvert project file.

a. Minimum data are:

- USGS site and location maps
- Embankment cross sections
- Roadway profile
- Existing channel profile
- Photographs
- Field visit (check for downstream controls, sediment, debris, erosion, high water marks, etc.)
- Surveyed elevations of nearby structures and design data of nearby hydraulic structures

b. Studies by other agencies including:

- Small dams (NRCS, USGS, etc.)
- Floodplain (NRCS, FEMA, USGS, NOAA, USACE, etc.)
- Storm drain (local or private)

c. Environmental constraints including:

- Commitments contained in Environmental documents
- Environmental mitigation
- Aquatic life movement, see Section 8.4.17

d. Review Design Criteria in Section 8.3, and the design directives

Step 2: Calculate design discharge (Q):

- a. Determine design frequency based on the design criteria for the roadway classification.
- b. Determine Q from Form 4-1 or Form 4-2 (Chapter 4)
- c. Divide Q by the total number of barrels, if more than one barrel is used.

Step 3: Determine tailwater conditions based on the downstream channel and stream flow:

- a. Review Chapter 7
- b. Minimum data are cross sections, an estimate of Manning's roughness coefficient for stream, geometry of channel and investigation of downstream controls.

Step 4: Summarize data on Form 8-1 (see Section 8.6):

- a. Fill in data from step 2.
- b. Fill in all other information including station, location, description, project number, etc.
- c. Determine maximum allowable headwater (in feet), which is the vertical distance from the culvert inlet invert (flow line) to the allowable water surface elevation in the headwater pool or approach channel upstream of the culvert.

Step 5: Select the design alternative.

- a. Choose culvert material, shape, entrance type, and trial size (for example, using inlet control nomographs, assume $HW/D = 1.2$ with the design discharge and determine a preliminary size). If the trial size is too large in dimension because of limited height of embankment or availability of size, multiple culverts may be considered by dividing the discharge equally between the number of barrels. Consider raising the embankment height or the use of a pipe arch or box culvert with a width greater than the height. Final selection should be based on an economic analysis of the alternatives.
- b. Review the West Virginia Standard Specifications and Standard Details to ensure compliance and evaluate the need for special details or special provisions.

Step 6: Determine inlet control headwater depth (HW_i)

Use the inlet control nomographs in Section 8.6 for the selected culvert shape and material.

- a. Locate the size or height on the scale.

- b. Locate the discharge.
 - For a circular or arch shape use discharge
 - For a box shape use Q per foot of width
- c. Locate HW/D ratio
 - Use a straight edge.
 - Extend a straight line from the culvert size through the flow rate.
 - Mark the first HW/D scale. Extend a horizontal line to the scale for the end treatment to be used and read HW/D and note it on Form 8-1.
- d. Calculate headwater depth (HW_i)
 - Multiply HW/D by D (pipe diameter if circular shape, height of culvert if box shape or arch shape is used) to obtain HW.
 - Neglecting the approach velocity $HW_i = HW$
 - Including the approach velocity $HW_i = HW - \text{approach velocity head}$.

Step 7: Determine outlet control headwater depth at inlet (HW_o)

- a. Calculate the normal depth (d_n) in feet above the outlet invert using the design flow rate (single section) or using a backwater profile for the downstream channel. A measurable tailwater (TW) should also be noted here.
- b. Calculate critical depth (d_c) using appropriate charts in Section 8.6.
 - Locate flow rate and read d_c (A is the area of flow)
 - d_c cannot exceed D
- c. Calculate $(d_c + D)/2$
- d. Determine (h_o)

$h_o = \text{the larger of the measurable TW, normal depth, or } (d_c + D) / 2$
- e. Determine the Entrance Loss Coefficient (k_e) used to determine the entrance head loss (H_e). Coefficient k_e is multiplied by the velocity head ($V^2 / 2g$) to determine the head loss at the entrance to a culvert operating full or partially full with control at the outlet. Entrance loss coefficients for various inlet configurations are provided in Table 8-3.
- f. Determine the total head losses (H_L).
 - Use outlet control nomographs.
 - Locate appropriate k_e scale.

- Locate culvert length (L) or (L1):
 - Use (L) if Manning's n matches the n value of the culvert and use (L1) to adjust for a different culvert n value.
 - $L1 = L (n_1 / n)^2$
 - Mark point on turning line:
 - Use a straight edge and connect culvert size with the length on the appropriate ke scale and mark a point on the turning line.
 - Read (H_L).
 - Use a straight edge,
 - Connect discharge (Q) and mark on the turning line,
 - Read (H_L) on Head Loss Scale.
- g. Calculate outlet control headwater (HW_o).

$$HW_o = H_L + h_o - LS_o$$

S_o = slope of culvert (ft/ft)

L = length of culvert (ft)

Therefore, LS_o is the difference in elevation of the invert in and invert out of the culvert (fall through the culvert).

Step 8: Determine controlling headwater (HW).

- a. Compare HW_i and HW_o . The higher headwater governs and indicates the flow control existing under the given conditions for the trial size selected.
- b. If outlet control governs and the HW is higher than is acceptable, select a larger trial size and return to Step 7.

Step 9: Compute Outlet Velocity and Depth.

- a. If inlet control governs, outlet velocity can be assumed to be equal to the mean velocity in open channel flow within the barrel as computed by Manning's equation for the rate of flow, barrel size, roughness, and slope of the selected culvert.
- b. If outlet control governs:
 - Use d_c if $d_c > TW$
 - Use TW if $d_c < TW < D$
 - Use D if $D < TW$

- Calculate flow area A
- Calculate exit velocity $V = Q / A$.

Step 10: Determine need for Culvert Outlet Protection.

- a. Determine mean and maximum allowable flow velocities for the natural stream.
- b. Design protection based on Section 8.4.12.3.

Step 11: Review Results:

Analyze the design alternative constraints and assumptions made in the design process. If any of the following constraints are not met, repeat steps 5 through 10 with another alternative design:

- a. Allowable headwater is not exceeded.
- b. Check storm criteria in Chapter 4 are met.
- c. Culvert barrel material has adequate cover.
- d. Actual length of the culvert is close to the approximated length.
- e. Culvert end treatments can be accommodated by site conditions.
- f. Allowable velocity is not exceeded.

If the above constraints are satisfied:

- Record final selection of culvert with size, type, required headwater, outlet velocity, and economic justification under recommendation on Form 8-1.

Step 12: Prepare a report if needed and file with the background information.

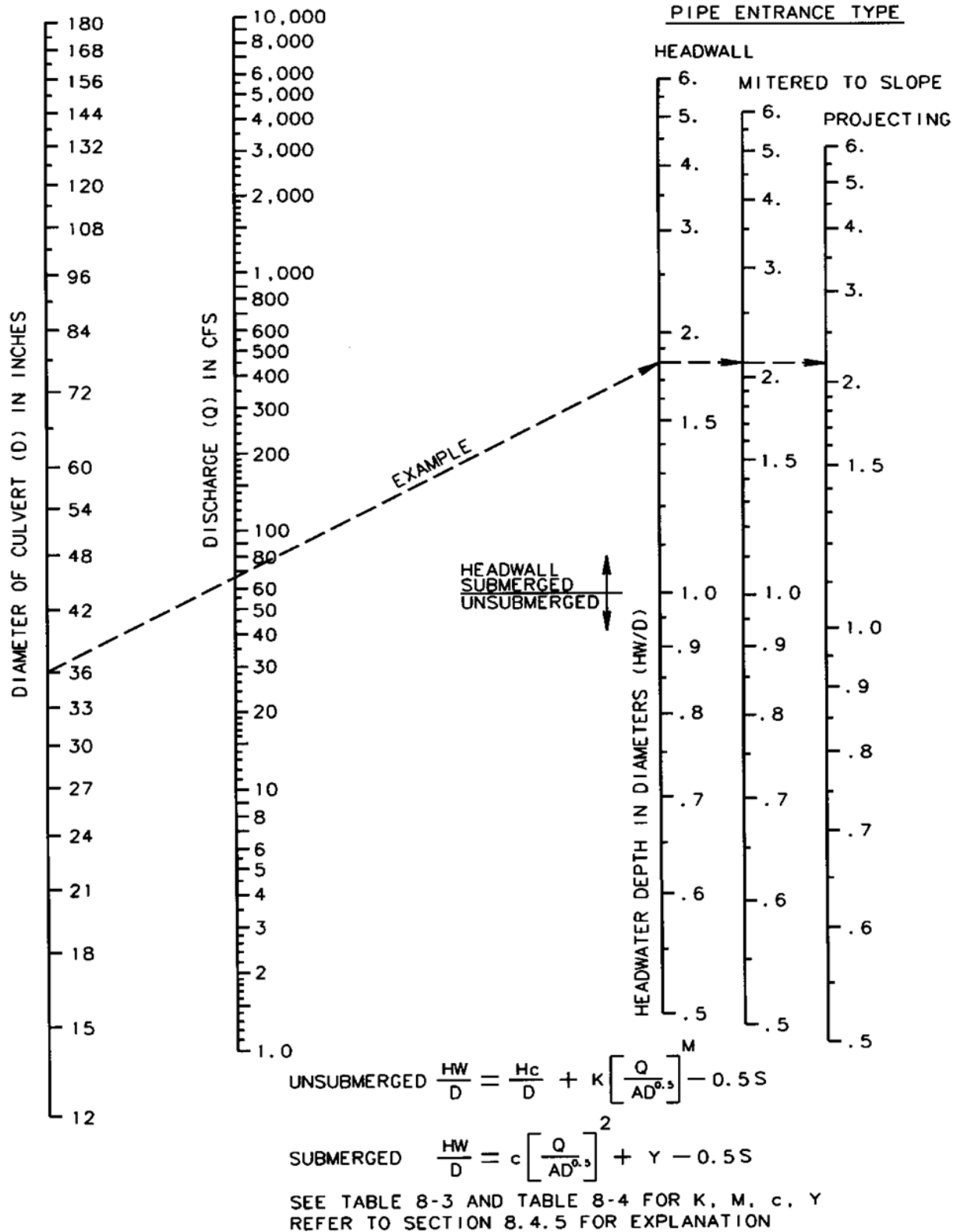
8.6 COMPUTATION FORMS AND DESIGN CHARTS

Nomographs, charts, computation forms, step-by-step procedures, and example problems pertaining to all aspects of hydraulic design of highway culverts can be found in HDS-5. Refer to the HDS-5 for complex situations not covered by the charts included in this section.

Form 8-1 Culvert Design Form

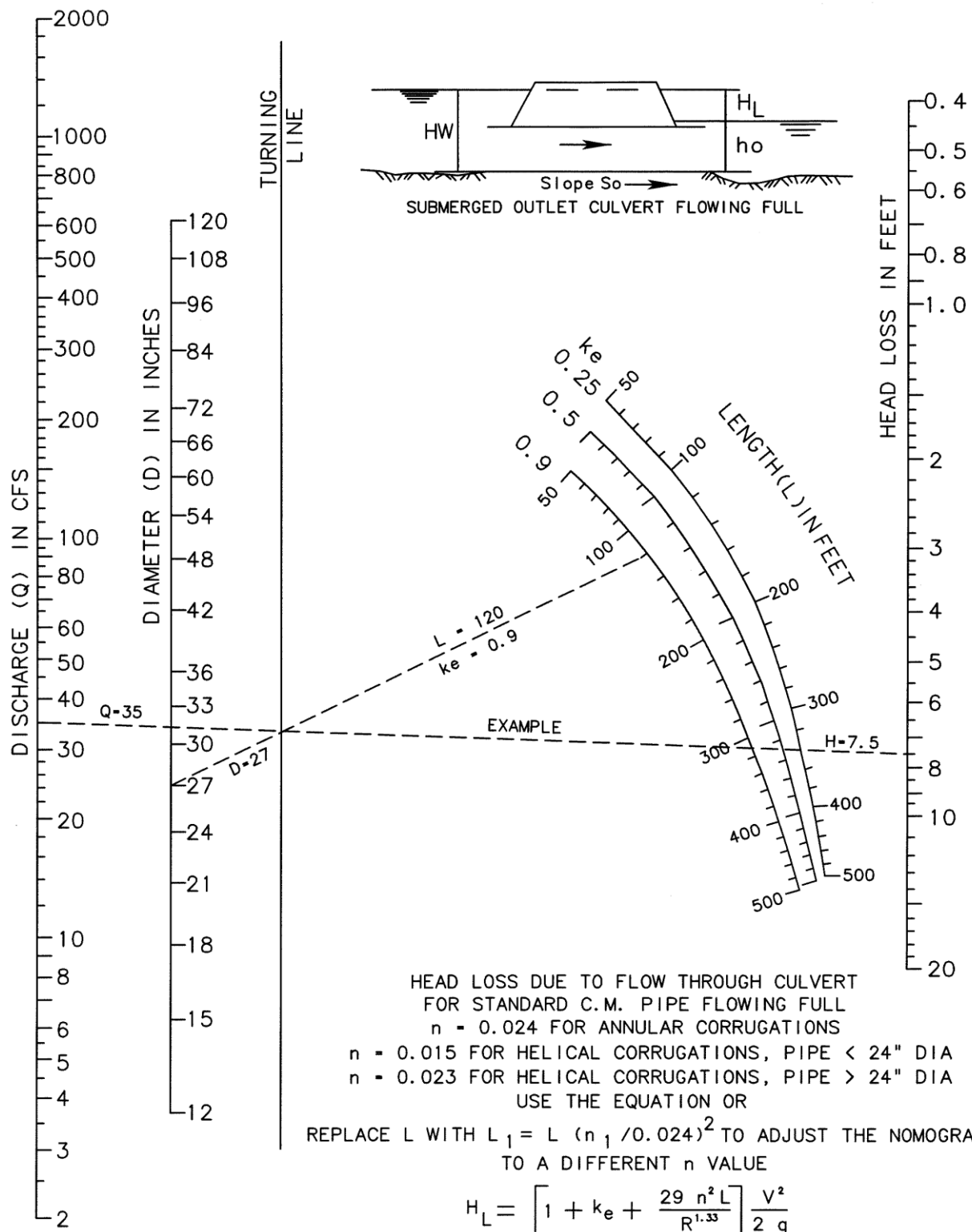
DRAINAGE COMPUTATION FORM 8-1 CULVERT DESIGN		STATION _____		DESIGNER _____ DATE _____ REVIEWER _____ DATE _____	
PROJECT NAME _____ PROJECT NUMBER _____		<p style="text-align: center;">DRAWING DEPICTS OUTLET CONTROL</p> <p style="text-align: center;">ACTUAL PIPE LENGTH S_o PIPE SLOPE</p> <p style="text-align: center;">HORIZONTAL PIPE LENGTH = L</p> <p style="text-align: center;">h_o larger of TW, d_n or $\frac{d_c + D}{2}$</p> <p style="text-align: center;">EL_{ws} EL_1 S_o L EL_o</p>			
OUTLET CHANNEL TAILWATER					
RETURN PERIOD TW OR NORMAL DEPTH					
DESIGN STORM					
CHECK STORM					
CULVERT FLOWS					
RETURN PERIOD					
FLOW					
DESIGN STORM					
CHECK STORM					
CULVERT DESCRIPTION		CULVERT DIAMETER OR SHAPE		TOTAL FLOW	MAX ALLOWABLE HEADWATER
MATERIAL, ENTRANCE, ROUGHNESS				Q	H_{max}
				cfs	ft
HEADWATER TO DEPTH RATIO		HW_1/D	ft		
		HW_1	ft		
TAILWATER OR NORMAL DEPTH IN CHANNEL		TW, d_n	ft		
		d_c	ft		
CRITICAL DEPTH IN PIPE		$(d_c + D)/2$	ft		
		h_o	ft		
PIPE AT THE PIPE OUTLET		k_e	ft		
		H_L	ft		
HEAD LOSS DUE TO FLOW THROUGH THE CULVERT		$L S_o$	ft		
		HW_o	ft		
FW AT INLET DUE TO INLET CONTROL		HW_o	ft		
		HW	ft		
CONTROLLING HEADWATER		V	ft/s		
		V	ft/s		
OUTLET VELOCITY					
REMARKS					
RECOMMENDATION:					

Chart 8-1
C.M. Pipe Culverts with Inlet Control



Source: *Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005*

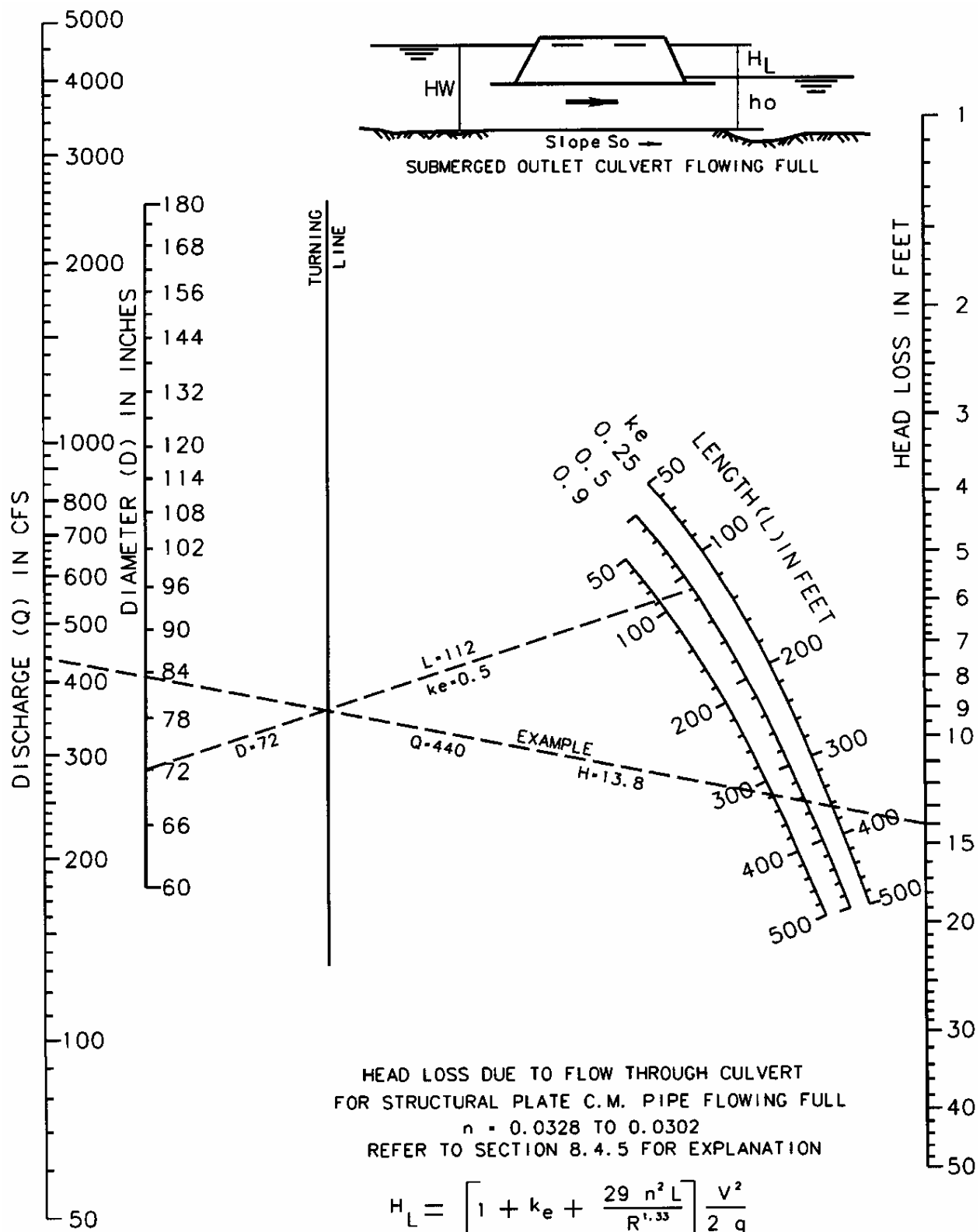
Chart 8-2
Standard C.M. Pipe Flowing Full



REFER TO SECTION 8.4.5 FOR EXPLANATION

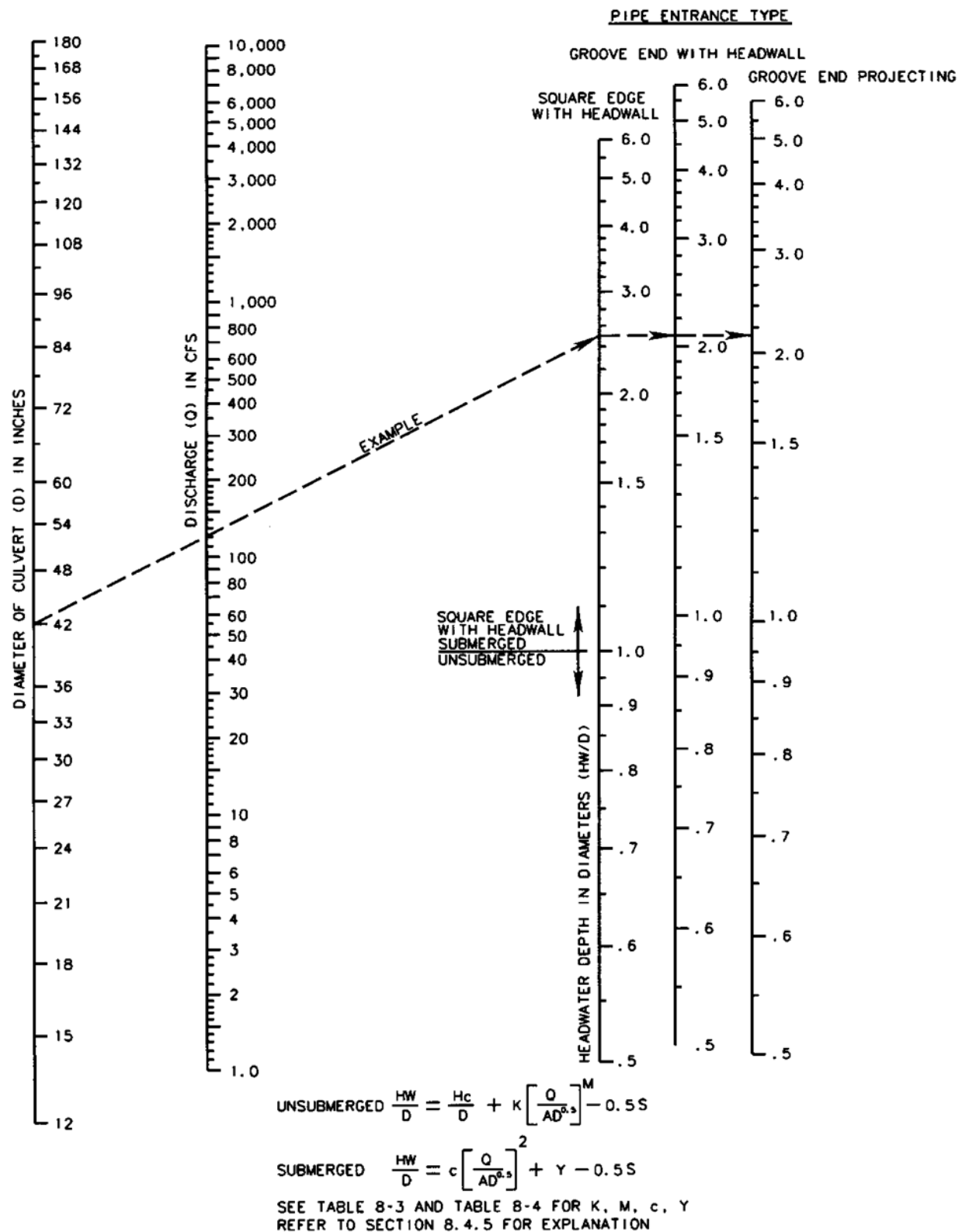
Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-3
Structural Plate C.M. Pipe Flowing Full



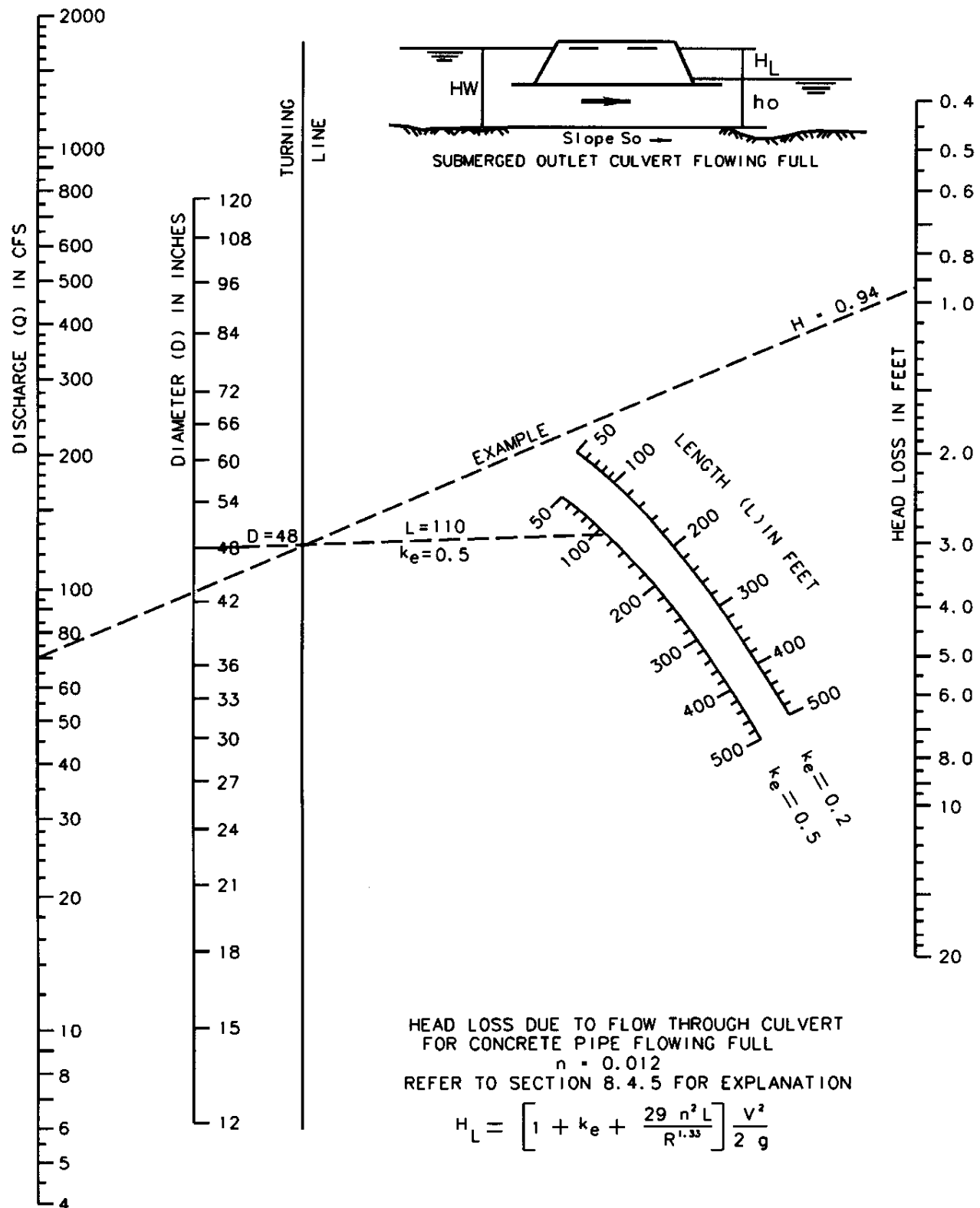
Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-4
Concrete Pipe Culverts with Inlet Control



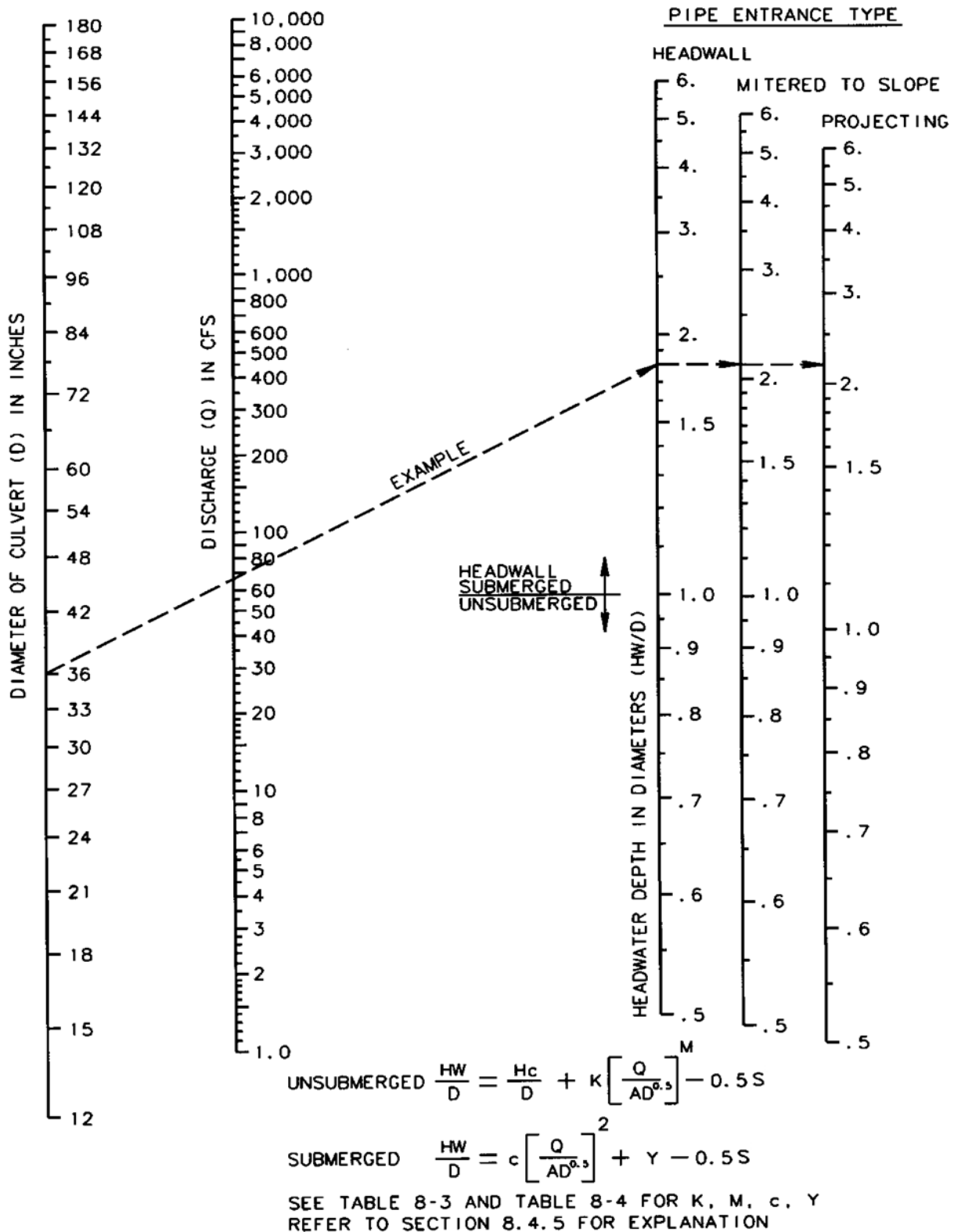
Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-5
Concrete Pipe Flowing Full



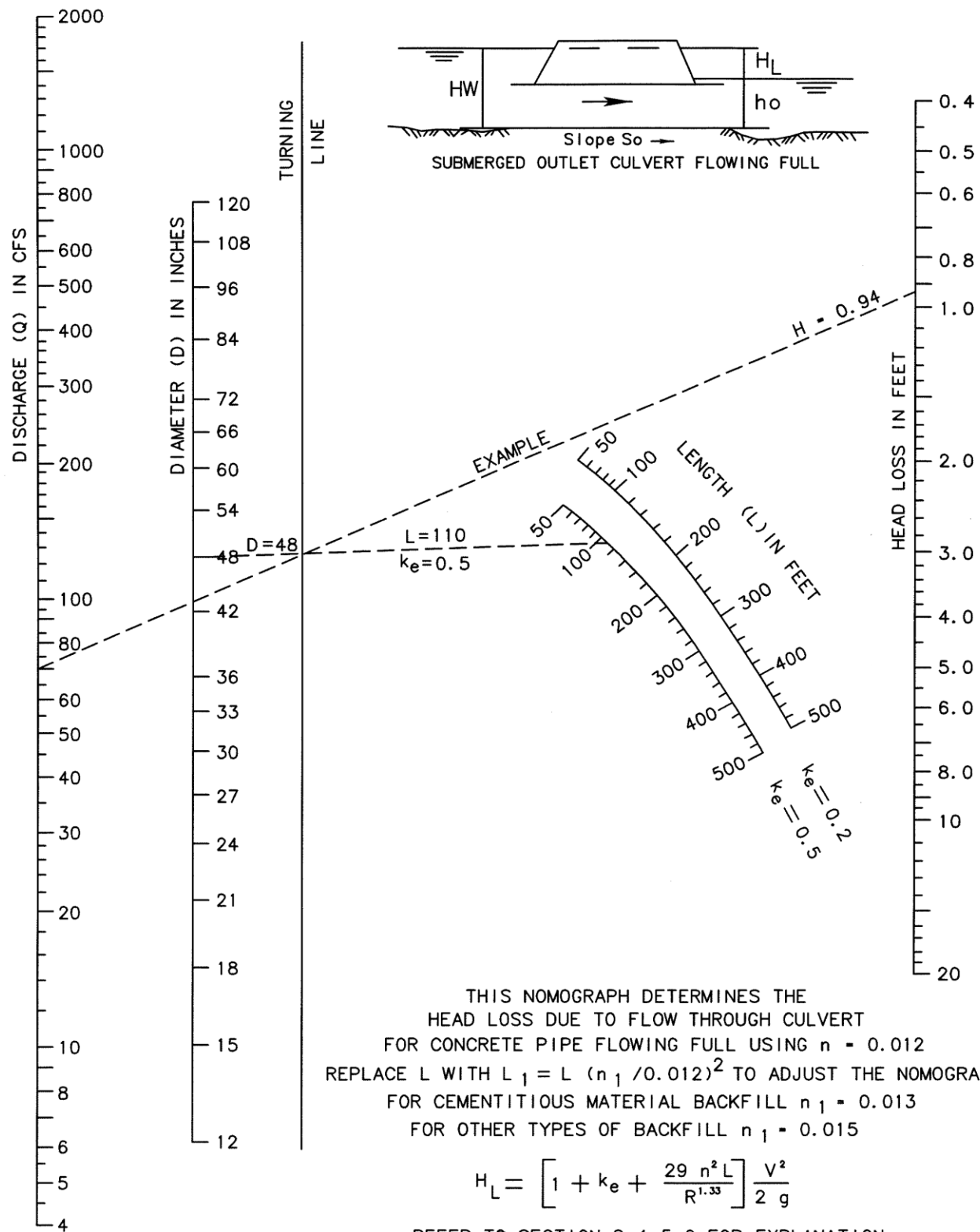
Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-6
HDPE Pipe Culverts with Inlet Control



Source: *Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005*

Chart 8-7
HDPE Pipe Flowing Full



Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-8
Critical Depth for Circular Pipe

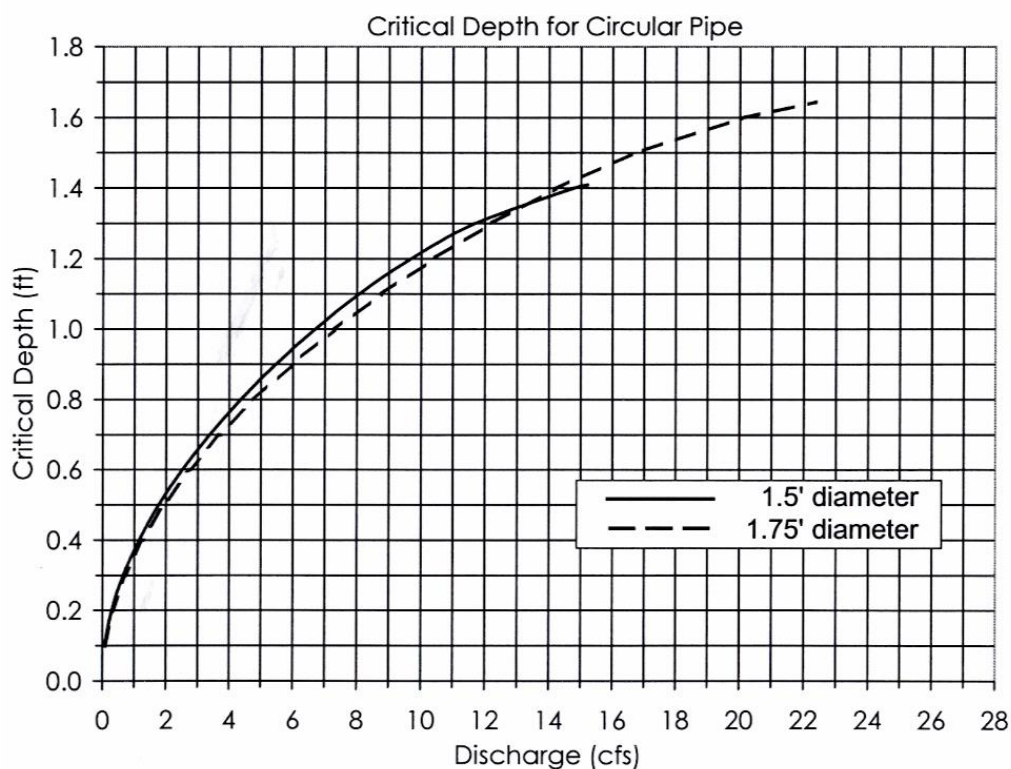
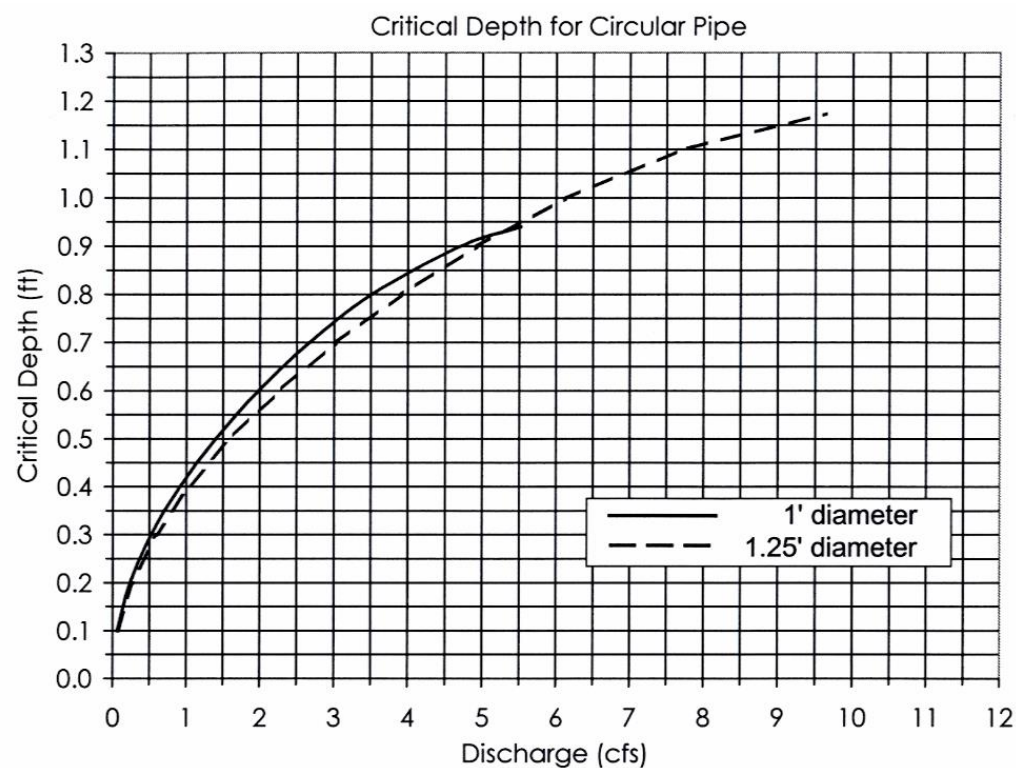


Chart 8-9
Critical Depth for Circular Pipe

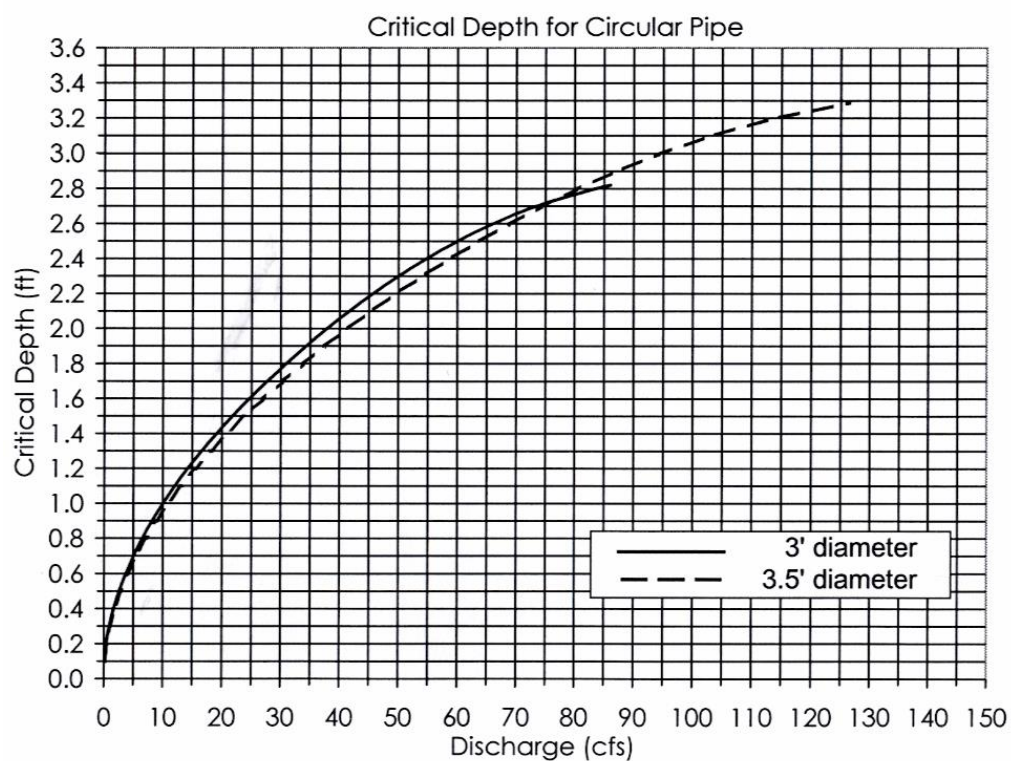
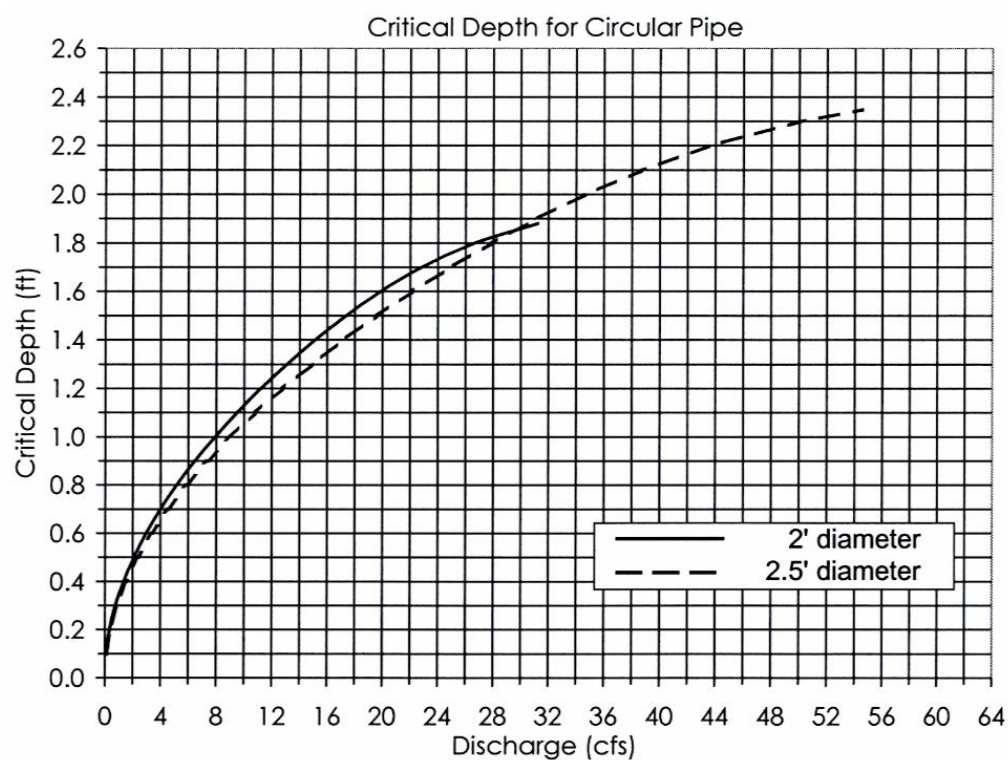


Chart 8-10
Critical Depth for Circular Pipe

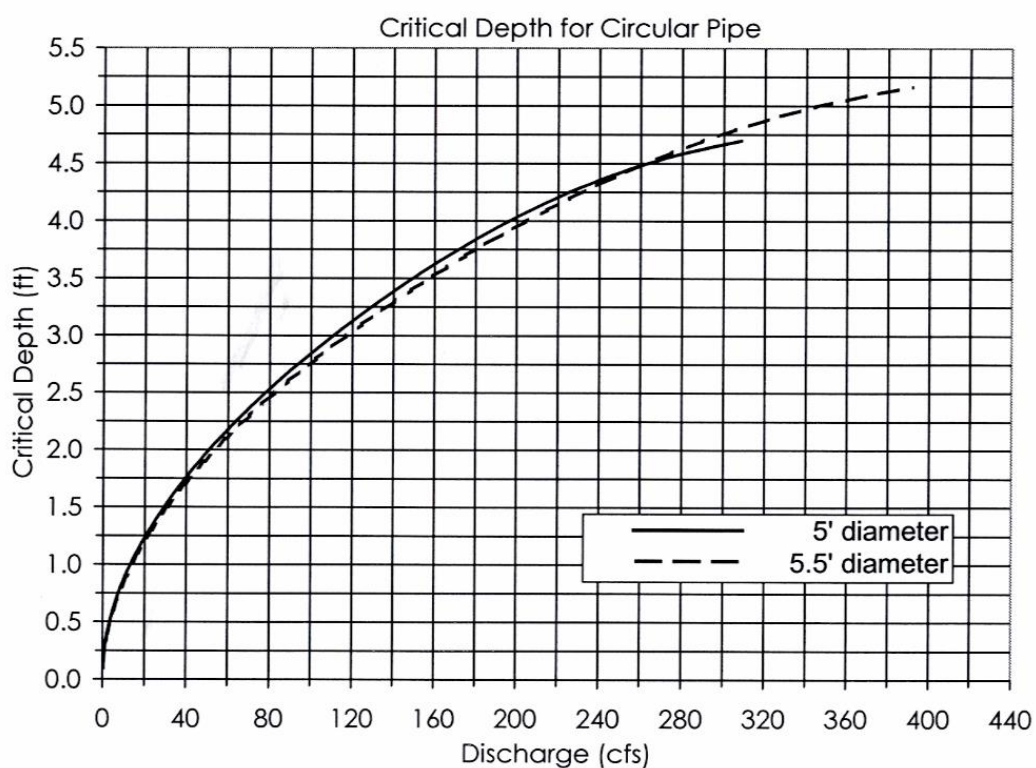
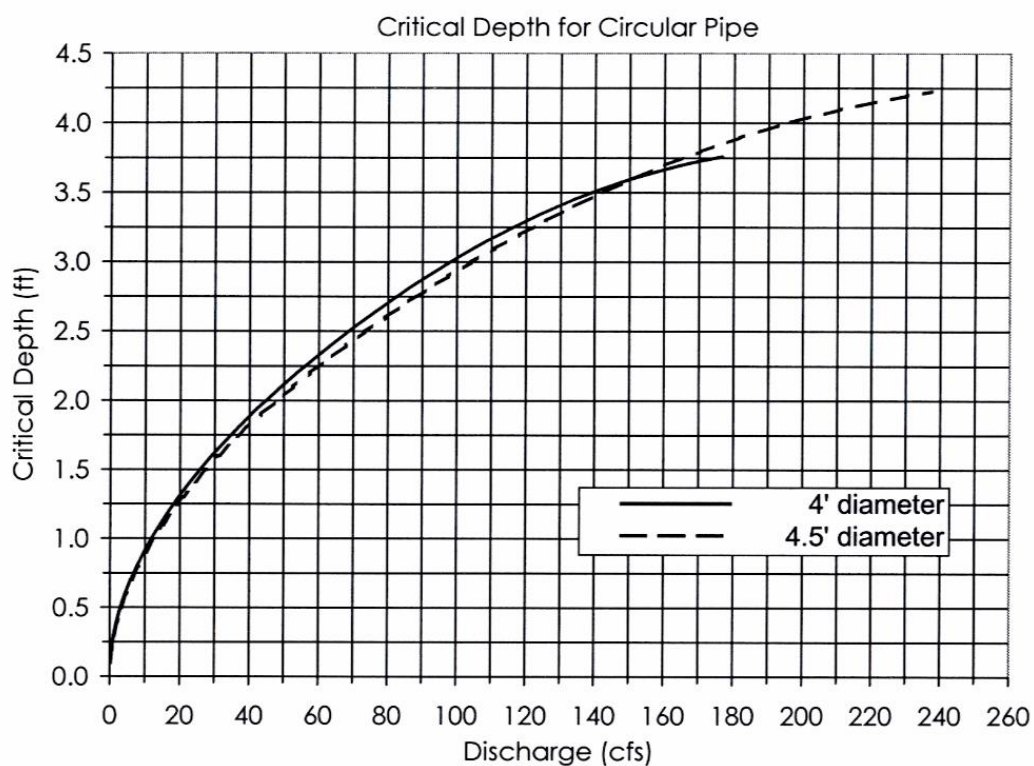


Chart 8-11
Critical Depth for Circular Pipe

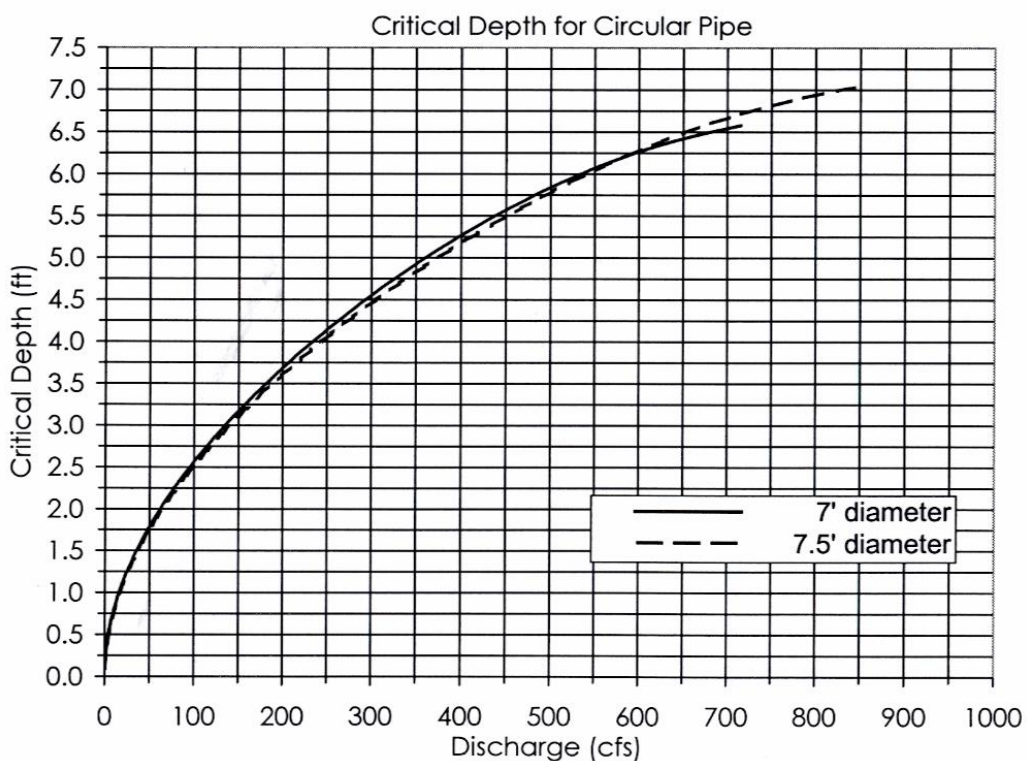
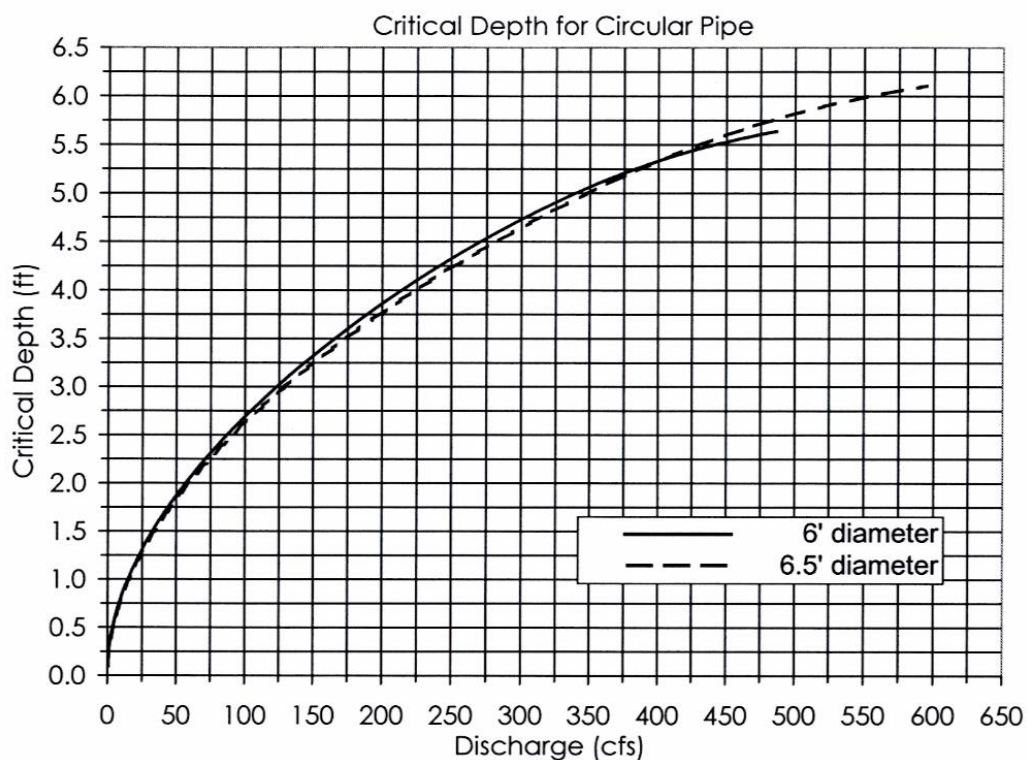
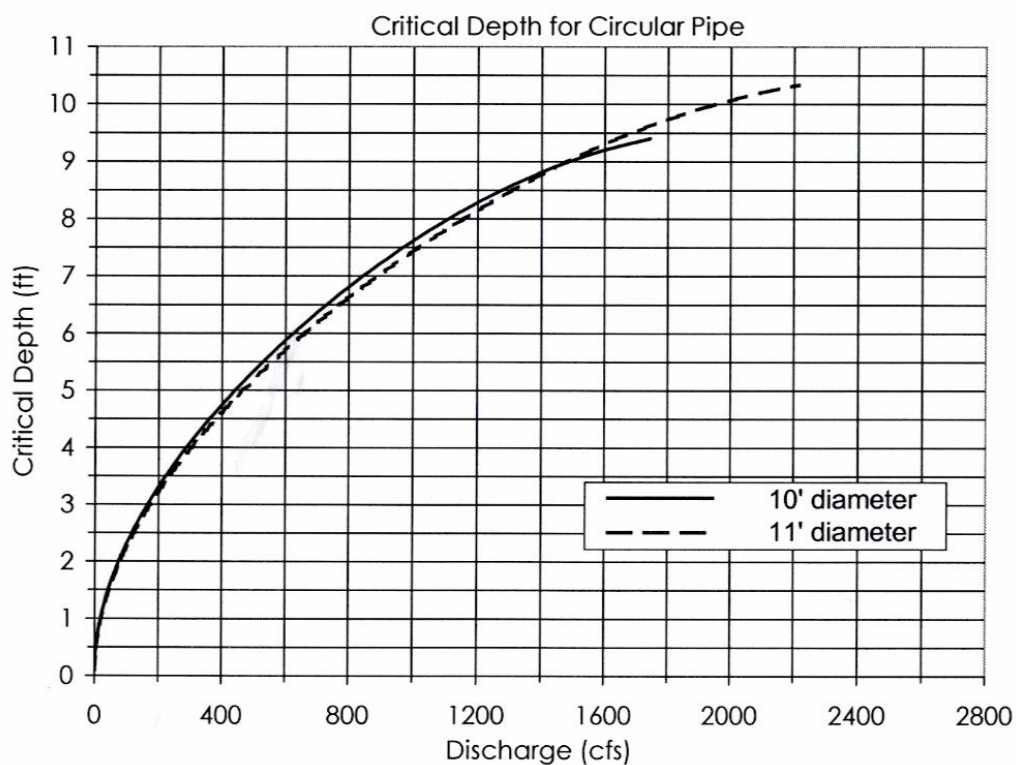
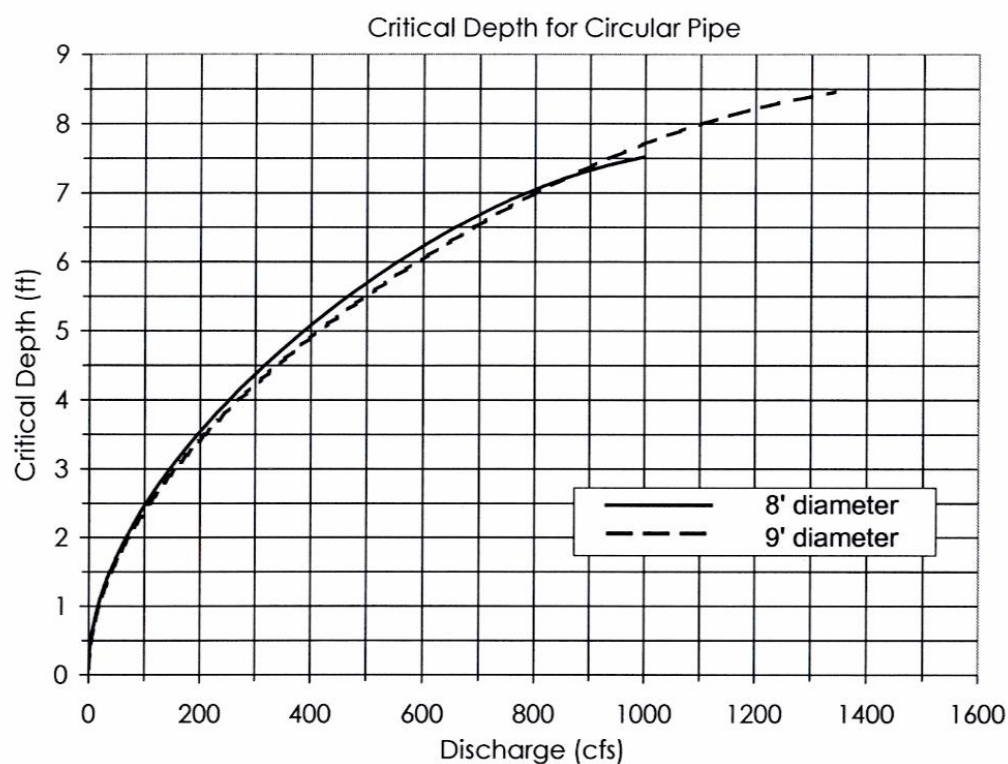


Chart 8-12
Critical Depth for Circular Pipe



Created by the WVDOH Hydraulic and Drainage Unit

Chart 8-13
Critical Depth for Circular Pipe

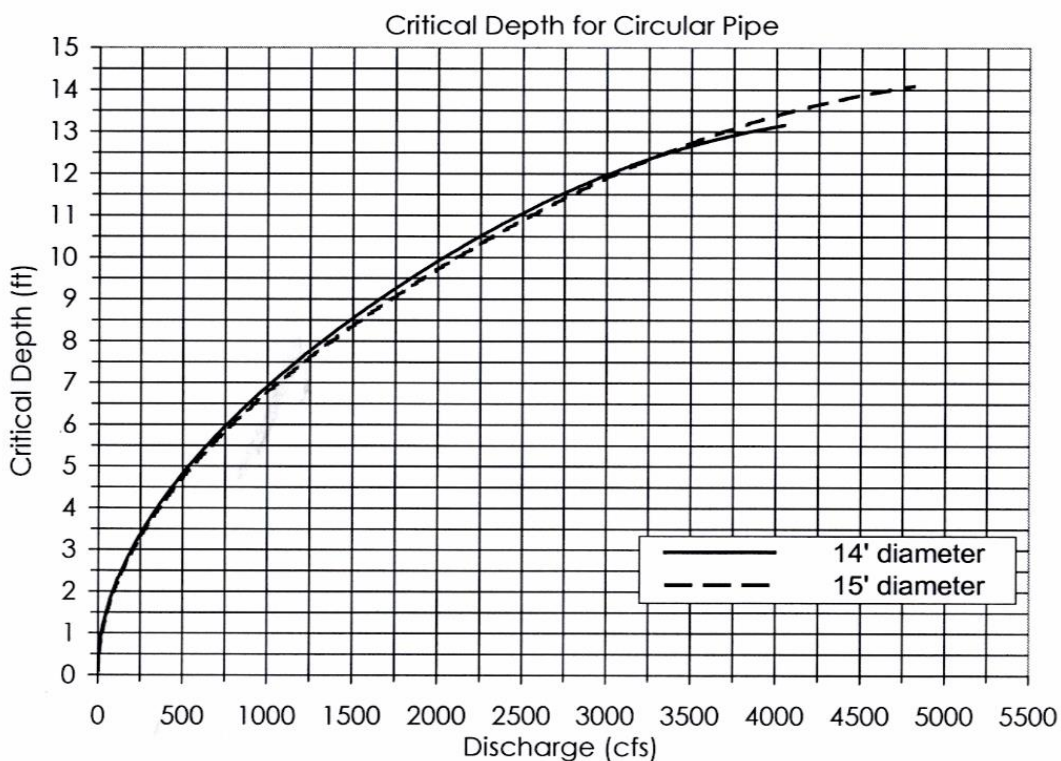
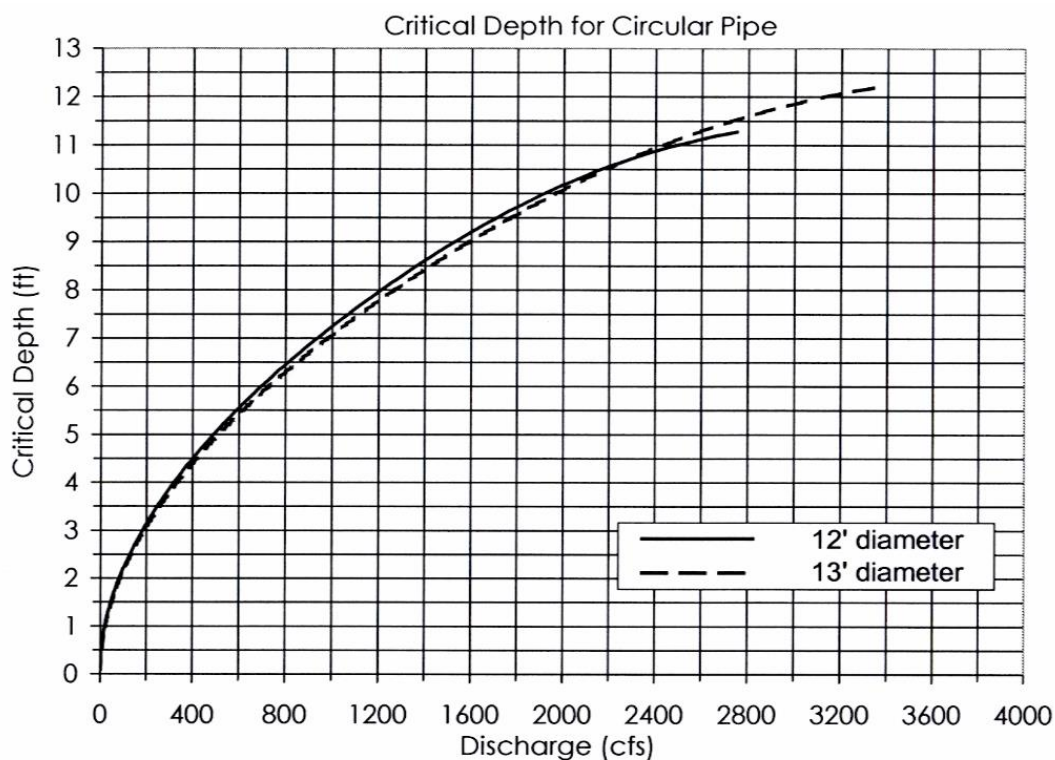
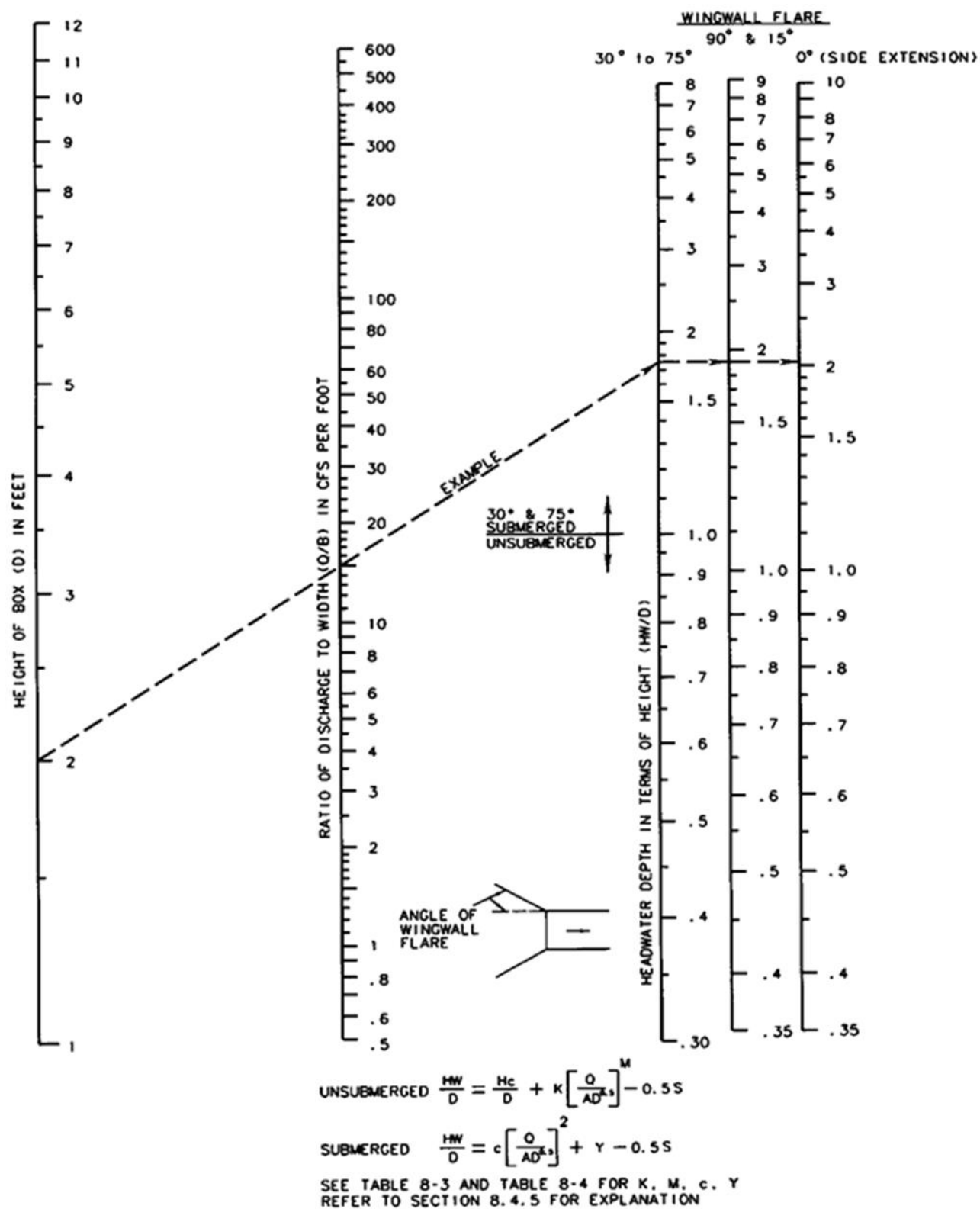
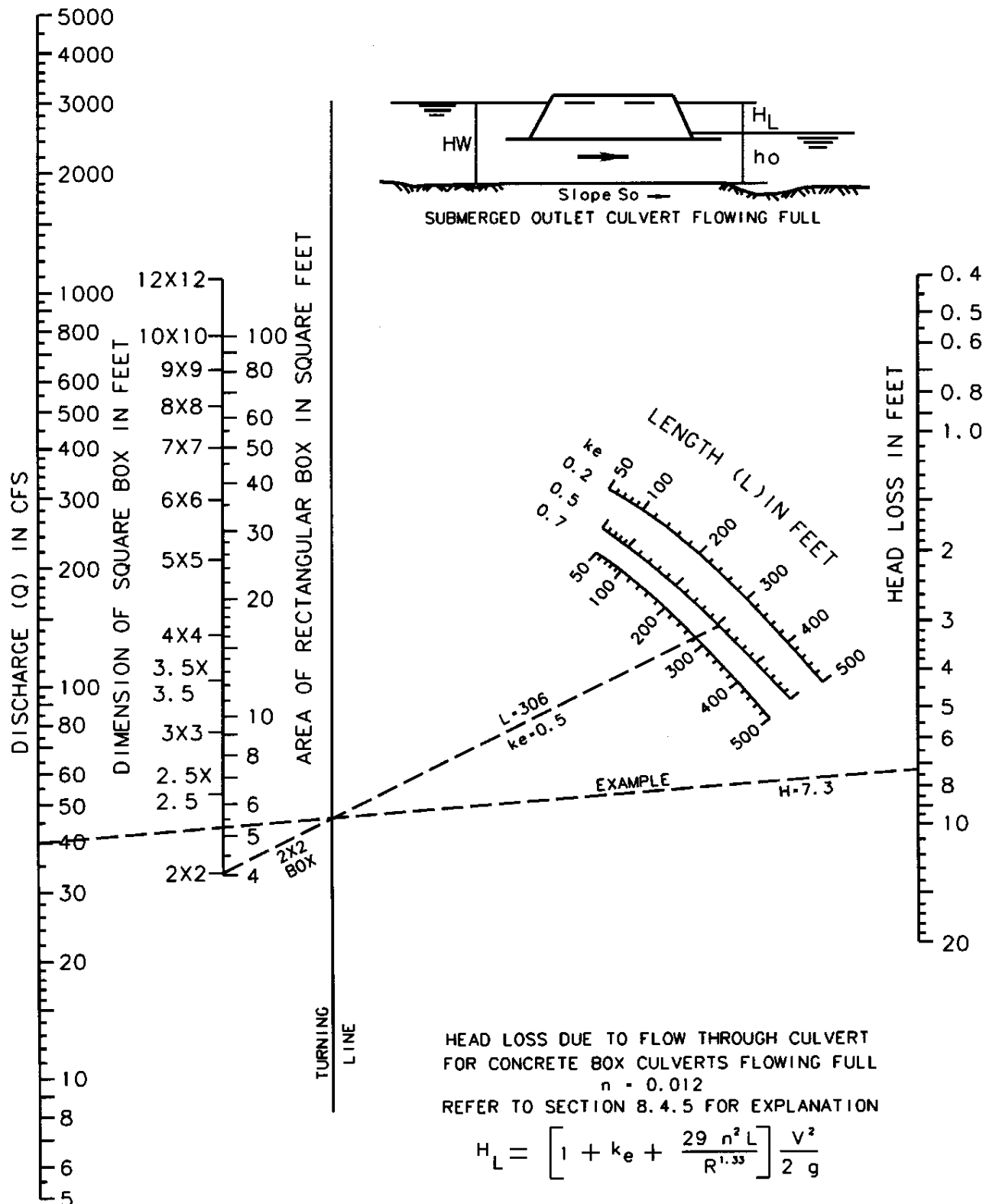


Chart 8-14
Box Culverts with Inlet Control



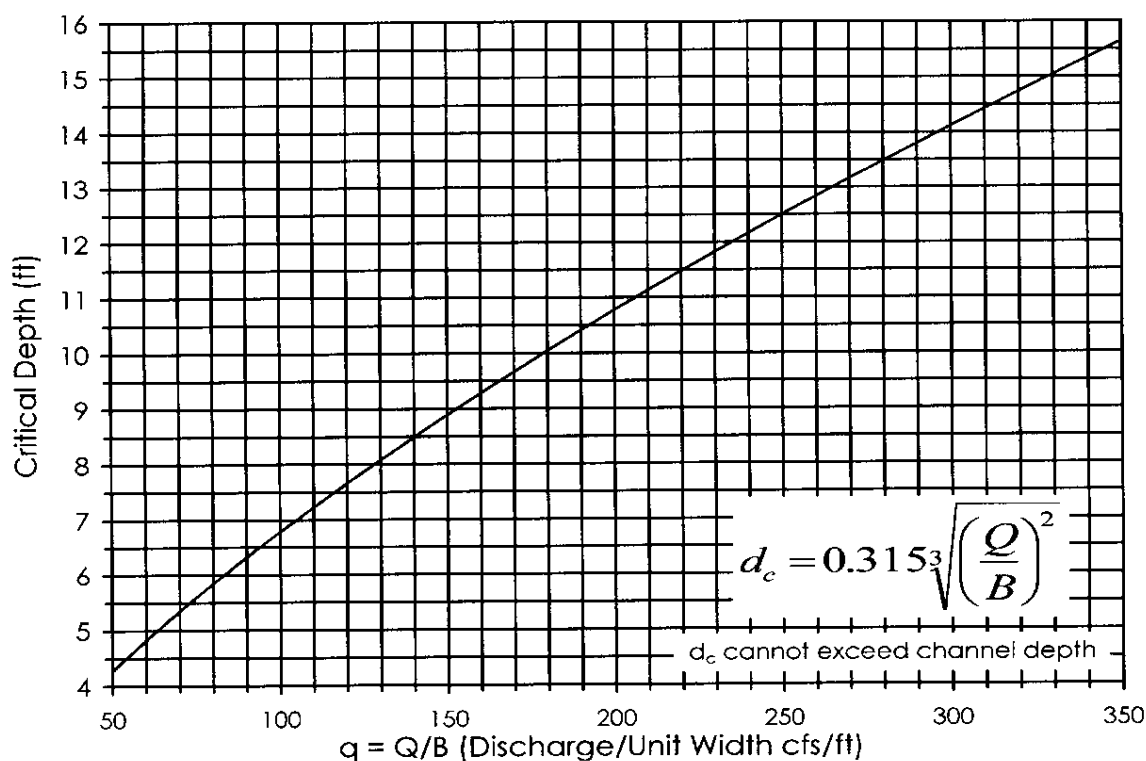
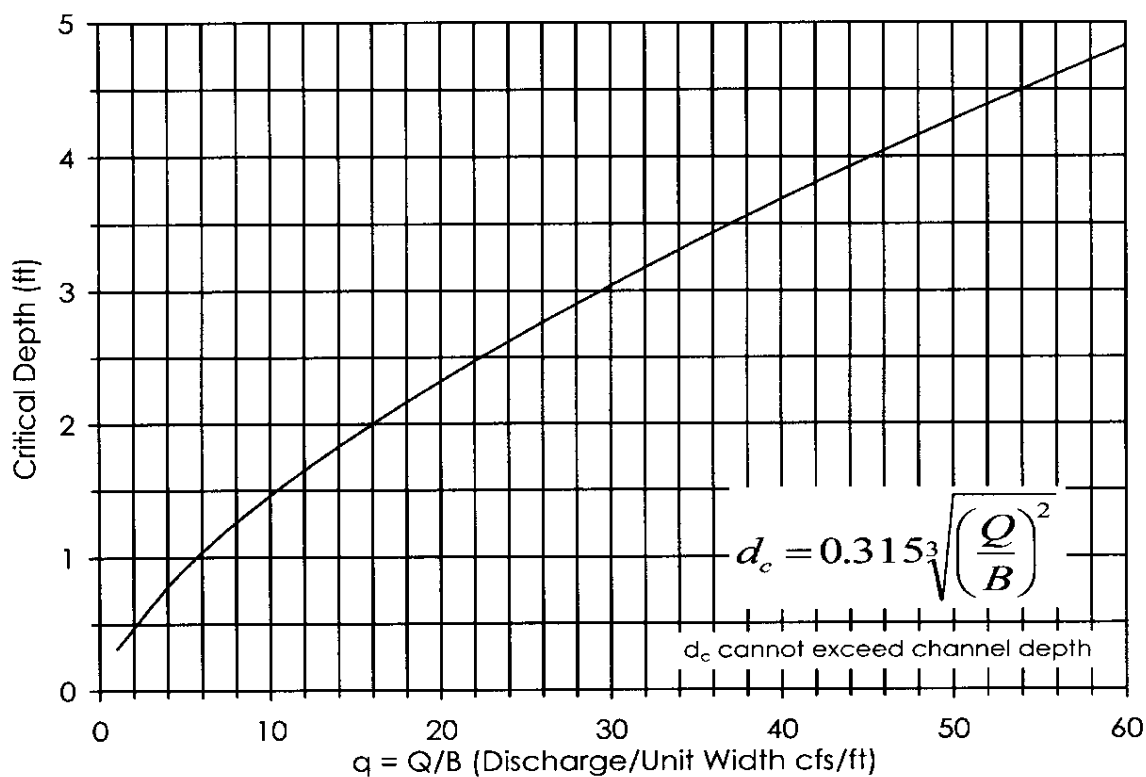
Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-15
Concrete Box Culverts Flowing Full



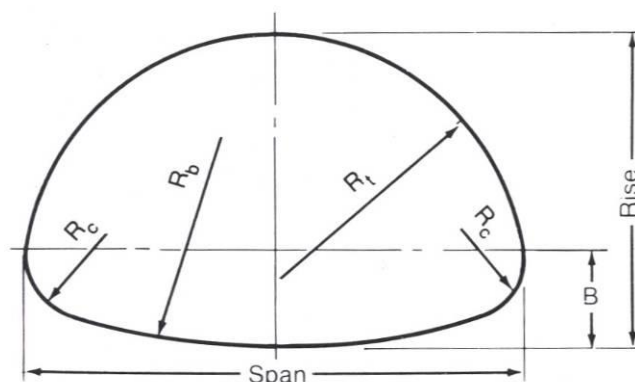
Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-16
Critical Depth for Box Culverts



Created by the WVDOH Hydraulic and Drainage Unit

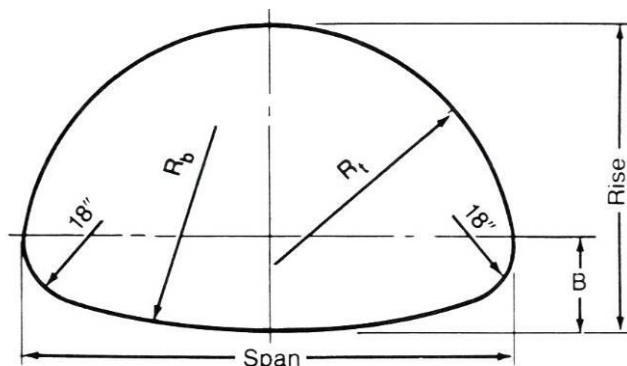
Chart 8-17
Standard Arch Pipe Details



Corrugated Steel Pipe Arch												
NOMINAL SIZE	Rise			Span			Corrugation	Area ft ²	B in	R _c in	R _t in	R _b in
	in	ft	ft - in	in	ft	ft - in						
13 x 17	13	1.08	1 - 1.0	17	1.42	1 - 5.0	2 2/3 x 1/2	1.1	4 1/8	3 1/2	8 5/8	25 5/8
15 x 21	15	1.25	1 - 3.0	21	1.75	1 - 9.0	2 2/3 x 1/2	1.6	4 7/8	4 1/8	10 3/4	33 1/8
18 x 24	18	1.50	1 - 6.0	24	2.00	2 - 0.0	2 2/3 x 1/2	2.2	5 7/8	4 7/8	11 7/8	34 5/8
20 x 28	20	1.67	1 - 8.0	28	2.33	2 - 4.0	2 2/3 x 1/2	2.9	6 1/2	5 1/2	14	42 1/4
24 x 35	24	2.00	2 - 0.0	35	2.92	2 - 11.0	2 2/3 x 1/2	4.5	8 1/8	6 7/8	17 7/8	55 1/8
29 x 42	29	2.42	2 - 5.0	42	3.50	3 - 6.0	2 2/3 x 1/2	6.5	9 3/4	8 1/4	21 1/2	66 1/8
33 x 49	33	2.75	2 - 9.0	49	4.08	4 - 1.0	2 2/3 x 1/2	8.9	11 3/8	9 5/8	25 1/8	77 1/4
38 x 57	38	3.17	3 - 2.0	57	4.75	4 - 9.0	2 2/3 x 1/2	11.6	13	11	28 5/8	88 1/4
43 x 64	43	3.58	3 - 7.0	64	5.33	5 - 4.0	2 2/3 x 1/2	14.7	14 5/8	12 3/8	32 1/4	99 1/4
47 x 71	47	3.92	3 - 11.0	71	5.92	5 - 11.0	2 2/3 x 1/2	18.1	16 1/4	13 3/4	35 3/4	110 1/4
52 x 77	52	4.33	4 - 4.0	77	6.42	6 - 5.0	2 2/3 x 1/2	21.9	17 7/8	15 1/8	39 3/8	121 1/4
57 x 83	57	4.75	4 - 9.0	83	6.92	6 - 11.0	2 2/3 x 1/2	26.0	19 1/2	16 1/2	43	132 1/4
41 x 53	41	3.42	3 - 5	53	4.42	4 - 5	3 x 1 or 5 x 1	11.7	15 1/4	10 3/16	28 1/16	73 7/16
46 x 60	48 1/2	4.04	4 - 1/2	58 1/2	4.88	4 - 10 1/2	3 x 1 or 5 x 1	15.6	20 1/2	18 3/4	29 3/8	51 1/8
51 x 66	54	4.50	4 - 6	65	5.42	5 - 5	3 x 1 or 5 x 1	19.3	22 3/4	20 3/4	32 5/8	56 1/4
55 x 73	58 1/4	4.85	4 - 10 1/4	72 1/2	6.04	6 - 1/2	3 x 1 or 5 x 1	23.2	25 1/8	22 7/8	36 3/4	63 3/4
59 x 81	62 1/2	5.21	5 - 2 1/2	79	6.58	6 - 7	3 x 1 or 5 x 1	27.4	23 3/4	20 7/8	39 1/2	82 5/8
63 x 87	67 1/4	5.60	5 - 7 1/4	86 1/2	7.21	7 - 2 1/2	3 x 1 or 5 x 1	32.1	25 3/4	22 5/8	43 3/8	92 1/4
67 x 95	71 3/4	5.98	5 - 11 3/4	93 1/2	7.79	7 - 9 1/2	3 x 1 or 5 x 1	37.0	27 3/4	24 3/8	47	100 1/4
71 x 103	76	6.33	6 - 4	101 1/2	8.46	8 - 5 1/2	3 x 1 or 5 x 1	42.4	29 3/4	26 1/8	51 1/4	111 5/8
75 x 112	80 1/2	6.71	6 - 8 1/2	108 1/2	9.04	9 - 1/2	3 x 1 or 5 x 1	48.0	31 5/8	27 3/4	54 7/8	120 1/4
79 x 117	84 3/4	7.06	7 - 3/4	116 1/2	9.71	9 - 8 1/2	3 x 1 or 5 x 1	54.2	33 5/8	29 1/2	59 3/8	131 3/4
83 x 128	89 1/4	7.44	7 - 5 1/4	123 1/2	10.29	10 - 3 1/2	3 x 1 or 5 x 1	60.5	35 5/8	31 1/4	63 1/4	139 3/4
87 x 137	93 3/4	7.81	7 - 9 3/4	131	10.92	10 - 11	3 x 1 or 5 x 1	67.4	37 5/8	33	67 3/8	149 1/2
91 x 142	98	8.17	8 - 2	138 1/2	11.54	11 - 6 1/2	3 x 1 or 5 x 1	74.5	39 1/2	34 3/4	71 5/8	162 3/8
96 x 150	102	8.50	8 - 6	146	12.17	12 - 2	3 x 1 or 5 x 1	81.0	41	36	76	172
101 x 157	107	8.92	8 - 11	153	12.75	12 - 9	3 x 1 or 5 x 1	89.0	43	38	80	180
105 x 164	113	9.42	9 - 5	159	13.25	13 - 3	3 x 1 or 5 x 1	98.0	45	40	82	184
110 x 171	118 1/2	9.88	9 - 10 1/2	165	13.75	13 - 9	3 x 1 or 5 x 1	107.0	47	41	85	190

Source: Handbook of Steel Drainage Products, American Iron & Steel Inst., 1994

Chart 8-18
Arch Pipe with 18-inch Corner Radius Details

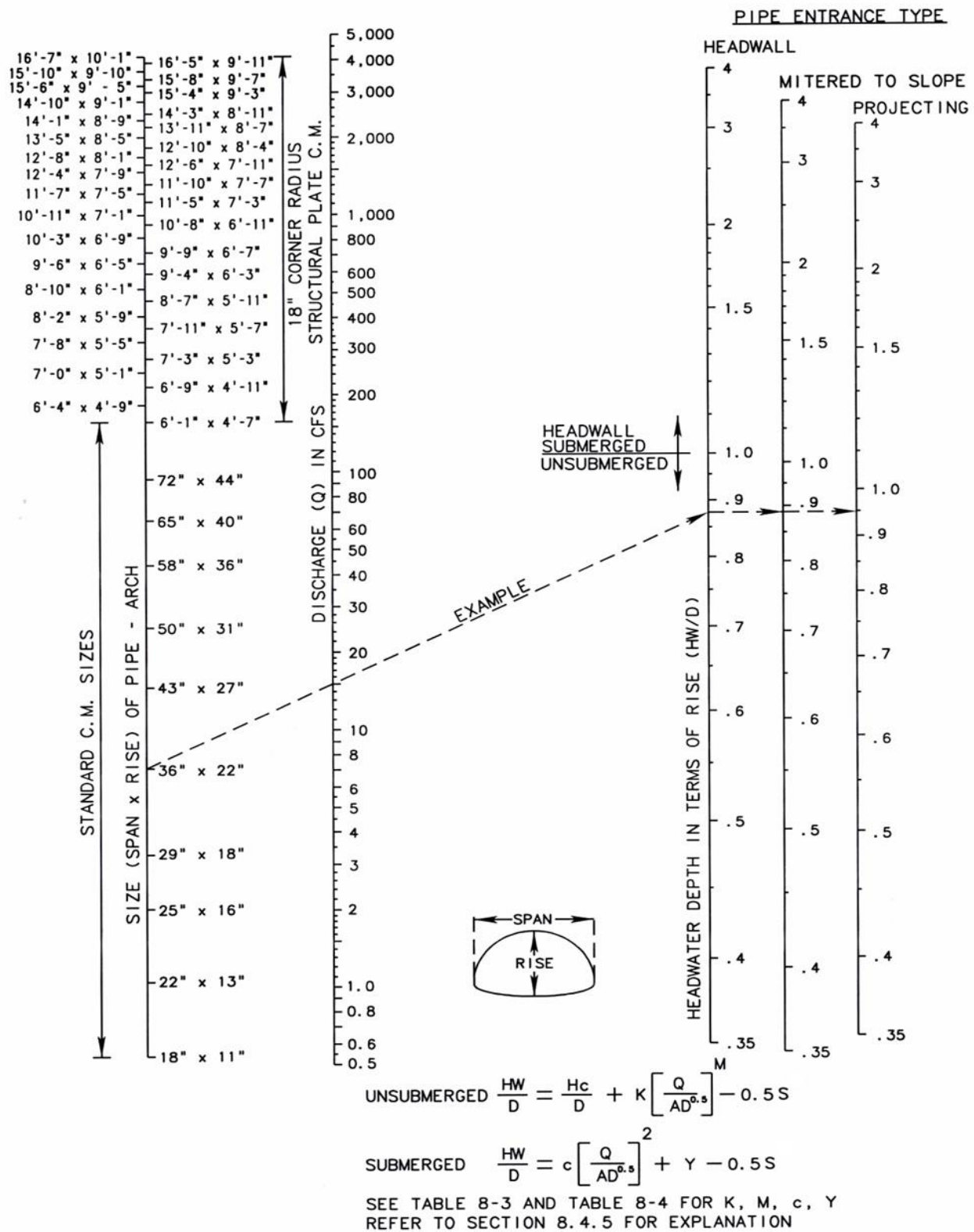


Corrugated Steel Pipe Arch 18 inch corner radius											
Rise			Span			Corrugation	Area	B	R_c	R_t	R_b
in	ft	ft - in	in	ft	ft - in	in x in	ft ²	in	in	ft	ft
55	4.58	4 - 7.0	73	6.08	6 - 1.0	6 x 2	22	21.0	18	3.07	6.36
57	4.75	4 - 9.0	76	6.33	6 - 4.0	6 x 2	24	20.5	18	3.18	8.22
59	4.92	4 - 11.0	81	6.75	6 - 9.0	6 x 2	26	22.0	18	3.42	6.96
61	5.08	5 - 1.0	84	7.00	7 - 0.0	6 x 2	28	21.4	18	3.53	8.68
63	5.25	5 - 3.0	87	7.25	7 - 3.0	6 x 2	31	20.8	18	3.63	11.35
65	5.42	5 - 5.0	92	7.67	7 - 8.0	6 x 2	33	22.4	18	3.88	9.15
67	5.58	5 - 7.0	95	7.92	7 - 11.0	6 x 2	35	21.7	18	3.98	11.49
69	5.75	5 - 9.0	98	8.17	8 - 2.0	6 x 2	38	20.9	18	4.08	15.24
71	5.92	5 - 11.0	103	8.58	8 - 7.0	6 x 2	40	22.7	18	4.33	11.75
73	6.08	6 - 1.0	106	8.83	8 - 10.0	6 x 2	43	21.8	18	4.42	14.89
75	6.25	6 - 3.0	112	9.33	9 - 4.0	6 x 2	46	23.8	18	4.68	12.05
77	6.42	6 - 5.0	114	9.50	9 - 6.0	6 x 2	49	22.9	18	4.78	14.79
79	6.58	6 - 7.0	117	9.75	9 - 9.0	6 x 2	52	21.9	18	4.86	18.98
81	6.75	6 - 9	123	10.25	10 - 3	6 x 2	55	23.9	18	5.13	14.86
83	6.92	6 - 11	128	10.67	10 - 8	6 x 2	58	26.1	18	5.41	12.77
85	7.08	7 - 1	131	10.92	10 - 11	6 x 2	61	25.1	18	5.49	15.03
87	7.25	7 - 3	137	11.42	11 - 5	6 x 2	64	27.4	18	5.78	13.16
89	7.42	7 - 5	139	11.58	11 - 7	6 x 2	67	26.3	18	5.85	15.27
91	7.58	7 - 7	142	11.83	11 - 10	6 x 2	71	25.2	18	5.93	18.03
93	7.75	7 - 9	148	12.33	12 - 4	6 x 2	74	27.5	18	6.23	15.54
95	7.92	7 - 11	150	12.50	12 - 6	6 x 2	78	26.4	18	6.29	18.07
97	8.08	8 - 1	152	12.67	12 - 8	6 x 2	81	25.2	18	6.37	21.45
100	8.33	8 - 4	154	12.83	12 - 10	6 x 2	85	24.0	18	6.44	26.23
101	8.42	8 - 5	161	13.42	13 - 5	6 x 2	89	26.3	18	6.73	21.23
103	8.58	8 - 7	167	13.92	13 - 11	6 x 2	93	28.9	18	7.03	18.39
105	8.75	8 - 9	169	14.08	14 - 1	6 x 2	97	27.6	18	7.09	21.18
107	8.92	8 - 11	171	14.25	14 - 3	6 x 2	101	26.3	18	7.16	24.80
109	9.08	9 - 1	178	14.83	14 - 10	6 x 2	105	28.9	18	7.47	21.19
111	9.25	9 - 3	184	15.33	15 - 4	6 x 2	109	31.6	18	7.78	18.90
113	9.42	9 - 5	186	15.50	15 - 6	6 x 2	113	30.2	18	7.83	21.31
115	9.58	9 - 7	188	15.67	15 - 8	6 x 2	118	28.8	18	7.89	24.29
118	9.83	9 - 10	190	15.83	15 - 10	6 x 2	122	27.4	18	7.96	28.18
119	9.92	9 - 11	197	16.42	16 - 5	6 x 2	126	30.1	18	8.27	24.24
121	10.08	10 - 1	199	16.58	16 - 7	6 x 2	131	28.7	18	8.33	27.73

Source: Handbook of Steel Drainage Products, American Iron & Steel Inst., 1994

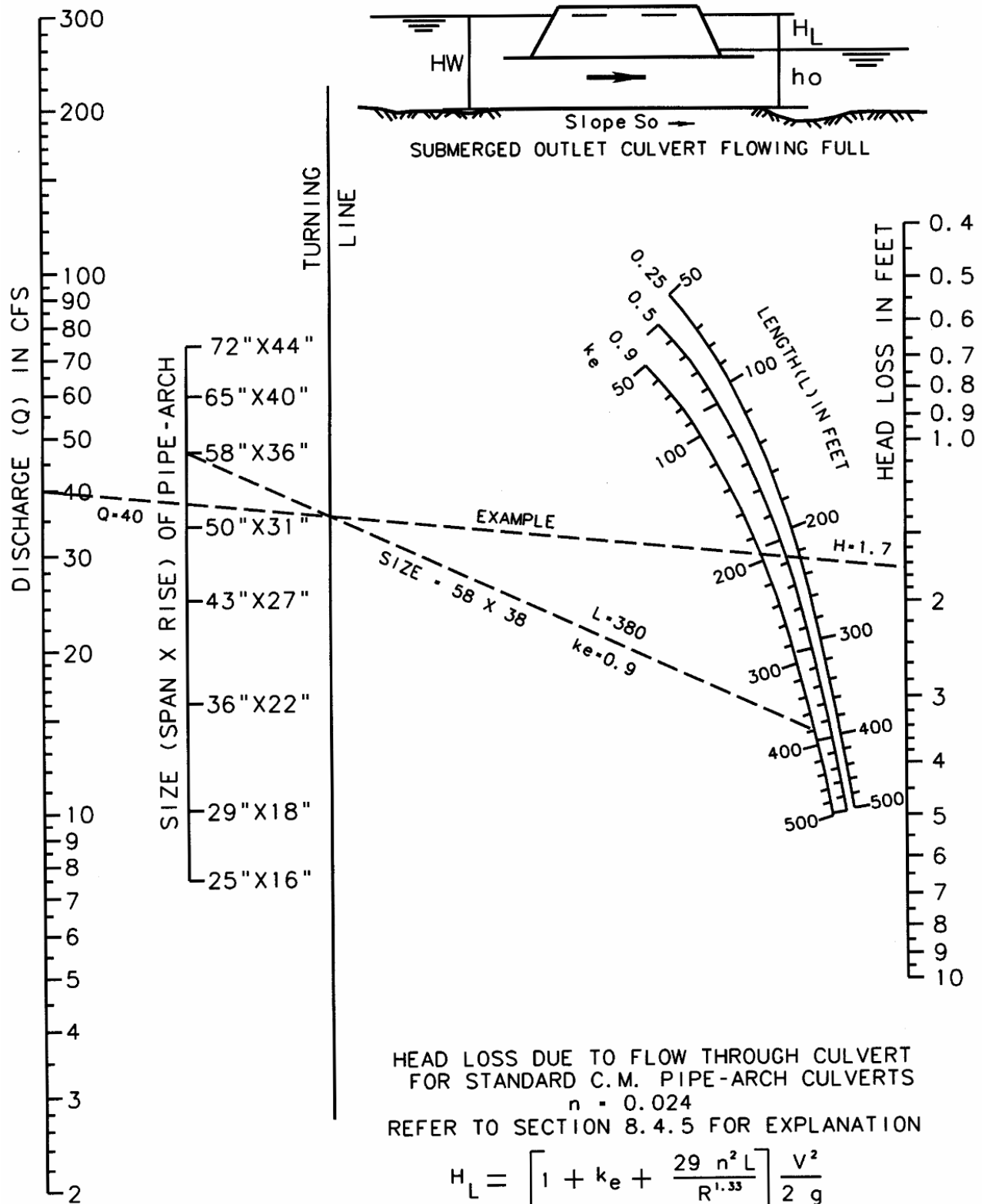
Chart 8-19

Standard C.M. Pipe Arch Culverts with Inlet Control

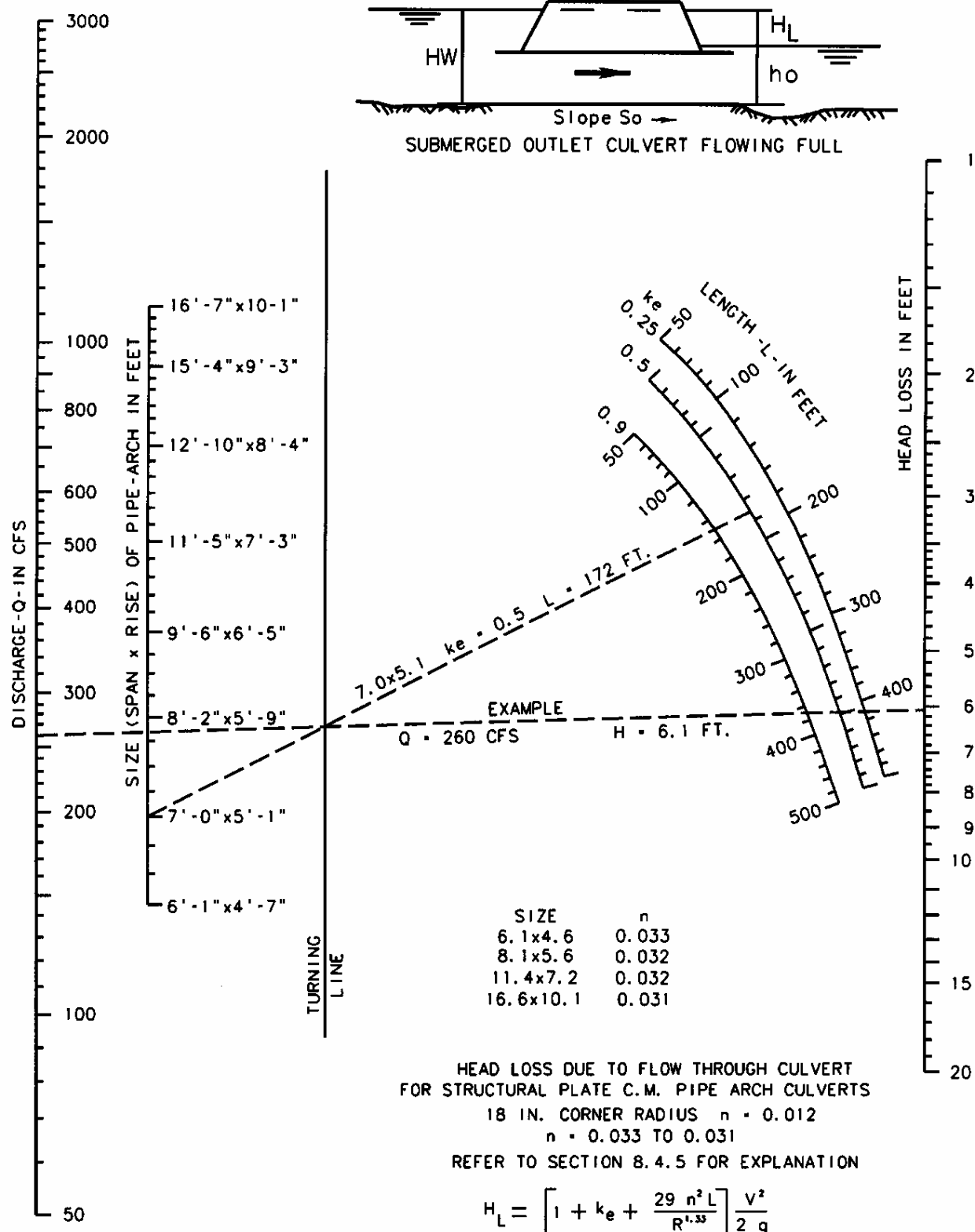


Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-20
Standard C.M. Pipe Arch Flowing Full

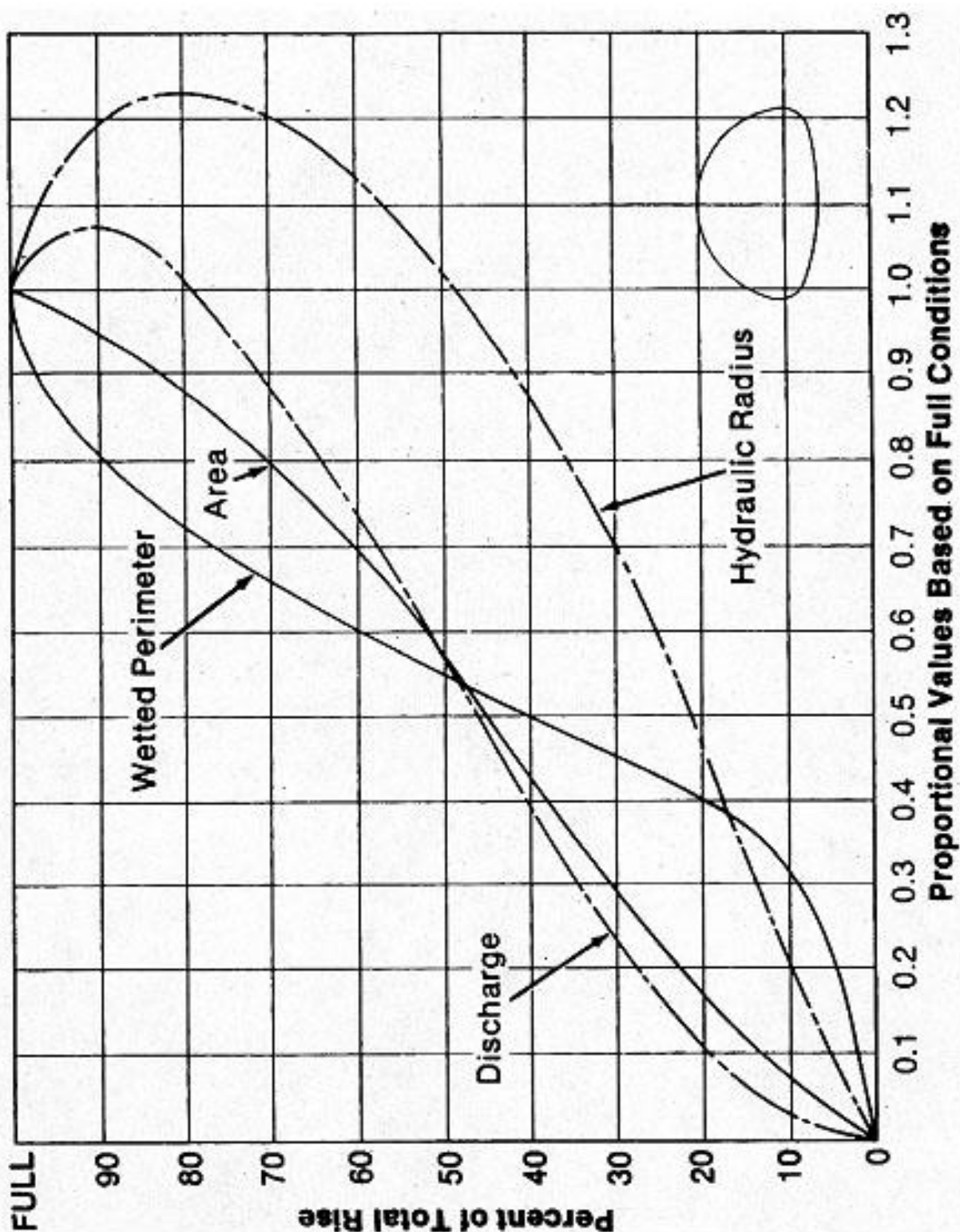


Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-21**Str. Plate Pipe Arch (18" corner rad.) Flowing Full**

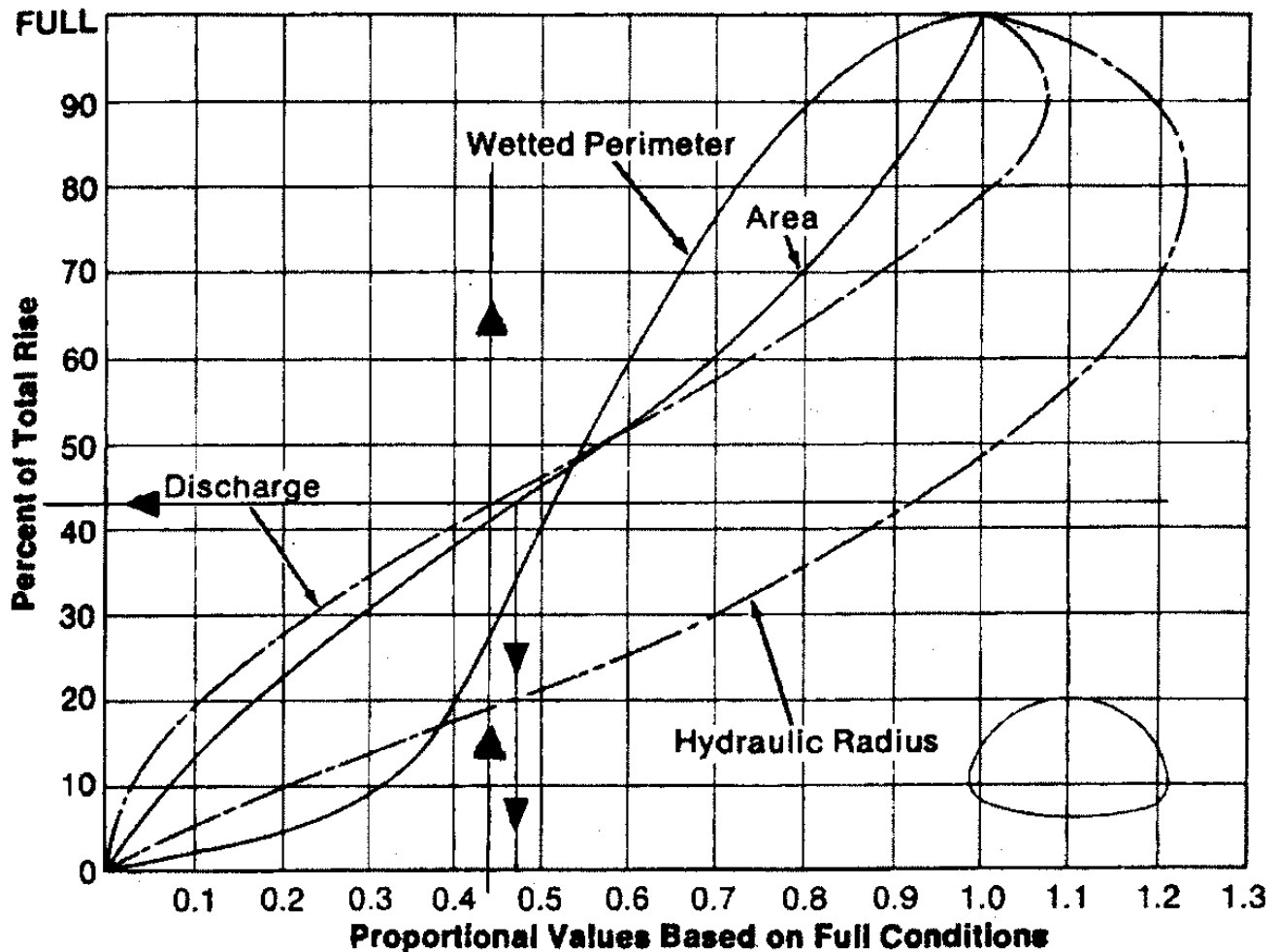
Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-22
Hydraulic Elements for Partially Full C.M. Pipe Arch



Source: Handbook of Steel Drainage Products, American Iron & Steel Inst., 1994

Chart 8-23
Hydraulic Elements for Partially Full C.M. Pipe Arch Example



24 X 35 pipe, $n = 0.024$, Slope = 0.02, $Q_{full} / S^{0.5} = 192$ (Table 8-5)

Given: $D_{full} = 24$ in, $Q = 12$ cfs

$$Q_{full} = 192 * (0.02)^{0.5} = 27.2 \text{ cfs}$$

Required: depth at Q , velocity at Q

Solution: $Q / Q_{full} = 12 / 27.2 = 0.44$

From figure for hydraulic elements, $d / d_{full} = 0.435$

$$d = d_{full} \times 0.435 = 10.4 \text{ in}$$

From figure for hydraulic elements, $A / A_{full} = 0.465$ (A_{full} from Table 8-5)

$$A = A_{full} \times 0.465 = 2.1 \text{ ft}^2$$

$$V = Q / A = 12 / 2.1 = 5.7 \text{ ft/s}$$

Table 8-5
Full Flow Values for C.M. Pipe Arch

Pipe Size Rise X Span	Corrugations	Equivalent Full Flow Area for Circular Diameter inches	A Area ft ²	R Hydraulic Radius ft	Value of Full Flow Conveyance K $\frac{Q}{\sqrt{S}} = \frac{1.486}{n} A R^{\frac{2}{3}}$		
					n = 0.024	n = 0.027	n = 0.033
13" X 17"	2 2/3 X 1/2	15	1.1	0.280	29	26	21
15" X 21"	2 2/3 X 1/2	18	1.6	0.340	48	43	35
18" X 24"	2 2/3 X 1/2	21	2.2	0.400	74	66	54
20" X 28"	2 2/3 X 1/2	24	2.9	0.462	107	95	78
24" X 35"	2 2/3 X 1/2	30	4.5	0.573	192	171	140
29" X 42"	2 2/3 X 1/2	36	6.5	0.690	314	279	229
33" X 49"	2 2/3 X 1/2	42	8.9	0.810	479	426	348
38" X 57"	2 2/3 X 1/2	48	11.6	0.924	681	606	496
43" X 64"	2 2/3 X 1/2	54	14.7	1.040	934	830	679
46" X 60"	3 X 1	54	15.6	1.104	1032	917	750
51" X 66"	3 X 1	60	19.3	1.230	1372	1219	998
55" X 73"	3 X 1	66	23.2	1.343	1749	1554	1272
59" X 81"	3 X 1	72	27.4	1.454	2177	1935	1584
63" X 87"	3 X 1	78	32.1	1.573	2688	2390	1955
67" X 95"	3 X 1	84	37.0	1.683	3241	2881	2357
71" X 103"	3 X 1	90	42.4	1.800	3885	3453	2825
75" X 112"	3 X 1	96	48.0	1.911	4577	4068	3329
4'-7" X 6'-1"	6 X 2		22.1	1.298	1628	1447	1184
5'-1" X 7'-0"	6 X 2		28.4	1.463	2266	2014	1648
5'-5" X 7'-8"	6 X 2		32.9	1.565	2746	2441	1997
5'-9" X 8'-2"	6 X 2		37.7	1.670	3286	2921	2390
6'-1" X 8'-10"	6 X 2		42.9	1.776	3895	3463	2833
6'-5" X 9'-6"	6 X 2		48.5	1.881	4576	4067	3328
6'-7" X 9'-9"	6 X 2		51.2	1.930	4914	4368	3574
7'-3" X 11'-5"	6 X 2		64.0	2.145	6591	5859	4793
8'-1" X 12'-8"	6 X 2		81.0	2.390	8965	7969	6520
8'-4" X 12'-10"	6 X 2		85.5	2.465	9660	8587	7026

Source: American Concrete Pipe Association Publication

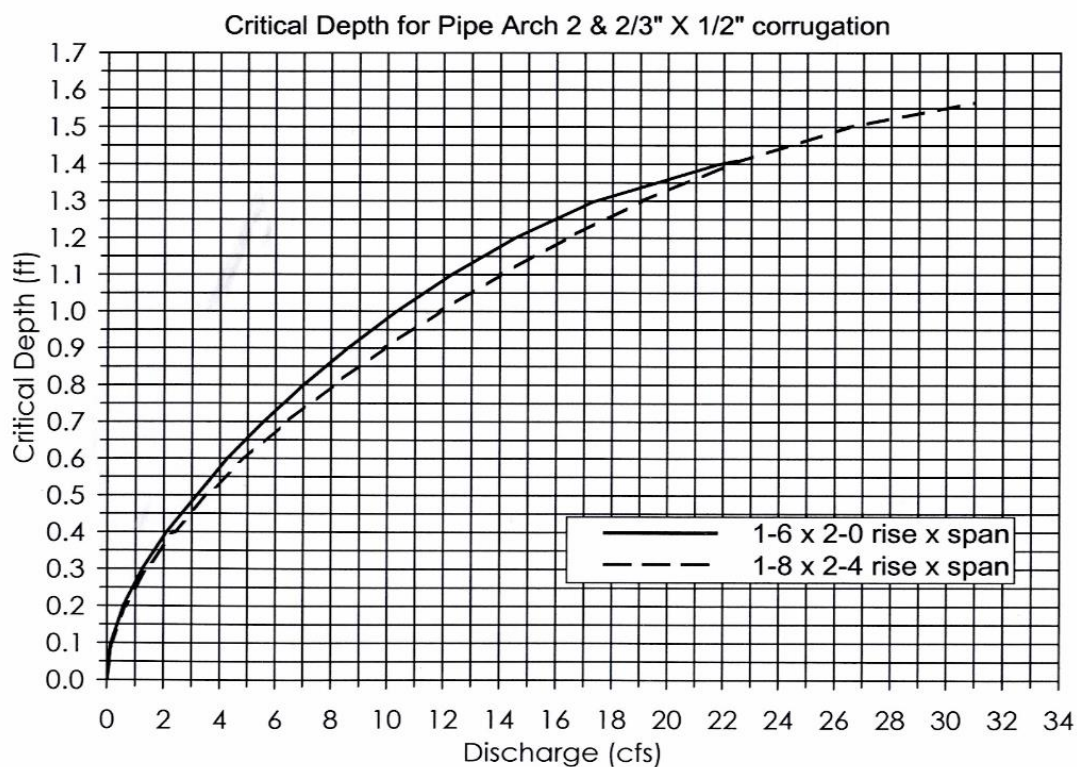
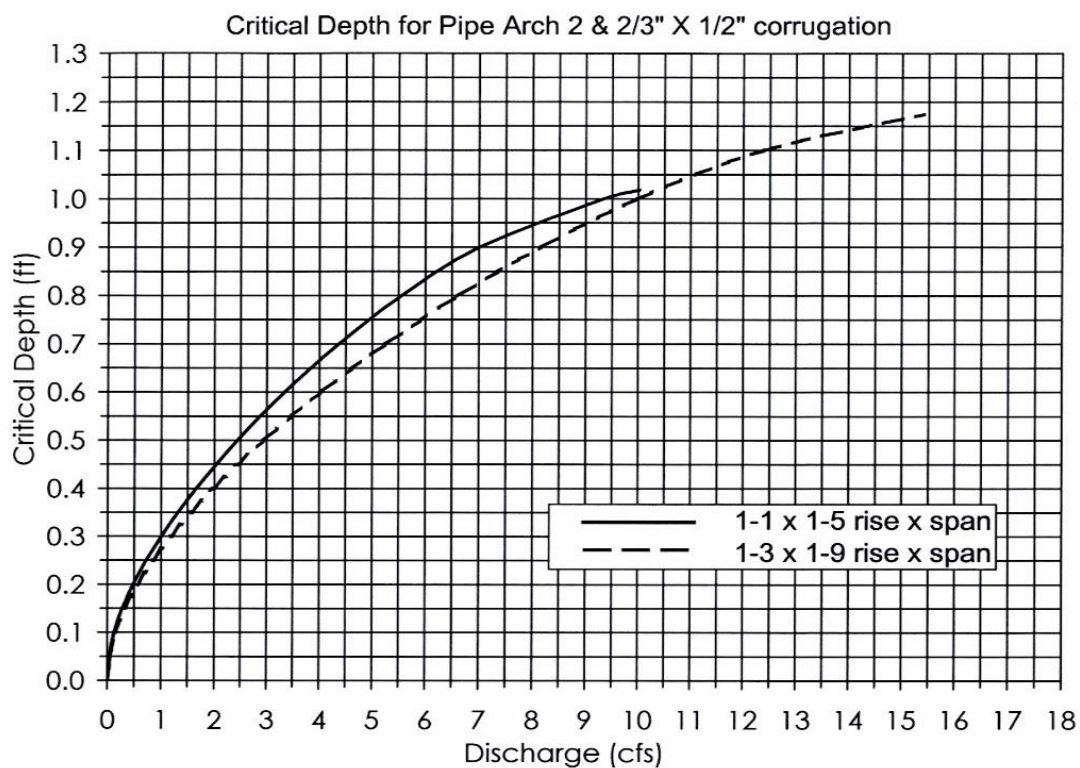
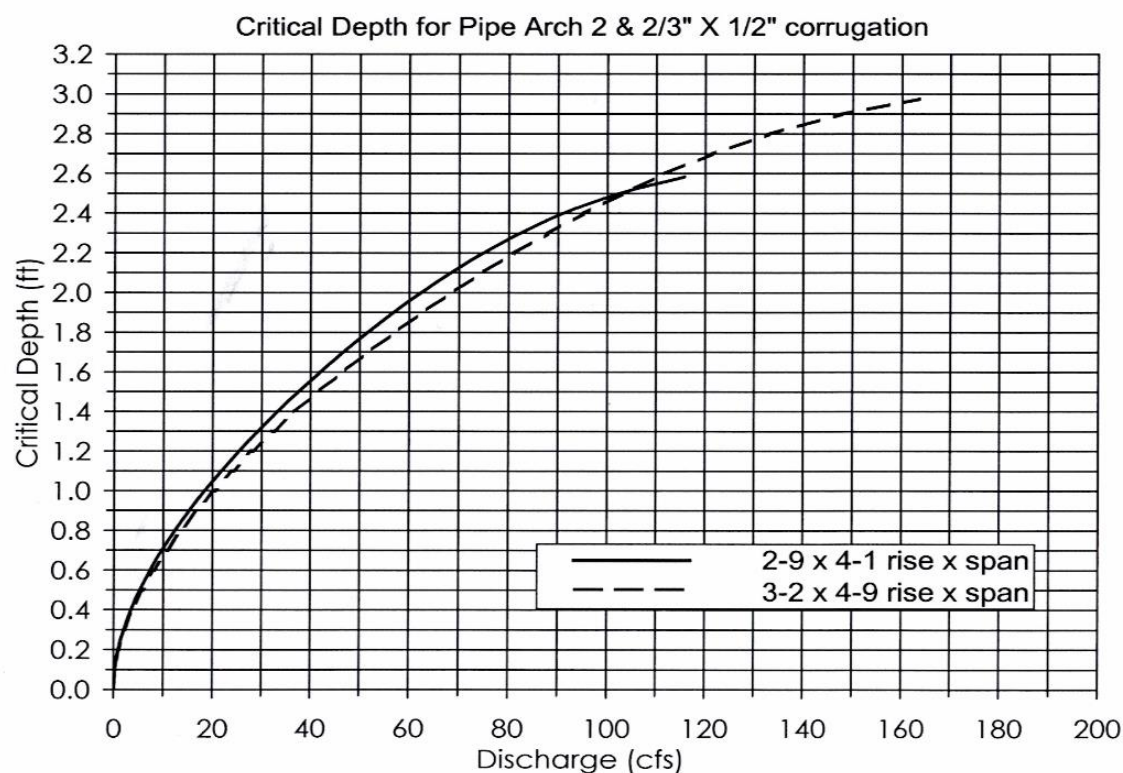
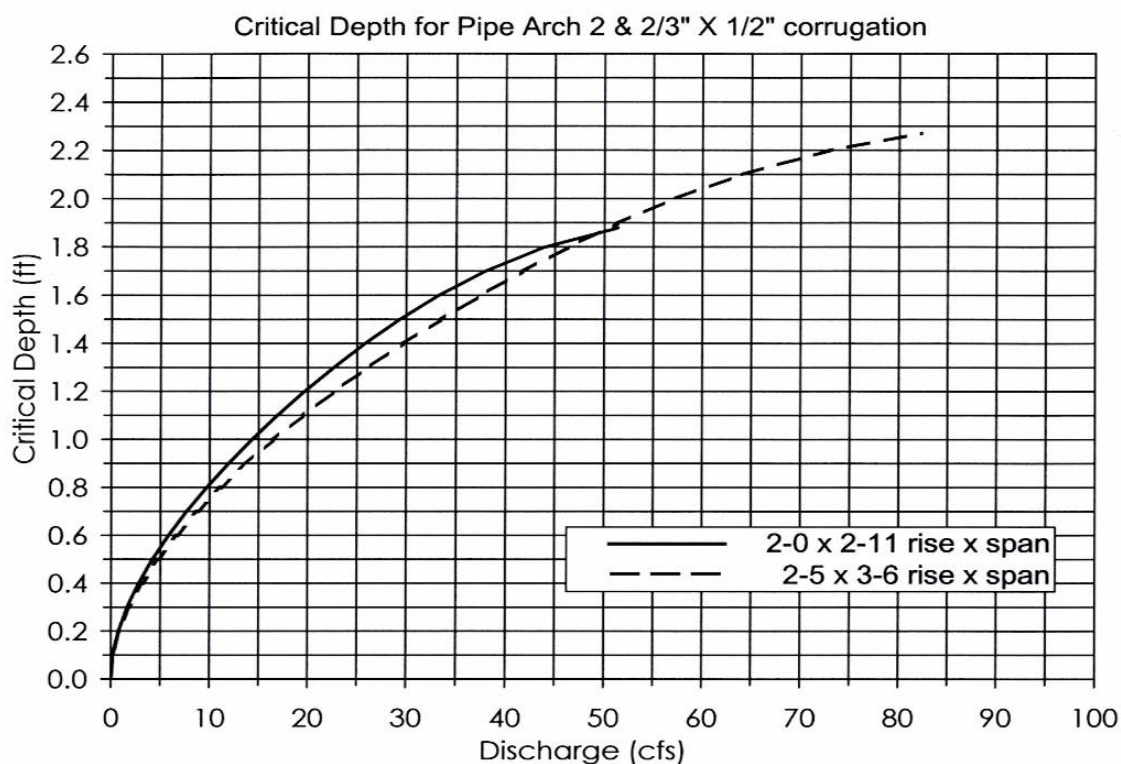
Chart 8-24**Critical Depth for Pipe Arch 2-2/3 x 1/2 in. Corrugation**

Chart 8-25**Critical Depth for Pipe Arch 2-2/3 x 1/2 in. Corrugation**

Created by the WVDOH Hydraulic and Drainage Unit

Chart 8-26
Critical Depth for Pipe Arch 2-2/3 x 1/2 in. Corrugation

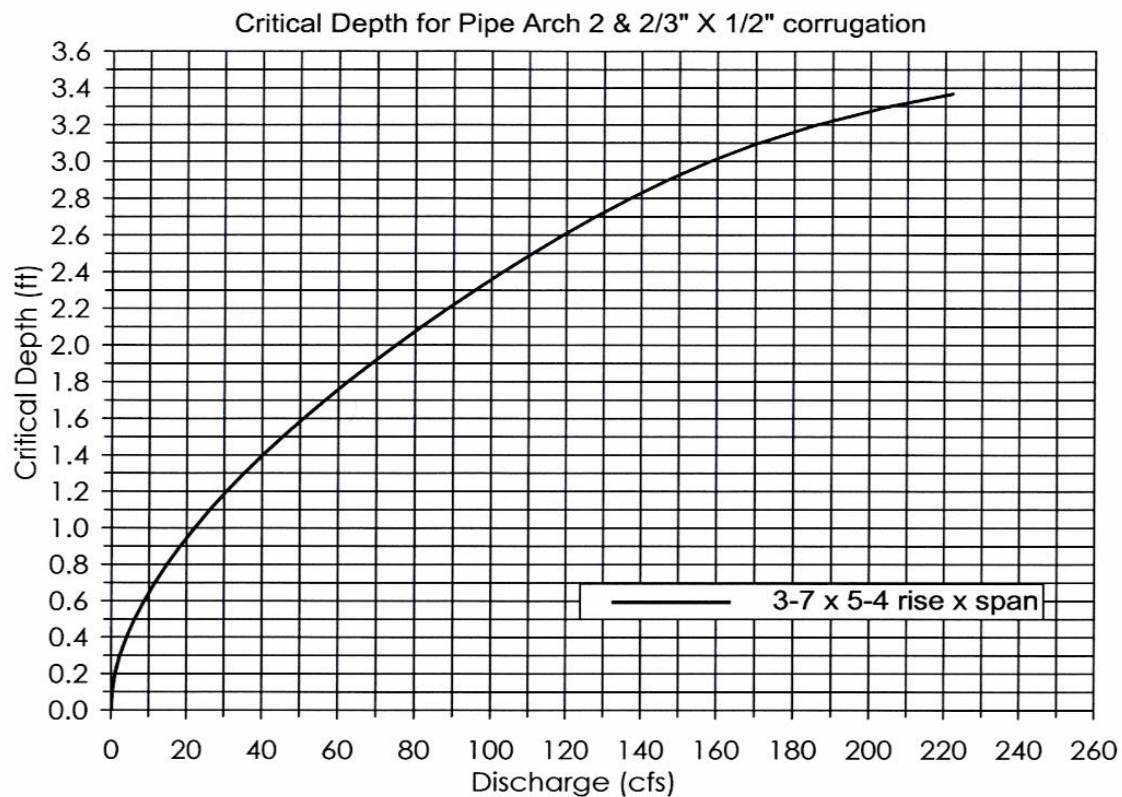


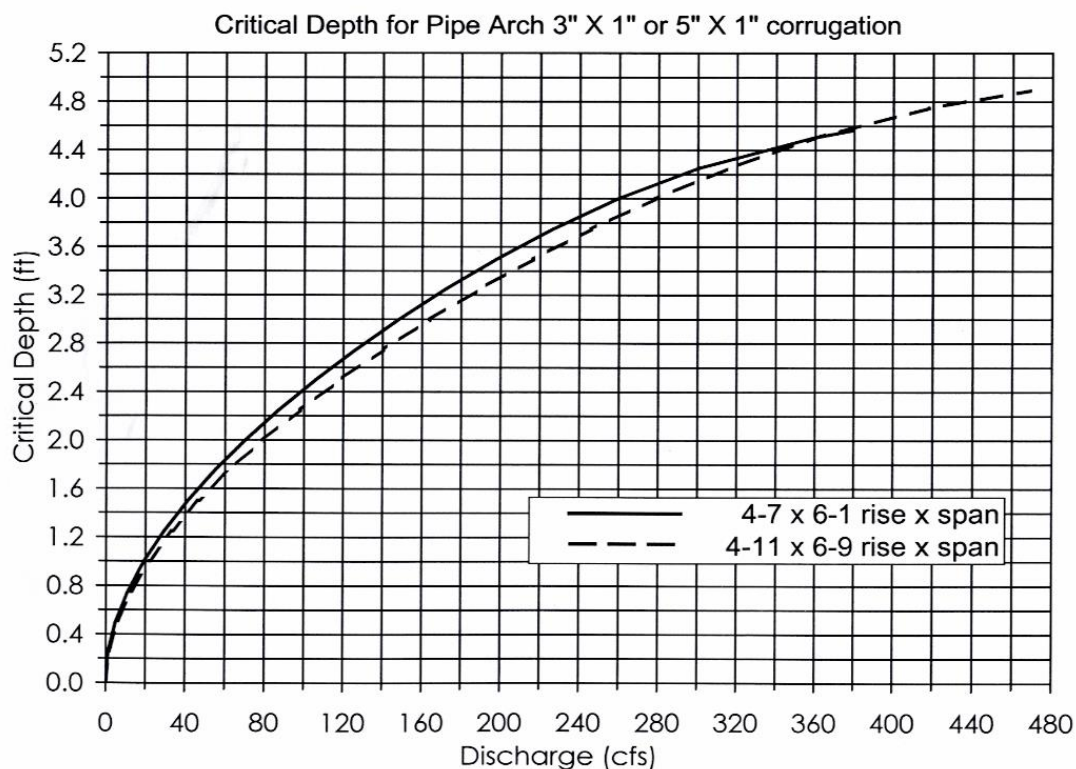
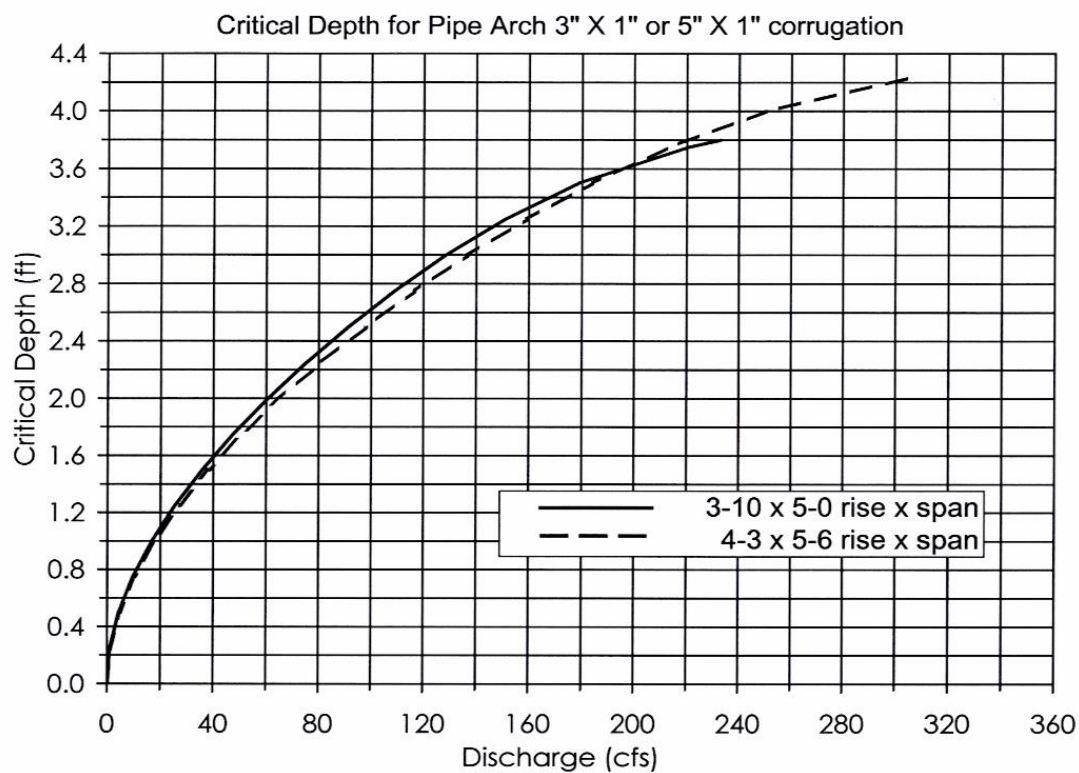
Chart 8-27**Critical Depth for Pipe Arch 3 x 1 or 5 x 1 in. Corrugation**

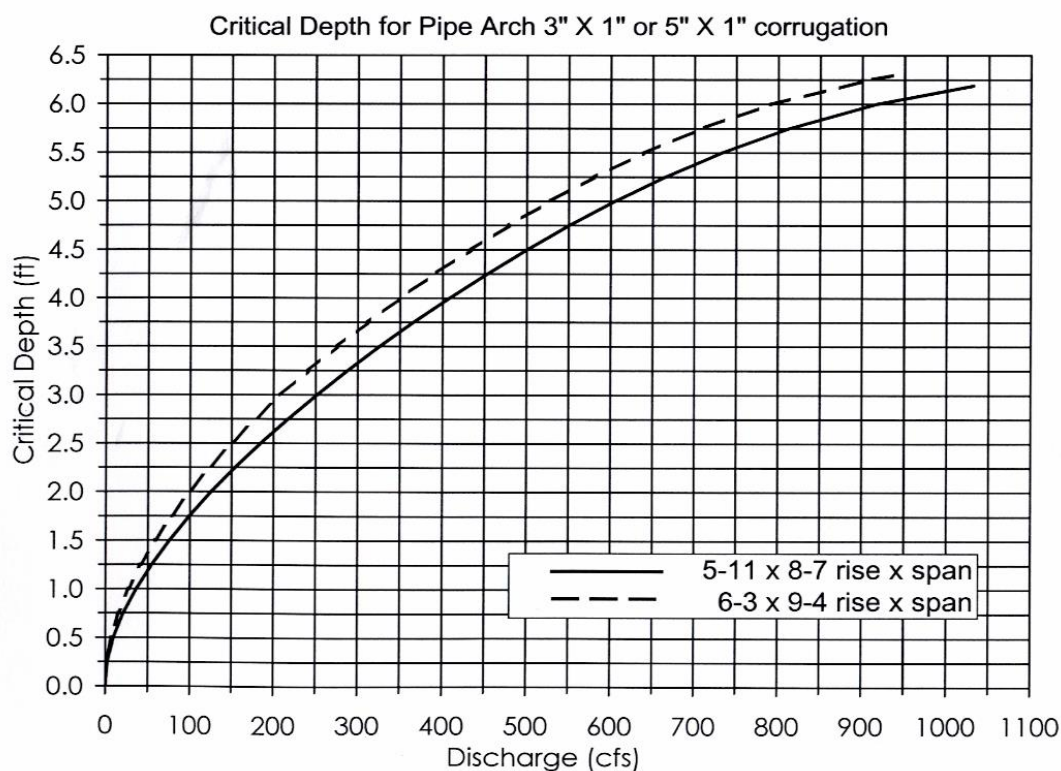
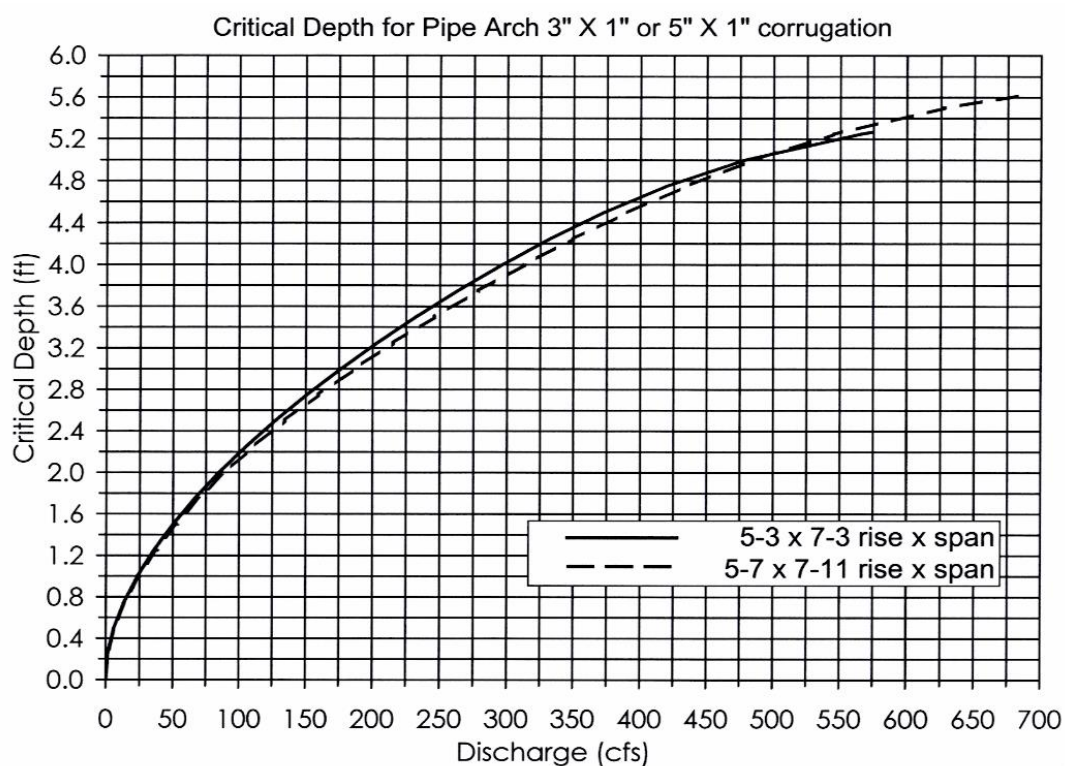
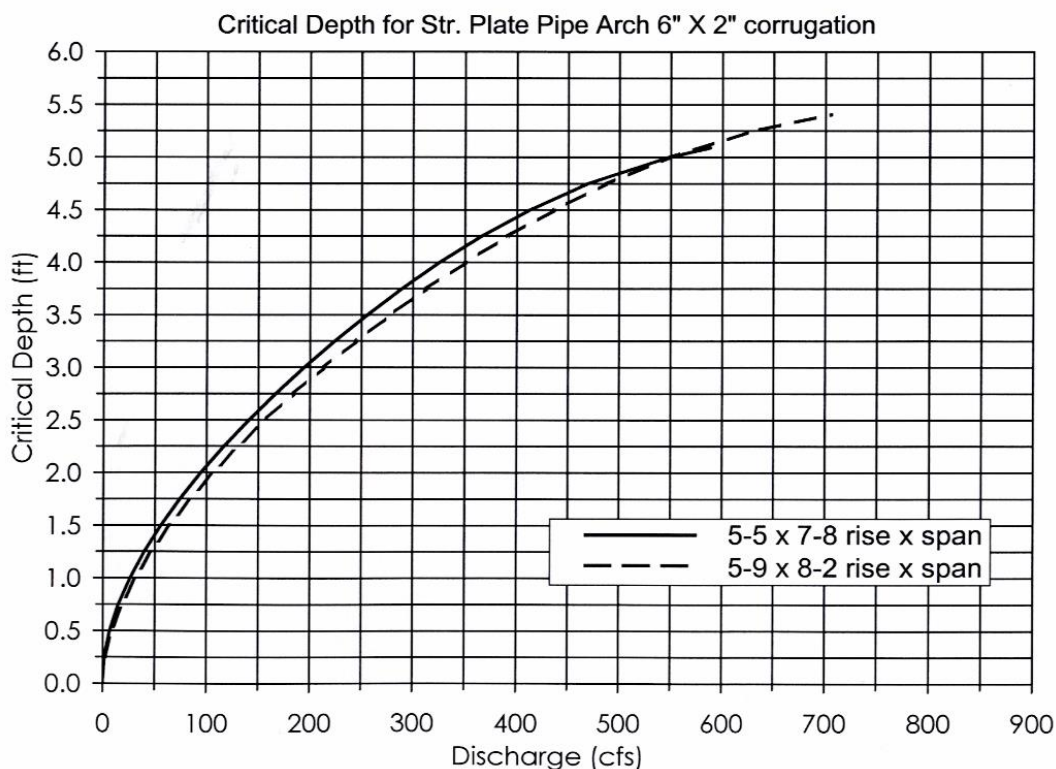
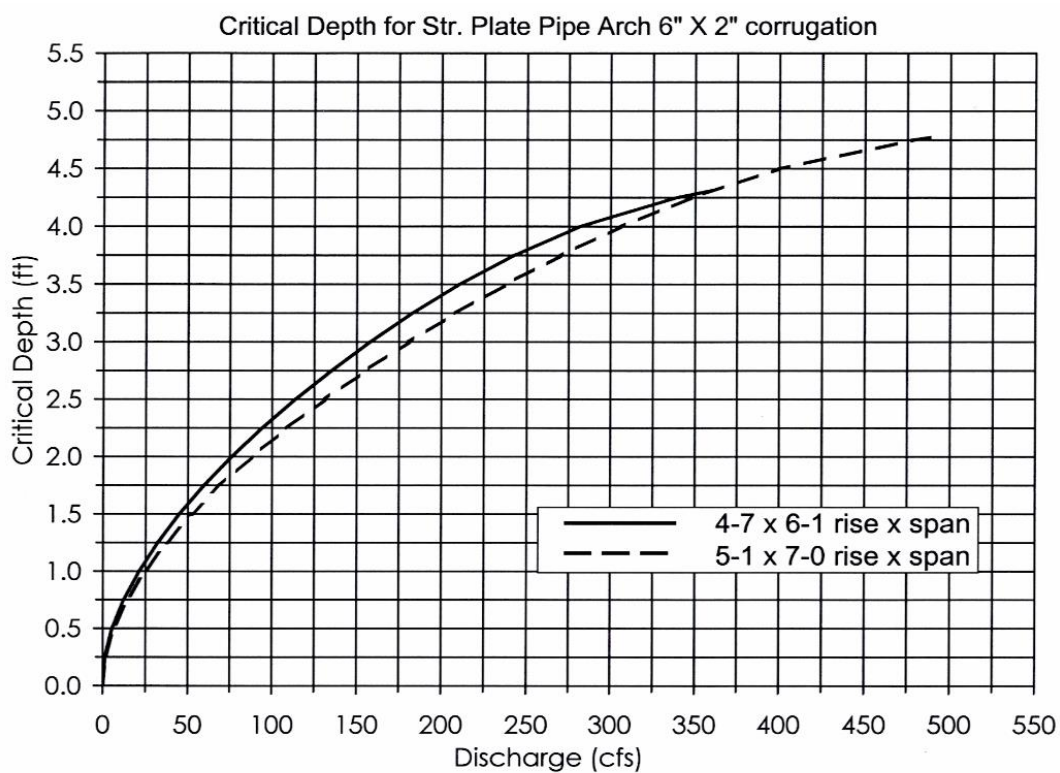
Chart 8-28**Critical Depth for Pipe Arch 3 x 1 or 5 x 1 in. Corrugation**

Chart 8-29**Critical Depth Str. Plate Pipe Arch 6 x 2 in. Corrugation**

Created by the WVDOH Hydraulic and Drainage Unit

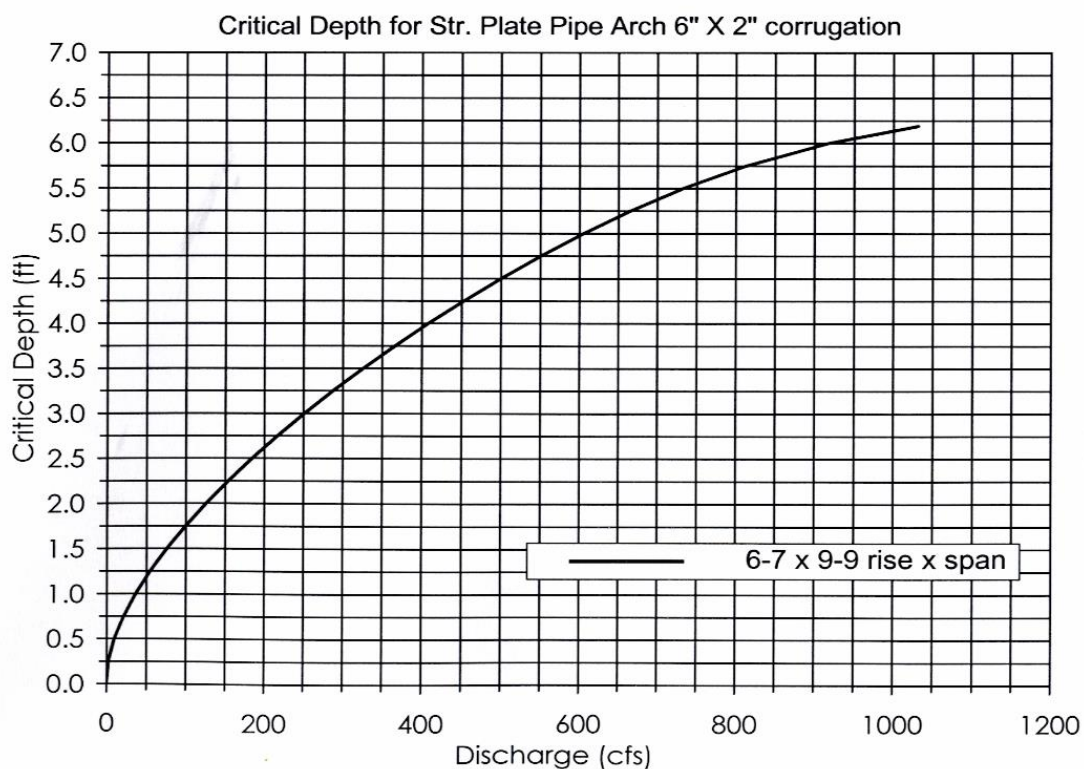
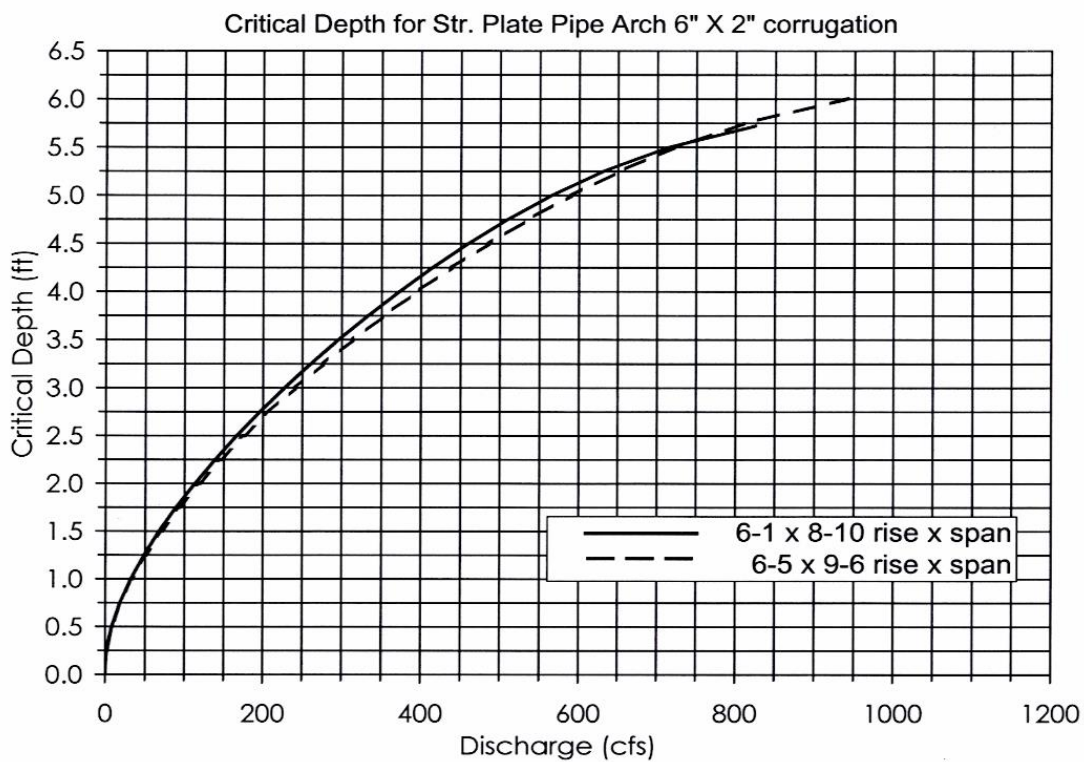
Chart 8-30**Critical Depth Str. Plate Pipe Arch 6 x 2 in. Corrugation**

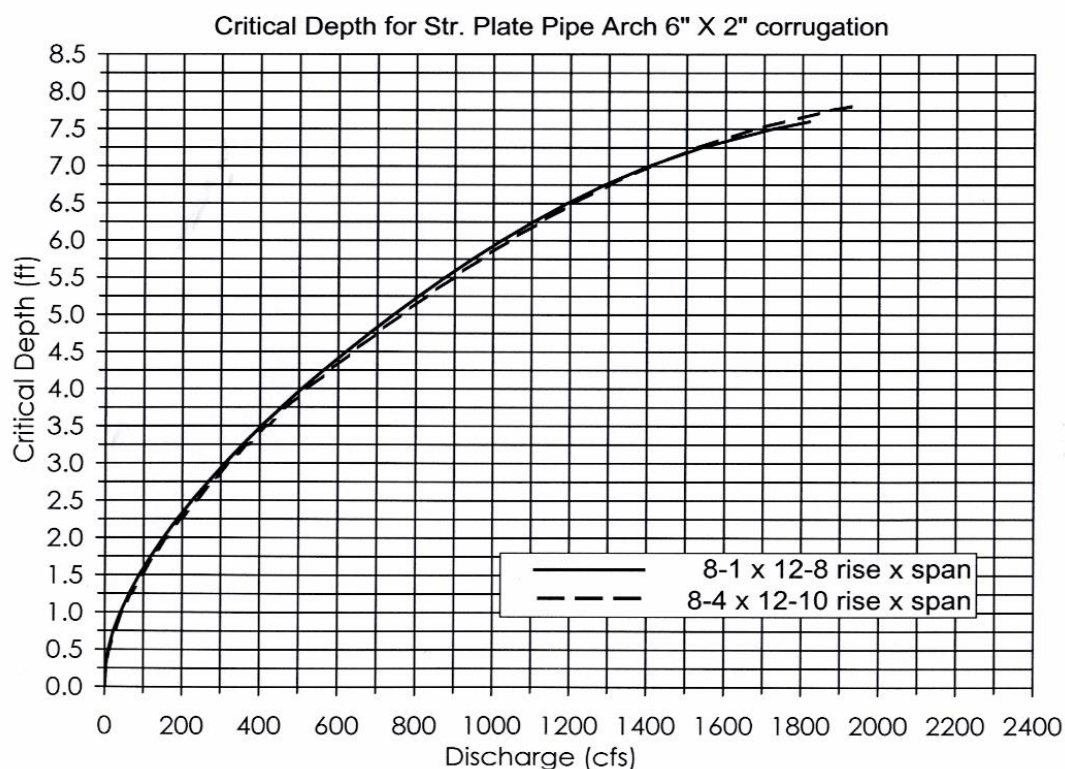
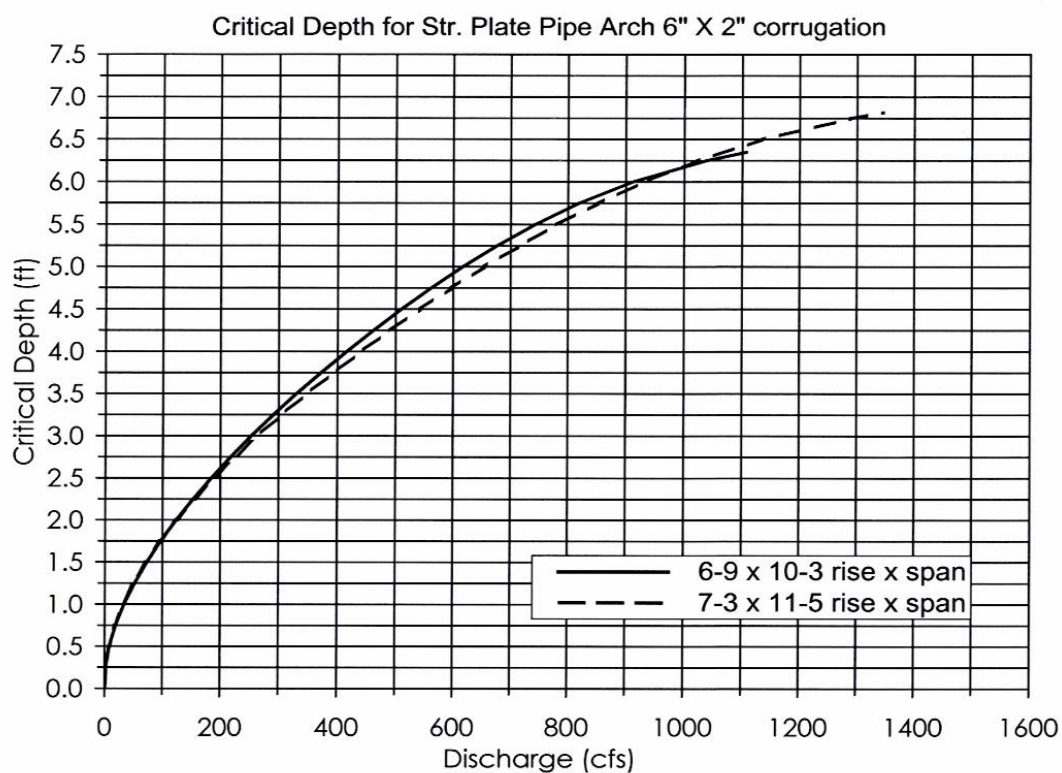
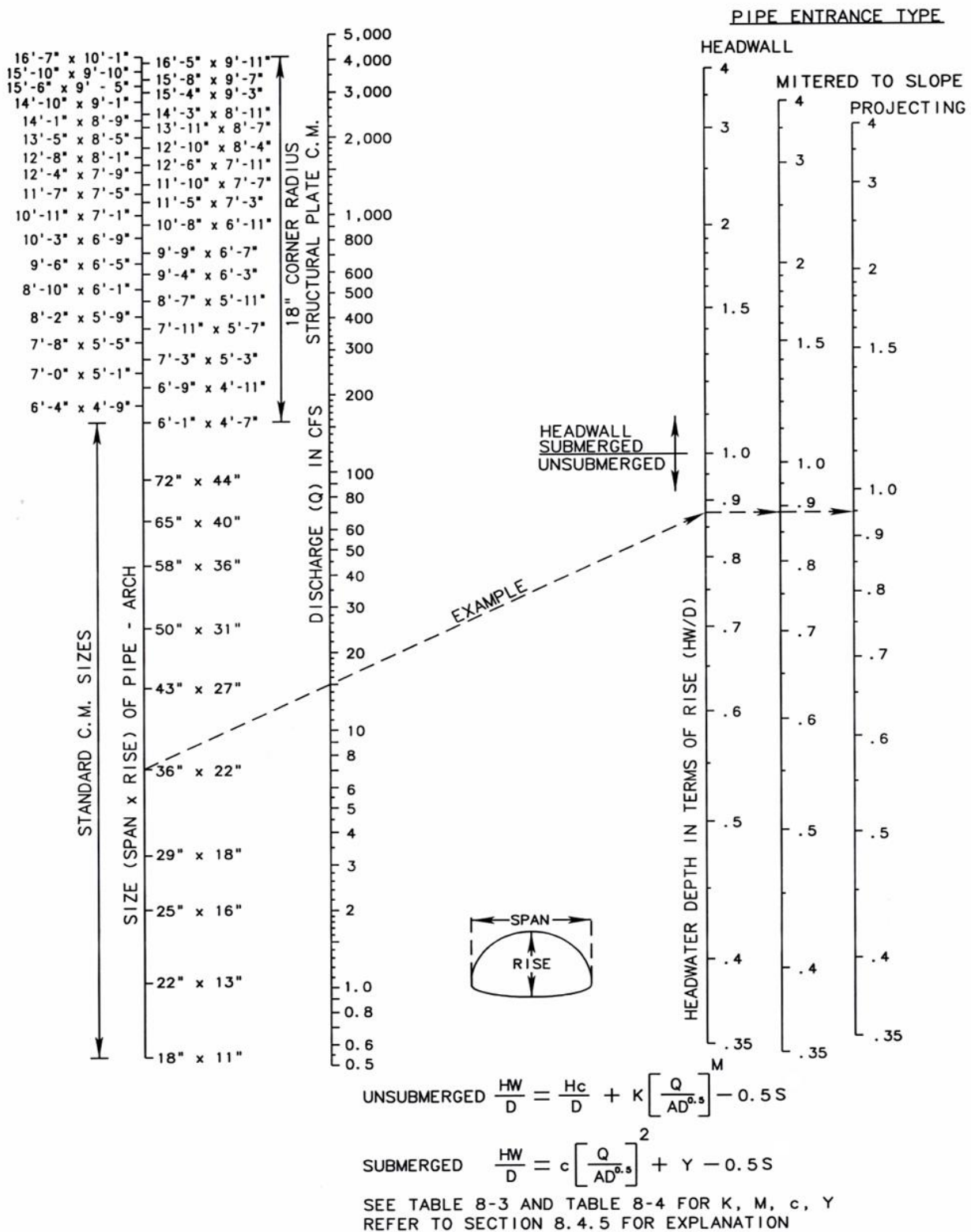
Chart 8-31**Critical Depth Str. Plate Pipe Arch 6 x 2 in. Corrugation**

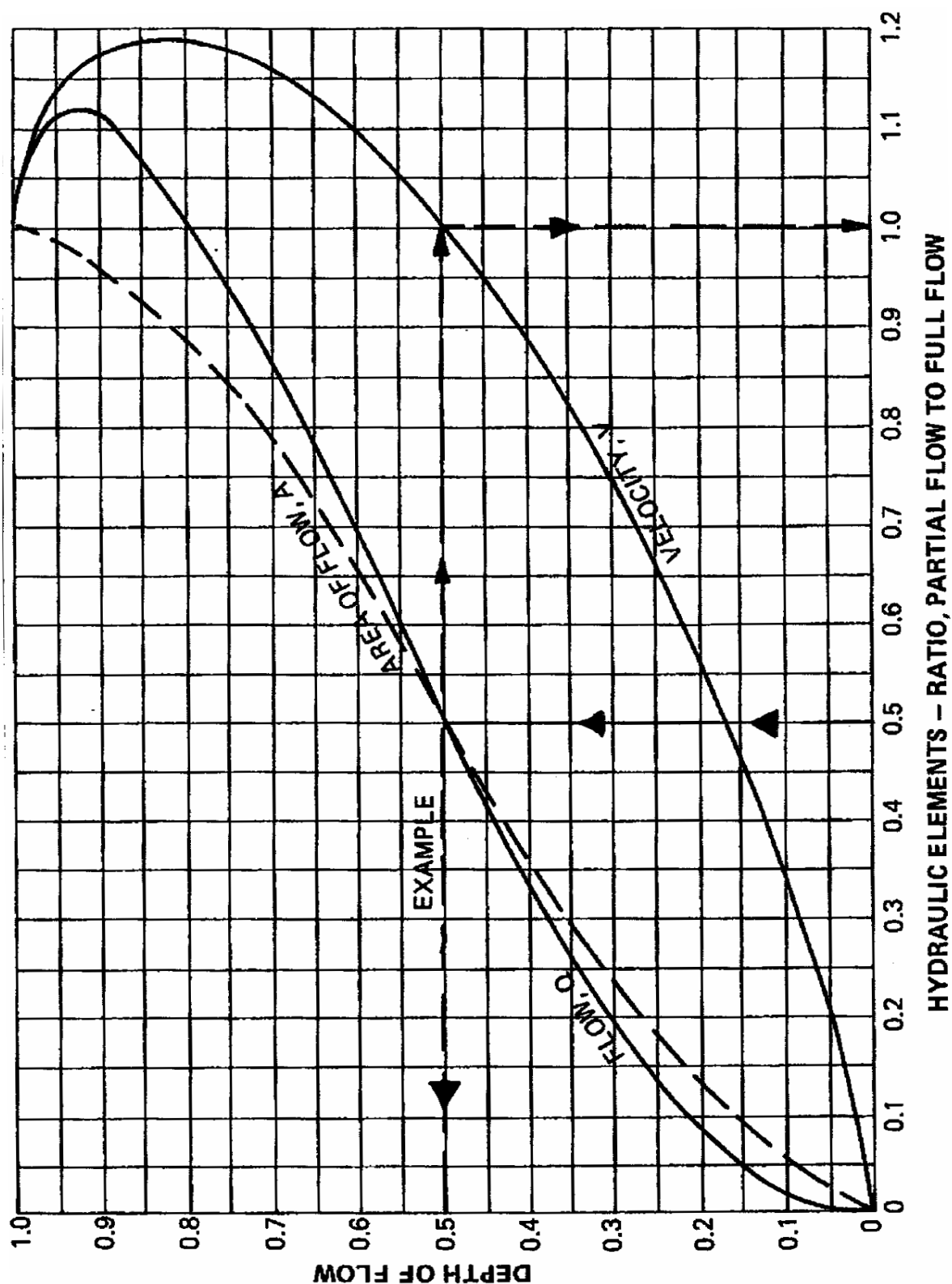
Chart 8-32
Horizontal Elliptical Concrete Pipe with Inlet Control



Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

Chart 8-33

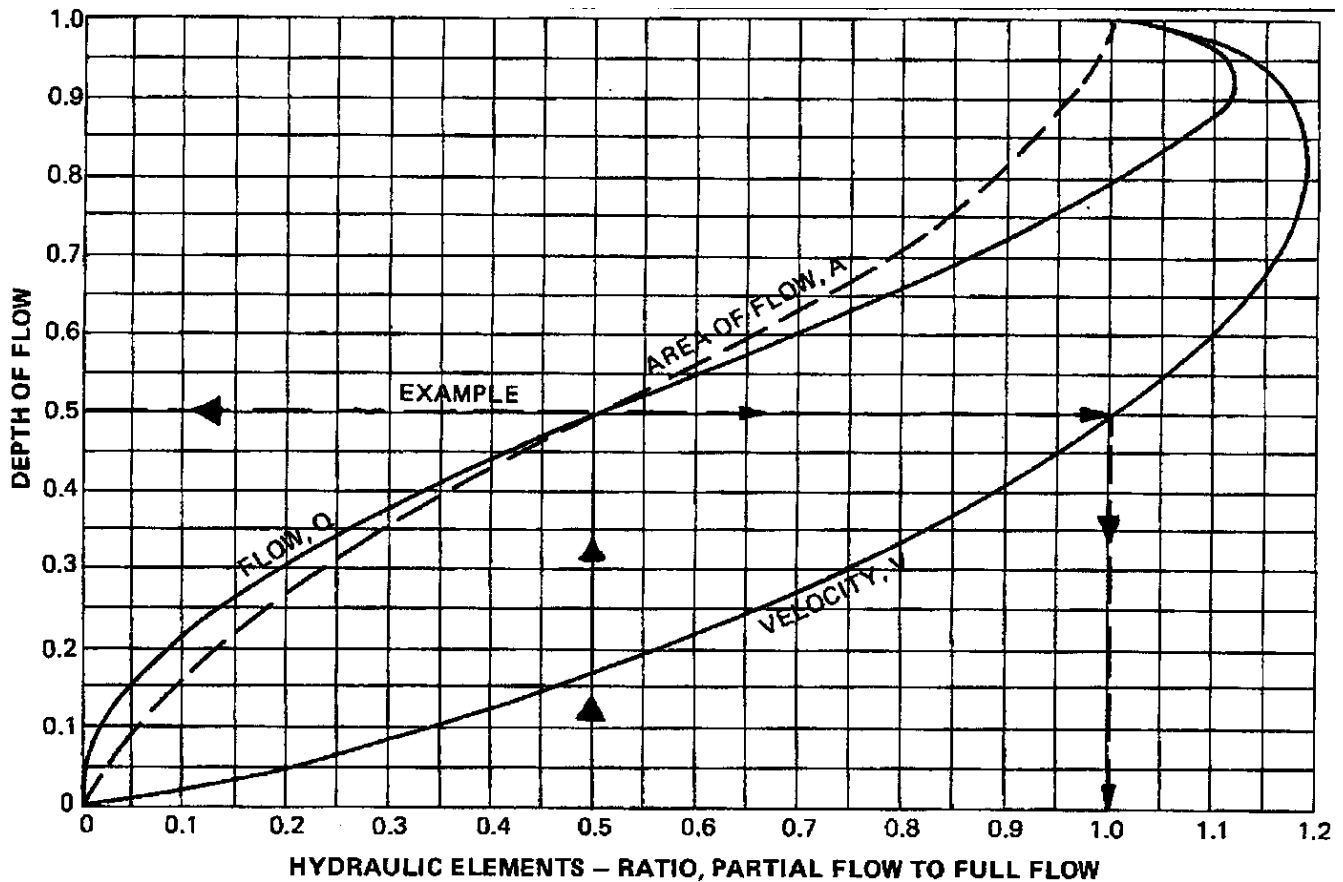
Hydraulic Elements for Partially Full Horizontal Elliptical Concrete Pipe



Source: Handbook of Steel Drainage Products, American Iron & Steel Inst., 1994

Chart 8-34

Hydraulic Elements for Partially Full Horizontal Elliptical Concrete Pipe Example



24 X 38 pipe, $n = 0.012$, Slope = 0.02, $Q_{full} / S^{0.5} = 456$ (from Table 8-6)

Given: $D_{full} = 24$ in, $Q = 32.2$ cfs

$Q_{full} = 456 * (0.02)^{0.5} = 64.5$ cfs

Required: depth at Q , velocity at Q

Solution: $Q / Q_{full} = 32.2 / 64.5 = 0.5$

From figure for hydraulic elements, $d / d_{full} = 0.5$

$d = d_{full} \times 0.5 = 12$ in

$V_{full} = Q_{full} / A_{full} = 64.5 / 5.1 = 12.6$ (A_{full} from Table 8-7)

From figure for hydraulic elements, $V / V_{full} = 1$

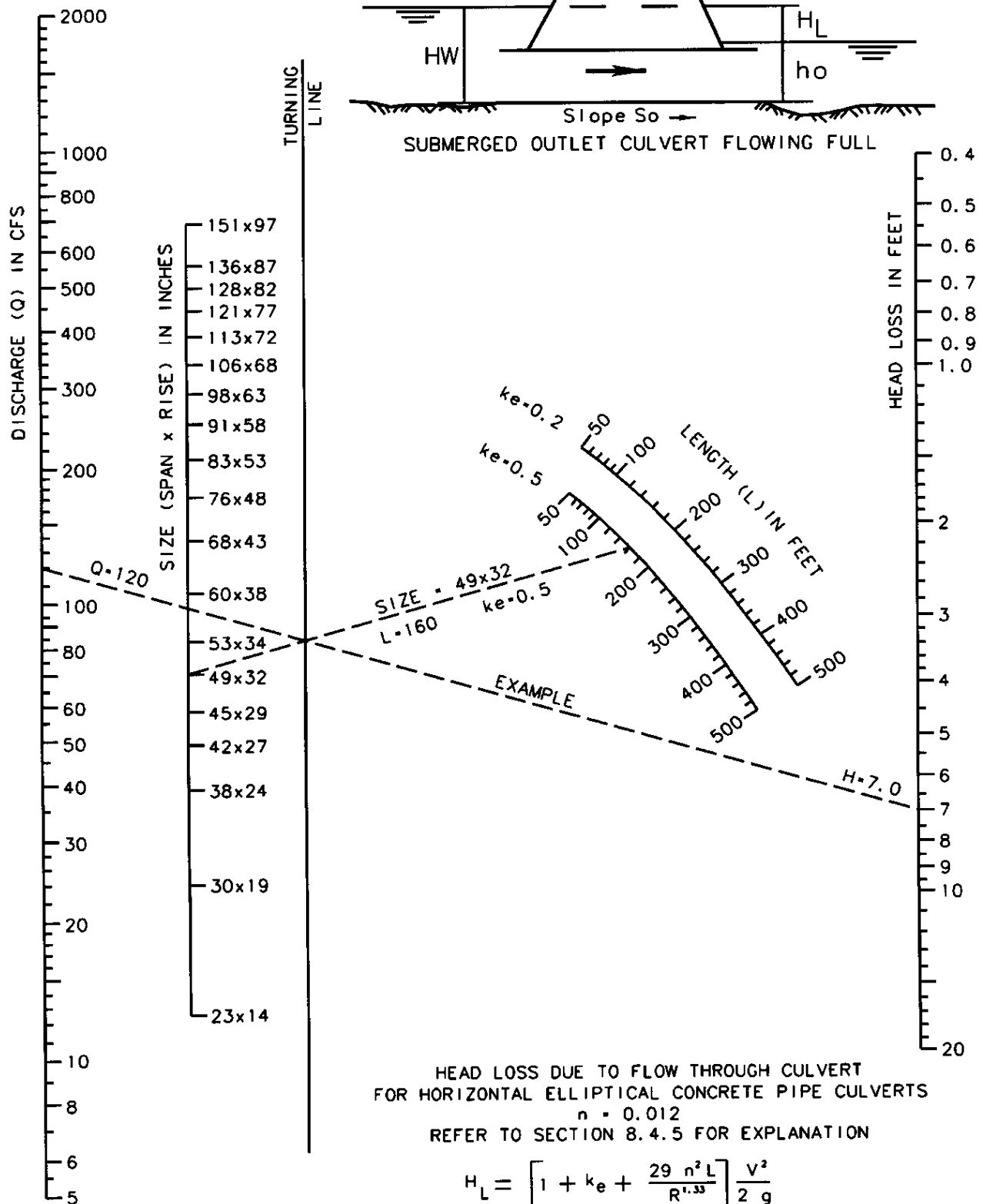
$V = V_{full} \times 1 = 12.6$ ft/s

Table 8-6
Full Flow Values for Horizontal Elliptical Concrete Pipe

Pipe Size Rise X Span inches	Equivalent Full Flow Area for Circular Diameter inches	A Area ft ²	R Hydraulic Radius ft	Value of Full Flow Conveyance K $\frac{Q}{\sqrt{S}} = \frac{1.486}{n} A R^{\frac{2}{3}}$			
				n = 0.010	n = 0.011	n = 0.012	n = 0.013
14 X 23	18	1.8	0.367	138	125	116	108
19 X 30	24	3.3	0.490	301	274	252	232
24 X 38	30	5.1	0.613	547	497	456	421
27 X 42	33	6.3	0.686	728	662	607	560
29 X 45	36	7.4	0.736	891	810	746	686
32 X 49	39	8.8	0.812	1140	1036	948	875
34 X 53	42	10.2	0.875	1386	1260	1156	1067
38 X 60	48	12.9	0.969	1878	1707	1565	1445
43 X 68	54	16.6	1.106	2635	2395	2196	2027
48 X 76	60	20.5	1.229	3491	3174	2910	2686
53 X 83	66	24.8	1.352	4503	4094	3753	3464
58 X 91	72	29.5	1.475	5680	5164	4734	4370
63 X 98	78	34.6	1.598	7027	6388	5856	5406
68 X 106	84	40.1	1.721	8560	7790	7140	6590
72 X 113	90	46.1	1.845	10300	9365	8584	7925
77 X 121	96	52.4	1.967	12220	11110	10190	9403
82 X 128	102	59.2	2.091	14380	13070	11980	11060
87 X 136	108	66.4	2.215	16770	15240	13970	12900
97 X 151	120	82.0	2.461	22190	20180	18490	17070

Source: Handbook of Steel Drainage Products, American Iron & Steel Inst., 1994

Chart 8-35
Horizontal Elliptical Concrete Pipe Flowing Full



Source: Hydraulic Design of Highway Culverts, HDS-5, FHWA, 2005

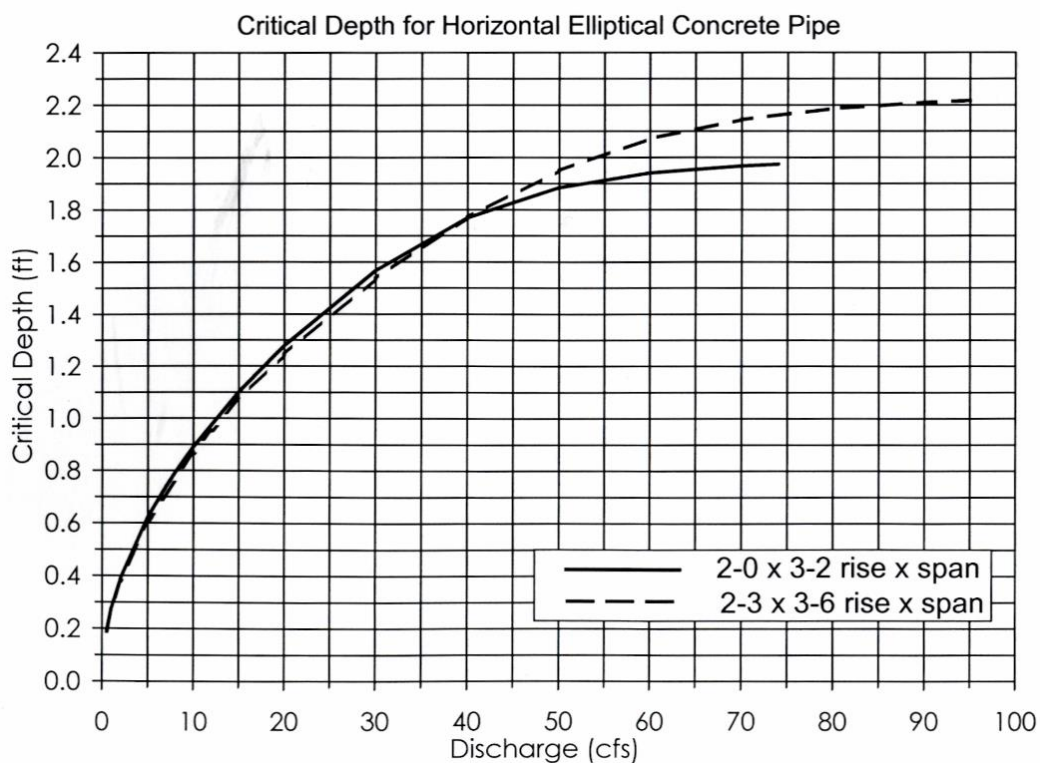
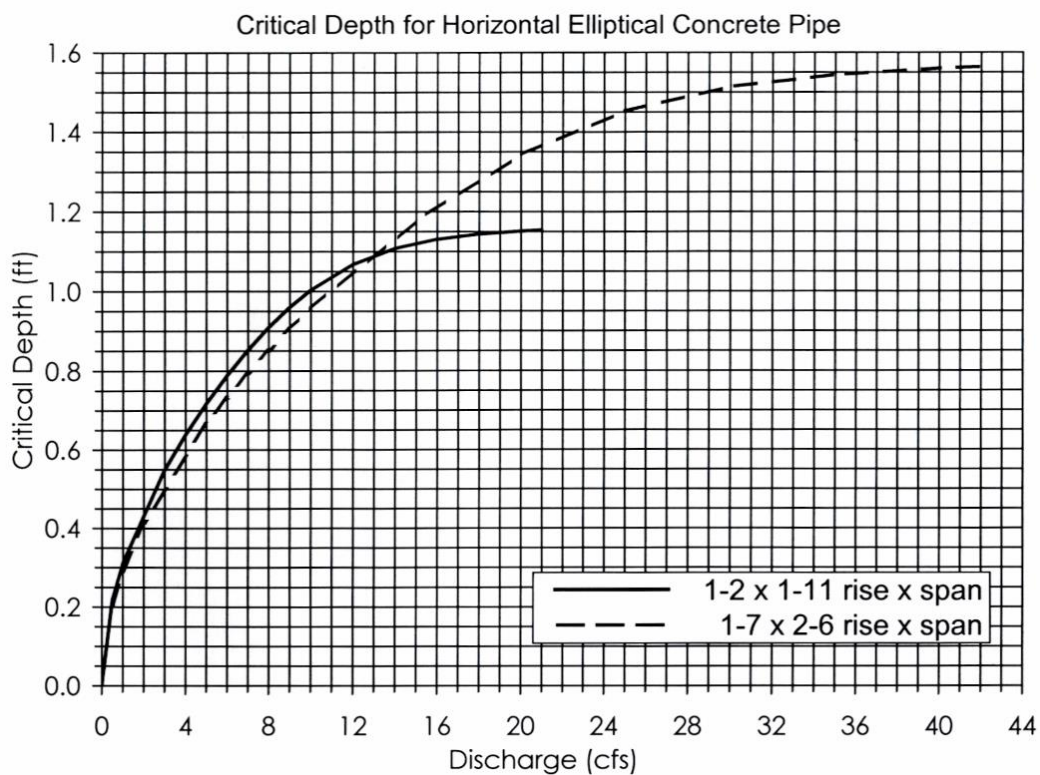
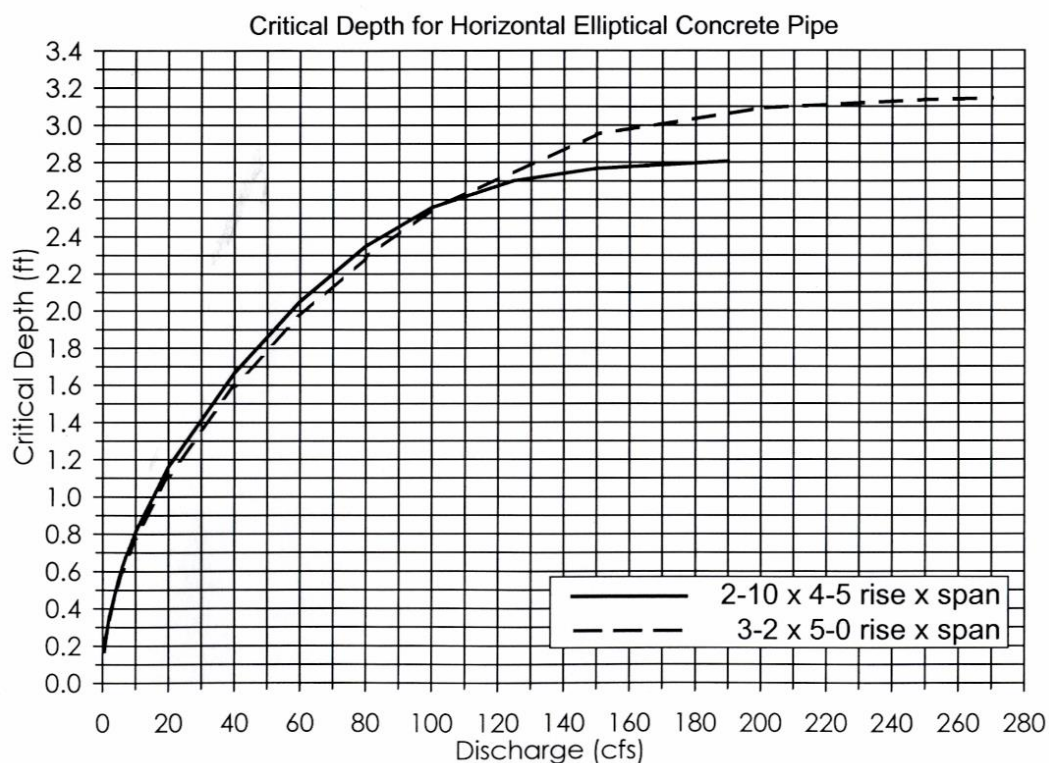
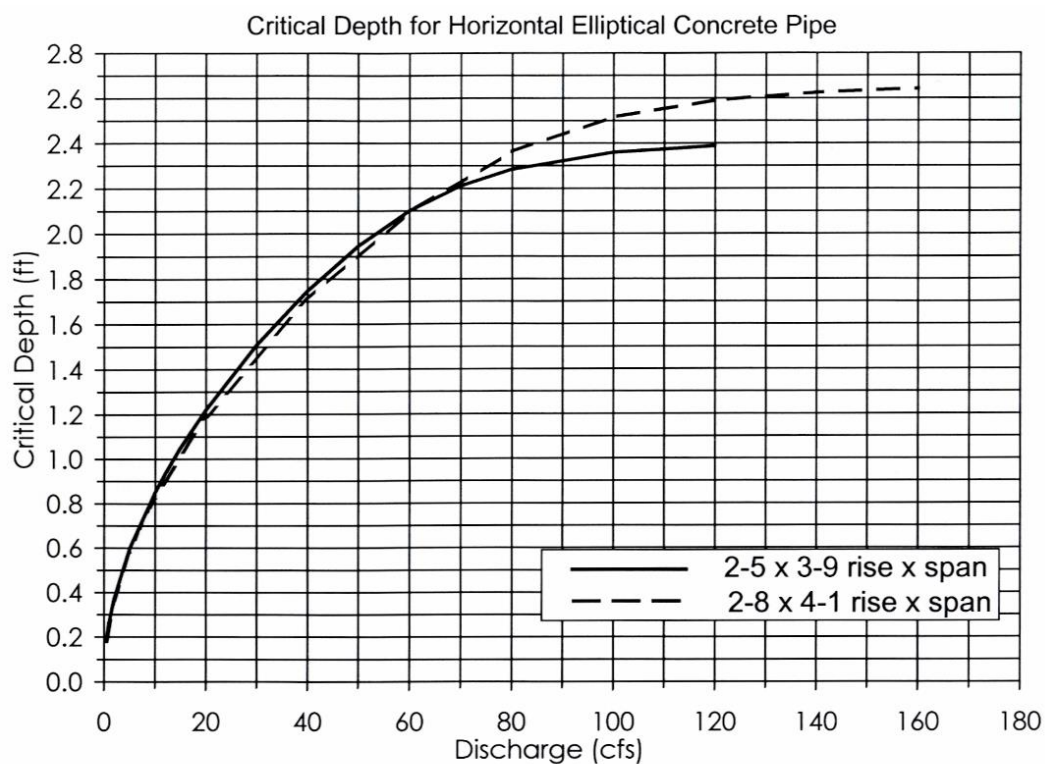
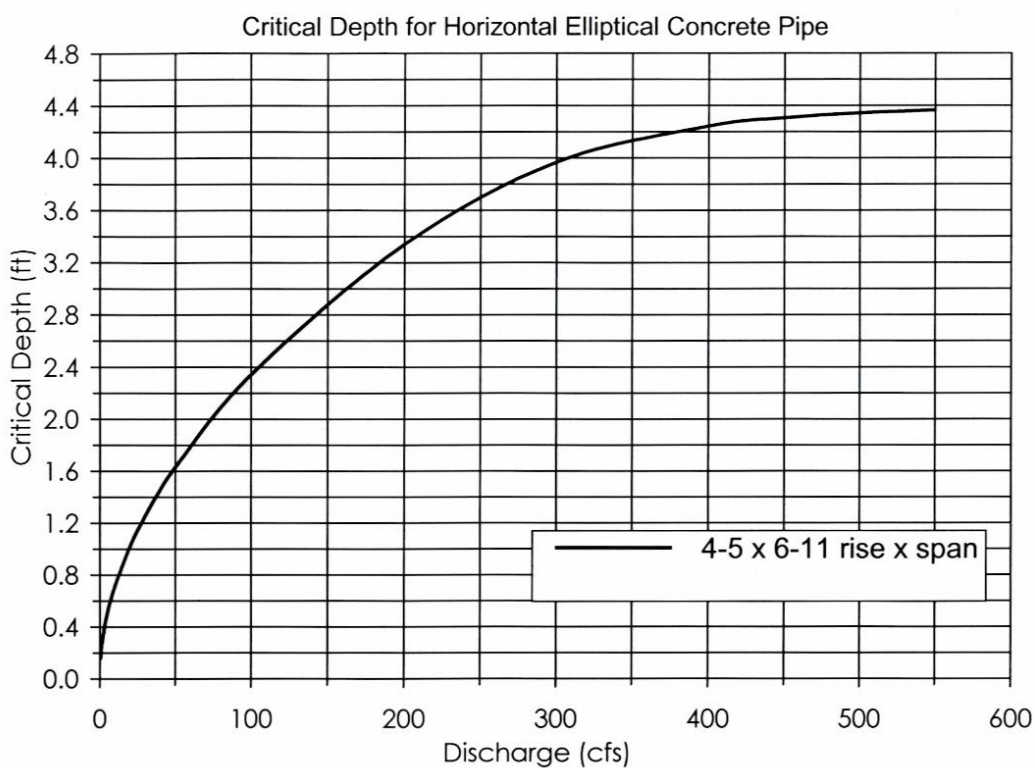
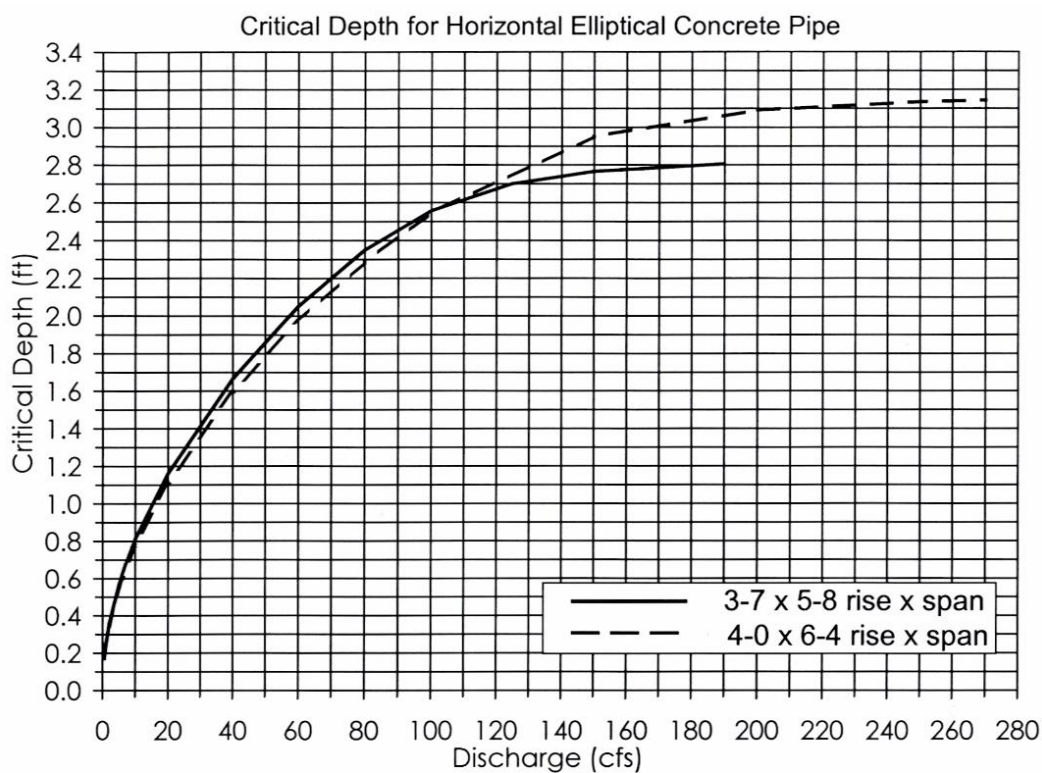
Chart 8-36**Critical Depth for Horizontal Elliptical Concrete Pipe**

Chart 8-37**Critical Depth for Horizontal Elliptical Concrete Pipe**

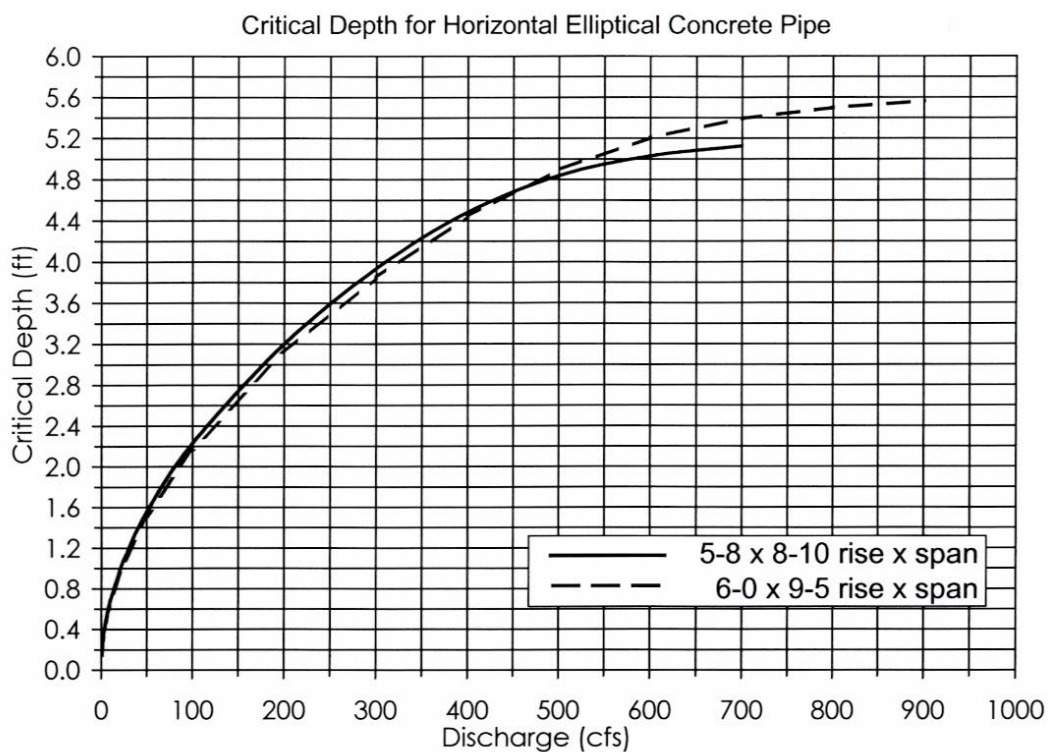
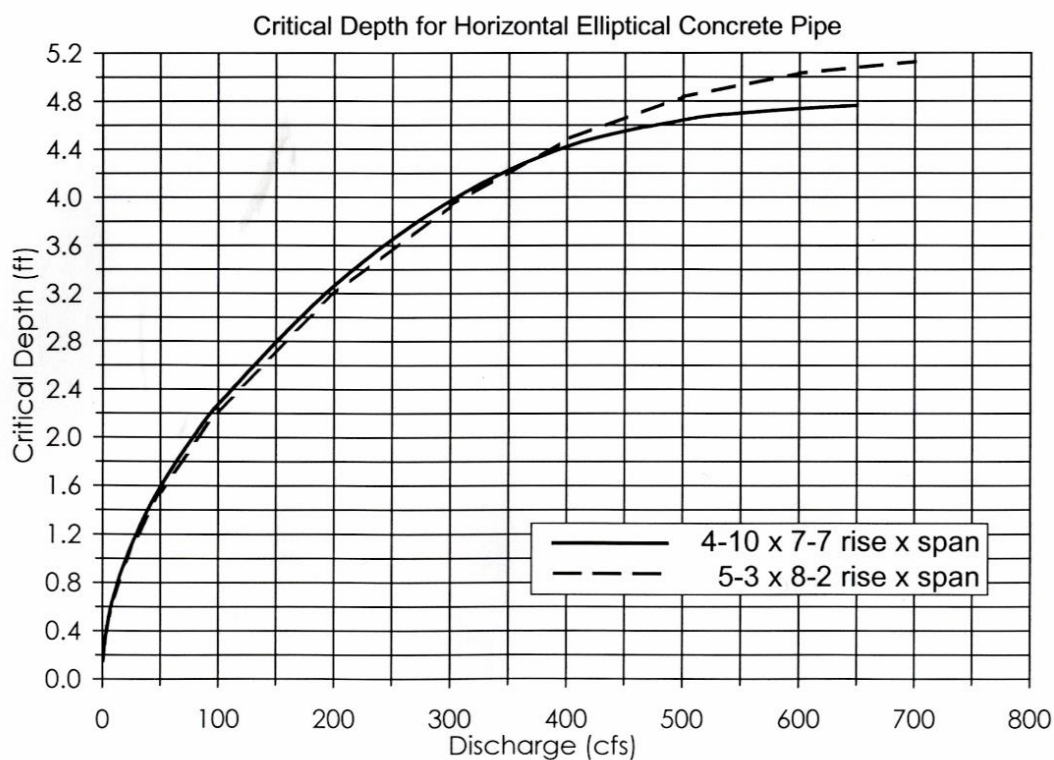
Created by the WVDOH Hydraulic and Drainage Unit

Chart 8-38
Critical Depth for Horizontal Elliptical Concrete Pipe



Created by the WVDOH Hydraulic and Drainage Unit

Chart 8-39
Critical Depth for Horizontal Elliptical Concrete Pipe



Created by the WVDOH Hydraulic and Drainage Unit

Chart 8-40
Critical Depth for Horizontal Elliptical Concrete Pipe

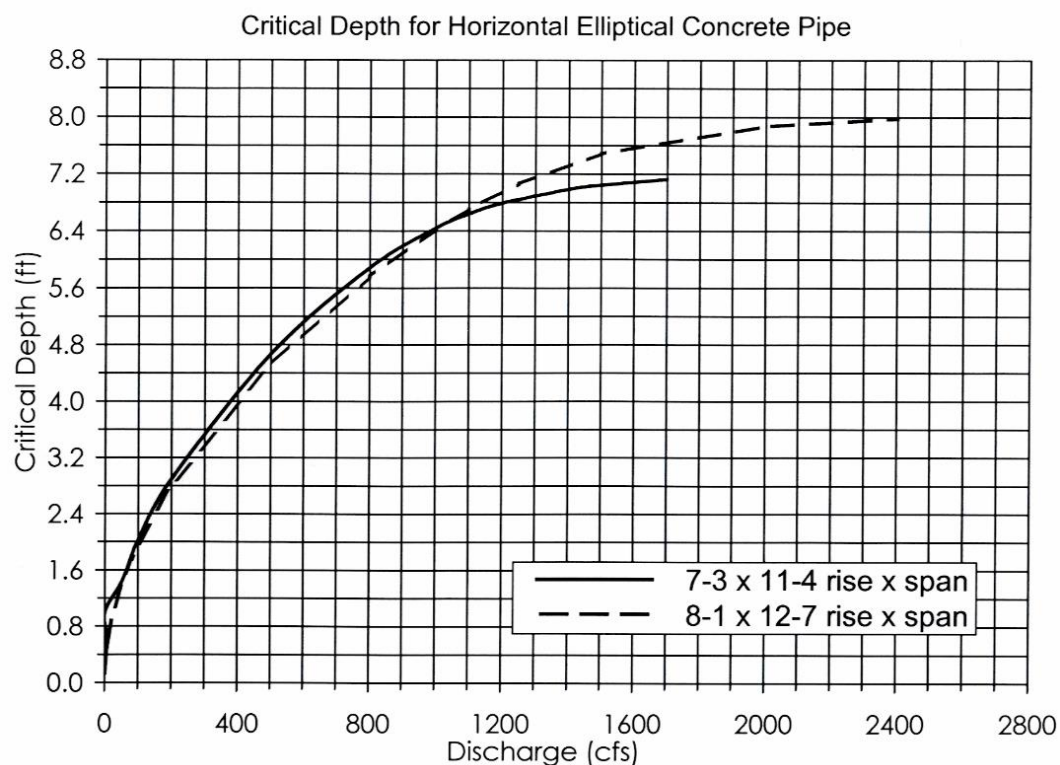
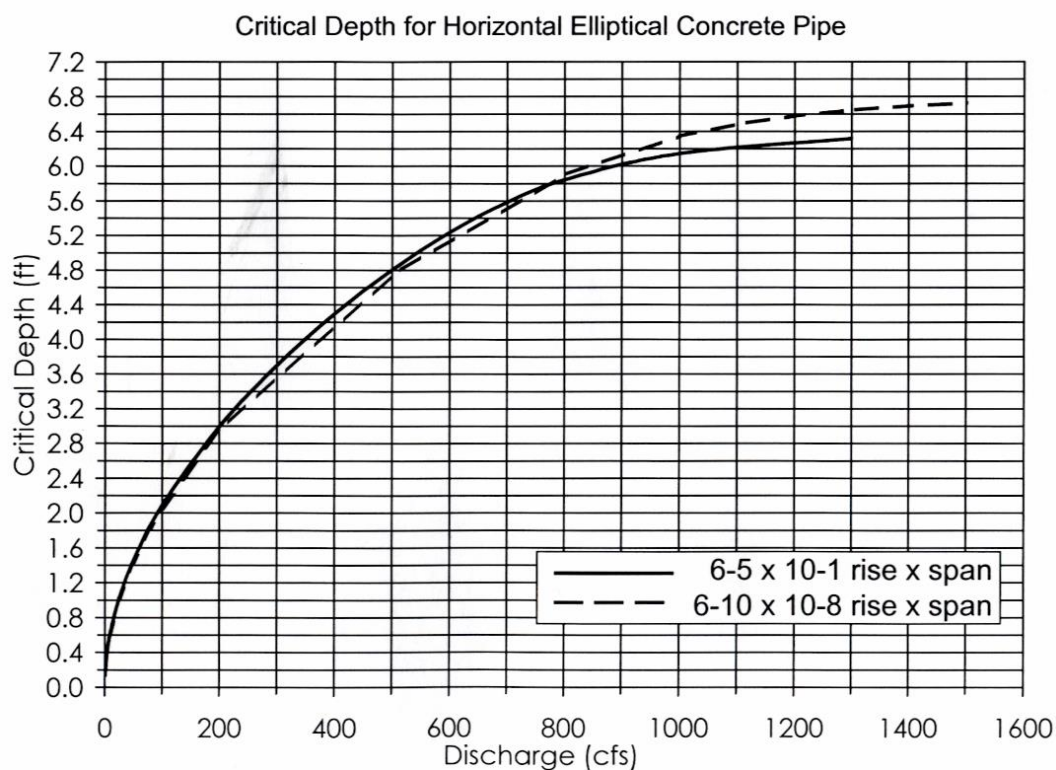
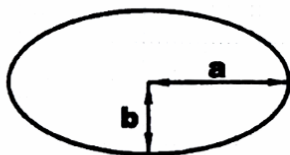
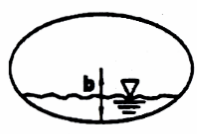



Figure 8-9
Elliptical Pipe Flow Area

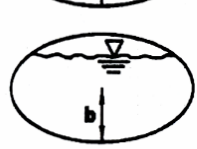




$$b - \text{depth} > 0 \quad A = a b \arccos\left(\frac{b - \text{depth}}{b}\right) - a(b - \text{depth})\sqrt{1 - \left(\frac{b - \text{depth}}{b}\right)^2}$$



$$b - \text{depth} = 0 \quad A = \frac{\pi}{2} a b$$



$$b - \text{depth} < 0 \quad A = \pi a b - \left[a b \arccos\left(\frac{\text{depth} - b}{b}\right) - a(\text{depth} - b)\sqrt{1 - \left(\frac{\text{depth} - b}{b}\right)^2} \right]$$

This chart provides equations for calculating the flow area for any flow depth within an elliptical pipe. It can be useful for calculating the critical depth of flow using the critical depth equation (see Section 8.4.5.1).

8.7 REFERENCES

- (1) Design of Roadside Channels with Flexible Linings, Hydraulic Engineering Circular-15 (HEC-15), Federal Highway Administration, April 1988
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- (3) Erosion Control Technology Council, Internet Website: <http://www.ectc.org/index.html>
- (4) Hydraulic Design of Flood Control Channels, EM 1110-2-1601, Engineer Manual, U.S. Army Corps of Engineers, July 1, 1991
- (5) AASHTO Drainage Manual, American Association of State Highway Transportation Officials (AASHTO), 2014
- (6) Handbook of Steel Drainage & Highway Construction Products, American Iron and Steel Institute, Fifth Edition 1994
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