Chapter 4
Bridge Program Drawings

Section 4.17-Culverts

Introduction

A culvert is any structure, except a siphon (Section 4.18-Miscellaneous Hydraulic Structures), that provides an opening under the roadway but does not fall under the classifications of a bridge. Culverts most commonly function as drainage or stockpass structures. A culvert is constructed of either concrete or steel and can be square, round, arched, or elliptical and can consist of single or multiple barrels. The most common types of culverts are cast-in-place reinforced concrete (RC) box culverts, precast concrete box culverts, and metal or concrete pipes. Often an existing culvert must be extended to meet current safety requirements or new roadway width.

Culvert Types

NON-RIGID FRAME RC BOX CULVERTS are designed when the clear span is 10'-0" or less. The slabs and walls of this type of culvert are considered to be simply supported beams for single barrel culverts, and the slabs for multi-barrel culverts are considered to be continuous.

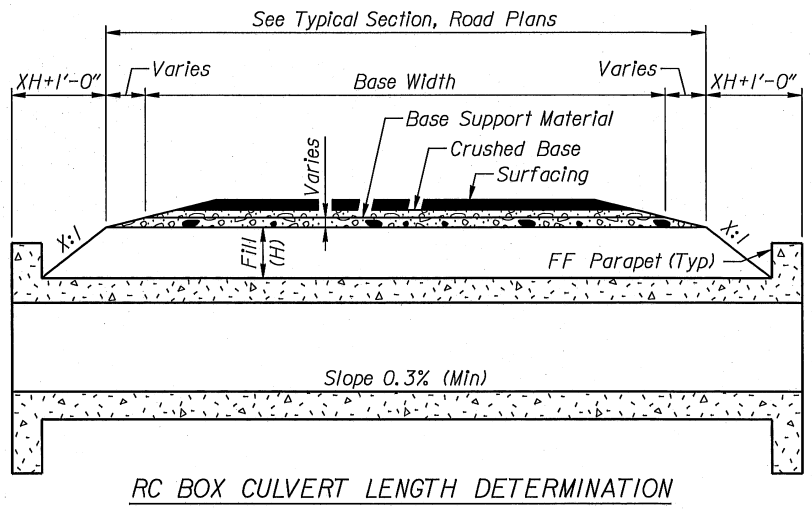
RIGID FRAME RC BOX CULVERTS are designed when the clear span is greater than 10'-0". This type of culvert uses moment resisting steel at the wall-to-slab joints in an effort to reduce the bending moment in the slabs. Reinforcing steel is continuous between the slabs and walls. Most commonly, these are limited to single barrel culverts.

PRECAST CONCRETE BOX CULVERTS are comprised of reinforced box segments that are precast and shipped to the site for placement as a whole joined unit. The only parts of the precast culvert that are cast-in-place are the wingwalls, parapets, and footings, thus reducing the construction time at the site. Precast wingwalls, parapets, and footings may be used. This type of culvert is generally designed by the fabricator and is considered a rigid frame culvert.

General Design and Detail Information

The most common sizes of **METAL AND CONCRETE PIPES** can be found in the Standard Plans. Sizes not in the Standard Plans can be found in other reference material.

The **LENGTH** of a culvert under fill will be determined using the figure below. The front face of the parapets shall be outside the clear zone established by the Project Development Program or protected by bridge railing if parapets lie within the clear zone. At- grade culvert lengths shall match the Project Development Program's typical section and any further requirements of AASHTO's A Policy on Geometric Design of Highways and Streets, inclusive of all revisions to date.



RC BOX CULVERT LENGTH DETERMINATION

The **SIZE** of a culvert used as a hydraulic structure is based on the Hydraulic Report, which provides several alternates of opening sizes and depths of cutoff walls. The Squad Team Leader will select one of the sizes recommended and include it in a Structure Selection Report.

Wall and slab thicknesses shall be determined by using the following guidelines.

For cast-in-place boxes:
- Minimum Wall Thickness: 8"
- Minimum Slab Thickness: 8"

For precast boxes:
- Minimum Wall Thickness: 6"
- Minimum Slab Thickness: 6"

For culverts that have **SKEWS LESS THAN OR EQUAL TO 20 DEGREES**, the transverse reinforcing steel in the top and bottom slabs shall be placed parallel with the skew.

For culverts that have **SKEWS GREATER THAN 20 DEGREES**, the transverse reinforcing steel in the top and bottom slabs shall be placed normal to centerline culvert.

A Geology Report will be supplied by the Geology Program. If **CULVERT SUBEXCAVATION** is required, the required depth will be recommended. A Log Boring Sheet is sometimes included with the culvert drawings.

CONSTRUCTION JOINTS shall be placed in top slabs and walls of culverts that are 50'-0" or longer or as directed by the Squad Team Leader. An Optional Construction Joint may be placed in the bottom slab of culverts that are 80'-0" or longer or when necessary to facilitate the placing of the concrete. The location of the joints shall be shown on the plan.

On cast-in-place RC box culverts having a clear height of 8'-0" or more, the wingwall shall be disconnected from the culvert and ½" joint filler shall be used in the joint between the wingwall and culvert. If the clear height is less than 8'-0", the wingwall shall be connected to the culvert with reinforcing steel extending from the culvert into the wingwall.

On a precast box culvert, the wingwall will generally be disconnected from the culvert and ¼" joint filler shall be used as stated above.

WINGWALL SIZE AND GEOMETRY is determined using the following formulas and detail. The minimum wingwall thickness (T) shall be 1'-0".

Length of Long Wing: $$L_1 = \frac{SH - T\left(1+\cos\left(\frac{90-\theta}{2}\right)\right) + X - P}{2\sin\left(\frac{90-\theta}{2}\right)}$$

Length of Short Wing: $$L_2 = \frac{SH - T\left(1+\cos\left(\frac{90-\theta}{2}\right)\right) + X - P}{2\sin\left(\frac{90+\theta}{2}\right)}$$

Length of Equal Wings: $L = \dfrac{SH - T(1.707) + X - P}{1.414}$

($\theta = 0°$)

Height of Wing End: $E = H - \dfrac{P + L_1\left(\sin\left(\dfrac{90-\theta}{2}\right)\right)}{S}$ or

$$E = \frac{SH + T\left(1 + \cos\left(\dfrac{90-\theta}{2}\right)\right) - X - P}{2S}$$

For $\theta = 0°$: $$E = \frac{SH + T(1.707) - X - P}{2S}$$

Where:

X = Horizontal clearance at toe of spill slope around the wingwall and the inside face of the exterior wall. For box opening height 6'-0" or less, X shall not be less than 2'-0". For box opening height greater than 6'-0", X shall be approximately one-third of the opening height. X may be adjusted to obtain desired values of E.

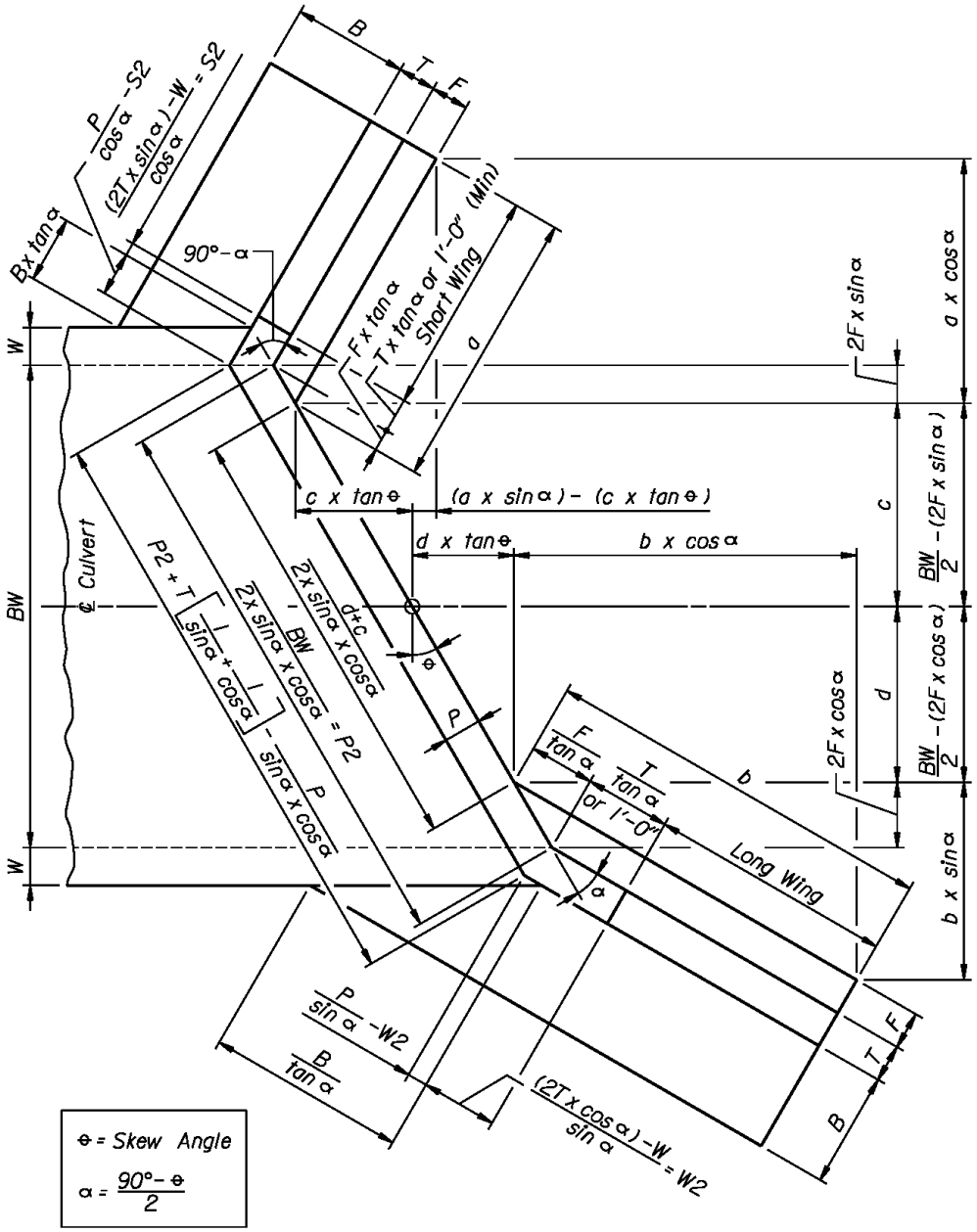
E = Height of wingwall end. For skewed boxes, use the end-height of the long wingwall. The end-height so computed shall also be used for the short wingwall.

S = Horizontal component, for a 1'-0" drop, of the earth slopes around box ends, assumed constant from rear face of parapet to toe of slope. S = 2 for fill slopes 2:1 and S = 3 for fill slopes greater than 2:1.

H = Vertical height in feet from flow line to top of parapet. The parapet is assumed level throughout its length.

When the formula for height of wing end gives values of E greater than 5'-0", the value of X and hence L_1 should be increased to make E less than 5'-0". The increased value of X shall then be used to recompute L_2.

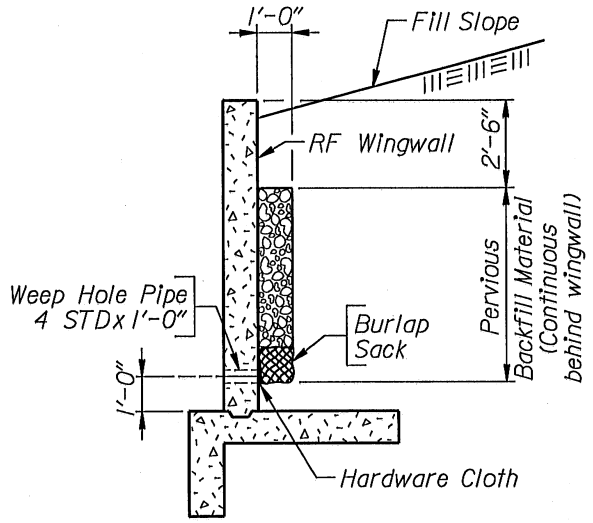
The value X should not appear on the detail drawings. The values L, L_1, L_2, and E should be rounded to the nearest six inches.



CULVERT DIMENSIONS

WEEP HOLES are placed in culvert wingwalls to provide drainage of the pervious material. They will be used only if the clear height of the box culvert opening is 8'-0" or greater.

Minimum Spacing: 5'-0"
Maximum Spacing: 9'-0"



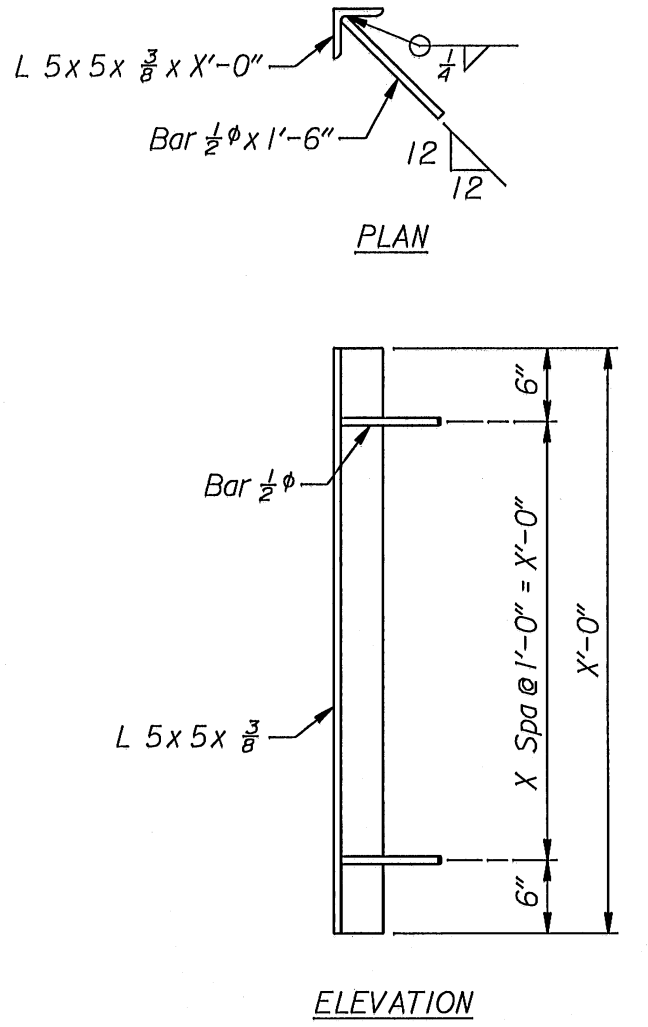
WEEP HOLE ASSEMBLY DETAIL

Each weep hole assembly consists of a pipe 4 STD through the wingwall, one 6" x 6" piece of aluminum or galvanized steel wire 4 mesh hardware cloth (Minimum wire diameter 0.03") centered over pipe end and firmly anchored to rear face of wingwall, and one cubic foot of coarse aggregate in a securely tied burlap sack.

PERVIOUS BACKFILL MATERIAL shall be placed behind culvert wingwalls to facilitate drainage when weep holes are provided. This material should be 1'-0" thick and have 2'-0" minimum of earth cover.

BEVELED INLETS are used when water has the potential of overtopping the culvert. The bevel, in the top slab, shall be ½" per vertical foot of culvert opening.

CUTWATER ANGLES are required on multi-barrel culverts when the drift potential for large objects or ice is present. Usually these are recommended by the Hydraulic Section.



CUTWATER ANGLE DETAILS

A **LOCATION PLAN** is used to show all information needed to locate new and existing structures. Any utilities near the culvert shall be shown on the Location Plan.

A **BULKHEAD** is a concrete wall placed at each end of a culvert. Bulkheads are used when a culvert is to be extended with a smaller pipe placed inside the culvert. They are more economical than a culvert extension and take less construction time.

The design and details of **CULVERT EXTENSIONS** are basically designed and detailed the same as any other cast-in-place culvert with a few minor exceptions. The extension is connected to the existing culvert with No. 6 dowel bars spaced at 12" and centered in the walls and slabs of the existing culvert, extending

1'-6" into the culvert extension. The interior dimensions of the extension should match those of the existing. The thicknesses of the exterior walls and slabs of the extensions may vary from those of the existing.

Standard Sheets

Standard sheets have been developed for RC box culvert wingwalls. These sheets were developed for box heights from 4'-0" to 12'-0" and skews, both left and right, from 0 degrees to 45 degrees. Due to the number of sheets, only a few examples of the sheet names will be shown.

Name	Description
4'_0 Deg Skew_Sht1	Wingwall details for a 4' high & 0 Deg Skew RCB, Sheet 1
4'_0 Deg Skew_Sht2	Wingwall details for a 4' high & 0 Deg Skew RCB, Sheet 2
5'_20 Deg Left Skew_Sht1	Wingwall details for a 5' high & 20 Deg Left Skew RCB, Sheet 1
5'_20 Deg Left Skew_Sht2	Wingwall details for a 5' high & 20 Deg Left Skew RCB, Sheet 2
12'_45 Deg Right Skew_Sht1	Wingwall details for a 12' high & 45 Deg Right Skew RCB, Sheet 1
12'_45 Deg Right Skew_Sht2	Wingwall details for a 12' high & 45 Deg Right Skew RCB, Sheet 2

Cells

Name	Description
CUTWATER	Culvert Cutwater Angle
LAPJOINT	Culvert Lap Joint
RFELE	Elev in Box
WEEPHOLE	Wingwall Weep Hole Detail

Cast-In-Place Culvert Checklist

Plan

- ❑ Centerline Culvert
- ❑ Skew and Complement
- ❑ Longitudinal Dimensions
- ❑ Parapet/Curb/Cutoff Wall Widths
- ❑ Reinforcing Size/Spacing/Location/Lap/Typ Row/Call-outs
- ❑ Dowel Bar Size/Number Required/Call-outs (extensions)
- ❑ Showing Top Slab/Bottom Slab Call-outs
- ❑ Construction Joint/Keyway Call-outs
- ❑ Optional Construction Joint Base Call-out
- ❑ See Cutwater Angle Detail Call-out
- ❑ Section Symbols
- ❑ Line Styles/Patterning

Longitudinal Section

- ❑ Detail Projected from Plan (preferred)
- ❑ Cutoff Wall Dimensions
- ❑ Reinforcing Size/Spacing/Location/Lap/Typ Row/Call-outs
- ❑ Bottom Slab Edge Bars (on skewed culverts with transverse reinforcing steel placed perpendicular to centerline culvert)
- ❑ Dowel Bar Size/Number Required/Call-outs (extensions)
- ❑ Elevations
- ❑ Slope in Percent (new)/Slope to Match Existing (extensions)
- ❑ Flow Line
- ❑ Top Slab Bevel Call-out
- ❑ Construction Joint/Keyway Call-outs
- ❑ Optional Construction Joint Base Call-out
- ❑ See Parapet Detail Call-out
- ❑ Line Styles/Patterning
- ❑ Showing Reinforcing Steel in Walls (under title)

Section Thru Barrel

- ❑ Width/Height/Thickness Dimensions
- ❑ Reinforcing Size/Spacing/Location/Clearance/Lap/Call-outs
- ❑ Construction Joint/Keyway Call-outs
- ❑ Line Styles/Patterning

Parapet Detail

- ❑ Width/Height Dimensions
- ❑ Reinforcing Size/Location/Clearance/Call-outs
- ❑ Line Styles/Patterning

Wingwall Plan

- ❑ Centerline Culvert
- ❑ Dimensions
- ❑ Angles
- ❑ Footing Reinforcing Size/Spacing/Location/Call-outs
- ❑ Weep Hole Pipe Call-out
- ❑ Line Styles/Patterning

Wingwall Elevation

- ❑ Centerline Weep Hole Pipe
- ❑ Dimensions
- ❑ Wingwall Reinforcing Size/Spacing/Location/Call-outs
- ❑ Construction Joint/Keyway/Joint Filler Call-out
- ❑ Line Styles/Patterning

Wingwall Section

- ❑ Dimensions
- ❑ Reinforcing Size/Clearance/Call-outs
- ❑ RF Wingwall Call-out
- ❑ Construction Joint/Keyway Call-out
- ❑ Weep Hole Pipe Call-out
- ❑ Line Styles/Patterning

Location Plan

- ❑ Detail to Scale
- ❑ Centerline Survey w/Stationing and Bearing
- ❑ Centerline Culvert
- ❑ Skew and Complement at Centerline Survey
- ❑ Horizontal Dimensions
- ❑ Center of Culvert Call-out
- ❑ Station Call-out at Centerline Culvert
- ❑ Flow Arrow w/Name of Channel
- ❑ North Arrow
- ❑ Utilities w/Name of Owner (if available)
- ❑ Right-of-Way Lines Call-out

Location Plan (Cont'd)

- ❑ TO X (destination)
- ❑ Riprap/Gabions Call-out
- ❑ Culvert Subexcavation Call-out
- ❑ Existing Structure Call-out
- ❑ Section Symbols
- ❑ Line Styles/Patterning

Miscellaneous

- ❑ Optional Construction Joint Base Detail
- ❑ Eyebolt Detail (4 req'd per wingwall)
- ❑ Weep Hole Assembly Detail
- ❑ Riprap/Gabions Details
- ❑ Railing Details
- ❑ Cutwater Angle Details
- ❑ Horizontal Curve Data
- ❑ Bill of Reinforcement

Notes

- ❑ Alternate Legs Left and Right (multiple barrels, if not shown in section)
- ❑ Bars Shown are Not Included in the Quantity (optional construction joint base)
- ❑ Reinforcing Steel Placement
- ❑ Center Dowel Bars (extension)
- ❑ Place Edge Bars In Bottom Slab Symmetrical About Centerline Culvert
- ❑ Weep Hole Assembly Consists Of
- ❑ Prefix Numbers (multiple locations)
- ❑ Estimated Quantity of Concrete (multiple locations)
- ❑ For Bridge Railing Details

Precast Culvert Checklist

(See Cast-In-Place Checklist if Cast-In-Place End Sections are required)

Longitudinal Section

- ❑ Culvert Length
- ❑ Precast Culvert Sections Length
- ❑ Cast-In-Place Lengths
- ❑ Precast End Section Lengths
- ❑ Parapet/Cutoff Wall Dimensions
- ❑ Cast-In-Place Bottom Slab Reinforcing/Size/Location/Call-out
- ❑ Precast Reinforcing Extension/Call-out
- ❑ Elevations
- ❑ Slope in Percent
- ❑ Male/Female/Normal Section Call-outs
- ❑ Flow Line
- ❑ See Lap Joint Detail Call-out
- ❑ Haunch Call-out
- ❑ See Parapet Detail Call-out
- ❑ Line Styles/Patterning

Section Thru Barrel

- ❑ Width/Height/Thickness Dimensions
- ❑ Haunch Dimensions/Call-out
- ❑ Optional Construction Joint Call-out
- ❑ Patterning

Parapet Plan (when no skew)

- ❑ Centerline Culvert
- ❑ Parapet Width
- ❑ Reinforcing Size/Spacing/Location/Call-out
- ❑ Line Styles/Patterning

Parapet Detail

- ❑ Width/Height Dimensions
- ❑ Reinforcing Size/Location/Call-out
- ❑ Precast End Section Call-out
- ❑ Line Styles/Patterning

Wingwall Plan

- ❑ Centerline Culvert
- ❑ Dimensions
- ❑ Angles
- ❑ Footing Reinforcing Size/Spacing/Location/Call-outs
- ❑ Weep Hole Pipe Call-out
- ❑ Line Styles/Patterning

Wingwall Elevation

- ❑ Centerline Weep Hole Pipe
- ❑ Dimensions
- ❑ Wingwall Reinforcing Size/Spacing/Location/Call-outs
- ❑ Construction Joint/Keyway/Joint Filler Call-out
- ❑ Line Styles/Patterning

Wingwall Section

- ❑ Dimensions
- ❑ Reinforcing Size/Clearance/Call-outs
- ❑ RF Wingwall Call-out
- ❑ Construction Joint/Keyway Call-out
- ❑ Weep Hole Pipe Call-out
- ❑ Line Styles/Patterning

Location Plan

- ❑ Detail to Scale
- ❑ Centerline Survey w/Stationing
- ❑ Bearing of Centerline Survey
- ❑ Centerline Culvert
- ❑ Skew and Complement at Centerline Survey
- ❑ Horizontal Dimensions
- ❑ Center of Culvert Call-out
- ❑ Station Call-out at Centerline Culvert
- ❑ Flow Arrow w/Name of Channel
- ❑ North Arrow
- ❑ Utilities w/Name of Owner (if available)
- ❑ Right-of-Way Lines Call-out

Location Plan (Cont'd)

- ❑ TO X (destination)
- ❑ Riprap/Gabions Call-out
- ❑ Culvert Subexcavation Call-out
- ❑ Existing Structure Call-out
- ❑ Section Symbols
- ❑ Line Styles/Patterning

Miscellaneous

- ❑ Lap Joint Detail
- ❑ Section Thru Precast Sloped End Section
- ❑ Eyebolt Detail (4 req’d per wingwall)
- ❑ Weep Hole Assembly Detail
- ❑ Riprap/Gabions Details
- ❑ Railing Details
- ❑ Cutwater Angle Details
- ❑ Horizontal Curve Data
- ❑ Bill of Reinforcement

Notes

- ❑ Fill Lifting Holes with Grout
- ❑ Mechanically Anchor Cutoff Walls and Parapets (precast sloped end sections)
- ❑ Weight of Each Precast Culvert Section
- ❑ Reinforcing Steel Placement
- ❑ Center Dowel Bars (extension)
- ❑ Weep Hole Assembly Consists Of
- ❑ Prefix Numbers (multiple locations)
- ❑ Estimated Quantity of Concrete (multiple locations)
- ❑ For Bridge Railing Details