Procedure # R-FM-051-07

Page 1 of 8

Date Issued: 12/31/07
Revision Issued: N/A
Rescinded: N/A

Subject: DEVIATION REVIEW AND DECISION FORM

1.1. PURPOSE

The purpose of this resource is to provide a form for documenting the findings and decision by the ECM Administrator concerning a deviation request.

1.2. BACKGROUND

A deviation is a critical aspect of the review process and needs to be documented to ensure that the deviations granted are applied to a specific development application in conformance with the criteria for approval and that the action is documented as such requests can point to potential needed revisions to the ECM.

1.3. APPLICABLE STATUTES AND REGULATIONS

Section 5.8 of the ECM establishes a mechanism whereby an engineering design standard can be modified when if strictly adhered to, would cause unnecessary hardship or unsafe design because of topographical or other conditions particular to the site, and that a departure may be made without destroying the intent of such provision.

1.4. APPLICABILITY

All provisions of the ECM are subject to deviation by the ECM Administrator provided that one of the following conditions is met:

- The ECM standard is inapplicable to a particular situation.
- Topography, right-of-way, or other geographical conditions or impediments impose an undue hardship on the applicant, and an equivalent alternative that can accomplish the same design objective is available and does not compromise public safety or accessibility.
- A change to a standard is required to address a specific design or construction problem, and if not modified, the standard will impose an undue hardship on the applicant with little or no material benefit to the public.

1.5. TECHNICAL GUIDANCE

The review shall ensure all criteria for approval are adequately considered and that justification for the deviation is properly documented.

1.6. RELATED PROCEDURES

1.6.1. Governing Procedures

P-AR-063-07 Deviation

1.6.2. Other Related Procedures

P-AR-012-07 Administrative Relief

1.7. RESOURCE

Attached is the Deviation Review and Decision Form that is used by the applicant/engineer for requesting and justifying a deviation. The form is reviewed by the ECM Administrator and approved or denied. The form is used to document the review and decision concerning a requested deviation. The request and decision concerning each deviation from a specific section of the ECM shall be recorded on a separate form.

Development Services Department
2880 International Circle
Colorado Springs, Colorado 80910

Phone: 719.520.6300
Fax: 719.520.6695
Website www.elpasoco.com

DEVIATION REVIEW AND DECISION FORM

Procedure # R-FM-051-07
Issue Date: 12/31/07
Revision Issued: 00/00/00

DSD FILE NO.:

General Property Information:

Address of Subject Property (Street Number/Name): 9210 Arroya Lane
Tax Schedule ID(s) #: 5222000023
Legal Description of Property:

Basis of bearings: The east line of the Southwest One-Quarter (SW1/4) of Section 22, Township 12 South, Range 65 West and is assumed to bear N 00° 18' 04" E, a distance of 2640.26 feet.

Commencing at the southeast corner of the Southwest One-Quarter (SW1/4) of said Section 22;

Thence S 88° 38' 37"W along the south line of the Southeast One-Quarter of the Southwest One-Quarter (SE 1/4 SW1/4), a distance of 30.00 feet to the point of beginning of the parcel of land herein described;
Thence S 88° 38' 37"W along said south line, a distance of 1300.52 feet to the southwest corner of the Southeast One-Quarter of the Southwest One-Quarter (SE 1/4 SW1/4);
Thence S 88° 38' 56"W along the south line of the Southeast One-Quarter of the Southwest One-Quarter (SE 1/4 SW1/4), a distance of 898.51 feet;
Thence N 47° 35' 42" E, a distance of 105.23 feet;
Thence N 36° 59' 01" E, a distance of 517.38 feet;
Thence N 56° 32' 31" E, a distance of 489.24 feet;
Thence N 38° 17' 19" E, a distance of 182.67 feet;
Thence N 89° 41' 56" E, a distance of 1283.66 feet;

Subdivision or Project Name: Timberridge Estates

Section of ECM from Which Deviation is Sought: DCM Section 6.4.2

Specific Criteria from Which a Deviation is Sought: “For box culverts classified as bridges or culverts at major drainageways (100-year flows greater than 1500 cfs) adequate freeboard shall be provided for the passage of debris and should be no less than 2 feet.”

Proposed Nature and Extent of Deviation: Use box culverts classified as bridges that do not provide a minimum of 2 feet of freeboard.

Applicant Information:

Applicant: Timberridge Estates, LLC. Email Address: rshomes@comcast.net
Applicant is: __X__ Owner _____ Consultant _____ Contractor
Mailing Address: 2760 Brogans Bluff, Colorado Springs State: CO Postal Code: 80919
Telephone Number: 719.499.6752 Fax Number: none

Engineer Information:

Engineer: L Ducett, P.E. Email Address: L@tnesinc.com
Company Name: Terra Nova Engineering, Inc.
Mailing Address: 721 S 23rd Street, Colorado Springs State: CO Postal Code: 80904
Registration Number: 32339 State of Registration: CO
Telephone Number: 719.635.6422 Fax Number: none

Explanation of Request (Attached diagrams, figures and other documentation to clarify request):

Section of ECM from Which Deviation is Sought: DCM Section 6.4.2

Specific Criteria from Which a Deviation is Sought: "For box culverts classified as bridges or culverts at major drainageways (100-year flows greater than 1500 cfs) adequate freeboard shall be provided for the passage of debris and should be no less than 2 feet."

Proposed Nature and Extent of Deviation: Use box culverts classified as bridges that do not provide a minimum of 2 feet of freeboard.

Reason for the Requested Deviation:

The currently proposed culverts are 3-barrel box culverts measuring 6' high by 12' wide. The calculations show this design has an inlet headwater of 10.51', which does not provide the minimum of 2' of freeboard.

An alternative culvert design is 3-barrel box culverts measuring 10' high by 15' wide. The calculations show this design has an inlet headwater of 7.9', which does provide the minimum of 2' of freeboard. Two issues with this alternative are that the culverts are wider than the upstream creek channel and the 10'x15' openings will be highly visible (due to their height) up and down stream of the culverts in areas planned for use as open space / regional trail areas.

The invert at the proposed culvert outlet is at an elevation of 7232'. Per FEMA, the 100-year flood elevation at the culvert outlet is 7242'. Based on this, both of the culvert designs will be submerged during a 100-year flood event, and 2' of freeboard will not be possible due to flood water conditions, regardless of what the culvert design calculations show for headwater. In other words, due to the relatively narrow creek bed, the capacity of the culvert designs is not the controlling factor for the 100-year water level.

Constructing even taller culverts, say 12' tall, would provide the 2' of freeboard above the floodwater level, but would worsen the visibility impact problem and would conflict with the proposed alignment for Arroya Lane. Additionally, the requirement to further raise the Arroya Lane surface would require that the culverts be lengthened, further increases the disturbance to Sand Creek and the cost.

A second alternative culvert design is 9-barrel box culverts measuring 6' high by 14' wide. The calculations show this design has an inlet headwater of 4.0', which does provide the minimum of 2' of freeboard. However, the combined width is 126', which is much wider than the 40'-60' creek channel immediately upstream of the culverts. Using culverts that are more than double the width of the creek channel is not appropriate or feasible.

A third alternative culvert design is 5-barrel box culverts measuring 8' high by 14' wide. The calculations show this design has an inlet headwater of 6.0', which does provide the minimum of 2' of freeboard. The combined width is 69' (~80' including concrete walls), which is considerably wider than the 40'-60' creek channel immediately upstream of the culverts. Constructing culverts that are wider than the immediately upstream creek channel is not advisable from a hydraulic perspective. Also, 8' tall culverts will have the same flood water elevation issue as the 10' tall culverts discussed above; they will be submerged during a 100-year flood event, and 2' of freeboard will not be possible due to flood water conditions, regardless of what the culvert design calculations show for headwater.

As neither the 3-10'x15' culvert design, 8-6'x14' culvert design, nor the 5-8'x14' culvert design will provide any freeboard at the 100-year event due to the floodwater level, it is requested that the 3-6'x12' design be allowed. This design provides the capacity to accommodate the 100-year event, while avoiding the construction of culverts that are wider than the creek channel and allowing for less expense for the culvert construction.

Comparison of Proposed Deviation to ECM Standard: As designing the box culverts to provide 2' of freeboard still results in the culverts being submerged during a 100-year event, there is no difference in actual freeboard between the proposed culvert design and the culvert design that follows the DCM standard.

Applicable Regional or National Standards Used as Basis: Not applicable.

Comparison of Proposed Design to the Drainage Basin Planning Study: The Sand Creek Drainage Basin Planning Study, Preliminary Design Report, prepared by Kiowa Engineering Corporation, dated March 1996 includes recommended improvements to the crossing of Sand Creek and Arroya Lane. The DBPS recommends replacing the existing culvert with a single 6' high by 12' wide concrete box culvert. This is the same size culvert as this deviation is requesting, and only a single barrel is recommended, rather than the triple barrel culvert that is proposed.

Types of Debris That May Be Present In Sand Creek Flow at Arroya Lane Crossing: Sand Creek flow upstream of the Arroya Lane crossing comes from three separate channels, all of which have ponds in the channels, and two of which have culverts in the channels. The land along these channels is almost entirely undeveloped land or rural residential parcels, which are comprised of a combination of grasslands and forestlands. The types of debris most likely to be found in the channel are loose vegetation debris (ex: leaves, grass, sticks) and small/light trash (ex: plastic bags, disposable cups. Medium size debris, such as branches, bushes, small logs, buckets, tires, etc., could be present in higher flows. It's possible that large debris, such as logs, trees, fencing posts, watercraft, etc., could be present in higher flows; however, this is less likely with ponds and culverts located approximately one quarter mile upstream of the Arroya Lane crossing (and few trees or residences in that distance).

Comparable Applicable Standard: The City of Colorado Springs Drainage Criteria Manual, Volume 1, dated May 2014, Chapter 11 has freeboard requirements that could be applied to the Arroya Lane crossing of Sand Creek. The Colorado Springs DCM (Table 11-1) requires zero freeboard (also allows overtopping) of collector roads (Arroya Lane is proposed as a rural minor collector) crossing culverts. If the Colorado Springs DCM was being used for the crossing in question, this deviation request would be unnecessary.

Application Consideration:

CHECK IF APPLICATION MEETS CRITERIA FOR CONSIDERATION	**JUSTIFICATION**
☐ The ECM standard is inapplicable to a particular	_____

situation.	_____ _____
☐ Topography, right-of-way, or other geographical conditions or impediments impose an undue hardship on the applicant, and an equivalent alternative that can accomplish the same design objective is available and does not compromise public safety or accessibility.	_____ _____ _____ _____ _____
X A change to a standard is required to address a specific design or construction problem, and if not modified, the standard will impose an undue hardship on the applicant with little or no material benefit to the public.	Due to the floodwater elevation, designing the proposed culverts to provide 2' of freeboard does not actually result in any freeboard being provided, while it does cause a visibility impact problem and increases the cost of constructing the culverts. Since following this specific portion of the standards increases the cost without provided the specified results, it will impose an undue hardship on the applicant with little or no material benefit to the public.

If at least one of the criteria listed above is not met, this application for deviation cannot be considered.

Criteria for Approval:

PLEASE EXPLAIN HOW EACH OF THE FOLLOWING CRITERIA HAVE BEEN SATISFIED BY THIS REQUEST

The request for a deviation is not based exclusively on financial considerations.	This deviation will eliminate a visual impact problem, while also allowing the use of a less expensive design that results in the same freeboard as the more expensive design.
The deviation will achieve the intended result with a comparable or superior design and quality of improvement.	As both the per standards design (3-10'x15' culverts) and the proposed design (3-6'x12' culverts) will not provide any freeboard at the 100-year event due to the floodwater level, and both designs provided the flow capacity required for the 100-year event, both the per standards design and the proposed design achieve the same result.
The deviation will not adversely affect safety or operations.	As both the per standards design (3-10'x15' culverts) and the proposed design (3-6'x12' culverts) provide the flow capacity required for the 100-year event and have zero freeboard due to the floodwater elevation, the safety and operations of both designs are equivalent.
The deviation will not adversely affect maintenance and its associated cost.	As both the per standards design (3-10'x15' culverts) and the proposed design (3-6'x12' culverts) provide the flow capacity required for the 100-year event and have zero freeboard due to the floodwater elevation, the effect on maintenance and its associated costs of both designs are equivalent.
The deviation will not adversely affect aesthetic appearance.	Granting this deviation will allow for the elimination of the visual impact problem that the per standards design creates.

Owner, Applicant and Engineer Declaration:
To the best of my knowledge, the information on this application and all additional or supplemental documentation is true, factual and complete. I am fully aware that any misrepresentation of any information on this application may be grounds for denial. I have familiarized myself with the rules, regulations and procedures with respect to preparing and filing this application. I also understand that an incorrect submittal will be cause to have the project removed from the agenda of the Planning Commission, Board of County Commissioners and/or Board of Adjustment or delay review, and that any approval of this application is based on the representations made in the application and may be revoked on any breach of representation or condition(s) of approval.

Scott Orth, Member, Timbe. Ridge Estates, LLC — 28 May 2019
Signature of owner (or authorized representative) — Date

Signature of applicant (if different from owner) — Date

L Ducett — 6/6/19
Signature of Engineer — Date

Engineer's Seal

COLORADO LICENSED
L DUCETT
32339
PROFESSIONAL ENGINEER

Review and Recommendation:
APPROVED by the ECM Administrator

_____ Date_____

This request has been determined to have met the criteria for approval. A deviation from Section _____of ECM is hereby granted based on the justification provided. Comments:

_____

_____

_____

_____

____ Additional comments or information are attached.

DENIED by the ECM Administrator

_____ Date_____

This request has been determined not to have met criteria for approval. A deviation from Section _____of ECM is hereby denied. Comments:

_____

_____

_____

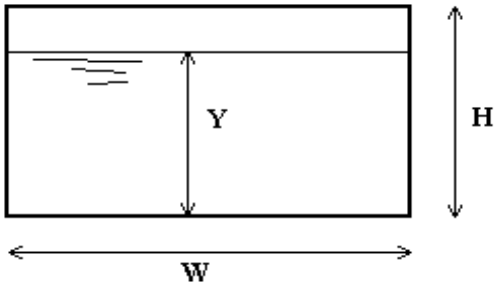
_____

____ Additional comments or information are attached.

BOX CONDUIT FLOW (Normal & Critical Depth Computation)

Project: Timberridge Estates

Box ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts



Design Information (Input)			
Box conduit invert slope	So =	0.0100	ft/ft
Box Manning's n-value	n =	0.0130	
Box Width	W =	12.00	ft
Box Height	H =	6.00	ft
Design discharge	**Q =**	**869.00**	**cfs**

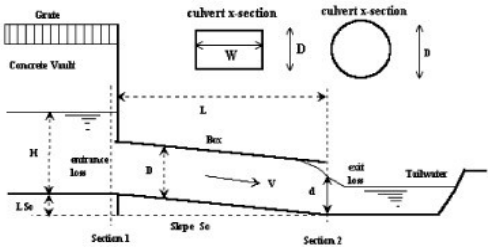
Full-flow capacity (Calculated)			
Full-flow area	Af =	72.00	sq ft
Full-flow wetted perimeter	Pf =	36.00	ft
Full-flow capacity	Qf =	1309.97	cfs

Calculations of Normal Flow Condition			
Normal flow depth (<H)	Yn =	3.66	ft
Flow area	An =	43.87	sq ft
Wetted perimeter	Pn =	19.31	ft
Flow velocity	Vn =	19.81	fps
Discharge	Qn =	869.00	cfs
Percent Full	Flow =	66.3%	of full flow
Normal Depth Froude Number	Fr_n =	1.83	supercritical

Calculation of Critical Flow Condition			
Critical flow depth	Yc =	5.46	ft
Critical flow area	Ac =	65.53	sq ft
Critical flow velocity	Vc =	13.26	fps
Critical Depth Froude Number	Fr_c =	1.00	

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Timberridge Estates
Basin ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts
Status:



Design Information (Input):

Circular Culvert:	Barrel Diameter in Inches	D =		inches
	Inlet Edge Type (choose from pull-down list)		Grooved End Projection	
OR:				
Box Culvert:	Barrel Height (Rise) in Feet	Height (Rise) =	6.00	ft.
	Barrel Width (Span) in Feet	Width (Span) =	12.00	ft.
	Inlet Edge Type (choose from pull-down list)		Square Edge w/ 90-15 Deg. Headwall	
	Number of Barrels	No =	3	
	Inlet Elevation at Culvert Invert	Inlet Elev =	7233	ft. elev.
	Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Outlet Elev =	7231.82	ft. elev.
	Culvert Length in Feet	L =	118	ft.
	Manning's Roughness	n =	0.013	
	Bend Loss Coefficient	K_b =	0	
	Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

Entrance Loss Coefficient	K_e =	0.50
Friction Loss Coefficient	K_f =	0.34
Sum of All Loss Coefficients	K_s =	1.84
Orifice Inlet Condition Coefficient	C_d =	0.82
Minimum Energy Condition Coefficient	KE_{low} =	0.4004

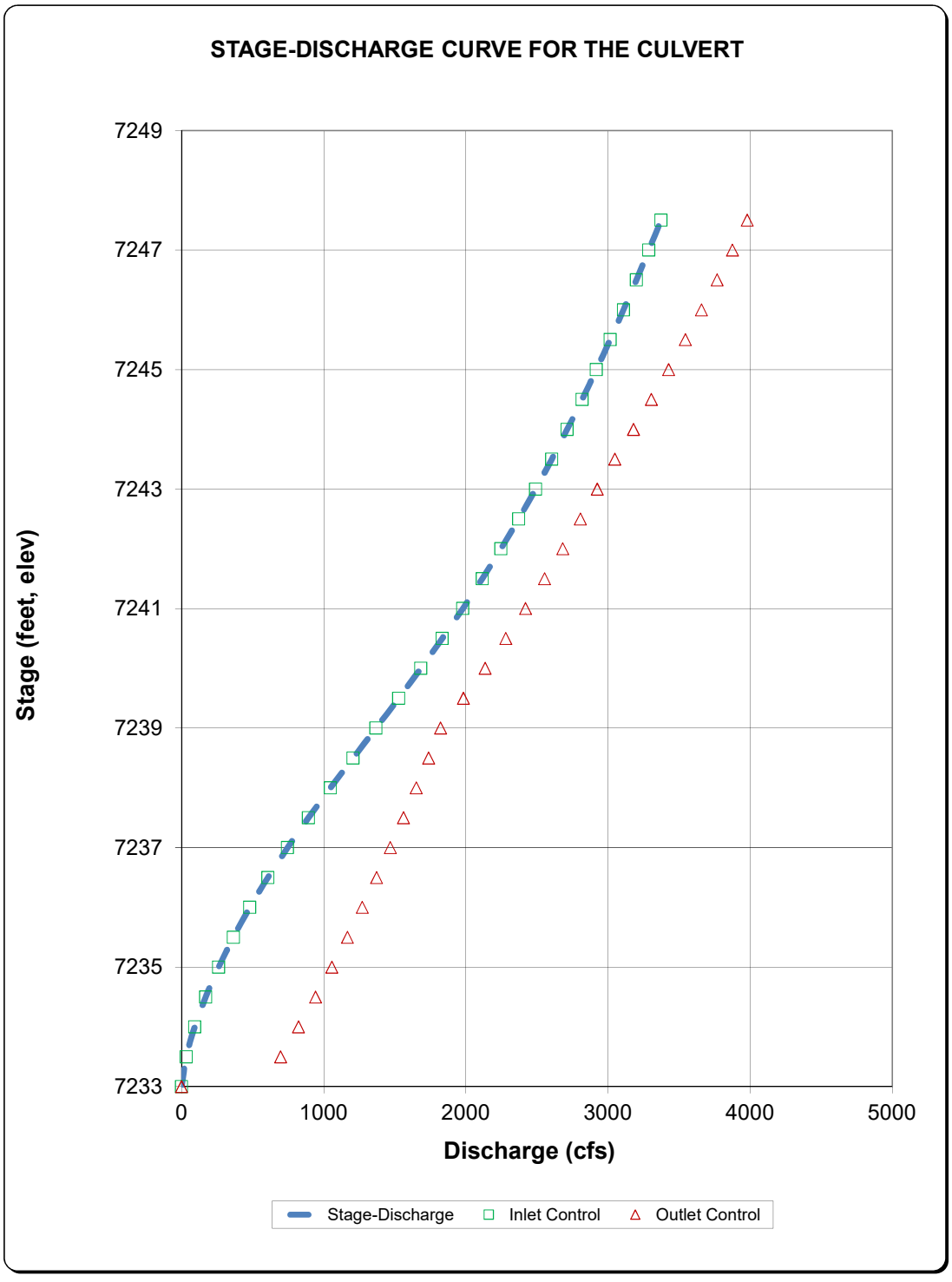
Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
7233.00		0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
7233.50		32.70	697.06	**32.70**	Min. Energy. Eqn.	INLET
7234.00		92.40	823.07	**92.40**	Min. Energy. Eqn.	INLET
7234.50		169.50	943.20	**169.50**	Min. Energy. Eqn.	INLET
7235.00		260.70	1,057.64	**260.70**	Min. Energy. Eqn.	INLET
7235.50		364.50	1,166.99	**364.50**	Min. Energy. Eqn.	INLET
7236.00		479.10	1,271.64	**479.10**	Min. Energy. Eqn.	INLET
7236.50		607.50	1,371.97	**607.50**	Regression Eqn.	INLET
7237.00		745.50	1,468.39	**745.50**	Regression Eqn.	INLET
7237.50		892.80	1,561.28	**892.80**	Regression Eqn.	INLET
7238.00		1,047.30	1,651.03	**1,047.30**	Regression Eqn.	INLET
7238.50		1,206.60	1,738.04	**1,206.60**	Regression Eqn.	INLET
7239.00		1,367.70	1,822.11	**1,367.70**	Regression Eqn.	INLET
7239.50		1,527.30	1,983.40	**1,527.30**	Regression Eqn.	INLET
7240.00		1,683.30	2,136.05	**1,683.30**	Regression Eqn.	INLET
7240.50		1,833.90	2,281.46	**1,833.90**	Regression Eqn.	INLET
7241.00		1,978.20	2,420.60	**1,978.20**	Regression Eqn.	INLET
7241.50		2,115.60	2,553.86	**2,115.60**	Regression Eqn.	INLET
7242.00		2,246.70	2,682.22	**2,246.70**	Regression Eqn.	INLET
7242.50		2,371.50	2,805.87	**2,371.50**	Regression Eqn.	INLET
7243.00		2,490.60	2,925.42	**2,490.60**	Regression Eqn.	INLET
7243.50		2,604.30	3,048.29	**2,604.30**	Regression Eqn.	INLET
7244.00		2,713.20	3,179.59	**2,713.20**	Regression Eqn.	INLET
7244.50		2,817.90	3,305.79	**2,817.90**	Regression Eqn.	INLET
7245.00		2,918.40	3,427.29	**2,918.40**	Regression Eqn.	INLET
7245.50		3,015.30	3,544.68	**3,015.30**	Regression Eqn.	INLET
7246.00		3,109.20	3,658.14	**3,109.20**	Regression Eqn.	INLET
7246.50		3,199.80	3,768.28	**3,199.80**	Regression Eqn.	INLET
7247.00		3,287.70	3,875.27	**3,287.70**	Regression Eqn.	INLET
7247.50		3,373.20	3,979.53	**3,373.20**	Regression Eqn.	INLET

Processing Time: 00.59 Seconds

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

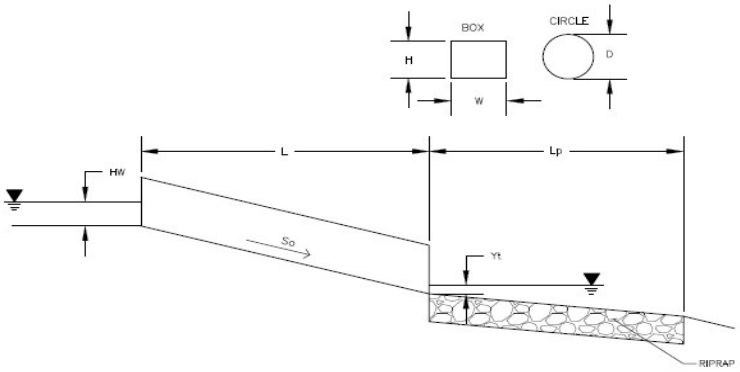
Project: Timberridge Estates
Basin ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts



Determination of Culvert Headwater and Outlet Protection

Project: Timberridge Estates

Basin ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts



Soil Type:
Choose One:
(•) Sandy
( ) Non-Sandy

Supercritical Flow! Using Ha to calculate protection type.

Design Information (Input):

	Design Discharge	Q =	2607	cfs
Circular Culvert:				
	Barrel Diameter in Inches	D =		inches
	Inlet Edge Type (Choose from pull-down list)			
Box Culvert:			**OR**	
	Barrel Height (Rise) in Feet	Height (Rise) =	6	ft
	Barrel Width (Span) in Feet	Width (Span) =	12	ft
	Inlet Edge Type (Choose from pull-down list)		Square Edge w/ 90-15 Deg. Headwall	
	Number of Barrels	No =	3	
	Inlet Elevation	Elev IN =	7233	ft
	Outlet Elevation **OR** Slope	Elev OUT =	7231.82	ft
	Culvert Length	L =	118	ft
	Manning's Roughness	n =	0.013	
	Bend Loss Coefficient	k_b =	0	
	Exit Loss Coefficient	k_x =	1	
	Tailwater Surface Elevation	Elev Y_t =		ft
	Max Allowable Channel Velocity	V =	5	ft/s

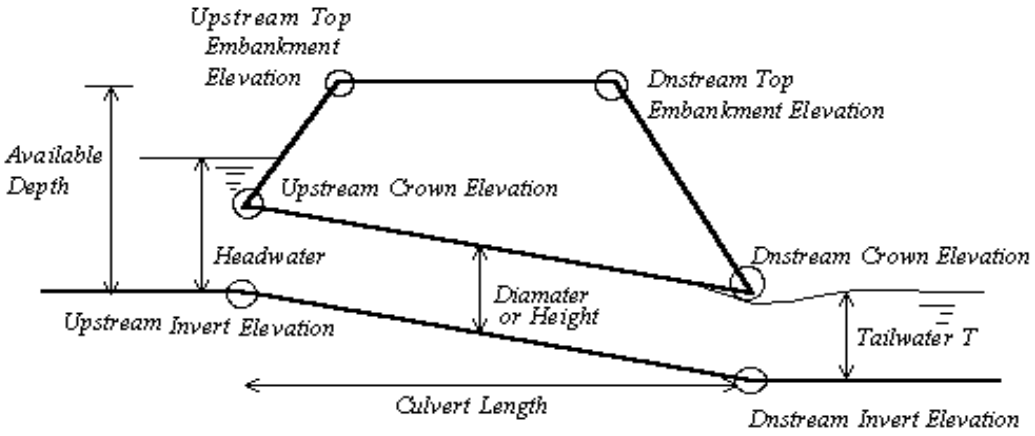
Required Protection (Output):

Tailwater Surface Height	Y_t =	2.40	ft
Flow Area at Max Channel Velocity	A_t =	173.80	ft^2
Culvert Cross Sectional Area Available	A =	72.00	ft^2
Entrance Loss Coefficient	k_e =	0.50	
Friction Loss Coefficient	k_f =	0.34	
Sum of All Losses Coefficients	k_s =	1.84	ft
Culvert Normal Depth	Y_n =	3.66	ft
Culvert Critical Depth	Y_c =	5.46	ft
Tailwater Depth for Design	d =	5.73	ft
Adjusted Diameter **OR** Adjusted Rise	H_a =	4.83	ft
Expansion Factor	1/(2*tan(Θ)) =	2.85	
Flow/Diameter$^{2.5}$ **OR** Flow/(Span * Rise$^{1.5}$)	Q/WH^1.5 =	4.93	$ft^{0.5}/s$
Froude Number	Fr =	1.83	**Supercritical!**
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/H =	0.50	
Inlet Control Headwater	HW_I =	10.51	ft
Outlet Control Headwater	HW_O =	8.71	
Design Headwater Elevation	**HW =**	**7,243.51**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/H =**	**1.75**	**HW/H > 1.5!**
Minimum Theoretical Riprap Size	d_{50} =	11	in
Nominal Riprap Size	d_{50} =	12	in
UDFCD Riprap Type	**Type =**	**M**	
Length of Protection	**L_p =**	**60**	**ft**
Width of Protection	**T =**	**34**	**ft**

Vertical Profile for the Culvert

Project = Timberridge Estates

Box ID = Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-6'x12' Conc Box Culverts



Culvert Information (Input)			
Barrel Diameter or Height	D or H =	72.00	inches
Barrel Length	L =	118.00	ft
Barrel Invert Slope	So =	0.0100	ft/ft
Downstream Invert Elevation	EDI =	7231.82	ft
Downstream Top Embankment Elevation	EDT =	7244.00	ft
Upstream Top Embankment Elevation	EUT =	7244.00	ft
Design Headwater Depth (not elev.)	Hw =	8.71	ft
Tailwater Depth (not elev.)	Yt =	5.73	ft

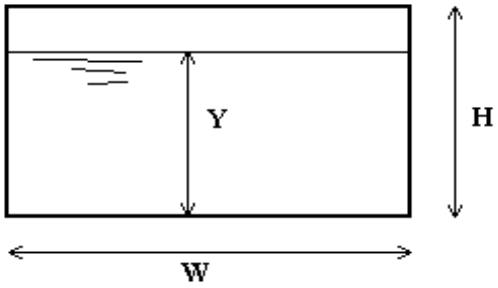
Culvert Hydraulics (Calculated)			
Available Headwater Depth	HW-a =	11.00	ft
Design Hw/D ratio	Hw/D =	1.45	

Culvert Vertical Profile			
Upstream Invert Elevation	EUI =	7233.00	ft
Upstream Crown Elevation	EUC =	7239.00	ft
Upstream Soil Cover Depth	Upsoil =	5.00	ft
Downstream Invert Elevation	EDI =	7231.82	ft
Downstream Crown Elevation	EDC =	7237.82	ft
Downstream Soil Cover Depth	Dnsoil =	6.18	ft

BOX CONDUIT FLOW (Normal & Critical Depth Computation)

Project: Timberridge Estates

Box ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-10'x15' Conc Box Culverts



Design Information (Input)			
Box conduit invert slope	So =	0.0100	ft/ft
Box Manning's n-value	n =	0.0130	
Box Width	W =	15.00	ft
Box Height	H =	10.00	ft
Design discharge	**Q =**	**869.00**	**cfs**

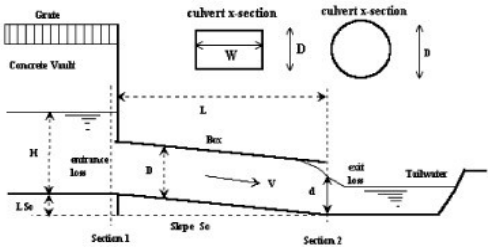
Full-flow capacity (Calculated)			
Full-flow area	Af =	150.00	sq ft
Full-flow wetted perimeter	Pf =	50.00	ft
Full-flow capacity	Qf =	3576.14	cfs

Calculations of Normal Flow Condition			
Normal flow depth (<H)	Yn =	3.03	ft
Flow area	An =	45.42	sq ft
Wetted perimeter	Pn =	21.06	ft
Flow velocity	Vn =	19.13	fps
Discharge	Qn =	869.02	cfs
Percent Full	Flow =	24.3%	of full flow
Normal Depth Froude Number	Fr_n =	1.94	supercritical

Calculation of Critical Flow Condition			
Critical flow depth	Yc =	4.71	ft
Critical flow area	Ac =	70.59	sq ft
Critical flow velocity	Vc =	12.31	fps
Critical Depth Froude Number	Fr_c =	1.00	

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

Project: Timberridge Estates
Basin ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-10'x15' Conc Box Culverts
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches — D = — inches
Inlet Edge Type (choose from pull-down list) — Grooved End Projection

OR:

Box Culvert: Barrel Height (Rise) in Feet — Height (Rise) = 10.00 ft.
Barrel Width (Span) in Feet — Width (Span) = 15.00 ft.
Inlet Edge Type (choose from pull-down list) — Square Edge w/ 90-15 Deg. Headwall

Number of Barrels	No =	3	
Inlet Elevation at Culvert Invert	Inlet Elev =	7233	ft. elev.
Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Outlet Elev =	7231.82	ft. elev.
Culvert Length in Feet	L =	118	ft.
Manning's Roughness	n =	0.013	
Bend Loss Coefficient	K_b =	0	
Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

Entrance Loss Coefficient	K_e =	0.50
Friction Loss Coefficient	K_f =	0.17
Sum of All Loss Coefficients	K_s =	1.67
Orifice Inlet Condition Coefficient	C_d =	0.82
Minimum Energy Condition Coefficient	KE_{low} =	0.4007

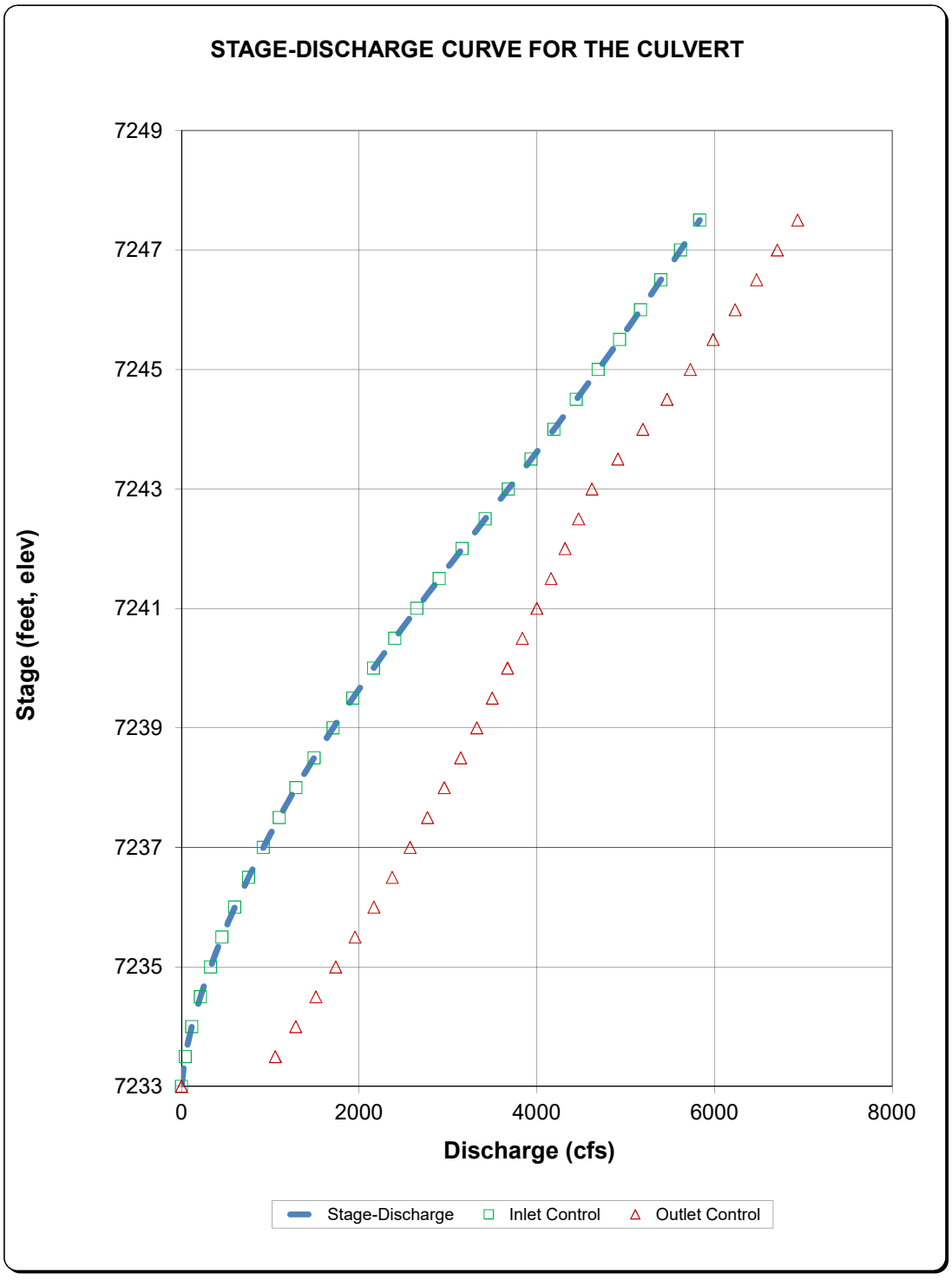
Calculations of Culvert Capacity (output):

Water Surface Elevation (ft., linked)	Tailwater Surface Elevation ft	Culvert Inlet-Control Flowrate cfs	Culvert Outlet-Control Flowrate cfs	Controlling Culvert Flowrate cfs (output)	Inlet Equation Used:	Flow Control Used
7233.00		0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
7233.50		40.80	1,055.04	**40.80**	Min. Energy. Eqn.	INLET
7234.00		115.20	1,285.24	**115.20**	Min. Energy. Eqn.	INLET
7234.50		211.80	1,512.66	**211.80**	Min. Energy. Eqn.	INLET
7235.00		325.80	1,735.69	**325.80**	Min. Energy. Eqn.	INLET
7235.50		455.40	1,953.49	**455.40**	Min. Energy. Eqn.	INLET
7236.00		598.50	2,165.55	**598.50**	Min. Energy. Eqn.	INLET
7236.50		754.20	2,371.89	**754.20**	Min. Energy. Eqn.	INLET
7237.00		921.60	2,572.57	**921.60**	Min. Energy. Eqn.	INLET
7237.50		1,099.50	2,767.73	**1,099.50**	Min. Energy. Eqn.	INLET
7238.00		1,287.90	2,957.59	**1,287.90**	Min. Energy. Eqn.	INLET
7238.50		1,491.90	3,142.48	**1,491.90**	Regression Eqn.	INLET
7239.00		1,705.80	3,322.56	**1,705.80**	Regression Eqn.	INLET
7239.50		1,928.70	3,498.14	**1,928.70**	Regression Eqn.	INLET
7240.00		2,160.60	3,669.44	**2,160.60**	Regression Eqn.	INLET
7240.50		2,400.90	3,836.73	**2,400.90**	Regression Eqn.	INLET
7241.00		2,648.10	4,000.22	**2,648.10**	Regression Eqn.	INLET
7241.50		2,901.30	4,160.12	**2,901.30**	Regression Eqn.	INLET
7242.00		3,158.40	4,316.61	**3,158.40**	Regression Eqn.	INLET
7242.50		3,417.90	4,469.88	**3,417.90**	Regression Eqn.	INLET
7243.00		3,678.00	4,620.10	**3,678.00**	Regression Eqn.	INLET
7243.50		3,936.90	4,911.93	**3,936.90**	Regression Eqn.	INLET
7244.00		4,192.80	5,193.33	**4,192.80**	Regression Eqn.	INLET
7244.50		4,444.50	5,465.16	**4,444.50**	Regression Eqn.	INLET
7245.00		4,691.40	5,728.26	**4,691.40**	Regression Eqn.	INLET
7245.50		4,932.30	5,983.45	**4,932.30**	Regression Eqn.	INLET
7246.00		5,167.20	6,231.25	**5,167.20**	Regression Eqn.	INLET
7246.50		5,395.50	6,472.31	**5,395.50**	Regression Eqn.	INLET
7247.00		5,617.50	6,707.06	**5,617.50**	Regression Eqn.	INLET
7247.50		5,833.20	6,935.98	**5,833.20**	Regression Eqn.	INLET

Processing Time: 00.61 Seconds

CULVERT STAGE-DISCHARGE SIZING (INLET vs. OUTLET CONTROL WITH TAILWATER EFFECTS)

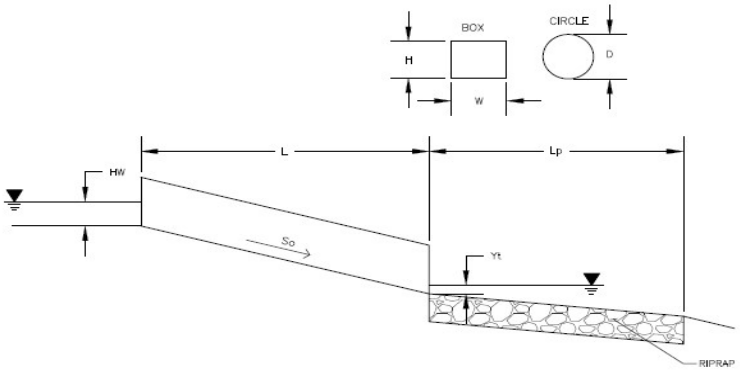
Project: Timberridge Estates
Basin ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-10'x15' Conc Box Culverts



Determination of Culvert Headwater and Outlet Protection

Project: Timberridge Estates

Basin ID: Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-10'x15' Conc Box Culverts



Soil Type:
Choose One:
(•) Sandy
( ) Non-Sandy

Supercritical Flow! Using Ha to calculate protection type.

Design Information (Input):

	Design Discharge	Q =	2607	cfs
Circular Culvert:				
	Barrel Diameter in Inches	D =		inches
	Inlet Edge Type (Choose from pull-down list)			
Box Culvert:			**OR**	
	Barrel Height (Rise) in Feet	Height (Rise) =	10	ft
	Barrel Width (Span) in Feet	Width (Span) =	15	ft
	Inlet Edge Type (Choose from pull-down list)		Square Edge w/ 90-15 Deg. Headwall	
	Number of Barrels	No =	3	
	Inlet Elevation	Elev IN =	7233	ft
	Outlet Elevation **OR** Slope	Elev OUT =	7231.82	ft
	Culvert Length	L =	118	ft
	Manning's Roughness	n =	0.013	
	Bend Loss Coefficient	k_b =	0	
	Exit Loss Coefficient	k_x =	1	
	Tailwater Surface Elevation	Elev Y_t =		ft
	Max Allowable Channel Velocity	V =	5	ft/s

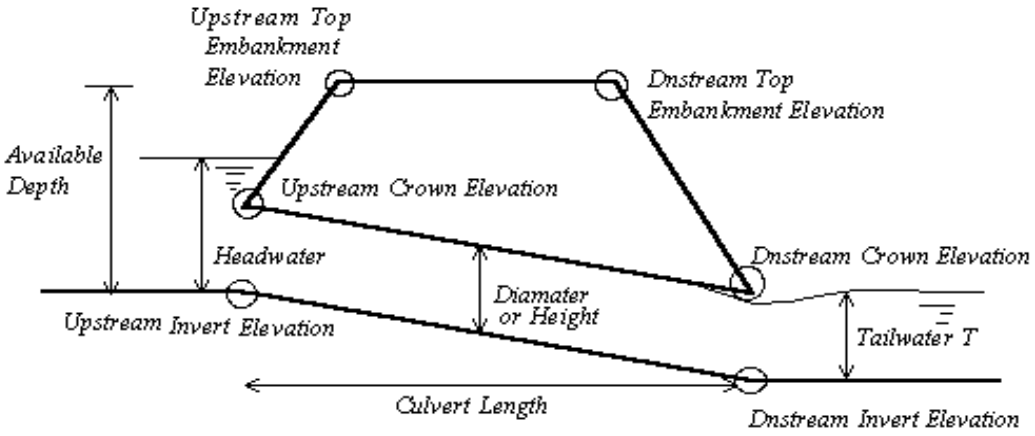
Required Protection (Output):

Tailwater Surface Height	Y_t =	4.00	ft
Flow Area at Max Channel Velocity	A_t =	173.80	ft^2
Culvert Cross Sectional Area Available	A =	150.00	ft^2
Entrance Loss Coefficient	k_e =	0.50	
Friction Loss Coefficient	k_f =	0.17	
Sum of All Losses Coefficients	k_s =	1.67	ft
Culvert Normal Depth	Y_n =	3.03	ft
Culvert Critical Depth	Y_c =	4.71	ft
Tailwater Depth for Design	d =	7.35	ft
Adjusted Diameter **OR** Adjusted Rise	H_a =	6.51	ft
Expansion Factor	1/(2*tan(Θ)) =	6.65	
Flow/Diameter$^{2.5}$ **OR** Flow/(Span * Rise$^{1.5}$)	Q/WH^1.5 =	1.83	$ft^{0.5}/s$
Froude Number	Fr =	1.94	**Supercritical!**
Tailwater/Adjusted Diameter **OR** Tailwater/Adjusted Rise	Yt/H =	0.61	
Inlet Control Headwater	HW_I =	7.92	ft
Outlet Control Headwater	HW_O =	7.04	
Design Headwater Elevation	**HW =**	**7,240.92**	**ft**
Headwater/Diameter OR Headwater/Rise Ratio	**HW/H =**	**0.79**	
Minimum Theoretical Riprap Size	d_{50} =	6	in
Nominal Riprap Size	d_{50} =	9	in
UDFCD Riprap Type	**Type =**	**L**	
Length of Protection	**L_p =**	**100**	**ft**
Width of Protection	**T =**	**31**	**ft**

Vertical Profile for the Culvert

Project = Timberridge Estates

Box ID = Arroya Lane Crossing Sand Creek (2,607 cfs) - 3-10'x15' Conc Box Culverts



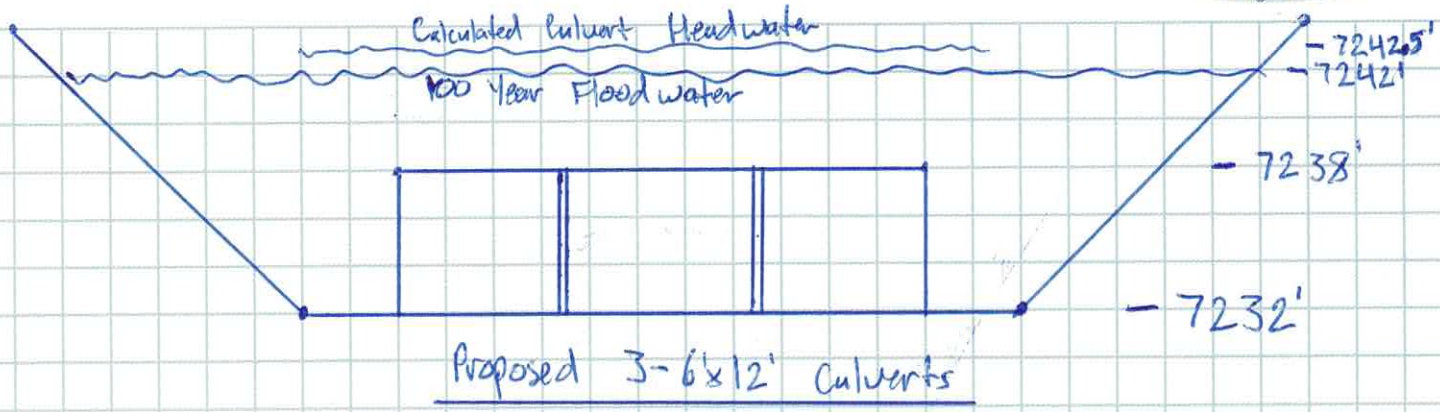
Culvert Information (Input)			
Barrel Diameter or Height	D or H =	120.00	inches
Barrel Length	L =	118.00	ft
Barrel Invert Slope	So =	0.0100	ft/ft
Downstream Invert Elevation	EDI =	7231.82	ft
Downstream Top Embankment Elevation	EDT =	7244.00	ft
Upstream Top Embankment Elevation	EUT =	7244.00	ft
Design Headwater Depth (not elev.)	Hw =	7.92	ft
Tailwater Depth (not elev.)	Yt =	7.35	ft

Culvert Hydraulics (Calculated)			
Available Headwater Depth	HW-a =	11.00	ft
Design Hw/D ratio	Hw/D =	0.79	

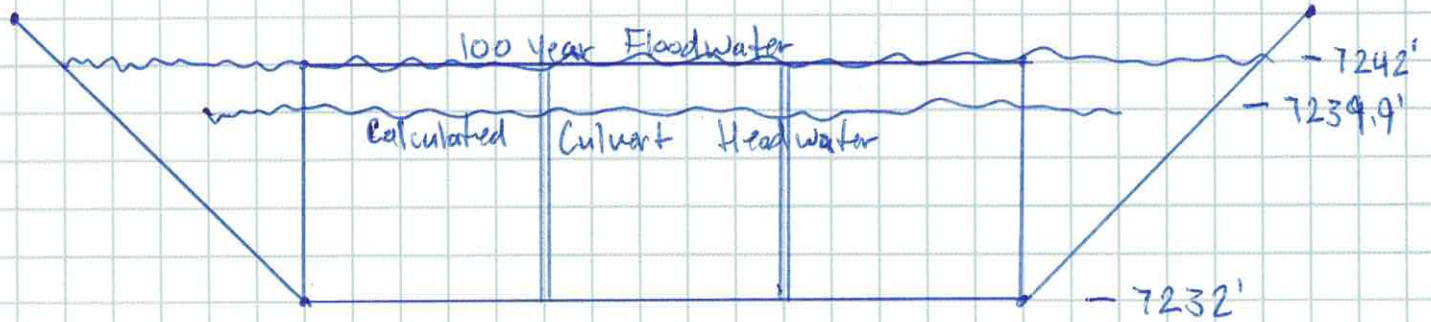
Culvert Vertical Profile			
Upstream Invert Elevation	EUI =	7233.00	ft
Upstream Crown Elevation	EUC =	7243.00	ft
Upstream Soil Cover Depth	Upsoil =	1.00	ft
Downstream Invert Elevation	EDI =	7231.82	ft
Downstream Crown Elevation	EDC =	7241.82	ft
Downstream Soil Cover Depth	Dnsoil =	2.18	ft

Job No. 1733.00 Timberridge Estates
Date 05/13/19
By Dave

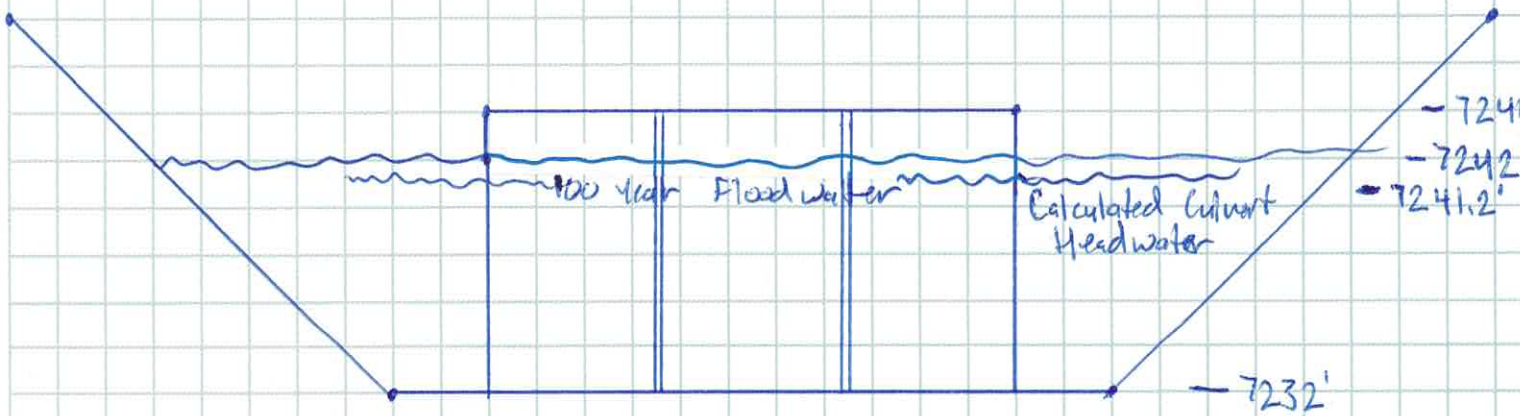
Terra Nova Engineering, Inc.
"Creative Civil Engineering Solutions"



Proposed 3-6'x12' Culverts



Per Standards 3- 10'x15' Culverts Design



Culvert with 2' Freeboard Above Floodwater (3-12'x12' ?)

~~125 N. Wahsatch Ave.~~ • Colorado Springs, CO 80903-3406
Phone: 719-635-6422 • Fax: 719-635-6426

TIMBERRIDGE ESTATES - 9210 ARROYA LANE

EL PASO COUNTY

STREET IMPROVEMENT PLAN

JUNE 2019

BENCHMARKS

A #4 REBAR 28.3 FEET SOUTH AND 77.2 FEET WEST OF THE SOUTHEAST PROPERTY CORNER.
ELEV = 7,319.85' (NGVD-1929)

LEGEND

- EXISTING 2' CONTOUR
- 7260 EXISTING 10' CONTOUR
- PROPOSED 2' CONTOUR
- 260 PROPOSED 10' CONTOUR
- SURFACE FLOW CHANNEL
- PROPOSED DRAINAGE EASEMENT
- W EXISTING WATER LINE
- DRAINAGE FLOW DIRECTION

N

100' 0 100' 200'

SCALE: 1"=100'

NOTES

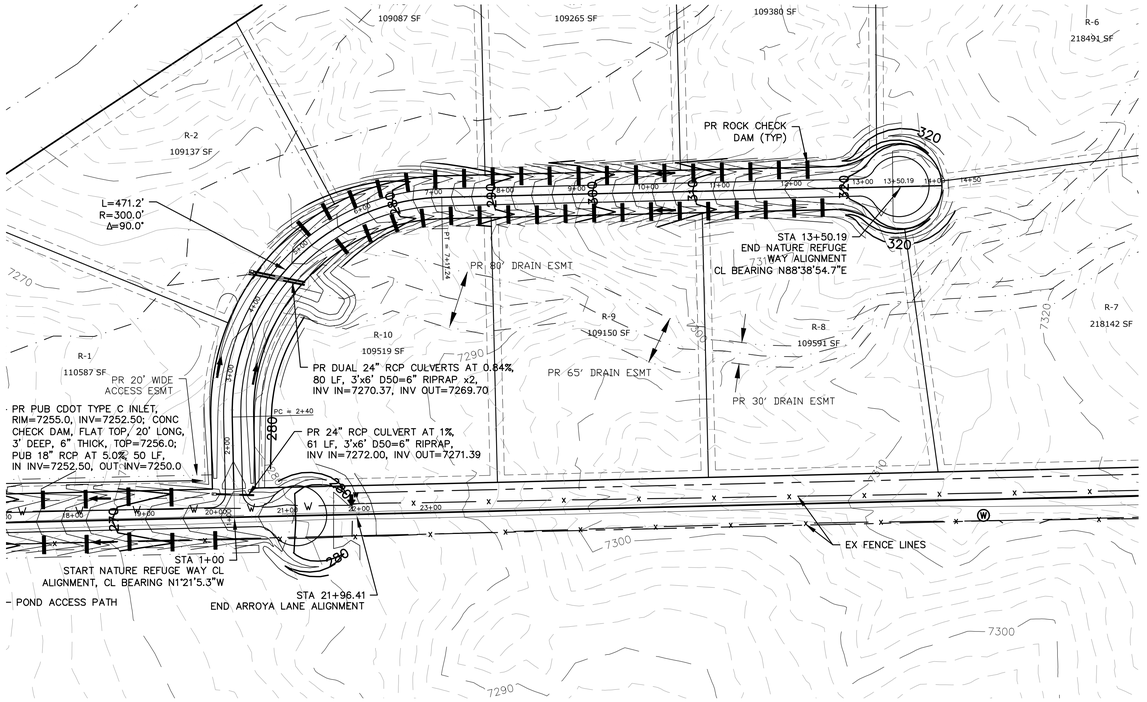
1. REINFORCE PROPOSED SWALES PR3, PR4, PR7, PR8, PR9, PR10, & PR11 WITH PERMANENT ROCK CHECK DAMS PER COUNTY CONSTRUCTION DETAIL CD-1 (IN DCM VOL 2). CHECK DAMS ARE NOT REQUIRED FOR SWALE AREAS WITH RIPRAP.

2. FUTURE SAND FILTERS TO BE INSTALLED PRIOR TO THE PAVING OF ARROYA LANE. SAND FILTERS WILL NOT BE PUT INTO OPERATION WHILE ARROYA LANE IS STILL A GRAVEL ROAD. FUTURE SAND FILTERS WILL BE ACCESSED FROM THE ADJACENT FUTURE ROADS. FINAL SAND FILTER DESIGN TO BE PREPARED WITH FINAL DESIGN OF PAVED ARROYA LANE.

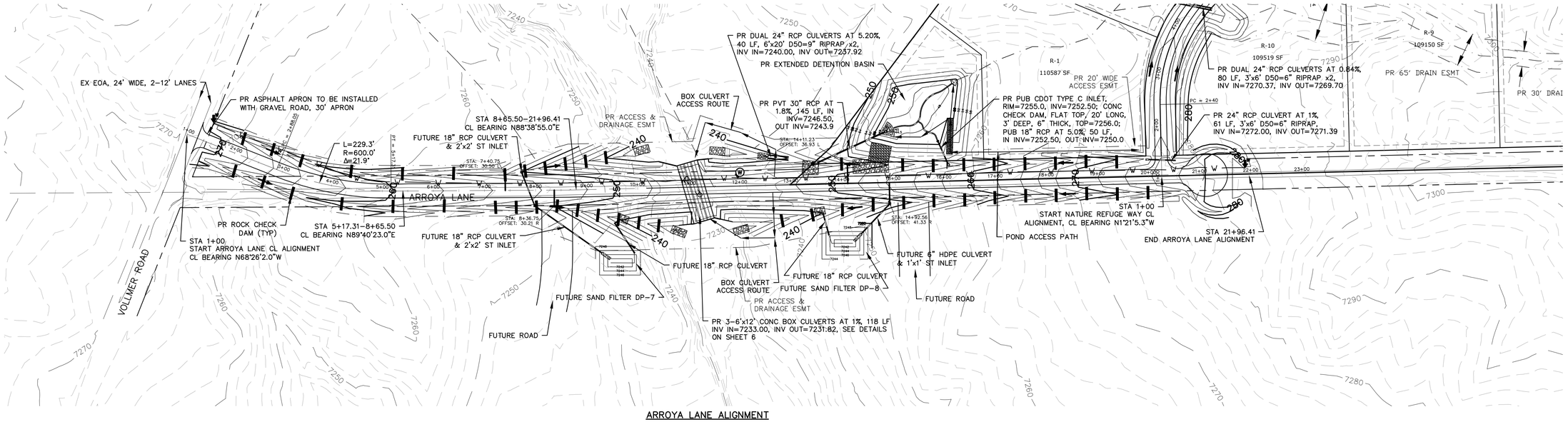
CHECK DAM SPACING

CHECK DAM SPACING IS BASED ON SLOPE AND CHECK DAM HEIGHT. THE TOP OF THE DOWNHILL CHECK DAM SHOULD BE AT THE SAME ELEVATION AS THE BOTTOM OF THE NEXT CHECK DAM UPSTREAM. SPECIFIC CHECK DAM LOCATIONS TO BE SET BY CONTRACTOR BASED ON FIELD CONDITIONS. A MINIMUM OF 9" TO BE MAINTAINED BETWEEN THE TOP OF CHECK DAMS AND THE TOP OF THE SWALE. MAX CHECK DAM HEIGHTS AND CHECK DAM SPACING RANGES ARE SHOWN BELOW. PRELIMINARY CHECK DAM LOCATIONS ARE SHOWN ON THE PLAN (CONTRACTOR TO FINALIZE).

SWALE	CHECK DAM MAX HEIGHT	CHECK DAM SPACING AT MAX HEIGHT
PR3	2.0'	31'-42'
PR4	2.0'	20'-60'
PR7	2.5'	58'-65'
PR8	3.0'	60'
PR9	2.5'	58'-65'
PR10	2.5'	40'-120'
PR11	2.5'	40'-120'



NATURE REFUGE WAY ALIGNMENT



ARROYA LANE ALIGNMENT

REVISIONS

NO.	DESCRIPTION	DATE

UNTIL SUCH TIME AS THESE DRAWINGS ARE APPROVED BY THE APPROPRIATE REVIEWING AGENCIES, TERRA NOVA ENGINEERING, INC. APPROVES THEIR USE ONLY FOR THE PURPOSES DESIGNATED BY WRITTEN AUTHORIZATION.

PREPARED FOR:
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Terra Nova Engineering, Inc.
Creative Civil Engineering Solutions
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www.tnepinc.com

TIMBERRIDGE ESTATES
9210 ARROYA LANE

STREET IMPROVEMENT PLAN OVERVIEW

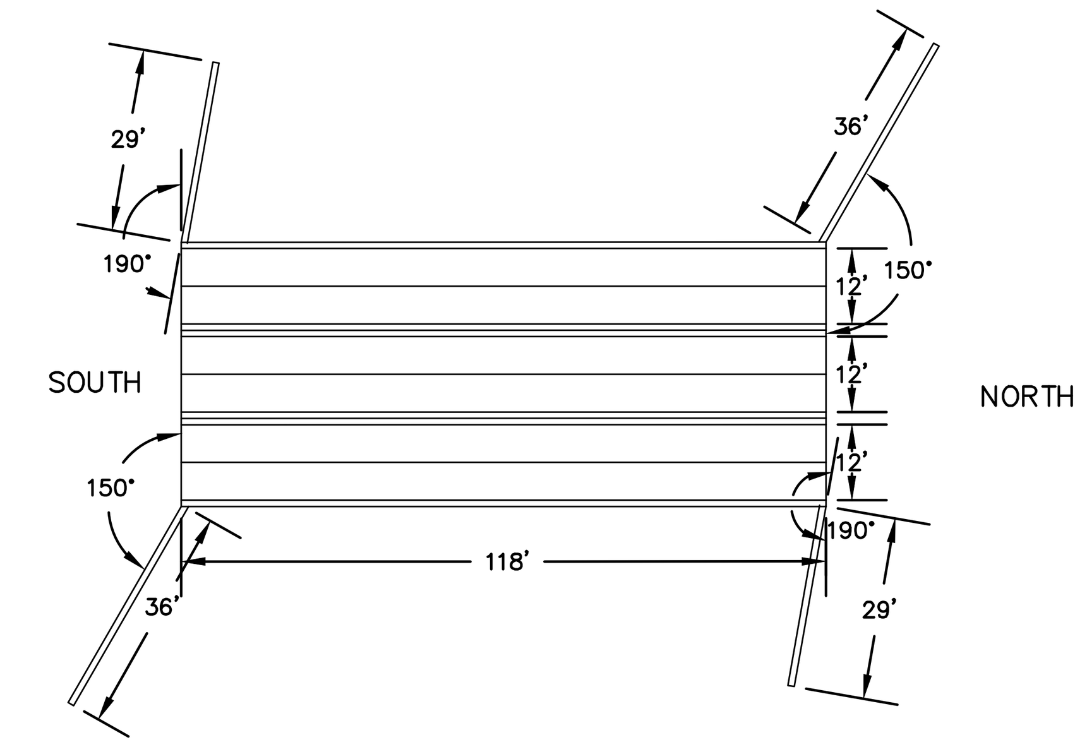
DESIGNED BY	LD
DRAWN BY	DLF
CHECKED BY	LD
H-SCALE	1"=100'
V-SCALE	NA
JOB NO.	1733.00
DATE ISSUED	06/03/19
SHEET NO.	2 OF 8

TIMBERRIDGE ESTATES - 9210 ARROYA LANE

EL PASO COUNTY

STREET IMPROVEMENT PLAN

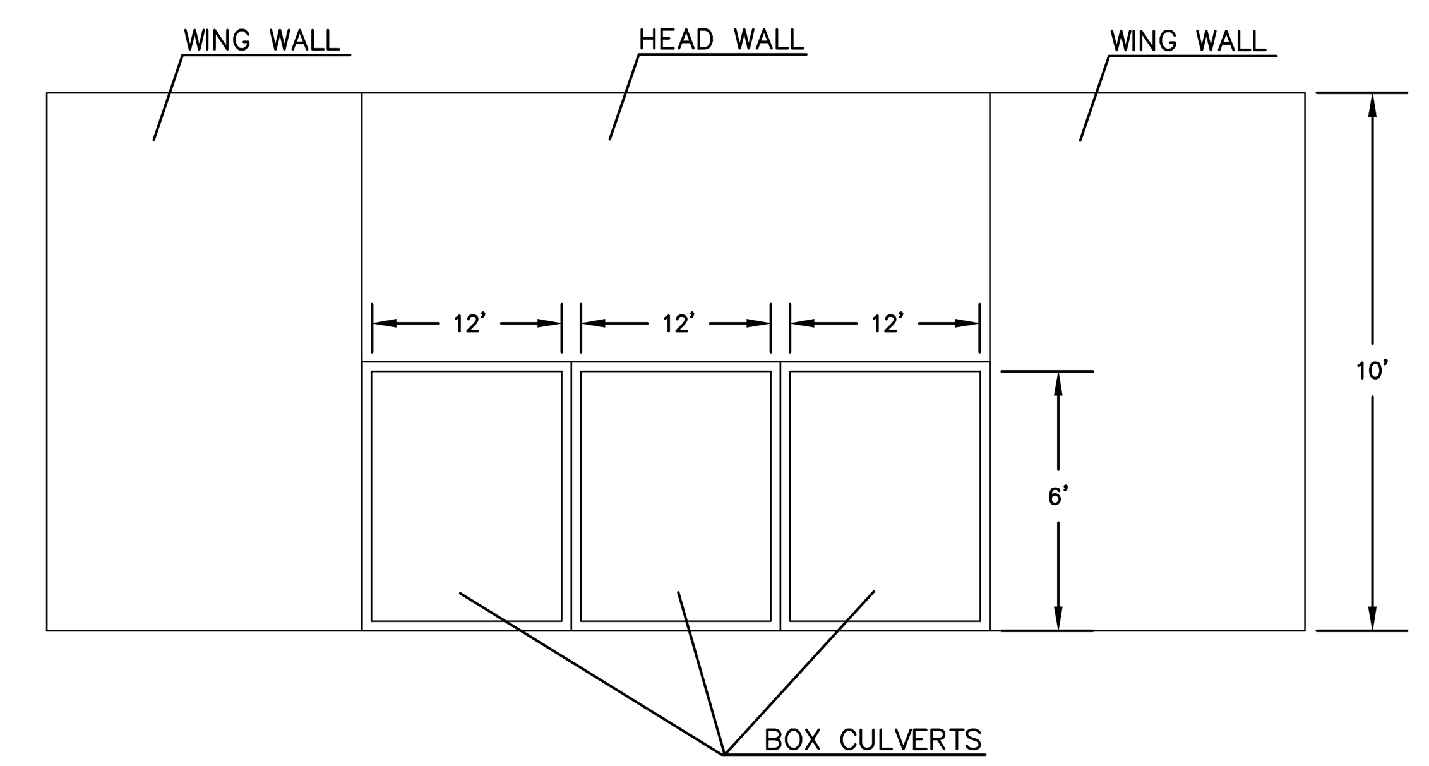
JUNE 2019



3–6'x12' CONCRETE BOX CULVERTS – PLAN VIEW

NOT TO SCALE

PR 3–6'x12' CONC BOX CULVERTS AT 1%, 118 LF,
INV IN (NORTH)=7233.00, INV OUT (SOUTH)=7231.82,
TOP OF NORTH HEAD/WING WALLS=7243.00,
TOP OF SOUTH HEAD/WING WALLS=7241.82



3–6'x12' CONCRETE BOX CULVERTS – PROFILE VIEW

NOT TO SCALE

TRIPLE CONCRETE BOX CULVERT DIMENSIONS, QUANTITIES & RATING FACTORS (EXCLUDING HEADWALL & TOEWALL QUANTITIES)

BOX SIZE				FILL HEIGHT ALLOWED	SLAB & WALL THICKNESS (INCHES)			BAR SIZES								d1▲	DIMENSIONS					QUANTITIES			RATING FACTORS			
S	R	HT.	WIDTH		T_t	T_b	TW & TW_i	t_1*	t_2	b_1	b_2	w_1* & w_2	w_3* & w_4	c_1*	c_2		h_1	h_2	v_1	v_2	v_3	CONCRETE	REBAR STL	WATERPROOFING	HL-93 INVENTORY	HL-93 OPERATING	COLORADO PERMIT	NRL VEHICLE
FT	FT	FT-IN	FT-IN	FT-FT				#	#	#	#	#	#	#	#	NO.	FT-IN	FT-IN	FT-IN	FT-IN	FT-IN	CY/LF	LBS/LF	SY/LF				
8	6	7-10.5	27-4	< 2	12.5	10	10	5	6	5	6	4	4	5	5	168	3-5	2-4	6-10	2-4	1-11	2.639	531	3.370	1.21	1.57	1.82	1.69
		7-9.5	27-4	2 TO 8	10.5	11	10	4	5	4	5	4	4	5	5	168	2-6	2-4	6-8	3-2	2-0	2.555	429		1.47	1.90	2.07	1.83
		8-0	27-4	8 TO 12	11	13	10	4	5	4	5	4	4	5	5	168	2-6	2-4	6-9	3-4	2-2	2.765	432		3.38	4.39	4.80	5.22
		8-0	27-4	12 TO 16	11	13	10	5	4	4	4	5	5	5	5	168	2-6	2-4	6-9	3-4	2-2	2.765	462		6.80	8.81	9.35	8.63
		8-0	27-4	16 TO 20	11	13	10	5	4	5	4	5	5	5	5	168	2-4	2-4	6-9	3-5	2-2	2.765	482		1.69	2.19	2.20	2.27
		8-3.5	27-4	20 TO 25.9	13	14.5	10	5	5	5	5	5	5	5	5	168	2-6	2-4	6-11	2-4	2-3	3.061	523		6.80	8.82	8.50	5.95
		8-4.5	27-10	26 TO 30	13.5	15	11.5	5	6	5	6	5	5	5	5	168	3-3	2-6	6-11	3-6	2-4	3.300	587		◆	◆	◆	◆
	8	9-10.5	27-4	< 2	12.5	10	10	5	6	5	6	4	4	5	5	184	3-5	2-4	8-10	3-1	1-11	2.886	566	3.370	1.21	1.57	1.82	1.65
		9-9.5	27-4	2 TO 8	10.5	11	10	4	5	4	5	4	4	5	5	175	2-6	2-4	8-8	3-2	2-0	2.801	461		1.46	1.89	2.00	1.82
		10-0	27-4	8 TO 12	11	13	10	4	5	4	5	4	4	5	5	184	2-6	2-4	8-9	3-4	2-2	3.012	464		3.45	4.47	4.89	5.12
		10-0	27-4	12 TO 16	11	13	10	5	4	4	5	4	4	5	5	184	2-6	2-4	8-9	2-4	2-2	3.012	460		2.53	3.27	3.47	3.73
		10-4	27-4	16 TO 20	13.5	14.5	10	5	4	5	5	4	4	5	5	184	3-3	2-4	8-11	3-5	2-2	3.350	490		3.07	3.98	3.84	2.72
		10-4	27-6	20 TO 25.9	13.5	14.5	10.5	5	6	5	6	6	6	5	5	184	3-3	2-4	8-11	3-6	2-3	3.414	675		1.78	2.32	2.23	1.56
		10-4.5	27-10	26 TO 30	13.5	15	11.5	5	5	5	5	5	5	5	5	184	3-3	2-6	8-11	3-6	2-4	3.584	578		◆	◆	◆	◆
10	6	8-0	33-4	< 2	14	10	10	6	7	6	7	5	5	5	5	192	3-5	2-4	6-11	3-1	1-11	3.210	796	4.037	1.20	1.55	1.44	1.37
		7-9	33-4	2 TO 8	11	10	10	6	7	6	7	5	5	5	5	192	2-6	2-4	6-9	2-4	1-11	2.901	774		1.56	2.02	1.81	1.73
		8-1	33-4	8 TO 12	11.5	13.5	10	5	7	5	7	5	5	5	5	192	2-6	2-4	6-9	3-4	2-2	3.313	721		2.81	3.65	3.73	4.04
		8-2.5	33-4	12 TO 16	12	14.5	10	6	6	5	7	5	5	5	5	192	2-6	2-4	6-10	3-7	2-4	3.467	720		2.67	3.47	3.58	3.84
		8-6	33-4	16 TO 22	14	16	10	6	5	6	5	5	5	5	5	192	2-6	2-4	7-0	3-7	2-5	3.827	658		2.44	3.17	3.04	3.14
	8	10-0	33-6	< 2	14	10	10.5	6	7	6	7	5	5	5	5	208	3-5	2-4	8-11	3-1	1-11	3.519	840	4.056	1.20	1.56	1.40	1.33
		9-11.5	33-4	2 TO 6	11.5	12	10	6	7	6	7	5	5	5	5	208	2-6	2-4	8-9	2-4	2-0	3.405	817		1.65	2.14	2.44	2.39
		10-1	33-4	6 TO 8	11.5	13.5	10	5	7	5	7	5	5	5	5	208	2-6	2-4	8-9	3-3	2-0	3.560	760		3.11	4.04	3.99	4.60
		10-1	33-4	8 TO 12	11.5	13.5	10	5	7	5	7	5	5	5	5	208	2-6	2-4	8-9	3-5	2-2	3.560	763		2.85	3.69	3.76	4.07
		10-5	33-4	12 TO 16	13.5	15.5	10	5	7	5	7	5	5	5	5	208	2-6	2-4	8-11	3-7	2-4	3.971	768		3.36	4.36	4.60	4.04
		10-6	33-4	16 TO 22	14	16	10	6	7	6	7	5	5	5	5	208	2-6	2-4	9-0	3-7	2-5	4.074	831		2.37	3.08	2.93	2.10
	10	12-0	33-6	< 2	14	10	10.5	6	7	6	7	5	5	5	5	224	3-5	2-4	10-11	2-4	1-11	3.778	879	4.056	1.17	1.52	1.36	1.30
		11-10.5	33-6	2 TO 8	11.5	11	10.5	6	7	6	7	5	5	5	5	224	2-6	2-4	10-9	3-2	2-0	3.623	864		1.65	2.14	2.15	2.06
		12-0.5	33-8	8 TO 12	11.5	13	11	5	7	5	7	5	5	5	5	224	2-6	2-5	10-9	3-4	2-2	3.904	808		3.09	4.00	3.92	3.08
		12-3	33-4	12 TO 14	12.5	14.5	10	5	5	5	5	5	5	5	5	224	2-6	2-4	10-10	3-6	2-3	4.012	675		1.68	2.17	2.10	1.50
		12-5	33-6	14 TO 16	13.5	15.5	10.5	5	7	5	7	5	5	5	5	224	2-6	2-4	10-11	3-7	2-4	4.295	812		1.59	2.06	1.99	1.41
		12-6	34-0	16 TO 22	14	16	12	6	7	6	7	5	5	6	6	224	2-10	2-8	11-0	2-4	2-5	4.630	914		1.40	1.82	1.75	1.24
12	6	8-1	39-6	< 2	15	10	10.5	6	7	6	7	5	5	5	5	216	3-9	2-4	7-0	3-1	1-11	3.826	905	4.722	1.03	1.33	1.14	1.15
		7-11.5	39-4	2 TO 4	12.5	11	10	6	7	6	7	5	5	5	5	203	2-6	2-4	6-10	3-2	2-0	3.594	881		1.34	1.74	1.46	1.55
		8-2	39-4	4 TO 8	13.5	12.5	10	5	7	5	7	5	5	5	5	216	2-6	2-4	6-11	3-7	2-5	3.897	818		1.10	1.42	1.27	1.36
		8-6.5	39-4	8 TO 10	14.5	16	10	5	7	5	7	5	5	5	5	216	3-3	2-4	7-0	3-7	2-5	4.443	823		2.22	2.88	2.82	3.06
		8-8	39-6	10 TO 12	16	16	10.5	6	5	6	5	5	5	5	5	216	3-3	2-4	7-2	2-4	2-3	4.679	735		3.48	4.51	4.97	5.27
		8-8	39-8	12 TO 16	16	16	11	6	5	6	5	5	5	5	5	216	3-3	2-5	7-2	3-7	2-5	4.733	745		2.48	3.22	3.40	3.59
		8-11	39-8	16 TO 18	17	18	11	6	5	6	5	5	5	5	5	216	3-3	2-4	7-3	3-9	2-7	5.100	748		2.09	2.71	2.79	2.86
	8	10-1.5	39-6	< 2	15	10.5	10.5	6	7	6	7	5	5	6	6	232	3-9	2-8	9-0	3-5	1-11	4.146	984	4.722	1.07	1.39	1.19	1.20
		9-11.5	39-4	2 TO 4	12.5	11	10	6	7	6	7	5	5	5	5	232	2-6	2-4	8-10	3-2	2-0	3.841	923		1.31	1.70	1.44	1.52
		10-2.5	39-4	4 TO 8	13.5	13	10	5	5	5	5	5	5	5	5	232	2-6	2-4	8-11	2-4	2-2	4.205	695		1.15	1.50	1.34	1.43
		10-9.5	39-8	8 TO 12	16	17.5	11	5	5	5	5	5	5	5	5	232	3-3	2-5	9-2	3-9	2-6	5.188	716		2.51	3.26	2.93	3.11
		10-11	39-8	12 TO 18	17	18	11	6	5	6	5	5	5	5	5	232	3-3	2-5	9-3	3-9	2-7	5.371	790		1.98	2.57	2.63	2.71
	10	12-3	39-6	< 2	16	11	10.5	6	7	6	7	5	5	6	6	248	4-4	2-8	11-1	2-8	2-0	4.588	1030	4.722	1.11	1.44	1.23	1.24
		11-11.5	39-4	2 TO 4	12.5	11	10	6	7	6	7	5	5	5	5	248	2-6	2-4	10-10	3-2	2-0	4.087	964		1.30	1.69	1.43	1.50
		12-4.5	39-4	4 TO 8	13.5	15	10	5	5	5	5	5	5	5	5	248	2-6	2-4	10-11	2-4	2-4	4.694	739		1.60	2.07	2.17	2.61
		12-9.5	39-8	8 TO 12	16	17.5	11	5	5	5	5	5	5	5	5	248	3-3	2-5	11-2	3-9	2-6	5.459	757		2.57	3.34	3.00	3.06
		12-11	39-8	12 TO 18	17	18	11	6	5	6	5	5	5	5	5	248	3-3	2-5	11-3	3-9	2-7	5.643	832		1.36	1.77	1.70	1.21
14	6	8-3	45-6	< 2	16	11	10.5	7	8	7	8	5	5	5	5	240	3-9	2-4	7-1	3-2	2-0	4.569	1243	5.389	1.00	1.30	1.10	1.12
		8-1	45-4	2 TO 4	13	12	10	7	8	7	8	5	5	5	5	240	2-6	2-4	6-11	3-3	2-1	4.239	1196		1.31	1.69	1.67	1.69
		8-2	45-4	4 TO 8	13	13	10	7	8	7	8	5	5	5	5	240	2-6	2-4	6-11	2-4	2-2	4.379	1193		1.98	2.57	2.82	2.90
		8-5	45-8	8 TO 12	14	15	11	7	8	7	8	5	5	6	6	240	2-10	2-9	7-0	3-10	2-4	4.902	1242		3.51	4.54	3.93	4.17
	8	10-3.5	45-6	< 2	16	11.5	10.5	7	8	7	8	5	5	5	5	256	3-9	2-4	9-1	3-2	2-0	4.899	1284	5.389	1.04	1.35	1.14	1.16
		10-1	45-4	2 TO 4	13	12	10	7	8	7	8	5	5	5	5	256	2-6	2-4	8-11	3-3	2-1	4.486	1237		1.43	1.86	1.63	1.65
		10-2	45-4	4 TO 8	13	13	10	7	8	7	8	5	5	5	5	256	2-6	2-4	8-11	3-4	2-2	4.626	1238		2.10	2.73	2.76	2.84
		10-5	46-0	8 TO 12	14	15	12	7	8	7	8	5	5	6	6	256	2-10	2-10	9-0	2-4	2-4	5.302	1285		3.52	4.56	3.95	4.19
	10	12-4.5	45-6	< 2	16.5	12	10.5	7	8	7	8	5	5	5	5	272	3-9	2-4	11-2	3-2	2-1	5.299	1328	5.389	1.07	1.39	1.18	1.20
		12-1	45-4	2 TO 4	13	12	10	7	8	7	8	5	5	5	5	272	2-6	2-4	10-11	3-3	2-1	4.733	1278		1.41	1.83	1.61	1.62
		12-2	45-4	4 TO 8	13	13	10	7	8	7	8	5	5	5	5	272	2-6	2-4	10-11	3-4	2-2	4.872	1280		1.95	2.53	2.62	2.81
		12-5.5	46-0	8 TO 12	14	15.5	12	7	8	7	8	7	7	6	6	272	2-10	2-10	11-0	3-11	2-4	5.670	1561		3.77	4.89	4.56	3.99
16	6	8-5	51-6	< 2	16.5	12.5	10.5	7	8	7	8	5	5	6	6	264	4-4	2-8	7-2	2-4	2-1	5.387	1410	6.056	1.07	1.39	1.13	1.18
		8-1.5	51-4	2 TO 4	13	12.5	10	7	8	7	8	5	5	6	6	264	2-10	2-8	6-11	3-8	2-1	4.781	1359		1.25	1.62	1.31	1.37
		8-2	51-4	4 TO 6	13	13	10	7	8	7	8	5	5	6	6	264	2-10	2-10	6-11	3-8	2-2	4.860	1361		1.64	2.13	1.75	1.77
		8-3.5	51-4	6 TO 8	13.5	14	10	7	8	7	8	5	5	6	6	264	2-10	2-8	6-11	3-9	2-3	5.098	1361		1.75	2.27	1.87	1.92
		8-6	51-8	8 TO 10	14.5	15.5	11	7	8	7	8	5	5	6	6	264	3-8	2-9	7-0	3-11	2-4	5.599	1377		2.06	2.68	2.21	2.28
	8	10-5	51-6	< 2	16.5	12.5	10.5	7	8	7	8	5	5	6	6	280	4-4	2-8	9-2	2-4	2-1	5.647	1455	6.056	1.02	1.33	1.08	1.13
		10-3	51-4	2 TO 4	14	13	10	7	8	7	8	5	5	6	6	280	2-10	2-8	9-0	3-8	2-2	5.265	1406		1.31	1.70	1.38	1.44
		10-3	51-4	4 TO 6	14	13	10	7	8	7	8	5	5	6	6	280	2-10	2-8	9-0	3-8	2-2	5.265	1406		1.57	2.03	1.67	1.70
		10-4.5	51-4	6 TO 8	14	14.5	10	7	8	7	8	5	5	6	6	280	2-10	2-8	9-0	3-10	2-4	5.503	1410		2.01	2.61	2.15	2.21
		10-6.5	51-8	8 TO 10	15	15.5	11	7	8	7	8	6	6	6	6	280	3-8	2-9	9-1	3-11	2-4	5.950	1519		1.99	2.58	2.13	2.21
	10	12-6	51-6	< 2	17	13	10.5	7	8	7	8	5	5	6	6	296	4-4	2-8	11-2	2-4	2-1	6.065	1500	6.056	1.06	1.37	1.12	1.16
		12-3	51-4	2 TO 4	14	13	10	7	8	7	8	5	5	6	6	296	2-10	2-8	11-0	3-8	2-2	5.512	1452		1.30	1.68	1.36	1.43
		12-3	51-4	4 TO 6	14	13	10	7	8	7	8	5	5	6	6	296	2-10	2-8	11-0	3-8	2-2	5.512	1452		1.54	2.00	1.64	1.68
		12-5	51-4	6 TO 8	14	15	10	7	8	7	8	5	5	6	6	296	2-10	2-8	11-0	3-10	2-4	5.829	1455		2.24	2.91	2.50	2.57
		12-7	51-8	8 TO 10	15	16	11	7	8	7	8	5	5	6	6	296	3-8	2-9	11-1	3-11	2-5	6.301	1469		2.35	3.05	2.52	2.61
18	6	8-6.5	57-6	< 2	17	13.5	10.5	7	8	7	8	5	5	7	7	288	5-0	3-1	7-2	2-4	2-1	6.191	1589	6.722	1.07	1.39	1.09	1.16
		8-5	57-4	2 TO 4	15	14	10	7	8	7	8	5	5	6	6	288	3-8	2-8	7-1	3-9	2-3	5.872	1499		1.15	1.50	1.15	1.25
		8-6.5	57-8	4 TO 6	15.5	15	11	7	8	7	8	5	5	6	6	288	3-8	2-9	7-1	3-10	2-4	6.243	1507		1.50	1.94	1.52	1.57
		8-9	57-8	6 TO 8	16	17	11	7	8	7	8	5	5	6	6	288	3-8	2-9	7-2	4-0	2-6	6.688	1512		1.91	2.48	1.98	2.04
	8	10-6.5	57-6	< 2	17	13.5	10.5	7	8	7	8	5	5	7	7	304	5-0	3-1	9-2	4-1	2-1	6.450	1653	6.722	1.02	1.33	1.05	1.11
		10-5	57-4	2 TO 4	15	14	10	7	8	7	8	5	5	6	6	304	3-8	2-8	9-1	2-4	2-3	6.119	1535		1.13	1.46	1.13	1.22
		10-6.5	57-8	4 TO 6	15.5	15	11	7	8	7	8	5	5	6	6	304	3-8	2-9	9-1	3-10	2-4	6.515	1552		1.44	1.87	1.47	1.52
		10-9	57-8	6 TO 8	16	17	11	7	8	7	8	5	5	6	6	304	3-8	2-9	9-2	4-0	2-6	6.960	1557		1.88	2.44	1.93	1.99
	10	12-7	57-6	< 2	17	14	10.5	7	8	7	8	5	5	7	7	320	5-0	3-1	11-2	4-1	2-2	6.798	1703	6.722	1.06	1.38	1.08	1.15
		12-5	57-4	2 TO 4	15	14	10	7	8	7	8	5	5	6	6	320	3-8	2-8	11-1	3-9	2-3	6.366	1589		1.11	1.44	1.11	1.20
		12-6.5	57-8	4 TO 6	15.5	15	11	7	8	7	8	5	5	6	6	320	3-8	2-9	11-1	2-4	2-4	6.787	1588		1.41	1.83	1.43	1.49
		12-9	57-8	6 TO 8	16	17	11	7	8	7	8	5	5	6	6	320	3-8	2-9	11-2	4-0	2-6	7.231	1602		1.85	2.40	1.90	1.97
20	6	8-8	63-8	< 2	18	14	11	8	9	8	9	6	6	7	7	312	5-0	3-2	7-3	4-2	2-6	7.103	2195	7.407	1.00	1.30	1.00	1.07
		8-8	63-8	2 TO 4	16	16	11	7	8	7	8	5	5	6	6	312	3-8	2-9	7-2	3-11	2-5	7.103	1639		1.14	1.47	1.13	1.25
		8-8	63-8	4 TO 6	16	16	11	8	8	8	8	5	5	6	6	312	3-8	2-9	7-2	3-11	2-5	7.103	1798		1.61	2.09	2.00	2.27
	8	10-8.5	63-8	< 2	18	14.5	11	8	9	8	9	6	6	7	7	328	5-0	3-2	9-3	2-4	2-6	7.473	2259	7.407	1.02	1.33	1.02	1.09
		10-8	63-8	2 TO 4	16	16	11	7	8	7	8	5	5	6	6	328	3-8	2-9	9-2	3-11	2-5	7.374	1684		1.14	1.48	1.10	1.22
		10-8	63-8	4 TO 6	16	16	11	8	8	8	8	5	5	6	6	328	3-8	2-9	9-2	3-11	2-5	7.374	1843		1.83	2.38	2.08	2.21
	10	12-9	63-8	< 2	18	15	11	8	9	8	9	6	6	7	7	344	5-0	3-2	11-3	4-3	2-6	7.843	2335	7.407	1.06	1.37	1.05	1.13
		12-8	63-8	2 TO 4	16	16	11	7	8	7	8	5	5	6	6	344	3-8	2-9	11-2	3-11	2-5	7.646	1729		1.12	1.46	1.09	1.20
		12-8	63-8	4 TO 6	16	16	11	8	8	8	8	5	5	6	6	344	3-8	2-9	11-2	2-4	2-5	7.646	1878		1.87	2.43	2.05	2.18

HEADWALL AND TOEWALL QUANTITIES

HEADWALL BENT ANGLE	90° TO 75°			74° TO 60°			59° TO 45°		
CLEAR SPAN (S)	Z	STIRRUPS	REBAR QUANT.	Z	STIRRUPS	REBAR QUANT.	Z	STIRRUPS	REBAR QUANT.
	#	#	LBS/LF	#	#	LBS/LF	#	#	LBS/LF
8	4	4	19.2	5	4	23.5	7	4	34.4
10	5	4	23.9	6	4	28.7	9	4■	54.0
12	6	4	28.7	6	4	28.2	9	5■	59.2
14	6	4	27.9	7	4	33.5	★	★	★
16	6	4	27.5	8	5	44.1	★	★	★
18	7	4	33.0	9	5	51.8	★	★	★
20	7	4	32.8	★	★	★	★	★	★
CONCRETE QUANTITY = 0.086 CY/LF									

NOTES

■ 1. SIX INCH SPACING AT EACH END OF THE SPAN FOR A DISTANCE OF 1/4 OF THE SPAN LENGTH; 12 INCH SPACING ELSEWHERE.

2. QUANTITIES ARE GIVEN FOR ONE HEADWALL AND ONE TOEWALL AND ARE BASED ON PER LINEAR FOOT OF HEADWALL. STEEL QUANTITIES INCLUDE ALL REINFORCING. QUANTITIES SHALL BE PAID FOR AS SHOWN ON THE PLANS.

★ 3. SKEWED HEADWALLS ARE NOT RECOMMENDED FOR THESE SPANS. A SPECIAL DESIGN IS REQUIRED.

4. FOR HEADWALL AND TOEWALL DETAILS SEE M-601-3, SHEET 1 OF 2.

5. WHEN THE FILL HEIGHTS ARE LESS THAN OR EQUAL TO 2 FT, ALL REINFORCING BARS IN THE HEADWALL, ALL REINFORCING BARS DESIGNATED BY AN ASTERISK (*), AND THE d_1 BARS IN THE TOP MAT OF THE TOP SLAB SHALL BE EPOXY COATED.

6. REINFORCING QUANTITIES INCLUDE BOTH EPOXY-COATED AND UNCOATED BARS.

7. WHEN A (RISE) R OF LESS THAN 6 FT IS REQUIRED, USE THE BAR SIZES AND THE SLAB AND WALL THICKNESSES FOR THE 6 FT RISE (IF AVAILABLE ON THE TABLE).

▲ 8. FOR SIZE AND SPACING OF THE BOTTOM MAT BARS IN THE TOP SLAB SEE TABLE ON M-601-3, SHEET 1 OF 2. ALL OTHER d_1 BARS ARE #4's AT 1'-0" SPACING. THE NUMBER OF BARS REQUIRED IS LISTED ON THIS SHEET AND INCLUDES BOTH #4 BARS AND THOSE FROM THE TABLE.

◆ 9. LIVE LOAD IS NEGLECTED AS PER AASHTO LRFD SECTION 3.6.1.2.6. FOR THESE STRUCTURES REFER TO THE CDOT RATING MANUAL.

10. FOR ALL NEW CULVERT DESIGNS, A RATING IS REQUIRED. THE RATING SUMMARY SHEET SHOULD BE PRINTED FROM THE CDOT EXTERNAL WEBSITE AND SUBMITTED TO THE BRIDGE RATING UNIT OR INCLUDED AS PART OF A LARGER DESIGN PACKAGE. FOR ADDITIONAL INFORMATION, SEE THE CDOT RATING MANUAL.

Computer File Information	
Creation Date: 07/04/12	Initials: JBE
Last Modification Date: 11/25/15	Initials: JBE
Full Path: www.codot.gov/business/designsupport	
Drawing File Name: 601030202.dgn	
CAD Ver.: MicroStation V8 Scale: Not to Scale Units: English	

	Sheet Revisions	
	Date:	Comments
(R-1)	08/27/13	LRFD Design
(R-2)	08/01/15	Analysis Program Updates

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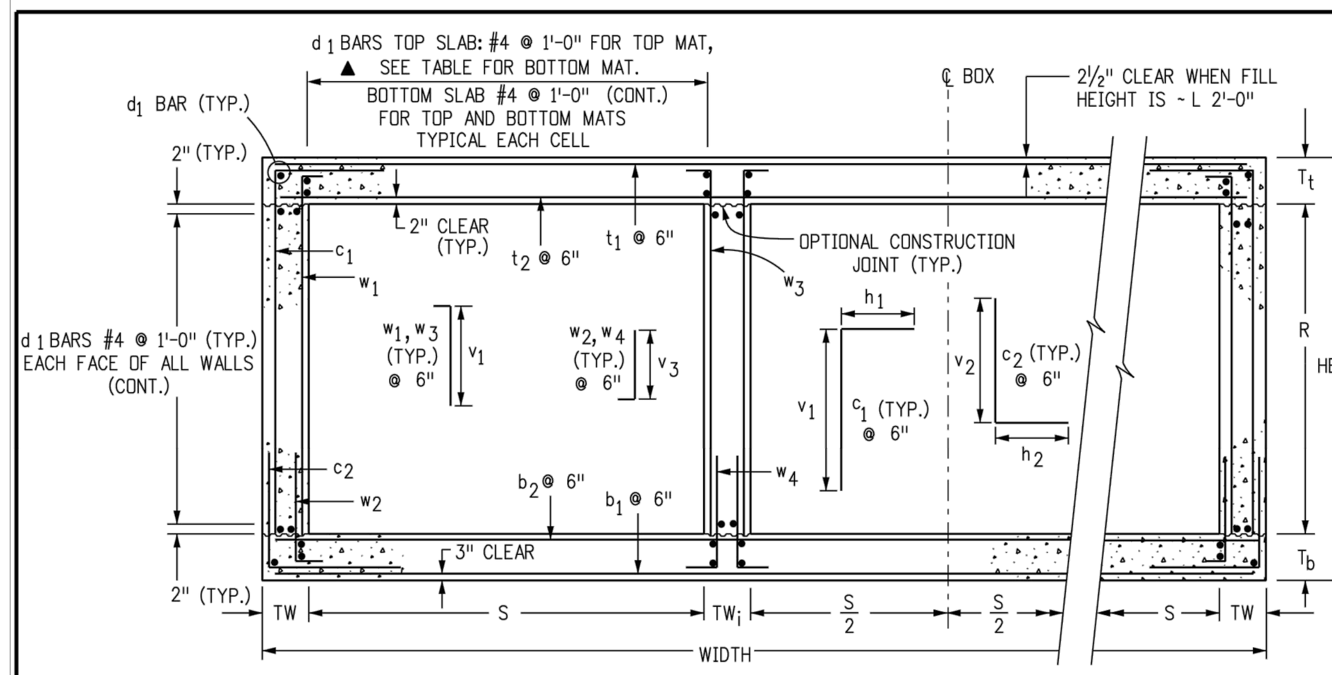
Division of Project Support DDG/Bridge

TRIPLE CONCRETE BOX CULVERT

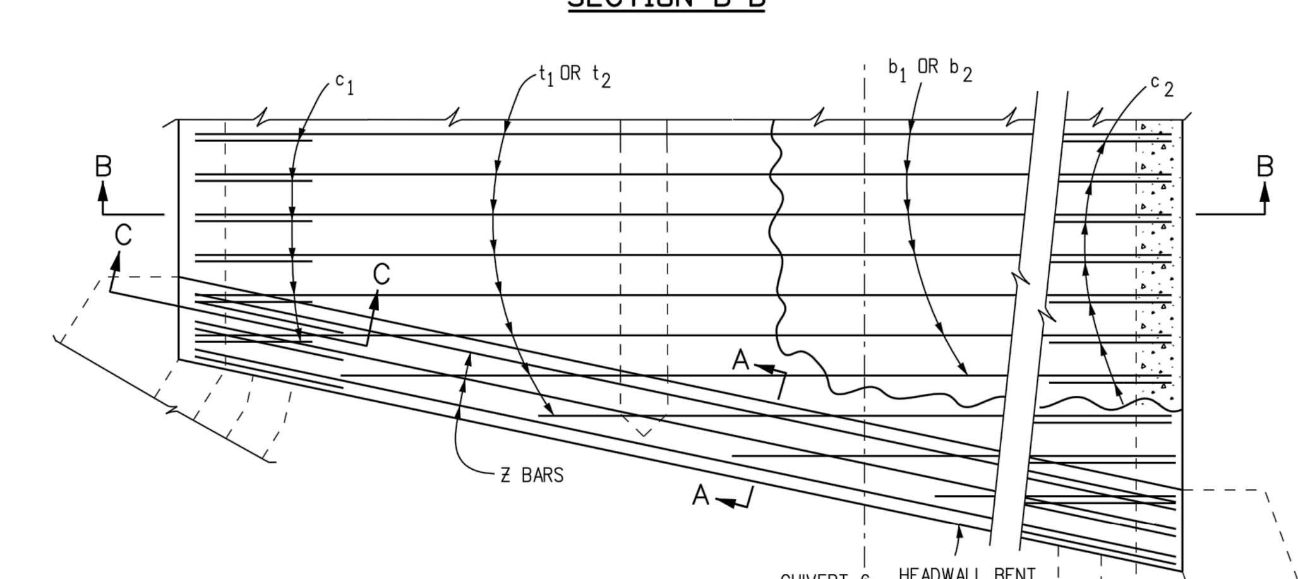
Issued By: Project Development Branch July 4, 2012

STANDARD PLAN NO. M-601-3

Sheet No. 2 of 2

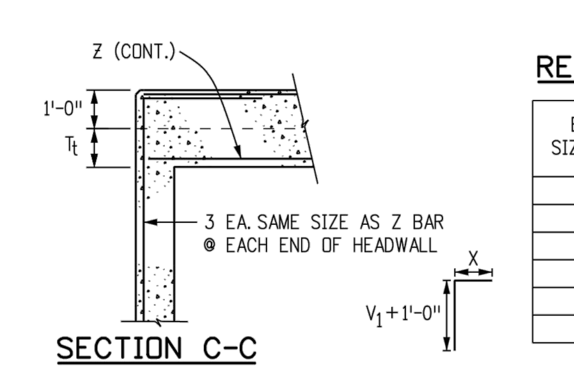


SECTION B-B



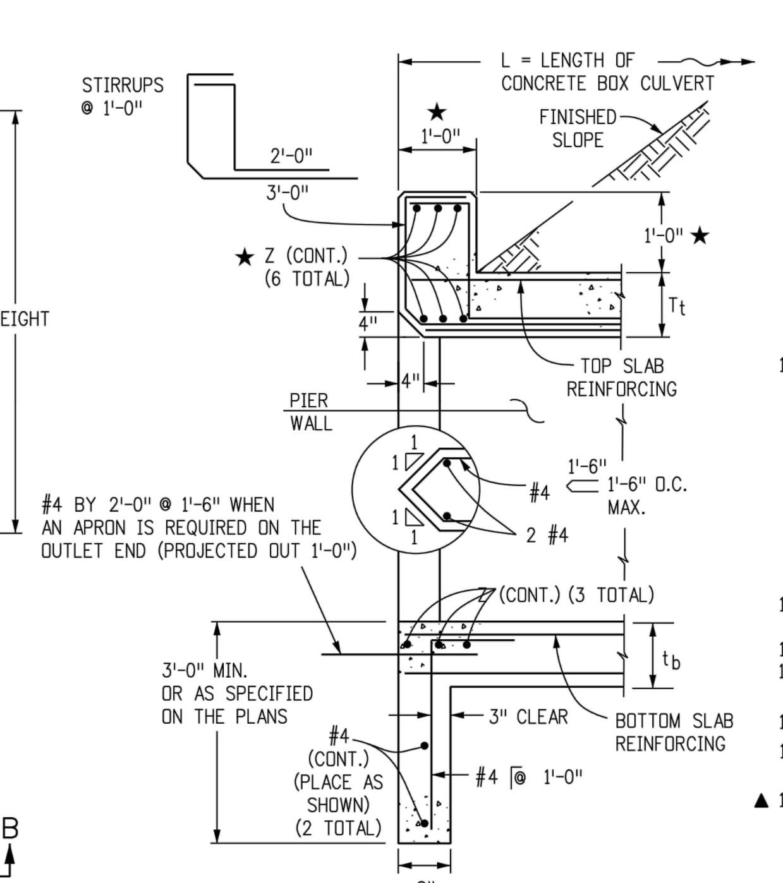
REINFORCING PLAN

BAR SIZE (#)	EPOXY X (FT.-IN.)	BLACK X (FT.-IN.)
4	2-4	1-11
5	2-10	2-4
6	3-5	2-10
7	4-1	3-3
8	5-3	4-3
9	6-8	5-5

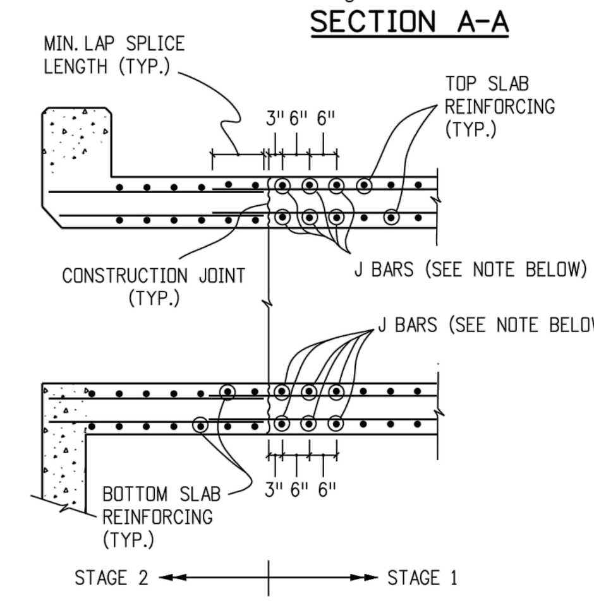


SECTION C-C

HEADWALL CORNER REINFORCING DETAIL



SECTION A-A



NOT TO SCALE

CONSTRUCTION JOINT DETAIL FOR STAGED CONSTRUCTION

NOTE: THIS DETAIL IS FOR CONSTRUCTION JOINTS INSTALLED PERPENDICULAR TO THE ℄ OF THE BOX ONLY. THE CONTRACTOR CAN DESIGN AND INSTALL J BARS AT HIS EXPENSE TO SUPPORT TEMPORARY LIVE LOADS DURING STAGE 1 CONSTRUCTION. J BARS SHALL BE THE SAME SIZE AS THE TOP AND BOTTOM SLAB REINFORCING WHEN THERE ARE NO TEMPORARY LIVE LOADS TO SUPPORT.

GENERAL NOTES

1. ALL CONCRETE SHALL BE CLASS D (BOX CULVERT).
2. ALL CONSTRUCTION JOINTS SHALL BE THOROUGHLY CLEANED BEFORE FRESH CONCRETE IS PLACED.
3. ALL CONSTRUCTION JOINTS NOT SHOWN ON THE PLANS SHALL BE CONSTRUCTED ONLY IF APPROVED BY THE ENGINEER.
4. THE CONTRACTOR SHALL MAINTAIN THE STABILITY OF THE STRUCTURE DURING CONSTRUCTION.
5. STRUCTURE EXCAVATION AND BACKFILL SHALL BE IN ACCORDANCE WITH STANDARD PLAN M-206-1.
6. FOR ANY CULVERT SPAN 20 FT. OR GREATER, A FOUNDATION INVESTIGATION AND REPORT ARE REQUIRED.
7. BACKFILL SHALL NOT BEGIN UNTIL TOP SLAB HAS REACHED DESIGN STRENGTH, f'c.
8. SPLICE QUANTITIES FOR LONGITUDINAL AND TRANSVERSE BARS ARE NOT INCLUDED.
9. REINFORCING STEEL SHALL BE GRADE 60.
10. THE MINIMUM LAP SPLICE LENGTH FOR EPOXY COATED REINFORCING BARS SHALL BE:

BAR SIZE:	#4	#5	#6	#7	#8	#9	#10	#11
SPLICE LENGTH:	1'-3"	1'-7"	2'-5"	2'-10"	3'-8"	4'-8"	5'-11"	7'-3"

THE MINIMUM LAP SPLICE LENGTH FOR BLACK REINFORCING BARS SHALL BE:

BAR SIZE:	#4	#5	#6	#7	#8	#9	#10	#11
SPLICE LENGTH:	1'-1"	1'-4"	1'-7"	1'-11"	2'-6"	3'-1"	3'-11"	4'-10"

THE ABOVE SPLICE LENGTHS ARE FOR CLASS B SPLICES.

11. ALL DIMENSIONS ARE PERPENDICULAR TO THE CENTERLINE OF THE BOX.
12. WINGWALLS SHALL BE TIED TO CONCRETE BOX CULVERT IN ACCORDANCE WITH STANDARD PLAN M-601-20.
13. ALL TRANSVERSE REINFORCING SHALL BE NORMAL TO THE CENTERLINE OF THE BOX.
14. THE FILL HEIGHT IS THE DISTANCE MEASURED FROM THE TOP OF THE TOP SLAB TO THE TOP OF PAVEMENT.
15. ALL EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED ¾ IN.
16. FOR FILL HIEGHTS LESS THAN 2 FT, A WATERPROOFING MEMBRANE SHALL BE PROVIDED FOR THE TOP OF THE TOP SLAB AND 18" DOWN ALONG THE TOPS OF THE EXTERIOR WALLS.

▲ 17. FOR FILL HIEGHTS LESS THAN 2 FT. THE d_1 BARS FOR THE BOTTOM MAT OF THE TOP SLAB SHALL BE AS FOLLOWS:

S	8, 9, 10	14, 16, 18	20
BAR SIZE:	#5	#6	#7
SPACING	1'-0"	1'-0"	1'-0"

DESIGN DATA: 7TH EDITION, 2014, OF THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS

RATING DATA: 2ND EDITION, 2011, OF THE AASHTO MANUAL FOR BRIDGE EVALUATION

LOADING DATA: f_y = 60,000 psi., f'_c = 4,500 psi.,

LIVE LOAD = AASHTO LRFD, HL-93 TRUCK, HL-93 TANDEM, COLORADO PERMIT TRUCK AND NRL

DEAD LOAD CASE 1: VERTICAL EARTH LOAD = 120 LBS./CU. FT. HORIZONTAL EARTH LOAD = 30 LBS./CU.FT.

DEAD LOAD CASE 2: VERTICAL EARTH LOAD = 120 LBS./CU. FT. HORIZONTAL EARTH LOAD = 60 LBS./CU. FT.

WEARING SURFACE - 12 IN. THICK CONCRETE PAVEMENT.
DEAD LOAD - TYPE 7 BARRIER.
THRUST IS NOT CONSIDERED IN THIS STANDARD, I.E. THRUST = 0.
EXTREME HEADWATER TO DEPTH RATIO IS IN ACCORDANCE WITH THE CDOT DRAINAGE MANUAL.
EXTREME HEADWATER TO DEPTH RATIO WAS INCLUDED IN THE CULVERT DESIGNS BUT EXCLUDED FROM THE RATINGS AS PER THE AASHTO MANUAL FOR BRIDGE EVALUATION.
LIVE LOAD SURCHARGE ON EXTERIOR WALLS = 2 FT. OF EARTH

★ IF HEADWALL MOUNT GUARDRAIL IS USED (SEE STANDARD PLAN M-606-1, SHEET 19 AND NOTES BELOW):
- ALL REINFORCING STEEL SHALL BE ACCORDING TO THIS BOX CULVERT PLAN.
- ANY SPECIAL DESIGN FOR STIRRUPS WILL NOT BE MEASURED AND PAID FOR SEPARATELY BUT SHALL BE INCLUDED IN THE WORK.
- HEADWALL DIMENSION AND CONCRETE QUANTITY SHALL BE ACCORDING TO STANDARD PLAN M-606-1, SHEET 19.
- POST ANCHORS SHALL BE PROVIDED ACCORDING TO STANDARD PLAN M-606-1, SHEET 19.
- POST ANCHORS AND CONCRETE FOR HEADWALL MOUNT OF GUARDRAIL WILL NOT BE MEASURED AND PAID FOR SEPARATELY BUT SHALL BE INCLUDED IN THE WORK.
- POST ANCHORS WHEN REQUIRED AND ENCASED IN HEADWALL CONCRETE, SHALL CONFORM TO ASTM A 36 OR AASHTO M 169 STEEL.

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(R-2)	08/01/15	Analysis Program Updates

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TRIPLE CONCRETE BOX CULVERT

Issued By: Project Development Branch July 4, 2012

STANDARD PLAN NO. M-601-3

Sheet No. 1 of 2

REVISIONS		
NO.	DESCRIPTION	DATE

UNTIL SUCH TIME AS THESE DRAWINGS ARE APPROVED BY THE APPROPRIATE REVIEWING AGENCIES, TERRA NOVA ENGINEERING, INC. APPROVES THEIR USE ONLY FOR THE PURPOSES DESIGNATED BY WRITTEN AUTHORIZATION.

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STREET IMPROVEMENT PLAN
DETAILS SHEET

DESIGNED BY LD
DRAWN BY DLF
CHECKED BY LD

H-SCALE 1"=100'
V-SCALE NA

JOB NO. 1733.00
DATE ISSUED 06/03/19