APPENDIX G

BAFFLE SAMPLE CALCULATIONS AND STRUCTURAL DETAILS

G.1 Concrete Baffle Sample Calculations

Job No.	No.

Project	Computed KD	Date 06/01/06
Subject	Checked	Date
Task Concrete Baffle Design	Sheet	Of

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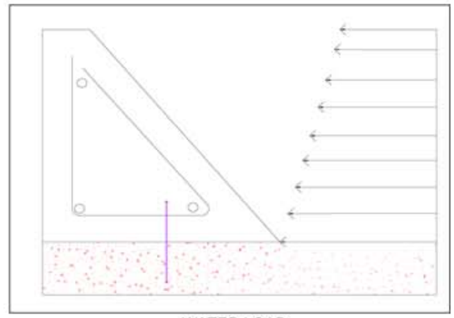
CONCRETE BAFFLE DESIGN

Assume Baffle is 5' Below WSE and 2.0' in Height
Assume 1 Foot Section

Commentary:
The following highlighted terms are inputs determined in the fielc

f'c =	2500	psi
fy =	60000	psi
phi =	0.9	
Baffle Height	2	FT
Baffle Depth	0.4	FT
Assumed Baffle Section	1	FT
Water Density	62.4	LB/FT^3
Distance From WSE to Top of Baffle	5	FT
Load at Top of Baffle	312	LB/FT
Distance From WSE to Bot of Baffle	7.5	FT
Load at Bottom of Baffle	468	LB/FT
Water Velocity	5	FT/S
Gravity	32.2	(lbm*ft)/(lbf*sec^2)



WATER LOAD

Reference: USACE EC 1110-2-6058, Stability Analysis of Concrete Structures

Assumptions: Use Westergaard equation (1933) to estimate hydrodynamic earthquake loading in stilling basin

Resultant Hydrodynamic Force P_E acts $0.4h_w$ above bottom of basin

=> See Figures 4-3 for wall geometry, pressures and forces

Equation for Hydrodynamic Force due to water above ground level (p. 4-5)

$P_E = (7/12)\ k_h\ _w\ h_w^2$

Where -
P_E = Hydrodynamic force per unit length
$_w$ = Unit weight of water
k_h = Horizontal seismic coefficient
h_w = Depth of water in basin

Earthquake Loading -
k_h = 0.07 g

Water Surface:
h_w = 7.5 ft.
$_w$= 62.4 cfs

Results -

Hydrodynamic Resultant -

			Location of Point Load (distance from base of wall) -		Moment (M_h) (kip-ft)
P_E =	**137**	lbs	@	3 ft	-0.41
H=	137	lbs			-0.41

Pressure at bottom of basin -

p_E = **27.3** psf

Hydrodynamic Force Due to Velocity of Water -

$$F \quad A\,v^2$$

			Location of Point Load (distance from base of wall) -		Moment (M_v) (kip-ft)
P_E =	**97**	lbs	@	1 ft	-0.10
H=	97	lbs			-0.10

Commentary:
Hydrodynamic Force Due to Water Velocity can usually be ignored, due to the magnitude compared to the hydrostatic force.

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Maximum Moment From Uniform Load = $M_{un} \quad \frac{wl^2}{2}$ 624 lb-ft

Maximum Moment From Triangular Load = $M_T \quad \frac{wl}{3}$ 104 lb-ft

Service Dead Load Factor 1.2
Combined Service Moment ($Mv+M_h + M_T + M_{un}$) 1481 LB-FT

Cover = 3 INCHES
d (Depth - Cover) = 1.8 INCHES
jd (0.875*d) = 1.575 INCHES

Determine Area of Required Steel $A_S \quad \frac{M_U}{f_Y jd}$ 0.21 in^2

Check Minimum Reinforcement (UBC-97 SEC. 1910.5.1) $A_{SMin} \quad \frac{3\sqrt{f'c}}{f_Y} b_w d$ 0.05 in^2

$A_{SMin} \quad \frac{200}{f_Y} b_w d$ 0.072 in^2

Use 0.21 in^2

2 - #4 Bars Adequate As = 0.40 in^2

Commentary:
1 - #4 Bar is adequate, an additional safety factor of 2 was used in order to account for any field uncertainties (i.e. excessive debris). Therefore, 2 - #4 bars are appropriate.

Check Shear

Phi 0.85
Service Dead Load Factor = 1.2
Maximum Shear From Uniform Load (WL)= 624 LB

Maximum Shear From Triangular Load (W) = 156 LB

Maximum Shear From Dynamic Load (Wh) = 137 LB

Maximum Shear From Water Velocity (Wv) = 97 LB

Total Shear = 1216.0733 LB

Shear Capacity (UBC-97 SEC 1911.3.1.1) $V_u \quad 2 \sqrt{f'c} db$ 1836.00 LB

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Concrete Strength Adequate for Shear
USE #4 STIRRUP AT 12" OC TO BE CONSERVATIVE

Commentary:
ACI equations show that concrete strength is adequate for the applied shear forces. In order to account for any field uncertainties (i.e. excessive debris) stirrups can be placed at 12, 18, or 24 inches o.c.

ANCHORAGE TO CONCRETE: ANCHOR BOLT DESIGN (UBC - SECTION 1923)

Note: Blue numbers are input.

f_{ut} = 60,000	psi	Min specified tensile strength of anchor, Assume 60ksi for A307 bolts or A108 stud
d_b = 0.50	in	
A_b = 0.20	in^2	
No. of Bolts = 1		
Bolt Pattern = 1	x2	
L_{emb} = 4.5	in	Embeded length of anchors
L= 24	in	Distance between anchor bolts

Commentary:
Based upon above loads, the loading on the bolt is minimal, and the diameter of the bolt can be small. The controlling factor, as can be seen from the table below, will be the concrete strength.

A_p= 90.0	in^2	Effective area of the projection of an assumed concrete failure surface, $2L>L_{emb}$. For $2L<L_{emb}$, need input.
(Shear)= 0.65		Strength reduction factor
f'c= 2500	psi	
= 1	Normal weight concrete,0.75 for all lightweight conc., 0.85 for sand-lightweight conc.	
d_e = 2	in	Edge distance from the anchor axis to the free edge
Load Factor: 1.4	DL	See 1909.2 for details
1.7	LL	
Multiplier= 2	2, if special inspection is not provided, 1.3 if it is provided	
Multiplier= 3	Anchors are embedded in tension zone of a member, 3 if special inspection is not provided, 2 if it is provided	
NT	T,Anchors are embedded in tension zone of a member;NT, not in tension zone	
L	G,Edge distance is greater than 10 diameters;L,less than 10 diameters away	

P_{DL}= 2432.147	lb	P_{LL}= 0	lb/bolt	Pu= 6810	lb
e= 0.5	in	Mu= 3405.0052	lb-in		
Pu= 6810	lb/bolt	Vu= 142	lb/bolt		

Design strength in tension: (Min of the following)

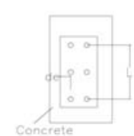
$P_{ss} \quad 0.9A_b f_{ut}$ $\qquad$ $P_c \quad 4A_p\sqrt{f'_c}$

Design strength in shear: (Min of the following)

$V_{ss} \quad 0.75A_b f_{ut}$

$Vc \quad 800A_b \sqrt{f'_c}$ Where loaded toward an edge greater than 10 diameters away

$V_c \quad 2 \; e^2 \sqrt{f'_c}$ Where loaded toward an edge less than 10 diameters away



Bolt		BOLT STRENGTH		CONCRETE STRENGTH			
Diam. (in.)	Area (in^2)	Tension	Shear	Tension		Shear	
d_b	A_b	Pss (lb)	Vss (lb)	Pc (lb)	Pc (lb)	Vc (lb)	Vc (lb)
1/2	0.20	10603	8836	11696	17994	817	1257
3/4	0.44	23856	19880	11696	17994	817	1257
1	0.79	42412	35343	11696	17994	817	1257
1 1/4	1.23	66268	55223	11696	17994	817	1257
1 1/2	1.77	95426	79522	11696	17994	817	1257
1 3/4	2.41	129885	108238	11696	17994	817	1257
2	3.14	169646	141372	11696	17994	817	1257

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COMBINED TENSION AND SHEAR (UBC-97 SEC. 1925.3.4)

$\frac{Pu}{Pc}$ = 0.58 **< 1.0, OK!**

$\frac{Vu}{Vc}$ = 0.17 **< 1.0, OK!**

$\frac{1}{[(Pu/Pc)^{(5/3)} + (Vu/Vc)^{(5/3)}]}$ = 0.35 **< 1.0, OK!**

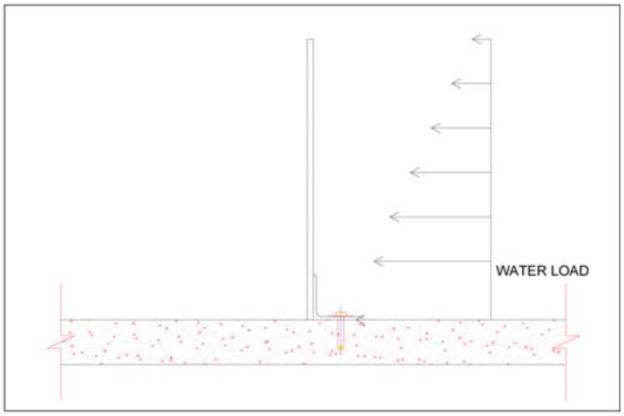
$[(Pu/Pss)^2 + (Vu/Vss)^2]$ = 0.41 **< 1.0, OK!**

ANCHOR BOLTS AT 24" OC OK, USE 1/2" DIAMETER ANCHOR BOLTS AT 18" OC WITH A 4.5" EMBEDMENT TO BE CONSERVATIVE

Commentary:
UBC equations show that anchor bolts at 24" OC with a 4.5" embedment are adequate. A spacing of 18" OC is used for field uncertainties. Embedment should be determined based upon culvert wall thickness. If adequate thickness is not available, a concrete slurry should be prepared so an adequate embedment can be achieved. A minimum embedment according to UBC of 2.5 inches can be used and checked, to be conservative a 4.5 inch embed was used.

G.2 Metal Baffle Sample Calculations

Metal Baffle Design



Forces Acting on Angle and Weld

Shear Force Pu =	6810	lb
Moment =	3405.005	lb-in

Commentary:
Forces come from previous page.

Determine Length of Required Weld

Throad of Weld W =	3/16	in
Electrode =	E70XX	
Fw =	31.5	ksi

Weld Strength = $0.707 * W * F_w$ 4.18 k/in

Total Required Length = 1.63 inches

Try 4x4x1/4 Angle Welded on all Edges to Baffle

Commentary:
The length of weld will not govern the size of the angle. The determining factor will be the size of the bolt being used along with the tearout. The angle needs to be large enough to support the bolt.

Check Connection Angle and Bolt Tearout

Diameter of Bolt d =	0.5	in
Area of Bolt Ab =	0.20	sq in
Hole Diameter =	0.625	in
Gross Area of Angle Ag =	1.94	sq in
Thickness of Angle t =	0.25	in
Edge Distance D =	1.75	in
Fy =	36	ksi
Fu =	58	ksi
Fv =	48	ksi
Phi (Shear) =	0.75	

Bolt Shear Capacity = $F_v A_b$ 7.07 kips > 6.81 kips **OK**
(AISC Table J3.2)

Phi (Bearing) =	0.75	
Dist from edge of hole to edge of angle Lc =	3.75	in
Angle Thickness t =	0.25	in

Tearout Capacity = $1.2 L_c t F_u$ 48.94 kips > 6.81 kips **OK**
(RCSC EQ LRFD 4.3)

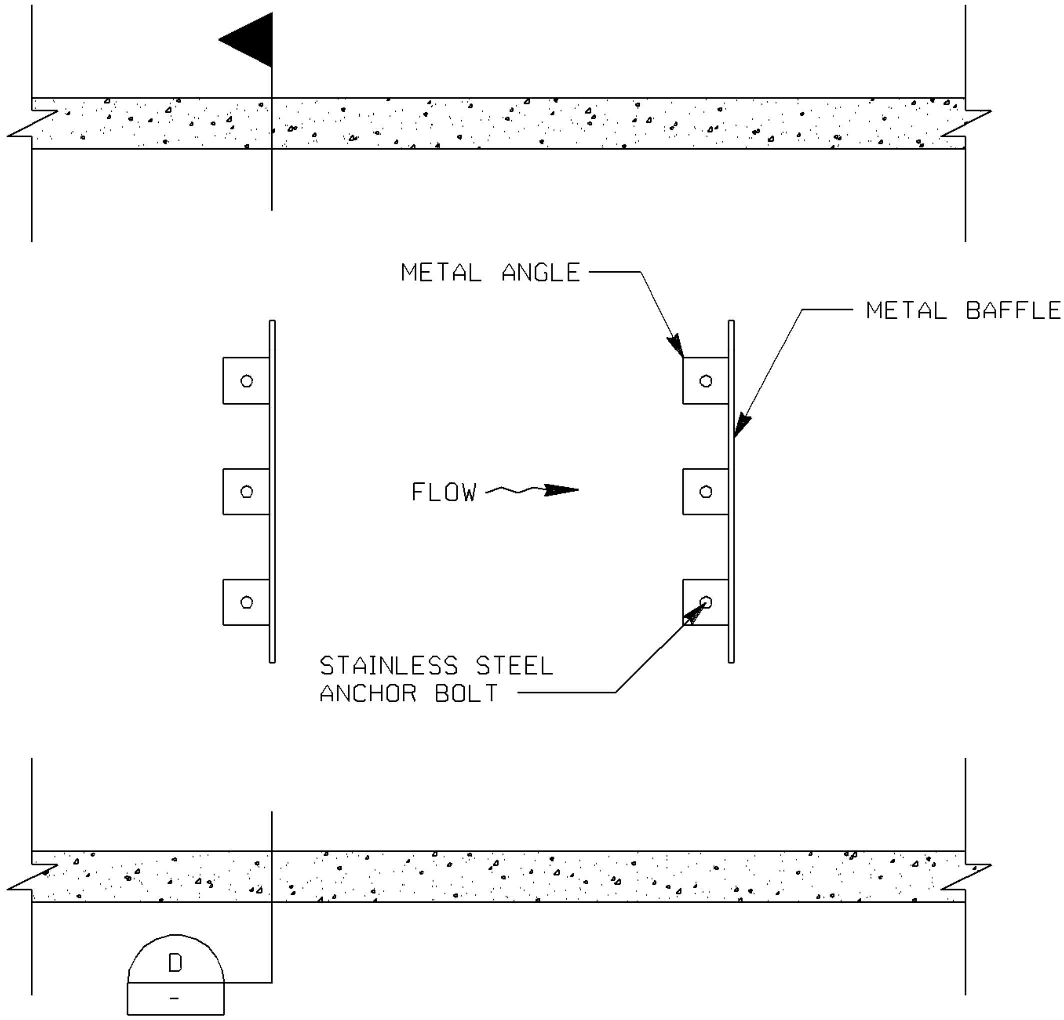
Tearout Capacity Max = $2.4 d t F_u$ 13.05 kips > 6.81 kips **OK**
(RCSC EQ LRFD 4.3)

Shear on Gross Area = 0.4Fy =	14.4 ksi		
Stress = Applied Load/Ag =	3.51 ksi <	14.4 ksi	**OK**
Shear on Net Area = 0.3Fu =	17.4 ksi		
Net Area = Ag - Hole Diameter =	1.63 sq in		
Stress = Applied Load/An =	4.17 ksi <	17.40 ksi	**OK**

Use 4x4x1/4 Angle with 1/2" Diameter Bolts Embedded 4-1/2"

Commentary:
Embedment was determined from the previous sheet. Above calculations show that a 1/2 inch bolt is sufficient.

G.3 Metal Baffle for Reinforced Concrete Circular Culverts (Details)



PLAN VIEW

NTS

NOTES: 1. NUMBER OF CONNECTION ANGELS AND THICKNESS OF BAFFLE TO BE DETERMINED BY ENGINEER BASED ON IMPOSED LOADS

NTS

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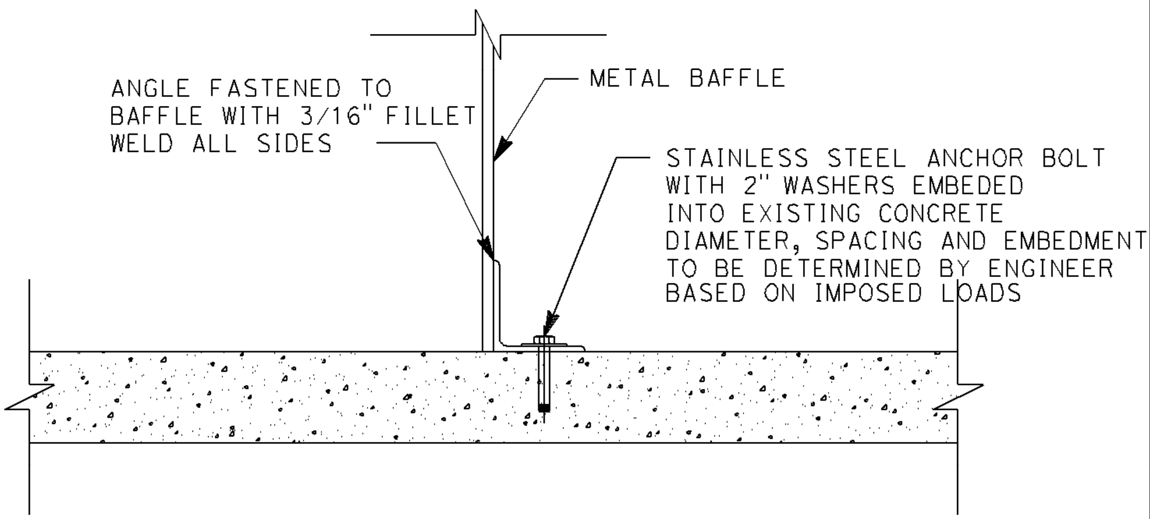
METAL BAFFLE FOR REINFORCED CONCRETE CIRCULAR CULVERTS

Date: 08/09

Sheet: 1



CONNECTION DETAIL

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C
-

NOTES: 1. SIZE OF THE ANGLE TO BE DETERMINED BY THE ENGINEER BASED ON IMPOSED LOADS

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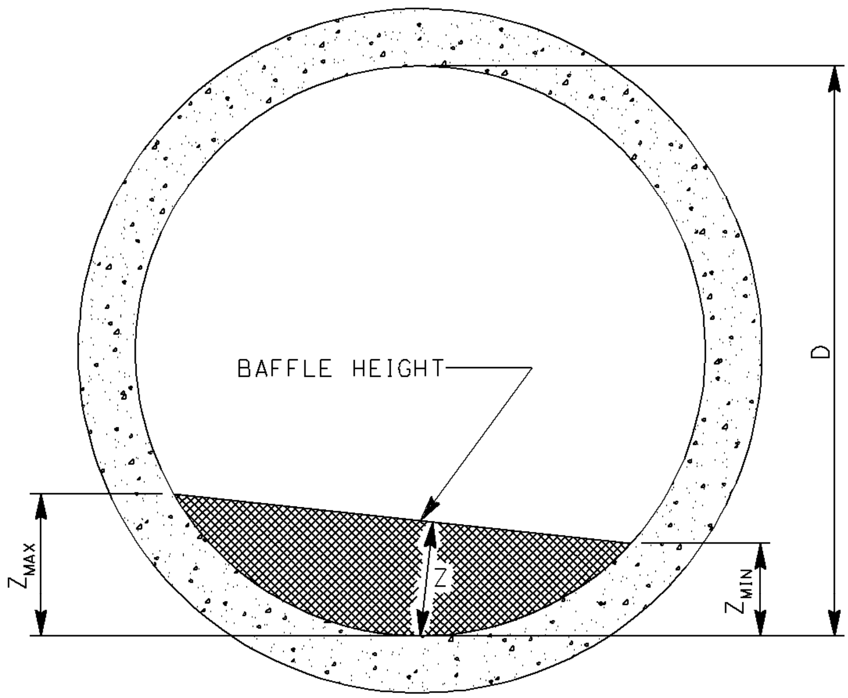
METAL BAFFLE FOR REINFORCED CONCRETE CIRCULAR CULVERTS

Date: 05/06
Sheet: 1



SECTION D

NTS

NOTES: 1. SEE DETAIL C FOR CONNECTION DETAILS

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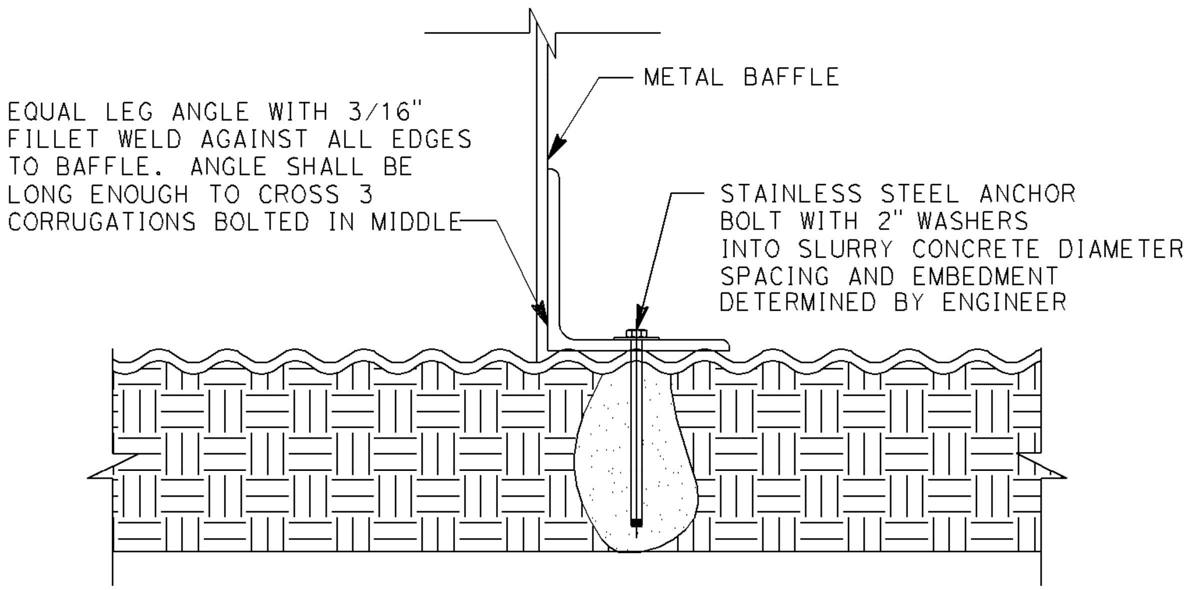
METAL BAFFLE FOR REINFORCED CONCRETE CIRCULAR CULVERTS

Date: 08/09
Sheet: 1

G.4 Metal Baffle for Corrugated Metals Circular Culverts (Details)



CONNECTION DETAIL

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E

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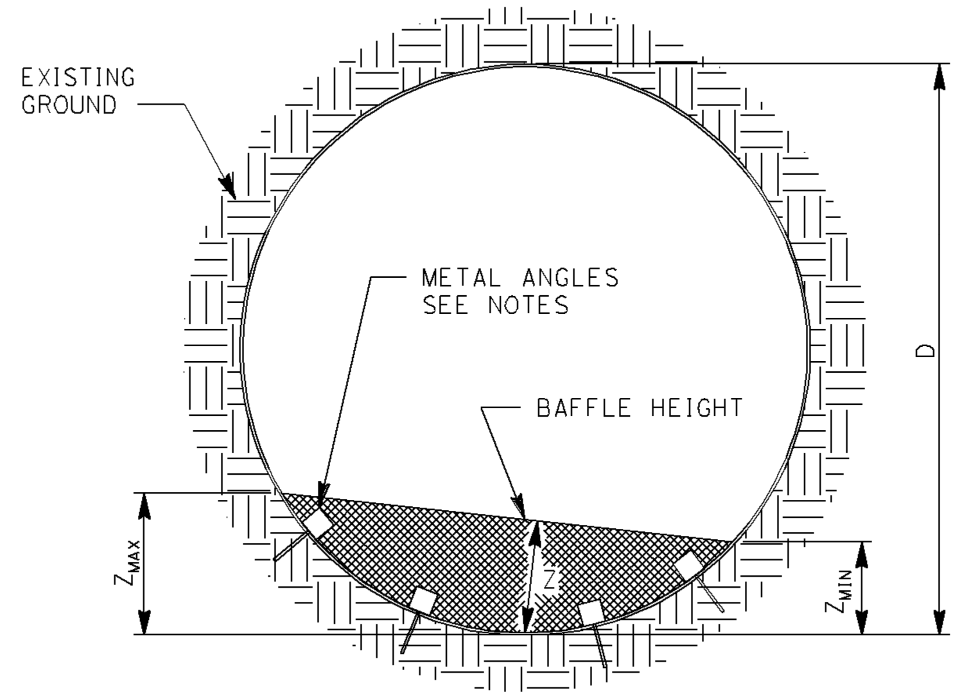
METAL BAFFLE FOR CORRUGATED METAL CIRCULAR CULVERTS

Date: 05/06

Sheet: 1



NOTES:
1. FASTEN ANGLES TO BAFFLE, 3/16" FILLET WELD ALL SIDES
2. BOTTOM ANGLE LEG TO BE LONG ENOUGH TO CROSS 3 CORRUGATIONS
3. ANGLES TO BE SPACED EVERY 18 INCHES ALONG CIRCUMFERENCE
4. SEE DETAIL E FOR CONNECTION

NTS
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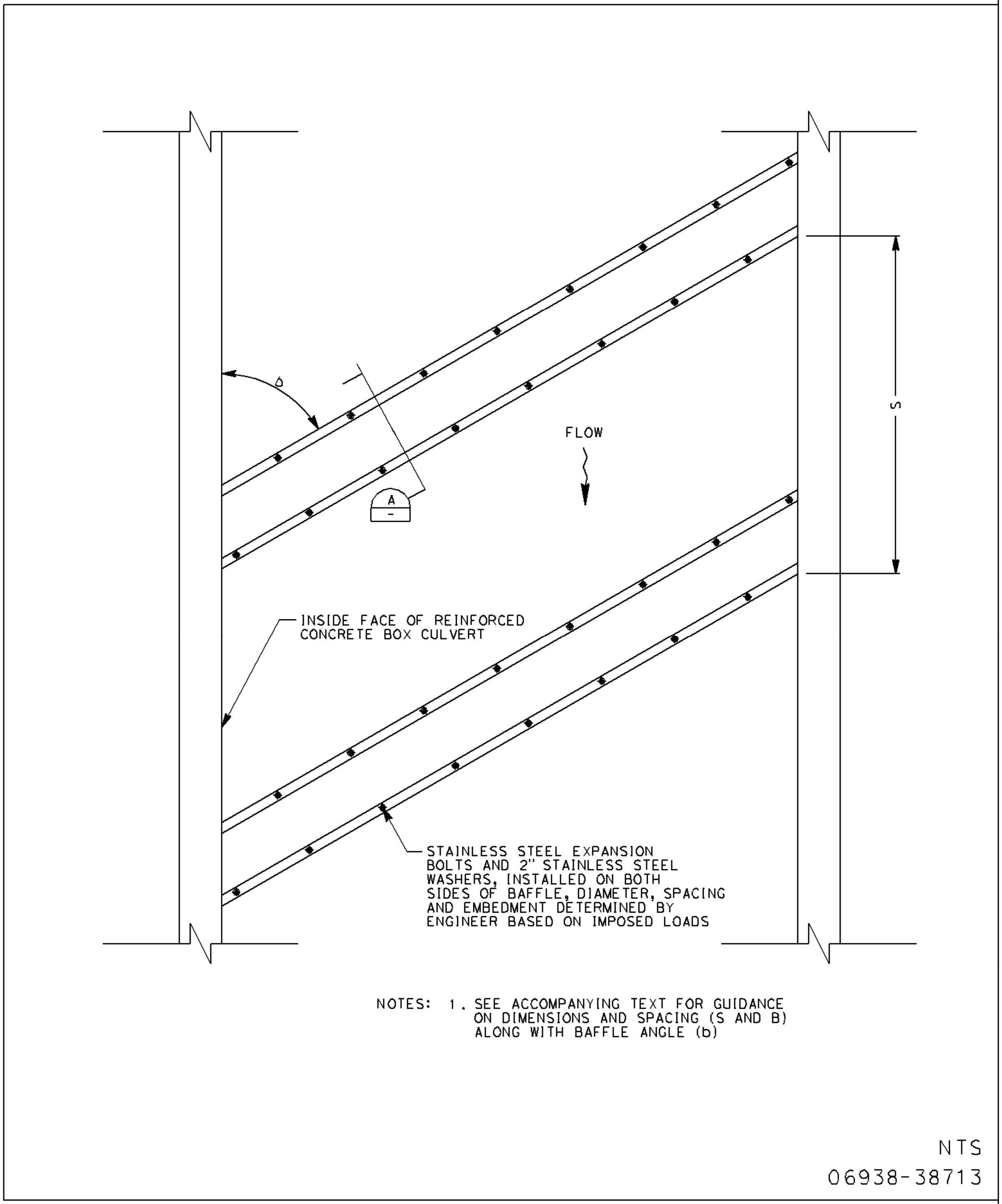
METAL BAFFLE FOR CORRUGATED METAL CIRCULAR CULVERTS

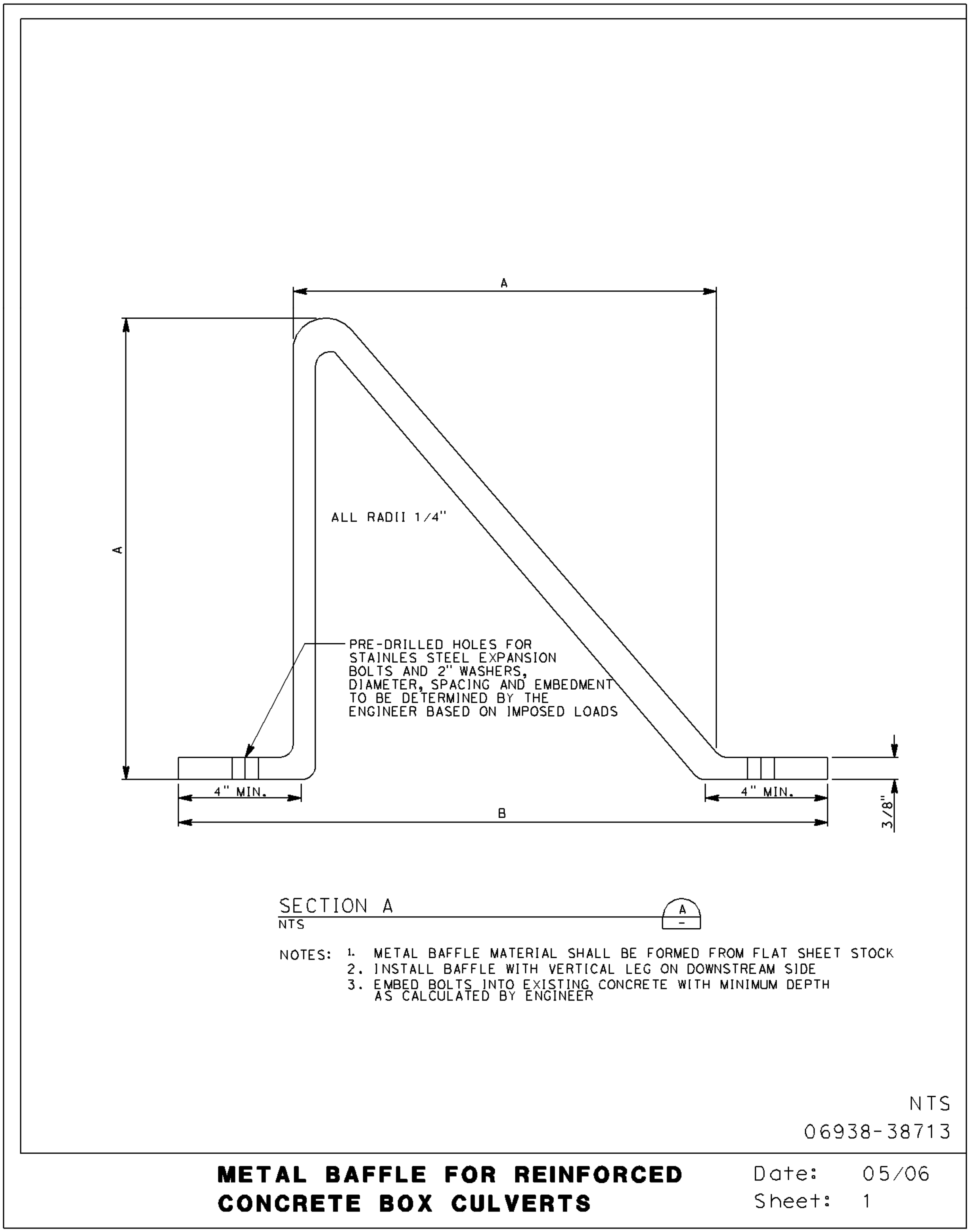
Date: 08/09
Sheet: 1

G.5 Metal Baffle for Reinforced Concrete Box Culverts (Details)

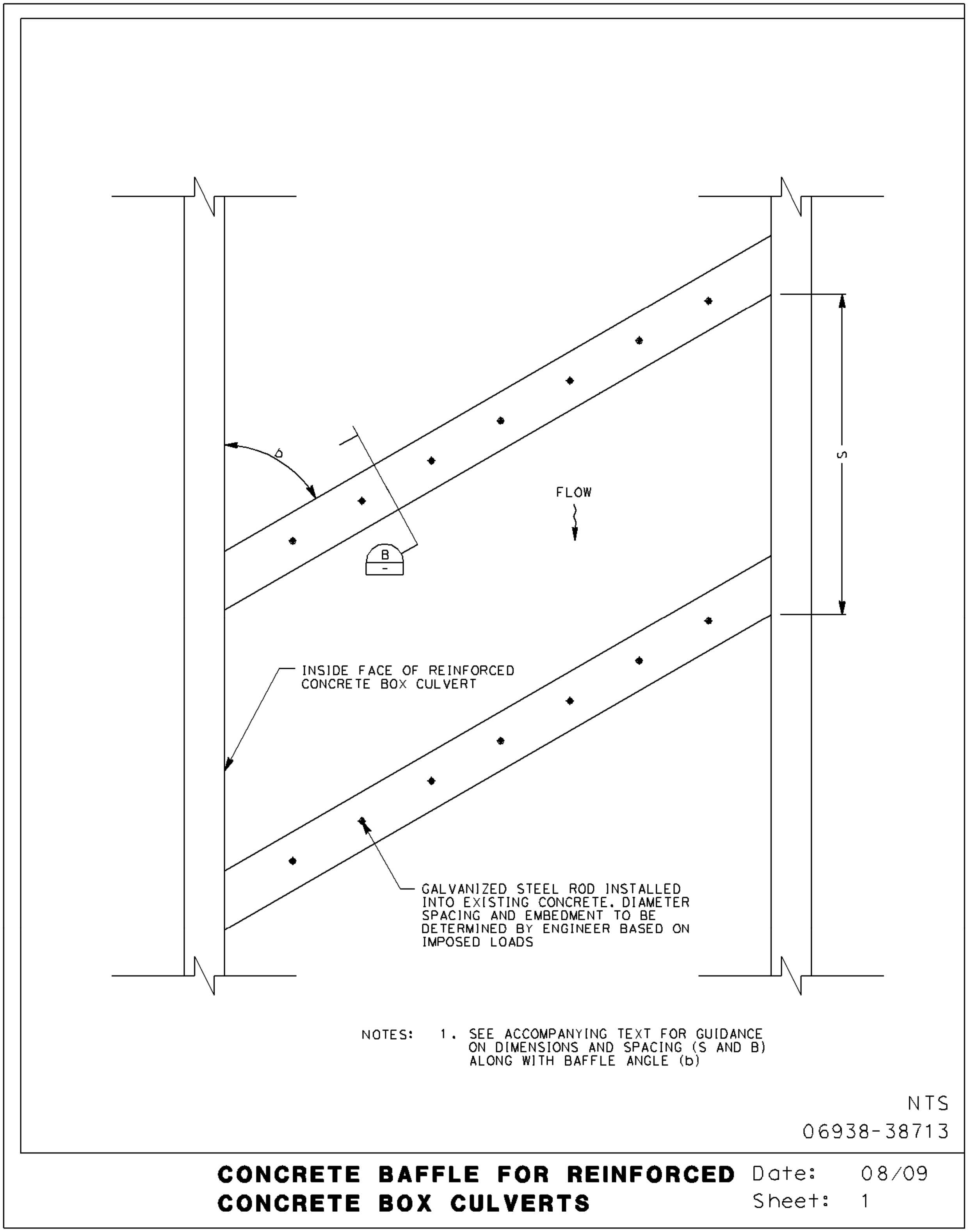


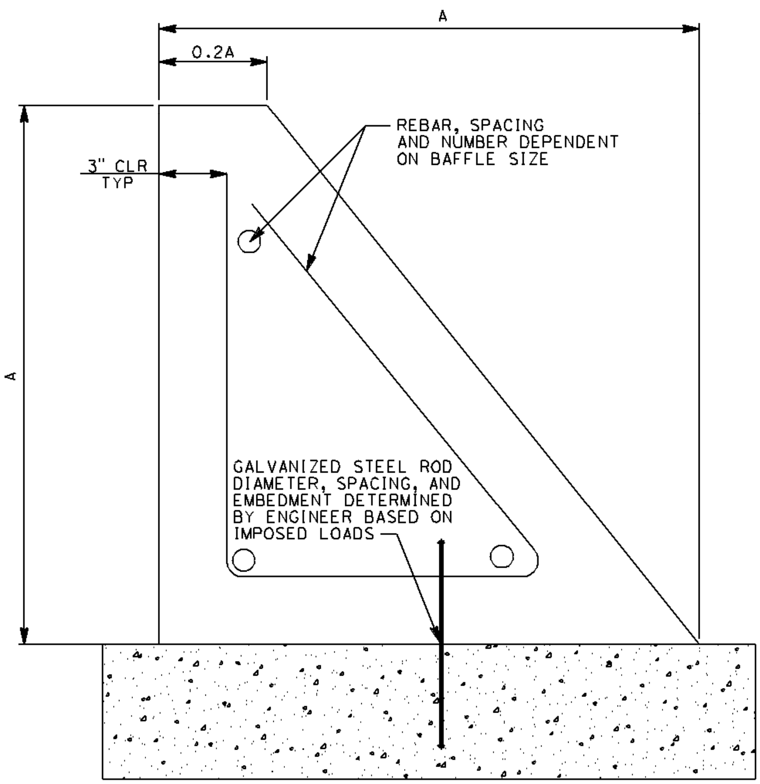
METAL BAFFLE FOR REINFORCED CONCRETE BOX CULVERTS

Date: 08/09
Sheet: 1


A
A
ALL RADII 1/4"
PRE-DRILLED HOLES FOR STAINLES STEEL EXPANSION BOLTS AND 2" WASHERS, DIAMETER, SPACING AND EMBEDMENT TO BE DETERMINED BY THE ENGINEER BASED ON IMPOSED LOADS
4" MIN.
4" MIN.
B
3/8"
SECTION A
NTS
A
-
NOTES: 1. METAL BAFFLE MATERIAL SHALL BE FORMED FROM FLAT SHEET STOCK
2. INSTALL BAFFLE WITH VERTICAL LEG ON DOWNSTREAM SIDE
3. EMBED BOLTS INTO EXISTING CONCRETE WITH MINIMUM DEPTH AS CALCULATED BY ENGINEER
NTS
06938-38713
METAL BAFFLE FOR REINFORCED CONCRETE BOX CULVERTS
Date: 05/06
Sheet: 1

G.6 Concrete Baffle for Reinforced Concrete Box Culverts (Details)


b
B
-
FLOW
S
INSIDE FACE OF REINFORCED CONCRETE BOX CULVERT
GALVANIZED STEEL ROD INSTALLED INTO EXISTING CONCRETE. DIAMETER SPACING AND EMBEDMENT TO BE DETERMINED BY ENGINEER BASED ON IMPOSED LOADS
NOTES: 1. SEE ACCOMPANYING TEXT FOR GUIDANCE ON DIMENSIONS AND SPACING (S AND B) ALONG WITH BAFFLE ANGLE (b)
NTS
06938-38713
CONCRETE BAFFLE FOR REINFORCED CONCRETE BOX CULVERTS
Date: 08/09
Sheet: 1



SECTION B
NTS

B
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NOTES:
1. CONCRETE SHALL HAVE A MINIMUM 28-DAY COMPRESSIVE STRENGTH OF 3000 PSI AND SHALL CONFORM TO SECTIONS 1903 AND 1905 OF THE UBC
2. INSTALL BAFFLE WITH VERTICAL LEG ON DOWNSTREAM SIDE
3. REBARS CAN BE SUBSTITUTED WITH EQUIVALENT DIAMETER THREADED STEEL ROD. REBAR SHALL BE GRADE 60 MINIMUM WITH EQUAL EMBEDMENT.

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CONCRETE BAFFLE FOR REINFORCED CONCRETE BOX CULVERTS

Date: 05/06
Sheet: 1