Final Drainage Plan,
Cherry Creek Crossing Filing No. 1 Lot 111
El Paso County, Colorado

Prepared for:
Colorado Highway 382 Limited Partnership
6070 North Camino Almonte
Tucson, Arizona 85718

Prepared by:

Kiowa
Engineering Corporation

1604 South 21st Street
Colorado Springs, Colorado 80904
(719) 630-7342

Kiowa Project No. 14028
August 3, 2017
Revised September 20, 2017
Revised July 19, 2018

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Engineer's Statement:

The attached drainage plan and report were prepared under my direction and supervision and are correct to the best of my knowledge and belief. Said drainage report has been prepared according to the criteria established by the County for drainage reports and said report is in conformity with the master plan of the drainage basin. I accept responsibility for any liability caused by any negligent acts, errors or omissions on my part in preparing this report.

Kiowa Engineering Corporation, 1604 South 21st Street, Colorado Springs, Colorado 80904

Richard N. Wray
Registered Engineer #19310
For and on Behalf of Kiowa Engineering Corporation

8/3/18
Date

Developer's Statement:

I, the Developer, have read and will comply with all of the requirements specified in this drainage report and plan.

Ibex Advisors, LLC, General Partner

BY: Nathan K. Miller, Managing Member 8/24/18
Date

Nathan K. Miller
Printed

ADDRESS: Colorado ~~Highway~~ Springs 382 Limited Partnership
6070 North Camino Almonte
Tucson, Arizona 85718

El Paso County:

Filed in accordance with the requirements of the Drainage Criteria Manual Volumes 1 and 2, El Paso County Engineering Criteria Manual and Land Development Code, as amended.

Jennifer Irvine, P.E.
County Engineer/ECM Administrator

Date

I. General Location and Description of Project

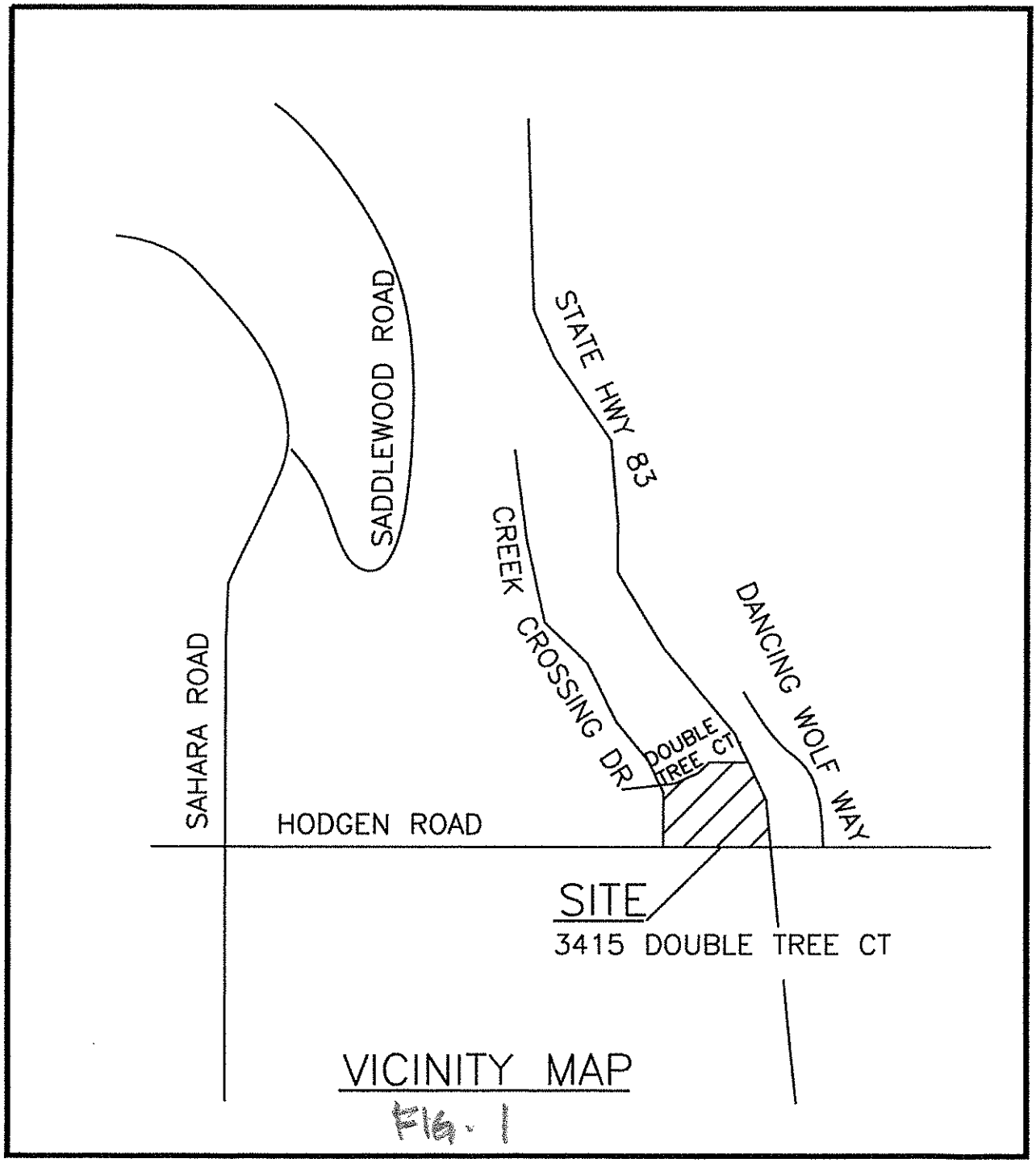
Cherry Creek Crossing Filing No. 1 is a platted subdivision in northern El Paso County that consists of 53 single family lots ranging in size from 2.5 to 5 acres, and one 8-acre commercial lot. The commercial lot, Lot 111, is located at the northwest corner of State Highway 83 and Hodgen Road. The owner of Lot 111 is proposing to carry out overlot grading in anticipation of a commercial use being established on the lot. The location of Lot 111 is shown on Figure 1.

The final drainage report for Filing No. 1 was approved by the County in 1998. Since that time the single-family lots have all been developed while Lot 111 has remains undeveloped. The public roadways that serve the subdivision have all been built and are currently maintained by the County. An overlot grading and erosion control plan has been prepared to show the extent of grading that is proposed for Lot 111. In addition to the overlot grading operations, the existing 54-inch reinforced concrete pipe presently maintained by the County that conveys runoff from offsite watersheds into Lot 111 is proposed for extension approximately 200 feet to the north. The proposed extension to this culvert is shown on Figure 2. When Filing 1 was platted, a drainage, floodplain and no-build easement was shown. This easement was created for access to the drainageway for the purposes of maintenance by the individual property owner. The County has a dedicated permanent easement that extends into the property 95-feet from the Hodgen Road right-of-way for the purposes of maintenance access to the 54-inch RCP that was extended when Hodgen Road was widened. These easements are shown on Figure 2.

Prior to the final development of Lot 111 a site plan will have to be provided to the County for review and approval per the requirements of the approved development plan for Cherry Creek Crossing. A specific use has not been identified for Lot 111. It is anticipated that onsite drainage facilities as well as water quality storage will be installed at that time. There are no stormwater detention or water quality facilities proposed for construction as part of the overlot grading. Permanent water quality measures will be installed when the site is developed into its final use. Permanent water quality measures such as water quality storage basins will not be placed in the area bounded by Double Tree Court, Cherry Crossing Road and the future access drives shown on Figure 2. A temporary sediment basin will be installed as part of the overlot grading work.

II. Hydrology

Onsite and offsite hydrology for Cherry Creek Crossing Filing 1 used to size the drainage facilities within the subdivision is summarized in the Filing 1 final drainage report. The hydrology work map from the Filing 1 final drainage plan showing the location of Lot 111 has been included within Appendix A. The overlot grading and eventual revegetation efforts will cause no change in the existing condition rates of runoff for Lot 111. The peak flow rates that are carried into the site by the existing 54-inch RCP under Hodgen Road are shown on Figure 2.



VICINITY MAP

Fig. 1

III. Hydraulic Calculations

The hydraulic capacity of the existing 48-inch CMP under Hodgen Road has been verified in its as-built condition. A field survey was conducted in 2014 whereby the as-built invert of the 54-inch RCP under Hodgen Road as well as for the 48-inch CMP culvert under Double Tree Court were confirmed. The overlot grading as proposed would not affect the culvert under Double Tree Court. The hydraulic capacity of the 54-inch RCP under Hodgen Road extended as shown on Figure 2 was reverified. Based upon the hydraulic calculations, extending the 54-inch into the site will not affect the hydraulic capacity of the culvert. The headwater-to-depth ratio is unchanged between the existing and extended condition. The culvert calculations have been included in Appendix A.

The outlet of the 54-inch will be stabilized by means of a standard CDOT headwall and wingwall. Due to the high outlet velocity in the 100-year condition (17.2 feet per second), and the anticipated super-critical flow condition, a low tailwater basin has been designed per UDFCD Volume 2. Based on the calculations a Type M soil/riprap low tailwater basin is required.

The present outlet condition of the 48-inch CMP under Double Tree Court was field checked and found to be stable and free of any scouring. The installation of the 54-inch RCP through Lot 111 will not affect the outlet hydraulics of the existing 48-inch CMP under Double Tree Court as this culvert functions under inlet control conditions.

IV. Floodplain Statement

The Floodplain Insurance Rate Map (FIRM) for El Paso County Flood Insurance Study (FIS) panel 285 was reviewed to determine any potential regulatory floodplains within Lot 111. There is no land within the Filing 1 subdivision that is located within a 100-year floodplain as delineated in the FIS. A copy of the relevant portion of FIRM panel 285F is shown on Figure 3.

V. Drainage and Bridge Fees

Drainage and bridge fees for Filing No.1 were determined in the Filing No. 1 final drainage report. The drainage and bridge fees were paid with the development of Filing 1. Therefore, there are no fees due for Lot 111.

VI. Economic Analysis

Summarized on Table 1 is the cost estimate for the extension of the 54-inch culvert through Lot 111.

LOCATIONS OF FUTURE ACCESS ROADS ARE APPROXIMATE. CONSTRUCTION OF ACCESS ROADS IS NOT PART OF THE OVERLOT GRADING.

LOT 40
DAVID L & VIRGINIA D READ

DOUBLE TREE COURT

EX. 24" CMP TO REMAIN

SITE ACCESS

EX. SWALE TO REMAIN

LOT 37
KEVIN S & BRANDEE L KNOWLES

LEGEND

2.1 DESIGN POINT

Q_5 = 75 cfs
Q_{100} = 163 cfs

2.1

PROVIDE 40 LF 24" CMP

EXIST. 48" RCP

EX. RIPRAP RUNDOWN TO REMAIN

EXIST. 24" CMP

STA 5+07
2.0±

STA 5+00

6" RISER

6" RISER
TOP=14.0
INV=13.75

SEDIMENT TRAP 2

7516
7514
7512
7511.0
3:1

PROVIDE 24" THICK TYPE M RIPRAP PLUNGE POOL AT OUTLET OF 54" RCP.

THIS AREA WILL NOT BE USED FOR ONSITE WATER QUALITY OR STORMWATER DETENTION.

RIPRAP CHANNEL SEE GRADING PLAN FOR SECTION.

LOW TAILWATER BASIN.

54" RCP FES
INV=7503.0

RIPRAP RUNDOWN SEE GRADING PLAN FOR SECTION.

NO-BUILD DRAINAGE EASEMENT TO BE PROVIDED ALONG WITH MAINTENANCE AGREEMENT. AREA WITHIN EASEMENT SHALL NOT BE USED FOR WQ OR DETENTION STORAGE FACILITIES

LOCATION OF FUTURE ACCESS ROAD

LOT 111
COLORADO SPRINGS 382 LTD. PARTNERSHIP

SOURCE: FINAL DRAINAGE AND EROSION CONTROL PLAN FILING NO. 1 CHERRY CREEK CROSSING SUBDIVISION PREPARED BY KIOWA ENGINEERING, APROVED DECEMBER 1998.

FUTURE 40 LF 18" CMP 16 GA

FUTURE ACCESS ROAD

CREEK CROSSING DRIVE

SEDIMENT TRAP 1

PROVIDE ROADSIDE SWALE
BW=2'
d=12"
SS=3:1

6" RISER
TOP=25.0
INV=23.75

EL PASO COUNTY EASEMENT
REC.NO:206076662
NO BUILD EASEMENT

TYP L SOIL/RIPRAP
18" THICK, BW=3'
d=12", TW=9'

54" RCP

EX INV=
7510±

CDOT STD. BOX BASE MANHOLE

PERMANENT EASEMENT

EXIST. 54" RCP

EXISTING TRAIL

STA 1+00 AT PL
FOR PROFILE,
SEE SHEET 6

Q5=75 cfs
Q10=163 cfs

LIMIT OF EXISTING HODGEN ROAD PAVING

HODGEN ROAD

EX TRAIL

50' PUBLIC UTILITY DRAINAGE & TRAIL EASEMENT

0 60' 120'

HORIZONTAL SCALE: 1"=60'

7498.0
7530
7540
7550
7554
7502

Kiowa Engineering Corporation
1604 South 21st Street
Colorado Springs, Colorado 80904
(719) 630-7342

CHERRY CREEK CROSSING, FILING NO. 1 LOT 111
AMENDED FINAL DRAINAGE PLAN

EL PASO COUNTY, COLORADO

Project No.:	14028
Date:	JULY 27, 2018
Design:	RNW
Drawn:	EAK
Check:	RNW
Revisions:	

FIG.2

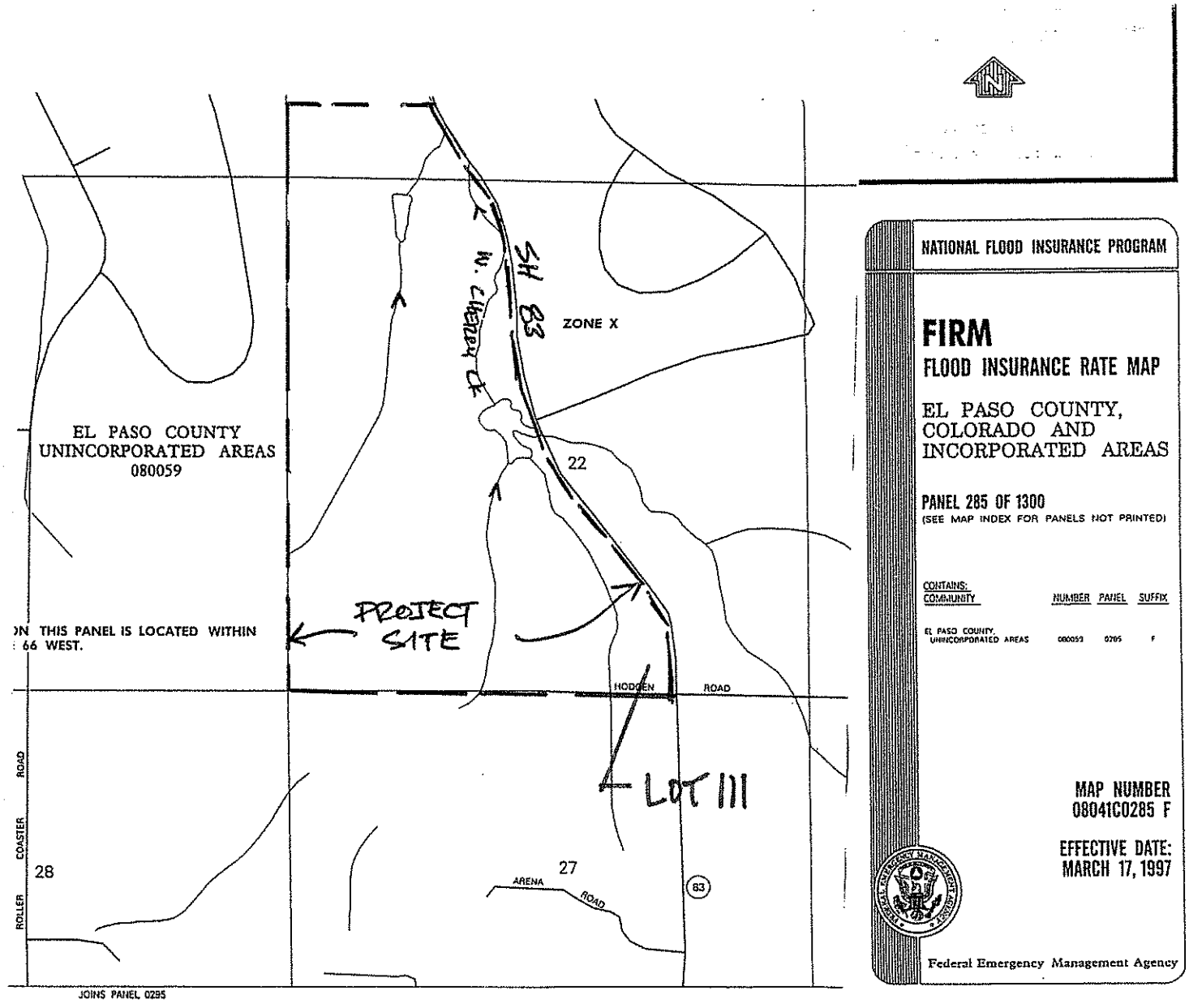


Figure 3
No Scale

Appendix A
Hydraulic Calculations

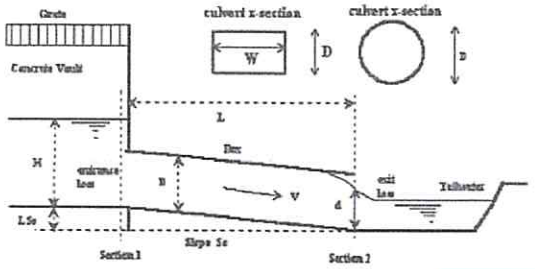
TABLE 1: CHERRY CREEK CROSSING FILING 1 LOT 111
DRAINAGE IMPROVEMENT COST ESTIMATE
KIOWA PROJECT NUMBER 14028

ITEM	UNIT COST	UNIT	QUANTITY	TOTAL
PUBLIC DRAINAGE FACILITIES				
54-INCH RCP	$225	LF	215	$48,375
CDoT std headwall/wingwall	$5,000	EA	1	$5,000
BOX BASE MANHOLE	$7,500	EA	1	$7,500
TYPE L SOIL/RIPRAP RUNDOWN	$70	CY	50	$3,500
TYPE M SOIL/RIPRAP	$85	CY	160	$13,600
SUBTOTAL				$77,975.00
CONTINGENCY (5 %)				$3,898.75
ENGINEERING (10 %)				$7,797.50
TOTAL				**$89,671.25**

Appendix A
Hydraulic Calculations

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

Project: 14028 Cherry Creek Crossing Filing No. 1, Lot 111
Basin ID: Hodgen Road culvert existing conditions
Status:



Design Information (Input):

Circular Culvert: Barrel Diameter in Inches — D = 54 inches
Inlet Edge Type (choose from pull-down list): Grooved End Projection

OR:

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

Number of Barrels	No =	1	
Inlet Elevation at Culvert Invert	Inlet Elev =	7316	ft. elev.
Outlet Elevation at Culvert Invert **OR** Slope of Culvert (ft v./ft h.)	Outlet Elev =	7310	ft. elev.
Culvert Length in Feet	L =	220	ft.
Manning's Roughness	n =	0.025	
Bend Loss Coefficient	K_b =	0	
Exit Loss Coefficient	K_x =	1	

Design Information (calculated):

Entrance Loss Coefficient	K_e =	0.20
Friction Loss Coefficient	K_f =	3.41
Sum of All Loss Coefficients	K_s =	4.61
Orifice Inlet Condition Coefficient	C_d =	0.95
Minimum Energy Condition Coefficient	KE_{low} =	-0.0739

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
7316.00	7310.00	0.00	0.00	**0.00**	No Flow (WS < inlet)	N/A
7318.00	7310.50	27.40	117.96	**27.40**	Min. Energy. Eqn.	INLET
7320.00	7311.00	89.80	129.53	**89.80**	Regression Eqn.	INLET
7322.00	7311.50	153.80	147.76	**147.76**	Regression Eqn.	OUTLET
7324.00	7312.00	199.20	166.26	**166.26**	Regression Eqn.	OUTLET
7326.00	7312.50	235.30	182.89	**182.89**	Regression Eqn.	OUTLET
7328.00	7313.00	266.60	198.09	**198.09**	Regression Eqn.	OUTLET
7330.00	7313.50	294.50	212.27	**212.27**	Orifice Eqn.	OUTLET
					Invalid Entry	
					Invalid Entry	
					Invalid Entry	
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$Q_{100} = 163$ cfs →

$Hw/D = \frac{7.5}{4.5}$

$= 1.67$

HY-8 Culvert Analysis Report

54" CULVERT EXTENSION

Table 1 - Summary of Culvert Flows at Crossing: 54-inch rcp

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
7507.00	0.00	0.00	0.00	1
7508.72	20.00	20.00	0.00	1
7509.55	40.00	40.00	0.00	1
7510.28	60.00	60.00	0.00	1
7510.93	80.00	80.00	0.00	1
7511.57	100.00	100.00	0.00	1
7512.26	120.00	120.00	0.00	1
7513.06	140.00	140.00	0.00	1
7513.97	160.00	160.00	0.00	1
7515.03	180.00	180.00	0.00	1
7516.22	200.00	200.00	0.00	1
7534.00	383.98	383.98	0.00	Overtopping

Rating Curve Plot for Crossing: 54-inch rcp

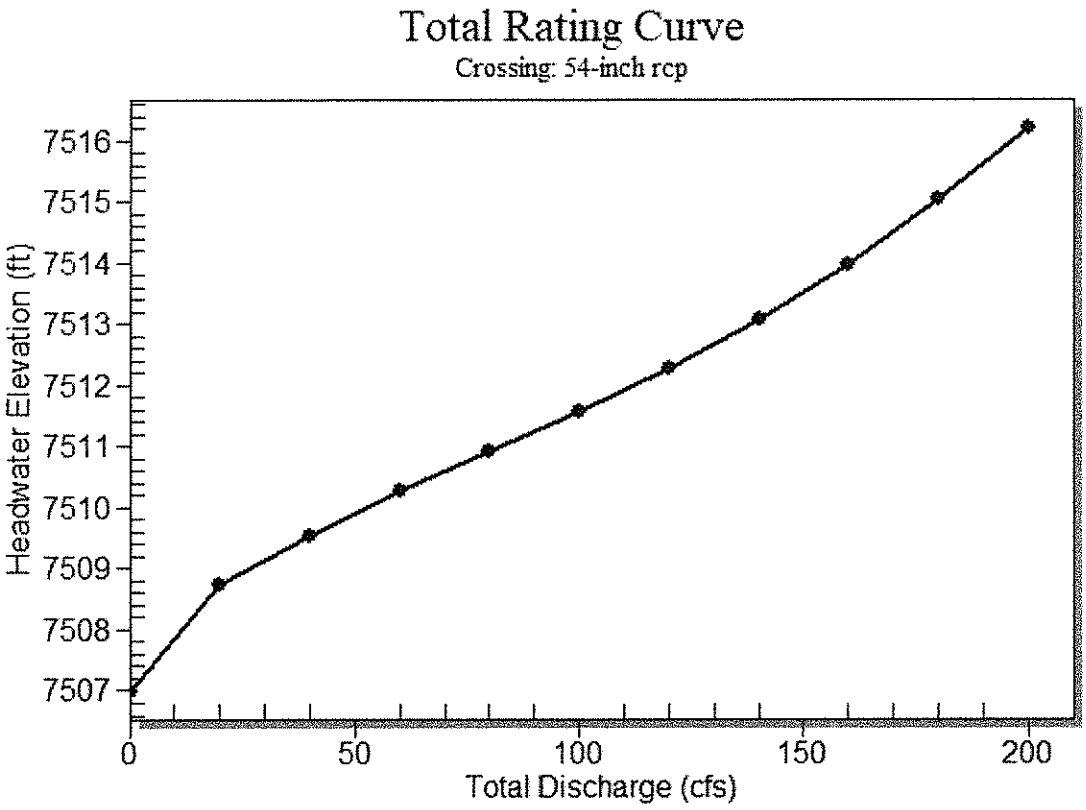

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	7507.00	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
20.00	20.00	7508.72	1.721	0.0*	1-S2n	0.786	1.260	0.800	0.446	10.287	3.956
40.00	40.00	7509.55	2.547	0.0*	1-S2n	1.124	1.819	1.141	0.666	12.500	5.008
60.00	60.00	7510.28	3.282	0.0*	1-S2n	1.402	2.250	1.409	0.838	14.062	5.718
80.00	80.00	7510.93	3.928	0.0*	1-S2n	1.628	2.610	1.630	0.985	15.346	6.266
100.00	100.00	7511.57	4.568	0.0*	5-S2n	1.846	2.928	1.854	1.116	16.176	6.717
120.00	120.00	7512.26	5.263	0.0*	5-S2n	2.041	3.218	2.148	1.233	16.012	7.103
140.00	140.00	7513.06	6.056	0.0*	5-S2n	2.237	3.467	2.361	1.342	16.571	7.441
160.00	160.00	7513.97	6.972	0.0*	5-S2n	2.423	3.682	2.568	1.442	17.072	7.744
180.00	180.00	7515.03	8.025	0.0*	5-S2n	2.608	3.856	2.771	1.537	17.528	8.018
200.00	200.00	7516.22	9.219	0.0*	5-S2n	2.797	4.031	2.975	1.626	17.950	8.270

* theoretical depth is impractical. Depth reported is corrected.

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Inlet Elevation (invert): 7507.00 ft, Outlet Elevation (invert): 7503.00 ft

Culvert Length: 228.04 ft, Culvert Slope: 0.0175

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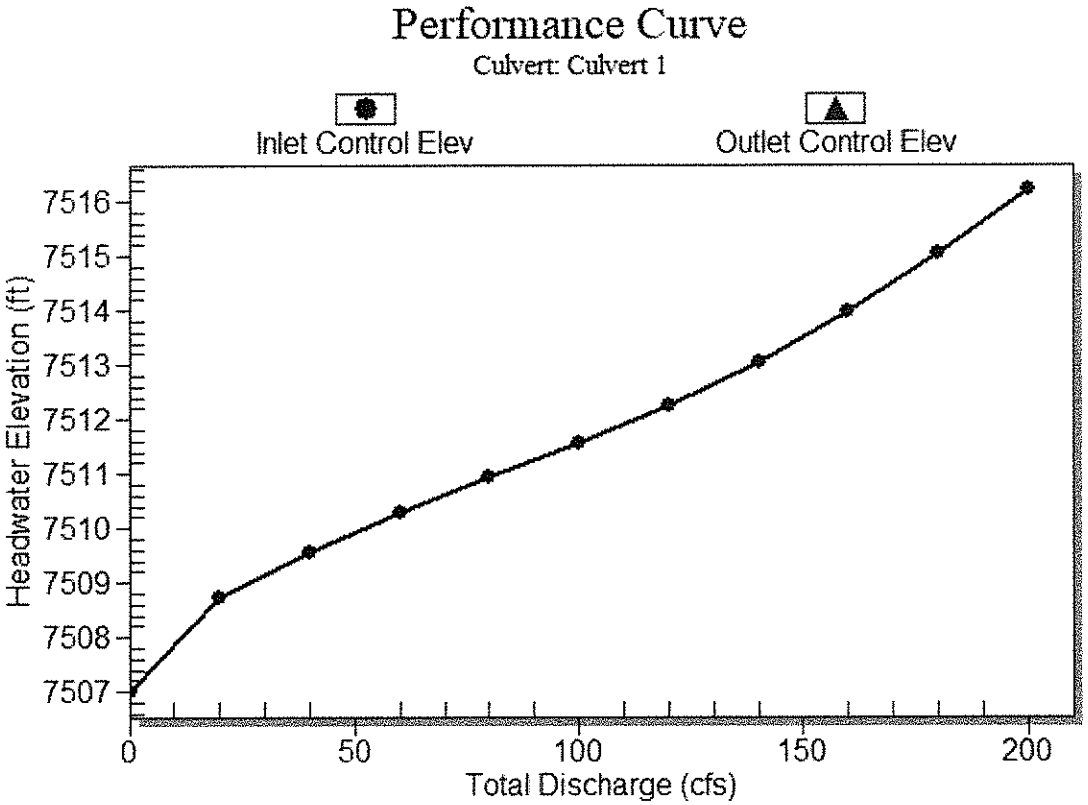
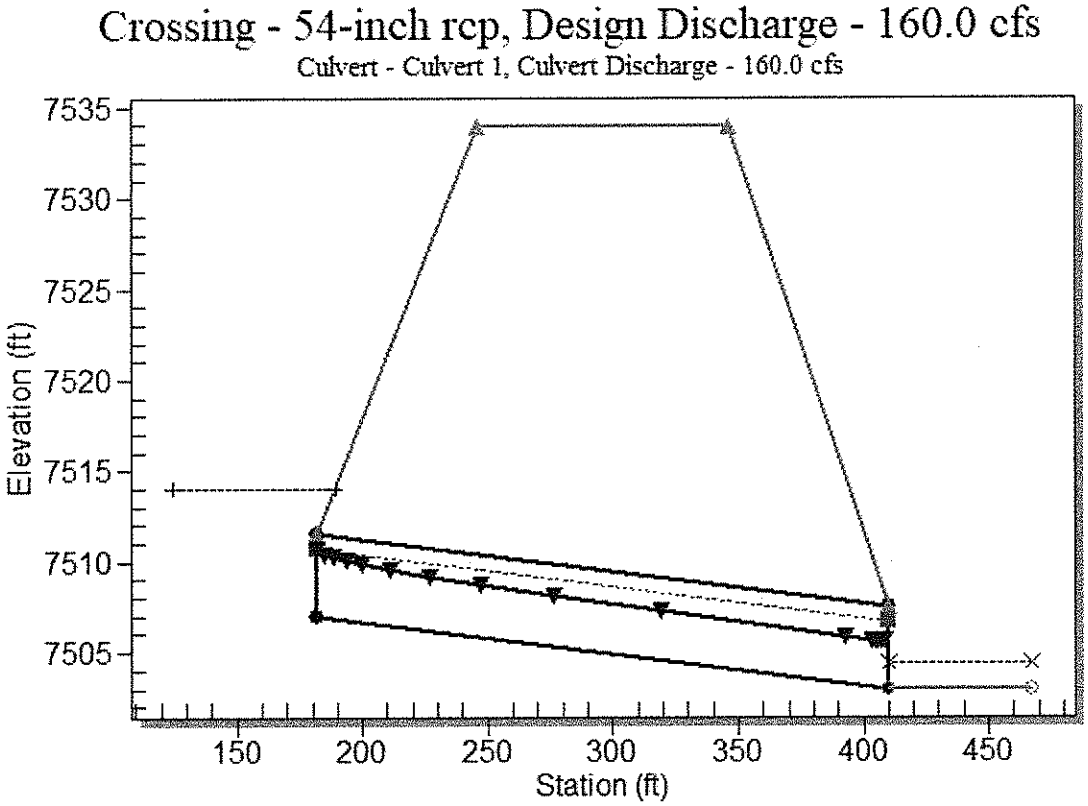
Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 182.00 ft

Inlet Elevation: 7507.00 ft

Outlet Station: 410.00 ft

Outlet Elevation: 7503.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 4.50 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: 54-inch rcp)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	7503.00	0.00	0.00	0.00	0.00
20.00	7503.45	0.45	3.96	0.83	1.10
40.00	7503.67	0.67	5.01	1.25	1.17
60.00	7503.84	0.84	5.72	1.57	1.21
80.00	7503.99	0.99	6.27	1.84	1.23
100.00	7504.12	1.12	6.72	2.09	1.25
120.00	7504.23	1.23	7.10	2.31	1.27
140.00	7504.34	1.34	7.44	2.51	1.28
160.00	7504.44	1.44	7.74	2.70	1.30
180.00	7504.54	1.54	8.02	2.88	1.31
200.00	7504.63	1.63	8.27	3.04	1.32

Tailwater Channel Data - 54-inch rcp

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 3.00 (_:1)

Channel Slope: 0.0300

Channel Manning's n: 0.0350

Channel Invert Elevation: 7503.00 ft

Roadway Data for Crossing: 54-inch rcp

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 7534.00 ft

Roadway Surface: Paved

Roadway Top Width: 100.00 ft

HY-8 Culvert Analysis Report

EX 48" RCP DOUBLE TREE CE

Table 1 - Summary of Culvert Flows at Crossing: ex double tree court 48"

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
7502.00	0.00	0.00	0.00	1
7503.75	20.00	20.00	0.00	1
7504.64	40.00	40.00	0.00	1
7505.36	60.00	60.00	0.00	1
7506.06	80.00	80.00	0.00	1
7506.87	100.00	100.00	0.00	1
7507.86	120.00	120.00	0.00	1
7509.03	140.00	140.00	0.00	1
7510.36	160.00	160.00	0.00	1
7510.58	163.00	163.00	0.00	1
7513.44	200.00	200.00	0.00	1
7515.50	221.67	221.67	0.00	Overtopping

Rating Curve Plot for Crossing: ex double tree court 48"

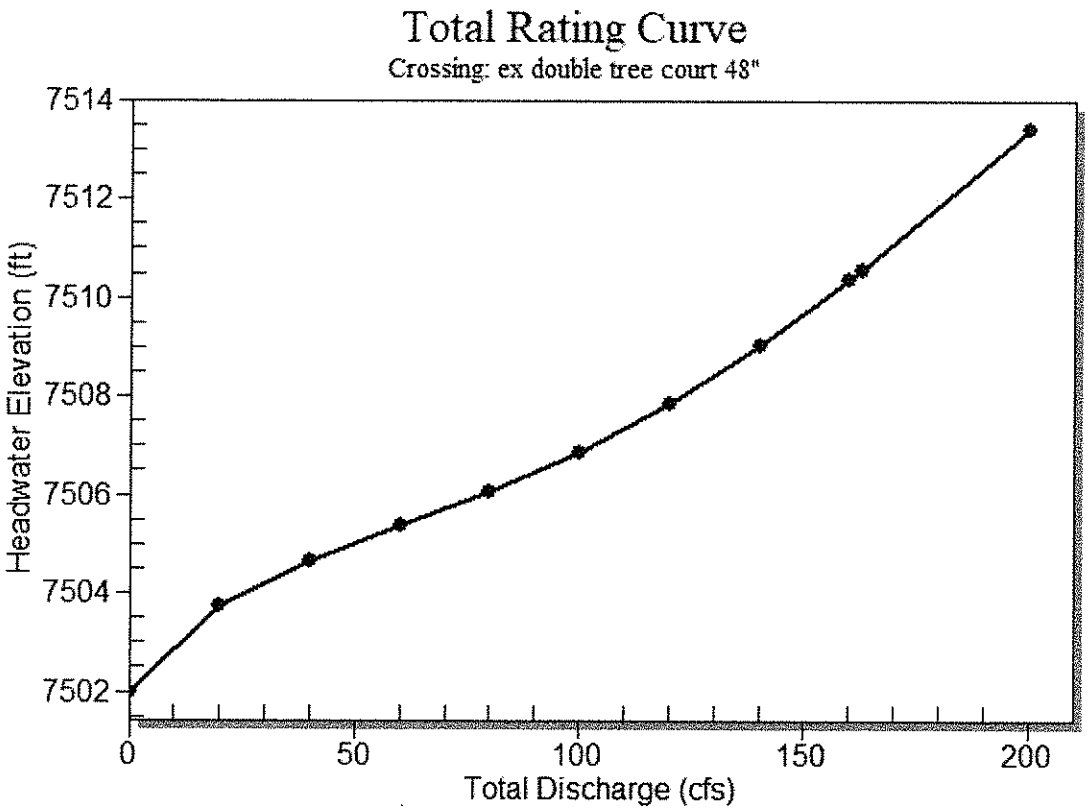


Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	7502.00	0.000	0.0*	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
20.00	20.00	7503.75	1.751	0.0*	1-S2n	0.713	1.305	0.729	0.323	12.598	3.722
40.00	40.00	7504.64	2.643	0.0*	1-S2n	1.017	1.879	1.031	0.484	15.454	4.745
60.00	60.00	7505.36	3.359	0.0*	1-S2n	1.267	2.329	1.368	0.611	15.749	5.442
80.00	80.00	7506.06	4.060	0.0*	5-S2n	1.474	2.703	1.628	0.719	16.667	5.984
100.00	100.00	7506.87	4.872	0.0*	5-S2n	1.670	3.018	1.862	0.815	17.437	6.431
120.00	120.00	7507.86	5.857	0.0*	5-S2n	1.850	3.281	2.088	0.902	18.092	6.815
140.00	140.00	7509.03	7.027	0.0*	5-S2n	2.028	3.490	2.300	0.983	18.734	7.152
160.00	160.00	7510.36	8.365	0.0*	5-S2n	2.198	3.698	2.503	1.058	19.359	7.454
163.00	163.00	7510.58	8.578	0.0*	5-S2n	2.223	3.729	2.529	1.069	19.486	7.497
200.00	200.00	7513.44	11.438	6.856	6-FFc	2.544	4.000	4.000	1.195	15.915	7.980

* theoretical depth is impractical. Depth reported is corrected.

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Inlet Elevation (invert): 7502.00 ft, Outlet Elevation (invert): 7498.00 ft

Culvert Length: 130.06 ft, Culvert Slope: 0.0308

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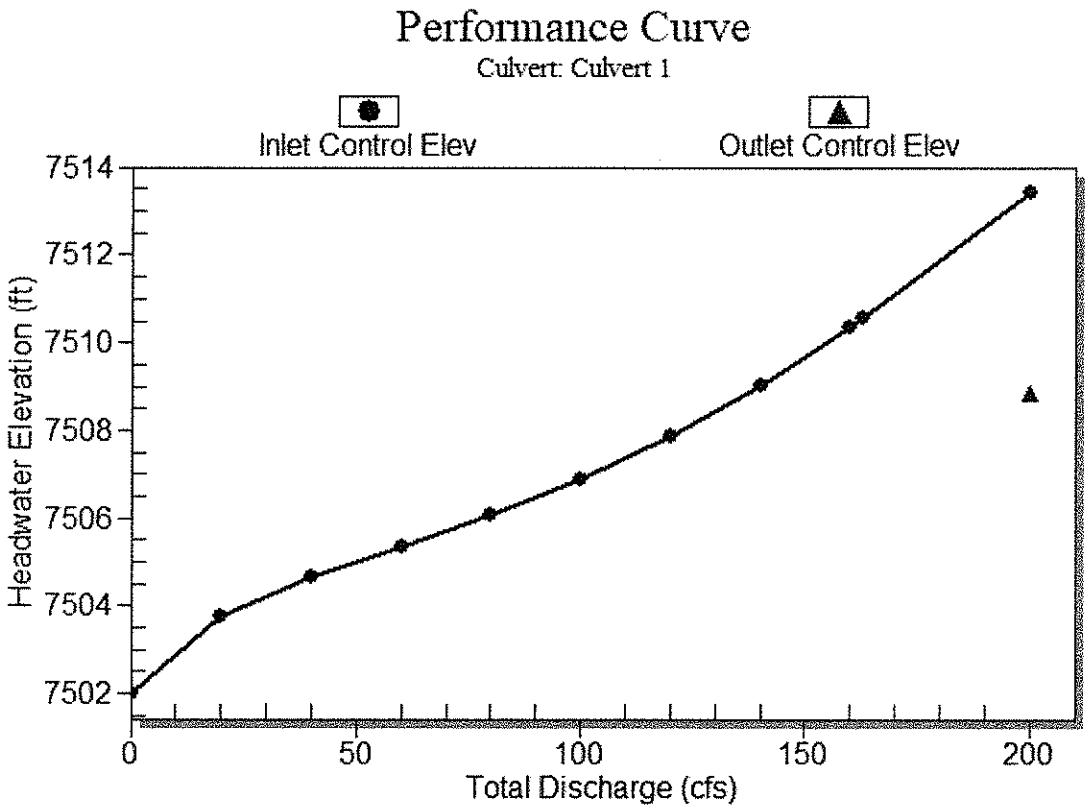
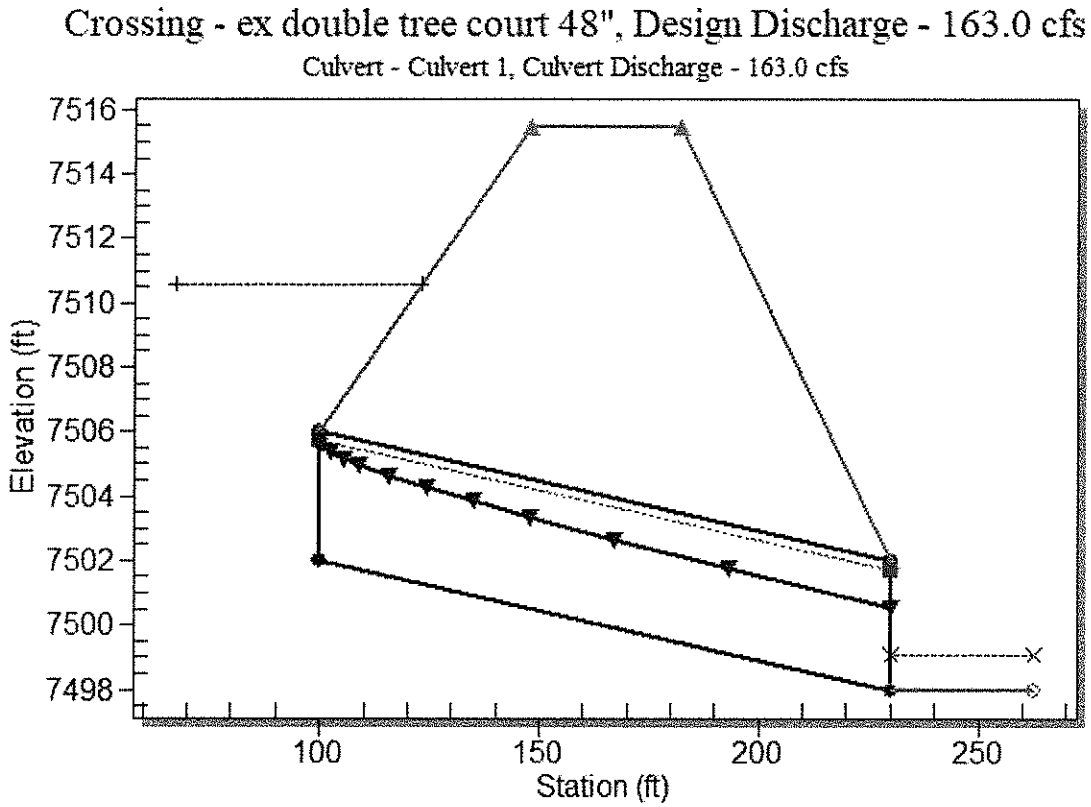
Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 100.00 ft

Inlet Elevation: 7502.00 ft

Outlet Station: 230.00 ft

Outlet Elevation: 7498.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 4.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Beveled Edge (1:1)

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: ex double tree court 48")

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	7498.00	0.00	0.00	0.00	0.00
20.00	7498.32	0.32	3.72	0.71	1.21
40.00	7498.48	0.48	4.75	1.06	1.28
60.00	7498.61	0.61	5.44	1.33	1.33
80.00	7498.72	0.72	5.98	1.57	1.36
100.00	7498.82	0.82	6.43	1.78	1.38
120.00	7498.90	0.90	6.81	1.97	1.40
140.00	7498.98	0.98	7.15	2.15	1.42
160.00	7499.06	1.06	7.45	2.31	1.43
163.00	7499.07	1.07	7.50	2.33	1.44
200.00	7499.19	1.19	7.98	2.61	1.46

Tailwater Channel Data - ex double tree court 48"

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 15.00 ft

Side Slope (H:V): 5.00 (_:1)

Channel Slope: 0.0350

Channel Manning's n: 0.0330

Channel Invert Elevation: 7498.00 ft

Roadway Data for Crossing: ex double tree court 48"

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 7515.50 ft

Roadway Surface: Paved

Roadway Top Width: 34.00 ft

KIOWA ENGINEERING CORPORATION

JOB Cherry Creek Xing Lot 111
SHEET NO. 14023 OF 1 of 3
CALCULATED BY DATE 7-18-23
CHECKED BY DATE TJW
SCALE Hydraulics

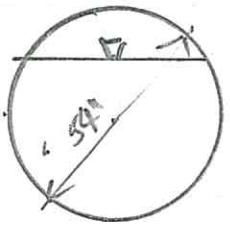
Outlet Velocity @ 54" RCP

$Q_{100} = 163$ cfs

54" RCP full area = 15.9 sf

Flowing full Q @ 1.9% = 278 cfs V = 17.5 fps

Check @ 2/3 full: Area = 10.3 sf.



$$Q = \frac{1.49}{n} S^{1/2} R^{2/3}$$

$A = 10.3$ $R = .90$

$$Q = \frac{1.49}{.013} \sqrt{.019} (10.3)(.9)^{2/3}$$

$Q = 156$ cf: check Velocity

$V = 156 / 10.3 = 15.1$

Per H&H Analysis, V @ outlet = 17.1 fps

KIOWA ENGINEERING CORPORATION

JOB Cherry Creek Crossing
SHEET NO. Lot 111 OF 2 of 3
CALCULATED BY KDS DATE 9/19/17
CHECKED BY RJW DATE Rev 11/21/17
SCALE Hydraulics

Riprap Sizing

Slope outlet of .54 to 48" under Double Tree
S = .028 ft/ft

$$\frac{VS^{.17}}{(S_s-1)^{.66}} = \frac{11.1(.028)^{.17}}{(2.6-1)^{.66}} = \frac{9.31}{1.536} = 6.06$$

Per Table 10-6 DCM
Rock Size > YH 24" D_{50} – lower end

Probably super critical @ outlet ∴ 10-6 does not apply;

Due to inlet control condition @ 48" under Double Tree, in 100-year flows would be stilled, ~15 fps @ outlet of 54" is not reasonable. Continuous layer of Type H should suffice @ this location as velocity would be < 10 fps. warranty Type M.

Slope @ 11 fps $VS^{.17}$

Check size of rock per UDFCD low tailwater basin requirements.

KIOWA ENGINEERING CORPORATION

JOB Cheery Creek Crossing
SHEET NO. Left 111 OF 3 of 3
CALCULATED BY 14028 DATE 7/17/18
CHECKED BY RJSW DATE
SCALE Hydraulics -

54" outlet Protection

use UDFCD chapt 9. Low tailwater bar...

per Fig 9-37

Rock Sizing: Figure 9.38

D = 4.5' y_t =

Assume critical Flow depth in barrel

54"

$$\therefore D_a = \frac{D_c + y_n}{2} \qquad D_c = 3.73 \quad y_n = 2.51$$

$$= \frac{(3.73 + 2.51)}{2}$$

$$= 3.12$$

$$Q/D_a^{1.5} = F_1.0 \frac{163}{(3.12)^{1.5}} = 29.6$$

$$y_t/D_a = 2.5/3.12 = .80$$

Per Figure 9-38: Type M (Soil Riprap)

Thickness $2 \times D_{50}$ = 24"

3.2.2 Low Tailwater Basin

The design of low tailwater riprap basins is necessary when the receiving channel may have little or no flow or tailwater at time when the pipe or culvert is in operation. Figure 9-37 provides a plan and profile view of a typical low tailwater riprap basin.

By providing a low tailwater basin at the end of a storm drain conduit or culvert, the kinetic energy of the discharge dissipates under controlled conditions without causing scour at the channel bottom.

Low tailwater is defined as being equal to or less than ⅓ of the height of the storm drain, that is:

$$y_t \leq \frac{D}{3} \quad \text{or} \quad y_t \leq \frac{H}{3}$$

Where:

y_t = tailwater depth at design flow (feet)

D = diameter of circular pipe (feet)

H = height of rectangular pipe (feet)

Rock Size
The procedure for determining the required riprap size downstream of a conduit outlet is in Section 3.2.3.

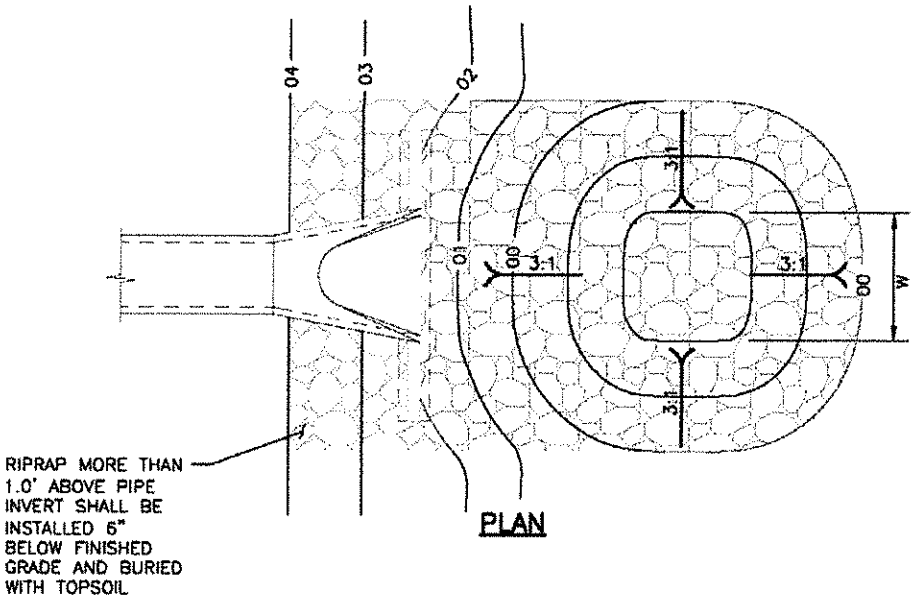
After selecting the riprap size, the minimum thickness of the riprap layer, T, in feet, in the basin is defined as:

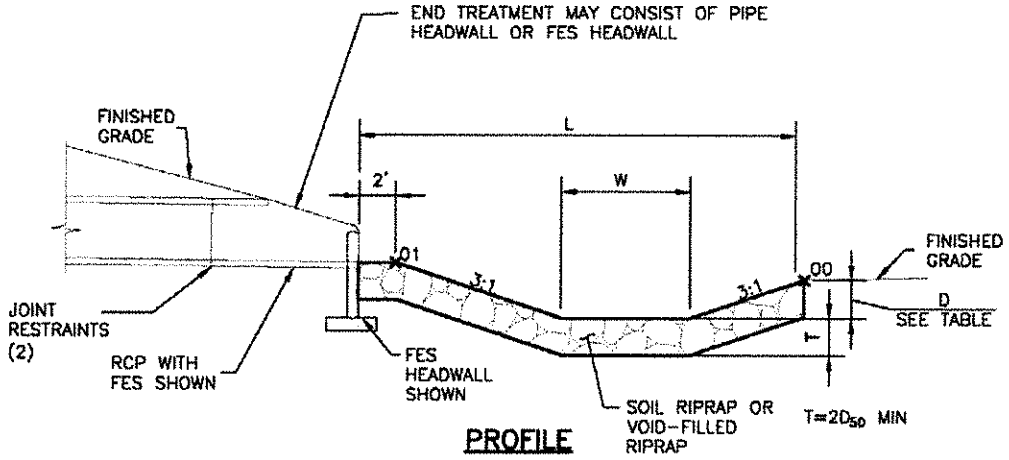
$$T = 2D_{50} \qquad \text{Equation 9-15}$$

Basin Geometry
Figure 9-37 includes a layout of a standard low tailwater riprap basin with the geometry parameters provided. The minimum length of the basin (L) and the width of the bottom of the basin (W1) are provided in a table at the bottom of Figure 9-37. All slopes in the low tailwater basin shall be 3(H):1(V), minimum.

Other Design Requirements
Extend riprap up the outlet embankment slope to the mid-pipe level, minimum. It is recommended that riprap that extends more than 1 foot above the outlet pipe invert be installed 6 inches below finished grade and buried with topsoil.

Provide pipe end treatment in the form of a pipe headwall or a flared-end section headwall. See Section 3.1 for options.





PIPE SIZE OR BOX HEIGHT	D	W*	L
18" – 24"	1'–0"	4'	15'
30" – 36"	1'–6"	6'	20'
42" – 48"	2'–0"	7'	24'
54" – 60"	2'–6"	8'	28'
66" – 72"	3'–0"	9'	32'

* IF OUTLET PIPE IS A BOX CULVERT WITH A WIDTH GREATER THAN W, THEN W = CULVERT WIDTH

Figure 9-37. Low tailwater riprap basin

3.2.3 Rock Sizing for Riprap Apron and Low Tailwater Basin

Scour resulting from highly turbulent, rapidly decelerating flow is a common problem at conduit outlets. The following section summarizes the method for sizing riprap protection for both riprap aprons (Section 3.2.1) and low tailwater basins (Section 3.2.2).

Use Figure 9-38 to determine the required rock size for circular conduits and Figure 9-39 for rectangular conduits. Figure 9-38 is valid for $Q/D_c^{2.5}$ of 6.0 or less and Figure 9-39 is valid for $Q/WH^{1.5}$ of 8.0 or less. The parameters in these two figures are:

1. $Q/D^{1.5}$ or $Q/WH^{0.5}$ in which Q is the design discharge in cfs, D_c is the diameter of a circular conduit in feet, and W and H are the width and height of a rectangular conduit in feet.

2. Y_t/D_c or Y_t/H in which Y_t is the tailwater depth in feet, D_c is the diameter of a circular conduit in feet, and H is the height of a rectangular conduit in feet. In cases where Y_t is unknown or a hydraulic jump is suspected downstream of the outlet, use $Y_t/D_t = Y_t/H = 0.40$ when using Figures 9-38 and 9-39.

3. The riprap size requirements in Figures 9-38 and 9-39 are based on the non-dimensional parametric Equations 9-16 and 9-17 (Steven, Simons, and Watts 1971 and Smith 1975).

Circular culvert:

$$d_{50} = \frac{0.023Q}{Y_t^{1.2} D_c^{0.3}} \qquad \text{Equation 9-16}$$

Rectangular culvert:

$$d_{50} = \frac{0.014H^{0.5}Q}{Y_t W} \qquad \text{Equation 9-17}$$

These rock size requirements assume that the flow in the culvert is subcritical. It is possible to use Equations 9-16 and 9-17 when the flow in the culvert is supercritical (and less than full) if the value of D_c or H is modified for use in Figures 9-38 and 9-39. Note that rock sizes referenced in these figures are defined in the *Open Channels* chapter. Whenever the flow is supercritical in the culvert, substitute D_a for D_c and H_a for H, in which D_a is defined as:

$$D_a = \frac{(D_c + Y_n)}{2} \qquad \text{Equation 9-18}$$

Where the maximum value of D_a shall not exceed D_c, and

$$H_a = \frac{(H + Y_n)}{2}$$ Equation 9-19

Where the maximum value of H_a shall not exceed H, and:

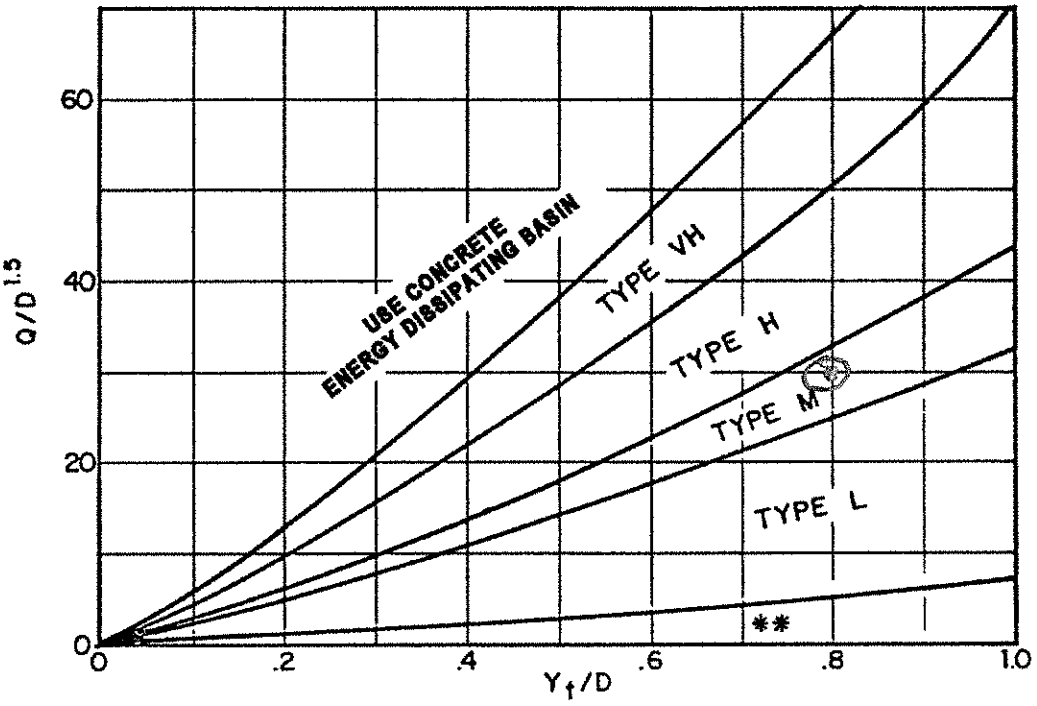
D_a = parameter to use in place of D in Figure 9-38 when flow is supercritical (ft)

D_c = diameter of circular culvert (ft)

H_a = parameter to use in place of H in Figure 9-39 when flow is supercritical (ft)

H = height of rectangular culvert (ft)

Y_n = normal depth of supercritical flow in the culvert (ft)

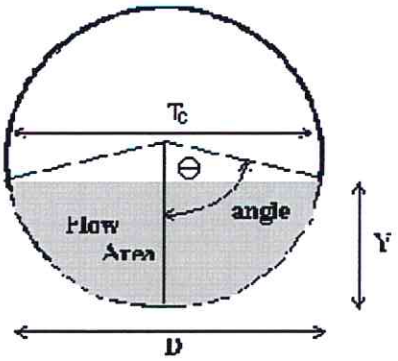


Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

Figure 9-38. Riprap erosion protection at circular conduit outlet (valid for Q/D2.5 ≤ 6.0)

CIRCULAR CONDUIT FLOW (Normal & Critical Depth Computation)

Project: 14028 Cherry Creek Crossing Filing No. 1, Lot 111
Pipe ID: Hodgen Road Culvert- Extended Condition



Design Information (Input)			
Pipe Invert Slope	So =	0.0190	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	54.00	inches
Design discharge	**Q =**	**163.00**	**cfs**

Full-flow Capacity (Calculated)			
Full-flow area	Af =	15.90	sq ft
Full-flow wetted perimeter	Pf =	14.14	ft
Half Central Angle	Theta =	3.14	radians
Full-flow capacity	Qf =	271.79	cfs

Calculation of Normal Flow Condition			
Half Central Angle (0<Theta<3.14)	Theta =	1.69	radians
Flow area	An =	9.13	sq ft
Top width	Tn =	4.47	ft
Wetted perimeter	Pn =	7.59	ft
Flow depth	Yn =	2.51	ft
Flow velocity	Vn =	17.86	fps
Discharge	Qn =	163.01	cfs
Percent Full Flow	Flow =	60.0%	of full flow
Normal Depth Froude Number	Fr_n =	2.20	supercritical

Calculation of Critical Flow Condition			
Half Central Angle (0<Theta-c<3.14)	Theta-c =	2.29	radians
Critical flow area	Ac =	14.09	sq ft
Critical top width	Tc =	3.39	ft
Critical flow depth	Yc =	3.73	ft
Critical flow velocity	Vc =	11.57	fps
Critical Depth Froude Number	Fr_c =	1.00	

NORTH
1" = 1000'

1 / .72 — SUB-BASIN #
— AREA (SM)

BASIN DIVIDE

103 Tc FLOWPATH

7 — DESIGN POINT

TR20 REACH ELEMENT

Lot 111

SCS No. 2

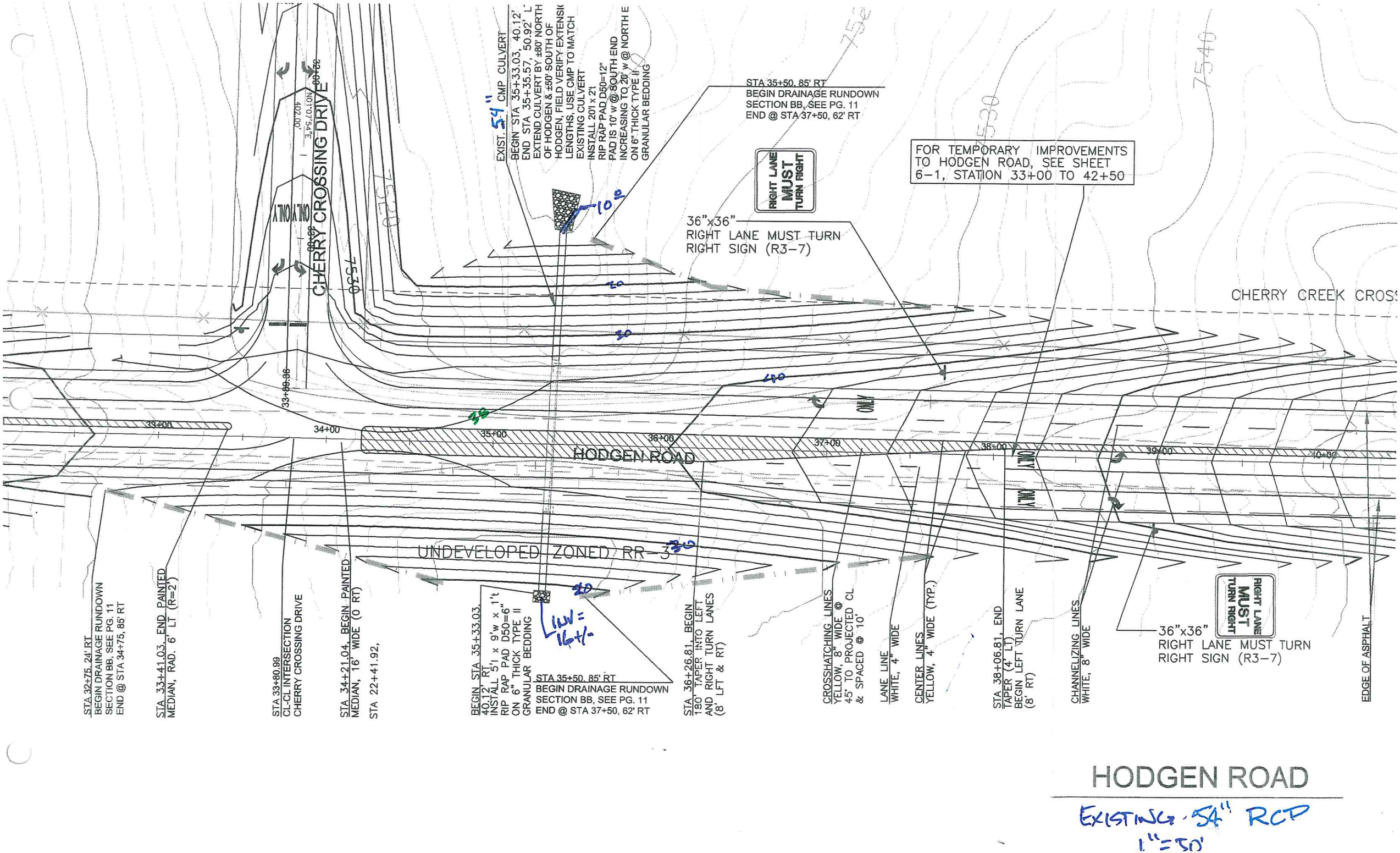
SCS No. 1

Cherry Creek

Hidden Valley Rd.

SH 83

TR/20 REACHES



HODGEN ROAD

EXISTING 54" RCP

1"=50'

KIOWA ENGINEERING CORPORATION

JOB Cherry Creek Valley Loft III
SHEET NO. 14028 OF 113
CALCULATED BY _____ DATE 7/17/18
CHECKED BY _____ DATE _____
SCALE Sed Basins.

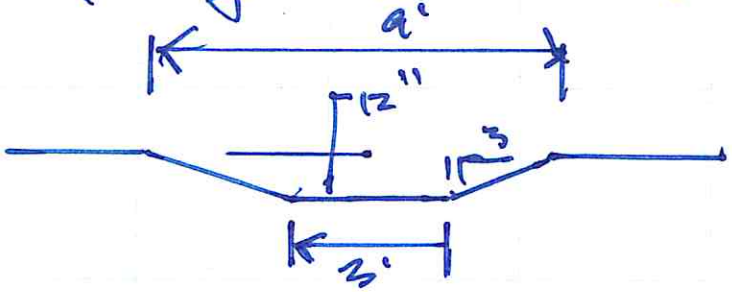
Spillways: Temp. Sediment Traps.

Sed. trap 1: DA = 1.4 ac - round up to 2 ac

∴ per SB details SC-7

Riser pipe = 6" PVC

Spillway D_{50} = 9" : Crest length = 3'

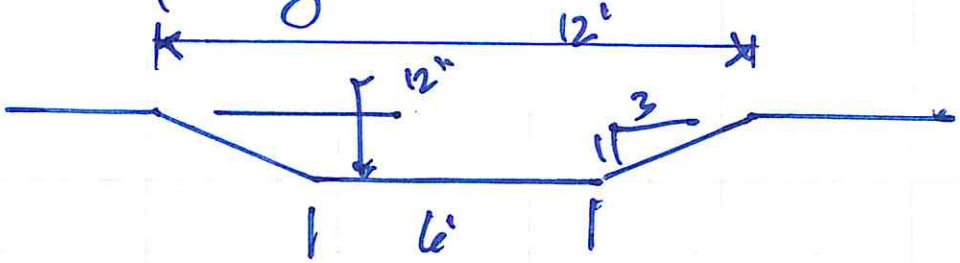


Sed Trap # 2: DA 5.3 Ac round to 5ac.

∴ per SB details SC-7

riser pipe = 6" PVC

Spillway D_{50} = 9" Crest length = 6'



Cherry Creek Crossing Lot 111
Sedimentation Basin 1
Volume Calculation

Stage	Elevation	Area sq. ft.	Area Acres	Avg. Area	Increment	Incremental Volume	Cumulative Volume
0	11	0	0.00				
				0.04	1	0.04	0.04
1	12	3,352	0.08				
				0.11	2	0.21	0.25
3	14	5,811	0.13				
				0.17	2	0.33	0.58
5	16	8,635	0.20				

Cherry Creek Crossing Lot 111
Sedimentation Basin 2
Volume Calculation

Stage	Elevation	Area sq. ft.	Area Acres	Avg. Area	Increment	Incremental Volume	Cumulative Volume
0	21	0	0.00				
				0.01	1	0.01	0.01
1	22	788	0.02				
				0.03	2	0.07	0.08
3	24	2,165	0.05				
				0.07	2	0.14	0.22
5	26	4,046	0.09				