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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Appendix A – Hydraulic Calculations

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
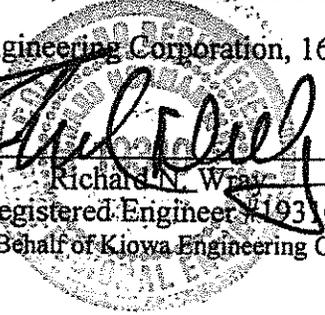
(signature)   8/3/18
Richard N. Wray   Date
Registered Engineer #19310
For and on Behalf of Kiowa Engineering Corporation

Developer's Statement:

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

Iber Advisors, LLC, General Partner

BY: _Nathan K. Miller, Managing Member_ 8/4/18
                                         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.   Date
County Engineer/ECM Administrator

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.
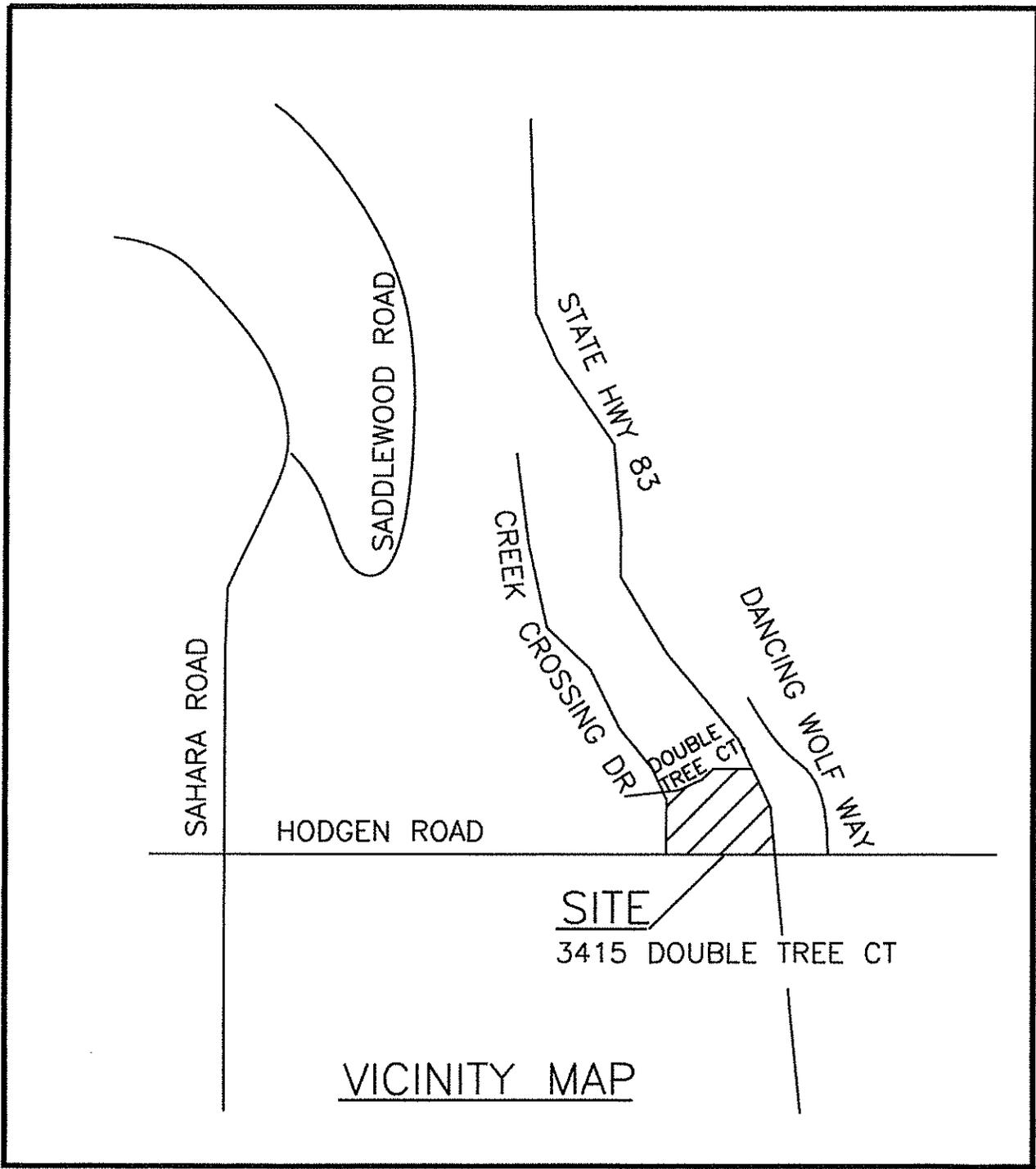
VICINITY MAP

LOT 40
DAVID L & VIRGINIA D READ
7498.0

LOT 37
KEVIN S & BRANDEE L KNOWLES

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

DOUBLE TREE COURT

EX. 24" CMP TO REMAIN

SITE ACCESS

EX. SWALE TO REMAIN

LEGEND

2.1 DESIGN POINT

$Q_5 = 75$ cfs
$Q_{100} = 163$ cfs

2.1

PROVIDE 40 LF 24" CMP

7516
7514
7512
SEDIMENT TRAP 2
7511.0
3:1
3:1
7512
7514
7516
7518

EX. RIPRAP RUNDOWN TO REMAIN

EXIST. 48" RCP

STA 5+07 2.0±

STA 5+00

6" RISER

6" RISER TOP=14.0 INV=13.75

0   60'   120'

HORIZONTAL SCALE: 1"=60'

EXIST. 24" CMP

RIPRAP CHANNEL SEE GRADING PLAN FOR SECTION.

LOW TAILWATER BASIN.

7502

54" RCP FES INV=7503.0
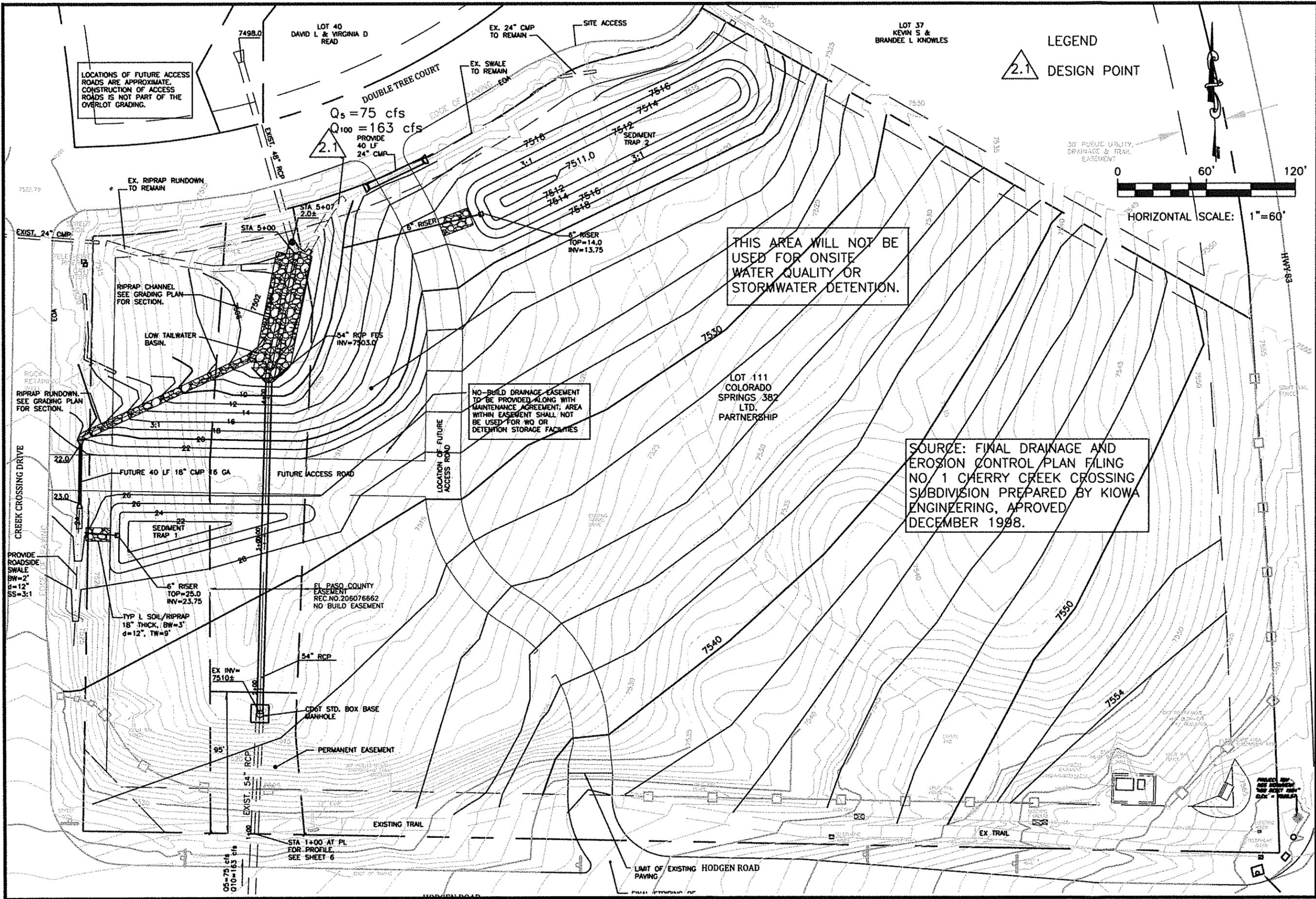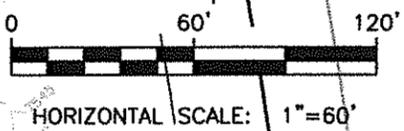
THIS AREA WILL NOT BE USED FOR ONSITE WATER QUALITY OR STORMWATER DETENTION.

30' PUBLIC UTILITY, DRAINAGE & TRAIL EASEMENT

RIPRAP RUNDOWN SEE GRADING PLAN FOR SECTION.

7530

LOT 111 COLORADO SPRINGS 382 LTD. PARTNERSHIP

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

12
14
16
18
20
22
3:1

CREEK CROSSING DRIVE

22.0

23.0

FUTURE 40 LF 18" CMP 16 GA

FUTURE ACCESS ROAD

LOCATION OF FUTURE ACCESS ROAD

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

7535

26
24
22
26
28

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

7540

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

54" RCP

EX INV= 7510±

EXIST. 54" RCP

95'

CDOT STD. BOX BASE MANHOLE

7540

7550

PERMANENT EASEMENT

EXISTING TRAIL

EX TRAIL

7554

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

$Q_5 = 75$ cfs
$Q_{10} = 163$ cfs

LIMIT OF EXISTING HODGEN ROAD PAVING

HODGEN ROAD

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

14028-FIG2.dwg/Jul 30, 2018/4:57pm

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.

FIRM

FLOOD INSURANCE RATE MAP

EL PASO COUNTY,
COLORADO AND
INCORPORATED AREAS

PANEL 285 OF 1300
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS: COMMUNITY	NUMBER	PANEL	SUFFIX
EL PASO COUNTY, UNINCORPORATED AREAS	080059	0285	F

MAP NUMBER
0804IC0285 F

EFFECTIVE DATE:
MARCH 17, 1997

Federal Emergency Management Agency

ZONE X

SH 83

N. CHERRY CK

22

HODGEN ROAD

LOT 111

83

ARENA ROAD

27

PROJECT SITE

EL PASO COUNTY
UNINCORPORATED AREAS
080059

ON THIS PANEL IS LOCATED WITHIN
: 66 WEST.

28

ROLLER COASTER ROAD

JOINS PANEL 0295
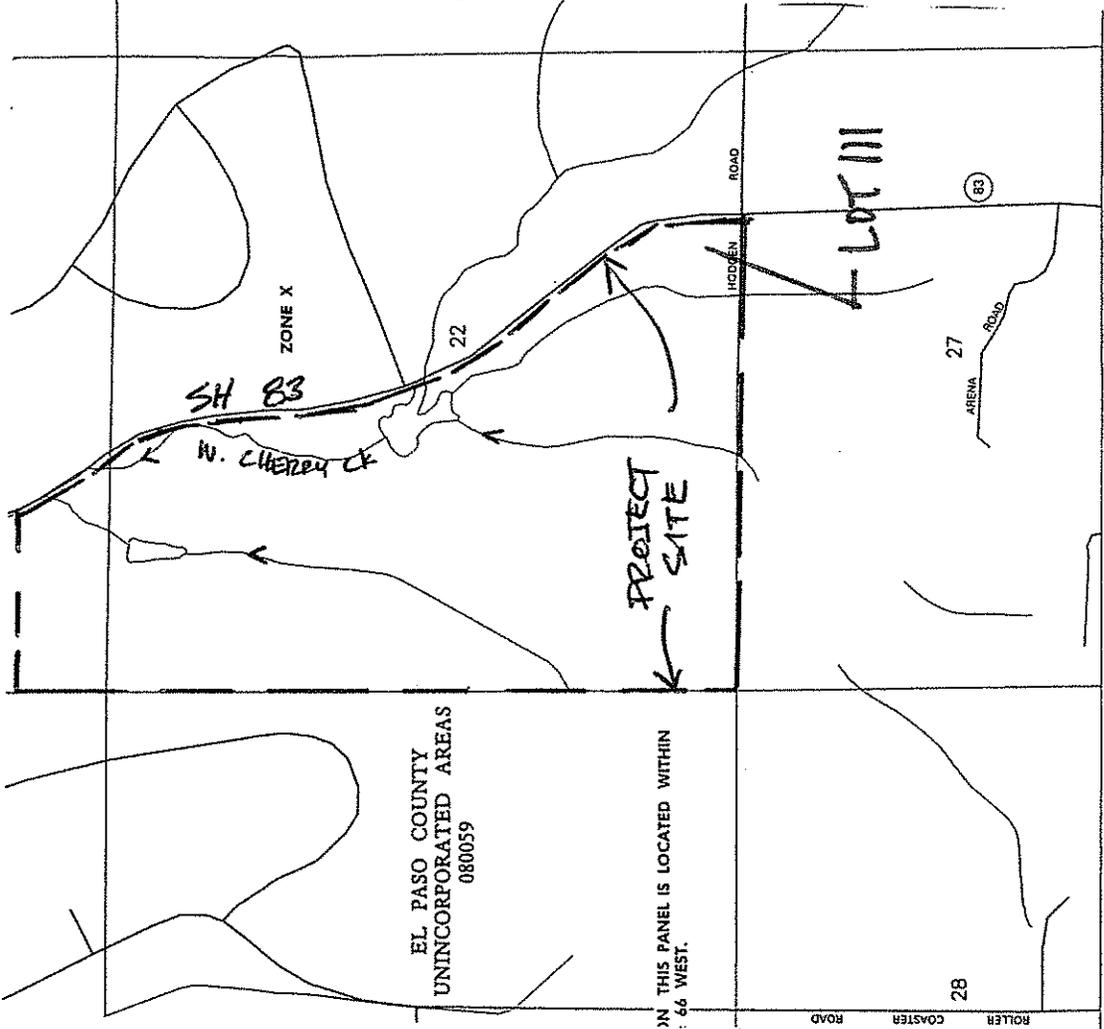
FIGURE 3
NO SCALE

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

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_o =	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	
					Invalid Entry	
					Invalid Entry	
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					Invalid Entry	

Handwritten annotations (left margin):

$Q_{100} = 163 cfs$

$HW/D = \dfrac{7.5}{4.5} = 1.67$

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

Total Rating Curve

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.

****

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

Culvert Length: 228.04 ft,   Culvert Slope: 0.0175

****

Culvert Performance Curve Plot: Culvert 1

Performance Curve

Culvert: Culvert 1

● Inlet Control Elev   ▲ Outlet Control Elev
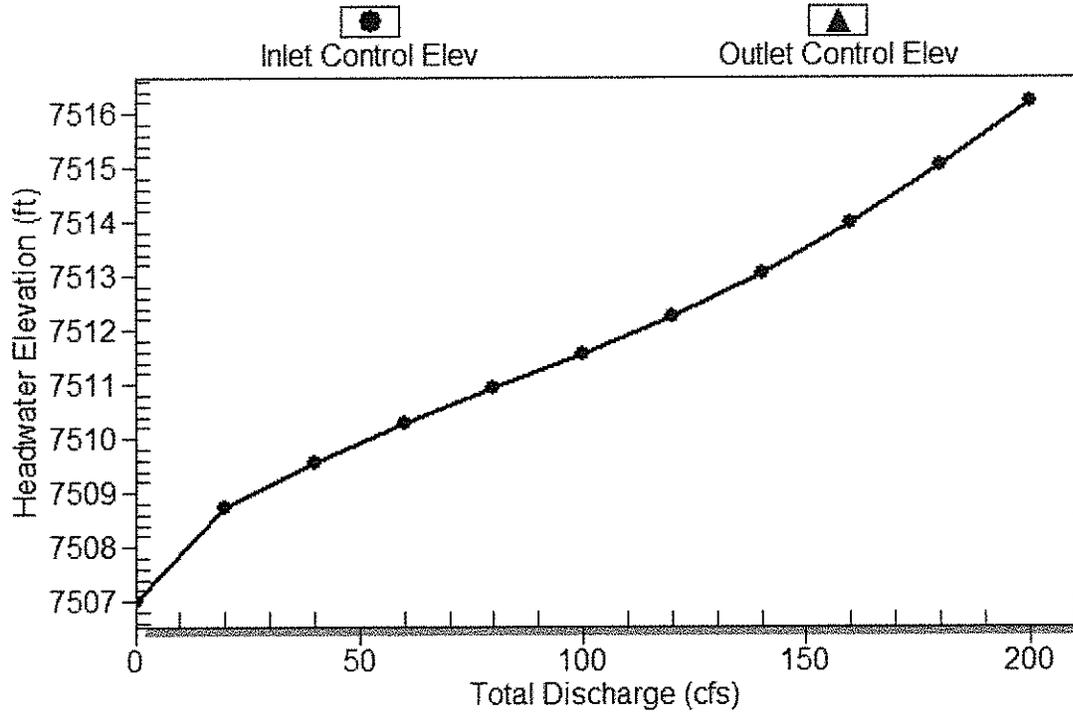
Water Surface Profile Plot for Culvert: Culvert 1

Crossing - 54-inch rcp, Design Discharge - 160.0 cfs

Culvert - Culvert 1, Culvert Discharge - 160.0 cfs
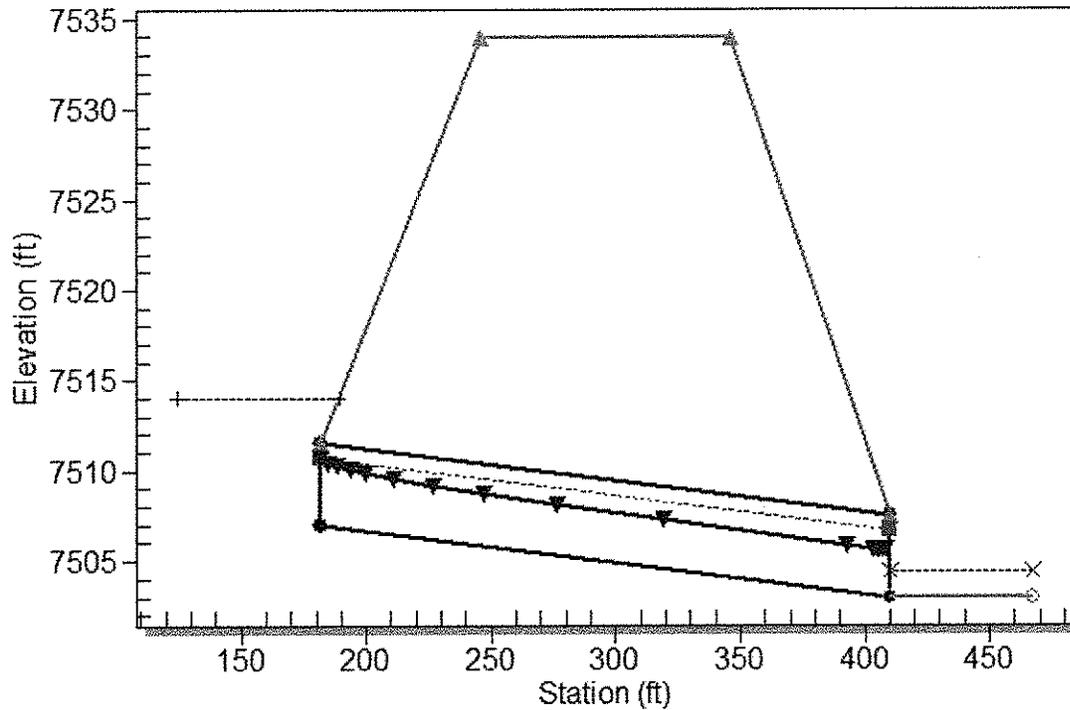
Site Data - Culvert 1

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 CT

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

Total Rating Curve
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.

****

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

Culvert Length: 130.06 ft,   Culvert Slope: 0.0308

***

Culvert Performance Curve Plot: Culvert 1

Performance Curve
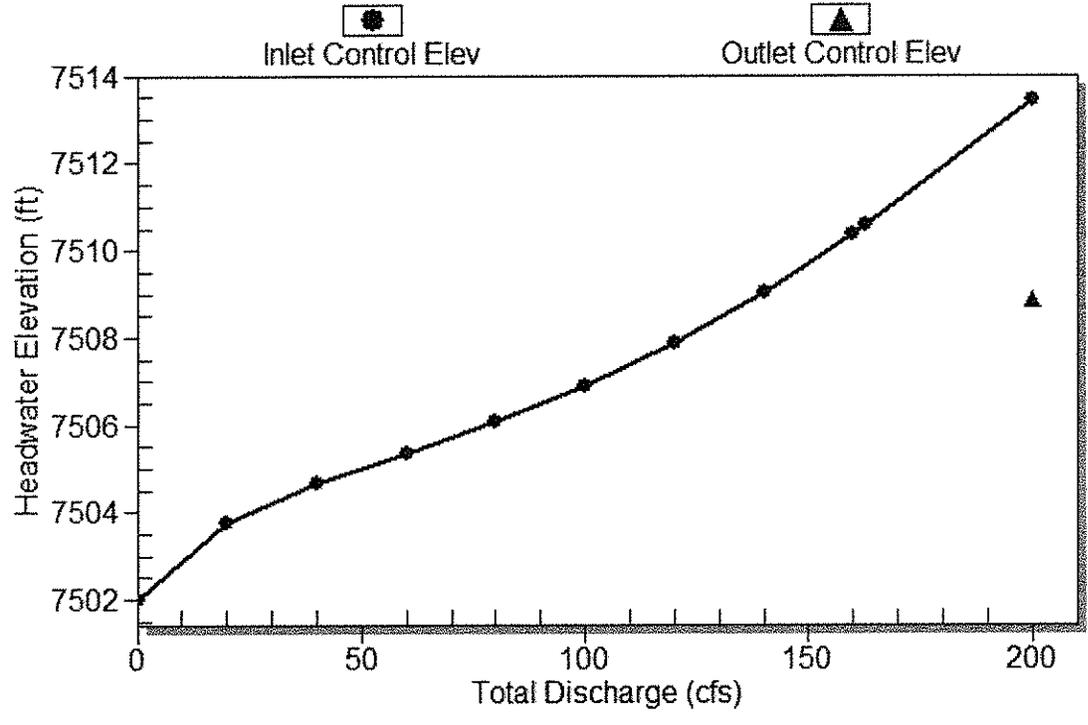
Culvert: Culvert 1

Water Surface Profile Plot for Culvert: Culvert 1

Crossing - ex double tree court 48", Design Discharge - 163.0 cfs

Culvert - Culvert 1, Culvert Discharge - 163.0 cfs
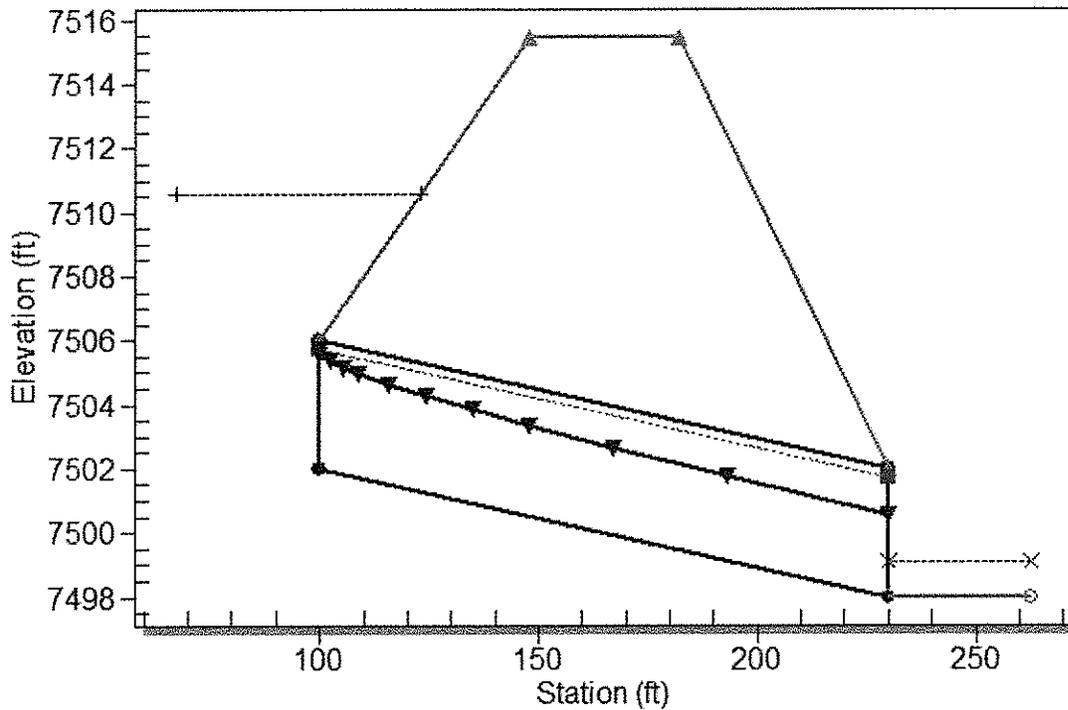
Site Data - Culvert 1

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 III_
SHEET NO. _14028_ OF _1 of 3_
CALCULATED BY _____ DATE _7-18-98_
CHECKED BY _____ DATE _JW_
SCALE _Hydraulics_

<u>Outlet Velocity @ 54" RCP</u> $Q_{100} = 163 \, cfs$

54" RCP x sec Area = 15.9 σ'

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

Check @ 2/3 full: Area = 10.3 sf
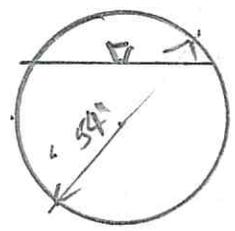
$$Q = \frac{1.49}{n} \, S^{1/2} A R^{2/3}$$

$$A = 10.3 \quad R \approx .90$$

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

$$Q = 156 \, cf: \quad check \; Velocity$$

$$\therefore V = (156)/10.3 = 15.1 \; fps$$

Per HY8 Analysis: V @ outlet = 17.1 fps

KIOWA ENGINEERING CORPORATION

JOB _Cherry Creek Crossy_
SHEET NO. _Lot 111_ OF _2 of 3_
CALCULATED BY _KOZB_ DATE _9/18/17_
CHECKED BY _PaJW_ DATE _Rev 2/12/18_
SCALE _Hydraulics_

Riprap Sizing

Slope outlet of .54 to 48" under Double Tree
$$S = .028 \, '/'$$

$$\frac{V S^{.17}}{(S_s - 1)^{.66}} = \frac{17.1 (.028)^{.17}}{(2.6 - 1)^{.66}} = \frac{9.31}{1.36}$$

$$= 6.8$$

Per Table 10-6 DCM

Rock Size > 4H 24" D_{50} — lower end

probably super critical @ outlet ∴ 10-6 <u>does</u>
<u>not</u> apply;

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

Check size of rock per UDFCD low
tailwater basin requirements.

KIOWA ENGINEERING CORPORATION

JOB Cherry Creek Crossing
SHEET NO. Lot 111 OF 3 of 3
CALCULATED BY 4028 DATE 7/17/18
CHECKED BY RJW DATE
SCALE Hydraulics -

54" outlet Protection

use USDCM chapt 9. Low tailwater basin.

per Fig 9-37

Rock Sizing: Figure 9-38

$$D = 4.5' \qquad y_t =$$

assume critical Flow depth in barrel
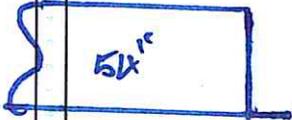
$$\therefore \quad D_a = \frac{D_c + y_n}{2} \qquad D_c = 3.73$$
$$y_n = 2.51$$

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

$$= 3.12$$

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

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

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:

$$T = 2D_{50} \hspace{6cm} \text{Equation 9-15}$$

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.

RIPRAP MORE THAN
1.0' ABOVE PIPE
INVERT SHALL BE
INSTALLED 6"
BELOW FINISHED
GRADE AND BURIED
WITH TOPSOIL

PLAN

END TREATMENT MAY CONSIST OF PIPE
HEADWALL OR FES HEADWALL

FINISHED
GRADE

JOINT
RESTRAINTS
(2)

RCP WITH
FES SHOWN

FES
HEADWALL
SHOWN

FINISHED
GRADE

D
SEE TABLE

SOIL RIPRAP OR
VOID-FILLED
RIPRAP

$T = 2D_{50}$ MIN

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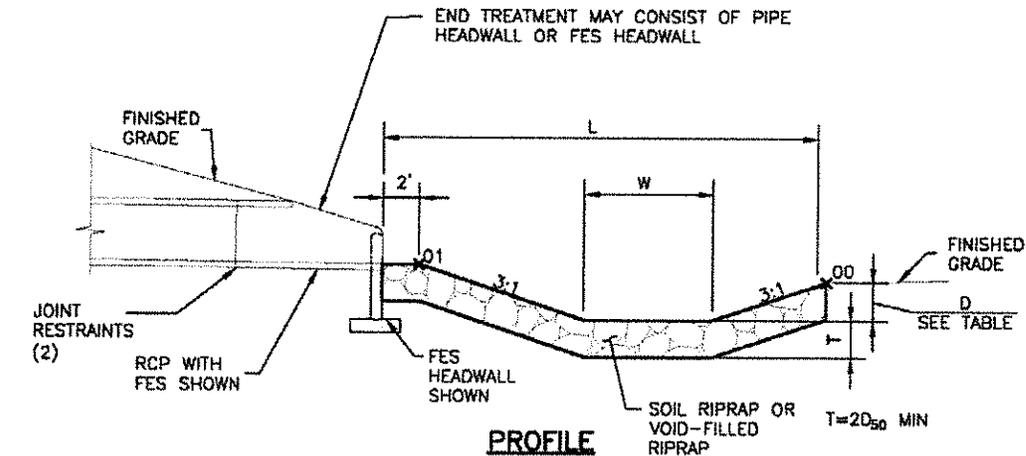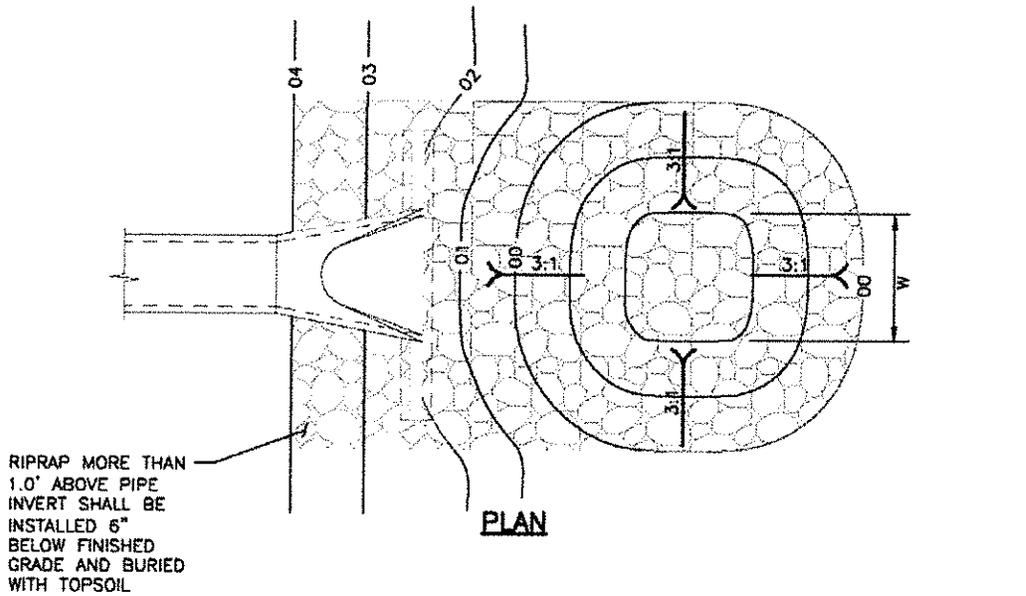
PIPE SIZE OR BOX HEIGHT	D	W*	L
18" – 24"	1'-0"	4'	15'
30" – 36"	1'-6"	6'	20'
42" – 48"	2'-0"	7'	24'
54" – 60"	2'-6"	8'	28'
66" – 72"	3'-0"	9'	32'

* 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:

$$d_{50} = \frac{0.023Q}{Y_t^{1.2}D_c^{0.3}}$$

Equation 9-16

Rectangular culvert:

$$d_{50} = \frac{0.014H^{0.5}Q}{Y_tW}$$

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:

$$D_a = \frac{(D_c + Y_n)}{2}$$

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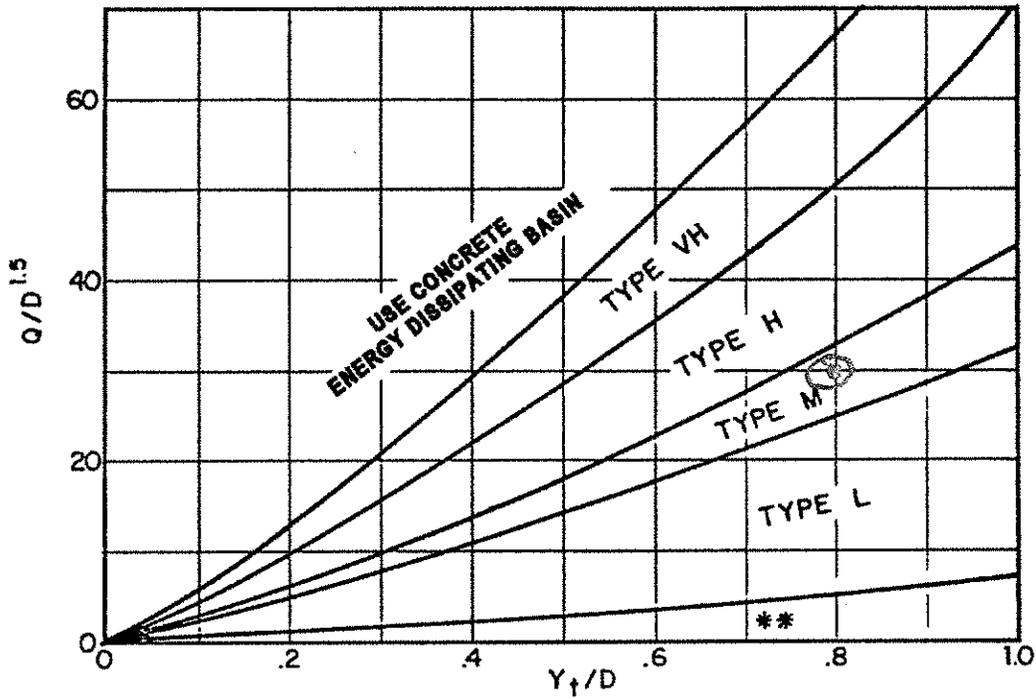
Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

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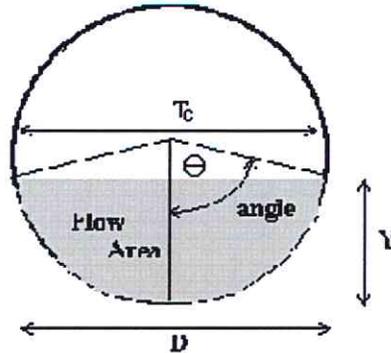
Design Information (Input)			
Pipe Invert Slope	So =	0.0190	ft/ft
Pipe Manning's n-value	n =	0.0130	
Pipe Diameter	D =	54.00	inches
Design discharge	**Q =**	**163.00**	**cfs**

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'

Lot H1

$\frac{1}{.72}$ — SUB-BASIN #
— AREA (SM)

— — — BASIN DIVIDE

$\boxed{103}$ — T_c FLOWPATH

$\triangle 7$ — DESIGN POINT

TR20 REACH ELEMENT

Cherry   Creek

SH 83

SCS No. 1

SCS NO. 2

TR/20 REACHES

CHERRY CROSSING DRIVE

EXIST. 54" CMP CULVERT
BEGIN STA 35+33.03, 40.12'
END STA 35+35.57, 50.92' L
EXTEND CULVERT BY ±80' NORTH
OF HODGEN & ±50' SOUTH OF
HODGEN, FIELD VERIFY EXTENSI
LENGTHS, USE CMP TO MATCH
EXISTING CULVERT
INSTALL 20'L x 2't
RIP RAP PAD D50=12"
PAD IS 10' w @ SOUTH END
INCREASING TO 20' w @ NORTH E
ON 6" THICK TYPE II
GRANULAR BEDDING

STA 35+50, 85' RT
BEGIN DRAINAGE RUNDOWN
SECTION BB, SEE PG. 11
END @ STA 37+50, 62' RT

RIGHT LANE MUST TURN RIGHT

FOR TEMPORARY IMPROVEMENTS
TO HODGEN ROAD, SEE SHEET
6-1, STATION 33+00 TO 42+50

36"x36"
RIGHT LANE MUST TURN
RIGHT SIGN (R3-7)

ONLY

CHERRY CREEK CROSS

HODGEN ROAD

ONLY

UNDEVELOPED ZONED RR-3

INV = 16+/-

RIGHT LANE MUST TURN RIGHT

36"x36"
RIGHT LANE MUST TURN
RIGHT SIGN (R3-7)

EDGE OF ASPHALT

STA 32+75 24' RT
BEGIN DRAINAGE RUNDOWN
SECTION BB, SEE PG. 11
END @ STA 34+75, 85' RT

STA 33+41.03, END PAINTED
MEDIAN, RAD. 6' LT (R=2)

CL-CL INTERSECTION
CHERRY CROSSING DRIVE

STA 34+21.04, BEGIN PAINTED
MEDIAN, 16' WIDE (0 RT)

STA 22+41.92,

BEGIN STA 35+33.03,
40.12' RT
INSTALL 5'L x 9'w x 1't
RIP RAP PAD D50=6"
ON 6" THICK TYPE II
GRANULAR BEDDING

STA 35+50, 85' RT
BEGIN DRAINAGE RUNDOWN
SECTION BB, SEE PG. 11
END @ STA 37+50, 62' RT

STA 36+26.81, BEGIN
180' TAPER INTO LEFT
AND RIGHT TURN LANES
(8' LFT & RT)

CROSSHATCHING LINES
YELLOW, 8" WIDE @
45° TO PROJECTED CL
& SPACED @ 10'

LANE LINE
WHITE, 4" WIDE

CENTER LINES
YELLOW, 4" WIDE (TYP.)

STA 38+06.81, END
TAPER (4' LT)
BEGIN LEFT TURN LANE
(8' RT)

CHANNELIZING LINES
WHITE, 8" WIDE

HODGEN ROAD

EXISTING 54" RCP

KIOWA ENGINEERING CORPORATION

JOB _Cherry Creek Ranch Lott 111_

SHEET NO. _14828_ OF _1/3_

CALCULATED BY _____ DATE _7/17/18_

CHECKED BY _____ DATE _Two_

SCALE _Sed Basins._
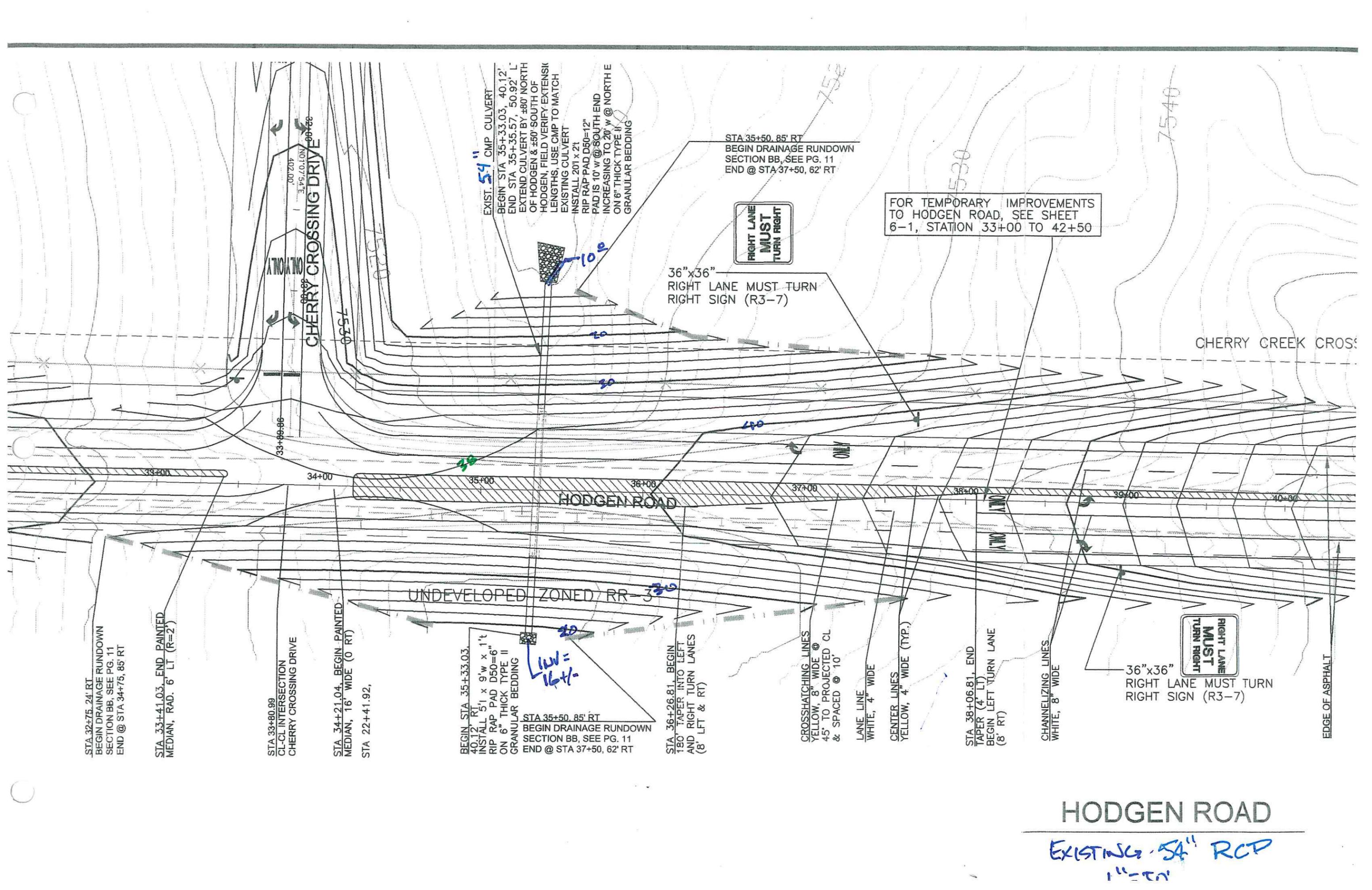
Spillways: Temp. Sediment Traps.

Sed. trap 1: DA = $\frac{1.4\,Ac}{}$ - round up to 2 Ac

∴ per SB details SC-7

riser pipe = 6" PVC

Spillway D_{50} = 9" : Crest length = 3'
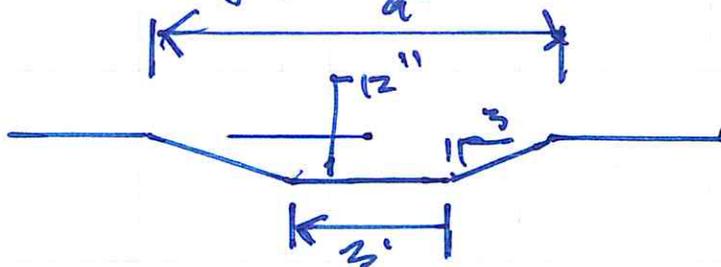
Sed. Trap #2: DA 5.3 Ac round to 5 ac.

∴ per SB details SC-7

riser pipe = 6" PVC

Spillway D_{50} = 9" Crest length = 6'
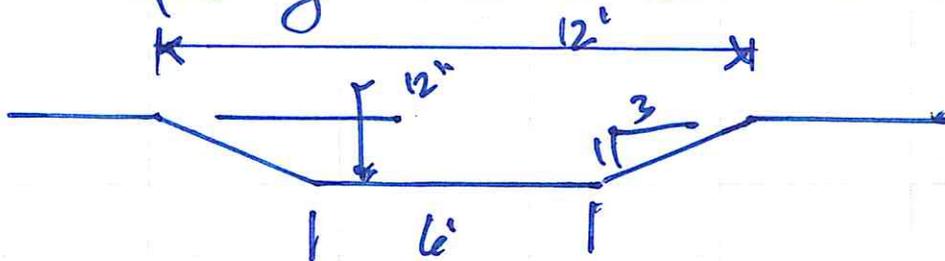
Cherry Creek Crossing Lot 111
Sedimentation Basin 1
Volume Calculation

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				