RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

Escalante Generating Station – Active Coal Combustion Residuals Landfill

Submitted To: Tri-State Generation and Transmission Association, Inc.
P.O. Box 33695
Denver, Colorado 80233

Submitted By: Golder Associates Inc.
44 Union Boulevard, Suite 300
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PROFESSIONAL ENGINEER
10/14/16

October 2016 **1663066**

Golder Associates

Table of Contents

List of Appendices

1.0 INTRODUCTION

This run-on and run-off control system (ROROCS) plan has been prepared by Golder Associates Inc. (Golder) on behalf of Tri-State Generation and Transmission Association, Inc. (Tri-State) for the active coal combustion residuals (CCR) landfill (the Facility) at the Escalante Generating Station, which is located near Prewitt, New Mexico. This ROROCS plan documents the Facility's run-on and run-off control system design and its compliance with the requirements of 40 CFR 257.81, including appropriate engineering calculations. This ROROCS plan is included in the Facility's operating record as required under 40 CFR 257.105(g)(3).

2.0 REGULATORY REQUIREMENTS

As required under 40 CFR 257.81, the owner or operator of an active CCR landfill must design, construct, operate, and maintain a run-on and run-off control system to appropriately manage surface water generated from a 25-year, 24-hour storm event. This includes the following:

- A run-on control system to prevent flow onto the active portion of the CCR landfill during the peak discharge from a 25-year, 24-hour storm event.
- A run-off control system from the active portion of the CCR landfill to collect and control the water volume resulting from the 25-year, 24-hour storm event.

In the context of the CCR Rule, "active portion" refers to constructed areas of an active CCR landfill on which a final cover system has not been constructed. The Facility encompasses approximately 48 acres. Currently, an area of the sideslopes totaling approximately 3 acres has received final cover.

3.0 DESIGN METHODOLOGY

3.1 Design Storm

The Facility's run-on and run-off control system is designed for hydraulic capacity to manage at least the 25-year, 24-hour storm event. A site-specific precipitation estimate corresponding to the design event was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 at the Facility location. The 25-year, 24-hour storm event generates 2.25 inches of precipitation at the Facility. Design calculations utilizing this design storm are included in Appendices A and B.

3.2 Rainfall Abstractions

Rainfall abstractions are water losses that occur before run-off begins. Losses may consist of infiltration, depression storage, and other factors. Rainfall abstractions can be estimated using the Soil Conservation Service (SCS) Method as presented in the following series of equations:

$$S = \frac{1000}{CN} - 10 \qquad \text{[Equation 1]}$$

$$I_a = 0.2S \qquad \text{[Equation 2]}$$

Therefore:

$$I_a = \frac{200}{CN} - 2$$ [Equation 3]

Where:
S = potential maximum retention after run-off begins (in)
CN = curve number
I_a = initial abstraction (in)

The initial abstraction is a function of the land use conditions as represented by the composite curve number for the tributary drainage area.

3.3 Routing Methodology

Stormwater calculations were performed using computer software (HEC-HMS) that employs the SCS Method to estimate run-on and run-off volumes. The routing methodology is described for the various engineering calculations in Appendices A and B.

4.0 RUN-ON CONTROL PLAN

Run-on is stormwater that may route towards the active portion of the Facility. Based on a review of the topography surrounding the Facility, run-on has the potential to enter the active portion from the west. A riprap-lined surface channel along the west perimeter of the Facility intercepts run-on and prevents flow onto the active portion. The surface channel is designed (by others) to convey run-on from the 100-year, 24-hour storm event, as shown in Appendix C. The existing condition represents the maximum expected run-on condition for the remaining life of the Facility.

5.0 RUN-OFF CONTROL PLAN

5.1 Active Portion of the Facility

Run-off from the CCR placement area (and other contributing areas) is contained within the CCR placement area by a containment berm maintained around its perimeter. The containment berm has a minimum height of 2 feet. The depth of water resulting from the design storm across the CCR placement area (and other contributing areas) is controlled behind the containment berm with ample freeboard, as demonstrated by the engineering calculations in Appendix A.

Run-off from future CCR placement areas (and other contributing areas) is contained within the Facility at the base of the CCR placement area along its western edge (contact water management area). The floor of the future CCR placement area, located to the west of the current CCR placement area, is graded to drain to the east so that run-off contributing to this area is collected in the contact water management area. The floor is also depressed approximately 5 feet relative to the surrounding topography so that run-off will be contained within the Facility footprint. The depth of water resulting from the design storm across the contributing areas is contained in the contact water management area with sufficient freeboard, as demonstrated by the engineering calculations in Appendix A.

The calculations in Appendix A were carried out based on existing topographic conditions, which reflect the highest contributing area for run-off. As fill sequencing progresses to the west, the contact water management area will also move west and the contributing area for run-off will decrease. Therefore, the existing condition represents the maximum run-off condition for the remaining life of the Facility.

5.2 Closed Portion of the Facility

During operation, the exterior sideslopes of the Facility will be covered periodically to limit the volume of contact water being generated. For future CCR placement, sloping benches will be constructed at approximate 15-foot vertical intervals to establish terrace channels for run-off control. Terrace channels will convey run-off to riprap-lined downchute channels and into a perimeter channel system. The terrace channels, downchute channels, and perimeter channels are capable of conveying run-off from the 25-year, 24-hour storm event, as demonstrated by the engineering calculations in Appendix B.

The calculations in Appendix B were carried out based on expected topographic conditions at Facility closure. This future condition represents the maximum run-off condition for the remaining life of the Facility.

6.0 CLOSING

As required under 40 CFR 257.81, the run-on and run-off control system for the active CCR landfill at Escalante Generating Station is designed to prevent flow onto the active portion of the CCR landfill during the peak discharge from a 25-year, 24-hour storm and to collect and control the water volume resulting from a 25-year, 24-hour storm.

GOLDER ASSOCIATES INC.

Micah Richey, PE
Project Engineer

Jason Obermeyer, PE
Associate and Senior Engineer

Tammy Rauen, PE
Senior Project Engineer

APPENDIX A
STORMWATER RUN-OFF CALCULATIONS – OPERATIONAL CONDITIONS

CALCULATIONS

Date:	October 13, 2016	**Made by:**	MBR
Project No.:	1663066	**Checked by:**	SPS
Site Name:	Escalante Generating Station Active Coal Combustion Residuals Landfill	**Reviewed by:**	JEO
Subject	**STORMWATER RUN-OFF CALCULATIONS – OPERATIONAL CONDITIONS**		

1.0 OBJECTIVES

These calculations have been carried out to meet the following objectives:

1. Estimate the run-off water depth generated from the 25-year, 24-hour storm across the coal combustion residuals (CCR) placement area (and other contributing areas) within the active CCR landfill and verify that the containment berms maintained around the perimeter of the CCR placement area will contain the design storm volume and prevent run-off.
2. Estimate the run-off depth generated from the 25-year, 24-hour storm that contributes to the future CCR placement area and verify that there is adequate capacity to control stormwater.

2.0 METHODOLOGY

2.1 Control of Run-off from the CCR Placement Area

The basin contributing to the CCR placement area (Basin AF) was delineated based on existing topography, as shown in Figure A-1. The United States Soil Conservation Service (USSCS) Curve Number Method was used to calculate the run-off volume due to the design storm. The depth of surface water resulting from the design storm was compared against the containment berm height to determine whether the containment berms maintained around the perimeter of the CCR placement area are sufficient to prevent run-off from the CCR placement area.

2.2 Control of Run-off from the Future CCR Placement Area

The basin contributing to the future CCR placement area (Basin RO) was delineated based on existing topography, as shown in Figure A-1. This basin includes portions of the sideslopes for the inactive CCR landfill. The USSCS Curve Number Method was used to calculate the run-off volume due to the design storm. The depth of surface water resulting from the design storm was compared against the perimeter embankment height to determine whether the available storage is sufficient to prevent run-off from the future CCR placement area.

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Project No.:	1663066	Made by:	MBR
Site Name:	Escalante Generation Station	Checked by:	SPS
Date:	October 13, 2016	Reviewed by:	JEO

3.0 ASSUMPTIONS

The following assumptions were made in carrying out the calculations:

- A design storm event of 2.25 inches was used in this analysis. This event is the 25-year-frequency, 24-hour-duration storm event from "NOAA Atlas 14" (Hydrometeorological Design Studies Center 2013), as shown in Attachment A-1.
- An SCS curve number of 99 was assumed for all basins, reflecting an impervious condition for conservatism.
- The stage-storage curve for the future CCR placement area was approximated with a 2% floor slope, 725 feet wide, with 3H:1V perimeter embankment slopes around three sides (north, east, and south).

4.0 RESULTS AND CONCLUSIONS

4.1 Control of Run-off from the CCR Placement Area

Basin delineations are identified on Figure A-1. The run-off water volume contributing to the CCR placement area due to the design storm and the resulting depth of water requiring containment for the existing condition are calculated in Table A-1. The depth of water requiring containment in the CCR placement area due to the design storm is 2.3 inches. The minimum 2-foot-high containment berms maintained around this area are sufficient to contain this depth of water with ample freeboard.

The run-off water volume routing onto the CCR placement area due to the design storm will change over time as CCR placement progresses. However, the ratio of total contributing area to run-off storage area is expected to remain approximately the same or decrease throughout the remaining life of the Facility. Correspondingly, the depth of water requiring containment in the CCR placement area is expected to remain approximately the same or decrease.

4.2 Control of Run-off from the Future CCR Placement Area

Basin delineations are identified on Figure A-1. The surface area of the basin that contributes run-off to the future CCR placement area will decrease over time as CCR placement progresses to the west. Thus, the existing condition represents the maximum run-off condition for the remaining life of the facility.

The run-off water volume contributing to the future CCR placement area for the existing condition due to the design storm is calculated in Table A-2. This volume of water, estimated as 329,000 cubic feet under the conservative assumption that an impervious material has been placed across the floor, will collect in the low points on the east side of the future CCR placement area (contact water containment areas). These areas are surrounded by 5-foot-high perimeter embankments. The volume from the design storm was compared to an estimated stage-storage curve for the contact water containment areas. The volume is

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Date:	October 13, 2016	Reviewed by:	JEO

estimated to reach a storage depth of approximately 4.1 feet, which leaves approximately 0.9 feet of freeboard as shown in Table A-2.

5.0 REFERENCES

Hydrometeorological Design Studies Center. 2013. Precipitation Frequency Data Server. National Oceanic and Atmospheric Administration (NOAA). Washington D. C.: NOAA.

United States Soil Conservation Service. 1986. Urban hydrology for small watersheds. Washington D.C.: United States Department of Agriculture.

United States Army Corps of Engineers Hydrologic Engineering Center. 2010. Hydrologic Modeling System (HEC-HMS). Version 3.5. Davis, California USA: United States Army Corps of Engineers.

TABLES

TABLE A-1
SUBBASIN SUMMARY TABLE

Tri State Generation & Transmission Association, Inc.
Escalante Generating Station
Project Number: 1663066

Date:	10/13/16
By:	MBR
Chkd:	SPS
Apprvd:	JEO

Design Storm 25 -Year Reccurence Interval

Storm Duration (hours)	2-Year Depth (inches)	25 -Year Depth (inches)	Storm Distribution
24	1.28	2.25	II

Subbasin ID	Subbasin Area (ft^2)	Subbasin Area (acres)	Subbasin Area (sq mile)	CN = 88 Desert Shrub, Poor Condition, HSG D (acres)	CN = 100 Impervious Areas (acres)	Composite SCS Curve No.	S = 1000 / CN - 10	Unit Runoff Q (in)	Runoff Volume (ac-ft)	Runoff Volume (ft^3)	Runoff Depth (in)
AF	367,435	8.4	0.0132		8.44	CN = 100	0.00	2.25	1.58	68,894	2.3
RO	1,755,037	40.3	0.0630		40.29	CN = 100	0.00	2.25	7.55	329,069	2.3

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TABLE A-2
FUTURE CCR PLACEMENT AREA STAGE-STORAGE CURVE

Date:	10/7/2016
By:	JEO
Chkd:	MBR
Approved:	TLR

Height (ft)	Area (ft^2)	Incremental Volume (ft^3)	Cumulative Volume (ft^3)
0.0	0	0	0
0.5	19,292	4,823	4,823
1.0	38,743	14,509	19,332
1.5	58,353	24,274	43,606
2.0	78,122	34,119	77,725
2.5	98,050	44,043	121,768
3.0	118,137	54,047	175,814
3.5	138,383	64,130	239,944
4.0	158,788	74,293	314,237
4.5	179,352	84,535	398,772
5.0	200,075	94,857	493,629

FIGURE

LEGEND

EXISTING GROUND SURFACE CONTOURS

SUBBASIN DELINEATION

AF — SUBBASIN ID

SUBBASIN INFORMATION

8.4 — SUBBASIN AREA (AC)

0 100 200

1" = 100' FEET

CLIENT
TRI-STATE G&T ASSOCIATION

PROJECT
TRI-STATE
2016 COAL COMBUSTION RESIDUALS ENGINEERING SUPPORT
ESCALANTE

TITLE
EXISTING RUN-ON/RUN-OFF CONDITIONS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-10-13
DESIGNED	AF
PREPARED	REDMOND
REVIEWED	MR
APPROVED	JO

PROJECT NO.	PHASE	REV.	FIGURE
1663066	0003	0	A-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

1 in

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ATTACHMENT A-1
NOAA ATLAS 14 DATA FOR ESCALANTE GENERATING STATION

NOAA Atlas 14, Volume 1, Version 5
Location name: Prewitt, New Mexico, US*
Latitude: 35.4158°, Longitude: -108.0746°
Elevation: 6867 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.177** (0.151-0.211)	**0.228** (0.195-0.271)	**0.307** (0.260-0.365)	**0.367** (0.310-0.435)	**0.453** (0.381-0.537)	**0.520** (0.434-0.616)	**0.591** (0.490-0.701)	**0.667** (0.548-0.791)	**0.771** (0.626-0.917)	**0.856** (0.689-1.02)
10-min	**0.270** (0.230-0.321)	**0.348** (0.296-0.413)	**0.467** (0.396-0.555)	**0.559** (0.472-0.663)	**0.689** (0.579-0.818)	**0.791** (0.660-0.938)	**0.899** (0.746-1.07)	**1.01** (0.833-1.20)	**1.17** (0.953-1.40)	**1.30** (1.05-1.55)
15-min	**0.334** (0.285-0.398)	**0.431** (0.367-0.512)	**0.579** (0.491-0.688)	**0.693** (0.586-0.821)	**0.854** (0.718-1.01)	**0.980** (0.818-1.16)	**1.11** (0.925-1.32)	**1.26** (1.03-1.49)	**1.45** (1.18-1.73)	**1.61** (1.30-1.93)
30-min	**0.450** (0.384-0.537)	**0.580** (0.494-0.689)	**0.780** (0.662-0.927)	**0.933** (0.789-1.11)	**1.15** (0.967-1.37)	**1.32** (1.10-1.57)	**1.50** (1.25-1.78)	**1.69** (1.39-2.01)	**1.96** (1.59-2.33)	**2.17** (1.75-2.59)
60-min	**0.557** (0.475-0.664)	**0.718** (0.612-0.853)	**0.965** (0.819-1.15)	**1.16** (0.976-1.37)	**1.42** (1.20-1.69)	**1.63** (1.36-1.94)	**1.86** (1.54-2.21)	**2.10** (1.72-2.48)	**2.42** (1.97-2.88)	**2.69** (2.17-3.21)
2-hr	**0.656** (0.558-0.779)	**0.841** (0.718-1.00)	**1.12** (0.946-1.33)	**1.34** (1.13-1.58)	**1.65** (1.39-1.95)	**1.91** (1.59-2.25)	**2.18** (1.80-2.58)	**2.47** (2.03-2.92)	**2.89** (2.33-3.41)	**3.23** (2.57-3.82)
3-hr	**0.700** (0.603-0.821)	**0.891** (0.766-1.05)	**1.17** (1.00-1.36)	**1.39** (1.19-1.62)	**1.70** (1.45-1.98)	**1.96** (1.65-2.28)	**2.23** (1.87-2.60)	**2.53** (2.10-2.94)	**2.95** (2.41-3.44)	**3.29** (2.66-3.85)
6-hr	**0.804** (0.705-0.929)	**1.01** (0.888-1.17)	**1.29** (1.13-1.49)	**1.52** (1.33-1.75)	**1.84** (1.59-2.12)	**2.10** (1.80-2.41)	**2.37** (2.03-2.72)	**2.65** (2.25-3.04)	**3.05** (2.55-3.51)	**3.38** (2.80-3.90)
12-hr	**0.915** (0.806-1.04)	**1.15** (1.01-1.31)	**1.45** (1.27-1.65)	**1.69** (1.48-1.91)	**2.01** (1.76-2.27)	**2.26** (1.97-2.56)	**2.52** (2.18-2.85)	**2.81** (2.41-3.18)	**3.20** (2.72-3.64)	**3.53** (2.97-4.02)
24-hr	**1.02** (0.922-1.14)	**1.28** (1.16-1.43)	**1.62** (1.45-1.79)	**1.88** (1.69-2.08)	**2.25** (2.01-2.49)	**2.54** (2.26-2.81)	**2.83** (2.51-3.13)	**3.14** (2.77-3.47)	**3.56** (3.11-3.94)	**3.89** (3.38-4.31)
2-day	**1.15** (1.04-1.28)	**1.44** (1.30-1.60)	**1.80** (1.63-2.00)	**2.09** (1.88-2.32)	**2.48** (2.23-2.75)	**2.79** (2.50-3.09)	**3.10** (2.77-3.43)	**3.42** (3.04-3.79)	**3.86** (3.40-4.27)	**4.19** (3.67-4.65)
3-day	**1.25** (1.14-1.39)	**1.57** (1.42-1.74)	**1.96** (1.77-2.17)	**2.27** (2.04-2.51)	**2.68** (2.41-2.97)	**3.01** (2.70-3.32)	**3.34** (2.98-3.69)	**3.68** (3.27-4.06)	**4.13** (3.65-4.56)	**4.48** (3.93-4.96)
4-day	**1.36** (1.23-1.50)	**1.69** (1.54-1.88)	**2.11** (1.91-2.34)	**2.44** (2.21-2.70)	**2.88** (2.60-3.18)	**3.22** (2.90-3.56)	**3.58** (3.20-3.94)	**3.93** (3.50-4.33)	**4.40** (3.90-4.86)	**4.76** (4.20-5.26)
7-day	**1.60** (1.46-1.77)	**2.01** (1.82-2.21)	**2.48** (2.26-2.74)	**2.86** (2.59-3.15)	**3.36** (3.04-3.69)	**3.74** (3.37-4.11)	**4.12** (3.70-4.53)	**4.51** (4.03-4.96)	**5.01** (4.46-5.51)	**5.40** (4.78-5.95)
10-day	**1.82** (1.65-2.00)	**2.27** (2.07-2.50)	**2.82** (2.56-3.10)	**3.24** (2.94-3.55)	**3.81** (3.44-4.17)	**4.23** (3.82-4.63)	**4.66** (4.19-5.10)	**5.08** (4.56-5.57)	**5.64** (5.04-6.19)	**6.06** (5.39-6.66)
20-day	**2.38** (2.17-2.61)	**2.97** (2.71-3.26)	**3.67** (3.34-4.02)	**4.20** (3.82-4.60)	**4.89** (4.44-5.36)	**5.41** (4.90-5.92)	**5.93** (5.35-6.49)	**6.44** (5.79-7.05)	**7.09** (6.35-7.79)	**7.58** (6.75-8.33)
30-day	**2.89** (2.63-3.15)	**3.61** (3.29-3.94)	**4.42** (4.03-4.83)	**5.04** (4.58-5.49)	**5.83** (5.29-6.34)	**6.40** (5.80-6.97)	**6.96** (6.30-7.58)	**7.51** (6.78-8.17)	**8.20** (7.37-8.94)	**8.70** (7.79-9.50)
45-day	**3.50** (3.19-3.82)	**4.36** (3.98-4.76)	**5.32** (4.85-5.80)	**6.01** (5.48-6.56)	**6.89** (6.27-7.51)	**7.52** (6.83-8.20)	**8.12** (7.36-8.86)	**8.69** (7.86-9.48)	**9.39** (8.47-10.3)	**9.88** (8.89-10.8)
60-day	**4.05** (3.67-4.42)	**5.04** (4.58-5.51)	**6.14** (5.57-6.70)	**6.93** (6.28-7.56)	**7.91** (7.16-8.62)	**8.61** (7.79-9.38)	**9.28** (8.38-10.1)	**9.90** (8.92-10.8)	**10.7** (9.58-11.6)	**11.2** (10.1-12.2)

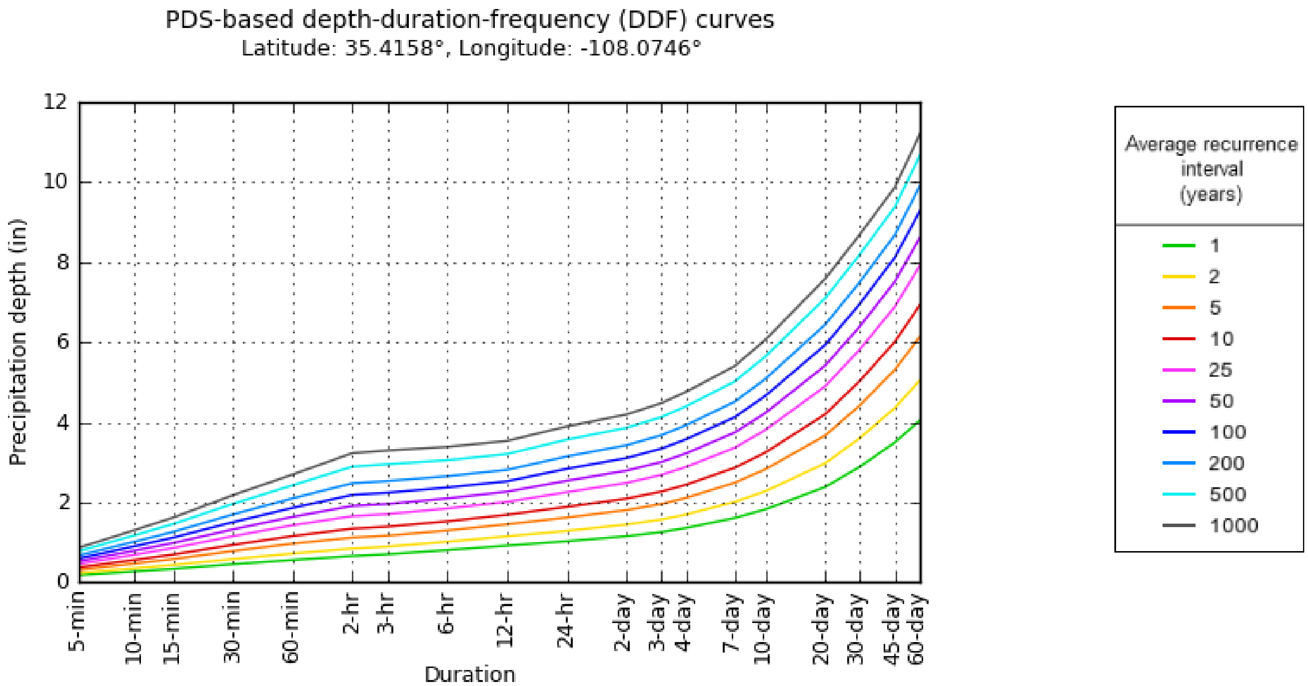
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

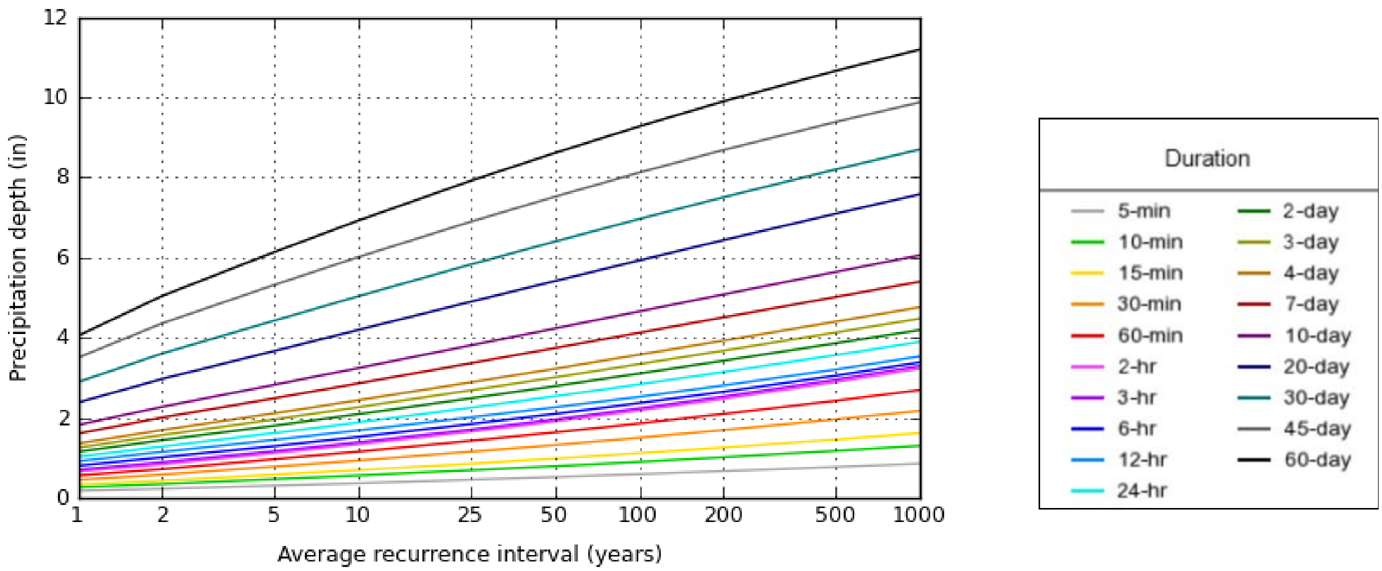
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical





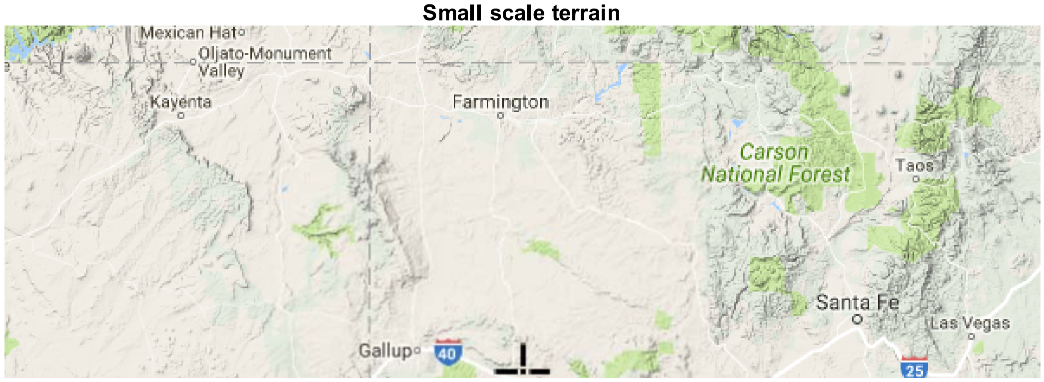
NOAA Atlas 14, Volume 1, Version 5

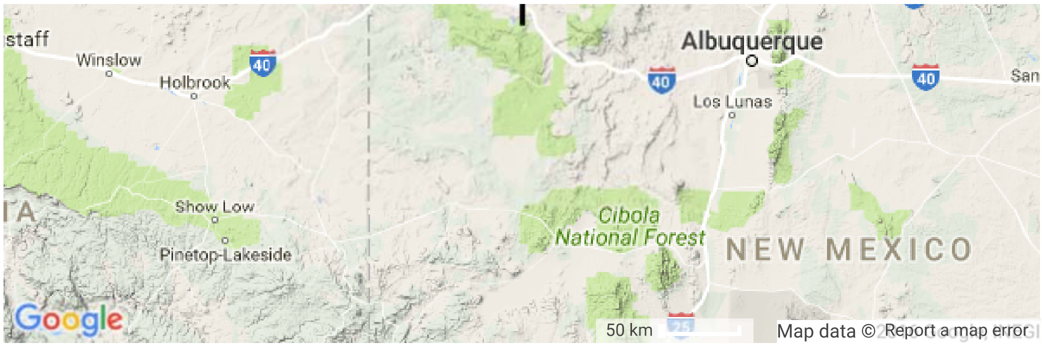
Created (GMT): Tue Aug 30 15:46:24 2016

Back to Top

Maps & aerials

Small scale terrain

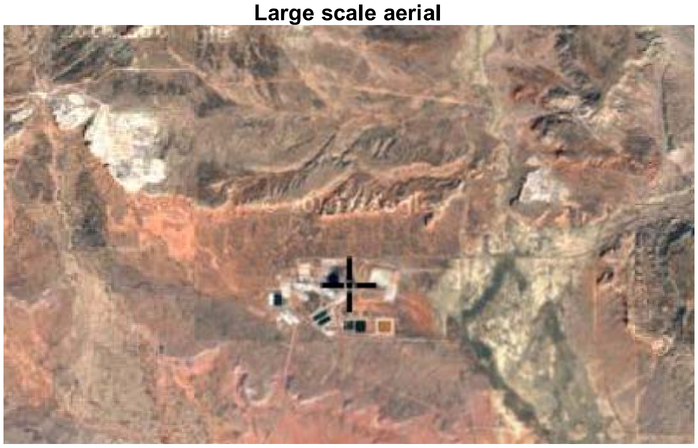




Large scale terrain

Large scale map

Large scale aerial



Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX B
STORMWATER RUN-OFF CALCULATIONS – CLOSURE CONDITIONS

Date:	October 13, 2016	**Made by:**	SPS
Project No.:	1663066	**Checked by:**	MBR
Site Name:	Escalante Generating Station Active Coal Combustion Residuals Landfill	**Reviewed by:**	JEO
Subject:	**STORMWATER RUN-OFF CALCULATIONS – CLOSURE CONDITIONS**		

1.0 OBJECTIVE

Determine the run-off water volume generated from the 25-year, 24-hour storm after closure of the active coal combustion residuals (CCR) landfill (the Facility) at the Escalante Generating Station and verify that the proposed channels (terrace channels, roadside channels, perimeter channels, and downchutes) as well as existing and proposed culvert crossings will adequately control stormwater run-off.

2.0 METHODOLOGY

Basins for the surface water control system were delineated based on existing and possible future channels and topography, shown in Figure B-1. Times of concentration were calculated using the methodology described in TR-55 (US SCS 1986) for sheet flow, shallow concentrated flow, and channel flow. HEC-HMS modeling software (US CoE Hydrologic Engineering Center 2015) was used to simulate the routing of surface run-off from the proposed slopes and the resulting peak flows that will occur. Peak flows were used to analyze terrace channels and downchutes using Manning's normal depth flow equations. Existing and proposed culverts were analyzed using the Federal Highway Administration's HY-8 modeling software (FHWA 2014).

3.0 ASSUMPTIONS

- A design storm event of 2.25 inches was used in this analysis. This event is the 25-year frequency, 24-hour duration, storm event from "NOAA Atlas 14" (HDSC 2013).
- The 2-year frequency, 24-hour duration storm depth, which is used in the TR-55 time of concentration method, is 1.28 inches (HDSC 2013).
- The design storm is distributed in time as an SCS Type II synthetic distribution.
- Lag time is equal to 60% of the time of concentration.
- The minimum lag time is 3.6 minutes (based on a minimum time of concentration of 6 minutes per TR-55).
- Maximum length of sheet flow is 100 feet.
- Kinematic wave methodology was used to route peak flows in the HEC-HMS model; some reaches did not include routing for conservatism and simplicity.

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- An SCS curve number of 88 was assumed for all basins, except for the active landfill face, reflecting a condition with established native vegetation (assumed to be desert shrub in poor condition, based on site observations) and hydrologic soil group (HSG) D.
- A Manning's roughness coefficient of 0.040 for capacity (0.035 for velocity) was assumed for riprap-lined channels. A Manning's roughness coefficient of 0.025 for capacity was assumed for earth-lined channels.

4.0 RESULTS AND CONCLUSIONS

Basin delineations are identified on Figure B-1. The run-off water volume routed from the Facility due to the design storm is calculated in Table B-1, basin time of concentration calculations are summarized in Table B-2, and the results of the peak discharge routing analysis are provided in Table B-3. Schematics of the HEC-HMS basin routing analysis and input values are provided in Attachment B-1.

The analysis of the terrace channel, roadside channel, and downchute reaches are summarized in Table B-4, with peak flows, depths, and velocities associated with the design storm event. All downchutes and channels will convey the 25-year, 24-hour peak flow event with a minimum freeboard of 1 foot. The three proposed downchutes and the roadside channel will require riprap channel lining. The required median diameter for riprap is summarized in Table B-5. An energy dissipation structure has been designed at the toe of each downchute. The minimum lengths of the energy dissipation structures are summarized in Table B-6.

The results of the culvert analysis are provided in Attachment B-2. Proposed culvert sizes to adequately convey the peak design discharges have been determined for the run-off reporting to the west side (one 24" corrugated metal pipe) and the southeast side (two 30" corrugated metal pipes) of the Facility. The existing culvert on the west side of the facility will need to be replaced with two 30" corrugated metal pipes at or before Facility closure.

5.0 REFERENCES

Bentley Systems, Inc. 2009. Bentley FlowMaster V8i [software package]. Watertown, CT: Bentley Systems, Inc.

Federal Highway Administration (FHWA). 2014. HY-8 Culvert Analysis Program [software package]. Version 7.3. August 2014.

Hydrometeorological Design Studies Center (HDSC). 2013. Precipitation Frequency Data Server. National Oceanic and Atmospheric Administration (NOAA). Washington D.C.: NOAA.

United States Soil Conservation Service (US SCS). 1986. Urban Hydrology for Small Watersheds. Washington D.C.: United States Department of Agriculture.

United States Army Corps of Engineers (US CoE) Hydrologic Engineering Center. 2015. Hydrologic Modeling System (HEC-HMS). (4.1). Davis, California, USA: US CoE. July 31.

TABLES

TABLE B-1
SUBBASIN SUMMARY TABLE

Tri State Generation & Transmission
Escalante Station
Project Number: 1663066

Date:	10/13/16
By:	MBR
Chkd:	SPS
Apprvd:	JEO

Design Storm **25 -Year Reccurence Interval**

Storm Duration (hours)	2-Year Depth (inches)	25 -Year Depth (inches)	Storm Distribution
24	1.28	2.25	II

Subbasin ID	Subbasin Area (ft^2)	Subbasin Area (acres)	Subbasin Area (sq mile)	CN = 88 Desert Shrub, Poor Condition, HSG D (acres)	Composite SCS Curve No.	$S = \frac{1000}{CN} - 10$	Unit Runoff Q (in)	Runoff Volume (ac-ft)	Runoff Volume (ft^3)
S1	222,079	5.1	0.0080	5.1	CN = 88	1.36	1.17	0.50	21,657
S2	182,650	4.2	0.0066	4.2	CN = 88	1.36	1.17	0.41	17,812
SE1	216,369	5.0	0.0078	5.0	CN = 88	1.36	1.17	0.48	21,100
SE2	102,860	2.4	0.0037	2.4	CN = 88	1.36	1.17	0.23	10,031
SE3	81,656	1.9	0.0029	1.9	CN = 88	1.36	1.17	0.18	7,963
SE L	72,826	1.7	0.0026	1.7	CN = 88	1.36	1.17	0.16	7,102
SE4	77,726	1.8	0.0028	1.8	CN = 88	1.36	1.17	0.17	7,580
SE5	112,908	2.6	0.0041	2.6	CN = 88	1.36	1.17	0.25	11,011
E1	118,610	2.7	0.0043	2.7	CN = 88	1.36	1.17	0.27	11,567
E2	124,238	2.9	0.0045	2.9	CN = 88	1.36	1.17	0.28	12,115
N1	145,290	3.3	0.0052	3.3	CN = 88	1.36	1.17	0.33	14,168
N2	139,592	3.2	0.0050	3.2	CN = 88	1.36	1.17	0.31	13,613
W1	201,147	4.6	0.0072	4.6	CN = 88	1.36	1.17	0.45	19,616
W2	338,546	7.8	0.0121	7.8	CN = 88	1.36	1.17	0.76	33,015
EX E	931,062	21.4	0.0334	21.4	CN = 88	1.36	1.17	2.08	90,796
EX W	1,081,771	24.8	0.0388	24.8	CN = 88	1.36	1.17	2.42	105,493
Total:	6,271,799	144.0	0.22					14.85	646,862

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TABLE B-2
BASIN TIME OF CONCENTRATION CALCULATIONS

Tri State Generation & Transmission
Escalante Station
Project Number: 1663066

Date:	10/13/16
By:	MBR
Chkd:	SPS
Apprvd:	SPS

					Flow Segment 1							Flow Segment 2						
Subbasin ID	Subbasin Area (sq mile)	Composite Curve Number	Total Lag (0.6*Tc) (min)	Total Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition(1)		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition(1)		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
S1	0.0080	88	9.5	15.8	Sheet	100.0	0.020	H	Range		13.8	Shallow	235.0	0.020	U	Unpaved		1.7
S2	0.0066	88	5.3	8.9	Sheet	45.0	0.330	H	Range		2.4	Channel	430.0	0.020	E	Earth-lined	0.23	2.3
SE1	0.0078	88	4.7	7.9	Sheet	45.0	0.330	H	Range		2.4	Channel	1075.0	0.020	E	Earth-lined	0.24	5.5
SE2	0.0037	88	4.7	7.8	Sheet	72.0	0.330	H	Range		3.5	Channel	790.0	0.020	E	Earth-lined	0.22	4.3
SE3	0.0029	88	8.5	14.1	Sheet	90.0	0.330	H	Range		4.1	Channel	1150.0	0.005	E	Earth-lined	0.31	10.0
SE L	0.0026	88	5.8	9.7	Sheet	135.0	0.330	H	Range		5.7	Channel	465.0	0.005	E	Earth-lined	0.32	3.9
SE4	0.0028	88	2.7	4.6	Sheet	45.0	0.330	H	Range		2.4	Channel	340.0	0.020	E	Earth-lined	0.17	2.2
SE5	0.0041	88	7.8	12.9	Sheet	130.0	0.330	H	Range		5.6	Channel	770.0	0.003	E	Earth-lined	0.39	7.4
E1	0.0043	88	11.3	18.9	Sheet	100.0	0.020	H	Range		13.8	Shallow	365.0	0.020	U	Unpaved		2.7
E2	0.0045	88	3.5	5.9	Sheet	45.0	0.330	H	Range		2.4	Channel	470.0	0.020	E	Earth-lined	0.20	2.7
N1	0.0052	88	11.1	18.6	Sheet	100.0	0.020	H	Range		13.8	Shallow	215.0	0.020	U	Unpaved		1.6
N2	0.0050	88	11.0	18.3	Sheet	100.0	0.020	H	Range		13.8	Shallow	200.0	0.020	U	Unpaved		1.5
W1	0.0072	88	11.3	18.8	Sheet	100.0	0.020	H	Range		13.8	Shallow	385.0	0.020	U	Unpaved		2.8
W2	0.0121	88	5.1	8.4	Sheet	45.0	0.330	H	Range		2.4	Channel	905.0	0.020	E	Earth-lined	0.28	4.2
EX E	0.0334	88	17.2	28.6	Sheet	100.0	0.020	H	Range		13.8	Shallow	460.0	0.020	U	Unpaved		3.4
EX W	0.0388	88	17.0	28.3	Sheet	100.0	0.020	H	Range		13.8	Shallow	455.0	0.020	U	Unpaved		3.3

TABLE B-2
BASIN TIME OF CONCENTRATION CALCULATIONS

Tri State Generation & Transmission
Escalante Station
Project Number: 1663066

Date:	10/13/16
By:	MBR
Chkd:	SPS
Apprvd:	SPS

			Flow Segment 3							Flow Segment 4						
Subbasin ID	Subbasin Area (sq mile)	Composite Curve Number	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition(1)		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition(1)		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
S1	0.0080	88	Shallow	40	0.330	U	Unpaved		0.1	Channel	40	0.020	E	Earth-lined	0.21	0.2
S2	0.0066	88	Channel	1145	0.065	R	Riprap	0.33	4.2							
SE1	0.0078	88														
SE2	0.0037	88														
SE3	0.0029	88														
SE L	0.0026	88														
SE4	0.0028	88														
SE5	0.0041	88														
E1	0.0043	88	Shallow	70	0.330	U	Unpaved		0.1	Channel	370	0.020	E	Earth-lined	0.18	2.3
E2	0.0045	88	Channel	210	0.330	R	Riprap	0.10	0.8							
N1	0.0052	88	Shallow	65	0.330	U	Unpaved		0.1	Channel	530	0.020	E	Earth-lined	0.20	3.1
N2	0.0050	88	Shallow	65	0.330	U	Unpaved		0.1	Channel	495	0.020	E	Earth-lined	0.20	2.9
W1	0.0072	88	Channel	380	0.020	E	Earth-lined	0.20	2.2							
W2	0.0121	88	Channel	160	0.330	R	Riprap	0.18	0.4	Channel	330	0.010	E	Earth-lined	0.50	1.5
EX E	0.0334	88	Shallow	220	0.330	U	Unpaved		0.4	Channel	535	0.007	E	Earth-lined	0.54	2.7
EX W	0.0388	88	Shallow	215	0.330	U	Unpaved		0.4	Channel	2000	0.007	E	Earth-lined	0.49	10.8

TABLE B-2
BASIN TIME OF CONCENTRATION CALCULATIONS

Tri State Generation & Transmission
Escalante Station
Project Number: 1663066

Date:	10/13/16
By:	MBR
Chkd:	SPS
Apprvd:	SPS

			Flow Segment 5						
Subbasin ID	Subbasin Area (sq mile)	Composite Curve Number	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[1]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
S1	0.0080	88							
S2	0.0066	88							
SE1	0.0078	88							
SE2	0.0037	88							
SE3	0.0029	88							
SE L	0.0026	88							
SE4	0.0028	88							
SE5	0.0041	88							
E1	0.0043	88							
E2	0.0045	88							
N1	0.0052	88							
N2	0.0050	88							
W1	0.0072	88							
W2	0.0121	88							
EX E	0.0334	88	Channel	1690	0.010	E	Earth-lined	0.43	8.3
EX W	0.0388	88							

TABLE B-3
FLOW RESULTS FROM HEC-HMS

Tri State Generation & Transmission
Escalante Station
Project Number: 1663066

Date:	10/13/16
By:	MBR
Chkd:	SPS
Apprvd:	JEO

HEC-HMS Basin Model:	Escalante Runoff
HEC-HMS Met. Model:	25-yr, 24-hr
HEC-HMS Control Specs:	48-hr, 1-min

Hydrologic Element	Drainage Area (sq mile)	Peak Discharge (cfs)	Time of Peak	Total Volume (ac-ft)
EX E	0.0334	23.522	09Aug2828, 01:10	1.17
N1	0.0052	4.632	09Aug2828, 01:04	1.17
E1	0.004	3.802	09Aug2828, 01:05	1.17
J-N1-E1	0.010	8.432	09Aug2828, 01:05	1.17
E-DC U	0.010	8.429	09Aug2828, 01:05	1.17
E2	0.005	5.478	09Aug2828, 00:57	1.17
J-E2	0.014	11.91	09Aug2828, 01:01	1.17
E-DC L	0.014	11.896	09Aug2828, 01:01	1.17
J-SE-1	0.047	32.201	09Aug2828, 01:07	1.17
R-SE5	0.047	32.147	09Aug2828, 01:11	1.17
SE5	0.004	4.2	09Aug2828, 01:01	1.17
J-SE5-2	0.052	34.36	09Aug2828, 01:09	1.17
SE1	0.008	9.089	09Aug2828, 00:58	1.17
SE4	0.003	3.409	09Aug2828, 00:57	1.17
J SE	0.011	12.459	09Aug2828, 00:58	1.17
SE-DC	0.011	12.419	09Aug2828, 00:58	1.17
SE2	0.004	4.312	09Aug2828, 00:58	1.17
SE3	0.003	2.888	09Aug2828, 01:02	1.17
J-SE2	0.007	6.937	09Aug2828, 01:00	1.17
R-SEL	0.007	6.882	09Aug2828, 01:04	1.17
SEL	0.003	2.894	09Aug2828, 00:59	1.17
J-SEL	0.009	9.32	09Aug2828, 01:03	1.17
Sink-E	0.071	48.596	09Aug2828, 01:04	1.17
EX W	0.039	27.52	09Aug2828, 01:10	1.17
W1	0.007	6.366	09Aug2828, 01:05	1.17
N2	0.005	4.475	09Aug2828, 01:04	1.17
J-W1-N2	0.012	10.833	09Aug2828, 01:05	1.17
W-DC	0.012	10.821	09Aug2828, 01:05	1.17
W2	0.012	13.873	09Aug2828, 00:59	1.17
J-W2	0.024	22.409	09Aug2828, 01:01	1.17
J-W2-2	0.063	43.964	09Aug2828, 01:05	1.17
Sink-Ex. Culv.	0.063	43.964	09Aug2828, 01:05	1.17
S1	0.008	7.636	09Aug2828, 01:03	1.17
R-S2	0.008	7.599	09Aug2828, 01:06	1.17
S2	0.007	7.513	09Aug2828, 00:59	1.17
J-S2	0.015	13.188	09Aug2828, 01:02	1.17
Sink-Prop Culv.	0.015	13.188	09Aug2828, 01:02	1.17

Table B-4
Channel Hydraulic Calculations

Tri State Generation & Transmission
Escalante Station
PROJECT NO.: 1663066

Date:	10/13/16
By:	MBR
Chkd:	SPS
Apprvd:	SPS

			Channel Design Geometry						Channel Roughness Parameters			
Reach Designation	Q25 from HEC-HMS (cfs)	HEC HMS Element ID for Q	Approximate Channel Length (ft)	Bed Slope (ft/ft)	Left Side Slope (H:1V)	Right Side Slope (H:1V)	Bottom Width (ft)	Minimum Channel Depth (ft)	Design Channel Lining		Mannings 'n' for Capacity (Depth Calculation)	Mannings 'n' for Stability (Velocity Calculation)
Haul Road	13.2	J-S2	1526	0.065	3.0	3.0	0	2.0	R	Riprap	0.040	0.035
DC NW	22.4	J-W2	445	0.180	3.0	3.0	10	1.5	R	Riprap	0.040	0.035
DC NE	11.9	J-E2	395	0.330	3.0	3.0	10	1.5	R	Riprap	0.040	0.035
DC-SE	12.5	J SE	485	0.280	3.0	2.0	10	1.5	R	Riprap	0.040	0.035
S Perim U	2.9	SE3	1565	0.005	3.0	3.0	5	1.5	E	Earth-lined	0.025	0.022
S Perim L	9.3	J-SEL	580	0.005	3.0	3.0	10	1.5	E	Earth-lined	0.025	0.022
W Perim	44.0	J-W2-2	1315	0.005	3.0	3.0	10	2.0	E	Earth-lined	0.025	0.022
E Perim	34.4	J-SE5-2	1815	0.009	3.0	3.0	10	2.0	E	Earth-lined	0.025	0.022

Table B-4
Channel Hydraulic Calculations

Date:	10/13/16
By:	MBR
Chkd:	SPS
Apprvd:	SPS

		Hydraulic Calculations							Channel Evaluations	
Reach Designation	**Q25 from HEC-HMS (cfs)**	**Maximum Velocity (ft/sec)**	**Maximum Normal Flow Depth (ft)**	**Froude Number**	**Normal Depth Shear Stress (lb/ft^2)**	**Stream Power (W/m^2)**	**Top Width of Flow (ft)**	**Top Width of Channel (ft)**	**Available Freeboard (ft)**	
Haul Road	13.2	6.0	0.90	1.60	3.66	316.71	5.4	12.0	1.1	ok
DC NW	22.4	7.3	0.30	2.53	3.42	364.24	11.8	19.0	1.2	ok
DC NE	11.9	7.0	0.18	3.15	3.61	367.32	11.1	19.0	1.3	ok
DC-SE	12.5	6.8	0.19	2.94	3.31	327.58	10.9	17.5	1.3	ok
S Perim U	2.9	1.8	0.29	0.66	0.09	2.4	6.8	14.0	1.2	ok
S Perim L	9.3	2.3	0.40	0.70	0.12	4.1	12.4	19.0	1.1	ok
W Perim	44.0	3.9	0.96	0.79	0.30	16.8	15.8	22.0	1.0	ok
E Perim	34.4	4.4	0.71	1.02	0.40	25.1	14.3	22.0	1.3	ok

Table B-5
Robinson Method Riprap Size Calculation

Tri State Generation & Transmission Association, Inc.
Escalante Generating Station
Project Number: 1663066

Date:	10/13/16
By:	MBR
Chkd:	SPS
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	Robinson Design of Rock Chutes Riprap Calculations for Steep Riprap (Bed Slopes >2% but <40%)						
Reach Designation	**Unit Flow q (1) (cfs/ft)**	**Design Flow Q (cms)**	**Unit Width Flow q (cms/m)**	**Flow Concentration Factor**	**Calculated Particle Size D_{50} (2) (mm)**	**Factor of Safety**	**Riprap Size D_{50} (inches)**
Haul Road	5.12	0.373	0.476	1.25	131	1.20	6.2
DC NW	2.07	0.635	0.192	1.25	137	1.20	6.5
DC NE	1.14	0.337	0.106	1.25	121	1.20	5.7
DC-SE	1.19	0.353	0.111	1.25	118	1.20	5.6

Design of Rock Chutes (ASAE Paper No. 982136 7/98)
Determine unit flow at incipient motion for rock particle size
(1) Unit flow rate is Q/ median width, adjusted by a flow concentration factor

1.25	Flow Concentration Factor (1.25 from USACE steep riprap method)

(2) Bed Slope < 10%, $q = 9.76e\text{-}7\ D_{50}^{1.89}\ S^{-1.50}$

10%<= Bed Slope <= 40%, $q = 8.07e\text{-}6\ D_{50}^{1.89}\ S^{-0.58}$

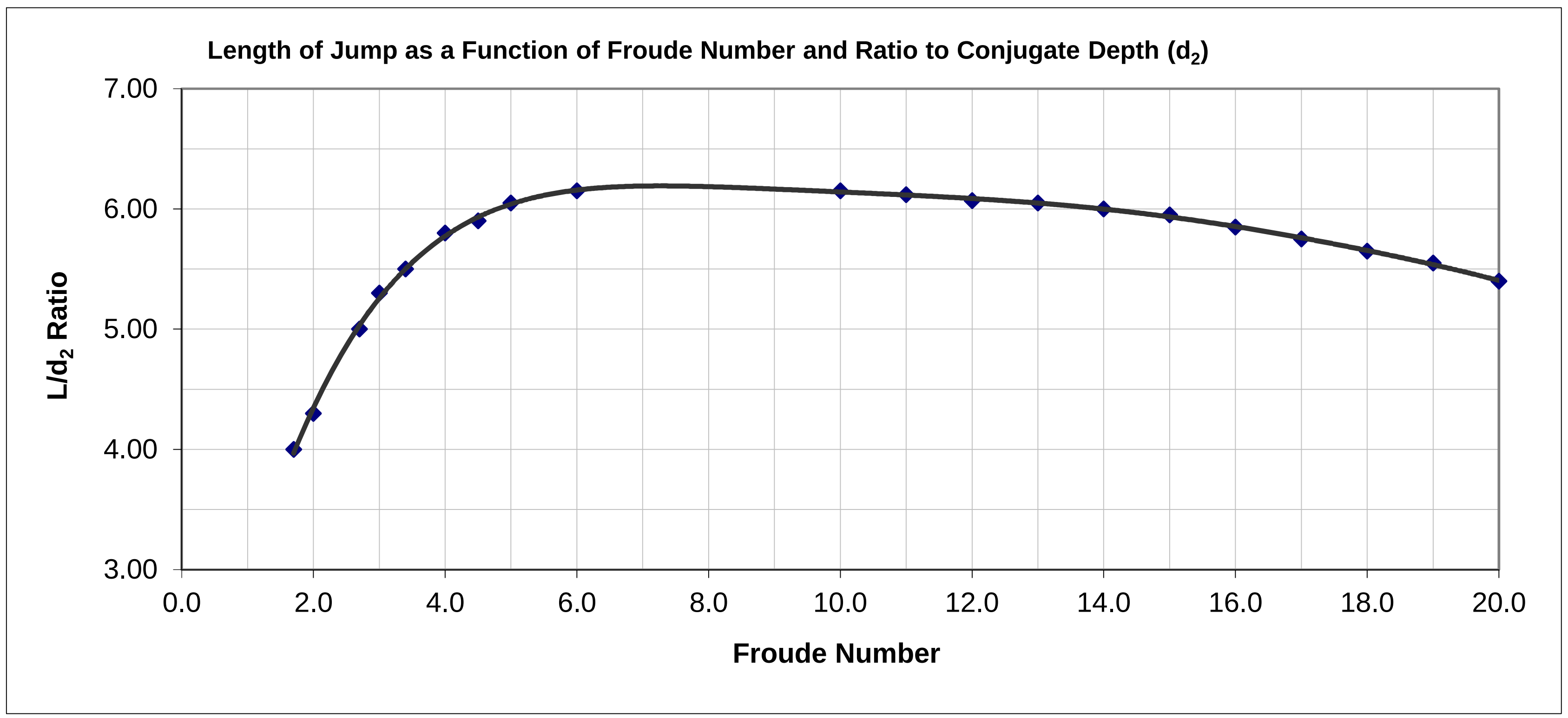
1.2	Factor of Safety over incipient motion

Table B-6
Hydraulic Jump Calculation

Tri State Generation & Transmission
Hydraulic Jump Calculation
PROJECT NO.: 1663066

Date:	10/13/16
By:	MBR
Chkd:	SPS
Apprvd:	JEO

		Channel Configuration							Hydraulic Calculations						
Reach Designation	Design Flow (cfs)	Bed Slope	Left Side Slope (H:1V)	Right Side Slope (H:1V)	Bottom Width (ft)	Maximum Channel Depth (ft)	Mannings 'n' for Capacity (Depth Calculation)	Mannings 'n' for Stability (Velocity Calculation)	Maximum Velocity (ft/sec)	Maximum Normal Flow Depth (ft)	Normal Depth with Velocity 'n' (ft)	Froude Number	Conjugate Depth (ft)	L/d2 Ratio	Minimum Length of Jump (ft)
DC NW	22.4	18.0%	3.0	3.0	10	1.5	0.040	0.035	7.3	0.30	0.28	2.53	0.84	4.89	4.11
DC NE	11.9	33.0%	3.0	3.0	10	1.5	0.040	0.035	7.0	0.18	0.16	3.15	0.63	5.35	3.36
DC-SE	12.5	28.0%	3.0	3.0	10	1.5	0.040	0.035	6.8	0.19	0.17	2.93	0.62	5.21	3.25



$$d_2 = -\frac{d_1}{2} + \sqrt{\frac{2V_1^2 d_1}{g} + \frac{d_1^2}{4}}$$

Where:

d1 = Depth before the jump
V1 = Velocity before the jump
d2 = Depth after the jump,
g = Acceleration of gravity

FIGURE

LEGEND

- EXISTING GROUND SURFACE CONTOURS
- PROPOSED GROUND SURFACE CONTOURS
- TERRACE CHANNEL WATER FLOW DIRECTION
- PERIMETER CHANNEL
- SUBBASIN DELINEATION
- DOWNCHUTE CHANNEL
- SE5 — SUBBASIN ID
- SUBBASIN INFORMATION
- 2.6 — SUBBASIN AREA (AC)

CHANNEL TABLE						
REACH I.D.	APPROXIMATE CHANNEL LENGTH (FT)	BED SLOPE (FT/FT)	LEFT SIDE SLOPE (H:1V)	RIGHT SIDE SLOPE (H:1V)	BOTTOM WIDTH (FT)	MINIMUM CHANNEL DEPTH (FT)
HAUL ROAD	1526	0.065	3	3	0	2
DC NW	445	0.180	3	3	10	1.5
DC NE	395	0.330	3	3	10	1.5
DC-SE	485	0.280	3	2	10	1.5
S PERIM U	1565	0.005	3	3	5	1.5
S PERIM L	580	0.005	3	3	10	1.5
W PERIM	1315	0.005	3	3	10	2

0 100 200
1" = 100' FEET

CLIENT
TRI-STATE G&T ASSOCIATION

PROJECT
TRI-STATE
2016 COAL COMBUSTION RESIDUALS ENGINEERING SUPPORT
ESCALANTE

TITLE
SCHEMATIC RUN-ON/RUN-OFF DESIGN

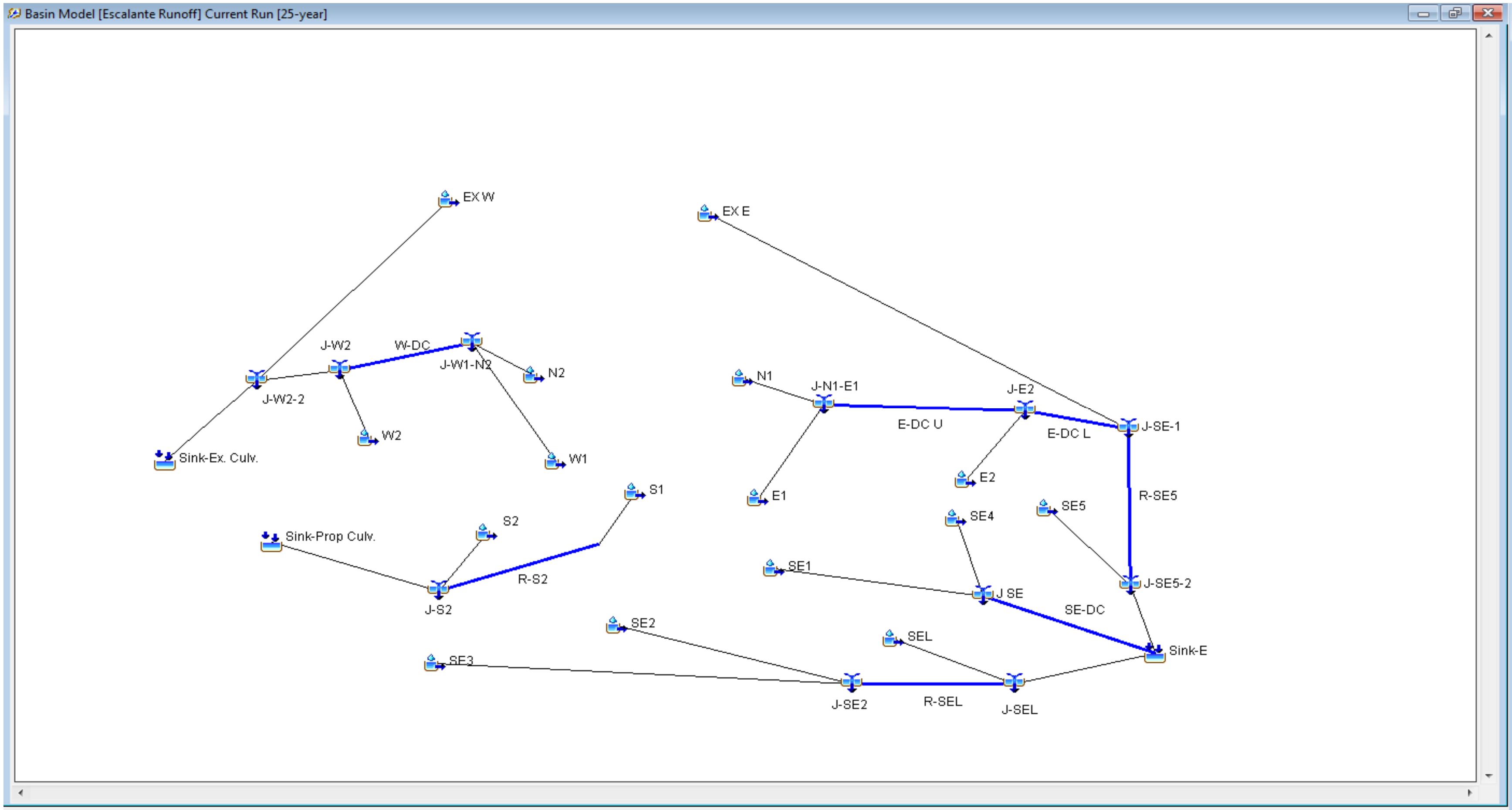
CONSULTANT
Golder Associates

YYYY-MM-DD	2016-10-13
DESIGNED	AF
PREPARED	REDMOND
REVIEWED	MR
APPROVED	JO

PROJECT NO.	PHASE	REV.	FIGURE
1663066	0003	0	B-1

ATTACHMENT B-1
CHANNEL REACH LOCATIONS AND BASIN DELINEATIONS

HEC-HMS Basin Model Schematic



Attachment B-1
HEC-HMS Screen Captures and Inputs

Sub Basin Area	
Subbasin	Area (mi^2)
EX E	0.033400
N1	0.005200
E1	0.004300
E2	0.004500
SE5	0.004100
SE1	0.007800
SE4	0.002800
SE2	0.003700
SE3	0.002900
SEL	0.002600
EX W	0.038800
W1	0.007200
N2	0.005000
W2	0.012100
S1	0.008000
S2	0.006600

Loss SCS Curve Number			
Subbasin	Initial Abstraction (in)	Curve Number	Impervious (%)
EX E		88	0
N1		88	0
E1		88	0
E2		88	0
SE5		88	0
SE1		88	0
SE4		88	0
SE2		88	0
SE3		88	0
SEL		88	0
EX W		88	0
W1		88	0
N2		88	0
W2		88	0
S1		88	0
S2		88	0

Transform SCS Unit Hydrograph	
Subbasin	Lag Time (min)
EX E	17.2
N1	11.1
E1	11.3
E2	3.6
SE5	7.8
SE1	4.7
SE4	3.6
SE2	4.7
SE3	8.5
SEL	5.8
EX W	17
W1	11.3
N2	11
W2	5.1
S1	9.5
S2	5.3

Routing Kinematic Wave Channel								
Reach	Length (ft)	Slope (ft/ft)	Manning's n	subreaches	Shape	Diameter (ft)	Width (ft)	Side Slope (xH:1V)
E-DC U	270	0.200	0.035	2	Trapezoid		10	3
E-DC L	125	0.280	0.035	2	Trapezoid		10	3
R-SE5	830	0.009	0.035	2	Trapezoid		10	3
SE-DC	180	0.222	0.035	2	Trapezoid		10	3
R-SEL	580	0.005	0.035	2	Trapezoid		10	3
W-DC	445	0.180	0.035	2	Trapezoid		10	3
R-S2	1325	0.065	0.035	2	Triangle			3

ATTACHMENT B-2
HEC-HMS MODEL INPUTS

HY-8 Culvert Analysis Report

Water Surface Profile Plot for Culvert: Culvert 2

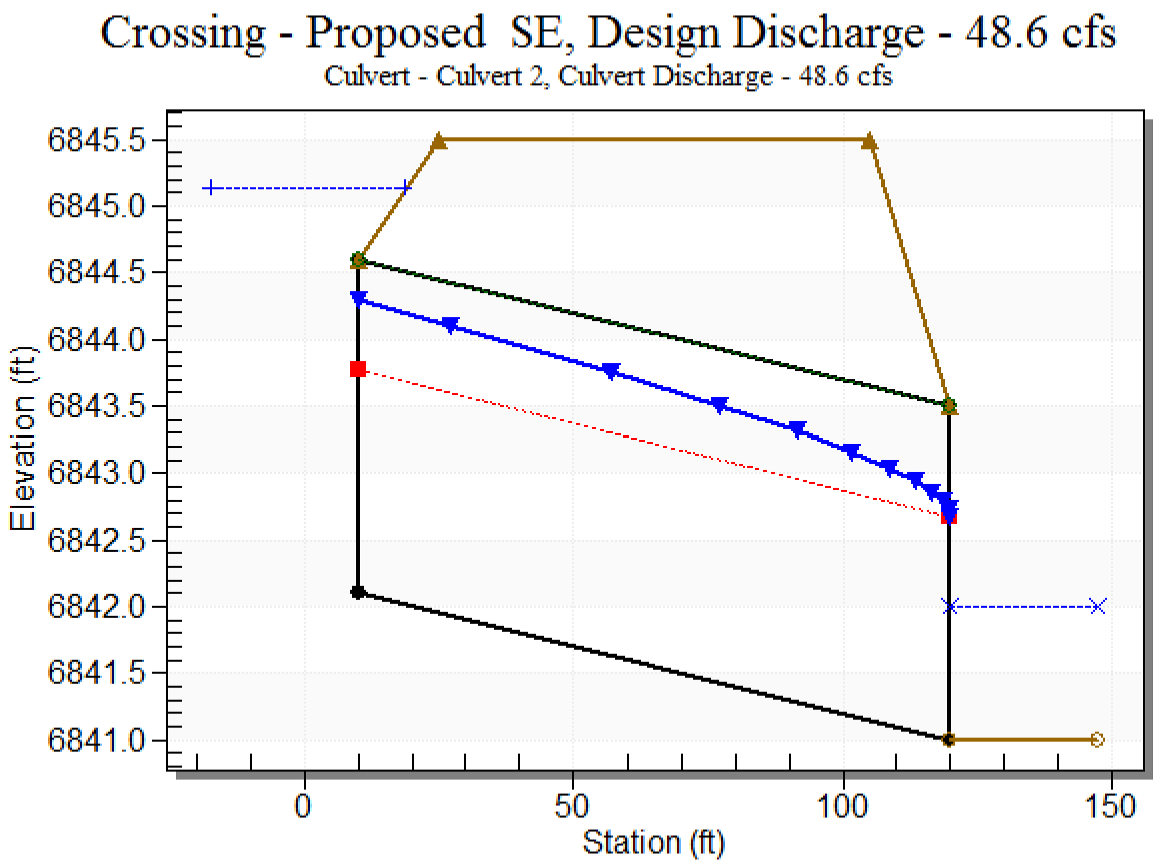


Table B-2-1 - Culvert Summary Table: Culvert 2

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	6842.10	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
4.86	4.86	6842.92	0.742	0.823	2-M2c	0.547	0.505	0.505	0.261	3.425	1.182
9.72	9.72	6843.28	1.076	1.185	2-M2c	0.787	0.722	0.722	0.393	4.133	1.529
14.58	14.58	6843.57	1.332	1.472	2-M2c	0.981	0.892	0.892	0.499	4.640	1.772
19.44	19.44	6843.82	1.572	1.723	2-M2c	1.155	1.038	1.038	0.591	5.044	1.963
24.30	24.30	6844.05	1.798	1.951	2-M2c	1.316	1.170	1.170	0.673	5.390	2.123
29.16	29.16	6844.27	2.018	2.166	2-M2c	1.476	1.286	1.286	0.748	5.732	2.261
34.02	34.02	6844.47	2.237	2.373	2-M2c	1.639	1.389	1.389	0.818	6.071	2.384
38.88	38.88	6844.68	2.462	2.580	7-M2c	1.809	1.491	1.491	0.883	6.368	2.494
43.74	43.74	6844.89	2.697	2.794	7-M2c	2.015	1.587	1.587	0.945	6.654	2.595
48.60	48.60	6845.13	2.947	3.031	7-M2c	2.500	1.675	1.675	1.004	6.952	2.688

****

Straight Culvert

Inlet Elevation (invert): 6842.10 ft,   Outlet Elevation (invert): 6841.00 ft

Culvert Length: 110.01 ft,   Culvert Slope: 0.0100

****

Site Data - Culvert 2

Site Data Option: Culvert Invert Data

Inlet Station: 10.00 ft

Inlet Elevation: 6842.10 ft

Outlet Station: 120.00 ft

Outlet Elevation: 6841.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 2

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 48.6 cfs

Maximum Flow: 48.6 cfs

Table B-2-2 - Summary of Culvert Flows at Crossing: Proposed SE

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6842.10	0.00	0.00	0.00	1
6842.92	4.86	4.86	0.00	1
6843.28	9.72	9.72	0.00	1
6843.57	14.58	14.58	0.00	1
6843.82	19.44	19.44	0.00	1
6844.05	24.30	24.30	0.00	1
6844.27	29.16	29.16	0.00	1
6844.47	34.02	34.02	0.00	1
6844.68	38.88	38.88	0.00	1
6844.89	43.74	43.74	0.00	1
6845.13	48.60	48.60	0.00	1
6845.50	53.93	53.93	0.00	Overtopping

Table B-2-3 - Downstream Channel Rating Curve (Crossing: Proposed SE)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	6841.00	0.00	0.00	0.00	0.00
4.86	6841.26	0.26	1.18	0.08	0.42
9.72	6841.39	0.39	1.53	0.12	0.45
14.58	6841.50	0.50	1.77	0.16	0.46
19.44	6841.59	0.59	1.96	0.18	0.47
24.30	6841.67	0.67	2.12	0.21	0.48
29.16	6841.75	0.75	2.26	0.23	0.49
34.02	6841.82	0.82	2.38	0.26	0.50
38.88	6841.88	0.88	2.49	0.28	0.50
43.74	6841.95	0.95	2.59	0.29	0.51
48.60	6842.00	1.00	2.69	0.31	0.51

Tailwater Channel Data - Proposed SE

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 15.00 ft

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

Channel Slope: 0.0050

Channel Manning's n: 0.0350

Channel Invert Elevation: 6841.00 ft

Roadway Data for Crossing: Proposed SE

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 500.00 ft

Crest Elevation: 6845.50 ft

Roadway Surface: Gravel

Roadway Top Width: 80.00 ft

Water Surface Profile Plot for Culvert: Culvert 3

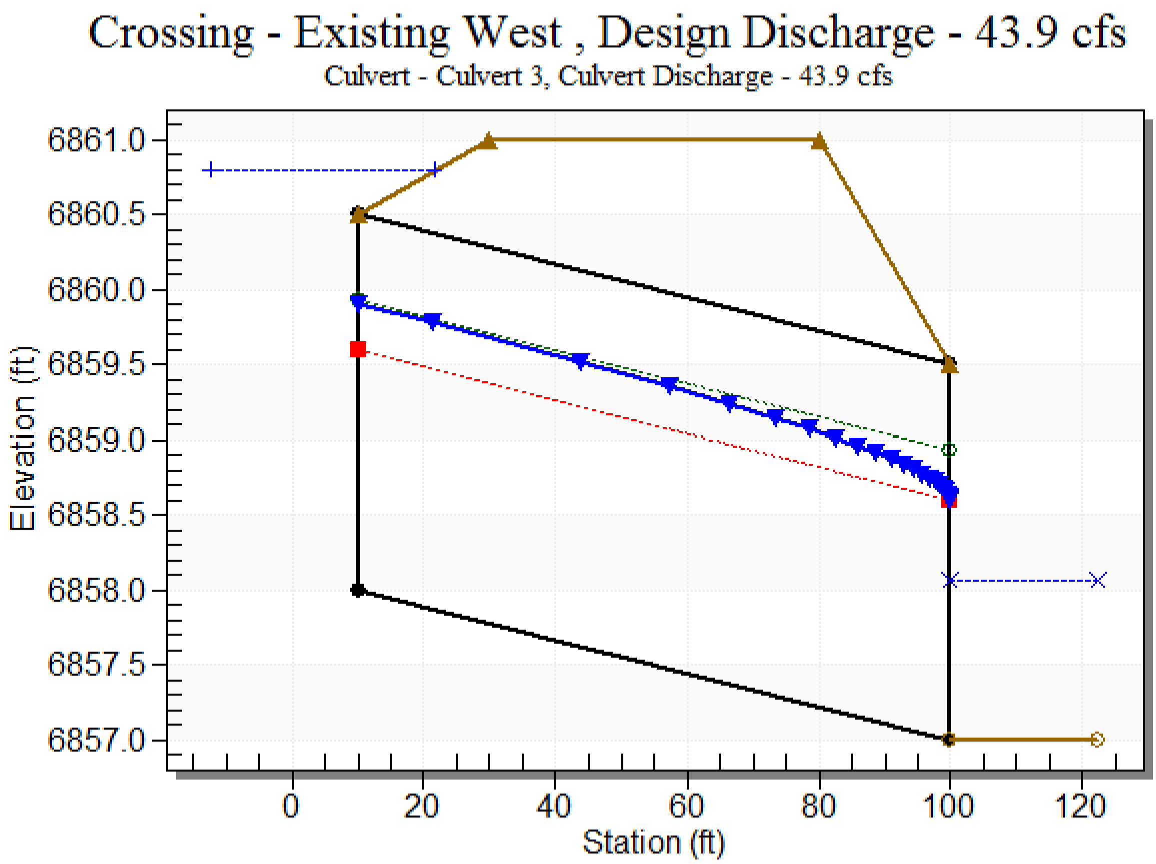


Table B-2-4 - Culvert Summary Table: Culvert 3

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	6858.00	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
4.39	4.39	6858.79	0.711	0.786	2-M2c	0.508	0.479	0.479	0.283	3.339	1.429
8.78	8.78	6859.13	1.016	1.131	2-M2c	0.728	0.685	0.685	0.425	4.025	1.831
13.17	13.17	6859.40	1.258	1.403	2-M2c	0.905	0.848	0.848	0.538	4.489	2.107
17.56	17.56	6859.64	1.480	1.642	2-M2c	1.056	0.982	0.982	0.635	4.909	2.321
21.95	21.95	6859.86	1.688	1.855	2-M2c	1.201	1.108	1.108	0.722	5.224	2.500
26.34	26.34	6860.05	1.889	2.054	2-M2c	1.339	1.220	1.220	0.801	5.534	2.653
30.73	30.73	6860.24	2.087	2.242	2-M2c	1.476	1.320	1.320	0.873	5.841	2.788
35.12	35.12	6860.43	2.286	2.425	2-M2c	1.614	1.416	1.416	0.942	6.124	2.909
39.51	39.51	6860.60	2.490	2.605	7-M2c	1.760	1.503	1.503	1.006	6.408	3.018
43.90	43.90	6860.79	2.704	2.788	7-M2c	1.926	1.590	1.590	1.066	6.663	3.120

****

Straight Culvert

Inlet Elevation (invert): 6858.00 ft, Outlet Elevation (invert): 6857.00 ft

Culvert Length: 90.01 ft, Culvert Slope: 0.0111

****

Site Data - Culvert 3

Site Data Option: Culvert Invert Data

Inlet Station: 10.00 ft

Inlet Elevation: 6858.00 ft

Outlet Station: 100.00 ft

Outlet Elevation: 6857.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 3

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 43.9 cfs

Maximum Flow: 43.9 cfs

Table B-2-5 - Summary of Culvert Flows at Crossing: Existing West

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 3 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6858.00	0.00	0.00	0.00	1
6858.79	4.39	4.39	0.00	1
6859.13	8.78	8.78	0.00	1
6859.40	13.17	13.17	0.00	1
6859.64	17.56	17.56	0.00	1
6859.86	21.95	21.95	0.00	1
6860.05	26.34	26.34	0.00	1
6860.24	30.73	30.73	0.00	1
6860.43	35.12	35.12	0.00	1
6860.60	39.51	39.51	0.00	1
6860.79	43.90	43.90	0.00	1
6861.00	48.69	48.69	0.00	Overtopping

Table B-2-6 - Downstream Channel Rating Curve (Crossing: Existing West)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	6857.00	0.00	0.00	0.00	0.00
4.39	6857.28	0.28	1.43	0.09	0.49
8.78	6857.43	0.43	1.83	0.13	0.52
13.17	6857.54	0.54	2.11	0.17	0.54
17.56	6857.64	0.64	2.32	0.20	0.55
21.95	6857.72	0.72	2.50	0.23	0.56
26.34	6857.80	0.80	2.65	0.25	0.57
30.73	6857.87	0.87	2.79	0.27	0.58
35.12	6857.94	0.94	2.91	0.29	0.58
39.51	6858.01	1.01	3.02	0.31	0.59
43.90	6858.07	1.07	3.12	0.33	0.59

Tailwater Channel Data - Existing West

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

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

Channel Slope: 0.0050

Channel Manning's n: 0.0300

Channel Invert Elevation: 6857.00 ft

Roadway Data for Crossing: Existing West

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 70.00 ft

Crest Elevation: 6861.00 ft

Roadway Surface: Gravel

Roadway Top Width: 50.00 ft

Water Surface Profile Plot for Culvert: Culvert 3

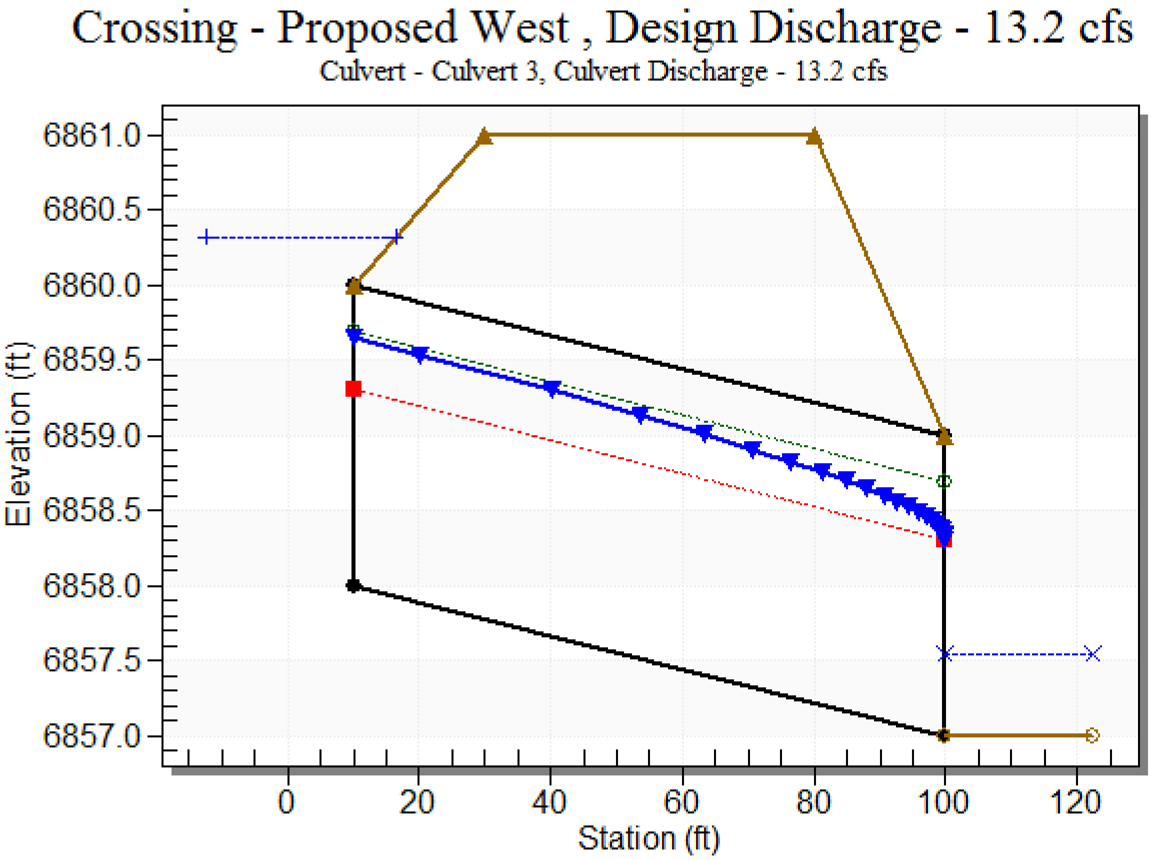


Table B-2-7 - Culvert Summary Table: Culvert 3

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	6858.00	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
1.32	1.32	6858.64	0.585	0.642	2-M2c	0.424	0.393	0.393	0.139	3.023	0.913
2.64	2.64	6858.92	0.834	0.924	2-M2c	0.608	0.562	0.562	0.210	3.647	1.185
3.96	3.96	6859.15	1.034	1.147	2-M2c	0.757	0.694	0.694	0.266	4.092	1.376
5.28	5.28	6859.34	1.218	1.341	2-M2c	0.888	0.807	0.807	0.316	4.448	1.528
6.60	6.60	6859.52	1.392	1.518	2-M2c	1.011	0.910	0.910	0.360	4.743	1.655
7.92	7.92	6859.68	1.559	1.682	2-M2c	1.131	1.001	1.001	0.400	5.034	1.766
9.24	9.24	6859.84	1.726	1.841	2-M2c	1.250	1.083	1.083	0.438	5.322	1.864
10.56	10.56	6860.00	1.894	1.996	2-M2c	1.376	1.161	1.161	0.474	5.581	1.953
11.88	11.88	6860.15	2.069	2.153	7-M2c	1.514	1.233	1.233	0.507	5.846	2.033
13.20	13.20	6860.32	2.253	2.320	7-M2c	1.691	1.305	1.305	0.539	6.082	2.108

****

Straight Culvert

Inlet Elevation (invert): 6858.00 ft,   Outlet Elevation (invert): 6857.00 ft

Culvert Length: 90.01 ft,   Culvert Slope: 0.0111

****

Site Data - Culvert 3

Site Data Option: Culvert Invert Data

Inlet Station: 10.00 ft

Inlet Elevation: 6858.00 ft

Outlet Station: 100.00 ft

Outlet Elevation: 6857.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 3

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: NONE

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 13.2 cfs

Maximum Flow: 13.2 cfs

Table B-2-8 - Summary of Culvert Flows at Crossing: Proposed West

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 3 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
6858.00	0.00	0.00	0.00	1
6858.64	1.32	1.32	0.00	1
6858.92	2.64	2.64	0.00	1
6859.15	3.96	3.96	0.00	1
6859.34	5.28	5.28	0.00	1
6859.52	6.60	6.60	0.00	1
6859.68	7.92	7.92	0.00	1
6859.84	9.24	9.24	0.00	1
6860.00	10.56	10.56	0.00	1
6860.15	11.88	11.88	0.00	1
6860.32	13.20	13.20	0.00	1
6861.00	16.21	16.21	0.00	Overtopping

Table B-2-9 - Downstream Channel Rating Curve (Crossing: Proposed West)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	6857.00	0.00	0.00	0.00	0.00
1.32	6857.14	0.14	0.91	0.04	0.44
2.64	6857.21	0.21	1.18	0.07	0.47
3.96	6857.27	0.27	1.38	0.08	0.49
5.28	6857.32	0.32	1.53	0.10	0.50
6.60	6857.36	0.36	1.66	0.11	0.51
7.92	6857.40	0.40	1.77	0.12	0.52
9.24	6857.44	0.44	1.86	0.14	0.52
10.56	6857.47	0.47	1.95	0.15	0.53
11.88	6857.51	0.51	2.03	0.16	0.54
13.20	6857.54	0.54	2.11	0.17	0.54

Tailwater Channel Data - Proposed West

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

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

Channel Slope: 0.0050

Channel Manning's n: 0.0300

Channel Invert Elevation: 6857.00 ft

Roadway Data for Crossing: Proposed West

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 70.00 ft

Crest Elevation: 6861.00 ft

Roadway Surface: Gravel

Roadway Top Width: 50.00 ft

APPENDIX C
STORMWATER RUN-ON CALCULATIONS AND FIGURE (BY OTHERS)

METRIC
Corporation

TABLE 3-1
LANDFILL EXPANSION STORMWATER CONTROL CHANNEL

WATERSHED DATA
PP-1

Drainage Area 42.2 acres 0.07 square miles

SOIL UNIT	UNIT AREA (ac)	SOIL	PERCENT OF UNIT	HYDROLOGIC GROUP	SOIL COVER COMPLEX	COVER DENSITY	RUNOFF CURVE#	ACRES	PRODUCT
	18	Rangeland	100.0%	C	Herbaceous	NA	80.0	18.2	1459.7
	24	Landfill	100.0%	C	Herbaceous	NA	85.0	23.9	2035.1
							TOTALS	42.2	3494.8

Curve Number 82.8
Watershed Length (mi) 0.45
Elevation Difference (ft) 32.7
Tc (hr) 0.27

TABLE 3-1 Continued
LANDFILL EXPANSION STORMWATER CONTROL CHANNEL

WATERSHED DATA
PP-1

Drainage Area	A=	42	acres
Runoff Curve Number	CN=	83	
Watershed Length	L=	2392	feet
Elevation Difference	d=	33	feet
Tc	Tc=	0.27	hours
cfs/ac/in		1.30	cfs/ac/in
(Reference SCS 1973)			

100-year 24-hour rainfall	p100=	2.90	inches
100-year 24-hour direct runoff	q100=	1.36	inches
100-year 24-hour volume	V100=	5	ac-ft
100-year 24-hour discharge	Q100=	74	cfs

METRIC
Corporation

TABLE 3-1 Continued
LANDFILL EXPANSION STORMWATER CONTROL CHANNEL

WATERSHED DATA
PP-2

Drainage Area 235.0 acres 0.37 square miles

SOIL UNIT	UNIT AREA (ac)	SOIL	PERCENT OF UNIT	HYDROLOGIC GROUP	SOIL COVER COMPLEX	COVER DENSITY	RUNOFF CURVE#	ACRES	PRODUCT
	184	Rangeland	100.0%	C	Herbaceous	NA	80.0	184.5	14756.5
	51	Landfill	100.0%	C	Herbaceous	NA	85.0	50.6	4297.5
							TOTALS	235.0	19054.0

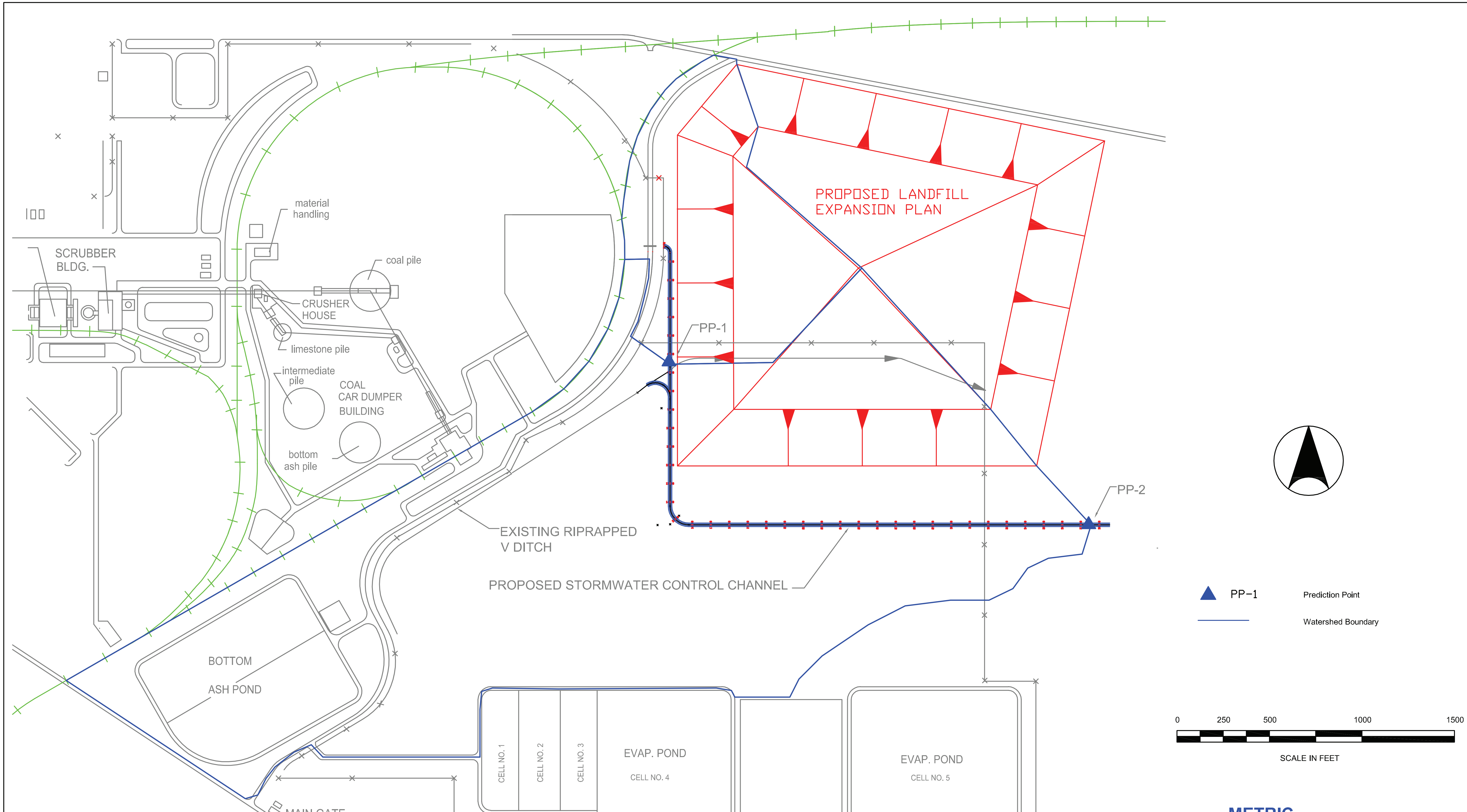
Curve Number 81.1
Watershed Length (mi) 1.24
Elevation Difference (ft) 50
Tc (hr) 0.74

TABLE 3-1 Continued
LANDFILL EXPANSION STORMWATER CONTROL CHANNEL

WATERSHED DATA
PP-2

Drainage Area	A=	235	acres
Runoff Curve Number	CN=	81	
Watershed Length	L=	6536	feet
Elevation Difference	d=	50	feet
Tc	Tc=	0.74	hours
cfs/ac/in		0.84	cfs/ac/in
(Reference SCS 1973)			

100-year 24-hour rainfall	p100=	2.90	inches
100-year 24-hour direct runoff	q100=	1.24	inches
100-year 24-hour volume	V100=	24	ac-ft
100-year 24-hour discharge	Q100=	245	cfs



METRIC CORPORATION

STORM WATER CONTROL SYSTEM

ASH LANDFILL EXPANSION PLAN
TRI-STATE GENERATION & TRANSMISSION
ESCALANTE GENERATING STATION

DATE 12/16/05

FIGURE - 3-1

Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

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North America	+ 1 800 275 3281
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Engineering Earth's Development, Preserving Earth's Integrity