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Run-On and Runoff Control System Plan

Nucla Station Ash Disposal Facility

Submitted to:

Tri-State Generation and Transmission Association, Inc.
P.O. Box 33695
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Submitted by:

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40294
10-15-21

21453425-2-R-0

October 15, 2021

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FIGURES

APPENDICES

1.0 INTRODUCTION

Golder Associates Inc. (Golder) prepared this Run-On and Runoff Control System (ROROCS) Plan on behalf of Tri-State Generation and Transmission Association, Inc. (Tri-State) for the Nucla Station Ash Disposal Facility (the Facility), which is located in Montrose County, Colorado. This ROROCS Plan documents the Facility's run-on and runoff control system design and its compliance with the requirements of 40 CFR 257.81, including appropriate engineering calculations. This ROROCS plan is to be 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 a coal combustion residuals (CCR) landfill must design, construct, operate, and maintain a run-on and runoff 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 into the active portion of the CCR landfill during the peak discharge from a 25-year, 24-hour storm event
- a runoff 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 a CCR landfill within the limit of waste on which a final cover system has not been constructed. The limit of waste for the Facility encompasses approximately 61 acres. Currently, an area totaling approximately 22 acres on the sideslopes has received final cover and an area totaling approximately 17 acres on the top surface of the northern half of the Facility has received final cover. The active portion is approximately 22 acres. These areas are shown in Figure 1.

3.0 DESIGN METHODOLOGY

3.1 Design Storm

The Facility's run-on and runoff 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 2.11 inches of precipitation at the Facility. Calculations using this design storm or larger are included in Appendices A and B.

3.2 Rainfall Abstractions

Rainfall abstractions are water losses that occur before runoff begins. Losses may result from 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:

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

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

Therefore:

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

where:
S = potential maximum retention after runoff begins (inches)
CN = curve number
I_a = initial abstraction (inches)

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 runoff 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, as shown in Figure 1, run-on only has the potential to enter the active portion from the northeast. A perimeter channel system has been constructed to intercept run-on and prevent flow onto the active portion. Based on topographic information and site observations, the minimum perimeter channel section is 2 feet deep with no bottom width and 3 (horizontal) to 1 (vertical) sideslopes (3H:1V). The perimeter channels are grass-lined or riprap-lined. The perimeter channel system is capable of conveying run-on from the 25-year, 24-hour storm event, as well as runoff from the landfill sideslopes for the same storm event, 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-on. As Tri-State proceeds with Facility operation and closure, the contributing area for run-on that could route onto to the active portion will decrease and eventually be eliminated. Therefore, the existing condition represents the maximum run-on condition for the remaining life of the Facility.

5.0 RUNOFF CONTROL PLAN

5.1 Active Portion of the Facility

Runoff from the active portion of the Facility (and other contributing areas) is contained within the ash 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 active portion (and other contributing areas) is controlled behind the containment berm with ample 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 runoff. As Tri-State proceeds with Facility operation and closure, the contributing area for runoff will decrease and eventually be eliminated. Therefore, the existing condition represents the maximum runoff condition for the remaining life of the Facility.

5.2 Closed Portion of the Facility

During operation, the exterior sideslopes of the Facility have been raised gradually as needed to contain the volume of CCRs being generated. The landfill height has been increased through the use of earthen containment berms that have been periodically constructed around the perimeter of the landfill in areas of active filling. Each individual containment berm, typically about 5 feet in height, has been constructed atop and slightly inside (upstream) of the previous (underlying) containment berm (i.e., closer to the center of the landfill) to cumulatively form the landfill sideslopes. At approximate 20-foot vertical intervals, the containment berms have been inwardly offset an additional 10 feet to establish benches with terrace channels for runoff control. Terrace channels convey runoff to riprap-lined rundown channels (i.e., downchutes) and into the perimeter channel system described in Section 4.0. The terrace channels, rundown channels, and perimeter channel system are capable of conveying runoff from the 100-year, 24-hour storm event, as demonstrated by the engineering calculations in Appendix B.

The calculations in Appendix B were carried out based on topographic conditions after Facility closure. This future condition represents the maximum runoff condition for the Facility.

6.0 CLOSING

As required under 40 CFR 257.81, the run-on and runoff control system for the Nucla Station Ash Disposal Facility 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.

Signature Page

Golder Associates Inc.

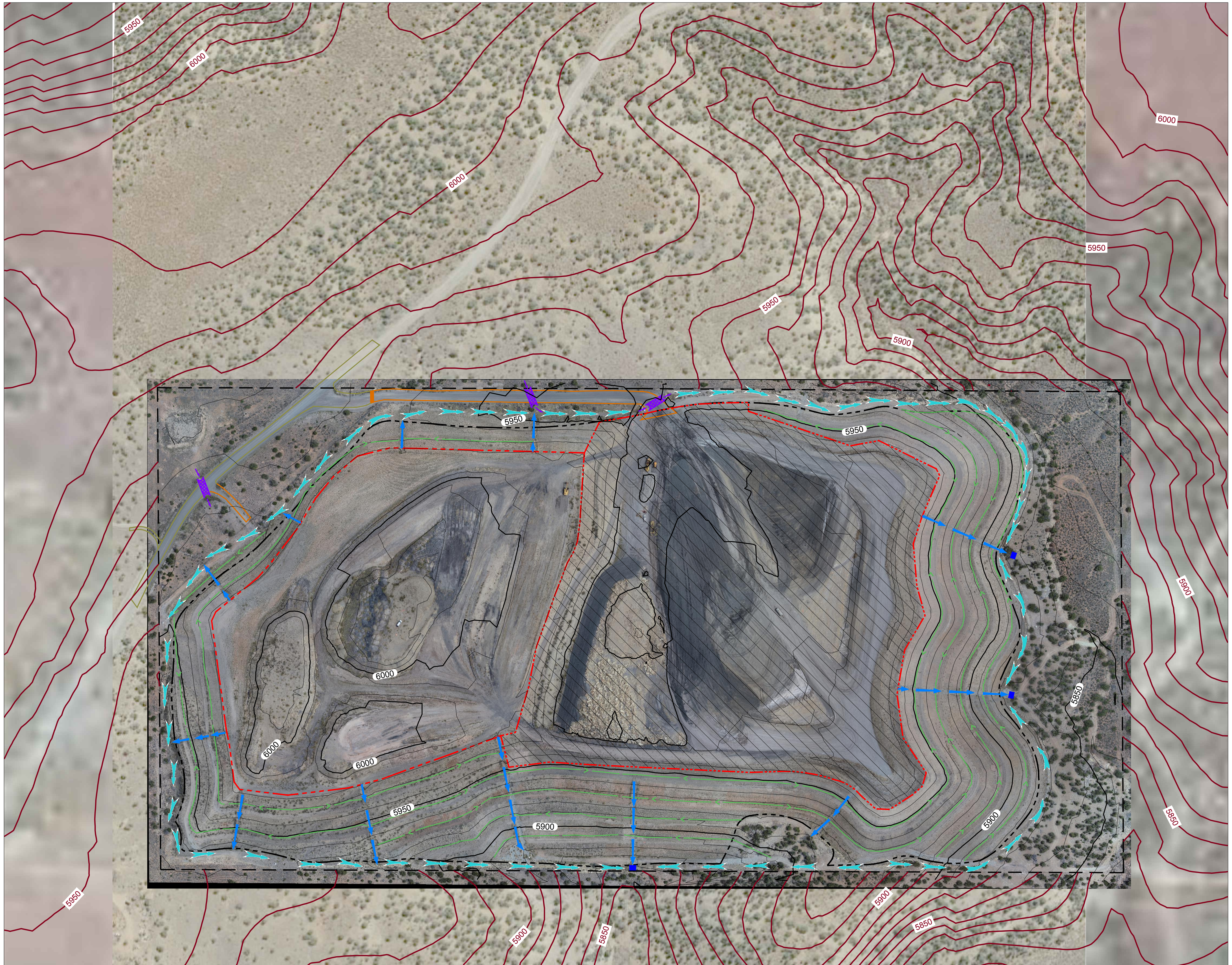
Brittany Bradley
Engineer

Jason Obermeyer, PE
Associate and Senior Consultant

BB/JO/rm

https://golderassociates.sharepoint.com/sites/141312/project files/6 deliverables/reports/2-r-rorocs_plan/2-r-0/21453425-2-r-0-run-on_and_runoff_control_system_plan_15oct21.docx

Figure



LEGEND

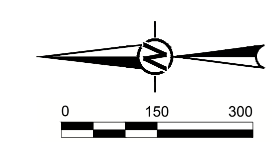
- EXISTING SITE TOPOGRAPHY (SEE REFERENCE 1)
- SURROUNDING TOPOGRAPHY (SEE REFERENCE 2)
- ACTIVE PORTION OF THE FACILITY
- PUBLIC ROADS
- TRI-STATE PRIVATE ROADS
- PROPERTY BOUNDARY
- EXISTING TERRACE CHANNEL
- EXISTING RUNDOWN CHANNEL
- LIMITS OF CLOSED PORTIONS OF THE FACILITY
- APPROXIMATE ASH DISPOSAL FOOTPRINT LIMIT (PROVIDED BY TRI-STATE)
- STORMWATER DISCHARGE POINT
- EXISTING PERIMETER CHANNEL
- CULVERT WITH FLOW DIRECTION

NOTES

1. THE LOCATIONS OF RUNDOWN CHANNELS ARE APPROXIMATE AND ARE BASED ON EXISTING GROUND TOPOGRAPHY AND AERIAL IMAGERY.

REFERENCES

1. EXISTING SITE TOPOGRAPHY AND AERIAL IMAGERY OBTAINED BY DEL-MONT CONSULTANTS ON MARCH 15, 2020, AND PROVIDED BY TRI-STATE (20034V_TOPO_ASHPIT(LOCAL).DWG) ON MAY 6, 2020.
2. SURROUNDING TOPOGRAPHY IS FROM THE UNITED STATES GEOLOGICAL SURVEY.
3. HORIZONTAL DATUM IS IN NUCLA PLANT LOCAL COORDINATES WITH UNITS IN U.S. SURVEY FEET. VERTICAL DATUM IS NAVD88.



REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
1	2021-10-08	ISSUED FOR RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN	ELH	ELH	JEO	JEO
O	2016-10-14	ISSUED FOR RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN	ELH	ELH	MAY	JEO

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PROJECT
NUCLA STATION ASH DISPOSAL FACILITY
RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

TITLE
RUN-ON AND RUN-OFF CONTROL SYSTEM EXISTING CONDITIONS

PROJECT NO. 21453425 | REV. 1 | FIGURE 1

Path: \\DEN1-V-FS1.golder.gds\acad\16\1657746\CIVIL 3D\CALCS\ | File Name: Existing Conditions H&H With USGS Topo JEO 2021.dwg

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APPENDIX A

Stormwater Run-On and Runoff Calculations – Active Portion

CALCULATIONS

Date:	October 13, 2016	**Made by:**	MBR
Project No.:	1657746	**Checked by:**	CPB
Site Name:	Nucla Station Ash Disposal Facility	**Reviewed by:**	JEO
Subject	**STORMWATER RUN-OFF AND RUN-ON CALCULATIONS – ACTIVE PORTION**		

1.0 OBJECTIVES

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

1. Determine the run-off water volume generated from the 25-year, 24-hour storm across the active portion of the Nucla Station Ash Disposal Facility (and other contributing areas) and verify that the containment berms maintained around the perimeter of the active portion will contain the design storm volume and prevent run-off.
2. Estimate the run-on volume generated from the 25-year, 24-hour storm that could route towards the active portion of the Nucla Station Ash Disposal Facility and verify that the existing perimeter channels have been designed and constructed to prevent run-on from flowing onto the active portion.

2.0 METHODOLOGY

2.1 Control of Run-off from the Active Portion of the Landfill

Basins contributing to the active portion of the landfill were 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 active portion are sufficient to prevent run-off from the active portion.

2.2 Prevention of Run-on to the Active Portion of the Landfill

Basins contributing to the perimeter channels preventing run-on to the active portion of the facility were delineated based on existing topography, as shown in Figure A-1. These basins include the existing landfill sideslopes. Times of concentration for basins contributing to the perimeter channels were calculated using the methodology described in TR-55 (USSCS 1986) for sheet, shallow concentrated flow and Manning's equation for channel flow. HEC-HMS modeling software (United States Army Corps of Engineers Hydrologic Engineering Center 2010) was used to simulate routing of the run-off from the landfill slopes and run-on from areas outside the landfill footprint through the perimeter channels. Peak flows were used to analyze channels, assuming normal depth using Manning's equation.

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Project No.:	1657746	Made by:	MBR
Site Name:	Nucla Station Ash Disposal Facility	Checked by:	CPB
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 2.11 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.
- The 2-year-frequency, 24-hour-duration storm depth, which is used in the TR-55 time of concentration method, is 1.20 inches (Hydrometeorological Design Studies Center 2013), as shown in Attachment A-1.
- 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 3.0 minutes (a time of concentration of 5 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.
- An SCS curve number of 70 was assumed for all basins, except contributing areas within the landfill footprint, reflecting a condition with established native vegetation (assumed to be Piñon-Juniper in good condition, based on site observations) and hydrologic soil group (HSG) D. The active portion and other contributing areas within the landfill footprint were assumed to be impervious (CN=99) for conservatism.
- A Manning's roughness coefficient of 0.035 (for capacity) was assumed for the vegetated perimeter channels.
- Stormwater that falls on the area of final cover on the top surface of the northern half of the facility was assumed to route to the southern half of the facility, which is topographically lower.
- Perimeter channels are grass-lined and were idealized as 2 feet deep with no bottom width and 3H:1V sideslopes, based on topographic information and site observation of the smallest perimeter channels.

4.0 RESULTS AND CONCLUSIONS

4.1 Control of Run-off from the Active Portion of the Landfill

Basin delineations are identified on Figure A-1. The run-off water volume routing onto the active potion of the landfill due to the design storm will decrease over time. This is because the active portion of the facility will decrease in size as the top surface elevation increases with additional waste placement and as additional final cover is placed. Thus, the existing condition represents the maximum run-off condition for the remaining life of the facility.

The run-off water volume routing onto the active portion of the facility 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 on the active portion of the facility due to the design storm

Project No.:	1657746	Made by:	MBR
Site Name:	Nucla Station Ash Disposal Facility	Checked by:	CPB
Date:	October 13, 2016	Reviewed by:	JEO

is 3.4 inches. The minimum 2-foot-high containment berms maintained around this area are sufficient to contain this depth of water with ample freeboard.

4.2 Prevention of Run-on to the Active Portion of the Landfill

Basin delineations are identified on Figure A-1. The surface area of basins that potentially contribute run-on to the facility (in the absence of perimeter channels) will decrease over time. This is because the top surface on the southern half of the facility will increase in elevation and the basin areas will correspondingly reduce in size. Thus, the existing condition represents the maximum run-on condition for the remaining life of the facility.

For run-on calculations, hydrologic parameters for the basins (Tables A-1 and A-2) and reaches were entered into the HEC-HMS modeling software and routed to calculate peak flows contributing to each perimeter channel (Table A-3). The HEC-HMS model inputs are included as Attachment A-2. The perimeter channels were analyzed using Manning's equation, as shown in Table A-4. The perimeter channels will convey the combined peak flow from the existing landfill sideslopes and areas routing towards the active portion of the facility, as delineated in Figure A-1, with more than 1 foot of freeboard.

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 and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 1657746

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

Design Storm 25 -Year Reccurence Interval

Storm Duration (hours)	2-Year Depth (inches)	25 -Year Depth (inches)	Storm Distribution
24	1.2	2.1	II

Subbasin ID	Subbasin Area (ft^2)	Subbasin Area (acres)	Subbasin Area (sq mile)	CN = 70 Sagebrush with grass understory HSG D, fair condition (acres)	CN = 99 Impervious (acres)	Composite SCS Curve No.	$S = \frac{1000}{CN} - 10$	Unit Runoff Q (in)	Runoff Volume (ac-ft)	Runoff Volume (ft^3)	Run-off Depth (in)
AF	1,006,506	23.11	0.0361		23.11	CN = 99	0.10	1.99	3.84	167,201	3.4
SA	689,013	15.82	0.0247		15.82	CN = 99	0.10	1.99	2.63	114,459	
RE	847,942	19.47	0.0304	19.47		CN = 70	4.29	0.28	0.46	20,026	N/A
RN	399,210	9.16	0.0143	9.16		CN = 70	4.29	0.28	0.22	9,428	
SP1	75,473	1.73	0.0027	1.73		CN = 70	4.29	0.28	0.04	1,782	
SP2	253,629	5.82	0.0091	5.82		CN = 70	4.29	0.28	0.14	5,990	
SP3	172,532	3.96	0.0062	3.96		CN = 70	4.29	0.28	0.09	4,075	
NP	389,751	8.95	0.0140	8.95		CN = 70	4.29	0.28	0.21	9,205	
Total:	3,834,056	88.02	0.14						7.63	332,166	

Table A-2. Basin Time of Concentration Calculations

Tri-State Generation and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 1657746

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

					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)
RE	0.0304	70	14.1	23.4	Sheet	100	0.020	H	Range		14.3	Shallow	910	0.066	U	Unpaved		3.7
RN	0.0143	70	12.7	21.2	Sheet	100	0.020	H	Range		14.3	Shallow	500	0.068	U	Unpaved		2.0
SP1	0.0027	70	11.5	19.1	Sheet	90	0.200	H	Range		5.2	Channel	475	0.005	E	Earth-lined	0.05	13.9
SP2	0.0091	70	7.2	11.9	Sheet	50	0.200	H	Range		3.3	Channel	1125	0.010	E	Earth-lined	0.22	8.7
SP3	0.0062	70	6.2	10.4	Sheet	50	0.174	H	Range		3.4	Channel	870	0.010	E	Earth-lined	0.21	6.9
NP	0.0140	70	13.9	23.1	Sheet	65	0.277	H	Range		3.5	Channel	2190	0.042	E	Earth-lined	0.06	19.6

Note:
(1) Refer to Attachment A for Roughness Condition descriptions and Tc Coeffiecients.

Table A-2. Basin Time of Concentration Calculations

Tri-State Generation and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 1657746

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

			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)
RE	0.0304	70	Channel	475	0.005	E	Earth-lined	0.20	5.5							
RN	0.0143	70	Channel	190	0.074	E	Earth-lined	0.07	1.2	Channel	245	0.005	E	Earth-lined	0.13	3.8
SP1	0.0027	70														
SP2	0.0091	70														
SP3	0.0062	70														
NP	0.0140	70														

Note:
(1) Refer to Attachment A for Roughness Condition descriptions and Tc Coeffiecients.

Table A-3. Flow Results from HEC-HMS

Tri-State Generation and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 1657746

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

HEC-HMS Basin Model:	Nucla
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)
RE	0.030	3.68	02Jun2525, 01:11	0.5
SP1	0.003	0.375	02Jun2525, 01:08	0
Junction-SP1-RE	0.033	4.035	02Jun2525, 01:10	0.5
Reach-SP2	0.033	4.002	02Jun2525, 01:21	0.5
SP2	0.017	3.126	02Jun2525, 01:03	0.3
SP3	0.006	1.186	02Jun2525, 01:02	0.1
Sink-1	0.057	5.299	02Jun2525, 01:20	0.8
RN	0.014	1.861	02Jun2525, 01:09	0.2
Reach-NP	0.014	1.851	02Jun2525, 01:13	0.2
NP	0.014	1.712	02Jun2525, 01:10	0.2
Sink-2	0.028	3.504	02Jun2525, 01:12	0.4

Table A-4. Channel Hydraulic Calculations

Tri-State Generation and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 1657746

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

			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)
North Perimeter	3.5	Sink-2		0.025	3.0	3.0	0	2.0	G	Grass-lined	0.035	0.030
South Perimeter	5.3	Sink-1		0.015	3.0	3.0	0	2.0	G	Grass-lined	0.035	0.030
SW Perimeter	1.2	SP3		0.010	3.0	3.0	0	2.0	G	Grass-lined	0.035	0.030

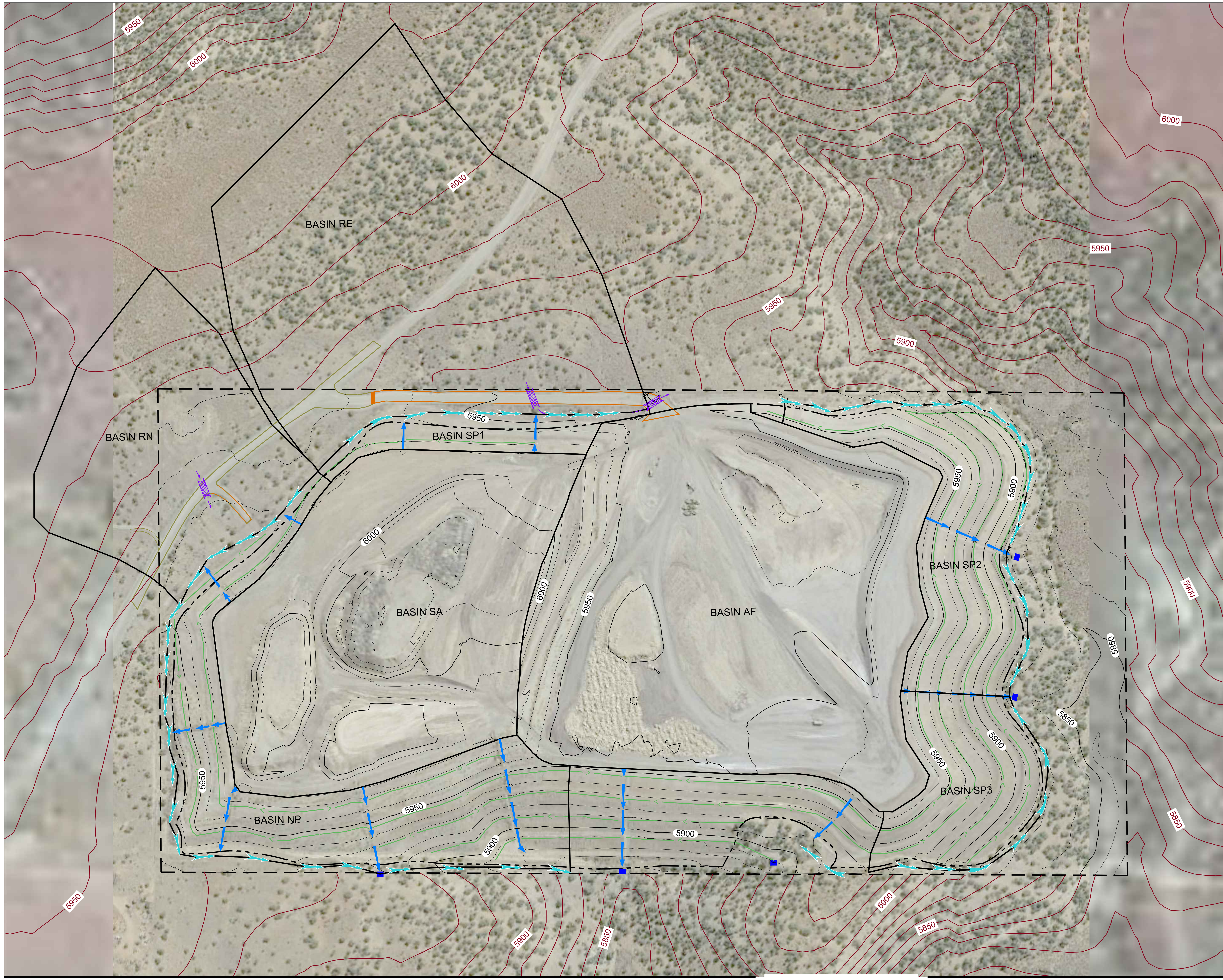
Table A-4. Channel Hydraulic Calculations

Tri-State Generation and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 1657746

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

			Hydraulic Calculations							Channel Evaluations	
Reach Designation	Q25 from HEC-HMS (cfs)	HEC HMS Element ID for Q	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)	
North Perimeter	3.5	Sink-2	3.4	0.62	1.09	0.97	47.49	3.7	12.0	1.4	OK
South Perimeter	5.3	Sink-1	3.1	0.80	0.88	0.75	33.53	4.8	12.0	1.2	OK
SW Perimeter	1.2	SP3	1.8	0.49	0.66	0.31	8.13	3.0	12.0	1.5	OK

FIGURE



LEGEND

- EXISTING SITE TOPOGRAPHY (SEE REFERENCE 1)
- SURROUNDING TOPOGRAPHY (SEE REFERENCE 2)
- PUBLIC ROADS
- TRI-STATE PRIVATE ROADS
- PROPERTY BOUNDARY
- EXISTING TERRACE CHANNEL
- EXISTING RUNDOWN CHANNEL
- BASIN BOUNDARY
- APPROXIMATE ASH DISPOSAL FOOTPRINT LIMIT (PROVIDED BY TRI-STATE) (61 ACRES)
- STORMWATER DISCHARGE POINT
- EXISTING PERIMETER CHANNEL
- CULVERT WITH FLOW DIRECTION

NOTES

1. THE LOCATIONS OF RUNDOWN CHANNELS ARE APPROXIMATE AND ARE BASED ON EXISTING GROUND TOPOGRAPHY AND AERIAL IMAGERY.

REFERENCES

1. EXISTING SITE TOPOGRAPHY WAS PROVIDED BY TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION, INC. TOPOGRAPHY IS A COMPOSITE BASED ON SURVEYS PERFORMED BY DEL-MONT CONSULTANTS BETWEEN 2008 AND 2015.
2. SURROUNDING TOPOGRAPHY IS FROM THE UNITED STATES GEOLOGICAL SURVEY.
3. AERIAL PHOTOGRAPH IS FROM GOOGLE EARTH PRO AND WAS TAKEN IN APRIL 2015.

0 150 300
SCALE FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2016-10-14	ISSUED FOR RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN	ELH	ELH	MAY	JEO

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PROJECT
NUCLA STATION ASH DISPOSAL FACILITY
RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

TITLE
BASIN DELINEATIONS

PROJECT NO. 1657746 | REV. 0 | FIGURE A-1

ATTACHMENT A-1
NOAA ATLAS 14 DATA FOR NUCLA STATION ASH DISPOSAL FACILITY

NOAA Atlas 14, Volume 8, Version 2
Location name: Redvale, Colorado, US*
Latitude: 38.2043°, Longitude: -108.4841°
Elevation: 5956 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

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	0.132 (0.103-0.171)	0.162 (0.127-0.210)	0.220 (0.172-0.286)	0.275 (0.213-0.359)	0.361 (0.276-0.507)	0.437 (0.323-0.619)	0.519 (0.370-0.757)	0.611 (0.417-0.919)	0.743 (0.487-1.15)	0.853 (0.540-1.33)
10-min	0.193 (0.151-0.250)	0.237 (0.186-0.308)	0.322 (0.251-0.419)	0.402 (0.312-0.526)	0.529 (0.404-0.743)	0.639 (0.473-0.906)	0.760 (0.542-1.11)	0.894 (0.610-1.35)	1.09 (0.713-1.69)	1.25 (0.790-1.95)
15-min	0.235 (0.185-0.305)	0.290 (0.227-0.376)	0.392 (0.306-0.511)	0.491 (0.381-0.642)	0.645 (0.492-0.906)	0.780 (0.577-1.10)	0.927 (0.661-1.35)	1.09 (0.744-1.64)	1.33 (0.869-2.06)	1.52 (0.964-2.38)
30-min	0.332 (0.261-0.430)	0.409 (0.321-0.530)	0.552 (0.431-0.718)	0.688 (0.534-0.900)	0.900 (0.686-1.26)	1.08 (0.800-1.53)	1.28 (0.914-1.87)	1.50 (1.02-2.26)	1.82 (1.19-2.83)	2.08 (1.32-3.25)
60-min	0.421 (0.330-0.545)	0.516 (0.405-0.669)	0.689 (0.538-0.897)	0.849 (0.659-1.11)	1.09 (0.830-1.52)	1.30 (0.960-1.83)	1.53 (1.08-2.21)	1.77 (1.21-2.65)	2.12 (1.39-3.28)	2.41 (1.52-3.76)
2-hr	0.510 (0.404-0.652)	0.623 (0.494-0.798)	0.826 (0.653-1.06)	1.01 (0.794-1.31)	1.29 (0.986-1.76)	1.52 (1.13-2.11)	1.77 (1.27-2.53)	2.04 (1.40-3.01)	2.42 (1.60-3.69)	2.73 (1.74-4.21)
3-hr	0.567 (0.453-0.720)	0.685 (0.547-0.871)	0.894 (0.711-1.14)	1.08 (0.855-1.39)	1.36 (1.05-1.85)	1.59 (1.19-2.19)	1.84 (1.33-2.61)	2.11 (1.46-3.09)	2.48 (1.65-3.76)	2.78 (1.79-4.27)
6-hr	0.684 (0.553-0.858)	0.818 (0.660-1.03)	1.05 (0.842-1.32)	1.25 (0.999-1.58)	1.54 (1.20-2.06)	1.78 (1.35-2.42)	2.04 (1.48-2.84)	2.30 (1.61-3.32)	2.67 (1.79-3.99)	2.97 (1.93-4.50)
12-hr	0.848 (0.693-1.05)	0.997 (0.814-1.24)	1.25 (1.02-1.56)	1.48 (1.20-1.85)	1.81 (1.43-2.39)	2.09 (1.60-2.79)	2.38 (1.75-3.28)	2.68 (1.89-3.83)	3.11 (2.11-4.59)	3.45 (2.27-5.16)
24-hr	1.04 (0.862-1.27)	1.20 (0.992-1.47)	1.48 (1.22-1.82)	1.73 (1.42-2.14)	2.11 (1.68-2.74)	2.42 (1.87-3.20)	2.75 (2.05-3.75)	3.10 (2.22-4.37)	3.60 (2.47-5.25)	4.00 (2.66-5.92)
2-day	1.25 (1.05-1.51)	1.42 (1.19-1.72)	1.72 (1.43-2.09)	1.99 (1.65-2.43)	2.39 (1.93-3.07)	2.73 (2.14-3.56)	3.08 (2.33-4.15)	3.46 (2.50-4.82)	4.00 (2.77-5.76)	4.43 (2.98-6.47)
3-day	1.39 (1.17-1.66)	1.58 (1.33-1.89)	1.91 (1.60-2.30)	2.21 (1.84-2.67)	2.63 (2.13-3.35)	2.99 (2.35-3.86)	3.36 (2.55-4.47)	3.75 (2.73-5.17)	4.30 (3.00-6.14)	4.74 (3.21-6.87)
4-day	1.50 (1.27-1.79)	1.71 (1.45-2.04)	2.07 (1.74-2.48)	2.38 (1.99-2.87)	2.83 (2.30-3.57)	3.20 (2.53-4.10)	3.58 (2.73-4.74)	3.99 (2.91-5.46)	4.54 (3.18-6.44)	4.99 (3.39-7.19)
7-day	1.78 (1.52-2.10)	2.02 (1.73-2.38)	2.42 (2.06-2.87)	2.77 (2.34-3.30)	3.26 (2.67-4.05)	3.65 (2.91-4.62)	4.06 (3.12-5.30)	4.48 (3.29-6.06)	5.05 (3.56-7.08)	5.50 (3.77-7.85)
10-day	2.03 (1.74-2.37)	2.29 (1.97-2.68)	2.72 (2.33-3.19)	3.09 (2.63-3.65)	3.61 (2.97-4.44)	4.02 (3.22-5.04)	4.44 (3.43-5.75)	4.87 (3.60-6.54)	5.46 (3.88-7.59)	5.92 (4.08-8.39)
20-day	2.70 (2.35-3.12)	3.02 (2.63-3.49)	3.55 (3.08-4.11)	3.98 (3.43-4.64)	4.59 (3.81-5.55)	5.06 (4.10-6.24)	5.53 (4.32-7.05)	6.01 (4.49-7.93)	6.65 (4.76-9.10)	7.13 (4.97-9.98)
30-day	3.25 (2.85-3.72)	3.63 (3.18-4.16)	4.25 (3.71-4.88)	4.75 (4.13-5.50)	5.44 (4.55-6.52)	5.96 (4.87-7.29)	6.48 (5.09-8.18)	7.00 (5.26-9.15)	7.67 (5.53-10.4)	8.17 (5.74-11.3)
45-day	3.92 (3.47-4.45)	4.39 (3.88-5.00)	5.15 (4.53-5.88)	5.75 (5.03-6.61)	6.56 (5.51-7.77)	7.16 (5.88-8.66)	7.74 (6.12-9.66)	8.30 (6.27-10.7)	9.01 (6.53-12.1)	9.53 (6.73-13.1)
60-day	4.48 (3.99-5.06)	5.05 (4.48-5.71)	5.93 (5.25-6.73)	6.63 (5.83-7.57)	7.55 (6.37-8.87)	8.21 (6.77-9.86)	8.84 (7.02-11.0)	9.45 (7.17-12.1)	10.2 (7.42-13.6)	10.7 (7.60-14.7)

[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.

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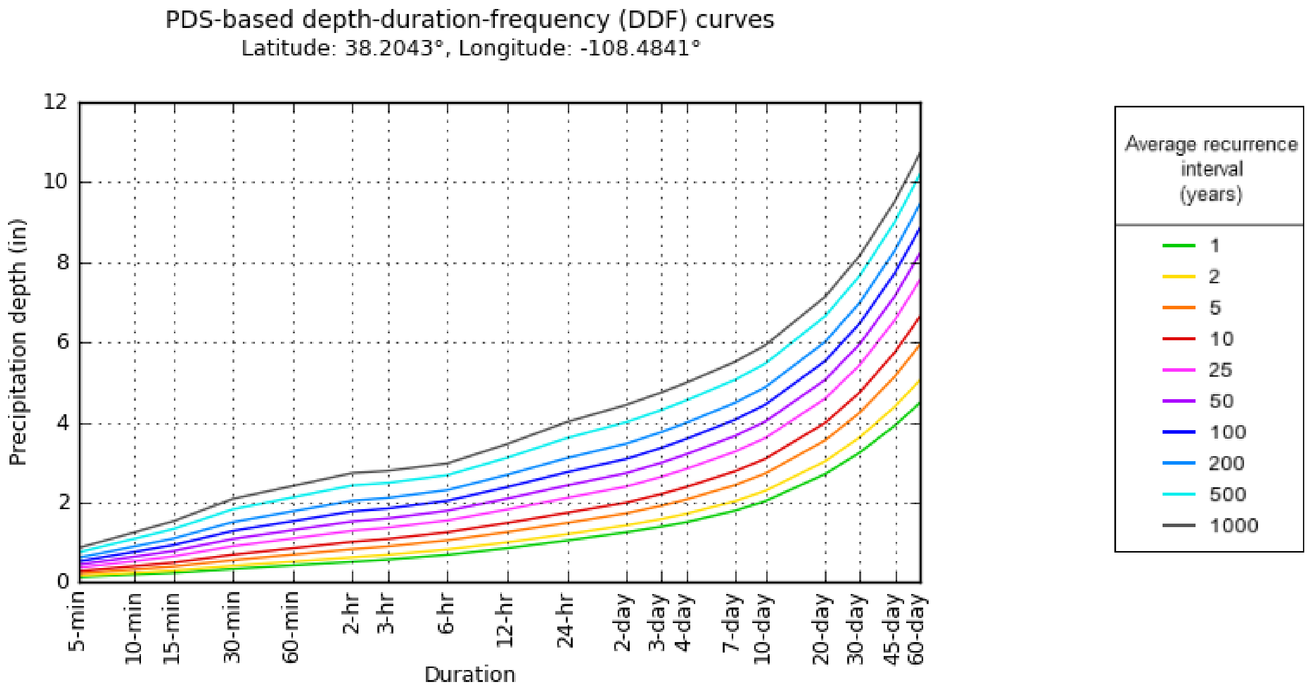
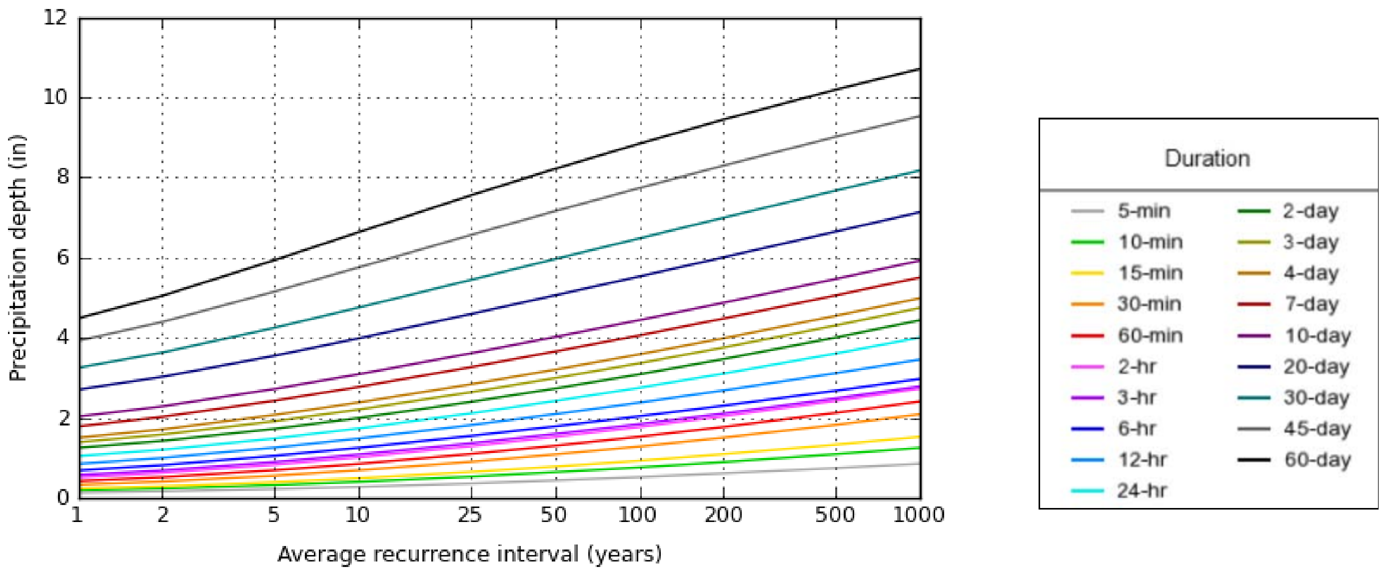
PF graphical





NOAA Atlas 14, Volume 8, Version 2 Created (GMT): Wed Jun 29 19:49:30 2016

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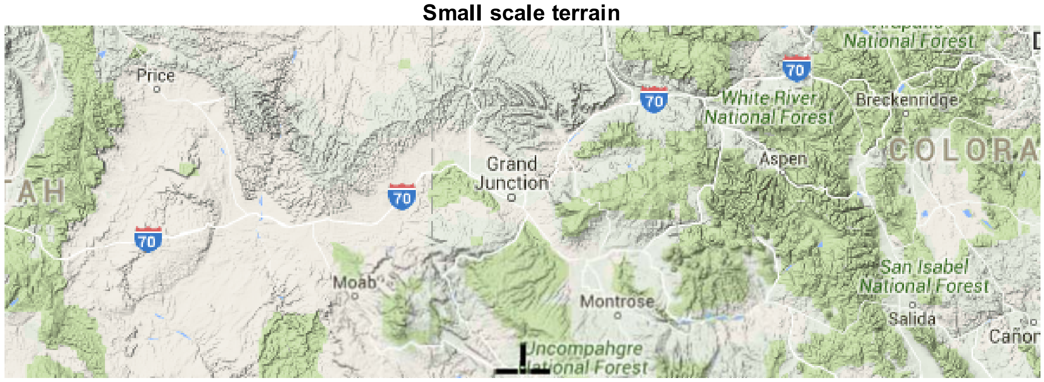
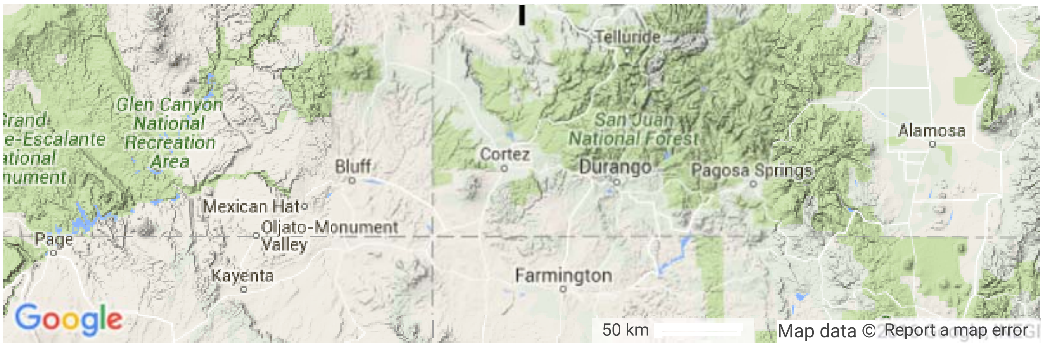
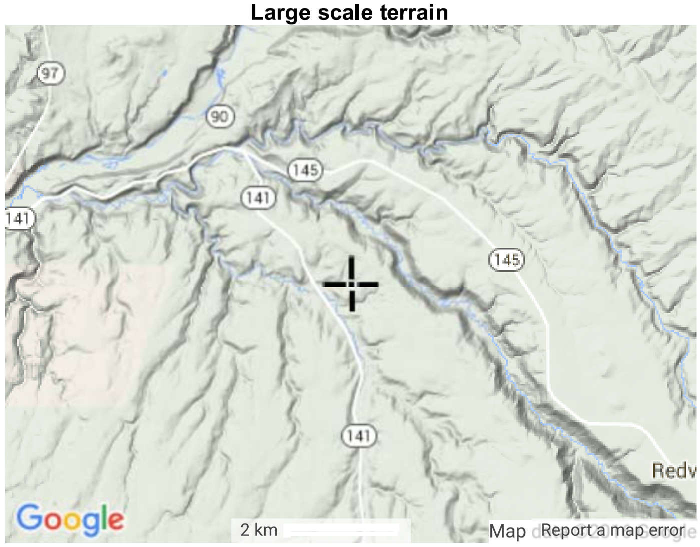
Maps & aerials

Small scale terrain



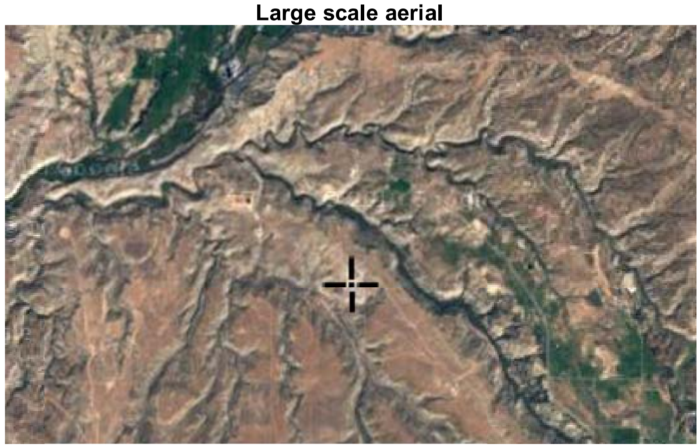


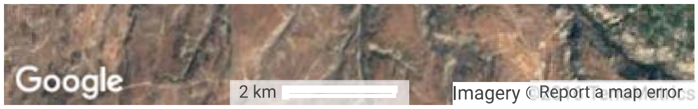
Large scale terrain



Large scale map

Large scale aerial





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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
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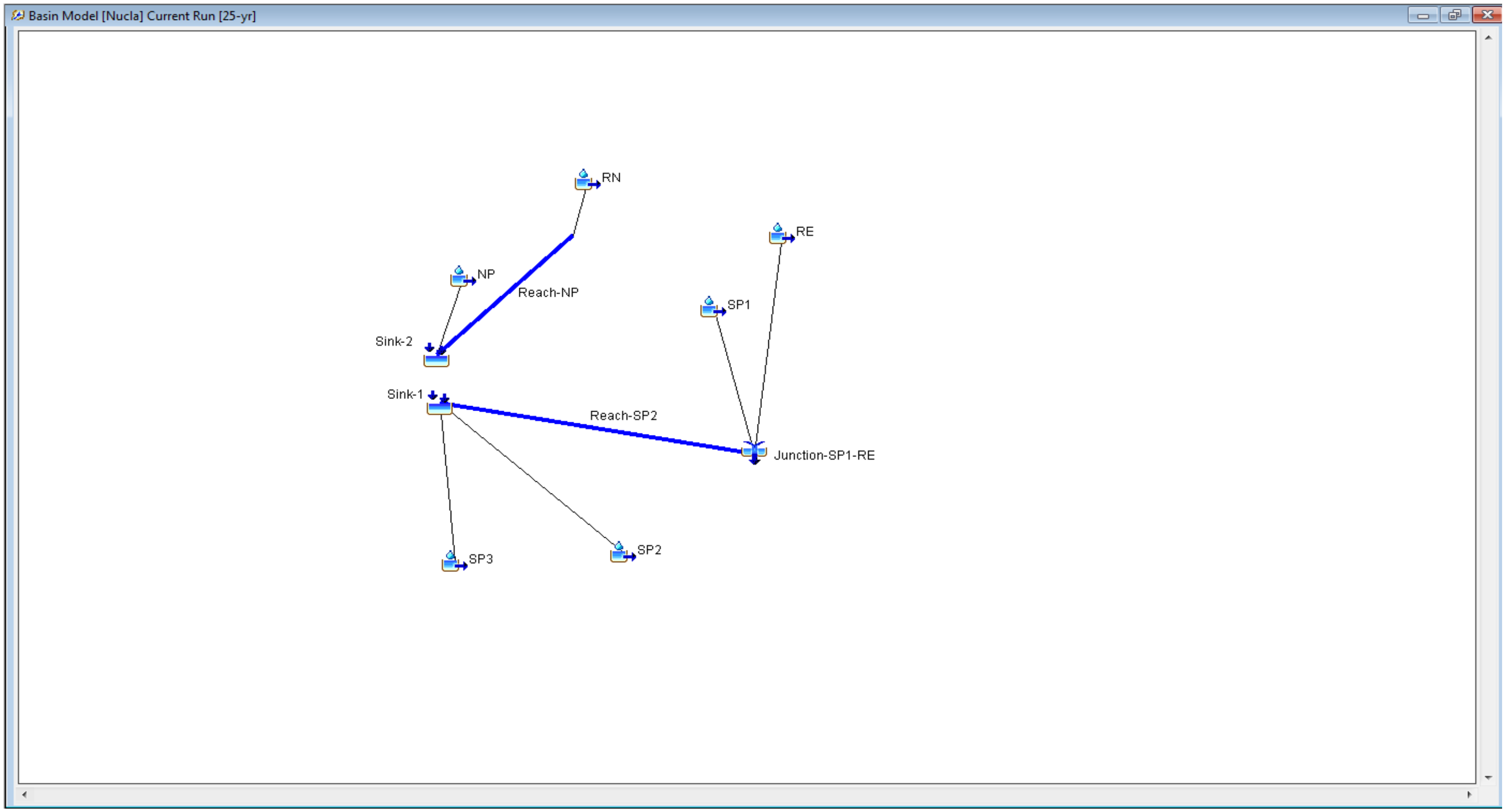
Disclaimer

ATTACHMENT A-2
HEC-HMS MODEL INPUTS

HEC-HMS Screen Captures and Inputs

HEC-HMS Basin Model Schematic



Sub Basin Area	
Subbasin	**Area (mi^2)**
RE	0.0304
SP1	0.0027
SP2	0.0174
SP3	0.0062
RN	0.0143
NP	0.0080

Loss SCS Curve Number			
Subbasin	**Initial Abstraction (in)**	**Curve Number**	**Impervious (%)**
RE		70	0
SP1		70	0
SP2		70	0
SP3		70	0
RN		70	0
NP		70	0

Transform SCS Unit Hydrograph		
Subbasin	**Graph Type**	**Lag Time (min)**
RE	Standard	14.1
SP1	Standard	11.5
SP2	Standard	7.2
SP3	Standard	6.2
RN	Standard	12.7
NP	Standard	13.9

Routing Kinematic Wave Channel								
Reach	**Length (ft)**	**Slope (ft/ft)**	**Manning's n**	**subreaches**	**Shape**	**Diameter (ft)**	**Width (ft)**	**Side Slope (xH:1V)**
Reach-SP2	2930	0.015	0.022	2	Triangle			3
Reach-NP	1270	0.024	0.022	2	Triangle			3

APPENDIX B

Stormwater Runoff Calculations – Closure Conditions

GOLDER
MEMBER OF WSP

TECHNICAL CALCULATIONS

DATE June 3, 2021 **Reference No.** 20138863-9-TM-0

TO Greg Wallingford, PE
Tri-State Generation and Transmission Association, Inc.

CC Jason Obermeyer, PE

FROM Brendan Purcell **EMAIL brendan_purcell@golder.com**

NUCLA STATION ASH DISPOSAL FACILITY CLOSURE DESIGN SITE RUN-OFF CALCULATIONS

Golder Associates Inc. (Golder) has prepared this technical calculation package for Tri-State Generation and Transmission Association, Inc. (Tri-State) to present the peak flow calculations and hydraulic designs for closure of the Nucla Station Ash Disposal Facility. The facility is located in Montrose County, Colorado, approximately six miles southeast of Nucla, Colorado.

1.0 OBJECTIVE

The objectives for these calculations are to:

- Determine the 100-year, 24-hour (design storm) peak stormwater flows for the Nucla Station Ash Disposal Facility after closure.
- Verify that the stormwater drainage features (terrace channels, downchutes, perimeter channels, and culverts) can convey the design storm peak flow rates.

2.0 METHODOLOGY

Basins and subbasins for the surface water control system were delineated based on existing and planned channels and topography, as shown in Figure 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 2020) was used to simulate the routing of surface run-off from the final cover system slopes and the resulting peak flows that will occur. Peak flows were used to analyze terrace channels, downchutes, and perimeter channels assuming normal depth using Flowmaster software (Bentley Systems 2009). Peak flows were also used to size proposed culverts from the top surface of the final cover system on the southern half of the facility to an existing perimeter channel using HY-8 software (FHWA 2020).

3.0 ASSUMPTIONS

The following assumptions were utilized for this calculation:

- A design storm event of 2.75 inches was used in the analysis. This event is the 24-hour duration, 100-year frequency 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 1.20 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 3.0 minutes (corresponding to a time of concentration of 5 minutes per TR-55).
- The maximum length of sheet flow is 100 feet.
- A kinematic wave methodology was used to route peak flows in the HEC HMS model; some channel reaches did not include routing for conservatism and simplicity.
- An SCS curve number of 70 was assumed for all basins and subbasins, reflecting a post-closure condition with native vegetation, which is assumed to be “sagebrush with grass understory in fair condition,” and surficial soils in hydrologic soil group (HSG) D.
- A Manning’s roughness coefficient of 0.035 (for capacity) was assumed for riprap-lined downchutes.
- A Manning’s roughness coefficient of 0.030 was assumed for the terrace channels.
- The perimeter channels were analyzed with Manning’s roughness coefficients of 0.030 and 0.035 (for stability and capacity, respectively) for the portions of the perimeter channels with the lowest slopes (generally grass-lined) and 0.035 and 0.040 (for stability and capacity, respectively) for the portions of the perimeter channels with the steepest slopes (generally riprap-lined).
- The downchutes were designed with an effective slope of 33%.
- The terrace channels were designed to slope at 0.5% toward downchutes.
- The perimeter channels were assumed to be v-channels with 3H:1V sideslopes and a 2-foot depth. Based on visual observations at the site, this idealized channel configuration is considered to be conservative.
- Culverts are assumed to be corrugated steel with a Manning’s roughness coefficient of 0.024 constructed at a minimum slope of 1.0%.

4.0 CALCULATIONS

Channel reach locations and basin and subbasin delineations are identified on Figure 1. Hydrologic parameters for the basins and subbasins (Tables 1 and 2) and channel reaches were entered into the HEC HMS modeling software and routed to calculate peak flows for each basin, subbasin, and channel (Table 3). Channels were checked for capacity to accommodate the peak flow (Attachment 1 and Table 4). The HEC-HMS model inputs are included in Attachment 2.

5.0 RESULTS AND CONCLUSIONS

Outputs for the downchute reaches are summarized in Attachment 1, with peak flows, depths, and velocities associated with the design storm event. The downchutes are parabolic, 1 foot deep, and 10 feet wide. The hydraulics for the worst-case terrace channel were evaluated; this is the longest terrace channel within Subbasin WS7-B. The full peak flow was conservatively assumed to flow in this terrace channel in the calculation. The terrace channels are formed by the 10 foot wide terraces sloping back toward the facility sideslope at 5%, which makes the channels 0.5 feet deep.

Culverts were sized to convey run-off from the top surface of the southern portion of the facility (Basin SW-S) to the existing East Perimeter channel. Two 18-inch-diameter, corrugated steel culverts were sized assuming a minimum 1% slope. Sizing of the culverts is summarized in Attachment 3.

All downchutes and perimeter channels and the worst-case terrace channel (and therefore all terrace channels) were found to have adequate capacity to convey run-off from the 100-year, 24-hour peak flow event without overtopping. The proposed culverts are adequately sized to convey run-off from the 100-year, 24-hour peak flow event.

6.0 REFERENCES

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Prepared by: Brendan Purcell

Checked by: Micah Richey

Reviewed by: Jason Obermeyer

Attachments: Table 1 – Basin and Subbasin Summary
Table 2 – Time of Concentration Calculations
Table 3 – Flow Results from HEC-HMS
Table 4 – Perimeter Channel Hydraulic Calculations
Figure 1 – Stormwater Basins and Subbasins
Attachment 1 – Channel Hydraulic Assessment Outputs
Attachment 2 – HEC-HMS Model Schematic and Model Inputs
Attachment 3 – HY-8 Outputs

Tables

Table 1: Basin and Subbasin Summary

Tri-State Generation and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 20138863

Date:	5/11/21
By:	BJP
Chkd:	MBR
Apprvd:	JEO

Design Storm	**100**	**-Year Reccurence Interval**	
Storm Duration (hours)	**2-Year Depth (inches)**	**100 -Year Depth (inches)**	**Storm Distribution**
24	**1.20**	**2.75**	**II**

Basin or Subbasin ID	Area (ft^2)	Area (acres)	Area (sq mile)	CN = 70 Sagebrush with grass understory HSG D, fair condition (acres)	Composite SCS Curve No.	S = 1000 - 10 CN	Unit Runoff Q (in)	Runoff Volume (ac-ft)	Runoff Volume (ft^3)
WS1-A	32,518	0.75	0.0012	0.75	CN = 70	4.29	0.58	0.04	1,571
WS1-B	36,065	0.83	0.0013	0.83	CN = 70	4.29	0.58	0.04	1,743
WS2-A	31,614	0.73	0.0011	0.73	CN = 70	4.29	0.58	0.04	1,528
WS2-B	38,587	0.89	0.0014	0.89	CN = 70	4.29	0.58	0.04	1,865
WS3-A	52,248	1.20	0.0019	1.20	CN = 70	4.29	0.58	0.06	2,525
WS3-B	37,135	0.85	0.0013	0.85	CN = 70	4.29	0.58	0.04	1,795
WS4-A	86,784	1.99	0.0031	1.99	CN = 70	4.29	0.58	0.10	4,194
WS5-C	13,685	0.31	0.0005	0.31	CN = 70	4.29	0.58	0.02	661
WS6-B	40,985	0.94	0.0015	0.94	CN = 70	4.29	0.58	0.05	1,981
WS6-C	60,840	1.40	0.0022	1.40	CN = 70	4.29	0.58	0.07	2,940
WS6-D	82,343	1.89	0.0030	1.89	CN = 70	4.29	0.58	0.09	3,979
WS7-A	63,287	1.45	0.0023	1.45	CN = 70	4.29	0.58	0.07	3,058
WS7-B	163,203	3.75	0.0059	3.75	CN = 70	4.29	0.58	0.18	7,887
WS8-B	46,968	1.08	0.0017	1.08	CN = 70	4.29	0.58	0.05	2,270
WS8-C	20,553	0.47	0.0007	0.47	CN = 70	4.29	0.58	0.02	993
WS9-C	68,254	1.57	0.0024	1.57	CN = 70	4.29	0.58	0.08	3,298
WS9-D	39,645	0.91	0.0014	0.91	CN = 70	4.29	0.58	0.04	1,916
WS9-E	17,278	0.40	0.0006	0.40	CN = 70	4.29	0.58	0.02	835
WS9-F	20,327	0.47	0.0007	0.47	CN = 70	4.29	0.58	0.02	982
WS10-A	57,105	1.31	0.0020	1.31	CN = 70	4.29	0.58	0.06	2,760
WS10-B	73,585	1.69	0.0026	1.69	CN = 70	4.29	0.58	0.08	3,556
WS10-C	42,943	0.99	0.0015	0.99	CN = 70	4.29	0.58	0.05	2,075
WS10-D	38,049	0.87	0.0014	0.87	CN = 70	4.29	0.58	0.04	1,839
WS11-A	36,942	0.85	0.0013	0.85	CN = 70	4.29	0.58	0.04	1,785
WS11-B	177,399	4.07	0.0064	4.07	CN = 70	4.29	0.58	0.20	8,573
WS11-C	27,920	0.64	0.0010	0.64	CN = 70	4.29	0.58	0.03	1,349
WS11-D	7,989	0.18	0.0003	0.18	CN = 70	4.29	0.58	0.01	386
WS12-A	40,005	0.92	0.0014	0.92	CN = 70	4.29	0.58	0.04	1,933
WS12-B	18,063	0.41	0.0006	0.41	CN = 70	4.29	0.58	0.02	873
WS12-C	21,623	0.50	0.0008	0.50	CN = 70	4.29	0.58	0.02	1,045
WS13-A	12,492	0.29	0.0004	0.29	CN = 70	4.29	0.58	0.01	604
WS13-B	54,105	1.24	0.0019	1.24	CN = 70	4.29	0.58	0.06	2,615
WS13-C	24,218	0.56	0.0009	0.56	CN = 70	4.29	0.58	0.03	1,170
WS13-D	14,029	0.32	0.0005	0.32	CN = 70	4.29	0.58	0.02	678
RE 1	933,453	21.43	0.0335	21.43	CN = 70	4.29	0.58	1.04	45,109
RE 2	64,310	1.48	0.0023	1.48	CN = 70	4.29	0.58	0.07	3,108
RN 1	423,214	9.72	0.0152	9.72	CN = 70	4.29	0.58	0.47	20,452
RN 2	605,036	13.89	0.0217	13.89	CN = 70	4.29	0.58	0.67	29,238
S 1	9,515	0.22	0.0003	0.22	CN = 70	4.29	0.58	0.01	460
SW 1	29,830	0.68	0.0011	0.68	CN = 70	4.29	0.58	0.03	1,442
WS-S	924,923	21.23	0.0332	21.23	CN = 70	4.29	0.58	1.03	44,696
Total:	**4,589,068**	**105.35**	**0.1646**					**5.09**	**221,764**

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Table 2: Time of Concentration Calculations

Tri-State Generation and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 20138863

Date:	5/11/21
By:	BJP
Chkd:	MBR

					Flow Segment 1							Flow Segment 2						
Basin or Subbasin ID	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		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
WS1-A	0.0012	70	9.0	14.9	Sheet	100	0.055	H	Range		9.5	Shallow	220	0.068	U	Unpaved		0.9
WS1-B	0.0013	70	6.4	10.7	Sheet	100	0.1	H	Range		7.5	Shallow	205	0.078	U	Unpaved		0.8
WS2-A	0.0011	70	6.6	11.1	Sheet	100	0.13	H	Range		6.7	Shallow	90	0.1	U	Unpaved		0.3
WS2-B	0.0014	70	4.7	7.9	Sheet	100	0.33	H	Range		4.6	Shallow	190	0.02	U	Unpaved		1.4
WS3-A	0.0019	70	11.1	18.5	Sheet	100	0.02	H	Range		14.3	Shallow	180	0.02	U	Unpaved		1.3
WS3-B	0.0013	70	9.3	15.5	Sheet	100	0.03	H	Range		12.1	Shallow	200	0.22	U	Unpaved		0.4
WS4-A	0.0031	70	8.0	13.3	Sheet	100	0.03	H	Range		12.1	Shallow	300	0.077	U	Unpaved		1.1
WS5-C	0.0005	70	6.3	10.5	Sheet	40	0.4	H	Range		2.1	Channel	460	0.005	E	Earth-lined	0.10	8.5
WS6-B	0.0015	70	4.9	8.2	Sheet	45	0.4	H	Range		2.3	Channel	400	0.005	E	Earth-lined	0.14	5.9
WS6-C	0.0022	70	5.3	8.8	Sheet	35	0.4	H	Range		1.9	Channel	435	0.005	E	Earth-lined	0.14	6.4
WS6-D	0.0030	70	4.4	7.4	Sheet	55	0.4	H	Range		2.7	Channel	270	0.005	E	Earth-lined	0.18	3.4
WS7-A	0.0023	70	3.8	6.4	Sheet	50	0.4	H	Range		2.5	Channel	210	0.005	E	Earth-lined	0.18	2.6
WS7-B	0.0059	70	6.1	10.2	Sheet	45	0.4	H	Range		2.3	Channel	620	0.005	E	Earth-lined	0.20	7.2
WS8-B	0.0017	70	3.5	5.8	Sheet	50	0.4	H	Range		2.5	Channel	225	0.005	E	Earth-lined	0.14	3.3
WS8-C	0.0007	70	10.3	17.1	Sheet	100	0.02	H	Range		14.3	Shallow	130	0.02	U	Unpaved		0.9
WS9-C	0.0024	70	4.4	7.3	Sheet	45	0.4	H	Range		2.3	Channel	285	0.005	E	Earth-lined	0.17	3.7
WS9-D	0.0014	70	3.7	6.2	Sheet	50	0.4	H	Range		2.5	Channel	170	0.005	E	Earth-lined	0.15	2.4
WS9-E	0.0006	70	5.2	8.7	Sheet	100	0.16	H	Range		6.2	Channel	215	0.02	E	Earth-lined	0.07	2.5
WS9-F	0.0007	70	4.0	6.7	Sheet	100	0.4	H	Range		4.3	Channel	290	0.04	E	Earth-lined	0.07	2.4
WS10-A	0.0020	70	7.5	12.5	Sheet	100	0.09	H	Range		7.8	Shallow	260	0.02	U	Unpaved		1.9
WS10-B	0.0026	70	10.2	17.1	Sheet	100	0.02	H	Range		14.3	Shallow	525	0.09	U	Unpaved		1.8
WS10-C	0.0015	70	3.5	5.8	Sheet	45	0.4	H	Range		2.3	Channel	165	0.005	E	Earth-lined	0.15	2.3
WS10-D	0.0014	70	3.9	6.5	Sheet	55	0.4	H	Range		2.7	Channel	190	0.005	E	Earth-lined	0.15	2.7
WS11-A	0.0013	70	9.7	16.2	Sheet	100	0.02	H	Range		14.3	Shallow	260	0.02	U	Unpaved		1.9
WS11-B	0.0064	70	9.0	14.9	Sheet	100	0.06	H	Range		9.2	Shallow	275	0.075	U	Unpaved		1.0
WS11-C	0.0010	70	3.9	6.4	Sheet	55	0.4	H	Range		2.7	Channel	205	0.005	E	Earth-lined	0.13	3.2
WS11-D	0.0003	70	2.4	4.1	Sheet	55	0.4	H	Range		2.7	Channel	100	0.005	E	Earth-lined	0.15	1.4
WS12-A	0.0014	70	9.6	16.0	Sheet	100	0.02	H	Range		14.3	Shallow	285	0.03	U	Unpaved		1.7
WS12-B	0.0006	70	4.4	7.3	Sheet	55	0.4	H	Range		2.7	Channel	270	0.005	E	Earth-lined	0.11	4.7
WS12-C	0.0008	70	8.5	14.1	Sheet	100	0.04	H	Range		10.8	Shallow	60	0.4	U	Unpaved		0.1
WS13-A	0.0004	70	8.7	14.5	Sheet	100	0.04	H	Range		10.8	Channel	90	0.005	E	Earth-lined	0.03	3.7
WS13-B	0.0019	70	8.4	14.0	Sheet	100	0.06	H	Range		9.2	Shallow	175	0.03	U	Unpaved		1.0
WS13-C	0.0009	70	4.2	7.1	Sheet	60	0.4	H	Range		2.9	Channel	300	0.005	E	Earth-lined	0.15	4.2
WS13-D	0.0005	70	3.2	5.3	Sheet	50	0.4	H	Range		2.5	Channel	200	0.005	E	Earth-lined	0.15	2.8
RE 1	0.0335	70	16.8	28.1	Sheet	100	0.02	H	Range		14.3	Shallow	910	0.066	U	Unpaved		3.7
RE 2	0.0023	70	3.7	6.2	Channel	1395	0.05	E	Earth-lined	0.15	6.2							
RN 1	0.0152	70	12.7	21.1	Sheet	100	0.02	H	Range		14.3	Shallow	500	0.068	U	Unpaved		2.0
RN 2	0.0217	70	16.4	27.4	Sheet	100	0.02	H	Range		14.3	Shallow	465	0.09	U	Unpaved		1.6
S 1	0.0003	70	1.2	2.1	Channel	330	0.05	E	Earth-lined	0.09	2.1							
SW 1	0.0011	70	5.2	8.7	Sheet	90	0.2	H	Range		5.2	Channel	700	0.06	E	Earth-lined	0.11	3.5
WS-S	0.0332	70	12.7	21.1	Sheet	100	0.03	H	Range		12.1	Shallow	1000	0.03	U	Unpaved		6.0

	Flow Segment 3							Flow Segment 4							Flow Segment 5						
Basin or Subbasin ID	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
WS1-A	Channel	175	0.005	E	Earth-lined	0.06	4.5														
WS1-B	Channel	105	0.005	E	Earth-lined	0.07	2.5														
WS2-A	Channel	155	0.005	E	Earth-lined	0.06	4.0														
WS2-B	Channel	80	0.005	E	Earth-lined	0.07	1.9						0.12								
WS3-A	Channel	125	0.005	E	Earth-lined	0.07	2.9														
WS3-B	Channel	115	0.005	E	Earth-lined	0.06	3.0														
WS4-A																					
WS5-C																					
WS6-B																					
WS6-C	Channel	70	0.330	R	Riprap	0.03	0.6														
WS6-D	Channel	240	0.330	R	Riprap	0.05	1.4														
WS7-A	Channel	260	0.330	R	Riprap	0.06	1.3														
WS7-B	Channel	150	0.330	R	Riprap	0.07	0.7														
WS8-B																					
WS8-C	Shallow	30	0.400	U	Unpaved		0.0	Channel	35	0.005	E	Earth-lined	0.16	0.5	Channel	130.0	0.330	R	Riprap	0.02	1.4
WS9-C	Channel	230	0.330	R	Riprap	0.05	1.3														
WS9-D	Channel	240	0.330	R	Riprap	0.05	1.4														
WS9-E																					
WS9-F																					
WS10-A	Channel	130	0.005	E	Earth-lined	0.08	2.8														
WS10-B	Channel	50	0.005	E	Earth-lined	0.09	1.0														
WS10-C	Channel	180	0.330	R	Riprap	0.04	1.2														
WS10-D	Channel	180	0.330	R	Riprap	0.04	1.2														
WS11-A																					
WS11-B	Shallow	440	0.020	U	Unpaved		3.2	Channel	100	0.005	E	Earth-lined	0.14	1.5							
WS11-C	Channel	75	0.330	R	Riprap	0.03	0.6														
WS11-D																					
WS12-A																					
WS12-B																					
WS12-C	Channel	110	0.005	E	Earth-lined	0.05	3.2														
WS13-A																					
WS13-B	Channel	175	0.005	E	Earth-lined	0.08	3.7														
WS13-C						0.08															
WS13-D						0.08															
RE 1	Channel	475	0.005	E	Earth-lined	0.08	10.1														
RE 2						0.08															
RN 1	Channel	190	0.074	E	Earth-lined	0.08	1.1	Channel	245	0.005	E	Earth-lined	0.13	3.8							
RN 2	Channel	1525	0.040	E	Earth-lined	0.08	11.5														
S 1						0.08															
SW 1						0.08															
WS-S	Channel	440	0.011	E	Earth-lined	0.24	3.0														

GOLDER
MEMBER OF WSP

Table 3: Flow Results from HEC-HMS

Tri-State Generation and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 20138863

Date:	5/11/21
By:	BJP
Chkd:	MBR
Apprvd:	JEO

HEC-HMS Basin Model:	Nucla - 2021		
HEC-HMS Met. Model:	100-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)
RE 1	0.0335	10.92	02Jun2525, 01:09	1
WS3-A	0.0019	0.72	02Jun2525, 01:06	0.1
WS3-B	0.0013	0.54	02Jun2525, 01:04	0
J_WS3-AB	0.0032	1.24	02Jun2525, 01:05	0.1
J-WS3	0.0367	12.02	02Jun2525, 01:09	1.1
WS4-A	0.0031	1.37	02Jun2525, 01:03	0.1
J_WS4-AB	0.0031	1.37	02Jun2525, 01:03	0.1
J-WS4	0.0398	13.04	02Jun2525, 01:08	1.2
WS5-C	0.0005	0.24	02Jun2525, 01:01	0
WS-S	0.0332	11.54	02Jun2525, 01:08	1
RE 2	0.0023	1.26	02Jun2525, 00:59	0.1
WS6-B	0.0015	0.78	02Jun2525, 01:00	0
J_WS5-AC	0.0005	0.24	02Jun2525, 01:01	0
J-WS5	0.0773	25.4	02Jun2525, 01:07	2.4
RN 1	0.0152	5.28	02Jun2525, 01:08	0.5
WS2-B	0.0014	0.73	02Jun2525, 01:00	0
WS2-A	0.0011	0.52	02Jun2525, 01:02	0
J_WS2-AB	0.0025	1.24	02Jun2525, 01:01	0.1
J-WS2	0.0177	5.99	02Jun2525, 01:06	0.5
WS1-B	0.0013	0.62	02Jun2525, 01:02	0
WS1-A	0.0012	0.5	02Jun2525, 01:04	0
J_WS1-AB	0.0025	1.1	02Jun2525, 01:03	0.1
RN 2	0.0217	7.66	02Jun2525, 01:07	0.7
J-WS1	0.0202	6.96	02Jun2525, 01:05	0.6
WS13-B	0.0019	0.82	02Jun2525, 01:03	0.1
WS13-A	0.0004	0.17	02Jun2525, 01:04	0
J-WS13-AB	0.0023	0.99	02Jun2525, 01:04	0.1
WS13-C	0.0009	0.48	02Jun2525, 00:59	0
WS13-D	0.0005	0.28	02Jun2525, 00:58	0
J-WS13-CD	0.0037	1.63	02Jun2525, 01:01	0.1
J-WS13	0.0456	15.74	02Jun2525, 01:06	1.4
WS12-A	0.0014	0.57	02Jun2525, 01:05	0
WS12-C	0.0008	0.34	02Jun2525, 01:04	0
WS12-B	0.0006	0.32	02Jun2525, 00:59	0
J-WS12-BC	0.0028	1.16	02Jun2525, 01:03	0.1
J-WS12	0.0484	16.78	02Jun2525, 01:06	1.5
WS11-B	0.0064	2.69	02Jun2525, 01:04	0.2
WS11-A	0.0013	0.53	02Jun2525, 01:05	0
J-WS11-AB	0.0077	3.21	02Jun2525, 01:04	0.2
WS11-C	0.001	0.55	02Jun2525, 00:59	0
WS11-D	0.0003	0.17	02Jun2525, 00:57	0
J-WS11-CD	0.009	3.67	02Jun2525, 01:03	0.3
J-WS11	0.0574	20.28	02Jun2525, 01:05	1.8
WS10-B	0.0026	1.03	02Jun2525, 01:05	0.1
WS10-A	0.002	0.91	02Jun2525, 01:03	0.1
J-WS10-AB	0.0046	1.9	02Jun2525, 01:04	0.1
WS10-C	0.0015	0.83	02Jun2525, 00:58	0
WS10-D	0.0014	0.76	02Jun2525, 00:59	0
J-WS10-CD	0.0075	3.2	02Jun2525, 01:01	0.2
J-WS10	0.0649	22.99	02Jun2525, 01:04	2
WS9-C	0.0024	1.27	02Jun2525, 00:59	0.1
WS9-D	0.0014	0.77	02Jun2525, 00:59	0
J-WS9-CD	0.0038	2.04	02Jun2525, 00:59	0.1
WS9-F	0.0007	0.38	02Jun2525, 00:59	0
WS9-E	0.0006	0.31	02Jun2525, 01:00	0
J-WS9-EF	0.0051	2.72	02Jun2525, 00:59	0.2
WS7-B	0.0059	2.88	02Jun2525, 01:01	0.2
WS7-A	0.0023	1.26	02Jun2525, 00:59	0.1
SW 1	0.0011	0.56	02Jun2525, 01:00	0
S 1	0.0003	0.17	02Jun2525, 00:58	0
Sink-WS7	0.0096	4.78	02Jun2525, 01:00	0.3
Sink-WS9	0.0051	2.72	02Jun2525, 00:59	0.2
WS6-D	0.003	1.59	02Jun2525, 00:59	0.1
WS6-C	0.0022	1.12	02Jun2525, 01:00	0.1
J_WS6-CD	0.0052	2.71	02Jun2525, 01:00	0.2
Sink-WS-6	0.0052	2.71	02Jun2525, 01:00	0.2
WS8-B	0.0017	0.94	02Jun2525, 00:58	0.1
WS8-C	0.0007	0.27	02Jun2525, 01:05	0
J_WS8-BC	0.0024	1.12	02Jun2525, 00:59	0.1
Sink-WS8	0.0024	1.12	02Jun2525, 00:59	0.1

Table 4: Perimeter Channel Hydraulic Calculations

Tri-State Generation and Transmission Association
Nucla Station Ash Disposal Facility
Project Number: 20138863

Date:	5/11/21
By:	BJP
Chkd:	MBR
Apprvd:	JEO

			Channel Design Geometry					Channel Roughness Parameters				Hydraulic Calculations							Channel Evaluations	
Reach Designation	Q100 from HEC-HMS (cfs)	HEC HMS Element ID for Q	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)	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)	
N Perimeter Capacity	23.0	J-WS10	0.005	3.0	3.0	0	2.0	G	Grass-lined	0.035	0.030	2.9	1.71	0.58	0.53	22.76	10.3	12.0	0.3	**ok**
N Perimeter Stability	23.0	J-WS10	0.100	3.0	3.0	0	2.0	R	Riprap	0.040	0.035	8.1	1.03	2.03	6.40	747.62	6.2	12.0	1.0	**ok**
E Perimeter Capacity	25.4	J-WS5	0.010	3.0	3.0	0	2.0	G	Grass-lined	0.035	0.030	3.9	1.56	0.80	0.97	55.17	9.4	12.0	0.4	**ok**
E Perimeter Stability	25.4	J-WS5	0.160	3.0	3.0	0	2.0	R	Riprap	0.040	0.035	9.8	0.97	2.55	9.73	1390.37	5.8	12.0	1.0	**ok**
S Perimeter Capacity	0.2	S 1	0.050	3.0	3.0	0	2.0	G	Grass-lined	0.035	0.030	2.0	0.18	1.25	0.55	16.32	1.1	12.0	1.8	**ok**
S Perimeter Stability	0.2	S 1	0.050	3.0	3.0	0	2.0	R	Riprap	0.040	0.035	1.8	0.19	1.08	0.58	15.29	1.1	12.0	1.8	**ok**
SW Perimeter Capacity	0.6	SW 1	0.010	3.0	3.0	0	2.0	G	Grass-lined	0.035	0.030	1.5	0.37	0.63	0.23	5.09	2.2	12.0	1.6	**ok**
SW Perimeter Capacity	0.6	SW 1	0.160	3.0	3.0	0	2.0	R	Riprap	0.040	0.035	3.8	0.23	2.01	2.33	128.15	1.4	12.0	1.8	**ok**

FIGURE 1

Stormwater Basins and Subbasins

0 80 160
SCALE FEET

LEGEND

- EXISTING GROUND TOPOGRAPHY MARCH 2020 SITE SURVEY
- EXISTING GROUND TOPOGRAPHY UNITED STATES GEOLOGICAL SURVEY
- CLOSURE GRADES
- BASIN BOUNDARY
- WS11 BASIN LABEL
- SUBBASIN BOUNDARY
- D SUBBASIN LABEL
- TERRACE CHANNEL
- PERIMETER CHANNEL
- DOWNCHUTE CHANNEL
- APPROXIMATE LIMITS OF ASH

CLIENT
TRI-STATE GENERATION AND TRANSMISSION ASSOCIATION

PROJECT
NUCLA STATION
ASH DISPOSAL FACILITY

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-11
DESIGNED	BJP
PREPARED	BJP
REVIEWED	MBR
APPROVED	JEO

TITLE
STORMWATER BASINS AND SUBBASINS

PROJECT NO.	REV.	FIGURE
20138863	A	1

ATTACHMENT 1

Channel Hydraulic Assessment Outputs

Worksheet for Terrace

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.030
Channel Slope	0.005 ft/ft
Left Side Slope	2.500 H:V
Right Side Slope	20.000 H:V
Discharge	2.88 cfs

Results	
Normal Depth	5.4 in
Flow Area	2.2 ft²
Wetted Perimeter	10.2 ft
Hydraulic Radius	2.7 in
Top Width	10.06 ft
Critical Depth	4.0 in
Critical Slope	0.024 ft/ft
Velocity	1.28 ft/s
Velocity Head	0.03 ft
Specific Energy	0.47 ft
Froude Number	0.477
Flow Type	Subcritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	5.4 in
Critical Depth	4.0 in
Channel Slope	0.005 ft/ft
Critical Slope	0.024 ft/ft

Worksheet for DC WS1

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	1.12 cfs

Results

Normal Depth	1.4 in
Flow Area	0.3 ft²
Wetted Perimeter	3.4 ft
Hydraulic Radius	0.9 in
Top Width	3.38 ft
Critical Depth	2.3 in
Critical Slope	0.036 ft/ft
Velocity	4.36 ft/s
Velocity Head	0.30 ft
Specific Energy	0.41 ft
Froude Number	2.790
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.4 in
Critical Depth	2.3 in
Channel Slope	0.330 ft/ft
Critical Slope	0.036 ft/ft

Worksheet for DC WS2

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	1.24 cfs

Results

Normal Depth	1.4 in
Flow Area	0.3 ft²
Wetted Perimeter	3.5 ft
Hydraulic Radius	1.0 in
Top Width	3.46 ft
Critical Depth	2.4 in
Critical Slope	0.035 ft/ft
Velocity	4.50 ft/s
Velocity Head	0.31 ft
Specific Energy	0.43 ft
Froude Number	2.811
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.4 in
Critical Depth	2.4 in
Channel Slope	0.330 ft/ft
Critical Slope	0.035 ft/ft

Worksheet for DC WS3

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	1.70 cfs

Results

Normal Depth	1.7 in
Flow Area	0.3 ft²
Wetted Perimeter	3.7 ft
Hydraulic Radius	1.1 in
Top Width	3.72 ft
Critical Depth	2.8 in
Critical Slope	0.033 ft/ft
Velocity	4.97 ft/s
Velocity Head	0.38 ft
Specific Energy	0.52 ft
Froude Number	2.887
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.7 in
Critical Depth	2.8 in
Channel Slope	0.330 ft/ft
Critical Slope	0.033 ft/ft

Worksheet for DC WS4

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	1.37 cfs

Results

Normal Depth	1.5 in
Flow Area	0.3 ft²
Wetted Perimeter	3.5 ft
Hydraulic Radius	1.0 in
Top Width	3.54 ft
Critical Depth	2.5 in
Critical Slope	0.035 ft/ft
Velocity	4.64 ft/s
Velocity Head	0.33 ft
Specific Energy	0.46 ft
Froude Number	2.832
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.5 in
Critical Depth	2.5 in
Channel Slope	0.330 ft/ft
Critical Slope	0.035 ft/ft

Worksheet for DC WS5

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	0.24 cfs

Results

Normal Depth	0.7 in
Flow Area	0.1 ft²
Wetted Perimeter	2.4 ft
Hydraulic Radius	0.4 in
Top Width	2.37 ft
Critical Depth	1.1 in
Critical Slope	0.046 ft/ft
Velocity	2.72 ft/s
Velocity Head	0.11 ft
Specific Energy	0.17 ft
Froude Number	2.478
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	0.7 in
Critical Depth	1.1 in
Channel Slope	0.330 ft/ft
Critical Slope	0.046 ft/ft

Worksheet for DC WS6

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	2.71 cfs

Results

Normal Depth	2.1 in
Flow Area	0.5 ft²
Wetted Perimeter	4.2 ft
Hydraulic Radius	1.4 in
Top Width	4.14 ft
Critical Depth	3.6 in
Critical Slope	0.031 ft/ft
Velocity	5.73 ft/s
Velocity Head	0.51 ft
Specific Energy	0.68 ft
Froude Number	2.985
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.1 in
Critical Depth	3.6 in
Channel Slope	0.330 ft/ft
Critical Slope	0.031 ft/ft

Worksheet for DC WS7

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	4.78 cfs

Results

Normal Depth	2.7 in
Flow Area	0.7 ft²
Wetted Perimeter	4.7 ft
Hydraulic Radius	1.8 in
Top Width	4.72 ft
Critical Depth	4.7 in
Critical Slope	0.028 ft/ft
Velocity	6.81 ft/s
Velocity Head	0.72 ft
Specific Energy	0.94 ft
Froude Number	3.117
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.7 in
Critical Depth	4.7 in
Channel Slope	0.330 ft/ft
Critical Slope	0.028 ft/ft

Worksheet for DC WS8

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	1.12 cfs

Results

Normal Depth	1.4 in
Flow Area	0.3 ft²
Wetted Perimeter	3.4 ft
Hydraulic Radius	0.9 in
Top Width	3.38 ft
Critical Depth	2.3 in
Critical Slope	0.036 ft/ft
Velocity	4.36 ft/s
Velocity Head	0.30 ft
Specific Energy	0.41 ft
Froude Number	2.790
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.4 in
Critical Depth	2.3 in
Channel Slope	0.330 ft/ft
Critical Slope	0.036 ft/ft

Worksheet for DC WS9

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	2.72 cfs

Results

Normal Depth	2.1 in
Flow Area	0.5 ft²
Wetted Perimeter	4.2 ft
Hydraulic Radius	1.4 in
Top Width	4.14 ft
Critical Depth	3.6 in
Critical Slope	0.031 ft/ft
Velocity	5.73 ft/s
Velocity Head	0.51 ft
Specific Energy	0.68 ft
Froude Number	2.986
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.1 in
Critical Depth	3.6 in
Channel Slope	0.330 ft/ft
Critical Slope	0.031 ft/ft

Worksheet for DC WS10

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	3.26 cfs

Results

Normal Depth	2.2 in
Flow Area	0.5 ft²
Wetted Perimeter	4.3 ft
Hydraulic Radius	1.5 in
Top Width	4.32 ft
Critical Depth	3.9 in
Critical Slope	0.030 ft/ft
Velocity	6.06 ft/s
Velocity Head	0.57 ft
Specific Energy	0.76 ft
Froude Number	3.030
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.2 in
Critical Depth	3.9 in
Channel Slope	0.330 ft/ft
Critical Slope	0.030 ft/ft

Worksheet for DC WS11

Project Description	
Friction Method	Manning Formula
Solve For	Normal Depth

Input Data	
Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	3.67 cfs

Results	
Normal Depth	2.4 in
Flow Area	0.6 ft²
Wetted Perimeter	4.5 ft
Hydraulic Radius	1.6 in
Top Width	4.44 ft
Critical Depth	4.1 in
Critical Slope	0.029 ft/ft
Velocity	6.28 ft/s
Velocity Head	0.61 ft
Specific Energy	0.81 ft
Froude Number	3.056
Flow Type	Supercritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	2.4 in
Critical Depth	4.1 in
Channel Slope	0.330 ft/ft
Critical Slope	0.029 ft/ft

Worksheet for DC WS12

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	1.16 cfs

Results

Normal Depth	1.4 in
Flow Area	0.3 ft²
Wetted Perimeter	3.4 ft
Hydraulic Radius	0.9 in
Top Width	3.40 ft
Critical Depth	2.3 in
Critical Slope	0.036 ft/ft
Velocity	4.41 ft/s
Velocity Head	0.30 ft
Specific Energy	0.42 ft
Froude Number	2.797
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.4 in
Critical Depth	2.3 in
Channel Slope	0.330 ft/ft
Critical Slope	0.036 ft/ft

Worksheet for DC WS13

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035
Channel Slope	0.330 ft/ft
Constructed Depth	12.0 in
Constructed Top Width	10.00 ft
Discharge	1.63 cfs

Results

Normal Depth	1.6 in
Flow Area	0.3 ft²
Wetted Perimeter	3.7 ft
Hydraulic Radius	1.1 in
Top Width	3.68 ft
Critical Depth	2.8 in
Critical Slope	0.034 ft/ft
Velocity	4.91 ft/s
Velocity Head	0.37 ft
Specific Energy	0.51 ft
Froude Number	2.880
Flow Type	Supercritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

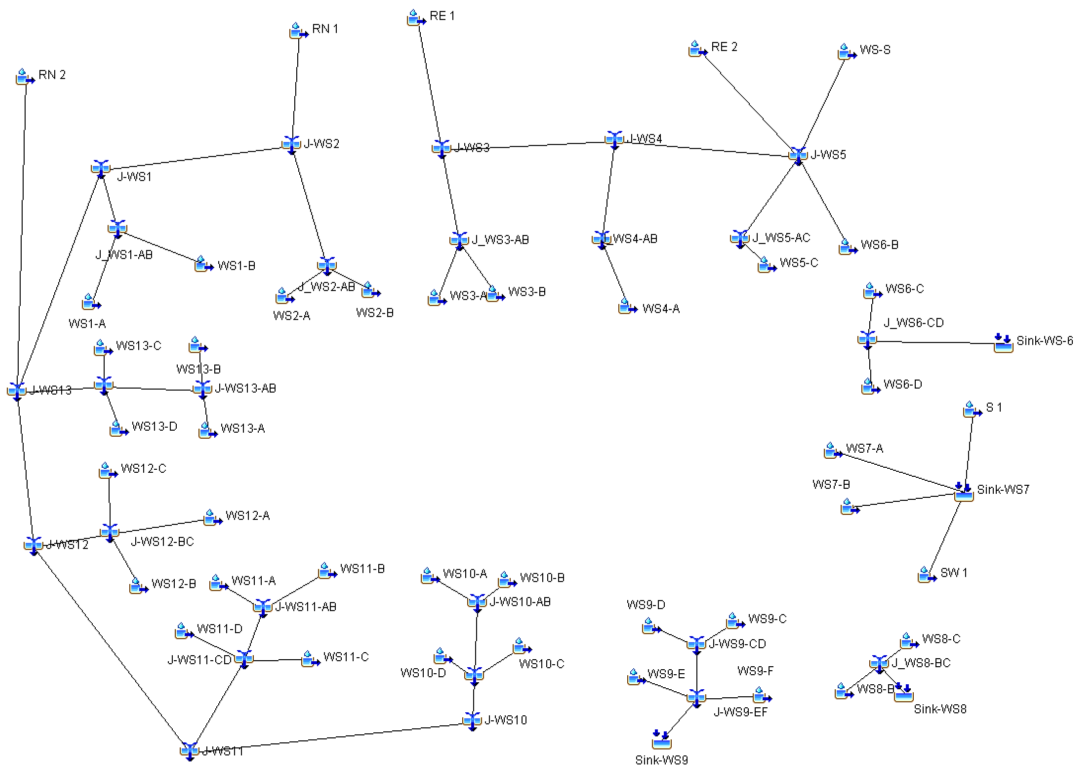
GVF Output Data

Upstream Depth	0.0 in
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	1.6 in
Critical Depth	2.8 in
Channel Slope	0.330 ft/ft
Critical Slope	0.034 ft/ft

ATTACHMENT 2

HEC-HMS Model Schematic and Model Inputs

HEC-HMS Model Schematic



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Area	
Basin or Subbasin	Area (mi^2)
RE 1	0.0335
WS3-A	0.0019
WS3-B	0.0013
WS4-A	0.0031
WS5-C	0.0005
WS-S	0.0332
RE 2	0.0023
WS6-B	0.0015
RN 1	0.0152
WS2-B	0.0014
WS2-A	0.0011
WS1-B	0.0013
WS1-A	0.0012
RN 2	0.0217
WS13-B	0.0019
WS13-A	0.0004
WS13-C	0.0009
WS13-D	0.0005
WS12-A	0.0014
WS12-C	0.0008
WS12-B	0.0006
WS11-B	0.0064
WS11-A	0.0013
WS11-C	0.0010
WS11-D	0.0003
WS10-B	0.0026
WS10-A	0.0020
WS10-C	0.0015
WS10-D	0.0014
WS9-C	0.0024
WS9-D	0.0014
WS9-F	0.0007
WS9-E	0.0006
WS7-B	0.0059
WS7-A	0.0023
SW 1	0.0011
S 1	0.0003
WS6-D	0.0030
WS6-C	0.0022
WS8-B	0.0017
WS8-C	0.0007

Loss SCS Curve Number			
Basin or Subbasin	Initial Abstraction (in)	Curve Number	Impervious (%)
RE 1		70	0
WS3-A		70	0
WS3-B		70	0
WS4-A		70	0
WS5-C		70	0
WS-S		70	0
RE 2		70	0
WS6-B		70	0
RN 1		70	0
WS2-B		70	0
WS2-A		70	0
WS1-B		70	0
WS1-A		70	0
RN 2		70	0
WS13-B		70	0
WS13-A		70	0
WS13-C		70	0
WS13-D		70	0
WS12-A		70	0
WS12-C		70	0
WS12-B		70	0
WS11-B		70	0
WS11-A		70	0
WS11-C		70	0
WS11-D		70	0
WS10-B		70	0
WS10-A		70	0
WS10-C		70	0
WS10-D		70	0
WS9-C		70	0
WS9-D		70	0
WS9-F		70	0
WS9-E		70	0
WS7-B		70	0
WS7-A		70	0
SW 1		70	0
S 1		70	0
WS6-D		70	0
WS6-C		70	0
WS8-B		70	0
WS8-C		70	0

Transform SCS Unit Hydrograph		
Basin or Subbasin	Graph Type	Lag Time (min)
RE 1	Standard	14.1
WS3-A	Standard	11.1
WS3-B	Standard	9.3
WS4-A	Standard	8.0
WS5-C	Standard	6.3
WS-S	Standard	12.7
RE 2	Standard	3.7
WS6-B	Standard	4.9
RN 1	Standard	12.7
WS2-B	Standard	4.7
WS2-A	Standard	6.6
WS1-B	Standard	6.4
WS1-A	Standard	9.0
RN 2	Standard	12.4
WS13-B	Standard	8.4
WS13-A	Standard	8.7
WS13-C	Standard	4.2
WS13-D	Standard	3.2
WS12-A	Standard	9.6
WS12-C	Standard	8.5
WS12-B	Standard	4.4
WS11-B	Standard	9.0
WS11-A	Standard	9.7
WS11-C	Standard	3.9
WS11-D	Standard	2.4
WS10-B	Standard	10.2
WS10-A	Standard	7.5
WS10-C	Standard	3.5
WS10-D	Standard	3.9
WS9-C	Standard	4.4
WS9-D	Standard	3.7
WS9-F	Standard	4.0
WS9-E	Standard	5.2
WS7-B	Standard	6.1
WS7-A	Standard	3.8
SW 1	Standard	5.2
S 1	Standard	3.0
WS6-D	Standard	4.4
WS6-C	Standard	5.3
WS8-B	Standard	3.5
WS8-C	Standard	10.3

ATTACHMENT 3

HY-8 Outputs

HY-8 Culvert Analysis Report

Crossing Discharge Data

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

Minimum Flow: 0 cfs

Design Flow: 11.5 cfs

Maximum Flow: 11.5 cfs

Table 1 - Summary of Culvert Flows at Crossing: Nucla Landfill Cover - 2 Barrel

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
100.10	0.00	0.00	0.00	1
100.55	1.15	1.15	0.00	1
100.75	2.30	2.30	0.00	1
100.90	3.45	3.45	0.00	1
101.04	4.60	4.60	0.00	1
101.16	5.75	5.75	0.00	1
101.28	6.90	6.90	0.00	1
101.39	8.05	8.05	0.00	1
101.50	9.20	9.20	0.00	1
101.60	10.35	10.35	0.00	1
101.71	11.50	11.50	0.00	1
105.00	30.05	30.05	0.00	Overtopping

Rating Curve Plot for Crossing: Nucla Landfill Cover - 2 Barrel

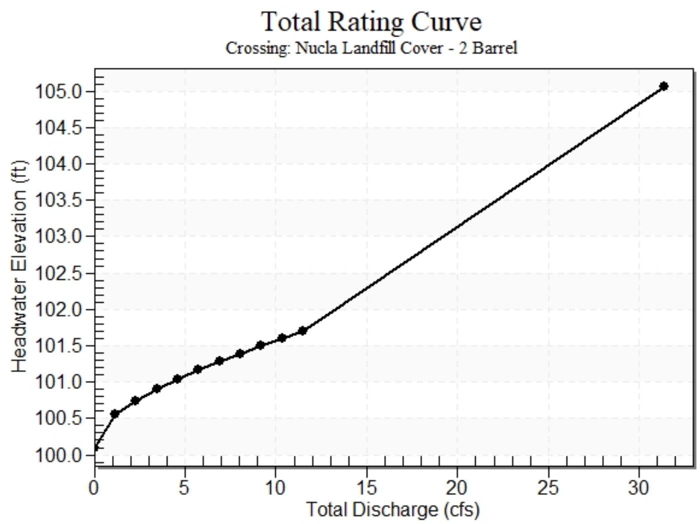


Table 2 - Culvert Summary Table: Culvert 1

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	100.10	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
1.15	1.15	100.55	0.409	0.448	2-M2c	0.321	0.281	0.281	0.126	2.511	0.916
2.30	2.30	100.75	0.588	0.646	2-M2c	0.457	0.401	0.401	0.191	3.033	1.203
3.45	3.45	100.90	0.730	0.803	2-M2c	0.566	0.494	0.494	0.245	3.403	1.409
4.60	4.60	101.04	0.857	0.939	2-M2c	0.663	0.573	0.573	0.292	3.704	1.575
5.75	5.75	101.16	0.977	1.064	2-M2c	0.754	0.644	0.644	0.335	3.966	1.716
6.90	6.90	101.28	1.091	1.180	2-M2c	0.842	0.708	0.708	0.375	4.201	1.841
8.05	8.05	101.39	1.203	1.291	2-M2c	0.930	0.768	0.768	0.412	4.422	1.952
9.20	9.20	101.50	1.314	1.398	2-M2c	1.021	0.823	0.823	0.448	4.630	2.054
10.35	10.35	101.60	1.428	1.503	7-M2c	1.121	0.876	0.876	0.482	4.830	2.148
11.50	11.50	101.71	1.545	1.606	7-M2c	1.242	0.925	0.925	0.515	5.026	2.235

****

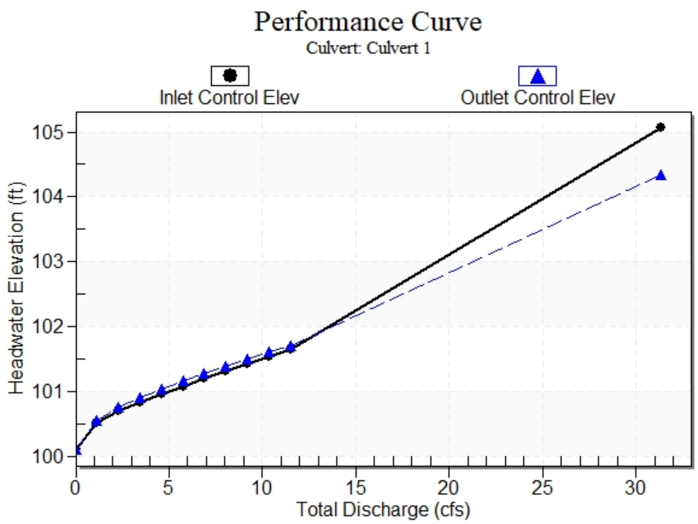
Straight Culvert

Inlet Elevation (invert): 100.10 ft,
Outlet Elevation (invert): 100.00 ft

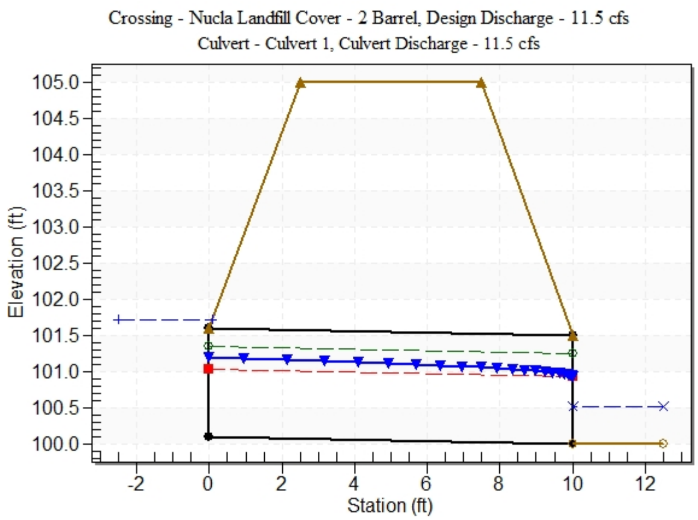
Culvert Length: 10.00 ft,
Culvert Slope: 0.0100

****

Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1



Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 100.10 ft

Outlet Station: 10.00 ft

Outlet Elevation: 100.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 1.50 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

Table 3 - Downstream Channel Rating Curve (Crossing: Nucla Landfill Cover - 2 Barrel)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	100.00	0.00	0.00	0.00	0.00
1.15	100.13	0.13	0.92	0.08	0.46
2.30	100.19	0.19	1.20	0.12	0.48
3.45	100.24	0.24	1.41	0.15	0.50
4.60	100.29	0.29	1.57	0.18	0.51
5.75	100.34	0.34	1.72	0.21	0.52
6.90	100.37	0.37	1.84	0.23	0.53
8.05	100.41	0.41	1.95	0.26	0.54
9.20	100.45	0.45	2.05	0.28	0.54
10.35	100.48	0.48	2.15	0.30	0.55
11.50	100.51	0.51	2.24	0.32	0.55

Tailwater Channel Data - Nucla Landfill Cover - 2 Barrel

Tailwater Channel Option: Rectangular Channel

Bottom Width: 10.00 ft

Channel Slope: 0.0100

Channel Manning's n: 0.0400

Channel Invert Elevation: 100.00 ft

Roadway Data for Crossing: Nucla Landfill Cover - 2 Barrel

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 105.00 ft

Roadway Surface: Paved

Roadway Top Width: 5.00 ft

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