STATE OF COLORADO

Eschberger - DNR, Amy <amy.eschberger@state.co.us>

Schwartzwalder Mine / M1977-300 / TR-28 - 5th Adequacy Review - Response to Comments (1 of 2)

Billy Ray <bray@ensero.com> Wed, Mar 25, 2020 at 9:34 AM
To: "Eschberger - DNR, Amy" <amy.eschberger@state.co.us>, CLL- Jim Harrington <jim@coloradolegacy.land>
Cc: "CLL - Paul Newman (Paul@ColoradoLegacy.Land)" <Paul@coloradolegacy.land>, "Cazier - DNR, Tim" <tim.cazier@state.co.us>, "Cunningham - DNR, Michael" <michaela.cunningham@state.co.us>, JoAnne Ary <jary@ensero.com>

Hello Amy,

As we discussed on Monday, we are submitting the response to the 5th Adequacy Review comments by e-mail and then we can follow it up with a hard copy submission to your office. The document has been split into the following sections to allow for submission by e-mail and to simplify the review –

- Adequacy Review 5 – Cover letter and comment/response log
- Attachment 1 – Gantt Chart (no change from previous submittal)
- Attachment 2 – Design Package (updated calculations)
- Attachment 3 – Construction Quality Assurance and Quality Control Plan (no change from previous submittal)
- Attachment 4 – Construction Specification (no change from previous submittal)

The Adequacy Review 5 and Attachments 1,3 & 4 are included with this e-mail. Due to the file size, Attachment 2 will follow in a separate e-mail.

We have not requested another extension to the decision date as the responses to the comments resulted in the updating of the calculations and a justification for the assumptions while the design remained unchanged.

Please let me know if you have any questions or if you need any additional information.

Regards,

Billy

From: Eschberger - DNR, Amy <amy.eschberger@state.co.us>
Sent: Monday, March 16, 2020 3:51 PM
To: CLL- Jim Harrington <jim@coloradolegacy.land>
Cc: Elizabeth Busby <ebusby@ensero.com>; CLL - Paul Newman (Paul@ColoradoLegacy.Land) <Paul@coloradolegacy.land>; Cazier - DNR, Tim <tim.cazier@state.co.us>; Cunningham - DNR, Michael <michaela.cunningham@state.co.us>; Billy Ray <bray@ensero.com>
Subject: Schwartzwalder Mine / M1977-300 / TR-28 - 5th Adequacy Review

Jim,

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We would be happy to discuss our comments with your team prior to the 3/31 decision date, if needed. Since we are currently operating under restricted travel/meeting conditions, we would need to set something up via teleconference or Google Hangouts. Just let me know.

Thanks,

Amy Eschberger

Environmental Protection Specialist

O: 303.866.3567 x 8129 | F: 303.832.8106 | C: 303.945.9014

1313 Sherman Street, Room 215, Denver, CO 80203

Amy.Eschberger@state.co.us | https://www.colorado.gov/drms

4 attachments

TR28_Schwartzwalder_MLR_Permit - Adequacy Review 5.pdf
760K

TR28_Schwartzwalder_MLR_Permit - Adequacy Review 5 - Attachment 1.pdf
292K

TR28_Schwartzwalder_MLR_Permit - Adequacy Review 5 - Attachment 3.pdf
1422K

TR28_Schwartzwalder_MLR_Permit - Adequacy Review 5 - Attachment 4.pdf
1002K

STATE OF COLORADO

Eschberger - DNR, Amy <amy.eschberger@state.co.us>

Schwartzwalder Mine / M1977-300 / TR-28 - 5th Adequacy Review - Response to Comments (2 of 2)

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Amy.Eschberger@state.co.us | https://www.colorado.gov/drms

TR28_Schwartzwalder_MLR_Permit - Adequacy Review 5 - Attachment 2.pdf
18009K

COLORADO LEGACY LAND
4601 DTC Boulevard, Suite 120, Denver, CO 80237
T. (303) 862-3928

March 25, 2020

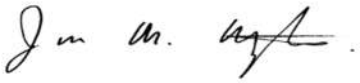
Ms. Amy Eschberger
Division of Reclamation, Mining, and Safety
Department of Natural Resources
1313 Sherman Street, Room 215
Denver, CO 80203

Subject: Response to Adequacy Review No. 5
Technical Revision #28: Revised North Waste Rock Pile Drainage Design, Construction, and Schedule for Implementation
Mine Land Reclamation Permit M-1977-300, Schwartzwalder Mine, Golden, Colorado

Dear Ms. Eschberger:

In response to the Adequacy Review No. 5 dated March 16, 2020, Colorado Legacy Land, LLC (CLL) has revised *Mine Land Reclamation Permit M-1977-300, Technical Revision #28* for the Schwartzwalder Mine, to address the reviewer's comments. Enclosed is a copy of the revised Technical Revision #28 and comment summary table. If you have any questions regarding this technical revision, please don't hesitate to contact me.

Sincerely,



Jim Harrington, Managing Director
COLORADO LEGACY LAND
Jim@ColoradoLegacy.Land

cc: Paul Newman – CLL, Managing Director, paul@coloradolegacy.land
Eric Williams – CLL, Managing Director, eric@coloradolegacy.land
Billy Ray – Ensero Solutions, Project Manager, bray@ensero.com

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TECHNICAL REVISION #28, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	**COMMENT**	**RESPONSE TO COMMENT**
1	Channel Design. P. 7, the fifth paragraph states "The HEC RAS model results are presented in Table 1. Note that the results are slightly different from those shown the hydraulic calculations (Attachment 2)." Please explain why there are differences.	There are differences in the hydraulic values because two different models were used. The HEC-RAS model was used to model the whole length of the channel. However, some offline calculations were made using HydraFlow to determine specific design features that were then incorporated into the HEC-RAS model. The HydraFlow calculations used an average channel slope of 17% to determine hydraulics which were used to determine: a. the added depth required in the alignment's curve section, and b. the riprap basin dimensions The paragraph following Table 1 in the Technical Revision #28 text has been amended and clarified. See the response to Comments 2, below, for further context regarding the different hydraulics.
2.	Hydraulic Analyses. In Attachment 2, multiple hydraulic evaluations are presented assuming a Manning's roughness coefficient of 0.029 for what is essentially a concrete-lined channel. Standard references [Chow (1959), Van Haveren (1986), UDCFD (2008), etc.] list a Manning's n of 0.011 to 0.013 in general for concrete. The high Manning's n may mean the hydraulic energy dissipation basin on Sheet No. 9 is undersized. Please explain why a value nearly three times as rough as generally accepted was selected for all the hydraulic analyses (i.e., HEC-RAS analysis, and the Burns & McDonnell "Stormwater Management Calculation"). Please provide a demonstration justifying the selection of 0.029	In the early stages of design, the concrete-filled geoweb channel, the manufacturer (Presto Geosystems) provided an engineered evaluation for application. This evaluation included anchoring recommendations to resist shear stresses expected in the completed channel. Their analysis of the concrete-filled geoweb system used a Manning's n-value of 0.029. They also provided a roughness range for a concrete-lined system of 0.018-0.027 (see page 11 of 19 of this document. Using a slightly higher n-value (0.029) is conservative when considering channel capacity and freeboard, however, a second modeling simulation should be run using a low Manning's n-value to develop hydraulics used to calculate requirements for energy dissipation. Therefore, a second HEC-RAS model was run using the an n-value of 0.018 within the channel. The results from the low n-value model are also included in the updated Attachment 2. The hydraulics produced from the HEC-RAS model at the end of the channel (immediately upstream of the riprap basin) where used to check the sizing of the riprap basin. The riprap basin was originally sized using the hydraulics from the Hydraflow analysis which used an average slope of 17%. The new hydraulics

TECHNICAL REVISION #28, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	**COMMENT**	**RESPONSE TO COMMENT**
		obtained from the low Manning's n model were very similar to those originally used. However, the riprap basin sizing was double checked with the new hydraulics and the riprap basin is sized adequately. See attached Lower Riprap Basin Sizing calculations. The attached calculations have also replaced the previous riprap basin calculations provided in Attachment 2.
3.	Seepage Uplift Pressure. Consistent with Urban Drainage and Flood Control District (UDFCD) design, uplift pressure and seepage relief considerations are extremely important to structural stability. There can be troublesome pressure differentials from either the upstream or downstream direction when there is shallow supercritical flow in the structure, as is predicted with this structure. Per UDFCD guidance, high drops (i.e., > 6 feet), more than one row of weep holes may be necessary. The proposed design includes an upstream cutoff to partially mitigate this problem. However, seepage from the slope north of the diversion structure should be expected. Our review found no visible way to mitigate potential seepage build-up. Please explain how potential seepage uplift pressure will be mitigated.	The design team does not believe the proposed channel will be subject to damaging uplift pressure due to groundwater seepage for the following reasons: a. The one place where groundwater has been observed along the project alignment has been near the intake structure of the channel. The intake structure has a seal wall that was designed to intercept potential groundwater by being imbedded into the shallow bedrock. Additionally, a perforated pipe will be buried parallel to the seal wall to collect any groundwater that reaches the seal wall. The perforated pipe will convey the groundwater downhill in a solid PVC pipe until it can discharge the water into the channel. b. In the summer of 2019, a small amount of excavation was performed along the upper region of the channel alignment. The excavation created an earthen-ditch to encourage any surface water coming down the drainage away from the NWRP and onto the access road. No groundwater was present during the excavation. c. There is no evidence of groundwater seeps below the access road (below the north facing slope). d. Since the Geoweb will be filled with concrete, the channel itself will provide 50 psf of force resisting any possible uplift force. e. The channel subgrade will be constructed primarily from on-site, non-cohesive soils.

TECHNICAL REVISION #28, COMMENT AND RESPONSE SUMMARY TABLE		
COMMENT NO.	**COMMENT**	**RESPONSE TO COMMENT**
		f. The channel depth is at most 3 feet deep and more typically 2 feet deep. UDFCD Chapter 9 section 2.4.2 calls for weep drains if a grade control structure is greater than 5 feet tall. Our channel is neither a grade control structure, nor over 5 feet tall. Furthermore, the addition of weep holes in the ditch itself would be counterintuitive to the purpose of the ditch which is keep water from reaching the waste rock pile. Seepage relief holes, would allow water out of the channel when water is present.

PRESTO GEOSYSTEMS

670 North Perkins Street
Appleton, WI 54914 USA
Tel: 1 920 738 1333
Fax: 1 920 738 1222
Email: sam.justice@prestogeo.com

October 21, 2019

Sam Lowe
ALEXCO WATER & ENVIRONMENTAL

RE: PR19640 - SCHWARTZWALDER NORTH WASTE ROCK PILE DIVERSION (REV 1)
Channel Protection System

Dear Sam:

Presto Geosystems has completed the revision 1 evaluation for the Schwartzwalder North Waste Rock Pile Diversion Channel Protection System project, located in Golden, CO. Our recommendations are provided and detailed in the attached cross section and calculation. The evaluation is copyrighted and based on the unique engineering properties of Genuine Geoweb® system. Any use of this evaluation for any product other than that manufactured by Presto Products makes this evaluation invalid.

The objective of this evaluation is to propose a Geoweb cellular confinement system for stabilization of the channel. This evaluation is not applicable to the stability of the channel against a deep-seated failure. It is assumed herein that the slope is stable against failure except for the problem of surface erosion.

As the originator and leader in geocell technology, Presto offers the following advantages:

- Manufacturer Certificate of Analysis. Presto Geosystems manufactures Geoweb, ATRA keys ATRA Stake Clips and ATRA tendon clips in accordance with stringent ISO and CE quality standards. Our quality management system allows Presto to provide Certificates of Compliance (COC) and Certificates of Analysis (COA) that allow traceability on all materials produced and supplied for this project. We **do not** provide geocell materials through private label manufacturers, which is often the case with our competitors. The ability for the Owner to receive COC and COA for geocell is critical to the integrity of the project.

- Design Calculations. The attached calculations are based specifically on Geoweb material characteristics, research/testing and accessories. Our design calculations are based on the site-specific characteristics and information contained in the request for project evaluation. The recommendations are based on Geoweb panels, ATRA® key connection device and ATRA tendon

clip load transfer device. The anchorage recommendations are specific to our product and DO NOT apply to any other geocell manufacturers.

- ATRA Key connection device. ATRA keys provide a permanent and stronger panel connection compared to metal staples or zip ties. ATRA keys are made of high density polyethylene and are the strongest method available for panel connection. ATRA keys will not corrode or degrade and provide a permanent connection. ATRA keys were used to determine the anchorage recommendations. If a different connection device is proposed, the Presto recommendation DOES NOT apply. ATRA keys allow multiple panels to be installed concurrently decreasing installation time and preventing panel separation during installation and compaction. Panel separation may occur with metal staples or zip ties during installation, which can lead to long-term maintenance issues.

- Installation Assistance. Representatives of Presto, or the local distributor, are available to be on-site at the beginning of construction to ensure that the Geoweb panels and accessories are installed as the design intended. We are committed to train the Contractor based on our in-depth product knowledge and installation experience. Our past project successes will minimize installation time and issues. As with any material, there are advantageous techniques of installation, which we can offer during our visit.

Design and Materials

It is our understanding that the relevant dimensions of the channel, for the purpose of this analysis, are as follows:

Parameters:

Flow, cfs	67.7
Velocity, fps	22.4
Base Width, ft	3
Side Slopes	1H:1V
Channel Depth, ft	2
Bed Slope, %	40% (Max)
Friction Angle ϕ, degree:	28
Infill Type:	Concrete
Infill Weight γ, lbs/ft^3	150

This recommendation has been amended. In addition to the one layer of geotextile placed against the subgrade, an impermeable geomembrane will be laid down next with a final layer of geotextile (per design plans). SJL

Based on the evaluation, the following materials are recommended for the Geoweb application at the site:

1. Presto Geosystems Geoweb GW30V4 (4 - inch) panels.
2. Provide a non-woven geotextile separation layer over the prepared sub grade. Install in accordance with Manufacturer recommendations including overlaps.
3. Connect the Geoweb sections with ATRA® Keys at each interleaf and end to end connection.
4. Provide three, TPP-55 tendons per Geoweb section, in rows 1, 4 & 7.
5. Provide an ATRA® Tendon Clip tied to each tendon every 2nd cell down the slope.
6. Provide a solid wall PVC pipe deadman, 4 inches in diameter, buried a minimum of 1 feet below crest elevation. If a deadman is not feasible, provide earth anchors with a minimum tension of 400 lbs (139 lbs/ft x 8.5 ft/panel ÷ 3 tendons/panel) plus the recommended Manufacturer's factor of safety tied to each tendon.
    a. Earth anchor pullout strength shall be determined by the Engineer of Record based on recommended Manufacturer's factor of safety and site soil conditions.
7. Pre-shape the Geoweb system before infill placement.
8. Limit the drop of the infill into the Geoweb panels to prevent distortion.
9. Geoweb infill shall be concrete. Adjust concrete slump in the field as necessary to allow for installation.

For additional Channel Protection Resources, click here:
Channel Design Engineering Resource Package

If you have any questions or need any additional information, please call.

Sincerely,

Sam Justice

Sam Justice, P.E.
Civil Design Engineer
Presto Geosystems

Notes:

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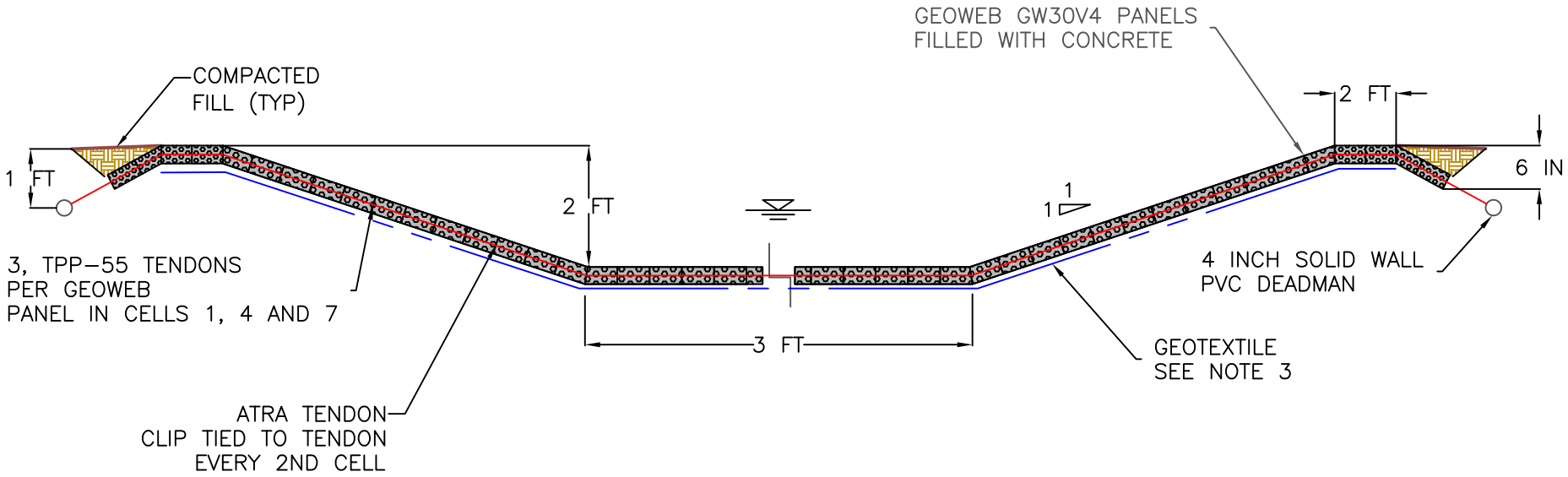
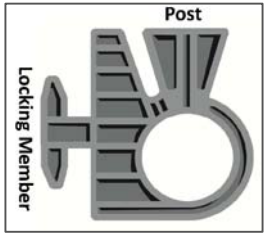
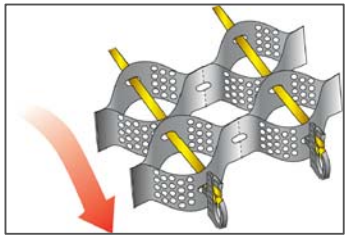
2. The evaluation assumes that the side slopes are globally stable.
3. Provide a non–woven geotextile separation layer and install according to Manufacturer's instructions including overlaps.
4. The Geoweb panels shall be connected with ATRA keys at each interleaf and end to end connection.
5. Limit the drop of infill to prevent panel distoration.
6. Infill shall consist of concrete. Adjust concrete slump in the field as necessary to allow installation.



ATRA KEY



ATRA TENDON CLIP



INSTALLATION

PRESTO® PRODUCTS CO.
670 NORTH PERKINS STREET
APPLETON, WI 54914
920–738–1342
WWW.PRESTOGEO.COM

PR19640 – SCHWARTZWALDER NORTH WASTE ROCK PILE DIVERSION (REV 1) GEOWEB CHANNEL PROTECTION

DATE	OCTOBER 21, 2019	FILE NAME	SHEET 1
SCALE	NTS	SHEET	1 OF 2

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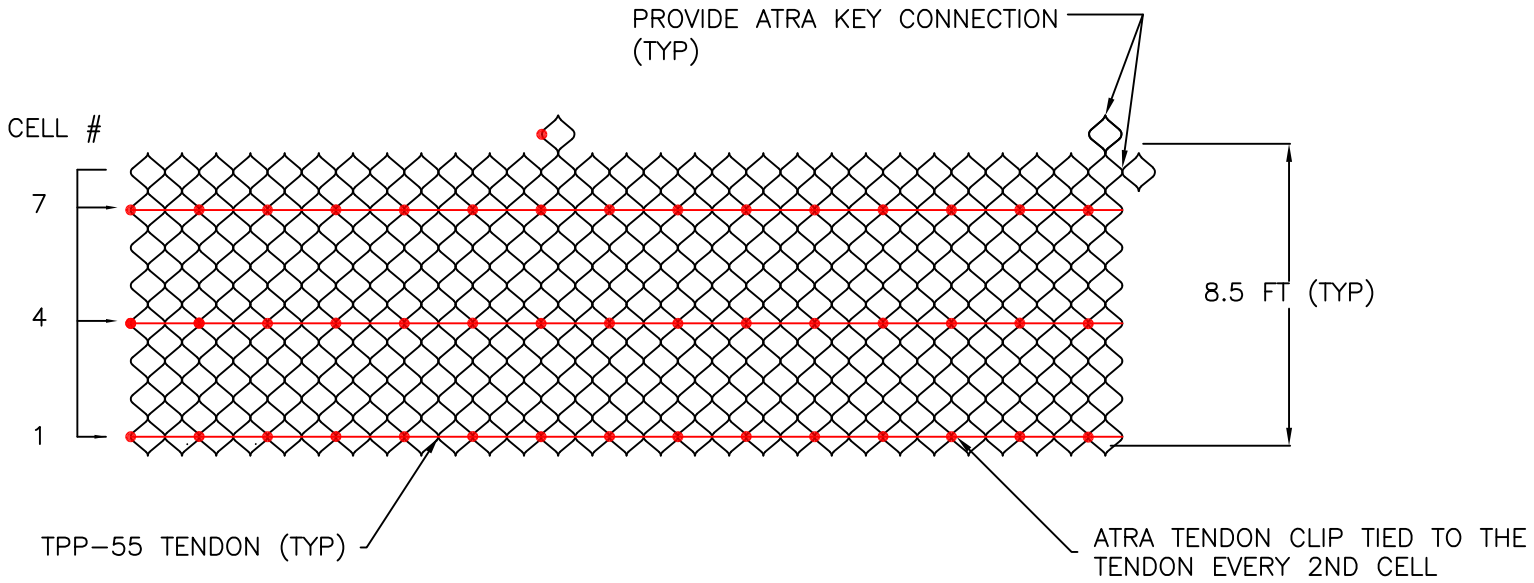
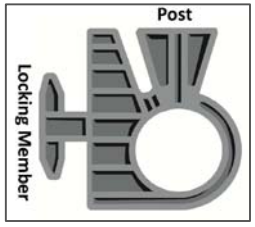


ATRA KEY



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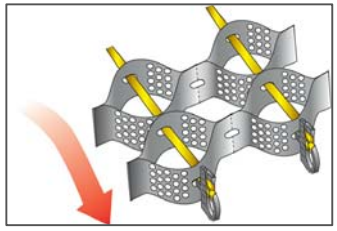

INSTALLATION

GEOSYSTEMS

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PR19640 – SCHWARTZWALDER NORTH WASTE ROCK PILE DIVERSION (REV 1) GEOWEB CHANNEL PROTECTION

DATE OCTOBER 21, 2019	FILE NAME SHEET 2
SCALE NTS	SHEET 2 OF 2

PRESTO GEOSYSTEMS

CHANNEL PROTECTION
GENUINE GEOWEB

Project Name: SCHWARTZWALDER NORTH WASTE TOCK PILE DIVERSION (REV 1)

Presto Project Number: PR 19640

Date: 10/21/2019

INPUT PARAMETERS

English or Metric (E or M)	E		Coefficient, Cm	Gravity	
			1.49	32.174	
Channel Lining System			Typical Kb Values		
Invert:	Concrete		Straight Reach: 1.0		
Sides:	Concrete		Mild Meandors: 1.1 to 1.4		
Kb (Bend Coefficient)	1.20		Looping Meandors: 1.5 to 1.8		
Max Discharge (cfs)	67.7		Sharp Turns: 1.9 to 2.1		
Bed Slope, %	40.0		Typical N Values for Lined Channel		
Channel Depth (ft)	2.00		Concrete Rough = 0.018 to 0.027		
Manning's Coefficient Invert	0.029		Aggregate Firm = 0.023		
Manning's Coefficient Side Slopes	0.029		Vegetated w/Grass & Weeds = 0.025		
Trial Channel Dimensions					
Base Width (ft)	3.00		Flow Area	2.99	
Water Depth (ft)	0.79		Wetted Perimeter	5.23	
Side Slope (**x**H:1V)	1.00		Hydraulic Radius	0.572	
Top Width 'T' of Flow line	4.58		R^2/3	0.689	
Velocity (ft/s)	22.39				
Flow (cfs)	67.04	Compare to Specified Flow Rate			
Froude No., F	4.63				
Channel Bottom - Stream Direction Stresses					
Geoweb Thickness (in)	4	0.33 ft			
Unit Weight of Infill (lb/ft3)	150				
Interface Friction (Geoweb/Infill)	28	0.489			
Depth of Flow (ft)	0.79				
Bedslope (%)	40.00	0.381 radians			
Unit Weight of Water (lb/ft3)	62.4				
Coefficient of Friction (Infill/Soil)	0.53				
Tractive Shear Stress (lb/ft2)	23.66				

PRESTO GEOSYSTEMS

SLOPE PROTECTION SYSTEM
GENUINE GEOWEB®

Project Name: SCHWARTZWALDER NORTH WASTE TOCK PILE DIVERSION (REV 1)
Presto Project Number: PR 19640
Date: 10/21/2019

INPUT PARAMETERS

English or Metric (E or M)	E	
Slope Angle	45	Slope (H:V)
Slope Length (ft)	2.83	1.00
Vertical Height (ft)	2	
Minimum Interface Friction Angle (degrees)	28	Between Different Surfaces
Geoweb Cell Type	GW30V	
Web Thickness (in)	4	
Infill type	Concrete	Infill Weight (lb/ft)
Infill Unit Weight (lb/ft3)	150	141.4
Additional Cover (in.)	0	Cover Weight (lb/ft)
Cover Unit Weight (lb/ft3)	0	0.0
Design Factor of Safety	1.4	Total Weight (lb/ft)
Tractive Force (lb/ft)	18.7	141.4
Passive Resistance at toe (Y or N)	No	Tractive force = 23.66 psf @ 0.79 ft water depth.
Angle of internal friction of soil at toe	0	
Unit weight of soil at toe (lb/ft3)	0	

Calculations

Factored Geoweb Seam Strength (lb/ft)	234.67	Allowable Tensile
Driving Force (lb/ft)	118.69	Weight+Toe Load (Gravity)
Factored Driving Force (lb/ft)	140.00	Weight Only
Factored Driving Force (lb/ft)	158.69	Weight+Toe Load
Resisting Force (lb/ft)	53.17	Shear Only (Min Between Surfaces)
Passive Earth Force (lb/ft)	0.00	
Available Resistance (lb/ft)	105.52	Geoweb
Factor of Safety	0.45	Shear Only
Maximum Available F.S.	2.43	Shear and Geoweb Seam Strength

ATRA® KEY

Connection Strength	275 lbs/ft

Note: Anchorage pattern is based on the use of ATRA keys for panel to panel connection. If staples or zip ties are used, the anchorage pattern will increase.

ATRA Key
Clickable Spec

ATRA® ANCHOR DETAILS

Net Driving (lb/sqft)	37.31	Factored
Max. Unrestrained GW length (ft)	6.3	Unrestrained

Input Parameters

Length (in)	No Stakes	ATRA Anchor	Spacing (in)
Diameter or Width (in)	0.00		
Downslope spacing (# of cells)	0		0.0
Horizontal spacing (# of cells)	0		0.0
Soil Friction Angle (degrees)	30		
Soil Cohesion (lb/ft2)	0		
Slope Soil Type	Native		
Unit Weight (lb/ft3)	120		
Kp (Coefficient)	0.00		
Buried Anchor Length (ft)	0.00		
Anchor Resistance (lb)	0.00	Single Anchor	
Number of Rows of Anchors	0		
Anchor Resistance (lb/ft)	0.0	Resultant	
Anchor Resistance (lb/ft2)	0.00	Net Resultant	
Resisting Force (lb/ft)	53	Shear plus Anchors	

Note: Anchorage pattern is based on the use of ATRA keys for panel to panel connection. If staples or zip ties are used, the anchorage pattern will increase.

ATRA Anchors
Clickable Spec

Anchor density (anchors/ft2)	0.00	
Anchors per Geoweb Section Width	0	
Factor of Safety	No Anchors	Shear and Atra Anchored Geoweb
Maximum Available F.S.	No Anchors	Atra Anchors and Geoweb Seam Strength

PRESTO GEOSYSTEMS

SLOPE PROTECTION SYSTEM
GENUINE GEOWEB®

TENDONS

Required Tension (lb/ft)	-129	Tendons and Geoweb Tensile	
Required Tension (lb/ft)	106	Tendons only	

Input Parameters

Tendon Type	TPP-55	Note: Tendons and load transfer device quantity and spacing is based on the use of only ATRA Tendon Clips for load transfer. If substitute devices are used, this analysis is void.	 ATRA Tendon Clip *Clickable Spec*
Ultimate Strength (lb)	1250		
F.S. (Creep)	1.10		
F.S. (Knots)	1.10		
F.S. (Construction damage)	1.10		
F.S. (Chemical/Biological Durability)	1.10		
F.S. (Overall Uncertainties)	1.25	Overall Factor of Safety	1.83
Number of Tendons/GW Section	3		
ATRA Tendon Clip Spacing (no. of cells downslope)	2	Maximum Allowable	2
Tendon Hole Spacing (in)	12.6		
Available Tension/tendon (lb)	683		
Average No. of Tendons/slot	0.375		
Available Tension/slot (lb)	256.1		
Available Tension (lb/ft)	244	OK	
Tendon density (ft/ft2)	0.616	Includes 15% extra for knots and wastage	
Tendon Length per 8.5' Geoweb Section	15	and deadman bury length.	
Atra Tendon Clips/8.5' Geoweb Section	9	Atra Tendon Clip Density (#/ft2)	0.379
Factor of Safety	2.50	Shear and Tendon Anchorage	
Factor of Safety	No Anchors	Atra Anchors and Tendon Anchorage	
Factor of Safety	4.48	Tendon Anchorage and Geoweb Strength	

CREST/SLOPE ANCHORAGE

Required Anchorage (lb/ft)	113	

Input Parameters

Horizontal Embedment Length (ft)	2	From Slope Face to Key Trench
Depth Below Crest (in)	4	Crest to Bottom of Geoweb
Slope Angle of Key Trench (degrees)	45	
Depth of Key Trench (in)	6	
Horiz. Length at Bottom of Trench (in)	0	
Soil Unit Weight (lb/ft3)	120	
Soil Friction (degrees)	30	
Available Resisting Force (lb/ft)	55.81	OK
Factor of Safety	0.92	Crest Anchorage and Shear
Factor of Safety	No Anchors	Crest Anchorage and Atra Anchors
Factor of Safety	2.97	Crest Anchorage and Tendons

Limitation of Use:

PRESTO GEOSYSTEMS

PROJECT: SCHWARTZWALDER NORTH WASTE TOCK PILE DIVERSION (REV 1)
DEADMAN ANCHORAGE

English or Metric (E or M)				E		
Required Anchorage				50	lb/ft	
Cell Depth				4	ft	
Height of Deadman, h				0.33	ft	
Width of Deadman, w				0.33	ft	
Unit weight of Deadman				0	lb/ft	
Length of Deadman, l				1	ft	
Depth to base of Deadman, H				1	ft	
Distance between centers, L				1	ft	
Soil Cover Friction Angle				30	degrees	
Unit weight of Deadman Soil Cover				120	lb/ft3	
Deadman to Soil Friction				5	degrees	
W - Weight of Deadman				0.00	lb/ft	
Vertical Stress @ Midpoint of Depth, qm				100	lb/ft3	
Earth Pressure Coefficient, Ka				0.333		
Hydrostatic Earth Pressure, Ph				60	ft	
Normal Earth Pressure, Pa				20.0	ft	
Tangential Earth Pressure, Fa				-11.5	ft	
				Chart	Rankine	Coulomb
Kg	Fig. 46c	tan(delta)=	0.087	3.00	3.00	3.51
Anchor Resistance Factor, Ro				2.67	2.67	3.17
E				0.67	0.67	0.67
B				0.00	0.00	0.00
Anchor Resistance Factor, R				3.80	3.80	4.69
Ultimate Anchor Resistance, A_{ult} lbs				125.8	125.8	155.1
Ultimate Anchor Resistance per foot, T_{ult} lb/ft				125.8	125.8	155.1
Factor of Safety - Deadman				2.53	2.53	3.12

Limitation of Use:

PRESTO GEOSYSTEMS

GEOWEB® CHANNEL PROTECTION SYSTEM
REQUEST FOR PROJECT EVALUATION

For preliminary evaluation, complete this form and email or fax to your Presto Geosystems distributor/representative or Presto Geosystems. Items marked with a * are required to proceed with a preliminary evaluation.

Project Information

*Project Name Schwartzwalder North Waste Rock Pile Diversion

*City Golden *State/Province CO *Country Jefferson

Estimated Geoweb® Area 8,400 ft2 ☐m² ☒ft²

*Describe problem to be solved by the Geoweb system: Convey flow around mine waste while resisting high velocities and shear stress.

Person Requesting Information

*Relationship with Project (check one)

☒ Consulting Engineer ☐ Contractor ☐ Owner Other

*Company Alexco Water & Environment *Contact Name Sam Lowe

*Address *City *State/Province *Zip/PC Country

*Phone 970.305.2000 *Fax Email slowe@alexcoenv.com

Presto Geosystems Distributor Information (if known)

Company Contact Office Location

Design Information

What is the channel type?

☒ Trapezoidal
☐ Parabolic
☐ Rectangular
☐ Stepped Trapezoidal
☐ Spillway / Chute
☐ Other

GEOWEB location?

☒ Full Channel ☐ Bottom only ☐ One embankment

What are the channel dimensions?

*Base Width 6 ☐ m ☒ft
*Side Slope 1:1 H:V
*Channel Depth 3 ☐ m ☒ ft

Top Width ☐ m ☐ ft
Length 777 ☐ m ☒ ft

NOTE: Include sketch of non-symmetric or unusual shaped channel

PRESTO GEOSYSTEMS
670 N PERKINS STREET, APPLETON, WISCONSIN, USA 54914
Ph: 920-738-1328 or 800-548-3424 ■ Fax: 920-738-1222
e-mail: INFO@PRESTOGEO.COM WWW.PRESTOGEO.COM/

PRESTO GEOSYSTEMS

GEOWEB® CHANNEL PROTECTION SYSTEM
REQUEST FOR PROJECT EVALUATION

What are the channel hydraulics?

Depth of Flow 1.43 ☐m ☒ft

Velocity 22.38 ☐ m/s ☒ ft/s

Manning's "n" 0.029

*Discharge Q 67.7 ☐m^3/s ☐ft^3/s

*Bed Slope 5-40 %

*☐ Flow ☐ Continuous OR ☒ Intermittent (duration hrs)

*What other hydraulic conditions apply?

☐ Wave Action / Wave Height ☐m ☐ft)

☐ Ice Action

☐ Rapid Drawdown / Time minutes

☐ Groundwater Seepage

☒ Other Momentum around two curves. Shear stress of ~15 lb/ft2

What is under the Geoweb? *Choose all that apply.*

☒ Native soil 3 ft depth m (ft)

☐ Gravel depth m (ft)

☐ Concrete

☒ Other bedding

☐ Geotextile ☐ Woven or ☐ Non-Woven

☐ Geomembrane ☐ Smooth or ☐ Textured

What are the foundation soil properties? (If Applicable)

Angle of Internal Friction degrees

Cohesion ☐kN/m^2 ☐lb/ft^2

Unit Weight ☐kN/m^3 ☐lb/ft^3

**What Geoweb infill is desired?*

☐ Topsoil

☐ Crushed Aggregate

☐ Grouted Stone

☒ Concrete

☐ Other

If topsoil or aggregate infill is desired:

Angle of Internal Friction degrees

Cohesion ☐kN/m^2 ☐lb/ft^2

Unit Weight ☐kN/m^3 ☐lb/ft^3

What Geoweb type is desired (if known)?

☐ GW20V Cell

☐ GW30V Cell

☐ GW40V Cell

☐ 75 mm (3 in) depth

☐ 100 mm (4 in) depth

☐ 150 mm (6 in) depth

☐ 200 mm (8 in) depth

What anchoring systems are desired?

☐ ATRA® Anchors

☐ Tendons and Deadman Anchor

☐ Tendons and Earth Anchors

☐ Other

PRESTO

GEOSYSTEMS

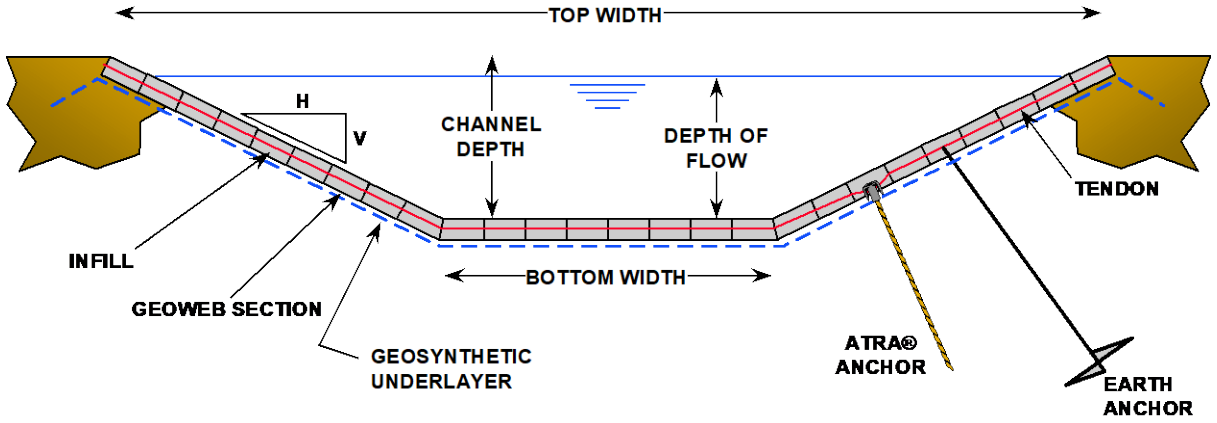
GEOWEB® CHANNEL PROTECTION SYSTEM REQUEST FOR PROJECT EVALUATION

Schedule

1) **Deadline Dates:** Project Evaluation Needed By Oct 31

Projected Bid Date Planned Construction Startup

Basic Channel Protection System Definitions



The project evaluation will be performed based on specification characteristics, structural values and limits for the Geoweb® material manufactured under an ISO 9001:2008 Quality Management program. The Evaluation is protected by copyright and any use of this Evaluation with materials manufactured by anyone other than Presto Products Company causes the recommendation and/or drawings to become invalid.

TECHNICAL REVISION #28

The primary goal of this project is to intercept and divert stormwater from the ephemeral drainage above the North Waste Rock Pile (NWRP) around the waste rock, and into Ralston Creek. The previous site owner, Cotter Corporation N.S.L. (Cotter) submitted a design in Technical Revision #23 for a diversion channel. CLL is submitting Technical Revision #28, to revise this design, provide a schedule for construction, and a construction quality assurance and quality control plan.

Channel Design:

The channel which will convey runoff around the NWRP is a trapezoidal section with a 3-foot bottom width, two feet deep with side slopes at 1:1. The channel will be lined with a 4-inch thick Geoweb liner filled with concrete. To keep water in the channel from seeping into the waste rock, below the Geoweb liner an impermeable geosynthetic liner (DuraSkrim), sandwiched between two layers of non-woven geotextile, will be placed.

The hydrology used for the design is the same hydrology used for Technical Revision #23, which used the SCS Runoff Curve Number procedure. The SCS method predicts a 100-year runoff event will have a peak flow of 67.7 cubic feet per second (cfs) from the unnamed drainage about the NWRP. This flow rate accounts for the entire amount of flow that the channel will intercept, including any runoff from the hillside above channel the NWRP access road.

The channel was modeled using HEC-RAS version 5.0.7. A unique cross section of the channel was added to the model for each of the designed grade changes. Within the HEC-RAS model additional cross sections were interpolated so that the distance between cross sections is never more than five feet. The distance between cross sections was reduced until no significant change in energy grade line and water surface elevation was observed. Table 1 summarizes the range of hydraulic conditions in the proposed channel, details are provided in the attached design sheets.

TABLE 1. CHANNEL HYDRAULIC SUMMARY TABLE

Channel Type	Slope	Slope (%)	Channel Depth (in)	Flow Depth (in) [B]	Additional Depth Due to Curve (in)	Channel Freeboard (in) [A]	Velocity (fps) [B]
Straight	Minimum	4.90	24	12.72	0.00	11.28	10.96
	Maximum	22.20	24	10.08	0.00	13.92	15.78
Curved	Minimum	13.00	36	10.68	4.56	20.76	14.45
	Maximum	20.70	36	9.24	4.56	22.20	17.75

Notes:

[A] (Channel Freeboard) = (Channel Depth) – (Flow Depth) – (Additional Depth Due to Curve).
[B] Value calculated in HEC-RAS model.
% = percent
cfs = cubic feet per second
in = inch(s)
fps = feet per second

The hydraulic calculations in Attachment 2 used the average slope above and below the channel curve to calculate a representative velocity to be used to shape the geometry of the channel. That geometry was then input into the HEC RAS model to evaluate the complete channel. The HEC RAS model results are presented in Table 1.

Channel and Access Road Construction:

The NWRP diversion channel will intercept all runoff originating from the ephemeral drainage above the NWRP up to the 100-year return interval runoff event. Additionally, two test pits were dug in the drainage above the NWRP to determine the depth to bedrock. One test pit identified a location where the bedrock is approximately 4 feet below grade. At this location a concrete seal (wall) will be poured against the bedrock to stop the flow of

groundwater towards the NWRP. A perforated PVC pipe in front of the seal wall will capture the groundwater and discharge it into the channel. The channel follows the alignment of the existing access road as it descends toward Ralston Creek. The channel will be lined with a geomembrane overlain by a Geoweb that is filled with concrete. A cushion geotextile will be installed above and below the geomembrane to protect it from the Geoweb / concrete and protrusions from the subgrade. The channel discharges flow into a riprap energy dissipation basin. The water will then flow through a riprap-lined channel to the Geoweb-lined, concrete-filled low-flow road crossing before discharging into Ralston Creek.

The NWRP was constructed with 3 feet of clean cover material. The design sheets in Attachment 2 identify three areas where excavation depths on the NWRP are anticipated to exceed 3 feet: at the bottom of the channel near Station 1+20, at the top of the access road near Station 4+45, and along the access road near Station 3+50. At a minimum, there will 3 feet of cover over all waste rock material in the roadway. If waste rock is exposed during construction activities in the Geoweb-lined channel, the waste rock shall be capped in place with the liner system (Geoweb liner filled with 4-inches of concrete underlain by a non-woven geotextile, an impermeable geosynthetic liner (DuraSkrim), and a second layer of non-woven geotextile). All excavated waste rock materials from the NWRP shall be transported to the Minnesota Adit for onsite disposal. Disturbed areas shall be reseeded in accordance with the specifications provided in Attachment 2.

Monitoring and Inspection Plan:

After construction, the drainage channel shall be inspected a minimum of once per year or after any major thunderstorm that causes the runoff to flow over the roadway crossing. The inspector shall walk the channel to:

- identify and remove any debris deposited by the storm event,
- inspect the channel for any damage, and
- inspect the surrounding earthen materials for signs of erosion such as rills, exposed roots, or overhanging soils.

Any deficiencies identified during the inspection shall be photo-documented and recommended for immediate maintenance or repair. All maintenance or repair activities shall be photo-documented. The results of the monitoring and inspection plan shall be reviewed with DRMS during the agency's quarterly inspection.

Schedule for Implementation:

The NWRP diversion project is expected to be completed in 2020. The attached Gantt chart presents the construction schedule and milestones for the project. This project includes four phases:

1. January to August 2019 – Engineering Design and Preparation,
2. May to February 2020 – Regulatory Review, Response and Approval,
3. March to May 2020 – Mobilization and Procurement, and
4. May to August 2020 – Construction

ATTACHMENT 1. GANTT CHART

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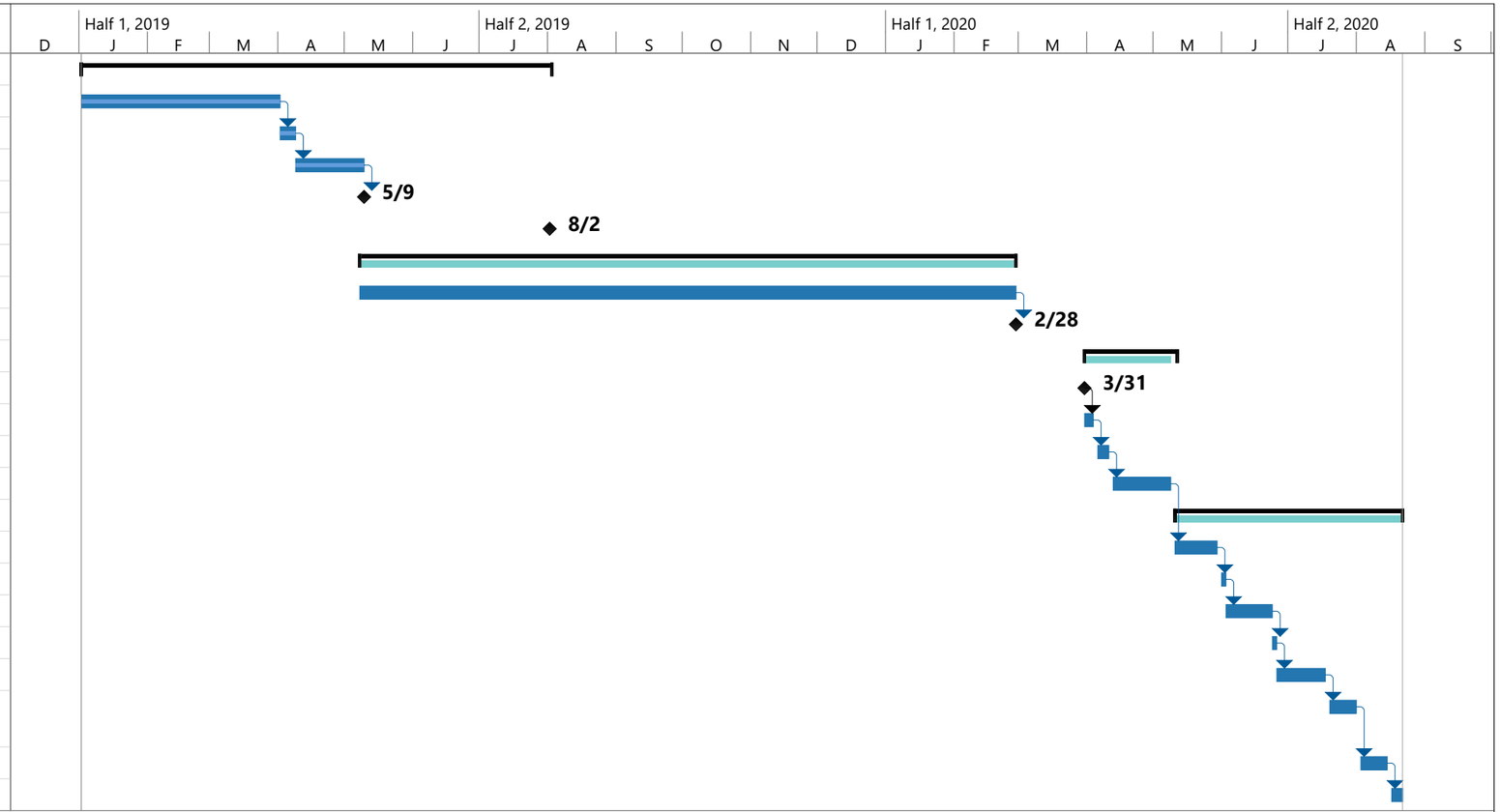
ID	Task Mode	Task Name	Duration
1		**Engineering Design and Preparation**	**153 days**
2		Review Technical Revision #23	64 days
3		Site walk	5 days
4		Prepare Revised Design (Technical Revision #28)	23 days
5		Submit Technical Revision #28	0 days
6		Natural Drainage Maintenance	0 days
7		**Regulatory Review, Response, and Approval**	**213 days**
8		Receive and Respond to Comments	213 days
9		Technical Revision #28 Decision Date	0 days
10		**Mobilization and Procurement**	**30 days**
11		Project Kick-off Meeting	0 days
12		Create Final Bill of Materials	4 days
13		Order Construction Materials	5 days
14		Delivery and Lead Time	20 days
15		**Construction**	**75 days**
16		Site Preparation and BMP Erosion Control	15 days
17		DRMS Inspection of Seal Wall	2 days
18		Install / Construct Upstream Seal Wall	15 days
19		DRMS Inspection of Ditch Grading	2 days
20		Install / Construct Ditch and Access Road	16 days
21		Install / Construct Energy Dissipator and Low Flow Crossing	10 days
22		Final Grading and Reseeding Disturbed Areas	10 days
23		Final DRMS Inspection	5 days



Attachment 1. Gantt Chart
Technical Revision #28
M-1977-300
Schwartzwalder Mine,
Golden, Colorado

Task	Project Summary	Manual Task	Start-only	Deadline	
Split	Inactive Task	Duration-only	Finish-only	Progress	
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress	
Summary	Inactive Summary	Manual Summary	External Milestone		

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ATTACHMENT 2. DESIGN PACKAGE

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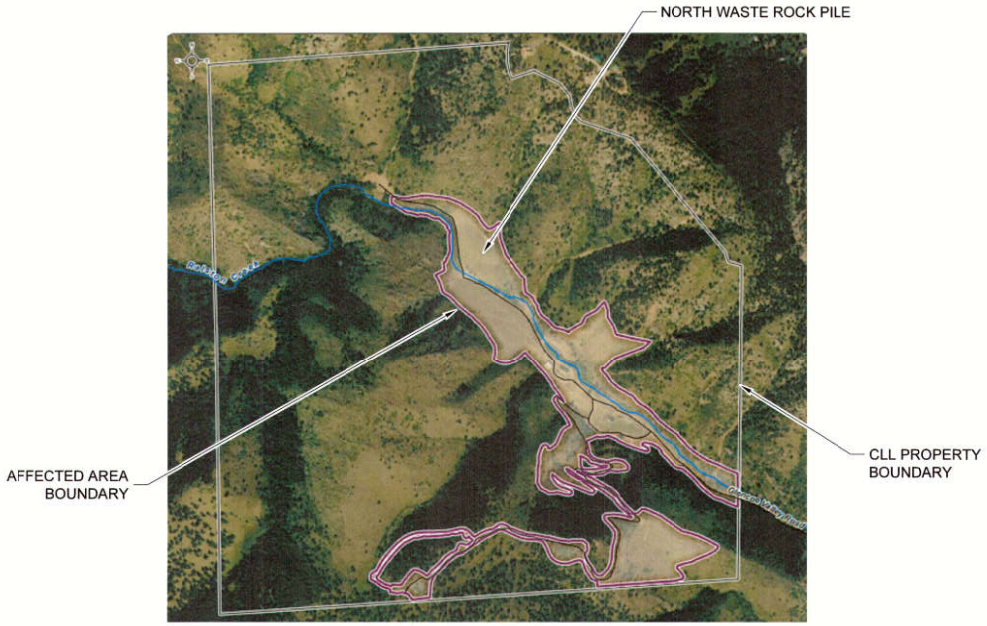
TR-28 NORTH WASTE ROCK PILE DIVERSION CHANNEL



PROJECT SITE

PROJECT AREA

N

N

TABLE OF CONTENTS

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
12-13-2019	For DRMS Review	E	TSC	--
8-5-2019	For DRMS Review	D	EW	--
6-10-2019	For DRMS Review	C	EW	--
5-22-2019	For DRMS Review	B	EW	--
4-23-2019	Draft for internal review	A	EW	--

COLORADO LEGACY LAND

ALEXCO WATER & ENVIRONMENT

COVER

NORTH WASTE ROCK PILE DIVERSION CHANNEL
FORMER SCHWARTZWALDER MINE, GOLDEN COLORADO
TECHNICAL REVISION #28
MINE LAND RECLAMATION PERMIT M-1977-300

REVISION: E	12-13-2019	SHEET No.: 1
DRAWN BY: TSC	DESIGNED BY: SL	REVIEWED BY: JL

GENERAL NOTES:

1.THE PROJECT SITE IS LOCATED IN SECTION 25, TOWNSHIP 2 SOUTH, RANGE 71 WEST ON THE PARCEL OWNED BY COLORADO LEGACY LAND (OWNER).

2.THE LOCATIONS OF UTILITIES SHOWN HAVE BEEN DETERMINED FROM AVAILABLE INFORMATION. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO LOCATE ALL EXISTING UTILITIES WHETHER OR NOT SHOWN ON THE DRAWINGS AND TO PROTECT THEM FROM DAMAGE. WHERE A UTILITY REQUIRES PROTECTION THE CONTRACTOR SHALL PROVIDE PROTECTION OF THE UTILITY THAT AT LEAST MEETS THE REQUIREMENTS OF THE UTILITY COMPANY. THE CONTRACTOR SHALL BEAR ALL EXPENSE OF REPAIR, REPLACEMENT OR ANY OTHER CHARGES RELATED TO EXISTING UTILITIES IN CONJUNCTION WITH THE EXECUTION OF THIS WORK. PRIOR TO ANY EXCAVATION THE CONTRACTOR SHALL CALL COLORADO 811 WITH SUITABLE NOTICE FOR THEIR LOCATING AND MARKING OF UTILITIES.

3.THE CONTRACT DRAWINGS REPRESENT THE FINISHED WORK. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL MEANS AND METHODS OF CONSTRUCTION. CONTRACTOR SHALL FURNISH ALL LABOR, EQUIPMENT, MATERIALS, AND TOOLS NECESSARY TO COMPLETELY PERFORM THE WORK IN A SAFE, EXPEDITIOUS, AND WORKMAN LIKE MANNER. CONTRACTOR SHALL COORDINATE SCHEDULE OF THE WORK WITH OWNER. THE CONTRACTOR ACCEPTS FULL RESPONSIBILITY FOR PROPER HANDLING AND INSTALLATION OF MATERIALS.

4.CONTRACTOR SHALL TAKE ALL NECESSARY MEASURES TO ENSURE SAFETY OF ALL PERSONS AND STRUCTURES AT THE SITE AND ADJACENT TO THE SITE. CONTRACTOR SHALL BE RESPONSIBLE FOR ANY CLAIMS RESULTING FROM PROJECT ACTIVITIES. VISITS TO THE SITE BY OWNER SHALL NOT RELIEVE THE CONTRACTOR OF SUCH RESPONSIBILITY.

5.THE CONTRACTOR SHALL ACCEPT FULL RESPONSIBILITY FOR MATERIALS THROUGH PROJECT COMPLETION. CONTRACTOR SHALL STORE MATERIALS IN A SECURE LOCATION (OR OFF-SITE). MATERIALS SHALL BE DELIVERED, STORED, AND HANDLED IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS.

6.THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PROPER SAFEGUARDING OF THE INSTALLATION AND MATERIALS STORED ON THE SITE TO PREVENT THEFT, VANDALISM OR DAMAGE.

7.CONTRACTOR SHALL MINIMIZE DISTURBANCES TO ADJACENT AREAS THAT ARE NOT WITHIN THE PROJECT WORK AREA.

8.CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL CONSTRUCTION PERMITS REQUIRED TO PERFORM THE WORK. CONTRACTOR SHALL PROVIDE CERTIFICATES OF INSURANCE AND OTHER DOCUMENTATION REQUIRED BY THE JURISDICTIONAL AGENCY BEFORE PERFORMING THE WORK.

9.ALL WORK SHALL BE PERFORMED IN ACCORDANCE WITH OSHA.

10.ALL WORK SHALL BE PERFORMED IN ACCORDANCE WITH LOCAL, STATE, AND FEDERAL REGULATIONS.

11.THESE NOTES AND OTHER DRAWING NOTES CONTAINED HEREWITH ARE PROVIDED TO MEET SPECIFIC REQUIREMENTS AND TO SUPPLEMENT THE CONTRACT DOCUMENTS. THESE NOTES NEITHER REPLACE NOR OVERRIDE THE PROVISIONS AND REQUIREMENTS OF THE CONTRACT DOCUMENTS.

12.UNKNOWN SITUATIONS OR CONDITIONS NOT COVERED IN THE CONTRACT DOCUMENTS MAY ARISE DURING CONSTRUCTION. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO NOTIFY THE OWNER IF SUCH A CONDITION IS IDENTIFIED. THE PRESENCE OF THE OWNER DOES NOT RELIEVE THE CONTRACTOR OF THE RESPONSIBILITY FOR A PROPER INSTALLATION.

13.ALL DIMENSIONS, ELEVATIONS, AND CONDITIONS SHALL BE VERIFIED IN THE FIELD BY THE CONTRACTOR AND ANY DISCREPANCIES SHALL BE BROUGHT TO THE ATTENTION OF THE OWNER FOR CLARIFICATION BEFORE PROCEEDING WITH THE AFFECTED PART OF WORK.

14.THE CONTRACTOR SHALL BECOME FAMILIAR WITH THE EXISTING CONDITIONS BEFORE SUBMITTING BID.

15. IF CERTAIN FEATURES ARE NOT CLEARLY SHOWN OR CALLED OUT ON THE CONTRACT DRAWINGS, CONSTRUCTION SHALL BE OF THE SAME CHARACTER AS FOR SIMILAR CONDITIONS THAT ARE SHOWN OR CALLED FOR, SUBJECT TO THE APPROVAL OF THE OWNER.

16. IN CASE OF DIFFERENCE BETWEEN DRAWINGS AND SPECIFICATIONS, THE SPECIFICATIONS SHALL GOVERN.

17. SURVEY DATA TAKEN FROM USGS LIDAR DATA PUBLISHED 07-21-2015. HORIZONTAL COORDINATES ARE SHOWN IN CO STATE PLANE COORDINATES. ELEVATION DATA BASED UPON NAD 1983 VERTICAL DATUM. SURVEY UNITS ARE IN US SURVEY FEET.

ABBREVIATIONS

Δ	ALIGNMENT DELTA ANGLE
D.S.	DOWNSTREAM
E	EASTING
E.F.	EACH FACE
E.G.	EXISTING GRADE
ELEV.	ELEVATION
E.W.	EACH WAY
L	LENGTH
N	NORTHING
NWRP	NORTH WASTE ROCK PILE
O.C.	ON CENTER
PC	POINT OF CURVATURE
PI	POINT OF INTERSECTION
PT	POINT OF TANGENCY
R	RADIUS
STA	STATION
T.O.W.	TOP OF WALL
U.S.	UPSTREAM

LEGEND

- AFFECTED AREA BOUNDARY
- RALSTON CREEK
- MAJOR CONTOUR (EXISTING)
- MINOR CONTOUR (EXISTING)
- MAJOR CONTOUR (DESIGN)
- MINOR CONTOUR (DESIGN)
- EDGE OF EXISTING ROADWAY
- CHANNEL CENTERLINE
- GEOWEB
- EARTHWORK
- RIPRAP
- GRAVEL
- BEDROCK
- CONCRETE
- WATER SURFACE ELEVATION
- MATCH LINE SEE SHEET 5 — ALIGNMENT MATCH LINE
- SECTION 5+00.00 — CHANNEL CROSS SECTION AT STATION "5+00"
- A A — SECTION CUT VIEW "A-A"

COLORADO LICENSED SAMUEL J LOWE PE 41234 PROFESSIONAL ENGINEER

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
12-13-2019	For DRMS Review	E	TSC	--
8-5-2019	For DRMS Review	D	EW	--
6-10-2019	For DRMS Review	C	EW	--
5-22-2019	For DRMS Review	B	EW	--
4-23-2019	Draft for internal review	A	EW	--

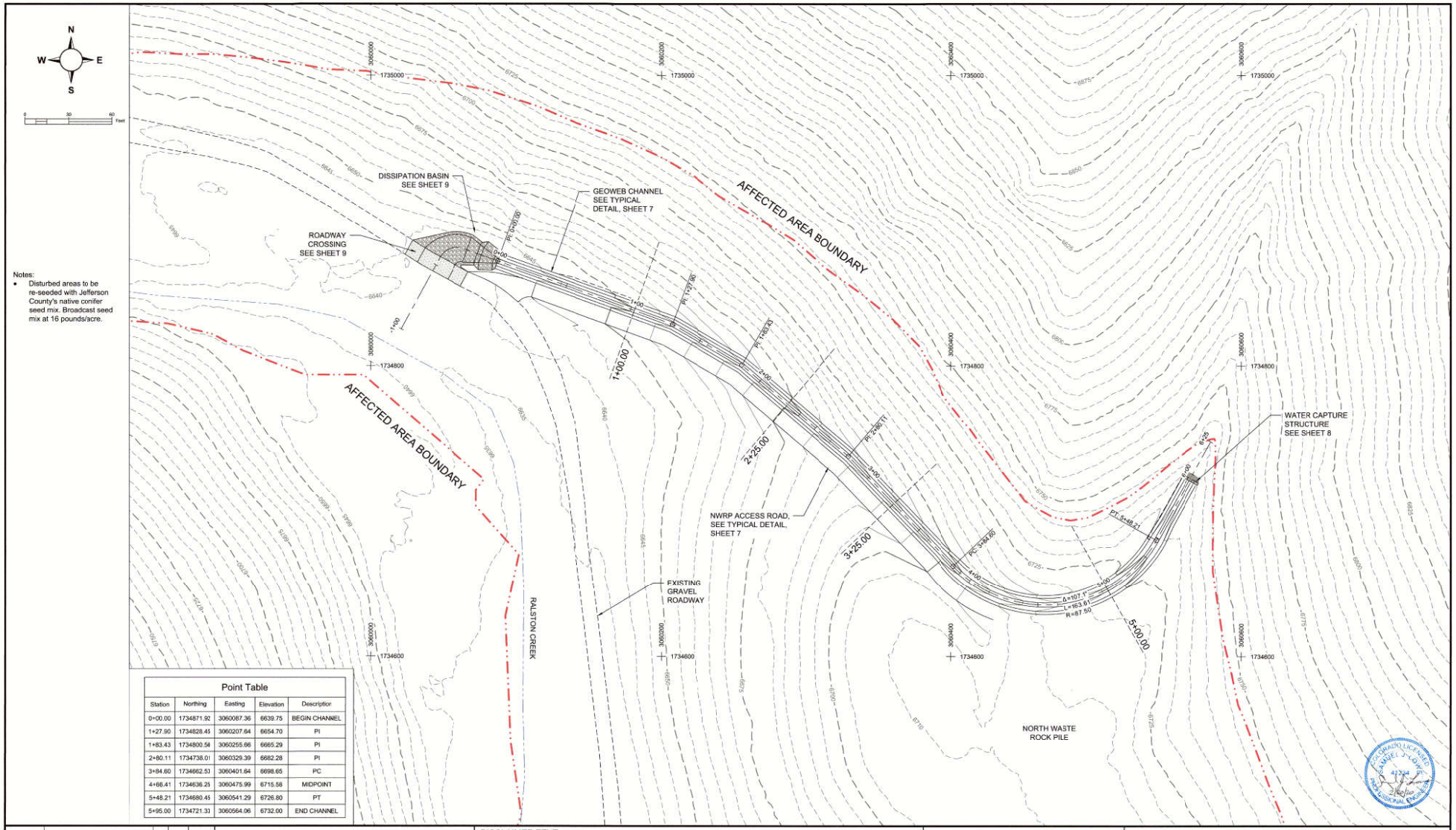
COLORADO LEGACY LAND

ALEXCO WATER & ENVIRONMENT

NOTES

NORTH WASTE ROCK PILE DIVERSION CHANNEL
FORMER SCHWARTZWALDER MINE, GOLDEN COLORADO
TECHNICAL REVISION #28
MINE LAND RECLAMATION PERMIT M-1977-300

REVISION: E	12-13-2019	SHEET No.: 2
DRAWN BY: TSC	DESIGNED BY: SL	REVIEWED BY: JL



Notes:

- Disturbed areas to be re-seeded with Jefferson County's native conifer seed mix. Broadcast seed mix at 16 pounds/acre.

Point Table

Station	Northing	Easting	Elevation	Description
0+00.00	1734871.92	3060087.36	6639.75	BEGIN CHANNEL
1+27.90	1734828.45	3060207.64	6654.70	PI
1+83.43	1734800.56	3060255.66	6665.29	PI
2+80.11	1734738.01	3060329.39	6682.28	PI
3+84.60	1734662.53	3060401.64	6698.65	PC
4+68.41	1734636.25	3060475.99	6715.58	MIDPOINT
5+48.21	1734680.45	3060541.29	6726.80	PT
5+95.00	1734721.33	3060564.06	6732.00	END CHANNEL

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
12-13-2019	For DRMS Review	E	TSC	–
8-5-2019	For DRMS Review	D	EW	–
6-10-2019	For DRMS Review	C	EW	–
5-22-2019	For DRMS Review	B	EW	–
4-23-2019	Draft for internal review	A	EW	–

COLORADO LEGACY LAND

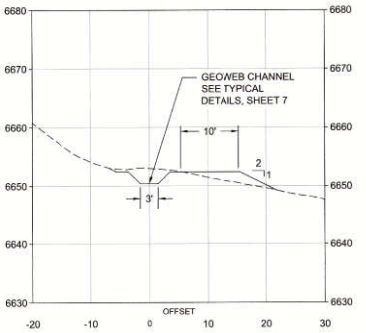
ALEXCO WATER & ENVIRONMENT

SITE PLAN

NORTH WASTE ROCK PILE DIVERSION CHANNEL
FORMER SCHWARTZWALDER MINE, GOLDEN COLORADO
TECHNICAL REVISION #28

MINE LAND RECLAMATION PERMIT M-1977-300

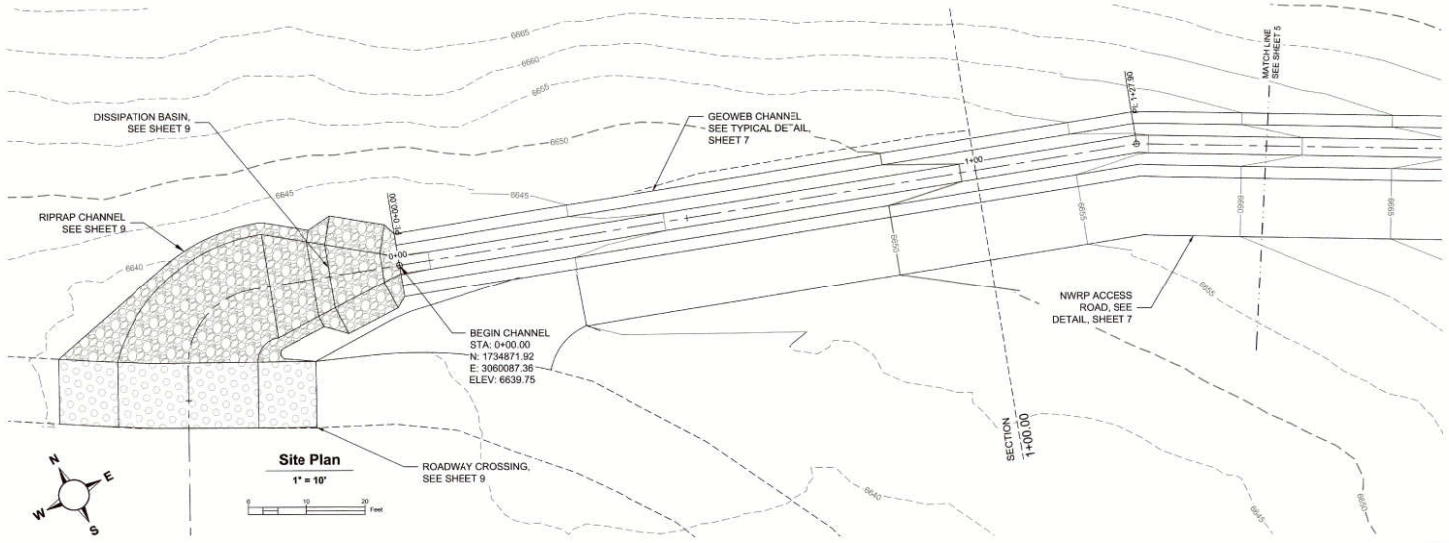
REVISION: E	12-13-2019	SHEET No.: 3
DRAWN BY: TSC	DESIGNED BY: SL	REVIEWED BY: JL



STATION 1+00

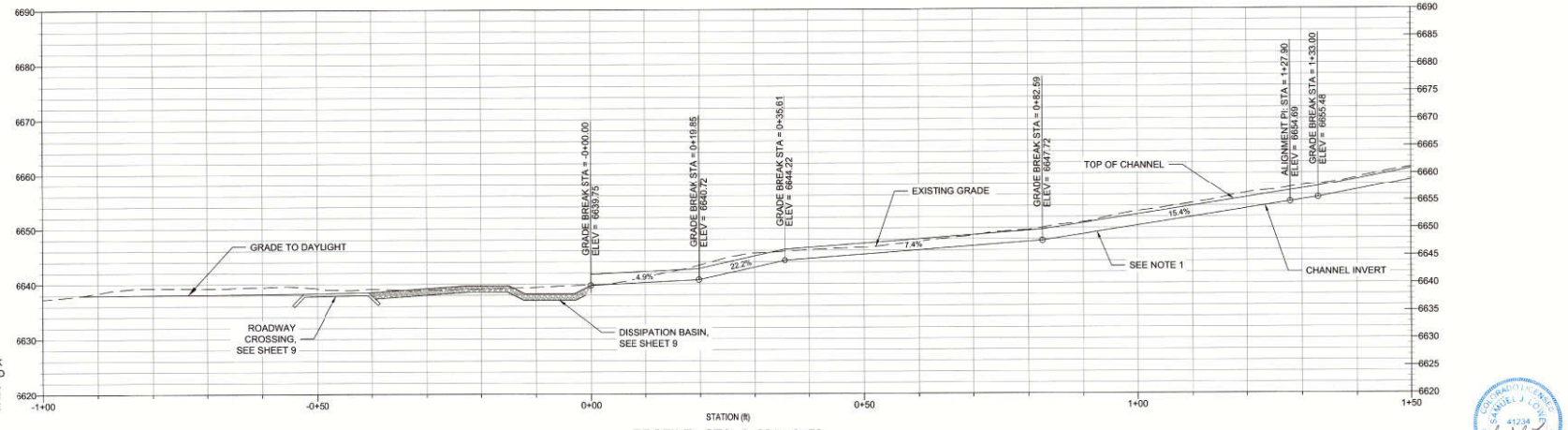
Scale: 1" = 10'
(Horizontal & Vertical)

NOTES:
1. AT A MINIMUM, THERE WILL BE 3 FEET OF COVER OVER ALL WASTE ROCK MATERIAL IN THE ROADWAY. ALL EXCAVATED WASTE ROCK MATERIALS FROM THE NWRP SHALL BE TRANSPORTED TO THE MINNESOTA ADIT FOR ONSITE DISPOSAL.



Site Plan

1" = 10'



PROFILE - STA -1+00 to 1+50

Scale: 1" = 10'
(Horizontal & Vertical)

NOTES:
1. IF WASTE ROCK IS EXPOSED DURING CONSTRUCTION ACTIVITIES ALONG THE GEOWEB-LINED CHANNEL, THE WASTE ROCK SHALL BE CAPPED WITH GEOMEMBRANE AND THE CONCRETE-FILLED GEOWEB LINER. ALL EXCAVATED WASTE ROCK MATERIALS FROM THE NWRP SHALL BE TRANSPORTED TO THE MINNESOTA ADIT FOR ONSITE DISPOSAL.

COLORADO LICENSED
SAMUEL J. LOWE
41234
7/15/20
CIVIL PROFESSIONAL ENGINEER

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
12-13-2019	For DRMS Review	E	TSC	--
8-5-2019	For DRMS Review	D	EW	--
6-10-2019	For DRMS Review	C	EW	--
5-22-2019	For DRMS Review	B	EW	--
4-23-2019	Draft for interna review	A	EW	--

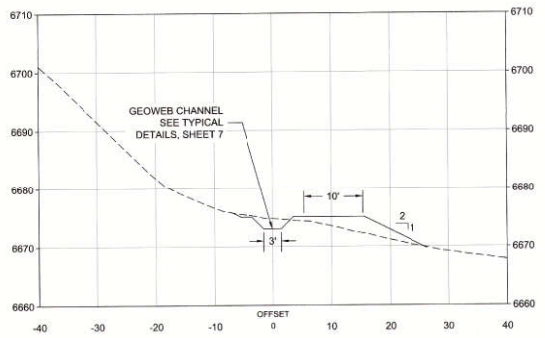
COLORADO LEGACY LAND

ALEXCO WATER & ENVIRONMENT

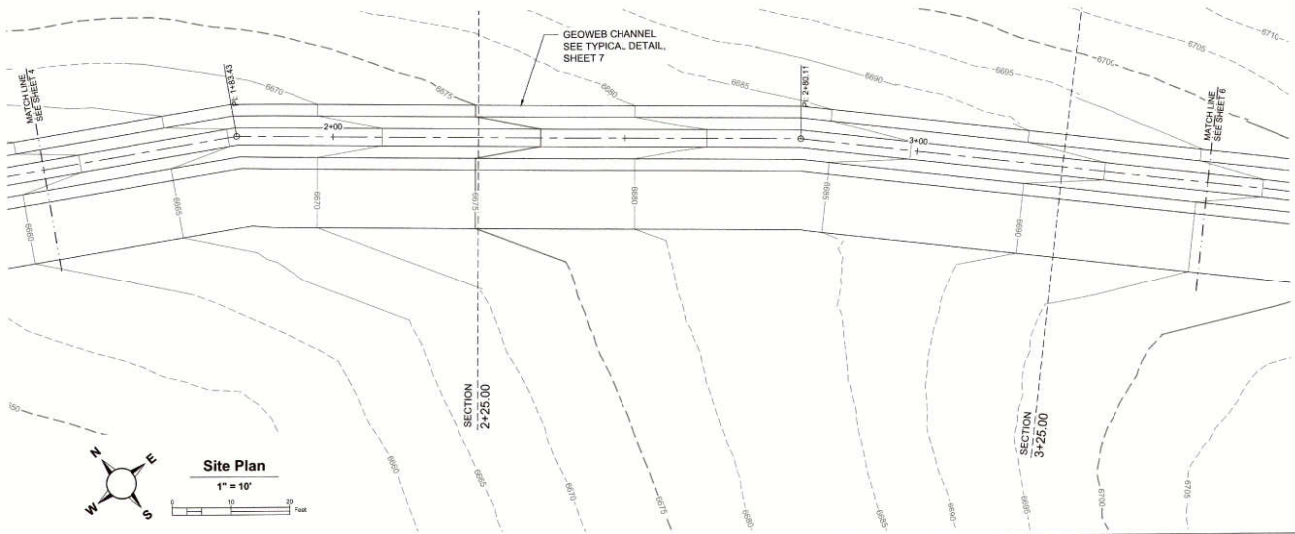
PLAN & PROFILE (STA -1+00 TO 1+50)

NORTH WASTE ROCK PILE DIVERSION CHANNEL
FORMER SCHWARTZWALDER MINE, GOLDEN COLORADO
TECHNICAL REVISION #28
MINE LAND RECLAMATION PERMIT M-1977-300

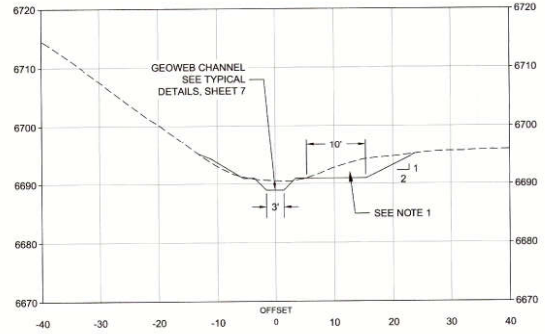
REVISION: E	12-13-2019	SHEET No.: 4
DRAWN BY: TSC	DESIGNED BY: SL	REVIEWED BY: JL



STATION 2+25
Scale: 1" = 10'
(Horizontal & Vertical)

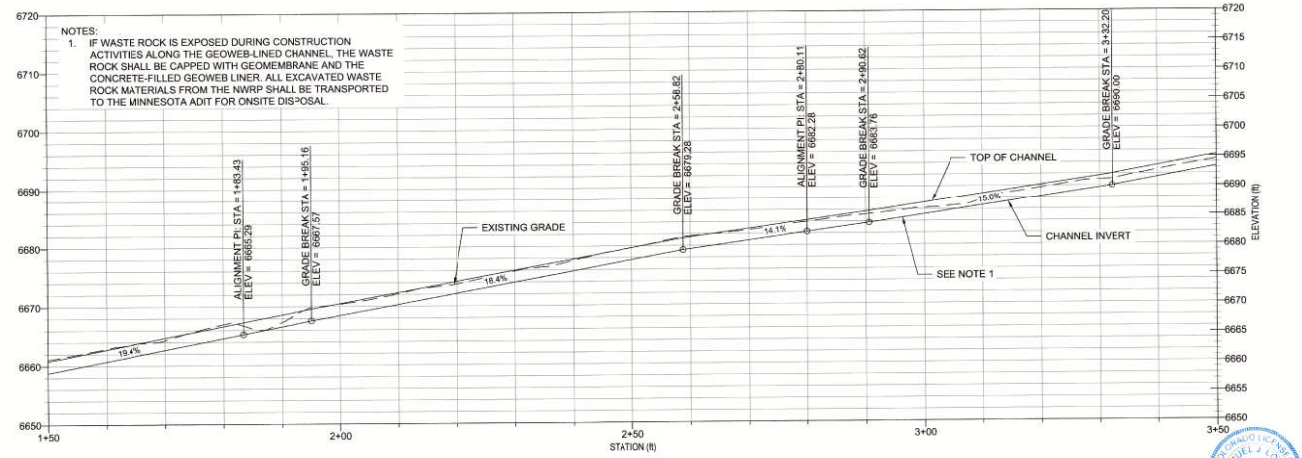


Site Plan
1" = 10'



STATION 3+25
Scale: 1" = 10'
(Horizontal & Vertical)

NOTES:
1. AT A MINIMUM, THERE WILL 3 FEET OF COVER OVER ALL WASTE ROCK MATERIAL IN THE ROADWAY. ALL EXCAVATED WASTE ROCK MATERIALS FROM THE NWRP SHALL BE TRANSPORTED TO THE MINNESOTA ADIT FOR ONSITE DISPOSAL. TYP.



PROFILE - STA 1+50 to 3+50
Scale: 1" = 10'
(Horizontal & Vertical)

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
12-13-2019	For DRMS Review	E	TSC	–
8-5-2019	For DRMS Review	D	EW	–
6-10-2019	For DRMS Review	C	EW	–
5-22-2019	For DRMS Review	B	EW	–
4-23-2019	Draft for internal review	A	EW	–

COLORADO LEGACY LAND

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ALEXCO WATER & ENVIRONMENT

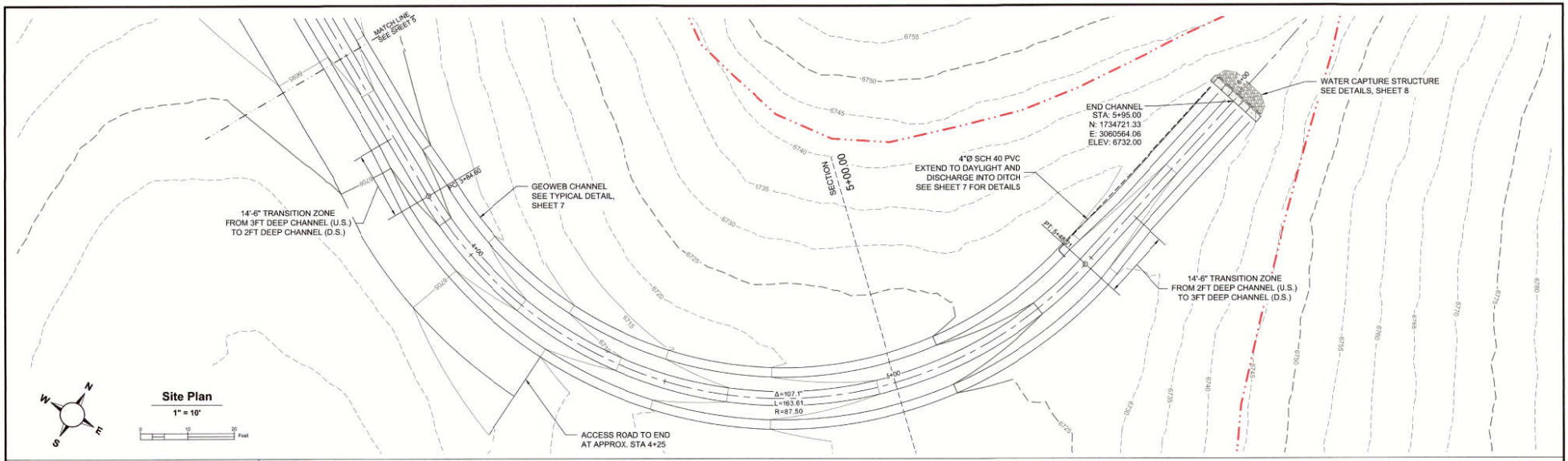
PLAN & PROFILE (STA 1+50 TO 3+50)

NORTH WASTE ROCK PILE DIVERSION CHANNEL
FORMER SCHWARTZWALDER MINE, GOLDEN COLORADO
TECHNICAL REVISION #28

MINE LAND RECLAMATION PERMIT M-1977-300

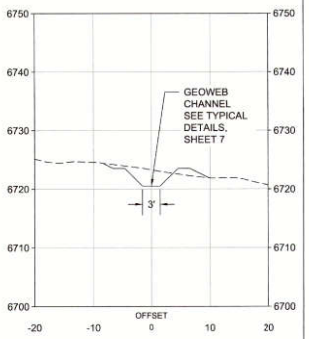
REVISION: E	12-13-2019	SHEET No.: 5
DRAWN BY: TSC	DESIGNED BY: SL	REVIEWED BY: JL

COLORADO LICENSED
SAMUEL J. LOWE
41234
PROFESSIONAL ENGINEER



Site Plan

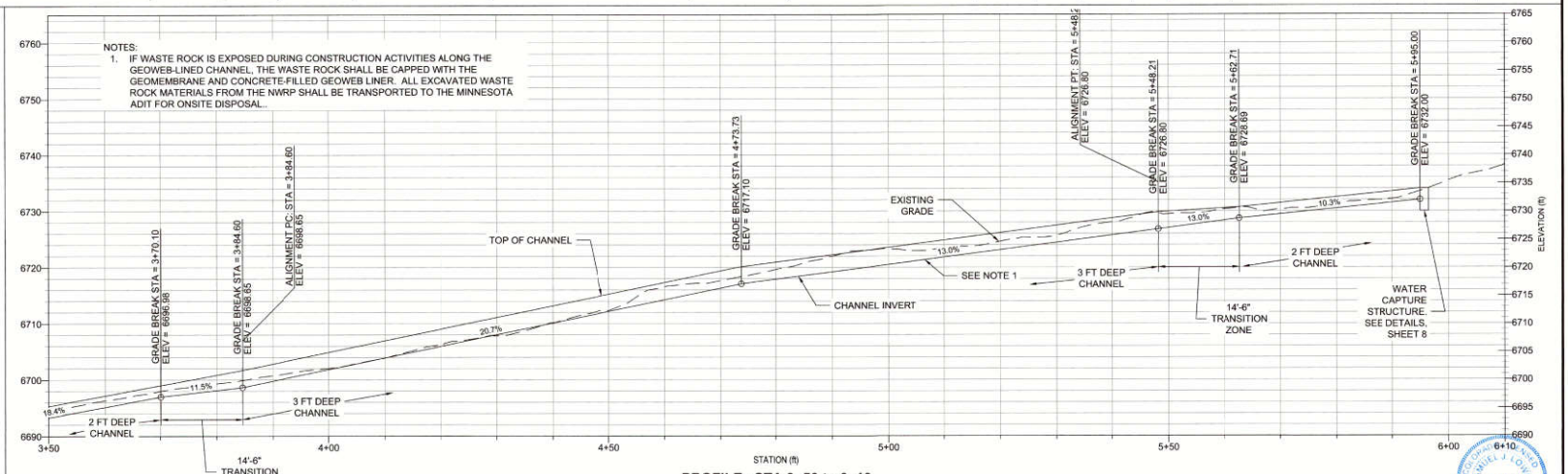
1" = 10'



STATION 5+00

Scale: 1" = 10'
(Horizontal & Vertical)

NOTES:
1. IF WASTE ROCK IS EXPOSED DURING CONSTRUCTION ACTIVITIES ALONG THE GEOWEB-LINED CHANNEL, THE WASTE ROCK SHALL BE CAPPED WITH THE GEOMEMBRANE AND CONCRETE-FILLED GEOWEB LINER. ALL EXCAVATED WASTE ROCK MATERIALS FROM THE NWRP SHALL BE TRANSPORTED TO THE MINNESOTA ADIT FOR ONSITE DISPOSAL..



PROFILE - STA 3+50 to 6+10

Scale: 1" = 10'
(Horizontal & Vertical)

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
12-13-2019	For DRMS Review	E	TSC	--
8-5-2019	For DRMS Review	D	EW	--
6-10-2019	For DRMS Review	C	EW	--
5-22-2019	For DRMS Review	B	EW	--
4-23-2019	Draft for internal review	A	EW	--

COLORADO LEGACY LAND

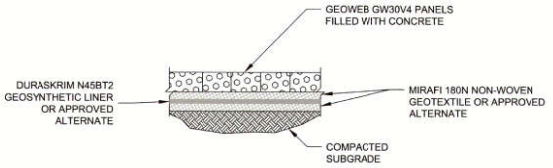
ALEXCO WATER & ENVIRONMENT

PLAN & PROFILE (STA 3+50 TO 6+10)

NORTH WASTE ROCK PILE DIVERSION CHANNEL
FORMER SCHWARTZWALDER MINE, GOLDEN COLORADO
TECHNICAL REVISION #28

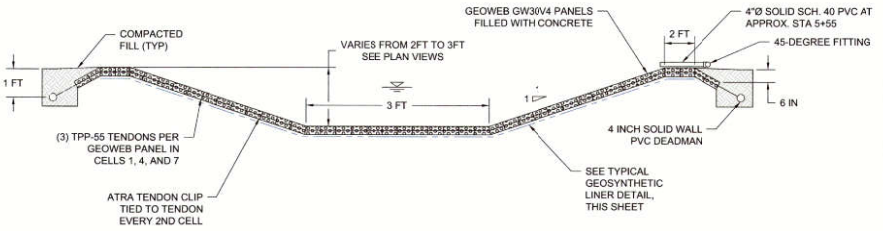
MINE LAND RECLAMATION PERMIT M-1977-300

REVISION: E	12-13-2019	SHEET No.: 6
DRAWN BY: TSC	DESIGNED BY: SL	REVIEWED BY: JL



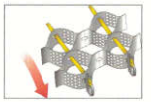
TYPICAL GEOSYNTHETIC LINER DETAIL

SCALE: NTS



ATRA KEY

ATRA TENDON CLIP

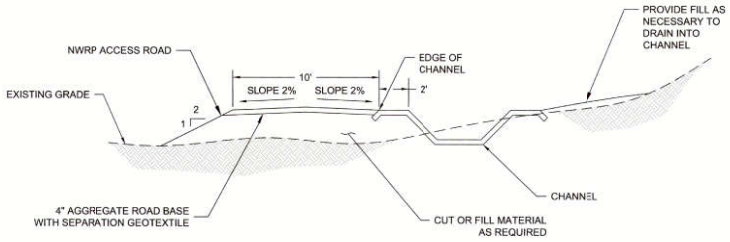


INSTALLATION

NOTES:
1. THE GEOWEB PANELS SHALL BE CONNECTED WITH ATRA KEYS AT EACH INTERLEAF AND END TO END CONNECTION.
2. LIMIT THE DROP OF INFILL TO PREVENT PANEL DISTORTION OR DAMAGE TO UNDERLYING GEOMEMBRANE.
3. INFILL SHALL CONSIST OF CONCRETE. ADJUST CONCRETE SLUMP IN THE FIELD AS NECESSARY TO ALLOW INSTALLATION.
4. IF A DEADMAN IS NOT FEASIBLE, PROVIDE EARTH ANCHORS WITH A MINIMUM TENSION OF 400 LBS (139 LBS/FT x 8.5 FT/PANEL / 3 TENDONS/PANEL) PLUS THE MANUFACTURER'S FACTOR OF SAFETY TIED TO EACH TENDON.

TYPICAL GEOWEB TRAPEZOIDAL CHANNEL SECTION DETAIL

SCALE: NTS



TYPICAL NWRP ACCESS ROADWAY SECTION DETAIL

SCALE: NTS

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
12-13-2019	For DRMS Review	E	TSC	--
8-5-2019	For DRMS Review	D	EW	--
6-10-2019	For DRMS Review	C	EW	--
5-22-2019	For DRMS Review	B	EW	--
4-23-2019	Draft for internal review	A	EW	--

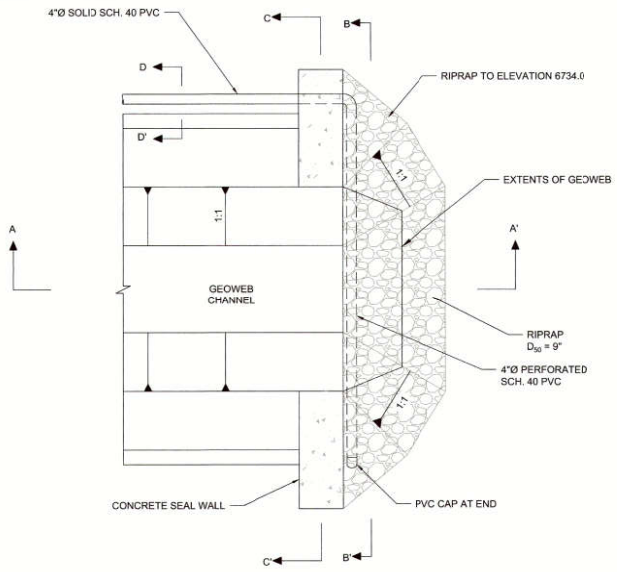
COLORADO LEGACY LAND

ALEXCO WATER & ENVIRONMENT

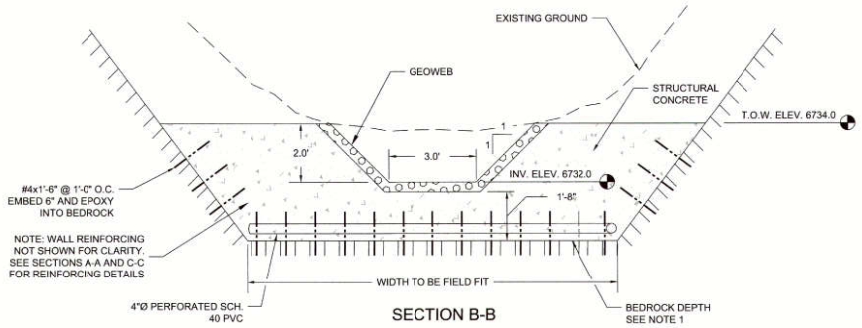
TYPICAL DETAILS

NORTH WASTE ROCK PILE DIVERSION CHANNEL
FORMER SCHWARTZWALDER MINE, GOLDEN COLORADO
TECHNICAL REVISION #28
MINE LAND RECLAMATION PERMIT M-1977-300

REVISION: E	12-13-2019	SHEET No.: 7
DRAWN BY: TSC	DESIGNED BY: SL	REVIEWED BY: JL

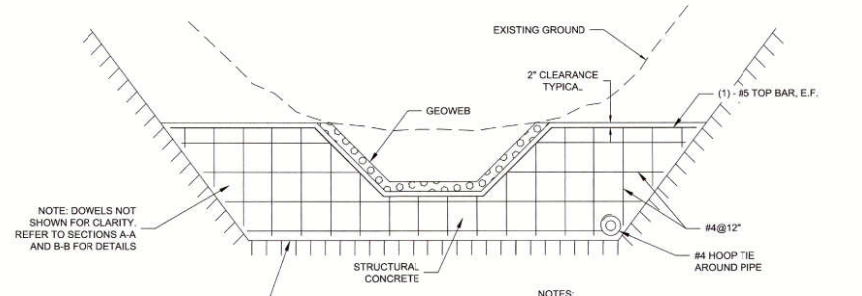


PLAN VIEW



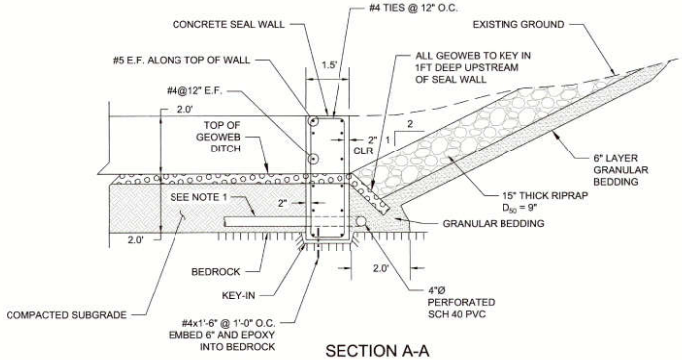
SECTION B-B

NOTES:
1. A TEST PIT WAS DUG IN AUGUST 2018 WHICH REVEALED BEDROCK APPROXIMATELY 4 FT BELOW EXISTING GROUND. SEAL WALL MUST BE POURED AGAINST TOP OF BEDROCK.



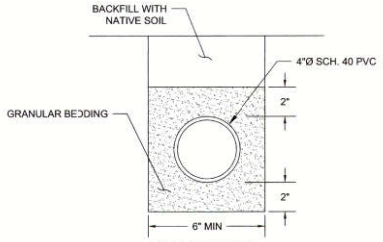
SECTION C-C

NOTES:
1. A TEST PIT WAS DUG IN AUGUST 2019 WHICH REVEALED BEDROCK APPROXIMATELY 4 FT BELOW EXISTING GROUND. SEAL WALL MUST BE POURED AGAINST TOP OF BEDROCK.



SECTION A-A

NOTES
1. PVC PIPE TO SLOPE AT 0.5% AND SPILL INTO DITCH AT APPROX. STA 5+55. SEE DETAIL SHEET 7.



SECTION D-D

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
12-13-2019	For DRMS Review	E	TSC	--
8-5-2019	For DRMS Review	D	EW	--
6-10-2019	For DRMS Review	C	EW	--
5-22-2019	For DRMS Review	B	EW	--
4-23-2019	Draft for internal review	A	EW	--

COLORADO LEGACY LAND

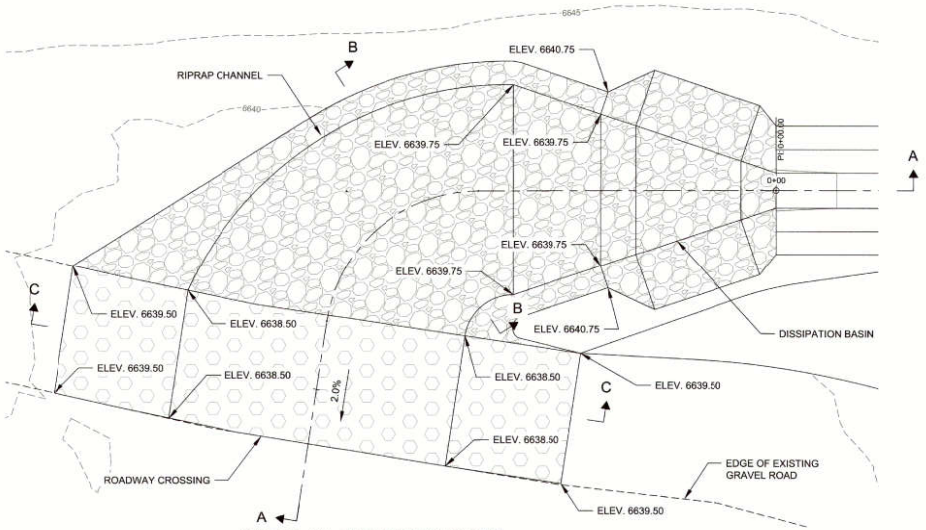
ALEXCO WATER & ENVIRONMENT

CAPTURE STRUCTURE DETAILS

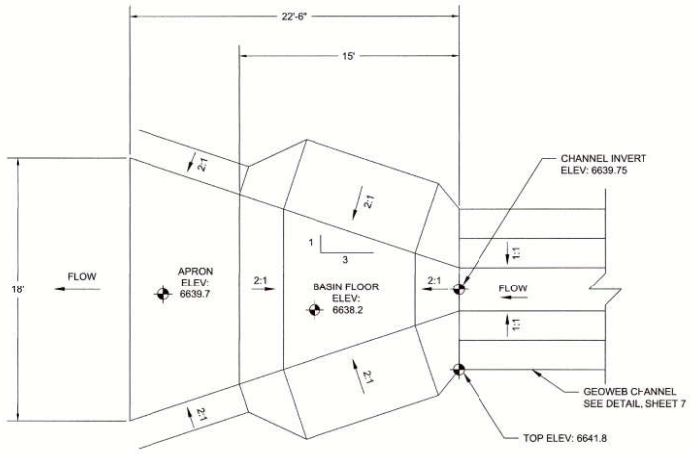
NORTH WASTE ROCK PILE DIVERSION CHANNEL
FORMER SCHWARTZWALDER MINE, GOLDEN COLORADO
TECHNICAL REVISION #28

MINE LAND RECLAMATION PERMIT M-1977-300

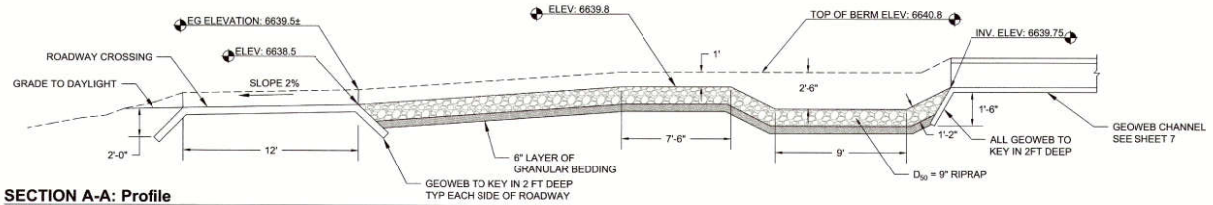
REVISION: E	12-13-2019	SHEET No.: 8
DRAWN BY: TSC	DESIGNED BY: SL	REVIEWED BY: JL



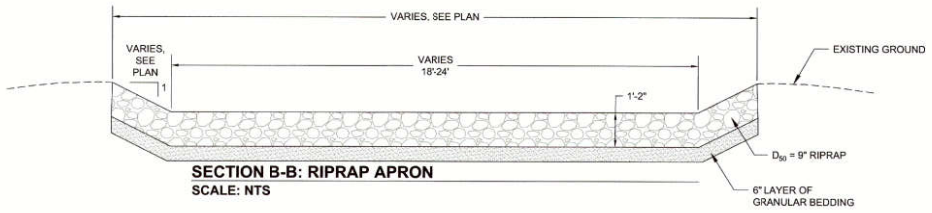
SITE PLAN: DISSIPATION BASIN
SCALE: 1" = 5'



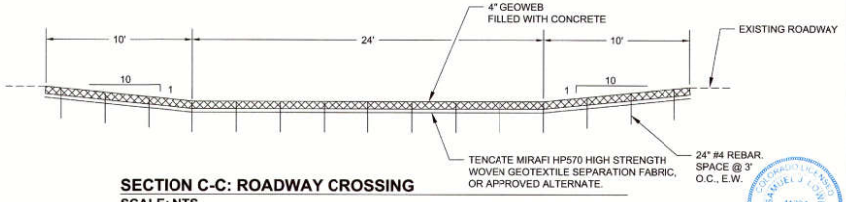
PLAN VIEW: DISSIPATION BASIN
SCALE: NTS



SECTION A-A: Profile
SCALE: NTS



SECTION B-B: RIPRAP APRON
SCALE: NTS



SECTION C-C: ROADWAY CROSSING
SCALE: NTS

DATE	ISSUE/REVISION	REV No.	DRW.	APP.
12-13-2019	For DRMS Review	E	TSC	--
8-5-2019	For DRMS Review	D	EW	--
6-10-2019	For DRMS Review	C	EW	--
5-22-2019	For DRMS Review	B	EW	--
~~4-25-2019~~	~~For DRMS Review~~	A	EW	--

COLORADO LEGACY LAND

ALEXCO WATER & ENVIRONMENT

DISSIPATION BASIN & ROADWAY CROSSING DETAILS

NORTH WASTE ROCK PILE DIVERSION CHANNEL
FORMER SCHWARTZWALDER MINE, GOLDEN COLORADO
TECHNICAL REVISION #28
MINE LAND RECLAMATION PERMIT M-1977-300

REVISION: E	12-13-2019	SHEET No.: 9
DRAWN BY: TSC	DESIGNED BY: SL	REVIEWED BY: JL

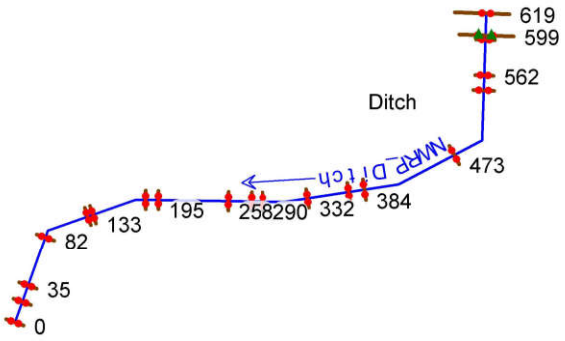
HEC-RAS Output

High Manning-n value Model

- XS Plan View (no interpolated sections) (1 page)
- XS Plan View (with interpolated sections) (1 page)
- XS Plots (5 pages)
- XS Output (7 pages)
- Profile Standard Output Table (2 page)
- Profile Custom Output Table (2 page)
- Summary of Errors, Warnings and Notes (2 pages)

Low Manning-n value Model

- XS Output (7 pages)
- Profile Standard Output Table (2 pages)
- Profile Custom Output Table (2 pages)
- Summary of Errors, Warnings and Notes (1 page)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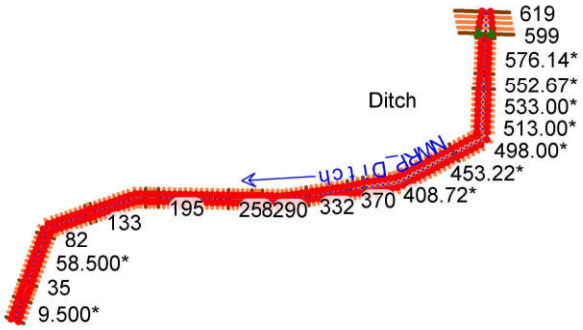
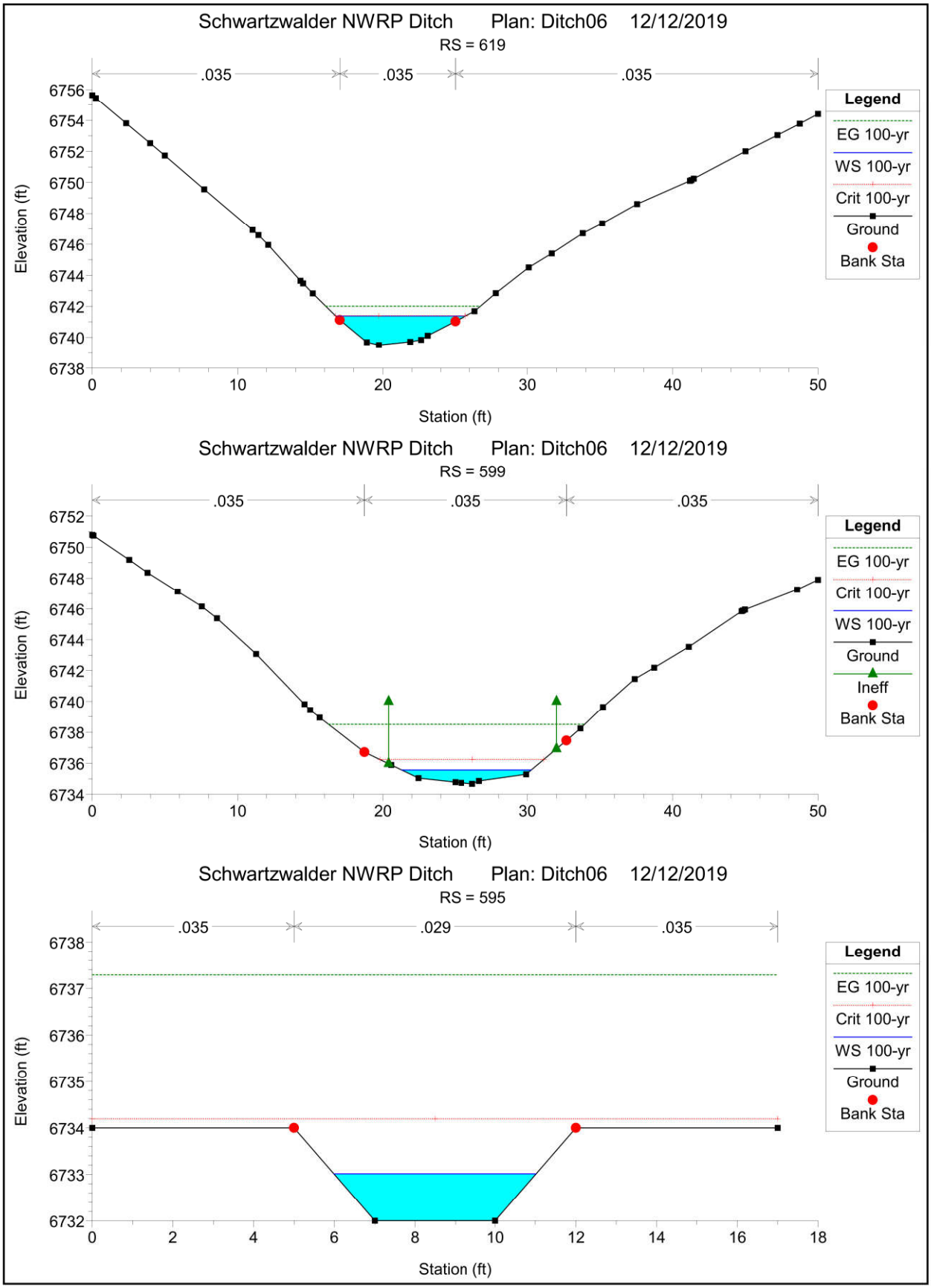
562
Ditch
MRP_Ditch
473
384
332
290
258
195
133
82
35
0



None of the XS's are Geo-Referenced (- Geo-Ref user entered XS - Geo-Ref interpolated XS - Non Geo-Ref user entered XS - Non Geo-Ref interpolated XS)


Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
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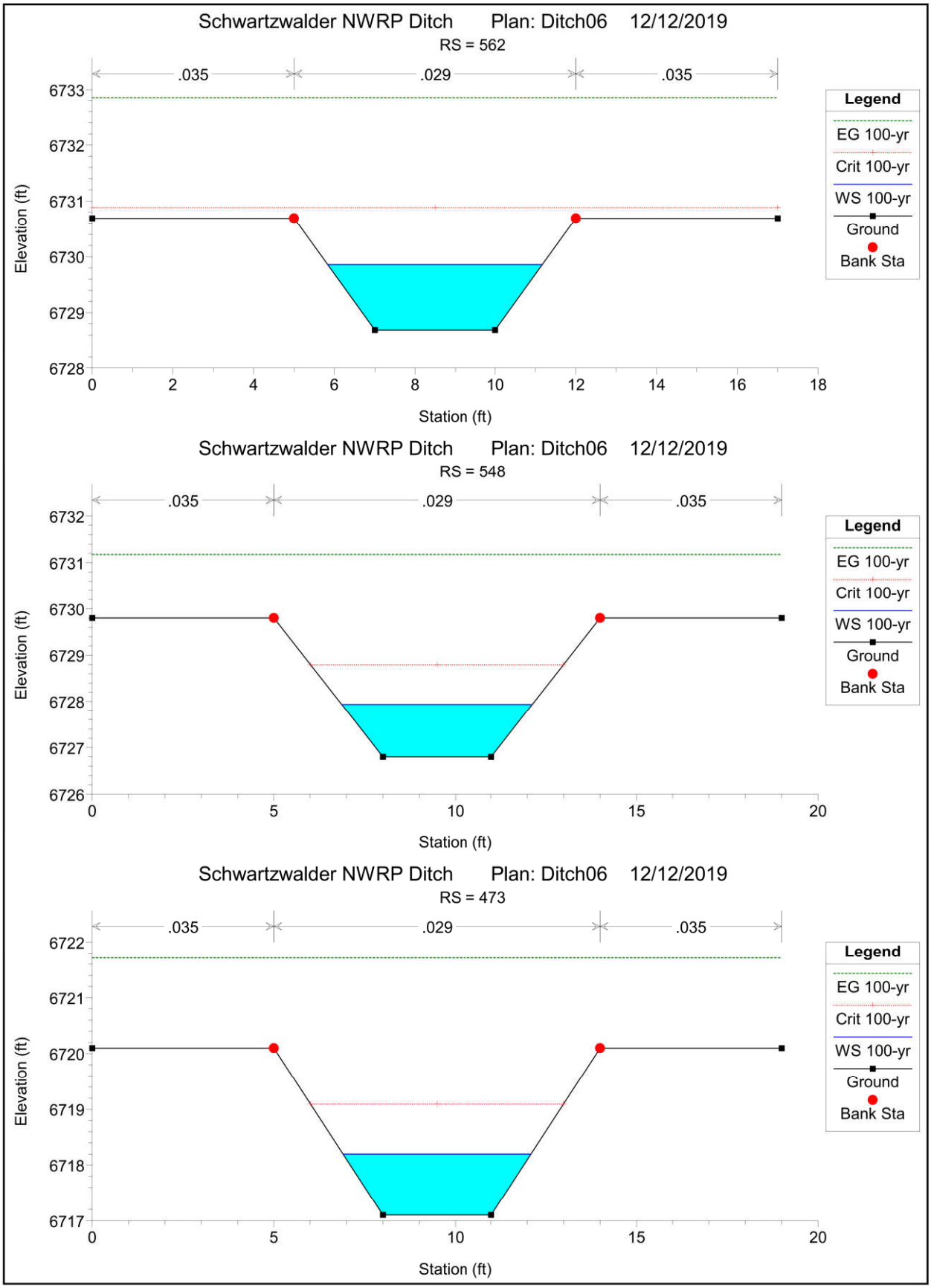
.035
.035
.035
Elevation (ft)
6756
6754
6752
6750
6748
6746
6744
6742
6740
6738
0
10
20
30
40
50
Station (ft)
Legend
EG 100-yr
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 599
.035
.035
.035
Elevation (ft)
6752
6750
6748
6746
6744
6742
6740
6738
6736
6734
0
10
20
30
40
50
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Ineff
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 595
.035
.029
.035
Elevation (ft)
6738
6737
6736
6735
6734
6733
6732
0
2
4
6
8
10
12
14
16
18
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta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.035
Elevation (ft)
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6732
6731
6730
6729
6728
0
2
4
6
8
10
12
14
16
18
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 548
.035
.029
.035
Elevation (ft)
6732
6731
6730
6729
6728
6727
6726
0
5
10
15
20
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 473
.035
.029
.035
Elevation (ft)
6722
6721
6720
6719
6718
6717
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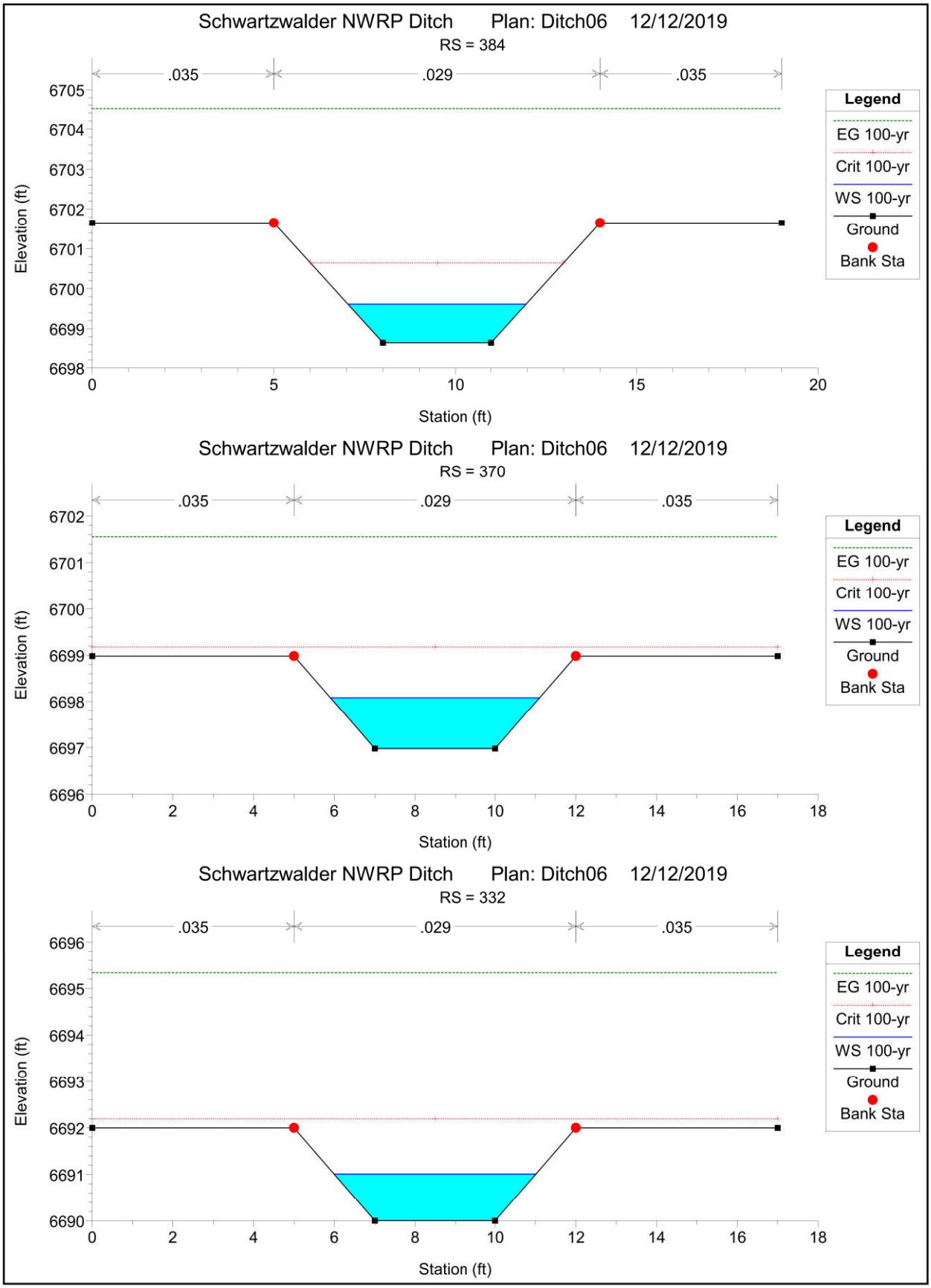
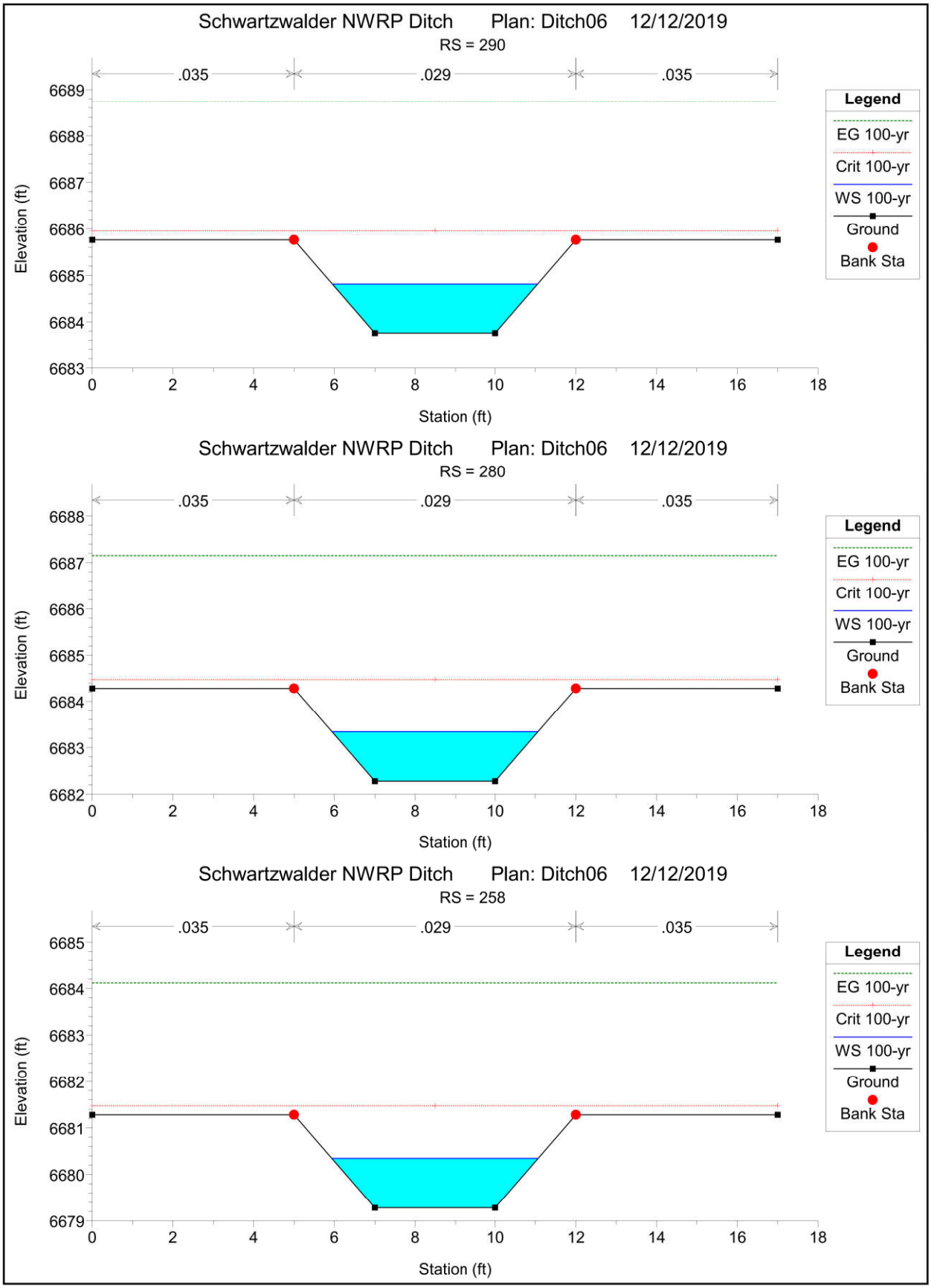
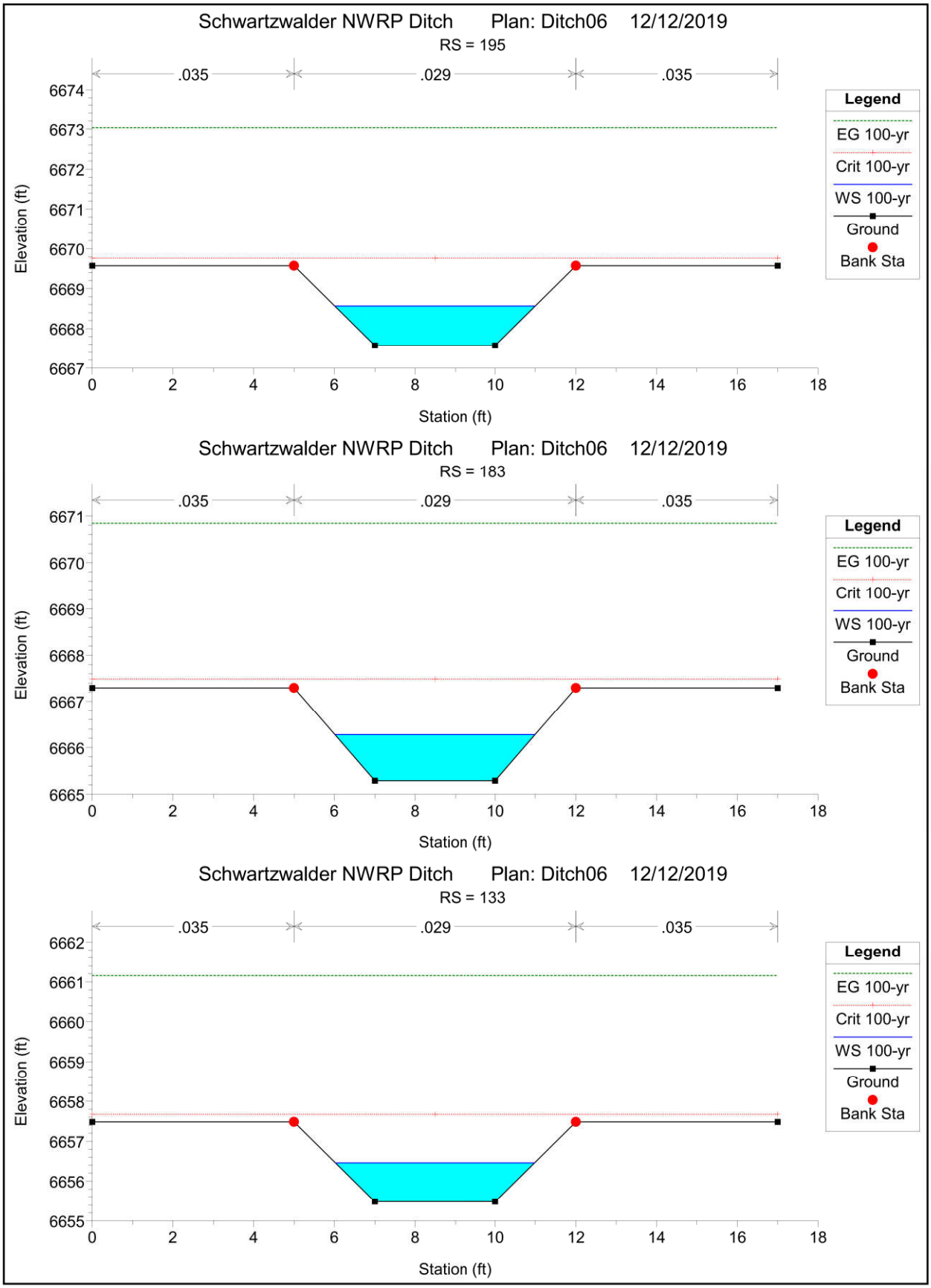
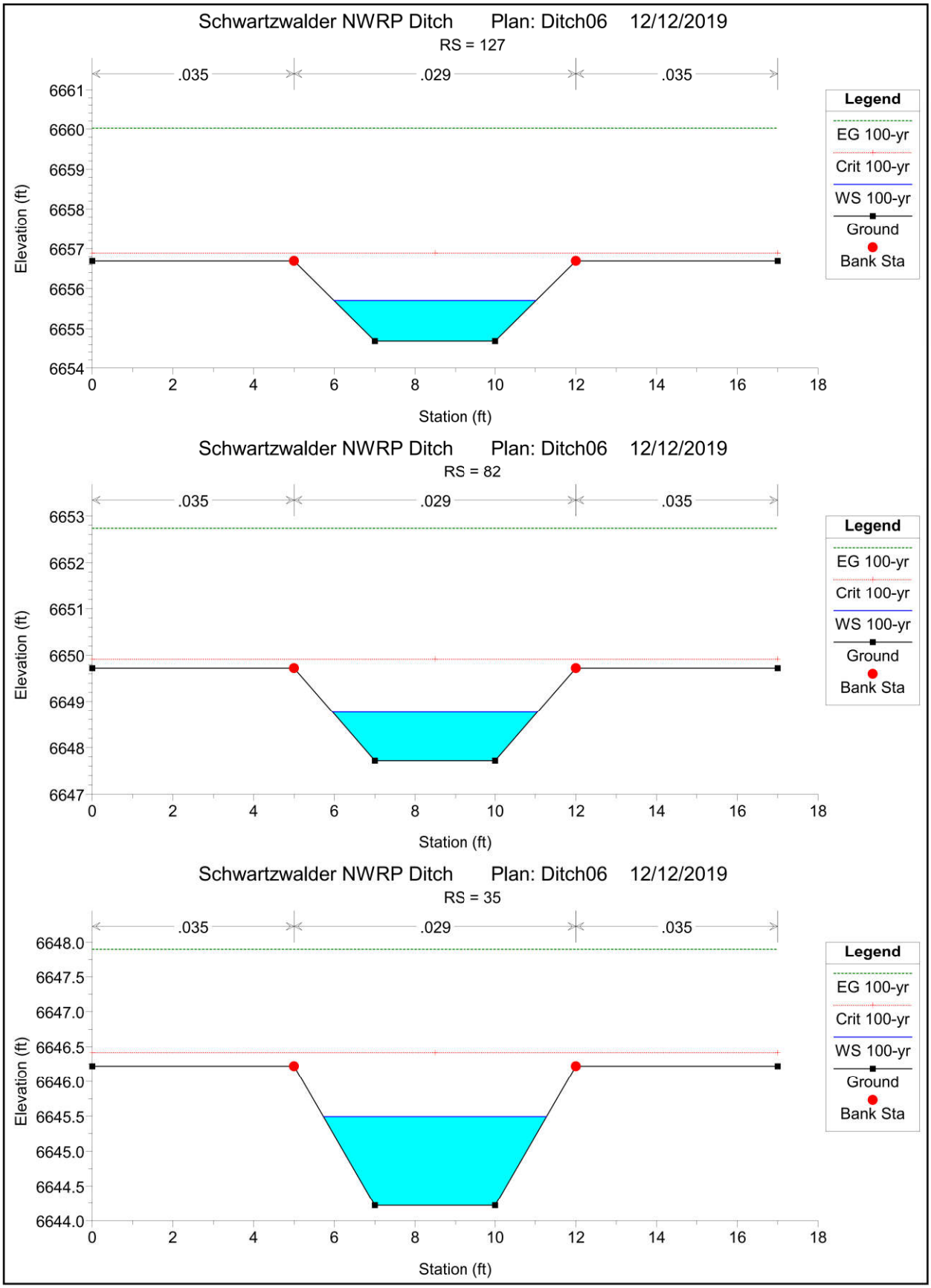
5
10
15
20
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta


Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 384
.035
.029
.035
Elevation (ft)
6705
6704
6703
6702
6701
6700
6699
6698
0
5
10
15
20
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 370
.035
.029
.035
Elevation (ft)
6702
6701
6700
6699
6698
6697
6696
0
2
4
6
8
10
12
14
16
18
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 332
.035
.029
.035
Elevation (ft)
6696
6695
6694
6693
6692
6691
6690
0
2
4
6
8
10
12
14
16
18
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta


Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 290
.035
.029
.035
Elevation (ft)
6689
6688
6687
6686
6685
6684
6683
0
2
4
6
8
10
12
14
16
18
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 280
.035
.029
.035
Elevation (ft)
6688
6687
6686
6685
6684
6683
6682
0
2
4
6
8
10
12
14
16
18
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 258
.035
.029
.035
Elevation (ft)
6685
6684
6683
6682
6681
6680
6679
0
2
4
6
8
10
12
14
16
18
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta


Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 195
.035
.029
.035
Elevation (ft)
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 183
.035
.029
.035
Elevation (ft)
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 133
.035
.029
.035
Elevation (ft)
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta


Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 127
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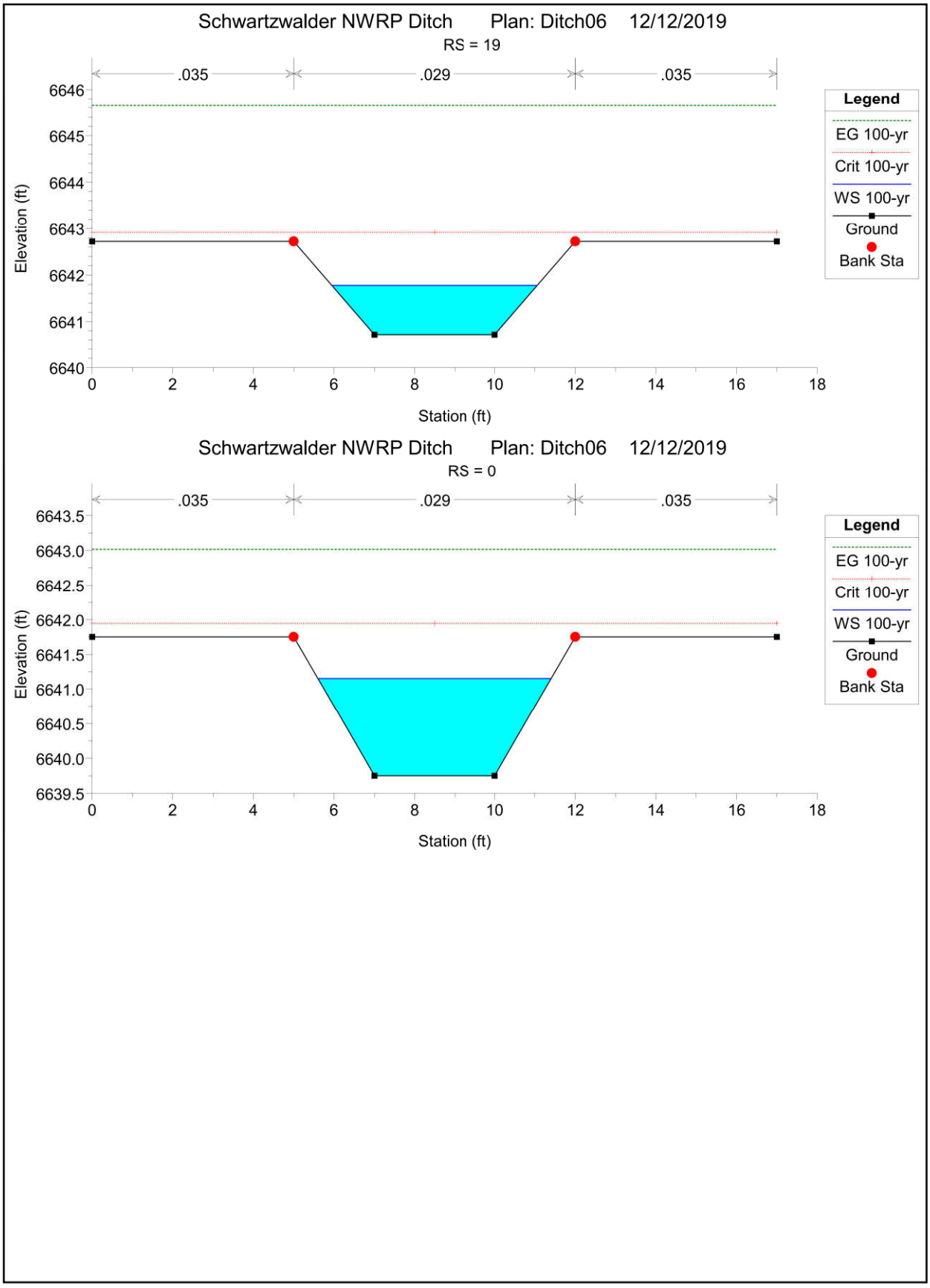
.029
.035
Elevation (ft)
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 82
.035
.029
.035
Elevation (ft)
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 35
.035
.029
.035
Elevation (ft)
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta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RS = 19
.035
.029
.035
Elevation (ft)
6646
6645
6644
6643
6642
6641
6640
0
2
4
6
8
10
12
14
16
18
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Schwartzwalder NWRP Ditch Plan: Ditch06 12/12/2019
RS = 0
.035
.029
.035
Elevation (ft)
6643.5
6643.0
6642.5
6642.0
6641.5
6641.0
6640.5
6640.0
6639.5
0
2
4
6
8
10
12
14
16
18
Station (ft)
Legend
EG 100-yr
Crit 100-yr
WS 100-yr
Ground
Bank Sta

Plan: Dec11_Model NWRP_Ditch Ditch RS: 619 Profile: 100-yr

E.G. Elev (ft)	6742.02	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.64	Wt. n-Val.	0.035	0.035	0.035
W.S. Elev (ft)	6741.38	Reach Len. (ft)	5.00	5.00	5.00
Crit W.S. (ft)	6741.38	Flow Area (sq ft)	0.03	10.52	0.13
E.G. Slope (ft/ft)	0.017953	Area (sq ft)	0.03	10.52	0.13
Q Total (cfs)	67.70	Flow (cfs)	0.04	67.45	0.21
Top Width (ft)	8.96	Top Width (ft)	0.27	7.97	0.72
Vel Total (ft/s)	6.34	Avg. Vel. (ft/s)	1.16	6.41	1.66
Max Chl Dpth (ft)	1.88	Hydr. Depth (ft)	0.12	1.32	0.17
Conv. Total (cfs)	505.3	Conv. (cfs)	0.3	503.4	1.6
Length Wtd. (ft)	5.00	Wetted Per. (ft)	0.37	8.79	0.80
Min Ch El (ft)	6739.50	Shear (lb/sq ft)	0.10	1.34	0.18
Alpha	1.02	Stream Power (lb/ft s)	0.12	8.60	0.29
Frctn Loss (ft)	0.18	Cum Volume (acre-ft)	0.00	0.06	0.00
C & E Loss (ft)	0.39	Cum SA (acres)	0.00	0.07	0.00

Plan: Dec11_Model NWRP_Ditch Ditch RS: 599 Profile: 100-yr

E.G. Elev (ft)	6738.50	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.94	Wt. n-Val.		0.035	
W.S. Elev (ft)	6735.56	Reach Len. (ft)	4.00	4.00	4.00
Crit W.S. (ft)	6736.23	Flow Area (sq ft)		4.92	
E.G. Slope (ft/ft)	0.242789	Area (sq ft)		4.92	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	8.95	Top Width (ft)		8.95	
Vel Total (ft/s)	13.76	Avg. Vel. (ft/s)		13.76	
Max Chl Dpth (ft)	0.88	Hydr. Depth (ft)		0.55	
Conv. Total (cfs)	137.4	Conv. (cfs)		137.4	
Length Wtd. (ft)	4.00	Wetted Per. (ft)		9.23	
Min Ch El (ft)	6734.68	Shear (lb/sq ft)		8.08	
Alpha	1.00	Stream Power (lb/ft s)		111.19	
Frctn Loss (ft)	0.81	Cum Volume (acre-ft)		0.06	
C & E Loss (ft)	0.40	Cum SA (acres)		0.07	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 595 Profile: 100-yr

E.G. Elev (ft)	6737.29	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.28	Wt. n-Val.		0.029	
W.S. Elev (ft)	6733.02	Reach Len. (ft)	4.62	4.62	4.62
Crit W.S. (ft)	6734.19	Flow Area (sq ft)		4.08	
E.G. Slope (ft/ft)	0.170373	Area (sq ft)		4.08	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.03	Top Width (ft)		5.03	
Vel Total (ft/s)	16.59	Avg. Vel. (ft/s)		16.59	
Max Chl Dpth (ft)	1.02	Hydr. Depth (ft)		0.81	
Conv. Total (cfs)	164.0	Conv. (cfs)		164.0	
Length Wtd. (ft)	4.62	Wetted Per. (ft)		5.87	
Min Ch El (ft)	6732.00	Shear (lb/sq ft)		7.39	
Alpha	1.00	Stream Power (lb/ft s)		122.59	
Frctn Loss (ft)	0.71	Cum Volume (acre-ft)		0.06	
C & E Loss (ft)	0.30	Cum SA (acres)		0.07	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 562 Profile: 100-yr

E.G. Elev (ft)	6732.86	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.00	Wt. n-Val.		0.029	
W.S. Elev (ft)	6729.86	Reach Len. (ft)	4.85	4.85	4.85
Crit W.S. (ft)	6730.89	Flow Area (sq ft)		4.88	
E.G. Slope (ft/ft)	0.103506	Area (sq ft)		4.88	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.34	Top Width (ft)		5.34	
Vel Total (ft/s)	13.88	Avg. Vel. (ft/s)		13.88	
Max Chl Dpth (ft)	1.17	Hydr. Depth (ft)		0.91	
Conv. Total (cfs)	210.4	Conv. (cfs)		210.4	
Length Wtd. (ft)	4.85	Wetted Per. (ft)		6.31	
Min Ch El (ft)	6728.69	Shear (lb/sq ft)		5.00	
Alpha	1.00	Stream Power (lb/ft s)		69.36	
Frctn Loss (ft)	0.51	Cum Volume (acre-ft)		0.06	
C & E Loss (ft)	0.03	Cum SA (acres)		0.07	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 548 Profile: 100-yr

E.G. Elev (ft)	6731.18	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.25	Wt. n-Val.		0.029	
W.S. Elev (ft)	6727.93	Reach Len. (ft)	4.95	4.95	4.95
Crit W.S. (ft)	6728.79	Flow Area (sq ft)		4.68	
E.G. Slope (ft/ft)	0.115755	Area (sq ft)		4.68	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.27	Top Width (ft)		5.27	
Vel Total (ft/s)	14.45	Avg. Vel. (ft/s)		14.45	
Max Chl Dpth (ft)	1.13	Hydr. Depth (ft)		0.89	
Conv. Total (cfs)	199.0	Conv. (cfs)		199.0	
Length Wtd. (ft)	4.95	Wetted Per. (ft)		6.21	
Min Ch El (ft)	6726.80	Shear (lb/sq ft)		5.46	
Alpha	1.00	Stream Power (lb/ft s)		78.84	
Frctn Loss (ft)	0.58	Cum Volume (acre-ft)		0.05	
C & E Loss (ft)	0.02	Cum SA (acres)		0.06	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 473 Profile: 100-yr

E.G. Elev (ft)	6721.72	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.52	Wt. n-Val.		0.029	
W.S. Elev (ft)	6718.20	Reach Len. (ft)	4.95	4.95	4.95
Crit W.S. (ft)	6719.09	Flow Area (sq ft)		4.50	
E.G. Slope (ft/ft)	0.129471	Area (sq ft)		4.50	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.20	Top Width (ft)		5.20	
Vel Total (ft/s)	15.04	Avg. Vel. (ft/s)		15.04	
Max Chl Dpth (ft)	1.10	Hydr. Depth (ft)		0.87	
Conv. Total (cfs)	188.1	Conv. (cfs)		188.1	
Length Wtd. (ft)	4.95	Wetted Per. (ft)		6.11	
Min Ch El (ft)	6717.10	Shear (lb/sq ft)		5.96	
Alpha	1.00	Stream Power (lb/ft s)		89.62	
Frctn Loss (ft)	0.68	Cum Volume (acre-ft)		0.05	
C & E Loss (ft)	0.09	Cum SA (acres)		0.06	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 384 Profile: 100-yr

E.G. Elev (ft)	6704.51	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.90	Wt. n-Val.		0.029	
W.S. Elev (ft)	6699.61	Reach Len. (ft)	4.85	4.85	4.85
Crit W.S. (ft)	6700.64	Flow Area (sq ft)		3.81	
E.G. Slope (ft/ft)	0.206223	Area (sq ft)		3.81	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.92	Top Width (ft)		4.92	
Vel Total (ft/s)	17.75	Avg. Vel. (ft/s)		17.75	
Max Chl Dpth (ft)	0.96	Hydr. Depth (ft)		0.77	
Conv. Total (cfs)	149.1	Conv. (cfs)		149.1	
Length Wtd. (ft)	4.85	Wetted Per. (ft)		5.72	
Min Ch El (ft)	6698.65	Shear (lb/sq ft)		8.58	
Alpha	1.00	Stream Power (lb/ft s)		152.32	
Frctn Loss (ft)	0.88	Cum Volume (acre-ft)		0.04	
C & E Loss (ft)	0.39	Cum SA (acres)		0.05	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 370 Profile: 100-yr

E.G. Elev (ft)	6701.56	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.47	Wt. n-Val.		0.029	
W.S. Elev (ft)	6698.08	Reach Len. (ft)	4.75	4.75	4.75
Crit W.S. (ft)	6699.18	Flow Area (sq ft)		4.53	
E.G. Slope (ft/ft)	0.127248	Area (sq ft)		4.53	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.21	Top Width (ft)		5.21	
Vel Total (ft/s)	14.95	Avg. Vel. (ft/s)		14.95	
Max Chl Dpth (ft)	1.10	Hydr. Depth (ft)		0.87	
Conv. Total (cfs)	189.8	Conv. (cfs)		189.8	
Length Wtd. (ft)	4.75	Wetted Per. (ft)		6.12	
Min Ch El (ft)	6696.98	Shear (lb/sq ft)		5.88	
Alpha	1.00	Stream Power (lb/ft s)		87.86	
Frctn Loss (ft)	0.63	Cum Volume (acre-ft)		0.04	
C & E Loss (ft)	0.06	Cum SA (acres)		0.04	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 332 Profile: 100-yr

E.G. Elev (ft)	6695.34	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.32	Wt. n-Val.		0.029	
W.S. Elev (ft)	6691.01	Reach Len. (ft)	4.62	4.62	4.62
Crit W.S. (ft)	6692.20	Flow Area (sq ft)		4.06	
E.G. Slope (ft/ft)	0.172995	Area (sq ft)		4.06	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.02	Top Width (ft)		5.02	
Vel Total (ft/s)	16.68	Avg. Vel. (ft/s)		16.68	
Max Chl Dpth (ft)	1.01	Hydr. Depth (ft)		0.81	
Conv. Total (cfs)	162.8	Conv. (cfs)		162.8	
Length Wtd. (ft)	4.62	Wetted Per. (ft)		5.86	
Min Ch El (ft)	6690.00	Shear (lb/sq ft)		7.48	
Alpha	1.00	Stream Power (lb/ft s)		124.74	
Frctn Loss (ft)	0.77	Cum Volume (acre-ft)		0.03	
C & E Loss (ft)	0.11	Cum SA (acres)		0.04	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 290 Profile: 100-yr

E.G. Elev (ft)	6688.73	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.92	Wt. n-Val.		0.029	
W.S. Elev (ft)	6684.81	Reach Len. (ft)	3.48	3.48	3.48
Crit W.S. (ft)	6685.96	Flow Area (sq ft)		4.26	
E.G. Slope (ft/ft)	0.150852	Area (sq ft)		4.26	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.10	Top Width (ft)		5.10	
Vel Total (ft/s)	15.89	Avg. Vel. (ft/s)		15.89	
Max Chl Dpth (ft)	1.05	Hydr. Depth (ft)		0.84	
Conv. Total (cfs)	174.3	Conv. (cfs)		174.3	
Length Wtd. (ft)	3.48	Wetted Per. (ft)		5.97	
Min Ch El (ft)	6683.76	Shear (lb/sq ft)		6.72	
Alpha	1.00	Stream Power (lb/ft s)		106.71	
Frctn Loss (ft)	0.52	Cum Volume (acre-ft)		0.03	
C & E Loss (ft)	0.04	Cum SA (acres)		0.03	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 280 Profile: 100-yr

E.G. Elev (ft)	6687.15	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.81	Wt. n-Val.		0.029	
W.S. Elev (ft)	6683.34	Reach Len. (ft)	4.27	4.27	4.27
Crit W.S. (ft)	6684.48	Flow Area (sq ft)		4.32	
E.G. Slope (ft/ft)	0.144820	Area (sq ft)		4.32	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.13	Top Width (ft)		5.13	
Vel Total (ft/s)	15.66	Avg. Vel. (ft/s)		15.66	
Max Chl Dpth (ft)	1.06	Hydr. Depth (ft)		0.84	
Conv. Total (cfs)	177.9	Conv. (cfs)		177.9	
Length Wtd. (ft)	4.27	Wetted Per. (ft)		6.01	
Min Ch El (ft)	6682.28	Shear (lb/sq ft)		6.51	
Alpha	1.00	Stream Power (lb/ft s)		101.86	
Frctn Loss (ft)	0.61	Cum Volume (acre-ft)		0.03	
C & E Loss (ft)	0.02	Cum SA (acres)		0.03	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 258 Profile: 100-yr

E.G. Elev (ft)	6684.12	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.77	Wt. n-Val.		0.029	
W.S. Elev (ft)	6680.35	Reach Len. (ft)	4.92	4.92	4.92
Crit W.S. (ft)	6681.48	Flow Area (sq ft)		4.35	
E.G. Slope (ft/ft)	0.142723	Area (sq ft)		4.35	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.14	Top Width (ft)		5.14	
Vel Total (ft/s)	15.58	Avg. Vel. (ft/s)		15.58	
Max Chl Dpth (ft)	1.07	Hydr. Depth (ft)		0.85	
Conv. Total (cfs)	179.2	Conv. (cfs)		179.2	
Length Wtd. (ft)	4.92	Wetted Per. (ft)		6.02	
Min Ch El (ft)	6679.28	Shear (lb/sq ft)		6.43	
Alpha	1.00	Stream Power (lb/ft s)		100.17	
Frctn Loss (ft)	0.72	Cum Volume (acre-ft)		0.03	
C & E Loss (ft)	0.04	Cum SA (acres)		0.03	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 195 Profile: 100-yr

E.G. Elev (ft)	6673.04	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.47	Wt. n-Val.		0.029	
W.S. Elev (ft)	6668.57	Reach Len. (ft)	3.88	3.88	3.88
Crit W.S. (ft)	6669.76	Flow Area (sq ft)		3.99	
E.G. Slope (ft/ft)	0.181172	Area (sq ft)		3.99	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.00	Top Width (ft)		5.00	
Vel Total (ft/s)	16.96	Avg. Vel. (ft/s)		16.96	
Max Chl Dpth (ft)	1.00	Hydr. Depth (ft)		0.80	
Conv. Total (cfs)	159.1	Conv. (cfs)		159.1	
Length Wtd. (ft)	3.88	Wetted Per. (ft)		5.82	
Min Ch El (ft)	6667.57	Shear (lb/sq ft)		7.75	
Alpha	1.00	Stream Power (lb/ft s)		131.47	
Frctn Loss (ft)	0.71	Cum Volume (acre-ft)		0.02	
C & E Loss (ft)	0.01	Cum SA (acres)		0.02	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 183 Profile: 100-yr

E.G. Elev (ft)	6670.85	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.57	Wt. n-Val.		0.029	
W.S. Elev (ft)	6666.28	Reach Len. (ft)	4.59	4.59	4.59
Crit W.S. (ft)	6667.49	Flow Area (sq ft)		3.95	
E.G. Slope (ft/ft)	0.186896	Area (sq ft)		3.95	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.98	Top Width (ft)		4.98	
Vel Total (ft/s)	17.14	Avg. Vel. (ft/s)		17.14	
Max Chl Dpth (ft)	0.99	Hydr. Depth (ft)		0.79	
Conv. Total (cfs)	156.6	Conv. (cfs)		156.6	
Length Wtd. (ft)	4.59	Wetted Per. (ft)		5.80	
Min Ch El (ft)	6665.29	Shear (lb/sq ft)		7.94	
Alpha	1.00	Stream Power (lb/ft s)		136.21	
Frctn Loss (ft)	0.86	Cum Volume (acre-ft)		0.02	
C & E Loss (ft)	0.01	Cum SA (acres)		0.02	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 133 Profile: 100-yr

E.G. Elev (ft)	6661.15	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.69	Wt. n-Val.		0.029	
W.S. Elev (ft)	6656.46	Reach Len. (ft)	2.55	2.55	2.55
Crit W.S. (ft)	6657.67	Flow Area (sq ft)		3.90	
E.G. Slope (ft/ft)	0.194204	Area (sq ft)		3.90	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.96	Top Width (ft)		4.96	
Vel Total (ft/s)	17.38	Avg. Vel. (ft/s)		17.38	
Max Chl Dpth (ft)	0.98	Hydr. Depth (ft)		0.79	
Conv. Total (cfs)	153.6	Conv. (cfs)		153.6	
Length Wtd. (ft)	2.55	Wetted Per. (ft)		5.77	
Min Ch El (ft)	6655.48	Shear (lb/sq ft)		8.19	
Alpha	1.00	Stream Power (lb/ft s)		142.28	
Frctn Loss (ft)	0.48	Cum Volume (acre-ft)		0.01	
C & E Loss (ft)	0.10	Cum SA (acres)		0.02	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 127 Profile: 100-yr

E.G. Elev (ft)	6660.03	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.32	Wt. n-Val.		0.029	
W.S. Elev (ft)	6655.70	Reach Len. (ft)	4.55	4.55	4.55
Crit W.S. (ft)	6656.89	Flow Area (sq ft)		4.06	
E.G. Slope (ft/ft)	0.172995	Area (sq ft)		4.06	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.02	Top Width (ft)		5.02	
Vel Total (ft/s)	16.68	Avg. Vel. (ft/s)		16.68	
Max Chl Dpth (ft)	1.01	Hydr. Depth (ft)		0.81	
Conv. Total (cfs)	162.8	Conv. (cfs)		162.8	
Length Wtd. (ft)	4.55	Wetted Per. (ft)		5.86	
Min Ch El (ft)	6654.69	Shear (lb/sq ft)		7.48	
Alpha	1.00	Stream Power (lb/ft s)		124.74	
Frctn Loss (ft)	0.77	Cum Volume (acre-ft)		0.01	
C & E Loss (ft)	0.08	Cum SA (acres)		0.02	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 82 Profile: 100-yr

E.G. Elev (ft)	6652.74	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.97	Wt. n-Val.		0.029	
W.S. Elev (ft)	6648.77	Reach Len. (ft)	4.70	4.70	4.70
Crit W.S. (ft)	6649.92	Flow Area (sq ft)		4.23	
E.G. Slope (ft/ft)	0.153606	Area (sq ft)		4.23	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.09	Top Width (ft)		5.09	
Vel Total (ft/s)	15.99	Avg. Vel. (ft/s)		15.99	
Max Chl Dpth (ft)	1.05	Hydr. Depth (ft)		0.83	
Conv. Total (cfs)	172.7	Conv. (cfs)		172.7	
Length Wtd. (ft)	4.70	Wetted Per. (ft)		5.96	
Min Ch El (ft)	6647.72	Shear (lb/sq ft)		6.81	
Alpha	1.00	Stream Power (lb/ft s)		108.94	
Frctn Loss (ft)	0.62	Cum Volume (acre-ft)		0.01	
C & E Loss (ft)	0.36	Cum SA (acres)		0.01	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 35 Profile: 100-yr

E.G. Elev (ft)	6647.90	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.41	Wt. n-Val.		0.029	
W.S. Elev (ft)	6645.49	Reach Len. (ft)	3.96	3.96	3.96
Crit W.S. (ft)	6646.42	Flow Area (sq ft)		5.44	
E.G. Slope (ft/ft)	0.076480	Area (sq ft)		5.44	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.54	Top Width (ft)		5.54	
Vel Total (ft/s)	12.45	Avg. Vel. (ft/s)		12.45	
Max Chl Dpth (ft)	1.27	Hydr. Depth (ft)		0.98	
Conv. Total (cfs)	244.8	Conv. (cfs)		244.8	
Length Wtd. (ft)	3.96	Wetted Per. (ft)		6.60	
Min Ch El (ft)	6644.22	Shear (lb/sq ft)		3.93	
Alpha	1.00	Stream Power (lb/ft s)		48.98	
Frctn Loss (ft)	0.34	Cum Volume (acre-ft)		0.00	
C & E Loss (ft)	0.14	Cum SA (acres)		0.00	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 19 Profile: 100-yr

E.G. Elev (ft)	6645.65	Element	Left OB	Channel	Right OB
Vel Head (ft)	3.87	Wt. n-Val.		0.029	
W.S. Elev (ft)	6641.78	Reach Len. (ft)	4.95	4.95	4.95
Crit W.S. (ft)	6642.92	Flow Area (sq ft)		4.29	
E.G. Slope (ft/ft)	0.147918	Area (sq ft)		4.29	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.12	Top Width (ft)		5.12	
Vel Total (ft/s)	15.78	Avg. Vel. (ft/s)		15.78	
Max Chl Dpth (ft)	1.06	Hydr. Depth (ft)		0.84	
Conv. Total (cfs)	176.0	Conv. (cfs)		176.0	
Length Wtd. (ft)	4.95	Wetted Per. (ft)		5.99	
Min Ch El (ft)	6640.72	Shear (lb/sq ft)		6.61	
Alpha	1.00	Stream Power (lb/ft s)		104.35	
Frctn Loss (ft)	0.59	Cum Volume (acre-ft)		0.00	
C & E Loss (ft)	0.48	Cum SA (acres)		0.00	

Plan: Dec11_Model NWRP_Ditch Ditch RS: 0 Profile: 100-yr

E.G. Elev (ft)	6643.02	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.87	Wt. n-Val.		0.029	
W.S. Elev (ft)	6641.15	Reach Len. (ft)			
Crit W.S. (ft)	6641.95	Flow Area (sq ft)		6.18	
E.G. Slope (ft/ft)	0.053675	Area (sq ft)		6.18	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	5.81	Top Width (ft)		5.81	
Vel Total (ft/s)	10.96	Avg. Vel. (ft/s)		10.96	
Max Chl Dpth (ft)	1.40	Hydr. Depth (ft)		1.06	
Conv. Total (cfs)	292.2	Conv. (cfs)		292.2	
Length Wtd. (ft)		Wetted Per. (ft)		6.97	
Min Ch El (ft)	6639.75	Shear (lb/sq ft)		2.97	
Alpha	1.00	Stream Power (lb/ft s)		32.55	
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

HEC-RAS Plan: Dec11_Model River: NWRP_Ditch Reach: Ditch Profile: 100-yr

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ditch	619	100-yr	67.70	6739.50	6741.38	6741.38	6742.02	0.017953	6.41	10.68	8.96	0.98
Ditch	614.00*	100-yr	67.70	6738.29	6739.51	6740.08	6741.45	0.101046	11.16	6.06	7.53	2.19
Ditch	609.00*	100-yr	67.70	6737.09	6738.13	6738.79	6740.65	0.158754	12.72	5.32	7.77	2.71
Ditch	604.00*	100-yr	67.70	6735.89	6736.83	6737.50	6739.65	0.207068	13.49	5.02	8.28	3.05
Ditch	599	100-yr	67.70	6734.68	6735.56	6736.23	6738.50	0.242789	13.76	4.92	8.95	3.27
Ditch	595	100-yr	67.70	6732.00	6733.02	6734.19	6737.29	0.170373	16.59	4.08	5.03	3.25
Ditch	590.29*	100-yr	67.70	6731.53	6732.61	6733.72	6736.29	0.137755	15.38	4.40	5.16	2.94
Ditch	585.57*	100-yr	67.70	6731.05	6732.17	6733.25	6735.55	0.122562	14.75	4.59	5.23	2.78
Ditch	580.86*	100-yr	67.70	6730.58	6731.72	6732.78	6734.91	0.112787	14.32	4.73	5.28	2.67
Ditch	576.14*	100-yr	67.70	6730.11	6731.27	6732.31	6734.33	0.106810	14.04	4.82	5.32	2.60
Ditch	571.43*	100-yr	67.70	6729.64	6730.81	6731.83	6733.82	0.104281	13.92	4.86	5.33	2.57
Ditch	566.71*	100-yr	67.70	6729.16	6730.33	6731.36	6733.34	0.104281	13.92	4.86	5.33	2.57
Ditch	562	100-yr	67.70	6728.69	6729.86	6730.89	6732.86	0.103506	13.88	4.88	5.34	2.56
Ditch	557.33*	100-yr	67.70	6728.06	6729.21	6730.05	6732.31	0.108460	14.12	4.80	5.31	2.62
Ditch	552.67*	100-yr	67.70	6727.43	6728.57	6729.42	6731.75	0.112392	14.30	4.73	5.28	2.66
Ditch	548	100-yr	67.70	6726.80	6727.93	6728.79	6731.18	0.115755	14.45	4.68	5.27	2.70
Ditch	543.00*	100-yr	67.70	6726.15	6727.28	6728.14	6730.58	0.118639	14.58	4.64	5.25	2.73
Ditch	538.00*	100-yr	67.70	6725.51	6726.63	6727.50	6729.98	0.120861	14.68	4.61	5.24	2.76
Ditch	533.00*	100-yr	67.70	6724.86	6725.97	6726.85	6729.37	0.123136	14.78	4.58	5.23	2.78
Ditch	528.00*	100-yr	67.70	6724.21	6725.32	6726.20	6728.74	0.124683	14.84	4.56	5.22	2.80
Ditch	523.00*	100-yr	67.70	6723.57	6724.68	6725.56	6728.12	0.125661	14.88	4.55	5.21	2.81
Ditch	518.00*	100-yr	67.70	6722.92	6724.03	6724.91	6727.49	0.126650	14.93	4.54	5.21	2.82
Ditch	513.00*	100-yr	67.70	6722.27	6723.37	6724.26	6726.85	0.127248	14.95	4.53	5.21	2.83
Ditch	508.00*	100-yr	67.70	6721.63	6722.73	6723.62	6726.21	0.127648	14.97	4.52	5.21	2.83
Ditch	503.00*	100-yr	67.70	6720.98	6722.08	6722.97	6725.57	0.128252	14.99	4.52	5.20	2.84
Ditch	498.00*	100-yr	67.70	6720.33	6721.43	6722.32	6724.93	0.128657	15.01	4.51	5.20	2.84
Ditch	493.00*	100-yr	67.70	6719.69	6720.79	6721.68	6724.30	0.129063	15.03	4.51	5.20	2.85
Ditch	488.00*	100-yr	67.70	6719.04	6720.14	6721.03	6723.66	0.129471	15.04	4.50	5.20	2.85
Ditch	483.00*	100-yr	67.70	6718.39	6719.49	6720.38	6723.01	0.129471	15.04	4.50	5.20	2.85
Ditch	478.00*	100-yr	67.70	6717.75	6718.85	6719.74	6722.37	0.129471	15.04	4.50	5.20	2.85
Ditch	473	100-yr	67.70	6717.10	6718.20	6719.09	6721.72	0.129471	15.04	4.50	5.20	2.85
Ditch	468.06*	100-yr	67.70	6716.08	6717.15	6718.07	6720.95	0.144585	15.65	4.33	5.13	3.00
Ditch	463.11*	100-yr	67.70	6715.05	6716.09	6717.04	6720.13	0.157204	16.12	4.20	5.08	3.13
Ditch	458.17*	100-yr	67.70	6714.02	6715.04	6716.01	6719.27	0.167518	16.49	4.11	5.04	3.22
Ditch	453.22*	100-yr	67.70	6713.00	6714.01	6714.99	6718.37	0.175369	16.76	4.04	5.02	3.29
Ditch	448.28*	100-yr	67.70	6711.98	6712.98	6713.97	6717.46	0.181797	16.98	3.99	5.00	3.35
Ditch	443.33*	100-yr	67.70	6710.95	6711.94	6712.94	6716.51	0.187220	17.15	3.95	4.98	3.40
Ditch	438.39*	100-yr	67.70	6709.92	6710.90	6711.91	6715.55	0.191505	17.29	3.91	4.97	3.43
Ditch	433.44*	100-yr	67.70	6708.90	6709.88	6710.89	6714.58	0.194545	17.39	3.89	4.96	3.46
Ditch	428.50*	100-yr	67.70	6707.88	6708.86	6709.87	6713.59	0.196605	17.46	3.88	4.95	3.48
Ditch	423.56*	100-yr	67.70	6706.85	6707.82	6708.84	6712.59	0.198692	17.52	3.86	4.95	3.49
Ditch	418.61*	100-yr	67.70	6705.83	6706.80	6707.82	6711.60	0.200100	17.56	3.85	4.94	3.51
Ditch	413.67*	100-yr	67.70	6704.80	6705.77	6706.79	6710.59	0.201877	17.62	3.84	4.94	3.52
Ditch	408.72*	100-yr	67.70	6703.77	6704.74	6705.76	6709.59	0.203313	17.66	3.83	4.93	3.53
Ditch	403.78*	100-yr	67.70	6702.75	6703.72	6704.74	6708.58	0.204035	17.69	3.83	4.93	3.54
Ditch	398.83*	100-yr	67.70	6701.73	6702.70	6703.72	6707.56	0.204398	17.70	3.83	4.93	3.54
Ditch	393.89*	100-yr	67.70	6700.70	6701.66	6702.69	6706.54	0.205126	17.72	3.82	4.93	3.55
Ditch	388.94*	100-yr	67.70	6699.67	6700.63	6701.66	6705.52	0.205856	17.74	3.82	4.93	3.55
Ditch	384	100-yr	67.70	6698.65	6699.61	6700.64	6704.51	0.206223	17.75	3.81	4.92	3.56
Ditch	379.33*	100-yr	67.70	6698.09	6699.12	6700.08	6703.24	0.161333	16.27	4.16	5.06	3.16
Ditch	374.67*	100-yr	67.70	6697.54	6698.62	6699.53	6702.30	0.137817	15.38	4.40	5.16	2.94
Ditch	370	100-yr	67.70	6696.98	6698.08	6699.18	6701.56	0.127248	14.95	4.53	5.21	2.83
Ditch	365.25*	100-yr	67.70	6696.11	6697.19	6698.30	6700.87	0.137976	15.39	4.40	5.16	2.94
Ditch	360.50*	100-yr	67.70	6695.23	6696.29	6697.43	6700.14	0.147196	15.75	4.30	5.12	3.03
Ditch	355.75*	100-yr	67.70	6694.36	6695.41	6696.56	6699.39	0.154114	16.01	4.23	5.09	3.10
Ditch	351.00*	100-yr	67.70	6693.49	6694.53	6695.69	6698.61	0.159839	16.22	4.17	5.07	3.15
Ditch	346.25*	100-yr	67.70	6692.62	6693.65	6694.81	6697.82	0.164447	16.38	4.13	5.05	3.19
Ditch	341.50*	100-yr	67.70	6691.75	6692.77	6693.95	6697.00	0.167801	16.50	4.10	5.04	3.22
Ditch	336.75*	100-yr	67.70	6690.87	6691.89	6693.07	6696.17	0.170951	16.61	4.08	5.03	3.25
Ditch	332	100-yr	67.70	6690.00	6691.01	6692.20	6695.34	0.172995	16.68	4.06	5.02	3.27
Ditch	327.33*	100-yr	67.70	6689.31	6690.34	6691.51	6694.45	0.161177	16.27	4.16	5.06	3.16
Ditch	322.67*	100-yr	67.70	6688.61	6689.65	6690.80	6693.68	0.156424	16.09	4.21	5.08	3.12
Ditch	318.00*	100-yr	67.70	6687.92	6688.97	6690.12	6692.94	0.153860	16.00	4.23	5.09	3.09
Ditch	313.33*	100-yr	67.70	6687.23	6688.28	6689.43	6692.23	0.152096	15.93	4.25	5.10	3.08
Ditch	308.67*	100-yr	67.70	6686.53	6687.58	6688.72	6691.52	0.152096	15.93	4.25	5.10	3.08
Ditch	304.00*	100-yr	67.70	6685.84	6686.89	6688.04	6690.83	0.151597	15.91	4.25	5.10	3.07
Ditch	299.33*	100-yr	67.70	6685.15	6686.20	6687.35	6690.13	0.151100	15.90	4.26	5.10	3.07
Ditch	294.67*	100-yr	67.70	6684.45	6685.50	6686.65	6689.42	0.150852	15.89	4.26	5.10	3.07
Ditch	290	100-yr	67.70	6683.76	6684.81	6685.96	6688.73	0.150852	15.89	4.26	5.10	3.07
Ditch	286.67*	100-yr	67.70	6683.27	6684.33	6685.47	6688.18	0.146956	15.74	4.30	5.12	3.03
Ditch	283.33*	100-yr	67.70	6682.77	6683.83	6684.96	6687.67	0.146478	15.72	4.31	5.12	3.02
Ditch	280	100-yr	67.70	6682.28	6683.34	6684.48	6687.15	0.144820	15.66	4.32	5.13	3.01
Ditch	275.60*	100-yr	67.70	6681.68	6682.75	6683.88	6686.52	0.142723	15.58	4.35	5.14	2.99
Ditch	271.20*	100-yr	67.70	6681.08	6682.15	6683.28	6685.92	0.142723	15.58	4.35	5.14	2.99
Ditch	266.80*	100-yr	67.70	6680.48	6681.55	6682.67	6685.32	0.142723	15.58	4.35	5.14	2.99
Ditch	262.40*	100-yr	67.70	6679.88	6680.95	6682.08	6684.72	0.142723	15.58	4.35	5.14	2.99

HEC-RAS Plan: Dec11_Model River: NWRP_Ditch Reach: Ditch Profile: 100-yr (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ditch	258	100-yr	67.70	6679.28	6680.35	6681.48	6684.12	0.142723	15.58	4.35	5.14	2.99
Ditch	253.15*	100-yr	67.70	6678.38	6679.43	6680.58	6683.35	0.150605	15.88	4.26	5.10	3.06
Ditch	248.31*	100-yr	67.70	6677.48	6678.52	6679.68	6682.55	0.156944	16.11	4.20	5.08	3.12
Ditch	243.46*	100-yr	67.70	6676.58	6677.61	6678.77	6681.74	0.162258	16.30	4.15	5.06	3.17
Ditch	238.62*	100-yr	67.70	6675.68	6676.70	6677.88	6680.91	0.166393	16.45	4.12	5.05	3.21
Ditch	233.77*	100-yr	67.70	6674.78	6675.80	6676.98	6680.06	0.169510	16.56	4.09	5.04	3.24
Ditch	228.92*	100-yr	67.70	6673.88	6674.89	6676.07	6679.21	0.172408	16.66	4.06	5.03	3.27
Ditch	224.08*	100-yr	67.70	6672.97	6673.98	6675.17	6678.34	0.175070	16.75	4.04	5.02	3.29
Ditch	219.23*	100-yr	67.70	6672.07	6673.08	6674.27	6677.46	0.176571	16.80	4.03	5.01	3.30
Ditch	214.38*	100-yr	67.70	6671.17	6672.17	6673.36	6676.58	0.177783	16.84	4.02	5.01	3.31
Ditch	209.54*	100-yr	67.70	6670.27	6671.27	6672.46	6675.70	0.178700	16.87	4.01	5.00	3.32
Ditch	204.69*	100-yr	67.70	6669.37	6670.37	6671.57	6674.81	0.179622	16.90	4.00	5.00	3.33
Ditch	199.85*	100-yr	67.70	6668.47	6669.47	6670.67	6673.93	0.180550	16.94	4.00	5.00	3.34
Ditch	195	100-yr	67.70	6667.57	6668.57	6669.76	6673.04	0.181172	16.96	3.99	5.00	3.34
Ditch	191.00*	100-yr	67.70	6666.81	6667.81	6669.01	6672.32	0.183688	17.04	3.97	4.99	3.37
Ditch	187.00*	100-yr	67.70	6666.05	6667.04	6668.25	6671.59	0.185604	17.10	3.96	4.98	3.38
Ditch	183	100-yr	67.70	6665.29	6666.28	6667.49	6670.85	0.186896	17.14	3.95	4.98	3.39
Ditch	178.45*	100-yr	67.70	6664.40	6665.39	6666.60	6669.98	0.188198	17.19	3.94	4.98	3.41
Ditch	173.91*	100-yr	67.70	6663.51	6664.50	6665.71	6669.11	0.189512	17.23	3.93	4.97	3.42
Ditch	169.36*	100-yr	67.70	6662.61	6663.59	6664.81	6668.23	0.190838	17.27	3.92	4.97	3.43
Ditch	164.82*	100-yr	67.70	6661.72	6662.70	6663.92	6667.35	0.191505	17.29	3.91	4.97	3.43
Ditch	160.27*	100-yr	67.70	6660.83	6661.81	6663.03	6666.47	0.191840	17.30	3.91	4.96	3.44
Ditch	155.73*	100-yr	67.70	6659.94	6660.92	6662.14	6665.58	0.192176	17.31	3.91	4.96	3.44
Ditch	151.18*	100-yr	67.70	6659.05	6660.03	6661.25	6664.70	0.192512	17.33	3.91	4.96	3.44
Ditch	146.64*	100-yr	67.70	6658.16	6659.14	6660.36	6663.81	0.192849	17.34	3.91	4.96	3.45
Ditch	142.09*	100-yr	67.70	6657.26	6658.24	6659.46	6662.93	0.193864	17.37	3.90	4.96	3.45
Ditch	137.55*	100-yr	67.70	6656.37	6657.35	6658.56	6662.04	0.194204	17.38	3.90	4.96	3.46
Ditch	133	100-yr	67.70	6655.48	6656.46	6657.67	6661.15	0.194204	17.38	3.90	4.96	3.46
Ditch	130.00*	100-yr	67.70	6655.08	6656.08	6657.28	6660.56	0.182111	16.99	3.99	4.99	3.35
Ditch	127	100-yr	67.70	6654.69	6655.70	6656.89	6660.03	0.172995	16.68	4.06	5.02	3.27
Ditch	122.50*	100-yr	67.70	6653.99	6655.02	6656.19	6659.17	0.163622	16.35	4.14	5.06	3.19
Ditch	118.00*	100-yr	67.70	6653.30	6654.34	6655.50	6658.39	0.157989	16.15	4.19	5.08	3.13
Ditch	113.50*	100-yr	67.70	6652.60	6653.64	6654.80	6657.67	0.156424	16.09	4.21	5.08	3.12
Ditch	109.00*	100-yr	67.70	6651.90	6652.94	6654.10	6656.96	0.155907	16.07	4.21	5.08	3.11
Ditch	104.50*	100-yr	67.70	6651.21	6652.26	6653.41	6656.24	0.154114	16.01	4.23	5.09	3.10
Ditch	100.00*	100-yr	67.70	6650.51	6651.56	6652.71	6655.54	0.154114	16.01	4.23	5.09	3.10
Ditch	95.50*	100-yr	67.70	6649.81	6650.86	6652.01	6654.84	0.154114	16.01	4.23	5.09	3.10
Ditch	91.00*	100-yr	67.70	6649.11	6650.16	6651.31	6654.14	0.154114	16.01	4.23	5.09	3.10
Ditch	86.50*	100-yr	67.70	6648.42	6649.47	6650.62	6653.44	0.153606	15.99	4.23	5.09	3.09
Ditch	82	100-yr	67.70	6647.72	6648.77	6649.92	6652.74	0.153606	15.99	4.23	5.09	3.09
Ditch	77.300*	100-yr	67.70	6647.37	6648.50	6649.57	6651.75	0.115933	14.46	4.68	5.27	2.70
Ditch	72.600*	100-yr	67.70	6647.02	6648.22	6649.22	6651.04	0.095162	13.47	5.03	5.39	2.46
Ditch	67.900*	100-yr	67.70	6646.67	6647.91	6648.87	6650.50	0.084582	12.91	5.24	5.47	2.33
Ditch	63.200*	100-yr	67.70	6646.32	6647.58	6648.51	6650.05	0.078959	12.60	5.37	5.52	2.25
Ditch	58.500*	100-yr	67.70	6645.97	6647.24	6648.17	6649.65	0.076480	12.45	5.44	5.54	2.22
Ditch	53.800*	100-yr	67.70	6645.62	6646.89	6647.82	6649.30	0.076480	12.45	5.44	5.54	2.22
Ditch	49.100*	100-yr	67.70	6645.27	6646.54	6647.46	6648.95	0.076480	12.45	5.44	5.54	2.22
Ditch	44.400*	100-yr	67.70	6644.92	6646.19	6647.11	6648.60	0.076480	12.45	5.44	5.54	2.22
Ditch	39.700*	100-yr	67.70	6644.57	6645.84	6646.77	6648.25	0.076480	12.45	5.44	5.54	2.22
Ditch	35	100-yr	67.70	6644.22	6645.49	6646.42	6647.90	0.076480	12.45	5.44	5.54	2.22
Ditch	31.000*	100-yr	67.70	6643.35	6644.54	6645.55	6647.42	0.098135	13.62	4.97	5.37	2.50
Ditch	27.000*	100-yr	67.70	6642.47	6643.60	6644.67	6646.88	0.117366	14.52	4.66	5.26	2.72
Ditch	23.000*	100-yr	67.70	6641.60	6642.69	6643.80	6646.28	0.133426	15.21	4.45	5.18	2.89
Ditch	19	100-yr	67.70	6640.72	6641.78	6642.92	6645.65	0.147918	15.78	4.29	5.12	3.04
Ditch	14.250*	100-yr	67.70	6640.48	6641.67	6642.67	6644.56	0.098859	13.66	4.96	5.37	2.51
Ditch	9.500*	100-yr	67.70	6640.24	6641.53	6642.44	6643.86	0.072893	12.24	5.53	5.58	2.17
Ditch	4.750*	100-yr	67.70	6639.99	6641.35	6642.19	6643.38	0.060246	11.42	5.93	5.72	1.98
Ditch	0	100-yr	67.70	6639.75	6641.15	6641.95	6643.02	0.053675	10.96	6.18	5.81	1.87

HEC-RAS Plan: Dec11_Model River: NWRP_Ditch Reach: Ditch Profile: 100-yr

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Chnl	Vel Head	Q Channel	Top Width	Shear Chan	Hydr Depth C
			(ft)	(ft)	(ft/s)	(ft)	(cfs)	(ft)	(lb/sq ft)	(ft)
Ditch	619	100-yr	6742.02	6741.38	6.41	0.64	67.45	8.96	1.34	1.32
Ditch	614.00*	100-yr	6741.45	6739.51	11.16	1.94	67.70	7.53	4.75	0.81
Ditch	609.00*	100-yr	6740.65	6738.13	12.72	2.51	67.70	7.77	6.46	0.69
Ditch	604.00*	100-yr	6739.65	6736.83	13.49	2.83	67.70	8.28	7.54	0.61
Ditch	599	100-yr	6738.50	6735.56	13.76	2.94	67.70	8.95	8.08	0.55
Ditch	595	100-yr	6737.29	6733.02	16.59	4.28	67.70	5.03	7.39	0.81
Ditch	590.29*	100-yr	6736.29	6732.61	15.38	3.68	67.70	5.16	6.25	0.85
Ditch	585.57*	100-yr	6735.55	6732.17	14.75	3.38	67.70	5.23	5.71	0.88
Ditch	580.86*	100-yr	6734.91	6731.72	14.32	3.19	67.70	5.28	5.34	0.89
Ditch	576.14*	100-yr	6734.33	6731.27	14.04	3.06	67.70	5.32	5.12	0.91
Ditch	571.43*	100-yr	6733.82	6730.81	13.92	3.01	67.70	5.33	5.02	0.91
Ditch	566.71*	100-yr	6733.34	6730.33	13.92	3.01	67.70	5.33	5.02	0.91
Ditch	562	100-yr	6732.86	6729.86	13.88	3.00	67.70	5.34	5.00	0.91
Ditch	557.33*	100-yr	6732.31	6729.21	14.12	3.10	67.70	5.31	5.18	0.90
Ditch	552.67*	100-yr	6731.75	6728.57	14.30	3.18	67.70	5.28	5.33	0.90
Ditch	548	100-yr	6731.18	6727.93	14.45	3.25	67.70	5.27	5.46	0.89
Ditch	543.00*	100-yr	6730.58	6727.28	14.58	3.30	67.70	5.25	5.56	0.88
Ditch	538.00*	100-yr	6729.98	6726.63	14.68	3.35	67.70	5.24	5.64	0.88
Ditch	533.00*	100-yr	6729.37	6725.97	14.78	3.39	67.70	5.23	5.73	0.88
Ditch	528.00*	100-yr	6728.74	6725.32	14.84	3.42	67.70	5.22	5.78	0.87
Ditch	523.00*	100-yr	6728.12	6724.68	14.88	3.44	67.70	5.21	5.82	0.87
Ditch	518.00*	100-yr	6727.49	6724.03	14.93	3.46	67.70	5.21	5.86	0.87
Ditch	513.00*	100-yr	6726.85	6723.37	14.95	3.47	67.70	5.21	5.88	0.87
Ditch	508.00*	100-yr	6726.21	6722.73	14.97	3.48	67.70	5.21	5.89	0.87
Ditch	503.00*	100-yr	6725.57	6722.08	14.99	3.49	67.70	5.20	5.91	0.87
Ditch	498.00*	100-yr	6724.93	6721.43	15.01	3.50	67.70	5.20	5.93	0.87
Ditch	493.00*	100-yr	6724.30	6720.79	15.03	3.51	67.70	5.20	5.94	0.87
Ditch	488.00*	100-yr	6723.66	6720.14	15.04	3.52	67.70	5.20	5.96	0.87
Ditch	483.00*	100-yr	6723.01	6719.49	15.04	3.52	67.70	5.20	5.96	0.87
Ditch	478.00*	100-yr	6722.37	6718.85	15.04	3.52	67.70	5.20	5.96	0.87
Ditch	473	100-yr	6721.72	6718.20	15.04	3.52	67.70	5.20	5.96	0.87
Ditch	468.06*	100-yr	6720.95	6717.15	15.65	3.81	67.70	5.13	6.50	0.84
Ditch	463.11*	100-yr	6720.13	6716.09	16.12	4.04	67.70	5.08	6.94	0.83
Ditch	458.17*	100-yr	6719.27	6715.04	16.49	4.23	67.70	5.04	7.29	0.81
Ditch	453.22*	100-yr	6718.37	6714.01	16.76	4.37	67.70	5.02	7.56	0.81
Ditch	448.28*	100-yr	6717.46	6712.98	16.98	4.48	67.70	5.00	7.77	0.80
Ditch	443.33*	100-yr	6716.51	6711.94	17.15	4.57	67.70	4.98	7.96	0.79
Ditch	438.39*	100-yr	6715.55	6710.90	17.29	4.65	67.70	4.97	8.10	0.79
Ditch	433.44*	100-yr	6714.58	6709.88	17.39	4.70	67.70	4.96	8.20	0.79
Ditch	428.50*	100-yr	6713.59	6708.86	17.46	4.73	67.70	4.95	8.27	0.78
Ditch	423.56*	100-yr	6712.59	6707.82	17.52	4.77	67.70	4.95	8.33	0.78
Ditch	418.61*	100-yr	6711.60	6706.80	17.56	4.79	67.70	4.94	8.38	0.78
Ditch	413.67*	100-yr	6710.59	6705.77	17.62	4.82	67.70	4.94	8.44	0.78
Ditch	408.72*	100-yr	6709.59	6704.74	17.66	4.85	67.70	4.93	8.49	0.78
Ditch	403.78*	100-yr	6708.58	6703.72	17.69	4.86	67.70	4.93	8.51	0.78
Ditch	398.83*	100-yr	6707.56	6702.70	17.70	4.87	67.70	4.93	8.52	0.78
Ditch	393.89*	100-yr	6706.54	6701.66	17.72	4.88	67.70	4.93	8.54	0.78
Ditch	388.94*	100-yr	6705.52	6700.63	17.74	4.89	67.70	4.93	8.57	0.77
Ditch	384	100-yr	6704.51	6699.61	17.75	4.90	67.70	4.92	8.58	0.77
Ditch	379.33*	100-yr	6703.24	6699.12	16.27	4.12	67.70	5.06	7.08	0.82
Ditch	374.67*	100-yr	6702.30	6698.62	15.38	3.68	67.70	5.16	6.26	0.85
Ditch	370	100-yr	6701.56	6698.08	14.95	3.47	67.70	5.21	5.88	0.87
Ditch	365.25*	100-yr	6700.87	6697.19	15.39	3.68	67.70	5.16	6.26	0.85
Ditch	360.50*	100-yr	6700.14	6696.29	15.75	3.85	67.70	5.12	6.59	0.84
Ditch	355.75*	100-yr	6699.39	6695.41	16.01	3.98	67.70	5.09	6.83	0.83
Ditch	351.00*	100-yr	6698.61	6694.53	16.22	4.09	67.70	5.07	7.03	0.82
Ditch	346.25*	100-yr	6697.82	6693.65	16.38	4.17	67.70	5.05	7.19	0.82
Ditch	341.50*	100-yr	6697.00	6692.77	16.50	4.23	67.70	5.04	7.30	0.81
Ditch	336.75*	100-yr	6696.17	6691.89	16.61	4.29	67.70	5.03	7.41	0.81
Ditch	332	100-yr	6695.34	6691.01	16.68	4.32	67.70	5.02	7.48	0.81
Ditch	327.33*	100-yr	6694.45	6690.34	16.27	4.11	67.70	5.06	7.07	0.82
Ditch	322.67*	100-yr	6693.68	6689.65	16.09	4.02	67.70	5.08	6.91	0.83
Ditch	318.00*	100-yr	6692.94	6688.97	16.00	3.98	67.70	5.09	6.82	0.83
Ditch	313.33*	100-yr	6692.23	6688.28	15.93	3.95	67.70	5.10	6.76	0.83
Ditch	308.67*	100-yr	6691.52	6687.58	15.93	3.95	67.70	5.10	6.76	0.83
Ditch	304.00*	100-yr	6690.83	6686.89	15.91	3.94	67.70	5.10	6.74	0.83
Ditch	299.33*	100-yr	6690.13	6686.20	15.90	3.93	67.70	5.10	6.73	0.83
Ditch	294.67*	100-yr	6689.42	6685.50	15.89	3.92	67.70	5.10	6.72	0.84

HEC-RAS Plan: Dec11_Model River: NWRP_Ditch Reach: Ditch Profile: 100-yr (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Chnl	Vel Head	Q Channel	Top Width	Shear Chan	Hydr Depth C
			(ft)	(ft)	(ft/s)	(ft)	(cfs)	(ft)	(lb/sq ft)	(ft)
Ditch	290	100-yr	6688.73	6684.81	15.89	3.92	67.70	5.10	6.72	0.84
Ditch	286.67*	100-yr	6688.18	6684.33	15.74	3.85	67.70	5.12	6.58	0.84
Ditch	283.33*	100-yr	6687.67	6683.83	15.72	3.84	67.70	5.12	6.56	0.84
Ditch	280	100-yr	6687.15	6683.34	15.66	3.81	67.70	5.13	6.51	0.84
Ditch	275.60*	100-yr	6686.52	6682.75	15.58	3.77	67.70	5.14	6.43	0.85
Ditch	271.20*	100-yr	6685.92	6682.15	15.58	3.77	67.70	5.14	6.43	0.85
Ditch	266.80*	100-yr	6685.32	6681.55	15.58	3.77	67.70	5.14	6.43	0.85
Ditch	262.40*	100-yr	6684.72	6680.95	15.58	3.77	67.70	5.14	6.43	0.85
Ditch	258	100-yr	6684.12	6680.35	15.58	3.77	67.70	5.14	6.43	0.85
Ditch	253.15*	100-yr	6683.35	6679.43	15.88	3.92	67.70	5.10	6.71	0.84
Ditch	248.31*	100-yr	6682.55	6678.52	16.11	4.03	67.70	5.08	6.93	0.83
Ditch	243.46*	100-yr	6681.74	6677.61	16.30	4.13	67.70	5.06	7.11	0.82
Ditch	238.62*	100-yr	6680.91	6676.70	16.45	4.21	67.70	5.05	7.25	0.82
Ditch	233.77*	100-yr	6680.06	6675.80	16.56	4.26	67.70	5.04	7.36	0.81
Ditch	228.92*	100-yr	6679.21	6674.89	16.66	4.31	67.70	5.03	7.46	0.81
Ditch	224.08*	100-yr	6678.34	6673.98	16.75	4.36	67.70	5.02	7.55	0.81
Ditch	219.23*	100-yr	6677.46	6673.08	16.80	4.39	67.70	5.01	7.60	0.80
Ditch	214.38*	100-yr	6676.58	6672.17	16.84	4.41	67.70	5.01	7.64	0.80
Ditch	209.54*	100-yr	6675.70	6671.27	16.87	4.42	67.70	5.00	7.67	0.80
Ditch	204.69*	100-yr	6674.81	6670.37	16.90	4.44	67.70	5.00	7.70	0.80
Ditch	199.85*	100-yr	6673.93	6669.47	16.94	4.46	67.70	5.00	7.73	0.80
Ditch	195	100-yr	6673.04	6668.57	16.96	4.47	67.70	5.00	7.75	0.80
Ditch	191.00*	100-yr	6672.32	6667.81	17.04	4.51	67.70	4.99	7.84	0.80
Ditch	187.00*	100-yr	6671.59	6667.04	17.10	4.55	67.70	4.98	7.90	0.79
Ditch	183	100-yr	6670.85	6666.28	17.14	4.57	67.70	4.98	7.94	0.79
Ditch	178.45*	100-yr	6669.98	6665.39	17.19	4.59	67.70	4.98	7.99	0.79
Ditch	173.91*	100-yr	6669.11	6664.50	17.23	4.61	67.70	4.97	8.03	0.79
Ditch	169.36*	100-yr	6668.23	6663.59	17.27	4.64	67.70	4.97	8.08	0.79
Ditch	164.82*	100-yr	6667.35	6662.70	17.29	4.65	67.70	4.97	8.10	0.79
Ditch	160.27*	100-yr	6666.47	6661.81	17.30	4.65	67.70	4.96	8.11	0.79
Ditch	155.73*	100-yr	6665.58	6660.92	17.31	4.66	67.70	4.96	8.12	0.79
Ditch	151.18*	100-yr	6664.70	6660.03	17.33	4.66	67.70	4.96	8.13	0.79
Ditch	146.64*	100-yr	6663.81	6659.14	17.34	4.67	67.70	4.96	8.14	0.79
Ditch	142.09*	100-yr	6662.93	6658.24	17.37	4.69	67.70	4.96	8.18	0.79
Ditch	137.55*	100-yr	6662.04	6657.35	17.38	4.69	67.70	4.96	8.19	0.79
Ditch	133	100-yr	6661.15	6656.46	17.38	4.69	67.70	4.96	8.19	0.79
Ditch	130.00*	100-yr	6660.56	6656.08	16.99	4.48	67.70	4.99	7.79	0.80
Ditch	127	100-yr	6660.03	6655.70	16.68	4.32	67.70	5.02	7.48	0.81
Ditch	122.50*	100-yr	6659.17	6655.02	16.35	4.16	67.70	5.06	7.16	0.82
Ditch	118.00*	100-yr	6658.39	6654.34	16.15	4.05	67.70	5.08	6.97	0.83
Ditch	113.50*	100-yr	6657.67	6653.64	16.09	4.02	67.70	5.08	6.91	0.83
Ditch	109.00*	100-yr	6656.96	6652.94	16.07	4.02	67.70	5.08	6.89	0.83
Ditch	104.50*	100-yr	6656.24	6652.26	16.01	3.98	67.70	5.09	6.83	0.83
Ditch	100.00*	100-yr	6655.54	6651.56	16.01	3.98	67.70	5.09	6.83	0.83
Ditch	95.50*	100-yr	6654.84	6650.86	16.01	3.98	67.70	5.09	6.83	0.83
Ditch	91.00*	100-yr	6654.14	6650.16	16.01	3.98	67.70	5.09	6.83	0.83
Ditch	86.50*	100-yr	6653.44	6649.47	15.99	3.97	67.70	5.09	6.81	0.83
Ditch	82	100-yr	6652.74	6648.77	15.99	3.97	67.70	5.09	6.81	0.83
Ditch	77.300*	100-yr	6651.75	6648.50	14.46	3.25	67.70	5.27	5.46	0.89
Ditch	72.600*	100-yr	6651.04	6648.22	13.47	2.82	67.70	5.39	4.67	0.93
Ditch	67.900*	100-yr	6650.50	6647.91	12.91	2.59	67.70	5.47	4.26	0.96
Ditch	63.200*	100-yr	6650.05	6647.58	12.60	2.47	67.70	5.52	4.03	0.97
Ditch	58.500*	100-yr	6649.65	6647.24	12.45	2.41	67.70	5.54	3.93	0.98
Ditch	53.800*	100-yr	6649.30	6646.89	12.45	2.41	67.70	5.54	3.93	0.98
Ditch	49.100*	100-yr	6648.95	6646.54	12.45	2.41	67.70	5.54	3.93	0.98
Ditch	44.400*	100-yr	6648.60	6646.19	12.45	2.41	67.70	5.54	3.93	0.98
Ditch	39.700*	100-yr	6648.25	6645.84	12.45	2.41	67.70	5.54	3.93	0.98
Ditch	35	100-yr	6647.90	6645.49	12.45	2.41	67.70	5.54	3.93	0.98
Ditch	31.000*	100-yr	6647.42	6644.54	13.62	2.88	67.70	5.37	4.79	0.92
Ditch	27.000*	100-yr	6646.88	6643.60	14.52	3.28	67.70	5.26	5.51	0.89
Ditch	23.000*	100-yr	6646.28	6642.69	15.21	3.59	67.70	5.18	6.10	0.86
Ditch	19	100-yr	6645.65	6641.78	15.78	3.87	67.70	5.12	6.61	0.84
Ditch	14.250*	100-yr	6644.56	6641.67	13.66	2.90	67.70	5.37	4.82	0.92
Ditch	9.500*	100-yr	6643.86	6641.53	12.24	2.33	67.70	5.58	3.79	0.99
Ditch	4.750*	100-yr	6643.38	6641.35	11.42	2.03	67.70	5.72	3.26	1.04
Ditch	0	100-yr	6643.02	6641.15	10.96	1.87	67.70	5.81	2.97	1.06

Errors Warnings and Notes for Plan : Dec11_Model

Location:	River: NWRP_Ditch Reach: Ditch RS: 614.00* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than
	0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 609.00* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 599 Profile: 100-yr
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Location:	River: NWRP_Ditch Reach: Ditch RS: 595 Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 590.29* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 413.67* Profile: 100-yr
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 408.72* Profile: 100-yr
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 403.78* Profile: 100-yr
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 398.83* Profile: 100-yr
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 393.89* Profile: 100-yr
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 388.94* Profile: 100-yr
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 384 Profile: 100-yr
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 379.33* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 77.300* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 14.250* Profile: 100-yr

Errors Warnings and Notes for Plan : Dec11_Model (Continued)

Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 9.500* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.

Plan: n=0.018 NWRP_Ditch Ditch RS: 619 Profile: 100-yr

E.G. Elev (ft)	6742.02	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.64	Wt. n-Val.	0.035	0.035	0.035
W.S. Elev (ft)	6741.38	Reach Len. (ft)	5.00	5.00	5.00
Crit W.S. (ft)	6741.38	Flow Area (sq ft)	0.03	10.52	0.13
E.G. Slope (ft/ft)	0.017953	Area (sq ft)	0.03	10.52	0.13
Q Total (cfs)	67.70	Flow (cfs)	0.04	67.45	0.21
Top Width (ft)	8.96	Top Width (ft)	0.27	7.97	0.72
Vel Total (ft/s)	6.34	Avg. Vel. (ft/s)	1.16	6.41	1.66
Max Chl Dpth (ft)	1.88	Hydr. Depth (ft)	0.12	1.32	0.17
Conv. Total (cfs)	505.3	Conv. (cfs)	0.3	503.4	1.6
Length Wtd. (ft)	5.00	Wetted Per. (ft)	0.37	8.79	0.80
Min Ch El (ft)	6739.50	Shear (lb/sq ft)	0.10	1.34	0.18
Alpha	1.02	Stream Power (lb/ft s)	0.12	8.60	0.29
Frctn Loss (ft)	0.18	Cum Volume (acre-ft)	0.00	0.05	0.00
C & E Loss (ft)	0.39	Cum SA (acres)	0.00	0.07	0.00

Plan: n=0.018 NWRP_Ditch Ditch RS: 599 Profile: 100-yr

E.G. Elev (ft)	6738.50	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.94	Wt. n-Val.		0.035	
W.S. Elev (ft)	6735.56	Reach Len. (ft)	4.00	4.00	4.00
Crit W.S. (ft)	6736.23	Flow Area (sq ft)		4.92	
E.G. Slope (ft/ft)	0.242789	Area (sq ft)		4.92	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	8.95	Top Width (ft)		8.95	
Vel Total (ft/s)	13.76	Avg. Vel. (ft/s)		13.76	
Max Chl Dpth (ft)	0.88	Hydr. Depth (ft)		0.55	
Conv. Total (cfs)	137.4	Conv. (cfs)		137.4	
Length Wtd. (ft)	4.00	Wetted Per. (ft)		9.23	
Min Ch El (ft)	6734.68	Shear (lb/sq ft)		8.08	
Alpha	1.00	Stream Power (lb/ft s)		111.19	
Frctn Loss (ft)	0.48	Cum Volume (acre-ft)		0.04	
C & E Loss (ft)	0.48	Cum SA (acres)		0.06	

Plan: n=0.018 NWRP_Ditch Ditch RS: 595 Profile: 100-yr

E.G. Elev (ft)	6737.54	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.55	Wt. n-Val.		0.018	
W.S. Elev (ft)	6732.99	Reach Len. (ft)	4.62	4.62	4.62
Crit W.S. (ft)	6734.13	Flow Area (sq ft)		3.96	
E.G. Slope (ft/ft)	0.071505	Area (sq ft)		3.96	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.98	Top Width (ft)		4.98	
Vel Total (ft/s)	17.10	Avg. Vel. (ft/s)		17.10	
Max Chl Dpth (ft)	0.99	Hydr. Depth (ft)		0.79	
Conv. Total (cfs)	253.2	Conv. (cfs)		253.2	
Length Wtd. (ft)	4.62	Wetted Per. (ft)		5.80	
Min Ch El (ft)	6732.00	Shear (lb/sq ft)		3.04	
Alpha	1.00	Stream Power (lb/ft s)		52.06	
Frctn Loss (ft)	0.34	Cum Volume (acre-ft)		0.04	
C & E Loss (ft)	0.03	Cum SA (acres)		0.06	

Plan: n=0.018 NWRP_Ditch Ditch RS: 562 Profile: 100-yr

E.G. Elev (ft)	6734.79	Element	Left OB	Channel	Right OB
Vel Head (ft)	5.16	Wt. n-Val.		0.018	
W.S. Elev (ft)	6729.63	Reach Len. (ft)	4.85	4.85	4.85
Crit W.S. (ft)	6730.82	Flow Area (sq ft)		3.72	
E.G. Slope (ft/ft)	0.085525	Area (sq ft)		3.72	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.88	Top Width (ft)		4.88	
Vel Total (ft/s)	18.22	Avg. Vel. (ft/s)		18.22	
Max Chl Dpth (ft)	0.94	Hydr. Depth (ft)		0.76	
Conv. Total (cfs)	231.5	Conv. (cfs)		231.5	
Length Wtd. (ft)	4.85	Wetted Per. (ft)		5.67	
Min Ch El (ft)	6728.69	Shear (lb/sq ft)		3.50	
Alpha	1.00	Stream Power (lb/ft s)		63.80	
Frctn Loss (ft)	0.42	Cum Volume (acre-ft)		0.04	
C & E Loss (ft)	0.05	Cum SA (acres)		0.06	

Plan: n=0.018 NWRP_Ditch Ditch RS: 548 Profile: 100-yr

E.G. Elev (ft)	6733.32	Element	Left OB	Channel	Right OB
Vel Head (ft)	5.61	Wt. n-Val.		0.018	
W.S. Elev (ft)	6727.71	Reach Len. (ft)	4.95	4.95	4.95
Crit W.S. (ft)	6728.79	Flow Area (sq ft)		3.56	
E.G. Slope (ft/ft)	0.096233	Area (sq ft)		3.56	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.82	Top Width (ft)		4.82	
Vel Total (ft/s)	19.00	Avg. Vel. (ft/s)		19.00	
Max Chl Dpth (ft)	0.91	Hydr. Depth (ft)		0.74	
Conv. Total (cfs)	218.2	Conv. (cfs)		218.2	
Length Wtd. (ft)	4.95	Wetted Per. (ft)		5.58	
Min Ch El (ft)	6726.80	Shear (lb/sq ft)		3.84	
Alpha	1.00	Stream Power (lb/ft s)		72.93	
Frctn Loss (ft)	0.48	Cum Volume (acre-ft)		0.04	
C & E Loss (ft)	0.04	Cum SA (acres)		0.06	

Plan: n=0.018 NWRP_Ditch Ditch RS: 473 Profile: 100-yr

E.G. Elev (ft)	6724.64	Element	Left OB	Channel	Right OB
Vel Head (ft)	6.69	Wt. n-Val.		0.018	
W.S. Elev (ft)	6717.95	Reach Len. (ft)	4.95	4.95	4.95
Crit W.S. (ft)	6719.09	Flow Area (sq ft)		3.26	
E.G. Slope (ft/ft)	0.123520	Area (sq ft)		3.26	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.70	Top Width (ft)		4.70	
Vel Total (ft/s)	20.74	Avg. Vel. (ft/s)		20.74	
Max Chl Dpth (ft)	0.85	Hydr. Depth (ft)		0.69	
Conv. Total (cfs)	192.6	Conv. (cfs)		192.6	
Length Wtd. (ft)	4.95	Wetted Per. (ft)		5.40	
Min Ch El (ft)	6717.10	Shear (lb/sq ft)		4.66	
Alpha	1.00	Stream Power (lb/ft s)		96.70	
Frctn Loss (ft)	0.63	Cum Volume (acre-ft)		0.03	
C & E Loss (ft)	0.09	Cum SA (acres)		0.05	

Plan: n=0.018 NWRP_Ditch Ditch RS: 384 Profile: 100-yr

E.G. Elev (ft)	6708.65	Element	Left OB	Channel	Right OB
Vel Head (ft)	9.26	Wt. n-Val.		0.018	
W.S. Elev (ft)	6699.39	Reach Len. (ft)	4.85	4.85	4.85
Crit W.S. (ft)	6700.64	Flow Area (sq ft)		2.77	
E.G. Slope (ft/ft)	0.196899	Area (sq ft)		2.77	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.48	Top Width (ft)		4.48	
Vel Total (ft/s)	24.41	Avg. Vel. (ft/s)		24.41	
Max Chl Dpth (ft)	0.74	Hydr. Depth (ft)		0.62	
Conv. Total (cfs)	152.6	Conv. (cfs)		152.6	
Length Wtd. (ft)	4.85	Wetted Per. (ft)		5.10	
Min Ch El (ft)	6698.65	Shear (lb/sq ft)		6.69	
Alpha	1.00	Stream Power (lb/ft s)		163.29	
Frctn Loss (ft)	0.90	Cum Volume (acre-ft)		0.03	
C & E Loss (ft)	0.36	Cum SA (acres)		0.04	

Plan: n=0.018 NWRP_Ditch Ditch RS: 370 Profile: 100-yr

E.G. Elev (ft)	6705.35	Element	Left OB	Channel	Right OB
Vel Head (ft)	7.57	Wt. n-Val.		0.018	
W.S. Elev (ft)	6697.79	Reach Len. (ft)	4.75	4.75	4.75
Crit W.S. (ft)	6699.11	Flow Area (sq ft)		3.07	
E.G. Slope (ft/ft)	0.147316	Area (sq ft)		3.07	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.61	Top Width (ft)		4.61	
Vel Total (ft/s)	22.06	Avg. Vel. (ft/s)		22.06	
Max Chl Dpth (ft)	0.81	Hydr. Depth (ft)		0.67	
Conv. Total (cfs)	176.4	Conv. (cfs)		176.4	
Length Wtd. (ft)	4.75	Wetted Per. (ft)		5.28	
Min Ch El (ft)	6696.98	Shear (lb/sq ft)		5.34	
Alpha	1.00	Stream Power (lb/ft s)		117.92	
Frctn Loss (ft)	0.71	Cum Volume (acre-ft)		0.03	
C & E Loss (ft)	0.04	Cum SA (acres)		0.04	

Plan: n=0.018 NWRP_Ditch Ditch RS: 332 Profile: 100-yr

E.G. Elev (ft)	6699.09	Element	Left OB	Channel	Right OB
Vel Head (ft)	8.31	Wt. n-Val.		0.018	
W.S. Elev (ft)	6690.78	Reach Len. (ft)	4.62	4.62	4.62
Crit W.S. (ft)	6692.13	Flow Area (sq ft)		2.93	
E.G. Slope (ft/ft)	0.168537	Area (sq ft)		2.93	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.55	Top Width (ft)		4.55	
Vel Total (ft/s)	23.13	Avg. Vel. (ft/s)		23.13	
Max Chl Dpth (ft)	0.78	Hydr. Depth (ft)		0.64	
Conv. Total (cfs)	164.9	Conv. (cfs)		164.9	
Length Wtd. (ft)	4.62	Wetted Per. (ft)		5.19	
Min Ch El (ft)	6690.00	Shear (lb/sq ft)		5.93	
Alpha	1.00	Stream Power (lb/ft s)		137.17	
Frctn Loss (ft)	0.77	Cum Volume (acre-ft)		0.02	
C & E Loss (ft)	0.09	Cum SA (acres)		0.04	

Plan: n=0.018 NWRP_Ditch Ditch RS: 290 Profile: 100-yr

E.G. Elev (ft)	6692.29	Element	Left OB	Channel	Right OB
Vel Head (ft)	7.73	Wt. n-Val.		0.018	
W.S. Elev (ft)	6684.56	Reach Len. (ft)	3.48	3.48	3.48
Crit W.S. (ft)	6685.89	Flow Area (sq ft)		3.03	
E.G. Slope (ft/ft)	0.152045	Area (sq ft)		3.03	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.60	Top Width (ft)		4.60	
Vel Total (ft/s)	22.31	Avg. Vel. (ft/s)		22.31	
Max Chl Dpth (ft)	0.80	Hydr. Depth (ft)		0.66	
Conv. Total (cfs)	173.6	Conv. (cfs)		173.6	
Length Wtd. (ft)	3.48	Wetted Per. (ft)		5.26	
Min Ch El (ft)	6683.76	Shear (lb/sq ft)		5.48	
Alpha	1.00	Stream Power (lb/ft s)		122.18	
Frctn Loss (ft)	0.53	Cum Volume (acre-ft)		0.02	
C & E Loss (ft)	0.04	Cum SA (acres)		0.03	

Plan: n=0.018 NWRP_Ditch Ditch RS: 280 Profile: 100-yr

E.G. Elev (ft)	6690.66	Element	Left OB	Channel	Right OB
Vel Head (ft)	7.58	Wt. n-Val.		0.018	
W.S. Elev (ft)	6683.09	Reach Len. (ft)	4.27	4.27	4.27
Crit W.S. (ft)	6684.41	Flow Area (sq ft)		3.07	
E.G. Slope (ft/ft)	0.147625	Area (sq ft)		3.07	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.61	Top Width (ft)		4.61	
Vel Total (ft/s)	22.08	Avg. Vel. (ft/s)		22.08	
Max Chl Dpth (ft)	0.81	Hydr. Depth (ft)		0.66	
Conv. Total (cfs)	176.2	Conv. (cfs)		176.2	
Length Wtd. (ft)	4.27	Wetted Per. (ft)		5.28	
Min Ch El (ft)	6682.28	Shear (lb/sq ft)		5.35	
Alpha	1.00	Stream Power (lb/ft s)		118.20	
Frctn Loss (ft)	0.63	Cum Volume (acre-ft)		0.02	
C & E Loss (ft)	0.02	Cum SA (acres)		0.03	

Plan: n=0.018 NWRP_Ditch Ditch RS: 258 Profile: 100-yr

E.G. Elev (ft)	6687.52	Element	Left OB	Channel	Right OB
Vel Head (ft)	7.42	Wt. n-Val.		0.018	
W.S. Elev (ft)	6680.09	Reach Len. (ft)	4.92	4.92	4.92
Crit W.S. (ft)	6681.41	Flow Area (sq ft)		3.10	
E.G. Slope (ft/ft)	0.143366	Area (sq ft)		3.10	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.63	Top Width (ft)		4.63	
Vel Total (ft/s)	21.86	Avg. Vel. (ft/s)		21.86	
Max Chl Dpth (ft)	0.81	Hydr. Depth (ft)		0.67	
Conv. Total (cfs)	178.8	Conv. (cfs)		178.8	
Length Wtd. (ft)	4.92	Wetted Per. (ft)		5.30	
Min Ch El (ft)	6679.28	Shear (lb/sq ft)		5.23	
Alpha	1.00	Stream Power (lb/ft s)		114.37	
Frctn Loss (ft)	0.71	Cum Volume (acre-ft)		0.02	
C & E Loss (ft)	0.04	Cum SA (acres)		0.03	

Plan: n=0.018 NWRP_Ditch Ditch RS: 195 Profile: 100-yr

E.G. Elev (ft)	6676.83	Element	Left OB	Channel	Right OB
Vel Head (ft)	8.49	Wt. n-Val.		0.018	
W.S. Elev (ft)	6668.34	Reach Len. (ft)	3.88	3.88	3.88
Crit W.S. (ft)	6669.70	Flow Area (sq ft)		2.90	
E.G. Slope (ft/ft)	0.173772	Area (sq ft)		2.90	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.54	Top Width (ft)		4.54	
Vel Total (ft/s)	23.37	Avg. Vel. (ft/s)		23.37	
Max Chl Dpth (ft)	0.77	Hydr. Depth (ft)		0.64	
Conv. Total (cfs)	162.4	Conv. (cfs)		162.4	
Length Wtd. (ft)	3.88	Wetted Per. (ft)		5.17	
Min Ch El (ft)	6667.57	Shear (lb/sq ft)		6.07	
Alpha	1.00	Stream Power (lb/ft s)		141.96	
Frctn Loss (ft)	0.68	Cum Volume (acre-ft)		0.01	
C & E Loss (ft)	0.02	Cum SA (acres)		0.02	

Plan: n=0.018 NWRP_Ditch Ditch RS: 183 Profile: 100-yr

E.G. Elev (ft)	6674.73	Element	Left OB	Channel	Right OB
Vel Head (ft)	8.68	Wt. n-Val.		0.018	
W.S. Elev (ft)	6666.05	Reach Len. (ft)	4.59	4.59	4.59
Crit W.S. (ft)	6667.42	Flow Area (sq ft)		2.87	
E.G. Slope (ft/ft)	0.179215	Area (sq ft)		2.87	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.52	Top Width (ft)		4.52	
Vel Total (ft/s)	23.63	Avg. Vel. (ft/s)		23.63	
Max Chl Dpth (ft)	0.76	Hydr. Depth (ft)		0.63	
Conv. Total (cfs)	159.9	Conv. (cfs)		159.9	
Length Wtd. (ft)	4.59	Wetted Per. (ft)		5.15	
Min Ch El (ft)	6665.29	Shear (lb/sq ft)		6.22	
Alpha	1.00	Stream Power (lb/ft s)		146.95	
Frctn Loss (ft)	0.83	Cum Volume (acre-ft)		0.01	
C & E Loss (ft)	0.02	Cum SA (acres)		0.02	

Plan: n=0.018 NWRP_Ditch Ditch RS: 133 Profile: 100-yr

E.G. Elev (ft)	6665.26	Element	Left OB	Channel	Right OB
Vel Head (ft)	9.03	Wt. n-Val.		0.018	
W.S. Elev (ft)	6656.23	Reach Len. (ft)	2.55	2.55	2.55
Crit W.S. (ft)	6657.61	Flow Area (sq ft)		2.81	
E.G. Slope (ft/ft)	0.189911	Area (sq ft)		2.81	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.50	Top Width (ft)		4.50	
Vel Total (ft/s)	24.11	Avg. Vel. (ft/s)		24.11	
Max Chl Dpth (ft)	0.75	Hydr. Depth (ft)		0.62	
Conv. Total (cfs)	155.4	Conv. (cfs)		155.4	
Length Wtd. (ft)	2.55	Wetted Per. (ft)		5.12	
Min Ch El (ft)	6655.48	Shear (lb/sq ft)		6.50	
Alpha	1.00	Stream Power (lb/ft s)		156.81	
Frctn Loss (ft)	0.48	Cum Volume (acre-ft)		0.01	
C & E Loss (ft)	0.09	Cum SA (acres)		0.01	

Plan: n=0.018 NWRP_Ditch Ditch RS: 127 Profile: 100-yr

E.G. Elev (ft)	6664.14	Element	Left OB	Channel	Right OB
Vel Head (ft)	8.69	Wt. n-Val.		0.018	
W.S. Elev (ft)	6655.45	Reach Len. (ft)	4.55	4.55	4.55
Crit W.S. (ft)	6656.82	Flow Area (sq ft)		2.86	
E.G. Slope (ft/ft)	0.179612	Area (sq ft)		2.86	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.52	Top Width (ft)		4.52	
Vel Total (ft/s)	23.65	Avg. Vel. (ft/s)		23.65	
Max Chl Dpth (ft)	0.76	Hydr. Depth (ft)		0.63	
Conv. Total (cfs)	159.7	Conv. (cfs)		159.7	
Length Wtd. (ft)	4.55	Wetted Per. (ft)		5.15	
Min Ch El (ft)	6654.69	Shear (lb/sq ft)		6.23	
Alpha	1.00	Stream Power (lb/ft s)		147.32	
Frctn Loss (ft)	0.80	Cum Volume (acre-ft)		0.01	
C & E Loss (ft)	0.11	Cum SA (acres)		0.01	

Plan: n=0.018 NWRP_Ditch Ditch RS: 82 Profile: 100-yr

E.G. Elev (ft)	6656.38	Element	Left OB	Channel	Right OB
Vel Head (ft)	7.86	Wt. n-Val.		0.018	
W.S. Elev (ft)	6648.51	Reach Len. (ft)	4.70	4.70	4.70
Crit W.S. (ft)	6649.85	Flow Area (sq ft)		3.01	
E.G. Slope (ft/ft)	0.155637	Area (sq ft)		3.01	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.59	Top Width (ft)		4.59	
Vel Total (ft/s)	22.49	Avg. Vel. (ft/s)		22.49	
Max Chl Dpth (ft)	0.79	Hydr. Depth (ft)		0.66	
Conv. Total (cfs)	171.6	Conv. (cfs)		171.6	
Length Wtd. (ft)	4.70	Wetted Per. (ft)		5.24	
Min Ch El (ft)	6647.72	Shear (lb/sq ft)		5.58	
Alpha	1.00	Stream Power (lb/ft s)		125.43	
Frctn Loss (ft)	0.68	Cum Volume (acre-ft)		0.01	
C & E Loss (ft)	0.37	Cum SA (acres)		0.01	

Plan: n=0.018 NWRP_Ditch Ditch RS: 35 Profile: 100-yr

E.G. Elev (ft)	6650.09	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.90	Wt. n-Val.		0.018	
W.S. Elev (ft)	6645.18	Reach Len. (ft)	3.96	3.96	3.96
Crit W.S. (ft)	6646.35	Flow Area (sq ft)		3.81	
E.G. Slope (ft/ft)	0.079590	Area (sq ft)		3.81	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.92	Top Width (ft)		4.92	
Vel Total (ft/s)	17.76	Avg. Vel. (ft/s)		17.76	
Max Chl Dpth (ft)	0.96	Hydr. Depth (ft)		0.77	
Conv. Total (cfs)	240.0	Conv. (cfs)		240.0	
Length Wtd. (ft)	3.96	Wetted Per. (ft)		5.72	
Min Ch El (ft)	6644.22	Shear (lb/sq ft)		3.31	
Alpha	1.00	Stream Power (lb/ft s)		58.80	
Frctn Loss (ft)	0.33	Cum Volume (acre-ft)		0.00	
C & E Loss (ft)	0.13	Cum SA (acres)		0.00	

Plan: n=0.018 NWRP_Ditch Ditch RS: 19 Profile: 100-yr

E.G. Elev (ft)	6648.05	Element	Left OB	Channel	Right OB
Vel Head (ft)	6.47	Wt. n-Val.		0.018	
W.S. Elev (ft)	6641.58	Reach Len. (ft)	4.95	4.95	4.95
Crit W.S. (ft)	6642.85	Flow Area (sq ft)		3.32	
E.G. Slope (ft/ft)	0.117764	Area (sq ft)		3.32	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.72	Top Width (ft)		4.72	
Vel Total (ft/s)	20.40	Avg. Vel. (ft/s)		20.40	
Max Chl Dpth (ft)	0.86	Hydr. Depth (ft)		0.70	
Conv. Total (cfs)	197.3	Conv. (cfs)		197.3	
Length Wtd. (ft)	4.95	Wetted Per. (ft)		5.43	
Min Ch El (ft)	6640.72	Shear (lb/sq ft)		4.49	
Alpha	1.00	Stream Power (lb/ft s)		91.63	
Frctn Loss (ft)	0.54	Cum Volume (acre-ft)		0.00	
C & E Loss (ft)	0.34	Cum SA (acres)		0.00	

Plan: n=0.018 NWRP_Ditch Ditch RS: 0 Profile: 100-yr

E.G. Elev (ft)	6645.31	Element	Left OB	Channel	Right OB
Vel Head (ft)	4.57	Wt. n-Val.		0.018	
W.S. Elev (ft)	6640.74	Reach Len. (ft)			
Crit W.S. (ft)	6641.88	Flow Area (sq ft)		3.95	
E.G. Slope (ft/ft)	0.072128	Area (sq ft)		3.95	
Q Total (cfs)	67.70	Flow (cfs)		67.70	
Top Width (ft)	4.98	Top Width (ft)		4.98	
Vel Total (ft/s)	17.15	Avg. Vel. (ft/s)		17.15	
Max Chl Dpth (ft)	0.99	Hydr. Depth (ft)		0.79	
Conv. Total (cfs)	252.1	Conv. (cfs)		252.1	
Length Wtd. (ft)		Wetted Per. (ft)		5.80	
Min Ch El (ft)	6639.75	Shear (lb/sq ft)		3.06	
Alpha	1.00	Stream Power (lb/ft s)		52.58	
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

HEC-RAS Plan: n=0.018 River: NWRP_Ditch Reach: Ditch Profile: 100-yr

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ditch	619	100-yr	67.70	6739.50	6741.38	6741.38	6742.02	0.017953	6.41	10.68	8.96	0.98
Ditch	614.00*	100-yr	67.70	6738.29	6739.51	6740.08	6741.45	0.101046	11.16	6.06	7.53	2.19
Ditch	609.00*	100-yr	67.70	6737.09	6738.13	6738.79	6740.65	0.158754	12.72	5.32	7.77	2.71
Ditch	604.00*	100-yr	67.70	6735.89	6736.83	6737.50	6739.65	0.207068	13.49	5.02	8.28	3.05
Ditch	599	100-yr	67.70	6734.68	6735.56	6736.23	6738.50	0.242789	13.76	4.92	8.95	3.27
Ditch	595	100-yr	67.70	6732.00	6732.99	6734.13	6737.54	0.071505	17.10	3.96	4.98	3.38
Ditch	590.29*	100-yr	67.70	6731.53	6732.51	6733.66	6737.17	0.074037	17.31	3.91	4.96	3.44
Ditch	585.57*	100-yr	67.70	6731.05	6732.02	6733.18	6736.79	0.076413	17.51	3.87	4.95	3.49
Ditch	580.86*	100-yr	67.70	6730.58	6731.55	6732.71	6736.40	0.078466	17.67	3.83	4.93	3.54
Ditch	576.14*	100-yr	67.70	6730.11	6731.07	6732.24	6736.01	0.080446	17.83	3.80	4.92	3.58
Ditch	571.43*	100-yr	67.70	6729.64	6730.59	6731.77	6735.61	0.082194	17.97	3.77	4.91	3.61
Ditch	566.71*	100-yr	67.70	6729.16	6730.11	6731.29	6735.20	0.083990	18.11	3.74	4.89	3.65
Ditch	562	100-yr	67.70	6728.69	6729.63	6730.82	6734.79	0.085525	18.22	3.72	4.88	3.68
Ditch	557.33*	100-yr	67.70	6728.06	6728.99	6730.05	6734.31	0.089429	18.51	3.66	4.86	3.76
Ditch	552.67*	100-yr	67.70	6727.43	6728.35	6729.42	6733.83	0.092967	18.77	3.61	4.84	3.83
Ditch	548	100-yr	67.70	6726.80	6727.71	6728.79	6733.32	0.096233	19.00	3.56	4.82	3.90
Ditch	543.00*	100-yr	67.70	6726.15	6727.05	6728.14	6732.79	0.099359	19.21	3.52	4.81	3.96
Ditch	538.00*	100-yr	67.70	6725.51	6726.41	6727.50	6732.26	0.102224	19.41	3.49	4.79	4.01
Ditch	533.00*	100-yr	67.70	6724.86	6725.75	6726.85	6731.71	0.104994	19.59	3.46	4.78	4.06
Ditch	528.00*	100-yr	67.70	6724.21	6725.09	6726.20	6731.16	0.107443	19.75	3.43	4.77	4.11
Ditch	523.00*	100-yr	67.70	6723.57	6724.45	6725.56	6730.59	0.109540	19.89	3.40	4.76	4.14
Ditch	518.00*	100-yr	67.70	6722.92	6723.79	6724.91	6730.02	0.111689	20.02	3.38	4.75	4.18
Ditch	513.00*	100-yr	67.70	6722.27	6723.14	6724.26	6729.45	0.113669	20.15	3.36	4.74	4.22
Ditch	508.00*	100-yr	67.70	6721.63	6722.50	6723.62	6728.86	0.115240	20.24	3.34	4.73	4.24
Ditch	503.00*	100-yr	67.70	6720.98	6721.84	6722.97	6728.27	0.116838	20.34	3.33	4.72	4.27
Ditch	498.00*	100-yr	67.70	6720.33	6721.19	6722.32	6727.67	0.118231	20.43	3.31	4.72	4.30
Ditch	493.00*	100-yr	67.70	6719.69	6720.55	6721.68	6727.08	0.119407	20.50	3.30	4.71	4.32
Ditch	488.00*	100-yr	67.70	6719.04	6719.89	6721.03	6726.47	0.120598	20.57	3.29	4.71	4.34
Ditch	483.00*	100-yr	67.70	6718.39	6719.24	6720.38	6725.86	0.121805	20.64	3.28	4.70	4.36
Ditch	478.00*	100-yr	67.70	6717.75	6718.60	6719.74	6725.25	0.122536	20.68	3.27	4.70	4.37
Ditch	473	100-yr	67.70	6717.10	6717.95	6719.09	6724.64	0.123520	20.74	3.26	4.70	4.39
Ditch	468.06*	100-yr	67.70	6716.08	6716.91	6718.07	6723.91	0.131760	21.22	3.19	4.67	4.52
Ditch	463.11*	100-yr	67.70	6715.05	6715.87	6717.04	6723.15	0.139551	21.65	3.13	4.64	4.65
Ditch	458.17*	100-yr	67.70	6714.02	6714.83	6716.01	6722.37	0.146699	22.03	3.07	4.61	4.76
Ditch	453.22*	100-yr	67.70	6713.00	6713.80	6714.99	6721.57	0.153014	22.36	3.03	4.59	4.86
Ditch	448.28*	100-yr	67.70	6711.98	6712.77	6713.97	6720.74	0.158656	22.64	2.99	4.58	4.94
Ditch	443.33*	100-yr	67.70	6710.95	6711.73	6712.94	6719.88	0.163855	22.90	2.96	4.56	5.02
Ditch	438.39*	100-yr	67.70	6709.92	6710.70	6711.91	6719.01	0.168537	23.13	2.93	4.55	5.08
Ditch	433.44*	100-yr	67.70	6708.90	6709.67	6710.89	6718.12	0.172633	23.32	2.90	4.54	5.14
Ditch	428.50*	100-yr	67.70	6707.88	6708.65	6709.87	6717.23	0.176467	23.50	2.88	4.53	5.20
Ditch	423.56*	100-yr	67.70	6706.85	6707.61	6708.84	6716.31	0.180010	23.66	2.86	4.52	5.24
Ditch	418.61*	100-yr	67.70	6705.83	6706.59	6707.82	6715.38	0.182828	23.79	2.85	4.51	5.28
Ditch	413.67*	100-yr	67.70	6704.80	6705.55	6706.79	6714.45	0.185703	23.92	2.83	4.51	5.32
Ditch	408.72*	100-yr	67.70	6703.77	6704.52	6705.76	6713.50	0.188213	24.03	2.82	4.50	5.36
Ditch	403.78*	100-yr	67.70	6702.75	6703.50	6704.74	6712.55	0.190338	24.13	2.81	4.50	5.39
Ditch	398.83*	100-yr	67.70	6701.73	6702.48	6703.72	6711.58	0.192060	24.20	2.80	4.49	5.41
Ditch	393.89*	100-yr	67.70	6700.70	6701.45	6702.69	6710.61	0.193802	24.28	2.79	4.49	5.43
Ditch	388.94*	100-yr	67.70	6699.67	6700.41	6701.66	6709.63	0.195564	24.36	2.78	4.49	5.45
Ditch	384	100-yr	67.70	6698.65	6699.39	6700.64	6708.65	0.196899	24.41	2.77	4.48	5.47
Ditch	379.33*	100-yr	67.70	6698.09	6698.86	6700.08	6707.39	0.175049	23.44	2.89	4.53	5.18
Ditch	374.67*	100-yr	67.70	6697.54	6698.33	6699.53	6706.31	0.159199	22.67	2.99	4.58	4.95
Ditch	370	100-yr	67.70	6696.98	6697.79	6699.11	6705.35	0.147316	22.06	3.07	4.61	4.77
Ditch	365.25*	100-yr	67.70	6696.11	6696.91	6698.24	6704.60	0.150765	22.24	3.04	4.60	4.82
Ditch	360.50*	100-yr	67.70	6695.23	6696.03	6697.36	6703.84	0.154319	22.43	3.02	4.59	4.88
Ditch	355.75*	100-yr	67.70	6694.36	6695.15	6696.49	6703.07	0.157305	22.58	3.00	4.58	4.92
Ditch	351.00*	100-yr	67.70	6693.49	6694.28	6695.62	6702.29	0.160022	22.71	2.98	4.57	4.96
Ditch	346.25*	100-yr	67.70	6692.62	6693.40	6694.75	6701.50	0.162448	22.83	2.97	4.57	5.00
Ditch	341.50*	100-yr	67.70	6691.75	6692.53	6693.88	6700.71	0.164565	22.93	2.95	4.56	5.03
Ditch	336.75*	100-yr	67.70	6690.87	6691.65	6693.00	6699.90	0.166717	23.04	2.94	4.56	5.06
Ditch	332	100-yr	67.70	6690.00	6690.78	6692.13	6699.09	0.168537	23.13	2.93	4.55	5.08
Ditch	327.33*	100-yr	67.70	6689.31	6690.09	6691.44	6698.23	0.163502	22.88	2.96	4.56	5.01
Ditch	322.67*	100-yr	67.70	6688.61	6689.40	6690.74	6697.42	0.160365	22.73	2.98	4.57	4.97
Ditch	318.00*	100-yr	67.70	6687.92	6688.71	6690.05	6696.64	0.157641	22.59	3.00	4.58	4.92
Ditch	313.33*	100-yr	67.70	6687.23	6688.02	6689.36	6695.89	0.155637	22.49	3.01	4.59	4.90
Ditch	308.67*	100-yr	67.70	6686.53	6687.32	6688.66	6695.16	0.154976	22.46	3.01	4.59	4.89
Ditch	304.00*	100-yr	67.70	6685.84	6686.64	6687.97	6694.44	0.153991	22.41	3.02	4.59	4.87
Ditch	299.33*	100-yr	67.70	6685.15	6685.95	6687.28	6693.72	0.153014	22.36	3.03	4.59	4.86
Ditch	294.67*	100-yr	67.70	6684.45	6685.25	6686.58	6693.02	0.153014	22.36	3.03	4.59	4.86
Ditch	290	100-yr	67.70	6683.76	6684.56	6685.89	6692.29	0.152045	22.31	3.03	4.60	4.84
Ditch	286.67*	100-yr	67.70	6683.27	6684.07	6685.40	6691.73	0.149814	22.19	3.05	4.60	4.81
Ditch	283.33*	100-yr	67.70	6682.77	6683.57	6684.90	6691.20	0.148871	22.15	3.06	4.61	4.79
Ditch	280	100-yr	67.70	6682.28	6683.09	6684.41	6690.66	0.147625	22.08	3.07	4.61	4.77
Ditch	275.60*	100-yr	67.70	6681.68	6682.49	6683.81	6690.02	0.146392	22.02	3.08	4.62	4.75
Ditch	271.20*	100-yr	67.70	6681.08	6681.89	6683.21	6689.39	0.145476	21.97	3.08	4.62	4.74
Ditch	266.80*	100-yr	67.70	6680.48	6681.29	6682.61	6688.76	0.144567	21.92	3.09	4.62	4.73
Ditch	262.40*	100-yr	67.70	6679.88	6680.69	6682.01	6688.13	0.143665	21.87	3.10	4.62	4.71

HEC-RAS Plan: n=0.018 River: NWRP_Ditch Reach: Ditch Profile: 100-yr (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Ditch	258	100-yr	67.70	6679.28	6680.09	6681.41	6687.52	0.143366	21.86	3.10	4.63	4.71
Ditch	253.15*	100-yr	67.70	6678.38	6679.19	6680.51	6686.75	0.147316	22.06	3.07	4.61	4.77
Ditch	248.31*	100-yr	67.70	6677.48	6678.28	6679.61	6685.98	0.151084	22.26	3.04	4.60	4.83
Ditch	243.46*	100-yr	67.70	6676.58	6677.38	6678.71	6685.19	0.154319	22.43	3.02	4.59	4.88
Ditch	238.62*	100-yr	67.70	6675.68	6676.47	6677.81	6684.39	0.157305	22.58	3.00	4.58	4.92
Ditch	233.77*	100-yr	67.70	6674.78	6675.57	6676.91	6683.58	0.160022	22.71	2.98	4.57	4.96
Ditch	228.92*	100-yr	67.70	6673.88	6674.66	6676.01	6682.76	0.162448	22.83	2.97	4.57	5.00
Ditch	224.08*	100-yr	67.70	6672.97	6673.75	6675.10	6681.94	0.164921	22.95	2.95	4.56	5.03
Ditch	219.23*	100-yr	67.70	6672.07	6672.85	6674.20	6681.10	0.166717	23.04	2.94	4.56	5.06
Ditch	214.38*	100-yr	67.70	6671.17	6671.95	6673.30	6680.26	0.168537	23.13	2.93	4.55	5.08
Ditch	209.54*	100-yr	67.70	6670.27	6671.04	6672.40	6679.41	0.170012	23.20	2.92	4.55	5.10
Ditch	204.69*	100-yr	67.70	6669.37	6670.14	6671.50	6678.56	0.171504	23.27	2.91	4.54	5.13
Ditch	199.85*	100-yr	67.70	6668.47	6669.24	6670.60	6677.69	0.172633	23.32	2.90	4.54	5.14
Ditch	195	100-yr	67.70	6667.57	6668.34	6669.70	6676.83	0.173772	23.37	2.90	4.54	5.16
Ditch	191.00*	100-yr	67.70	6666.81	6667.58	6668.94	6676.13	0.175691	23.46	2.89	4.53	5.18
Ditch	187.00*	100-yr	67.70	6666.05	6666.81	6668.18	6675.44	0.177638	23.55	2.87	4.53	5.21
Ditch	183	100-yr	67.70	6665.29	6666.05	6667.42	6674.73	0.179215	23.63	2.87	4.52	5.23
Ditch	178.45*	100-yr	67.70	6664.40	6665.16	6666.53	6673.89	0.180809	23.70	2.86	4.52	5.26
Ditch	173.91*	100-yr	67.70	6663.51	6664.27	6665.64	6673.04	0.182017	23.76	2.85	4.52	5.27
Ditch	169.36*	100-yr	67.70	6662.61	6663.37	6664.74	6672.19	0.183644	23.83	2.84	4.51	5.29
Ditch	164.82*	100-yr	67.70	6661.72	6662.48	6663.85	6671.34	0.184876	23.88	2.83	4.51	5.31
Ditch	160.27*	100-yr	67.70	6660.83	6661.58	6662.96	6670.48	0.185703	23.92	2.83	4.51	5.32
Ditch	155.73*	100-yr	67.70	6659.94	6660.69	6662.07	6669.61	0.186535	23.96	2.83	4.51	5.33
Ditch	151.18*	100-yr	67.70	6659.05	6659.80	6661.18	6668.75	0.187372	24.00	2.82	4.50	5.35
Ditch	146.64*	100-yr	67.70	6658.16	6658.91	6660.29	6667.89	0.188213	24.03	2.82	4.50	5.36
Ditch	142.09*	100-yr	67.70	6657.26	6658.01	6659.39	6667.01	0.189060	24.07	2.81	4.50	5.37
Ditch	137.55*	100-yr	67.70	6656.37	6657.12	6658.50	6666.14	0.189485	24.09	2.81	4.50	5.37
Ditch	133	100-yr	67.70	6655.48	6656.23	6657.61	6665.26	0.189911	24.11	2.81	4.50	5.38
Ditch	130.00*	100-yr	67.70	6655.08	6655.84	6657.21	6664.69	0.184464	23.87	2.84	4.51	5.31
Ditch	127	100-yr	67.70	6654.69	6655.45	6656.82	6664.14	0.179612	23.65	2.86	4.52	5.24
Ditch	122.50*	100-yr	67.70	6653.99	6654.76	6656.12	6663.23	0.173011	23.34	2.90	4.54	5.15
Ditch	118.00*	100-yr	67.70	6653.30	6654.08	6655.43	6662.35	0.167442	23.07	2.93	4.55	5.07
Ditch	113.50*	100-yr	67.70	6652.60	6653.38	6654.73	6661.53	0.163855	22.90	2.96	4.56	5.02
Ditch	109.00*	100-yr	67.70	6651.90	6652.69	6654.03	6660.75	0.161402	22.78	2.97	4.57	4.98
Ditch	104.50*	100-yr	67.70	6651.21	6652.00	6653.34	6659.98	0.158996	22.66	2.99	4.58	4.94
Ditch	100.00*	100-yr	67.70	6650.51	6651.30	6652.64	6659.24	0.157979	22.61	2.99	4.58	4.93
Ditch	95.50*	100-yr	67.70	6649.81	6650.60	6651.94	6658.51	0.156970	22.56	3.00	4.58	4.91
Ditch	91.00*	100-yr	67.70	6649.11	6649.90	6651.24	6657.80	0.156635	22.54	3.00	4.58	4.91
Ditch	86.50*	100-yr	67.70	6648.42	6649.21	6650.55	6657.08	0.155637	22.49	3.01	4.59	4.90
Ditch	82	100-yr	67.70	6647.72	6648.51	6649.85	6656.38	0.155637	22.49	3.01	4.59	4.90
Ditch	77.300*	100-yr	67.70	6647.37	6648.20	6649.50	6655.31	0.135030	21.40	3.16	4.65	4.58
Ditch	72.600*	100-yr	67.70	6647.02	6647.87	6649.15	6654.45	0.120598	20.57	3.29	4.71	4.34
Ditch	67.900*	100-yr	67.70	6646.67	6647.55	6648.80	6653.71	0.109966	19.91	3.40	4.75	4.15
Ditch	63.200*	100-yr	67.70	6646.32	6647.22	6648.45	6653.03	0.101258	19.34	3.50	4.80	3.99
Ditch	58.500*	100-yr	67.70	6645.97	6646.89	6648.10	6652.44	0.094805	18.90	3.58	4.83	3.87
Ditch	53.800*	100-yr	67.70	6645.62	6646.55	6647.75	6651.89	0.089684	18.53	3.65	4.86	3.77
Ditch	49.100*	100-yr	67.70	6645.27	6646.21	6647.40	6651.39	0.085992	18.26	3.71	4.88	3.69
Ditch	44.400*	100-yr	67.70	6644.92	6645.87	6647.05	6650.93	0.083236	18.05	3.75	4.90	3.64
Ditch	39.700*	100-yr	67.70	6644.57	6645.53	6646.70	6650.50	0.081169	17.89	3.78	4.91	3.59
Ditch	35	100-yr	67.70	6644.22	6645.18	6646.35	6650.09	0.079590	17.76	3.81	4.92	3.56
Ditch	31.000*	100-yr	67.70	6643.35	6644.28	6645.48	6649.62	0.089849	18.54	3.65	4.86	3.77
Ditch	27.000*	100-yr	67.70	6642.47	6643.37	6644.60	6649.12	0.099735	19.24	3.52	4.80	3.96
Ditch	23.000*	100-yr	67.70	6641.60	6642.48	6643.73	6648.60	0.108906	19.84	3.41	4.76	4.13
Ditch	19	100-yr	67.70	6640.72	6641.58	6642.85	6648.05	0.117764	20.40	3.32	4.72	4.29
Ditch	14.250*	100-yr	67.70	6640.48	6641.38	6642.61	6647.17	0.100683	19.30	3.51	4.80	3.98
Ditch	9.500*	100-yr	67.70	6640.24	6641.18	6642.37	6646.44	0.088054	18.41	3.68	4.87	3.74
Ditch	4.750*	100-yr	67.70	6639.99	6640.95	6642.12	6645.85	0.079449	17.75	3.81	4.92	3.56
Ditch	0	100-yr	67.70	6639.75	6640.74	6641.88	6645.31	0.072128	17.15	3.95	4.98	3.40

HEC-RAS Plan: n=0.018 River: NWRP_Ditch Reach: Ditch Profile: 100-yr

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Chnl	Vel Head	Q Channel	Top Width	Shear Chan	Hydr Depth C
			(ft)	(ft)	(ft/s)	(ft)	(cfs)	(ft)	(lb/sq ft)	(ft)
Ditch	619	100-yr	6742.02	6741.38	6.41	0.64	67.45	8.96	1.34	1.32
Ditch	614.00*	100-yr	6741.45	6739.51	11.16	1.94	67.70	7.53	4.75	0.81
Ditch	609.00*	100-yr	6740.65	6738.13	12.72	2.51	67.70	7.77	6.46	0.69
Ditch	604.00*	100-yr	6739.65	6736.83	13.49	2.83	67.70	8.28	7.54	0.61
Ditch	599	100-yr	6738.50	6735.56	13.76	2.94	67.70	8.95	8.08	0.55
Ditch	595	100-yr	6737.54	6732.99	17.10	4.55	67.70	4.98	3.04	0.79
Ditch	590.29*	100-yr	6737.17	6732.51	17.31	4.66	67.70	4.96	3.13	0.79
Ditch	585.57*	100-yr	6736.79	6732.02	17.51	4.76	67.70	4.95	3.21	0.78
Ditch	580.86*	100-yr	6736.40	6731.55	17.67	4.85	67.70	4.93	3.27	0.78
Ditch	576.14*	100-yr	6736.01	6731.07	17.83	4.94	67.70	4.92	3.34	0.77
Ditch	571.43*	100-yr	6735.61	6730.59	17.97	5.02	67.70	4.91	3.39	0.77
Ditch	566.71*	100-yr	6735.20	6730.11	18.11	5.09	67.70	4.89	3.45	0.76
Ditch	562	100-yr	6734.79	6729.63	18.22	5.16	67.70	4.88	3.50	0.76
Ditch	557.33*	100-yr	6734.31	6728.99	18.51	5.32	67.70	4.86	3.62	0.75
Ditch	552.67*	100-yr	6733.83	6728.35	18.77	5.48	67.70	4.84	3.74	0.75
Ditch	548	100-yr	6733.32	6727.71	19.00	5.61	67.70	4.82	3.84	0.74
Ditch	543.00*	100-yr	6732.79	6727.05	19.21	5.74	67.70	4.81	3.94	0.73
Ditch	538.00*	100-yr	6732.26	6726.41	19.41	5.85	67.70	4.79	4.02	0.73
Ditch	533.00*	100-yr	6731.71	6725.75	19.59	5.96	67.70	4.78	4.11	0.72
Ditch	528.00*	100-yr	6731.16	6725.09	19.75	6.06	67.70	4.77	4.18	0.72
Ditch	523.00*	100-yr	6730.59	6724.45	19.89	6.15	67.70	4.76	4.25	0.72
Ditch	518.00*	100-yr	6730.02	6723.79	20.02	6.23	67.70	4.75	4.31	0.71
Ditch	513.00*	100-yr	6729.45	6723.14	20.15	6.31	67.70	4.74	4.37	0.71
Ditch	508.00*	100-yr	6728.86	6722.50	20.24	6.37	67.70	4.73	4.42	0.71
Ditch	503.00*	100-yr	6728.27	6721.84	20.34	6.43	67.70	4.72	4.46	0.70
Ditch	498.00*	100-yr	6727.67	6721.19	20.43	6.48	67.70	4.72	4.51	0.70
Ditch	493.00*	100-yr	6727.08	6720.55	20.50	6.53	67.70	4.71	4.54	0.70
Ditch	488.00*	100-yr	6726.47	6719.89	20.57	6.58	67.70	4.71	4.58	0.70
Ditch	483.00*	100-yr	6725.86	6719.24	20.64	6.62	67.70	4.70	4.61	0.70
Ditch	478.00*	100-yr	6725.25	6718.60	20.68	6.65	67.70	4.70	4.63	0.70
Ditch	473	100-yr	6724.64	6717.95	20.74	6.69	67.70	4.70	4.66	0.69
Ditch	468.06*	100-yr	6723.91	6716.91	21.22	7.00	67.70	4.67	4.90	0.68
Ditch	463.11*	100-yr	6723.15	6715.87	21.65	7.28	67.70	4.64	5.12	0.67
Ditch	458.17*	100-yr	6722.37	6714.83	22.03	7.54	67.70	4.61	5.33	0.67
Ditch	453.22*	100-yr	6721.57	6713.80	22.36	7.77	67.70	4.59	5.50	0.66
Ditch	448.28*	100-yr	6720.74	6712.77	22.64	7.97	67.70	4.58	5.66	0.65
Ditch	443.33*	100-yr	6719.88	6711.73	22.90	8.15	67.70	4.56	5.80	0.65
Ditch	438.39*	100-yr	6719.01	6710.70	23.13	8.31	67.70	4.55	5.93	0.64
Ditch	433.44*	100-yr	6718.12	6709.67	23.32	8.45	67.70	4.54	6.04	0.64
Ditch	428.50*	100-yr	6717.23	6708.65	23.50	8.58	67.70	4.53	6.15	0.64
Ditch	423.56*	100-yr	6716.31	6707.61	23.66	8.70	67.70	4.52	6.24	0.63
Ditch	418.61*	100-yr	6715.38	6706.59	23.79	8.80	67.70	4.51	6.32	0.63
Ditch	413.67*	100-yr	6714.45	6705.55	23.92	8.89	67.70	4.51	6.39	0.63
Ditch	408.72*	100-yr	6713.50	6704.52	24.03	8.98	67.70	4.50	6.46	0.63
Ditch	403.78*	100-yr	6712.55	6703.50	24.13	9.05	67.70	4.50	6.52	0.62
Ditch	398.83*	100-yr	6711.58	6702.48	24.20	9.10	67.70	4.49	6.56	0.62
Ditch	393.89*	100-yr	6710.61	6701.45	24.28	9.16	67.70	4.49	6.61	0.62
Ditch	388.94*	100-yr	6709.63	6700.41	24.36	9.22	67.70	4.49	6.65	0.62
Ditch	384	100-yr	6708.65	6699.39	24.41	9.26	67.70	4.48	6.69	0.62
Ditch	379.33*	100-yr	6707.39	6698.86	23.44	8.54	67.70	4.53	6.11	0.64
Ditch	374.67*	100-yr	6706.31	6698.33	22.67	7.98	67.70	4.58	5.67	0.65
Ditch	370	100-yr	6705.35	6697.79	22.06	7.57	67.70	4.61	5.34	0.67
Ditch	365.25*	100-yr	6704.60	6696.91	22.24	7.69	67.70	4.60	5.44	0.66
Ditch	360.50*	100-yr	6703.84	6696.03	22.43	7.82	67.70	4.59	5.54	0.66
Ditch	355.75*	100-yr	6703.07	6695.15	22.58	7.92	67.70	4.58	5.62	0.65
Ditch	351.00*	100-yr	6702.29	6694.28	22.71	8.02	67.70	4.57	5.70	0.65
Ditch	346.25*	100-yr	6701.50	6693.40	22.83	8.10	67.70	4.57	5.76	0.65
Ditch	341.50*	100-yr	6700.71	6692.53	22.93	8.17	67.70	4.56	5.82	0.65
Ditch	336.75*	100-yr	6699.90	6691.65	23.04	8.25	67.70	4.56	5.88	0.65
Ditch	332	100-yr	6699.09	6690.78	23.13	8.31	67.70	4.55	5.93	0.64
Ditch	327.33*	100-yr	6698.23	6690.09	22.88	8.14	67.70	4.56	5.79	0.65
Ditch	322.67*	100-yr	6697.42	6689.40	22.73	8.03	67.70	4.57	5.71	0.65
Ditch	318.00*	100-yr	6696.64	6688.71	22.59	7.93	67.70	4.58	5.63	0.65
Ditch	313.33*	100-yr	6695.89	6688.02	22.49	7.86	67.70	4.59	5.58	0.66
Ditch	308.67*	100-yr	6695.16	6687.32	22.46	7.84	67.70	4.59	5.56	0.66
Ditch	304.00*	100-yr	6694.44	6686.64	22.41	7.80	67.70	4.59	5.53	0.66
Ditch	299.33*	100-yr	6693.72	6685.95	22.36	7.77	67.70	4.59	5.50	0.66
Ditch	294.67*	100-yr	6693.02	6685.25	22.36	7.77	67.70	4.59	5.50	0.66

HEC-RAS Plan: n=0.018 River: NWRP_Ditch Reach: Ditch Profile: 100-yr (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Chnl	Vel Head	Q Channel	Top Width	Shear Chan	Hydr Depth C
			(ft)	(ft)	(ft/s)	(ft)	(cfs)	(ft)	(lb/sq ft)	(ft)
Ditch	290	100-yr	6692.29	6684.56	22.31	7.73	67.70	4.60	5.48	0.66
Ditch	286.67*	100-yr	6691.73	6684.07	22.19	7.66	67.70	4.60	5.41	0.66
Ditch	283.33*	100-yr	6691.20	6683.57	22.15	7.62	67.70	4.61	5.39	0.66
Ditch	280	100-yr	6690.66	6683.09	22.08	7.58	67.70	4.61	5.35	0.66
Ditch	275.60*	100-yr	6690.02	6682.49	22.02	7.53	67.70	4.62	5.32	0.67
Ditch	271.20*	100-yr	6689.39	6681.89	21.97	7.50	67.70	4.62	5.29	0.67
Ditch	266.80*	100-yr	6688.76	6681.29	21.92	7.47	67.70	4.62	5.27	0.67
Ditch	262.40*	100-yr	6688.13	6680.69	21.87	7.43	67.70	4.62	5.24	0.67
Ditch	258	100-yr	6687.52	6680.09	21.86	7.42	67.70	4.63	5.23	0.67
Ditch	253.15*	100-yr	6686.75	6679.19	22.06	7.57	67.70	4.61	5.34	0.67
Ditch	248.31*	100-yr	6685.98	6678.28	22.26	7.70	67.70	4.60	5.45	0.66
Ditch	243.46*	100-yr	6685.19	6677.38	22.43	7.82	67.70	4.59	5.54	0.66
Ditch	238.62*	100-yr	6684.39	6676.47	22.58	7.92	67.70	4.58	5.62	0.65
Ditch	233.77*	100-yr	6683.58	6675.57	22.71	8.02	67.70	4.57	5.70	0.65
Ditch	228.92*	100-yr	6682.76	6674.66	22.83	8.10	67.70	4.57	5.76	0.65
Ditch	224.08*	100-yr	6681.94	6673.75	22.95	8.19	67.70	4.56	5.83	0.65
Ditch	219.23*	100-yr	6681.10	6672.85	23.04	8.25	67.70	4.56	5.88	0.65
Ditch	214.38*	100-yr	6680.26	6671.95	23.13	8.31	67.70	4.55	5.93	0.64
Ditch	209.54*	100-yr	6679.41	6671.04	23.20	8.36	67.70	4.55	5.97	0.64
Ditch	204.69*	100-yr	6678.56	6670.14	23.27	8.41	67.70	4.54	6.01	0.64
Ditch	199.85*	100-yr	6677.69	6669.24	23.32	8.45	67.70	4.54	6.04	0.64
Ditch	195	100-yr	6676.83	6668.34	23.37	8.49	67.70	4.54	6.07	0.64
Ditch	191.00*	100-yr	6676.13	6667.58	23.46	8.56	67.70	4.53	6.12	0.64
Ditch	187.00*	100-yr	6675.44	6666.81	23.55	8.62	67.70	4.53	6.18	0.63
Ditch	183	100-yr	6674.73	6666.05	23.63	8.68	67.70	4.52	6.22	0.63
Ditch	178.45*	100-yr	6673.89	6665.16	23.70	8.73	67.70	4.52	6.26	0.63
Ditch	173.91*	100-yr	6673.04	6664.27	23.76	8.77	67.70	4.52	6.29	0.63
Ditch	169.36*	100-yr	6672.19	6663.37	23.83	8.82	67.70	4.51	6.34	0.63
Ditch	164.82*	100-yr	6671.34	6662.48	23.88	8.87	67.70	4.51	6.37	0.63
Ditch	160.27*	100-yr	6670.48	6661.58	23.92	8.89	67.70	4.51	6.39	0.63
Ditch	155.73*	100-yr	6669.61	6660.69	23.96	8.92	67.70	4.51	6.41	0.63
Ditch	151.18*	100-yr	6668.75	6659.80	24.00	8.95	67.70	4.50	6.44	0.63
Ditch	146.64*	100-yr	6667.89	6658.91	24.03	8.98	67.70	4.50	6.46	0.63
Ditch	142.09*	100-yr	6667.01	6658.01	24.07	9.00	67.70	4.50	6.48	0.63
Ditch	137.55*	100-yr	6666.14	6657.12	24.09	9.02	67.70	4.50	6.49	0.62
Ditch	133	100-yr	6665.26	6656.23	24.11	9.03	67.70	4.50	6.50	0.62
Ditch	130.00*	100-yr	6664.69	6655.84	23.87	8.85	67.70	4.51	6.36	0.63
Ditch	127	100-yr	6664.14	6655.45	23.65	8.69	67.70	4.52	6.23	0.63
Ditch	122.50*	100-yr	6663.23	6654.76	23.34	8.46	67.70	4.54	6.05	0.64
Ditch	118.00*	100-yr	6662.35	6654.08	23.07	8.27	67.70	4.55	5.90	0.64
Ditch	113.50*	100-yr	6661.53	6653.38	22.90	8.15	67.70	4.56	5.80	0.65
Ditch	109.00*	100-yr	6660.75	6652.69	22.78	8.06	67.70	4.57	5.74	0.65
Ditch	104.50*	100-yr	6659.98	6652.00	22.66	7.98	67.70	4.58	5.67	0.65
Ditch	100.00*	100-yr	6659.24	6651.30	22.61	7.94	67.70	4.58	5.64	0.65
Ditch	95.50*	100-yr	6658.51	6650.60	22.56	7.91	67.70	4.58	5.61	0.65
Ditch	91.00*	100-yr	6657.80	6649.90	22.54	7.90	67.70	4.58	5.60	0.66
Ditch	86.50*	100-yr	6657.08	6649.21	22.49	7.86	67.70	4.59	5.58	0.66
Ditch	82	100-yr	6656.38	6648.51	22.49	7.86	67.70	4.59	5.58	0.66
Ditch	77.300*	100-yr	6655.31	6648.20	21.40	7.12	67.70	4.65	5.00	0.68
Ditch	72.600*	100-yr	6654.45	6647.87	20.57	6.58	67.70	4.71	4.58	0.70
Ditch	67.900*	100-yr	6653.71	6647.55	19.91	6.16	67.70	4.75	4.26	0.72
Ditch	63.200*	100-yr	6653.03	6647.22	19.34	5.81	67.70	4.80	3.99	0.73
Ditch	58.500*	100-yr	6652.44	6646.89	18.90	5.55	67.70	4.83	3.79	0.74
Ditch	53.800*	100-yr	6651.89	6646.55	18.53	5.34	67.70	4.86	3.63	0.75
Ditch	49.100*	100-yr	6651.39	6646.21	18.26	5.18	67.70	4.88	3.52	0.76
Ditch	44.400*	100-yr	6650.93	6645.87	18.05	5.06	67.70	4.90	3.43	0.77
Ditch	39.700*	100-yr	6650.50	6645.53	17.89	4.97	67.70	4.91	3.36	0.77
Ditch	35	100-yr	6650.09	6645.18	17.76	4.90	67.70	4.92	3.31	0.77
Ditch	31.000*	100-yr	6649.62	6644.28	18.54	5.34	67.70	4.86	3.64	0.75
Ditch	27.000*	100-yr	6649.12	6643.37	19.24	5.75	67.70	4.80	3.95	0.73
Ditch	23.000*	100-yr	6648.60	6642.48	19.84	6.12	67.70	4.76	4.23	0.72
Ditch	19	100-yr	6648.05	6641.58	20.40	6.47	67.70	4.72	4.49	0.70
Ditch	14.250*	100-yr	6647.17	6641.38	19.30	5.79	67.70	4.80	3.98	0.73
Ditch	9.500*	100-yr	6646.44	6641.18	18.41	5.27	67.70	4.87	3.58	0.76
Ditch	4.750*	100-yr	6645.85	6640.95	17.75	4.90	67.70	4.92	3.31	0.77
Ditch	0	100-yr	6645.31	6640.74	17.15	4.57	67.70	4.98	3.06	0.79

Errors Warnings and Notes for Plan : n=0.018

Location:	River: NWRP_Ditch Reach: Ditch RS: 614.00* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than
	0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 609.00* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 599 Profile: 100-yr
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid,
	energy was used.
Location:	River: NWRP_Ditch Reach: Ditch RS: 595 Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than
	0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 379.33* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 374.67* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 77.300* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross
	section. This may indicate the need for additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 72.600* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 14.250* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.
Location:	River: NWRP_Ditch Reach: Ditch RS: 9.500* Profile: 100-yr
Warning:	The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for
	additional cross sections.

Former Schwartzwalder Mine North Waste Rock Pile Diversion Channel
STORM WATER MANAGEMENT CALCULATION

BURNS McDONNELL

PROJECT	Former Schwartzwalder Mine North Waste Rock Pile Diversion Channel			
SUBJECT	Storm Water Management Calculation			
PROJECT NUMBER	112016			
DATE	11/15/2019	Page 1	of	7

Purpose: The purpose of this calculation package is to calculate shear stress in the drainage channel, evaluate superelevation around the channel bend, determine the length of protection for the channel bend, and evaluate the required size for the dissipator basin that will be located at the outlet of the lower channel.

Background: Runoff from a steep drainage flows onto the north part of the North Waste Rock Pile at the Former Schwartzwalder Mine. To capture and convey the flow from the drainage a channel will be constructed across the pile and down an existing access road discharging into Ralston Creek located south of the pile. The outlet of the lower channel will include a riprap dissipator basin and lower water road crossing. The dissipator basin will slow outlet velocity as water enters Ralston Creek.

Methodology: Shear stress, superelevation, and length of protection values were calculated using FHWA HEC No 15 Urban Drainage Design Manual. The riprap basin constructed to dissipate energy and velocity was evaluated using FHWA HEC No. 14 Hydraulic Design of Energy Dissipators for Culverts and Channels. All channel parameters, including dimensions and slopes, were provided by Alexco Water & Environment. The capacity of the channel was determined via the Hydraflow extension of Autodesk Civil 3D 2019.

Assumptions:
1. Peak runoff for the drainage basin is 67.7 cfs. This was verified by the Rational Method.
2. The Manning's n coefficient of the Geoweb is 0.029.

References:
1. Presto Geosystems Geoweb® Channel Protection Overview **(Attachment 1)**
2. Federal Highway Administration Hydraulic Engineering Circular No. 15 Design of Roadside Channels with Flexible Linings, Third Edition. (2005). **(Attachment 2)**
3. Federal Highway Administration Hydraulic Engineering Circular No. 14 Hydraulic Design of Energy Dissipators for Culverts and Channels, Third Edition. (2005). **(Attachment 3)**
4. TR-28 North Waste Rock Pile Diversion Channel Design Drawings, Revision E (Dated 11-22-2019). **(Attachment 4)**

7222 = Data Input Cell
7222 = Calculated and/or Referenced Cell

Conclusions: The entire geoweb channel is capable of withstanding the expected shear stress and velocity of stormwater generated in a 100-year storm. The design depth of the channel provides more than the required one foot of freeboard. Furthermore, the depth at the channel bend exceeds the flow depth adjusted for the superelevation, while providing one foot of freeboard. The riprap basin dissipates stormwater to a suitable velocity for grass-lined channels to convey.

Prepared By: Sarah Foreman, E.I.T. Date: 11/7/2019
Checked By: Tyler Schmidt, E.I.T. Date: 11/15/2019

Approved By: Joshua Lee Digitally signed by Joshua Lee DN: C=US, E=jllee@burnsmcd.com, O=Burns & McDonnell Engineering, OU=Environmental, CN=Joshua Lee Reason: I have reviewed this document Date: 2019.11.26 08:54:29-07'00' Date: 11/25/2019

Channel Report

Former Schwartzalder Mine North Waste Rock - Upper Channel

Trapezoidal

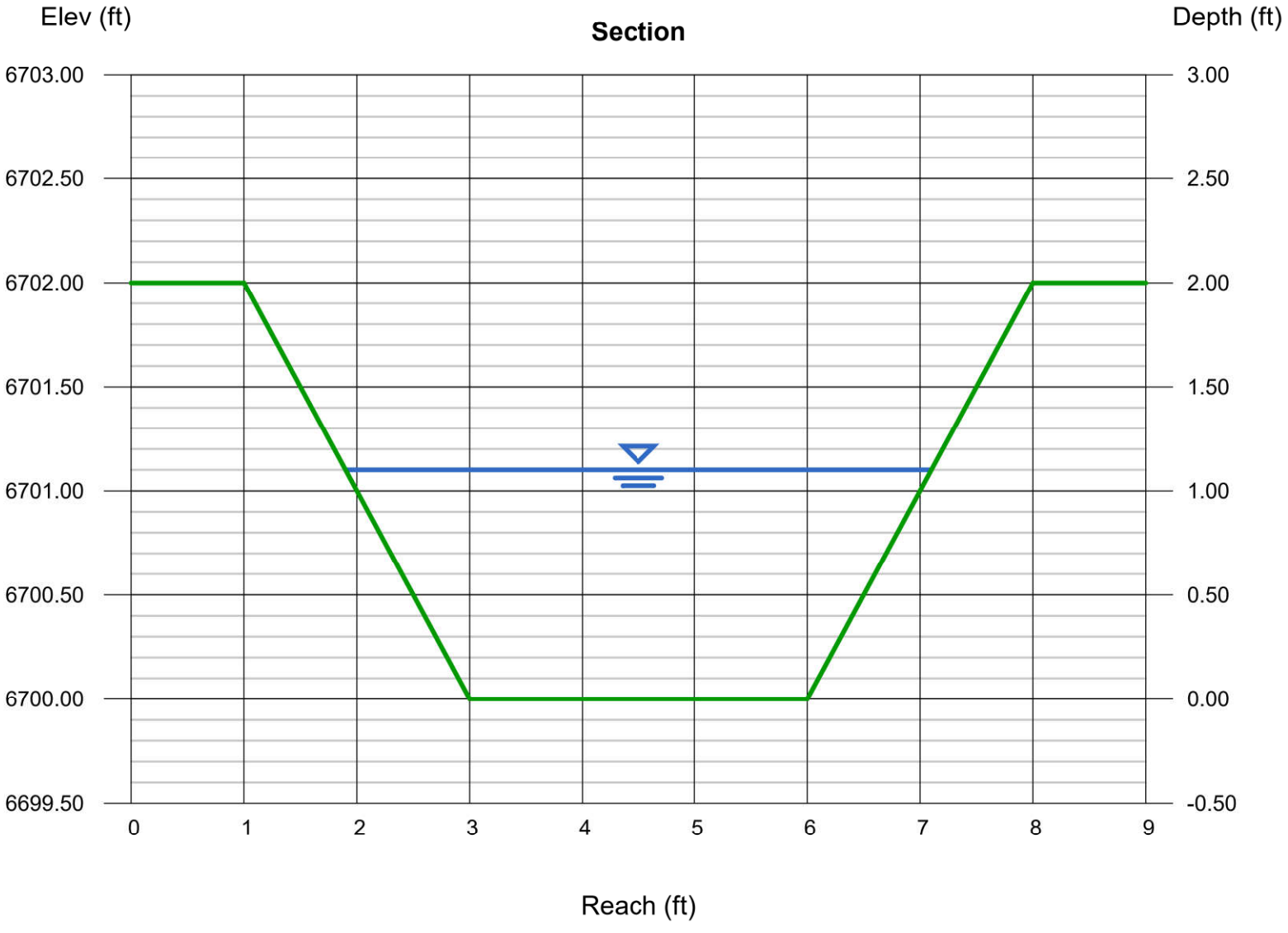
Bottom Width (ft)	= 3.00
Side Slopes (z:1)	= 1.00, 1.00
Total Depth (ft)	= 2.00
Invert Elev (ft)	= 6700.00
Slope (%)	= 13.00
N-Value	= 0.029

Calculations

Compute by:	Known Q
Known Q (cfs)	= 67.70

Highlighted

Depth (ft)	= 1.10
Q (cfs)	= 67.70
Area (sqft)	= 4.51
Velocity (ft/s)	= 15.01
Wetted Perim (ft)	= 6.11
Crit Depth, Yc (ft)	= 2.00
Top Width (ft)	= 5.20
EGL (ft)	= 4.60



Channel Report

Former Schwartzalder Mine North Waste Rock - Lower Channel

Trapezoidal

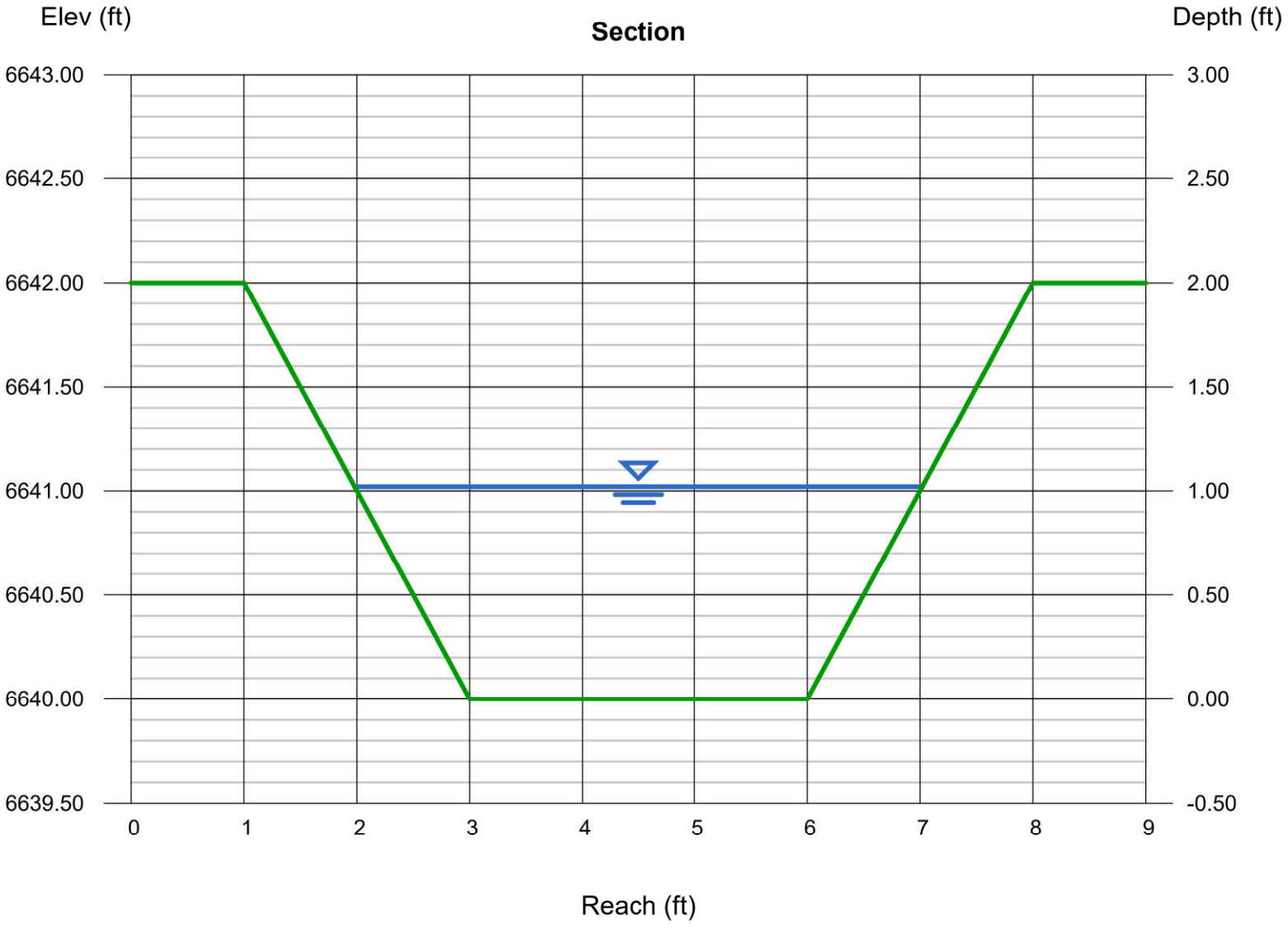
Bottom Width (ft)	= 3.00
Side Slopes (z:1)	= 1.00, 1.00
Total Depth (ft)	= 2.00
Invert Elev (ft)	= 6640.00
Slope (%)	= 17.00
N-Value	= 0.029

Calculations

Compute by:	Known Q
Known Q (cfs)	= 67.70

Highlighted

Depth (ft)	= 1.02
Q (cfs)	= 67.70
Area (sqft)	= 4.10
Velocity (ft/s)	= 16.51
Wetted Perim (ft)	= 5.88
Crit Depth, Yc (ft)	= 2.00
Top Width (ft)	= 5.04
EGL (ft)	= 5.26



Former Schwartzwalder Mine North Waste Rock Pile Diversion Channel
STORM WATER MANAGEMENT CALCULATION

Calculation by: SJF Date: 11/7/2019
Checked by: JLL Date: 11/15/2019

Upper Channel Velocity

				Reference
Design Flow Rate, Q	$Q =$	67.7	ft^3/s	See Page 2
Depth of Flow, d	$d =$	1.10	ft	See Page 2
Channel Width, w_b	$w_b =$	3	ft	Design Drawings
Top Width of Flow, w_f	$w_f =$	5.20	ft	
Channel Velocity, V = Q/A	$V =$	15.01	ft/s	See Page 2
Maximum Allowable Velocity, V_a	$V_a =$	36.0	ft/s	Attachment 1-1
$V_a > V$		OK		

Upper Channel Shear Stress

Average channel slope, S_0	$S_0 =$	0.13	ft/ft	See Page 2
specific weight of water, y	$y =$	62.4	lb/ft^3	Attachment 2-1
Shear Stress at max depth, $t_d = ydS_0$	$t_d =$	8.93	lb/ft^2	Attachment 2-2
Maximum Allowable Shear Stress, t_p	$t_p =$	20.90	lb/ft^2	Attachment 1-1
Safety Factor, SF =	$SF =$	1.00		
$SF*t_d$	$SF*t_d =$	8.93	lb/ft^2	
$t_p > SF*t_d$		OK		

Flow in Channel Bend

Acceleration due to gravity, g	$g =$	32.2	ft/s^2	
Radius to Channel Centerline, R_c	$R_c =$	87.5	ft	Design Drawings
Superelevation, $\Delta d = (V^2*w_f) / (g*R_c)$	$\Delta d =$	0.42	ft	Attachment 2-4
Freeboard, f	$f =$	1.0	ft	
Minimum Channel Depth, $d_c = d + \Delta d + f$	$d_c =$	2.52	ft	
Bend Channel Depth, d_d	$d_d =$	3.0	ft	Design Drawings
$d_d > d_c$		OK		

Shear Stress in Channel Bend

Shear Stress at max depth, $t_d = ydS_0$	$t_d =$	8.93	lb/ft^2	
	$R_c/w_f =$	16.83	ft/ft	See Attachment 2-4
Ratio of channel bend to bottom shear stress, K_b	$K_b =$	0.98		See Attachment 2-4

$K_b = 2.00$ if $R_c/w_f \leq 2$

$K_b = 2.38 - 0.206(R_c/w_f) + 0.0073(R_c/w_f)^2$ if $2 < R_c/w_f < 10$

$K_b = 1.05$ if $10 \leq R_c/w_f$

Shear stress on the channel, $t_b = K_b t_d$	$t_b =$	8.75	lb/ft^2	Attachment 2-3
$t_p > SF*t_b$		OK		Attachment 2-5

Former Schwartzwalder Mine North Waste Rock Pile Diversion Channel
STORM WATER MANAGEMENT CALCULATION

Calculation by: SJF Date: 11/7/2019
Checked by: JLL Date: 11/15/2019

Length of Protection in Channel Bend

				Reference
Channel Bottom Width, W_b	w_b =	3	ft	Design Drawings
Cross Sectional Area of Flow, A	A =	4.51	ft^2	
Wetted Perimeter, P	P =	6.11	ft	
Hydraulic Radius of Channel, R = A/P	R =	0.74		
Mannings roughness coefficient, n	n =	0.029		See Assumptions
Unit conversion constant, α	α =	0.60		Attachment 2-4
Length of Protection, $L_P = \alpha(R^{7/6}/n)$	L_P =	14.5	ft	Attachment 2-4

Minimum channel depth is required for the entire curve length and distance downstream.

Lower Channel Velocity

Design Flow Rate, Q	Q =	67.7	ft^3/s	See Page 3
Depth of Flow, d	d =	1.02	ft	See Page 3
Channel Width, w_b	w_b =	3	ft	Design Drawings
Top Width of Flow, w_f	w_f =	5.04	ft	
Channel Velocity, V = Q/A	V =	16.51	ft/s	See Page 3
Maximum Allowable Velocity, V_a	V_a =	36.0	ft/s	Attachment 1-1
$V_a > V$		OK		

Lower Channel Shear Stress

Average channel slope, S_0	S_0 =	0.13	ft/ft	See Page 2
specific weight of water, y	y =	62.4	lb/ft^3	Attachment 2-1
Shear Stress at max depth, $t_d = ydS_0$	t_d =	8.28	lb/ft^2	Attachment 2-2
Maximum Allowable Shear Stress, t_p	t_p =	20.90	lb/ft^2	Attachment 1-1
Safety Factor, SF =	SF =	1.00		
$SF*t_d$	$SF*t_d$ =	8.28	lb/ft^2	
$t_p > SF*t_d$		OK		

Former Schwartzwalder Mine North Waste Rock Pile Diversion Channel
STORM WATER MANAGEMENT CALCULATION

Calculation by: SJF Date: 3/19/2020
Checked by: JLL Date: 3/19/2019

Lower Riprap Basin Sizing - Ensero Channel Dimensions

				Source
Design Flow Rate, Q	**Q =**	67.7	ft^3/s	See Page 3
Depth of Flow, d	**d =**	0.79	ft	See Page 3
Channel/Outlet Width, $w_b = w_o$	**$w_b = w_o$ =**	3.0	ft	Design Drawings
Acceleration due to gravity, g	**g =**	32.2	ft/s^2	
Outlet Velocity, V_o	**V_o =**	17.15	ft/s	See Page 3
Tailwater depth, TW	**TW =**	0	ft	
TW / d < 0.75	**TW / d =**	0		Attachment 3-1
Tailwater Parameter, C_o	**C_o =**	1.4		Attachment 3-1
Mean Rock Size, D_{50}	**D_{50} =**	0.75	ft	
Calculate $h_s / d = 0.86 (D_{50} / d)^{-0.55} (V_o / (gd)^{0.5}) - C_o$	**h_s / d =**	1.53		Attachment 3-1
Dissipator Pool Depth, $h_s = (h_s / d)*d$	**h_s =**	1.21	ft	Attachment 3-1

The recommended ratio of h_s / D_{50} is ≥ 2. Dissipator pool depth will be rounded up to the next 0.5 foot. Attachment 3-2

Dissipator Pool Depth, h_s	**h_s =**	1.50	ft	
Ratio of scour depth to Mean Rock Size, h_s/D_{50}	**h_s/D_{50} =**	2.00	ft	Attachment 3-2
Dissipator Pool Length, $L_s = 10*h_s$ or $3*W_o$ (minimum)	**L_s =**	15.0	ft	Attachment 3-3
Total Basin Length, $L_B = 15*h_s$ or $4*W_o$ (minimum)	**L_B =**	22.5	ft	Attachment 3-3
Basin Width, $W_B = W_o + 2(L_B / 3)$	**W_B =**	18.0	ft	Attachment 3-3
Side slope eg. 3:1, z	**z =**	3		

Determine exit depth and velocity by trial and success using the following equation

$Q^2 / g = [y_c*(W_B + z*y_c)]^3 / (W_B + 2*z*y_c)$ Attachment 3-4

3. The channel (Actual Q^2 / g	**Q^2 / g =**	142.34		Attachment 3-4
Exit Depth, y_c	**y_c =**	0.73	ft	
Calculated Q^2 / g	**Q^2 / g =**	140.02		Attachment 3-4
Cross-sectional Area of Flow Prism, $A = W_B y_c + z y_c^2$	**A =**	14.63	ft^2	
Exit Velocity, $V_c = Q / A$	**V_c =**	4.63	ft/s	

Channel Report

Former Schwartzalder Mine North Waste Rock - Road Crossing

Trapezoidal

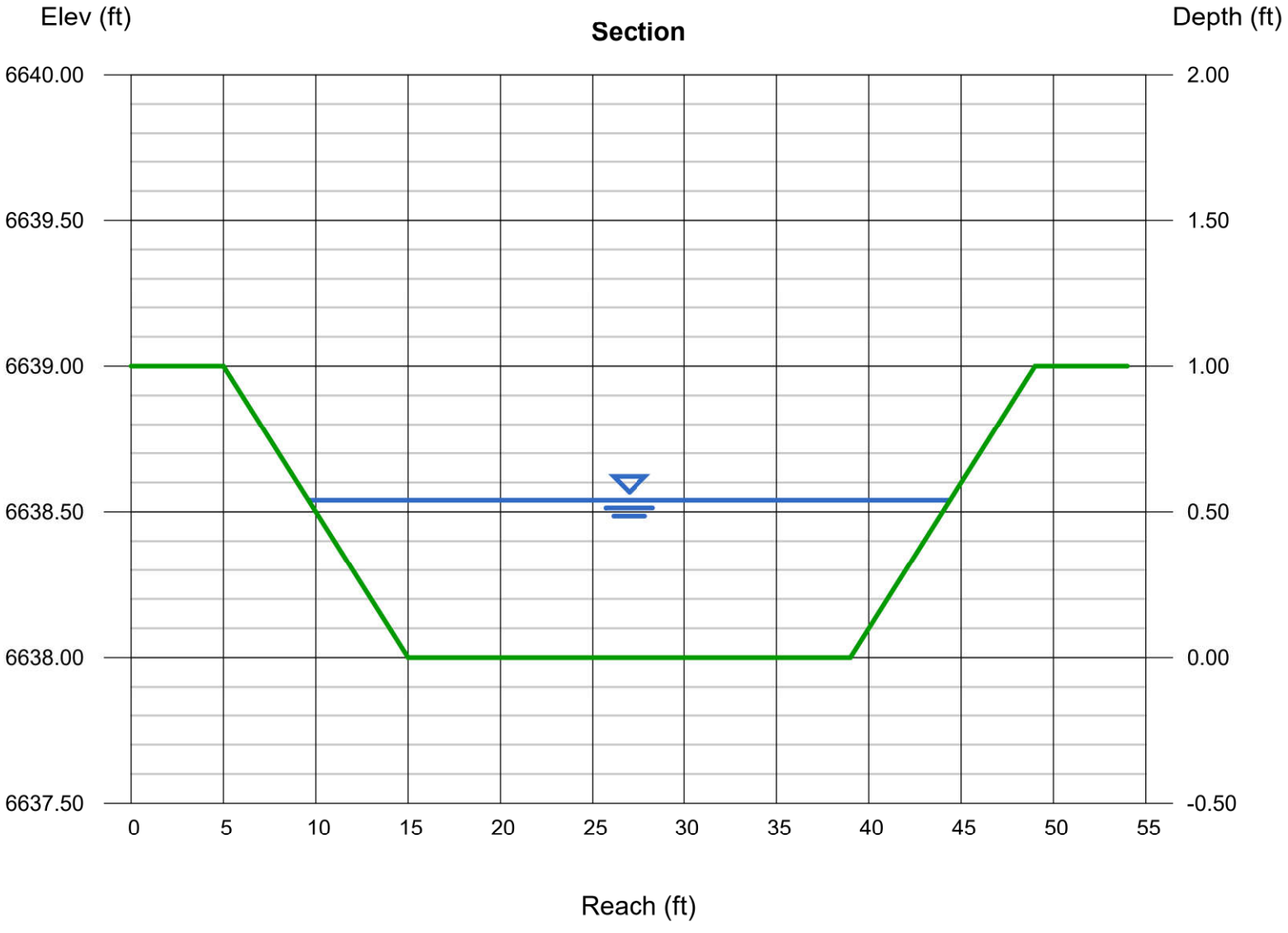
Bottom Width (ft)	= 24.00
Side Slopes (z:1)	= 10.00, 10.00
Total Depth (ft)	= 1.00
Invert Elev (ft)	= 6638.00
Slope (%)	= 2.00
N-Value	= 0.029

Calculations

Compute by:	Known Q
Known Q (cfs)	= 67.70

Highlighted

Depth (ft)	= 0.54
Q (cfs)	= 67.70
Area (sqft)	= 15.88
Velocity (ft/s)	= 4.26
Wetted Perim (ft)	= 34.85
Crit Depth, Yc (ft)	= 0.58
Top Width (ft)	= 34.80
EGL (ft)	= 0.82

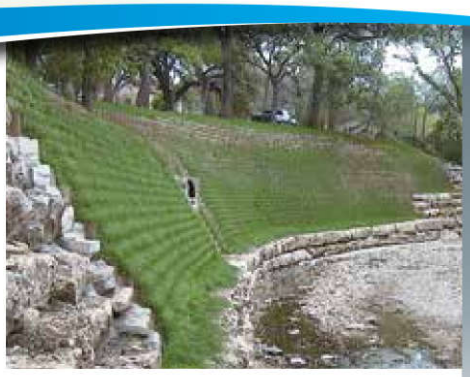


Attachment 1

PRESTO GEOSYSTEMS®
GLOBAL LEADER • GLOBAL PARTNER

SOIL STABILIZATION

GEOWEB®
channel protection
OVERVIEW



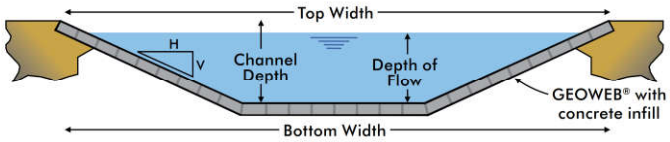
Attachment 1-1

DESIGN OPTION

4 Hard-Armored Concrete Channels

PORTLAND CEMENT CONCRETE FOR CHANNELS WITH HIGH HYDRAULIC STRESSES

GEOWEB® Concrete Channels are a poured-in-place, hard-armored solution for channels exposed to severe velocities and hydraulic stresses. The system becomes a flexible slab that conforms to minor subgrade movement and is more economical than pre-formed concrete systems or Articulated Concrete Blocks (ACBs).



GEOWEB® concrete channels are proven* to withstand sustained flow velocities in excess of 36 ft/s (11 m/s) and shear stresses of 20.9 psf (1.0 kPa). The cellular confinement technology creates a flexible mat of concrete reinforced by the GEOWEB® interconnected high density polyethylene structure. The GEOWEB® system acts as a construction form to allow even steep slopes to be constructed using ordinary concrete slump. The system regulates concrete depth, assuring consistent adherence to design specifications. GEOWEB® channels can be designed to withstand higher velocities and shear stresses with proper cell depth and anchorage.

*Results from research at Colorado State University.

DESIGN MODELS: Critical velocities, Manning's "n" and other hydraulic design parameters have been established for GEOWEB® channels and are incorporated in Presto's proprietary design modeling tools.

Concrete Channel System Comparisons	 Concrete Slump	 Forms & Reinforcement	 Uniform Concrete Depth	 Heavy Equipment & Worker Safety
GEOWEB® Channels	✓ Easier-to-pour higher slump concrete can be used, even on steeper channel embankments due to confinement.	✓ No forms or reinforcement required. Installation is fast, efficient and flexible.	✓ The cell wall height assures defined, consistent concrete depth. Allows a thinner cross section.	✓ No heavy-lifting equipment is required. Installation is safe for workers.
Reinforced Concrete	Low slump required especially on steeper channel embankments.	Reinforcement required.	Over pours and short pours are common.	✓ No heavy-lifting equipment required.
Articulated Concrete Block (ACB)	Concrete ACBs are manufactured offsite and transported after curing.	Cable reinforcement required. Requires heavy-lifting equipment to place.	✓ ACB matresses are a consistent depth.	Heavy equipment is required. Worker injury is more likely.

Attachment 2

Publication No. FHWA-NHI-05-114
September 2005

U.S. Department of Transportation

Federal Highway Administration

Hydraulic Engineering Circular No. 15, Third Edition

Design of Roadside Channels with Flexible Linings

National Highway Institute

static equilibrium, remaining basically unchanged during all stages of flow. Principles of rigid boundary hydraulics can be applied to evaluate this type of system.

In a dynamic system, some change in the channel bed and/or banks is to be expected due to transport of the sediments that comprise the channel boundary. Stability in a dynamic system is attained when the incoming supply of sediment equals the sediment transport rate. This condition, where sediment supply equals sediment transport, is referred to as dynamic equilibrium. Although some detachment and transport of bed and/or bank sediments occurs, this does not preclude attainment of a channel configuration that is basically stable. A dynamic system can be considered stable so long as the net change does not exceed acceptable levels. Because of the need for reliability, static equilibrium conditions and use of linings to achieve a stable condition is usually preferable to using dynamic equilibrium concepts.

Two methods have been developed and are commonly applied to determine if a channel is stable in the sense that the boundaries are basically immobile (static equilibrium): 1) the permissible velocity approach and 2) the permissible tractive force (shear stress) approach. Under the permissible velocity approach the channel is assumed stable if the mean velocity is lower than the maximum permissible velocity. The tractive force (boundary shear stress) approach focuses on stresses developed at the interface between flowing water and materials forming the channel boundary. By Chow's definition, permissible tractive force is the maximum unit tractive force that will not cause serious erosion of channel bed material from a level channel bed (Chow, 1979).

Permissible velocity procedures were first developed around the 1920's. In the 1950's, permissible tractive force procedures became recognized, based on research investigations conducted by the U.S. Bureau of Reclamation. Procedures for design of vegetated channels using the permissible velocity approach were developed by the SCS and have remained in common use.

In spite of the empirical nature of permissible velocity approaches, the methodology has been employed to design numerous stable channels in the United States and throughout the world. However, considering actual physical processes occurring in open-channel flow, a more realistic model of detachment and erosion processes is based on permissible tractive force which is the method recommended in this publication.

2.2.2 Applied Shear Stress

The hydrodynamic force of water flowing in a channel is known as the tractive force. The basis for stable channel design with flexible lining materials is that flow-induced tractive force should not exceed the permissible or critical shear stress of the lining materials. In a uniform flow, the tractive force is equal to the effective component of the drag force acting on the body of water, parallel to the channel bottom (Chow, 1959). The mean boundary shear stress applied to the wetted perimeter is equal to:

$$\tau_o = \gamma RS_o \qquad (2.3)$$

where,

τ_o = mean boundary shear stress, N/m^2 (lb/ft^2)
γ = unit weight of water, 9810 N/m^3 (62.4 lb/ft^3)
R = hydraulic radius, m (ft)
S_o = average bottom slope (equal to energy slope for uniform flow), m/m (ft/ft)

Shear stress in channels is not uniformly distributed along the wetted perimeter (USBR, 1951; Olsen and Florey, 1952; Chow, 1959; Anderson, et al., 1970). A typical distribution of shear stress in a prismatic channel is shown in Figure 2.1. The shear stress is zero at the water surface and reaches a maximum on the centerline of the channel. The maximum for the side slopes occurs at about the lower third of the side.

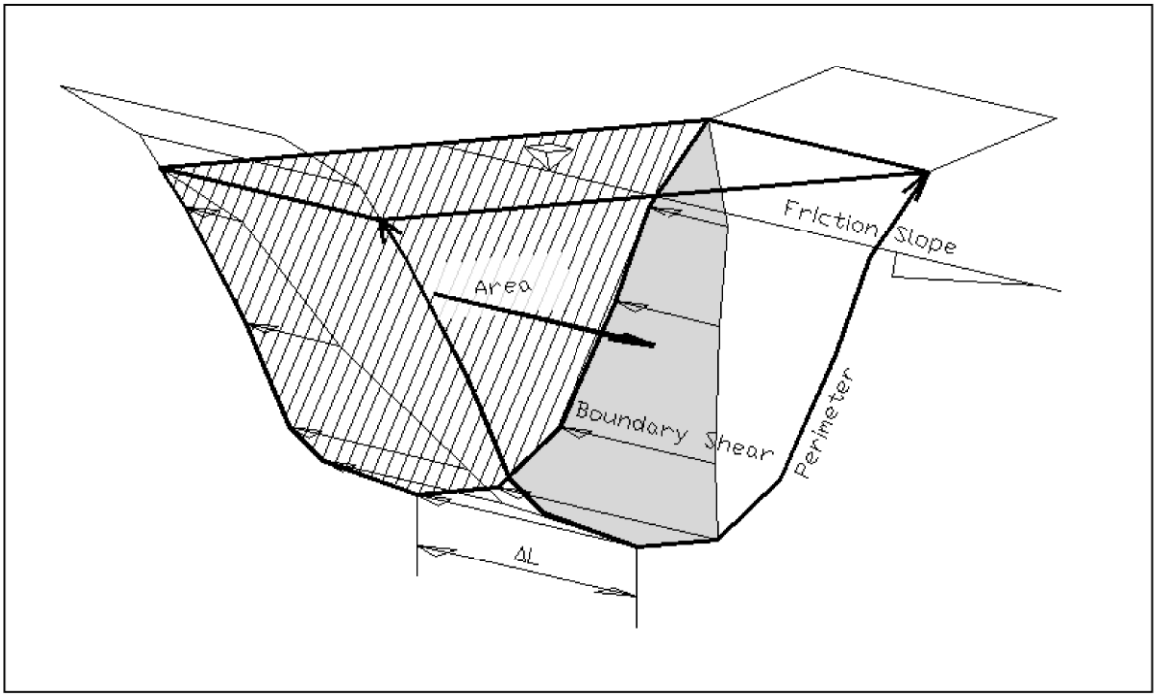


Figure 2.1. Typical Distribution of Shear Stress

The maximum shear stress on a channel bottom, τ_d, and on the channel side, τ_s, in a straight channel depends on the channel shape. To simplify the design process, the maximum channel bottom shear stress is taken as:

$$\tau_d = \gamma \, dS_o \qquad (2.4)$$

where,

τ_d = shear stress in channel at maximum depth, N/m^2 (lb/ft^2)
d = maximum depth of flow in the channel for the design discharge, m (ft)

For trapezoidal channels where the ratio of bottom width to flow depth (B/d) is greater than 4, Equation 2.4 provides an appropriate design value for shear stress on a channel bottom. Most roadside channels are characterized by this relatively shallow flow compared to channel width. For trapezoidal channels with a B/d ratio less than 4, Equation 2.4 is conservative. For example, for a B/d ratio of 3, Equation 2.4 overestimates actual bottom shear stress by 3 to 5 percent for side slope values (Z) of 6 to 1.5, respectively. For a B/d ratio of 1, Equation 2.5 overestimates actual bottom shear stress by 24 to 35 percent for the same side slope values of 6 to 1.5, respectively. In general, Equation 2.4 overestimates in cases of relatively narrow channels with steep side slopes.

Concrete is a non-erodible, rigid lining so it has a very high rigid permissible shear stress. By using the techniques in Section 4.3 (Equation 4.7 and Table 4.5) the permissible shear stress of the vegetative portion of the lining is 2.5 lb/ft^2.

A safety factor of 1.0 is chosen for this situation.

Step 7. The maximum shear stress on the channel side slopes (0.67 lb/ft^2) is less than permissible shear stress on the vegetation (2.5 lb/ft^2) so the lining is acceptable. (The concrete bottom lining is non-erodible.)

3.4 STABILITY IN BENDS

Flow around a bend creates secondary currents, which impose higher shear stresses on the channel sides and bottom compared to a straight reach (Nouh and Townsend, 1979) as shown in Figure 3.3. At the beginning of the bend, the maximum shear stress is near the inside and moves toward the outside as the flow leaves the bend. The increased shear stress caused by a bend persists downstream of the bend.

Equation 3.6 gives the maximum shear stress in a bend.

$$\tau_b = K_b \tau_d \qquad (3.6)$$

where,

τ_b = side shear stress on the channel, N/m^2 (lb/ft^2)

K_b = ratio of channel bend to bottom shear stress

τ_d = shear stress in channel at maximum depth, N/m^2 (lb/ft^2)

The maximum shear stress in a bend is a function of the ratio of channel curvature to the top (water surface) width, R_C/T. As R_C/T decreases, that is as the bend becomes sharper, the maximum shear stress in the bend tends to increase. K_b can be determined from the following equation from Young, et al., (1996) adapted from Lane (1955):

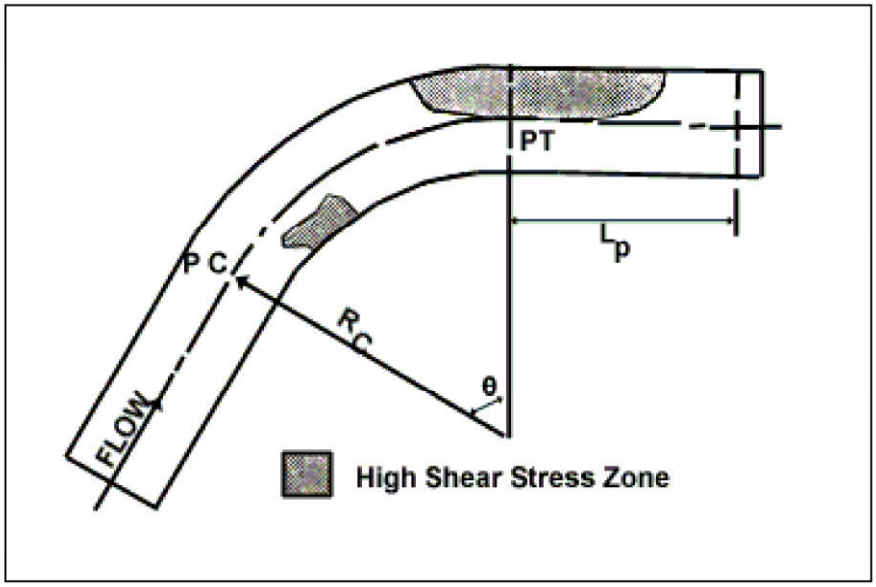


Figure 3.3. Shear Stress Distribution in a Channel Bend (Nouh and Townsend, 1979)

$$K_b = 2.00 \qquad R_C/T \le 2$$

$$K_b = 2.38 - 0.206\left(\frac{R_c}{T}\right) + 0.0073\left(\frac{R_c}{T}\right)^2 \qquad 2 < R_C/T < 10 \qquad (3.7)$$

$$K_b = 1.05 \qquad 10 \le R_C/T$$

where,

R_c = radius of curvature of the bend to the channel centerline, m (ft)

T = channel top (water surface) width, m (ft)

The added stress induced by bends does not fully attenuate until some distance downstream of the bend. If added lining protection is needed to resist the bend stresses, this protection should continue downstream a length given by:

$$L_p = \alpha\left(\frac{R^{7/6}}{n}\right) \qquad (3.8)$$

where,

L_p = length of protection, m (ft)

R = hydraulic radius of the channel, m (ft)

n = Manning's roughness for lining material in the bend

α = unit conversion constant, 0.74 (SI) and 0.60 (CU)

A final consideration for channel design at bends is the increase in water surface elevation at the outside of the bend caused by the superelevation of the water surface. Additional freeboard is necessary in bends and can be calculated use the following equation:

$$\Delta d = \frac{V^2 T}{g R_c} \qquad (3.9)$$

where,

Δd = additional freeboard required because of superelevation, m (ft)

V = average channel velocity, m/s (ft/s)

T = water surface top width, m (ft)

g = acceleration due to gravity, m/s^2 (ft/s^2)

R_c = radius of curvature of the bend to the channel centerline, m (ft)

The design procedure for channel bends is summarized in the following steps:

Step 1. Determine the shear stress in the bend and check whether or not an alternative lining is needed in the bend.

Step 2. If an alternative lining is needed, select a trial lining type and compute the new hydraulic properties and bend shear stress.

Step 3. Estimate the required length of protection.

Step 4. Calculate superelevation and check freeboard in the channel.

Design Example: Channel Bends (SI)

Determine an acceptable channel lining for a trapezoidal roadside channel with a bend. Also compute the necessary length of protection and the superelevation. The location is shown in Figure 3.4. A riprap lining (D_{50} = 0.15 m) has been used on the approaching straight channel (τ_p = 113 N/m^2 from Table 2.3).

Given:

Q = 0.55 m^3/s
d = 0.371 m
T = 3.42 m
B = 1.2 m
Z = 3
S_o = 0.015 m/m
R_C = 10 m

Shear stress in the approach straight reach, τ_d = 54.5 N/m^2

Solution

Step 1. Determine the shear stress in the bend using Equation 3.6. First, calculate Kb from Equation 3.7:

$$K_b = 2.38 - 0.206\left(\frac{R_c}{T}\right) + 0.0073\left(\frac{R_c}{T}\right)^2 = 2.38 - 0.206\left(\frac{10.0}{3.42}\right) + 0.0073\left(\frac{10.0}{3.42}\right)^2 = 1.84$$

Bend shear stress is then calculated from Equation 3.6:

$$\tau_b = K_b \tau_d = 1.84(54.5) = 100\ \text{N/m}^2$$

Step 2. Compare the bend shear stress with the permissible shear stress. The permissible shear stress has not been exceeded in the bend. Therefore, the lining in the approach channel can be maintained through the bend. If the permissible shear stress had been exceeded, a more resistant lining would need to be evaluated. A new normal depth would need to be found and then Step 1 repeated.

Step 3. Calculate the required length of protection. Since the same lining is being used in the approach channel and the bend, the length of protection is not relevant in this situation. However, we will calculate it to illustrate the process. Using Equation 3.8 and the channel geometrics, the hydraulic radius, R is 0.24 m and n = 0.074 (using Equation 6.1).

$$L_p = \alpha\left(\frac{R^{7/6}}{n}\right) = 0.74\left(\frac{0.24^{7/6}}{0.074}\right) = 1.9\ \text{m}$$

Step 4. Calculate the superelevation of the water surface. First, top width and cross-sectional area must be computed using the geometric properties,

T = B + 2Zd = 1.2 + 2(3)(0.371) = 3.42 m

A = Bd + Zd^2 = 1.2(0.371) + 3(0.371)^2 = 0.86 m^2

Attachment 3

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July 2006

U.S. Department of Transportation

Federal Highway Administration

Hydraulic Engineering Circular No. 14, Third Edition

Hydraulic Design of Energy Dissipators for Culverts and Channels

National Highway Institute

useful for design and were eliminated. An additional 69 runs where $h_s/D_{50}<2$ were also eliminated by the authors of this edition of HEC 14. These runs were not considered reliable for design, especially those with $h_s = 0$. Therefore, the final design development used 149 runs from the study. Of these, 106 were for pipe culverts and 43 were for box culverts. Based on these data, two design relationships are presented here: an envelope design and a best fit design.

To balance the need for avoiding an underdesigned basin against the costs of oversizing a basin, an envelope design relationship in the form of Equation 10.1 and Equation 10.2 was developed. These equations provide a design envelope for the experimental data equivalent to the design figure (Figure XI-2) provided in the previous edition of HEC 14 (Corry, et al., 1983). Equations 10.1 and 10.2, however, improve the fit to the experimental data reducing the root-mean-square (RMS) error from 1.24 to 0.83.

$$\frac{h_s}{y_e} = 0.86\left(\frac{D_{50}}{y_e}\right)^{-0.55}\left(\frac{V_o}{\sqrt{gy_e}}\right) - C_o \qquad (10.1)$$

where,

h_s = dissipator pool depth, m (ft)

y_e = equivalent brink (outlet) depth, m (ft)

D_{50} = median rock size by weight, m (ft)

C_o = tailwater parameter

The tailwater parameter, C_o, is defined as:

$$\begin{array}{ll} C_o = 1.4 & TW/y_e < 0.75 \\ C_o = 4.0(TW/y_e) - 1.6 & 0.75 < TW/y_e < 1.0 \\ C_o = 2.4 & 1.0 < TW/y_e \end{array} \qquad (10.2)$$

A best fit design relationship that minimizes the RMS error when applied to the experimental data was also developed. Equation 10.1 still applies, but the description of the tailwater parameter, C_o, is defined in Equation 10.3. The best fit relationship for Equations 10.1 and 10.3 exhibits a RMS error on the experimental data of 0.56.

$$\begin{array}{ll} C_o = 2.0 & TW/y_e < 0.75 \\ C_o = 4.0(TW/y_e) - 1.0 & 0.75 < TW/y_e < 1.0 \\ C_o = 3.0 & 1.0 < TW/y_e \end{array} \qquad (10.3)$$

Use of the envelope design relationship (Equations 10.1 and 10.2) is recommended when the consequences of failure at or near the design flow are severe. Use of the best fit design relationship (Equations 10.1 and 10.3) is recommended when basin failure may easily be addressed as part of routine maintenance. Intermediate risk levels can be adopted by the use of intermediate values of C_o.

10.1.2 Basin Length

Frequency tables for both box culvert data and pipe culvert data of relative length of scour hole ($L_s/h_s < 6$, $6 < L_s/h_s < 7$, $7 < L_s/h_s < 8$ . . . $25 < L_s/h_s < 30$), with relative tailwater depth TW/y_e in increments of 0.03 m (0.1 ft) as a third variable, were constructed using data from 346

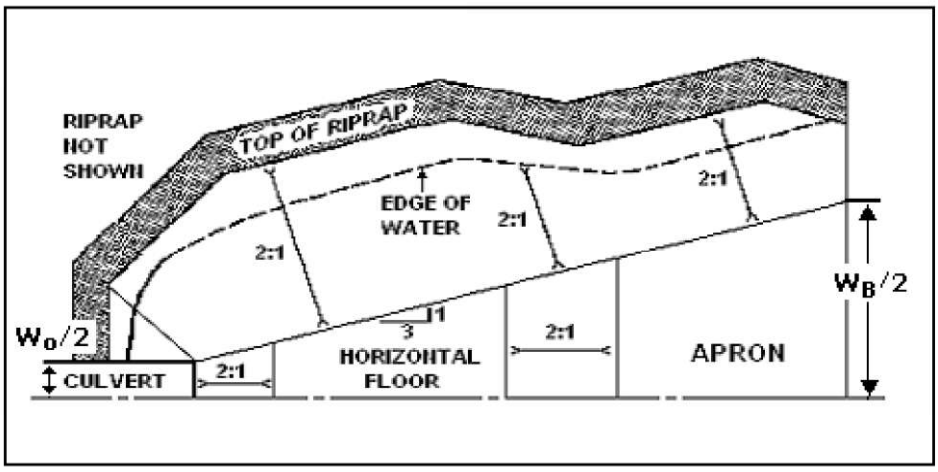

Figure 10.2. Half Plan of Riprap Basin

10.1.1 Design Development

Tests were conducted with pipes from 152 mm (6 in) to 914 mm (24 in) and 152 mm (6 in) high model box culverts from 305 mm (12 in) to 610 mm (24 in) in width. Discharges ranged from 0.003 to 2.8 m^3/s (0.1 to 100 ft^3/s). Both angular and rounded rock with an average size, D_{50}, ranging from 6 mm (1.4 in) to 177 mm (7 in) and gradation coefficients ranging from 1.05 to 2.66 were tested. Two pipe slopes were considered, 0 and 3.75%. In all, 459 model basins were studied. The following conclusions were drawn from an analysis of the experimental data and observed operating characteristics:

- The scour hole depth, h_s; length, L_s; and width, W_s, are related to the size of riprap, D_{50}; discharge, Q; brink depth, y_o; and tailwater depth, TW.
- Rounded material performs approximately the same as angular rock.
- For low tailwater ($TW/y_o < 0.75$), the scour hole functions well as an energy dissipator if $h_s/D_{50} > 2$. The flow at the culvert brink plunges into the hole, a jump forms and flow is generally well dispersed.
- For high tailwater ($TW/y_o > 0.75$), the high velocity core of water passes through the basin and diffuses downstream. As a result, the scour hole is shallower and longer.
- The mound of material that forms downstream contributes to the dissipation of energy and reduces the size of the scour hole. If the mound is removed, the scour hole enlarges somewhat.

Plots were constructed of h_s/y_e versus $V_o/(gy_e)^{1/2}$ with D_{50}/y_e as the third variable. Equivalent brink depth, y_e, is defined to permit use of the same design relationships for rectangular and circular culverts. For rectangular culverts, $y_e = y_o$ (culvert brink depth). For circular culverts, $y_e = (A/2)^{1/2}$, where A is the brink area.

Anticipating that standard or modified end sections would not likely be used when a riprap basin is located at a culvert outlet, the data with these configurations were not used to develop the design relationships. This assumption reduced the number of applicable runs to 346. A total of 128 runs had a D_{50}/y_e of less than 0.1. These data did not exhibit relationships that appeared

CHAPTER 10: RIPRAP BASINS AND APRONS

Riprap is a material that has long been used to protect against the forces of water. The material can be pit-run (as provided by the supplier) or specified (standard or special). State DOTs have standard specifications for a number of classes (sizes or gradations) of riprap. Suppliers maintain an inventory of frequently used classes. Special gradations of riprap are produced on-demand and are therefore more expensive than both pit-run and standard classes.

This chapter includes discussion of both riprap aprons and riprap basin energy dissipators. Both can be used at the outlet of a culvert or chute (channel) by themselves or at the exit of a stilling basin or other energy dissipator to protect against erosion downstream. Section 10.1 provides a design procedure for the riprap basin energy dissipator that is based on armoring a pre-formed scour hole. The riprap for this basin is a special gradation. Section 10.2 includes discussion of riprap aprons that provide a flat armored surface as the only dissipator or as additional protection at the exit of other dissipators. The riprap for these aprons is generally from State DOT standard classes. Section 10.3 provides additional discussion of riprap placement downstream of energy dissipators.

10.1 RIPRAP BASIN

The design procedure for the riprap basin is based on research conducted at Colorado State University (Simons, et al., 1970; Stevens and Simons, 1971) that was sponsored by the Wyoming Highway Department. The recommended riprap basin that is shown on Figure 10.1 and Figure 10.2 has the following features:

- The basin is pre-shaped and lined with riprap that is at least $2D_{50}$ thick.
- The riprap floor is constructed at the approximate depth of scour, h_s, that would occur in a thick pad of riprap. The h_s/D_{50} of the material should be greater than 2.
- The length of the energy dissipating pool, L_s, is $10h_s$, but no less than $3W_o$; the length of the apron, L_A, is $5h_s$, but no less than W_o. The overall length of the basin (pool plus apron), L_B, is $15h_s$, but no less than $4W_o$.
- A riprap cutoff wall or sloping apron can be constructed if downstream channel degradation is anticipated as shown in Figure 10.1.

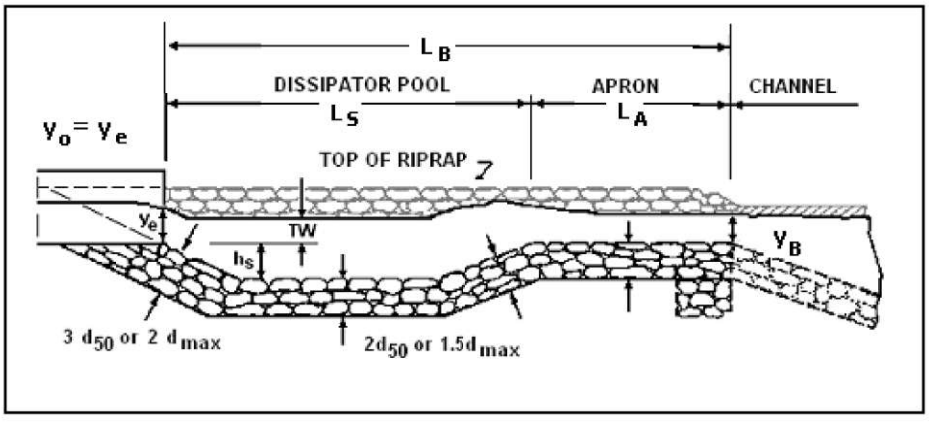

Figure 10.1. Profile of Riprap Basin

10.1.5 Design Procedure

The design procedure for a riprap basin is as follows:

Step 1. Compute the culvert outlet velocity, V_o, and depth, y_o.

For subcritical flow (culvert on mild or horizontal slope), use Figure 3.3 or Figure 3.4 to obtain y_o/D, then obtain V_o by dividing Q by the wetted area associated with y_o. D is the height of a box culvert or diameter of a circular culvert.

For supercritical flow (culvert on a steep slope), V_o will be the normal velocity obtained by using the Manning's Equation for appropriate slope, section, and discharge.

Compute the Froude number, Fr, for brink conditions using brink depth for box culverts ($y_e=y_o$) and equivalent depth ($y_e = (A/2)^{1/2}$) for non-rectangular sections.

Step 2. Select D_{50} appropriate for locally available riprap. Determine C_o from Equation 10.2 or 10.3 and obtain h_s/y_e from Equation 10.1. Check to see that $h_s/D_{50} \geq 2$ and $D_{50}/y_e \geq 0.1$. If h_s/D_{50} or D_{50}/y_e is out of this range, try a different riprap size. (Basins sized where h_s/D_{50} is greater than, but close to, 2 are often the most economical choice.)

Step 3. Determine the length of the dissipation pool (scour hole), L_s, total basin length, L_B, and basin width at the basin exit, W_B, as shown in Figures 10.1 and 10.2. The walls and apron of the basin should be warped (or transitioned) so that the cross section of the basin at the exit conforms to the cross section of the natural channel. Abrupt transition of surfaces should be avoided to minimize separation zones and resultant eddies.

Step 4. Determine the basin exit depth, $y_B = y_c$, and exit velocity, $V_B = V_c$ and compare with the allowable exit velocity, V_{allow}. The allowable exit velocity may be taken as the estimated normal velocity in the tailwater channel or a velocity specified based on stability criteria, whichever is larger. Critical depth at the basin exit may be determined iteratively using Equation 7.14:

$Q^2/g = (A_c)^3/T_c = [y_c(W_B + zy_c)]^3/ (W_B + 2zy_c)$ by trial and success to determine y_B.

$V_c = Q/A_c$

z = basin side slope, z:1 (H:V)

If $V_c \leq V_{allow}$, the basin dimensions developed in step 3 are acceptable. However, it may be possible to reduce the size of the dissipator pool and/or the apron with a larger riprap size. It may also be possible to maintain the dissipator pool, but reduce the flare on the apron to reduce the exit width to better fit the downstream channel. Steps 2 through 4 are repeated to evaluate alternative dissipator designs.

Step 5. Assess need for additional riprap downstream of the dissipator exit. If $TW/y_o \leq 0.75$, no additional riprap is needed. With high tailwater ($TW/y_o \geq 0.75$), estimate centerline velocity at a series of downstream cross sections using Figure 10.3 to determine the size and extent of additional protection. The riprap design details should be in accordance with specifications in HEC 11 (Brown and Clyde, 1989) or similar highway department specifications.

ATTACHMENT 3. CONSTRUCTION QUALITY ASSURANCE / QUALITY CONTROL PLAN

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COLORADO LEGACY LAND

ATTACHMENT 3.
CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL PLAN

PERMIT NUMBER M-1977-300
TECHNICAL REVISION #28

FORMER SCHWARTZWALDER MINE
JEFFERSON COUNTRY, GOLDEN, COLORADO

FEBRUARY 2020

ALEXCO WATER & ENVIRONMENT

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List of Acronyms and Abbreviations

%	percent
±	plus or minus
>	greater than
°C	degrees Celsius
ASTM	ASTM International
AWE	Alexco Water and Environment Inc.
CDRMS	Colorado Division of Reclamation, Mining, and Safety
CLL	Colorado Legacy Land, LLC
ft	feet/foot
in	inch(es)
lb	pound(s)
lbf	pound-force
lbf / msf	pound(s) per thousand square feet
N/A	not applicable or not available
NWRP	North Waste Rock Pile
mm	millimeter
OIT	Oxidative Induction Time
oz/yd^2	ounce(s) per square yard
psi	pounds per square inch
PVC	Polyvinyl chloride
QA	Quality Assurance
QC	Quality Control
the Project	North Waste Rock Pile Diversion Channel Construction
SF	square foot
the Site	Former Schwartzwalder Mine

1 Introduction

1.1 Purpose

This Construction Quality Assurance (QA)/Quality Control (QC) Plan provides guidance in attaining and maintaining high quality in the planned North Waste Rock Pile (NWRP) diversion channel construction project (the Project) at the former Schwartzwalder Mine (the Site), located near Golden, Colorado. Key components of the Project are excavating cover soils from the NWRP and constructing a diversion channel. Execution of this plan will provide confidence that this Project is completed in accordance with contract documents and Technical Revision #28 of Mine Land Reclamation Permit Number M-1977-300. This *Construction QA/QC Plan* along with the design drawing and specifications constitutes the Construction Quality Assurance Program for this Project.

1.2 Scope

This plan has been written to include both QA and QC elements that will be applicable during Site work. The overall requirement for inspection and QA, as addressed in the Construction Quality Assurance Program, are the responsibility of the Prime Contractor. Construction QC requirements are the responsibility of the Construction Subcontractor as addressed in Section 2 of this document.

1.3 Limitations

This plan focuses on the most critical elements to the success of the Project. All elements of the Project will be inspected for compliance with specifications by the Prime Contractor. Some elements represent routine types of civil engineering construction (e.g., regrading an existing road) and require no additional QA or QC provisions. The testing frequencies listed herein constitute a minimum. In the event of a change in materials or change in conditions, the Prime Contractor and Construction Subcontractor may use their professional judgment to conduct additional testing. Several pertinent design and QA/QC requirements from the design specifications and drawings are summarized and presented in this document. In the event of a discrepancy, which leads to conflicting language, the design specifications shall govern over the drawings and the drawings shall govern over this *Construction QA/QC Plan*.

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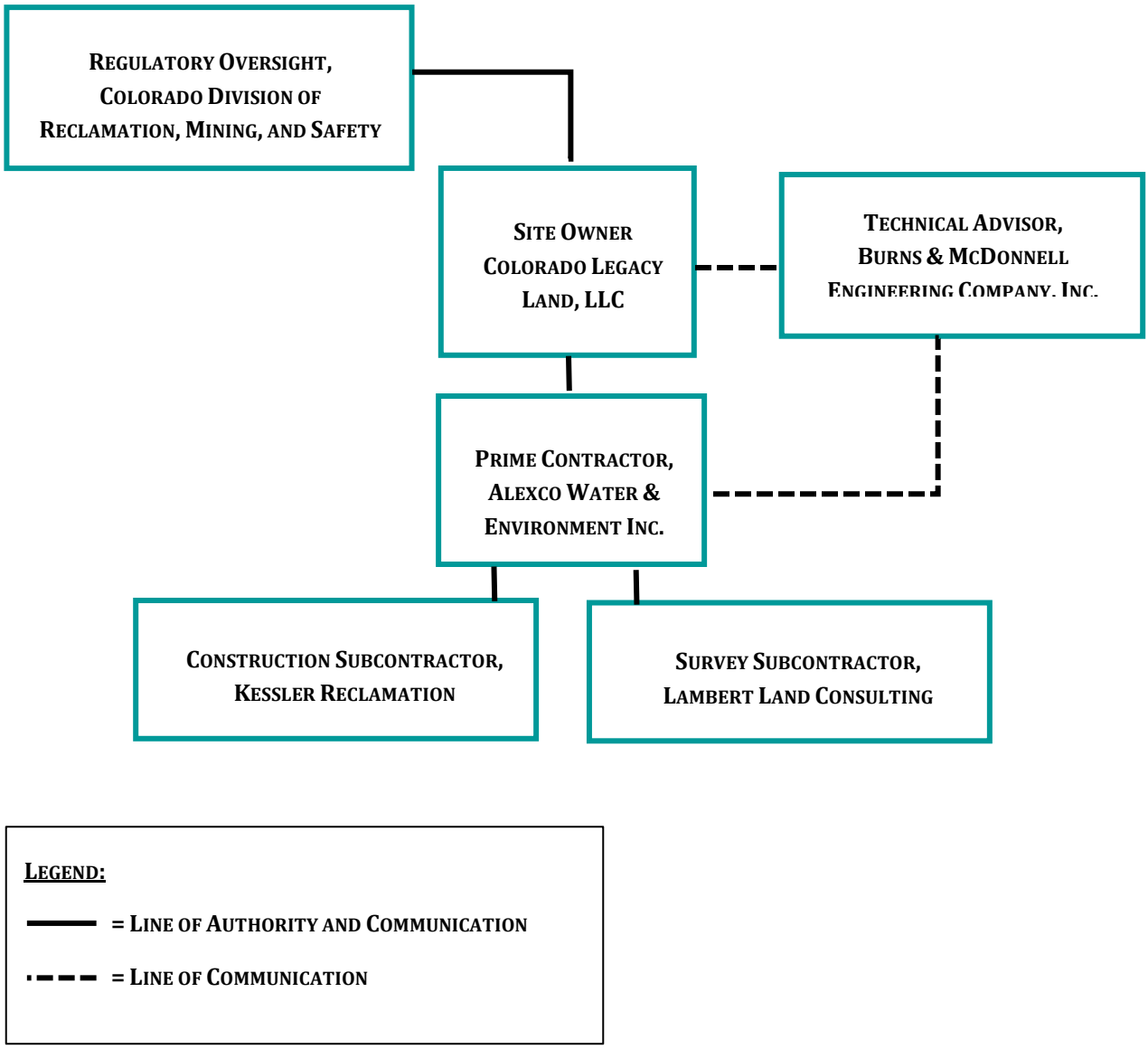
2 Construction Quality Assurance Plan Elements

The following sections address construction QA/QC responsibilities and authorities, record keeping, data management, and reporting.

2.1 Responsibility and Authority

Figure 2-1 shows the QA/QC organizational chart for this Project. Lines of authority are shown with solid black lines. Lines of communication are shown with dashed lines.

Figure 2-1. North Waste Rock Pile Diversion Channel Construction Organization Chart



2.1.1 Regulatory Agencies

The Colorado Department of Public Health and Environment Radiation Program and the Colorado Division of Reclamation, Mining, and Safety (CDRMS) are the applicable regulatory Agencies responsible for ensuring that the public health and the environment are protected. CDRMS administers the Mine Reclamation Permit (No. M-19977-300), which permits the construction of this diversion channel.

2.1.2 Site Owner

Colorado Legacy Land, LLC is the site owner. CLL is responsible for the control and implementation of the Site activates. The Site Owner's QA/QC role includes the following:

- Controls implementation of project,
- Assigns work to contractors,
- Responsible for site environmental actions,
- Obtains approvals needed to accomplish the project,
- Verifies completion of work and approves project closeout,
- Ensures protection of public health and environment, and
- Communicates with regulatory agencies regarding the project's progress.

2.1.3 Prime Contractor

Alexco Water and Environment Inc., (AWE) is the Prime Contractor for the Project. The overall responsibility of the Prime Contractor is to execute the activities specified in this *Construction QA/QC Plan* and to oversee the routine inspection of the Project and ensure that quality standards specified by the design documents are met.

The Project Manager (Elizabeth Busby, P.E.) is responsible for the organization and reporting of Project documentation to ensure appropriate quality records are maintained and retained. The Construction Quality Manager (Billy Ray) is responsible for the execution and oversight of this plan, including the verification that the Project is executed in accordance with the Project specifications as defined in Attachment 4 of Technical Revision #28 and supporting appendices. The Design Engineer, (Samuel Lowe, P.E) is responsible for developing designs, plans, and specifications that meet Project requirements. The Design Engineer will review all as-built surveys provided by the Surveying Subcontractor as they are completed. Construction activities will continue upon approval of as-built surveys.

The Prime Contractor will designate a construction QA representative(s) responsible for ensuring adherence to this document. The Prime Contractor QA/QC role includes the following:

- Assesses compliance with permits and approvals;

- Maintains project records;
- Implements portions of this *Construction QA/QC Plan*, including testing, reporting, and construction inspection;
- Ensure submittals are received, reviewed, and approved as consistent with project specifications;
- Provide the Construction Subcontractor with necessary subconsultants (e.g. professional land surveyor, Geoweb vendors, etc.), a list of equipment and materials, and proposed methods of work; and
- Performs independent site inspections, which may include implementation or oversight of performance and certification testing.

2.1.4 Technical Advisor

Burns and McDonnell Engineering Company, Inc is the technical advisor to CLL and communicates with the Site Owner and Prime Contractor on technical project specifications and designs. The Technical Advisor also serves as a third-party reviewer of Technical Revision #28.

2.1.5 Construction Subcontractor

Kessler Reclamation is the Construction Subcontractor for the Project and is responsible for construction QC. The Construction Subcontractor's staff will include a Site Superintendent who is responsible for executing the Project excavation, earthwork, construction, and geosynthetic liner installation activities. The Construction Subcontractor will provide all submittals and documentation to the Prime Contractor.

The Construction Subcontractor will designate a QC representative responsible for ensuring adherence to this document. The QC services may be performed by a third-party firm. The construction subcontractor QC role includes the following:

- Implements the *Construction QA/QC Plan* for specific construction activities;
- Provides required submittals, including progress reports, schedules, and QC documentation;
- Submits manufactures' or suppliers' certification that materials meet specifications.

2.1.6 Installer

The individual or firm responsible for geosynthetic-related construction activities. The Installer is a subcontractor to the Construction Subcontractor. This definition applies to any party performing work defined as geosynthetic material installation.

2.1.7 Surveying Subcontractor

Lambert Land Consulting is the Surveying Subcontractor for the Project and is responsible for identifying local control points, setting construction staking, and performing a final (as-built) survey of the channel. The Surveyor will be a licensed professional land surveying organization experienced in providing record surveys on projects of similar complexity, means, and methods. The Surveyor will provide a person who directly manages the record survey activities who is a registered Professional Land Surveyor in the State of Colorado. The Surveyor must provide signed and sealed copies of all survey data and reports as required by the Specifications, Drawings, and this *Construction QA/QC Plan* for use by the Engineer in certifying that the work meets the requirements of this *Construction QA/QC Plan*.

2.2 Project Records

Project records will be maintained by the Prime Contractor's Project Manager. Submittals by various subcontractors and their vendors will include pertinent shop drawings, data sheets, material certifications, mix designs, permits, test results, and other relevant or required submittals. The Project Manager will prepare various reports that describe the construction activities and provide documentation that the construction conforms to approved plans and specifications. The specific reports, their content, distribution, and distribution schedule will be developed for each specific construction activity. At a minimum, the following reports will be part of the project records:

- Submittals,
- Meeting minutes (as applicable),
- A copy of the CDRMS Construction Inspection Report(s),
- Daily Construction Inspection Reports,
- Field Observation and Test Forms
- Professional Land Surveyor Report,
- Load tickets.

Examples of typical project reports are included in Appendix A of this document.

2.3 Submittals

All submittals shall be reviewed, certified, and managed by the Construction Quality Manager. Copies of manufacturers' data (material, equipment, etc.), including catalog cut-sheets showing dimensions, performance characteristics, capacities, schedules, operation and maintenance manuals, and any other relevant information are reviewed by the Construction Quality Manager. The Construction Quality Manager is an authorized submittal reviewer and testing laboratory report reviewer. One (1) copy of the submittal remains with the Construction Subcontractor and one (1) copy is retained in the Project files.

2.3.1 Submittal Register

The Submittal Register is maintained by the Project Manager.

2.3.2 Construction Quality Manager Review and Approval

Upon submittal by the Construction Subcontractor, all items are checked and approved by the Construction Quality Manager, Design Engineer, or designee. If an item is found to be in strict conformance with the contract requirements, it is stamped, signed, and dated by the Construction Quality Manager. Copies of review comments indicating action(s) taken are included with each submittal response to Construction Subcontractor.

2.4 Data Management

All information relevant to construction activities will be categorized as either data or construction project records. Data are results from measuring some parameter of media and can include sampling and analytical results and other tests or measurements (e.g., survey information or geotechnical testing). Construction project records consist of all documentation pertinent to project construction activities.

The QA methods and procedures outlined in this *Construction QA/QC Plan* will be used to verify and document that the project is completed in accordance with plans and specifications and codes, standards, and practices referenced therein.

2.5 Phases of Inspection

2.5.1 Preparatory Meetings

Preparatory Meetings are performed before the beginning of any major Definable Feature of Work. A meeting is held for each crew performing such a feature or when members of the crew change. Preparatory Meetings are conducted by the Construction Quality Manager and/or designee after a complete review of all applicable plans, specifications, shop drawings, and related submittals. At the Preparatory Meeting, the Superintendent and Foreman (involved in this phase of construction) will coordinate with QA, QC, and safety personnel and introduce their plan for accomplishing the work. The following items are discussed at each meeting:

- Review of applicable specifications;
- Review of relevant plans and shop drawings (if applicable);
- Review of related submittals and a check that all related submittals, shop drawings, and materials have been tested (if applicable), submitted, and approved;
- Review of the detailed sequence of the execution of the work;
- Discuss required testing and frequency;

- Review provisions to ensure controlled inspection and testing;
- Examination of the work area to ensure that all required preliminary work has been completed and is in compliance with the plans and/or specifications;
- Examination of the related material and verification that the items received are in compliance with the contract and are appropriately stored;
- Review of the Site Health and Safety Plan to ensure that all safety precautions are met and the required safety equipment has been purchased and is available; and
- Review the work plan and the workmanship expected for the features of the work.

2.5.2 Initial Inspections

Initial Inspections are performed at the beginning of any new stage of the project and must be repeated any time new workers or new crews are assigned to the work or if the required standard of work is not being met. The same personnel who attended the Preparatory Meeting also will attend the Initial Inspection. The following tasks are accomplished during these meetings:

- The minutes of the Preparatory Meeting are reviewed and verified that the work complies with the design documents (i.e., submittals, specifications, and/or shop drawings).
- All differences are resolved,
- The adequacy of inspection and testing is verified,
- A level of workmanship is established and verified that it meets the requirements,
- Documentation is provided of the previous inspection of the work area, and
- The work area is re-examined for compliance.

2.5.3 Follow-Up Inspections

Follow-Up Inspections are performed as required to ensure that the control established during the Preparatory Meeting and the Initial Inspection continues to provide a product that conforms to the contractual requirements.

- Construction daily activities are inspected by QC Staff in accordance with this plan and documented on the Daily Construction Inspection Report.
- Installation and testing activities that do not comply with the requirements are documented on the Daily Construction Inspection Report.

- Modifications or repairs to and/or replacement of materials and/or parts performed subsequent to the Final Inspection require replacement of materials and/or parts installed. Reinspection and retesting are required to verify acceptability.

2.6 Meetings

To effectively implement this *Construction QA/QC Plan,* regular meetings will be held to promote communication. The Construction Subcontractor and Prime Contractor will attend progress meetings to monitor overall project progress and issues, particularly those related to QA and QC. Meeting frequency may vary with the amount of construction activity but is anticipated to be weekly. While discussions at these meetings may include a wide variety of topics, it should also include any problems encountered or anticipated that are related to QA and QC. Quality Control Testing and Verification

2.6.1 Purpose

The purpose of these QA and QC procedures are to ensure that tests of the Contractor's and Subcontractor's work are adequately planned and that the necessary procedures are available to perform the tests in a satisfactory manner. This procedure establishes the methods to be used when performing the tests listed in the specifications. Test reports are submitted to the Construction Quality Manager for review and are filed and logged with other project documentation.

2.6.2 Testing (Onsite, Factory/Offsite)

A list of tests required to verify that control measures are adequate are detailed in Table 3-1 and Table 4-1of this document. The lists include the test description, method, frequency, standard, and test rejection criteria for each type of material or work element.

2.6.3 Failed Test

Failing tests are cleared by one of the following methods:

- Retest – Retest if there is any doubt that the first test was not adequate.
- Rework – Reinspect and retest.
- Failed Material – Remove, replace, reinspect, and retest.

2.6.4 Procedures

The Construction Quality Manager reviews the testing requirements to ensure that the planned test is in accordance with the design documents (i.e., plans, specifications, shop drawings and/or other documents). The review includes the following:

- Instruments used for testing are calibrated in accordance with established calibration procedures. Specialists experienced in such work shall perform the calibration.

- Technicians performing the tests shall provide copies of calibration certificates and their field notes and reports to the Construction Quality Manager.

- The Construction Quality Manager, or designee, shall witness all required tests detailed in the design documents (plans, specifications, shop drawings, etc.).

2.7 Tracking Deficiencies

2.7.1 Nonconforming Items

Nonconforming items are those conditions that deviate from the requirements detailed in the specifications, plans, and/or shop drawings. The Design Engineer is responsible for the control and documentation of nonconforming items.

Minor nonconforming items, which are identified and corrected in the same day, are documented in the *Daily Construction Inspection Report* (Appendix A). All other nonconformances are documented in a Nonconformance Memo prepared by the Design Engineer, or designee and maintained with the project files. The memo shall be sequentially numbered, dated, and include the following information, as appropriate:

- Description of the nonconformance, including relevant details of the occurrence;

- Identification of material, component, or system by part number, plan, shop drawing, and/or specification number and intended installation location;

- Source of material or item (name of supplier, owner, or subcontractor);

- Current status or item in shop, warehouse, lay-down yard, or structure;

- Individual and organization that detected the nonconformance;

- Recommendation for corrective action, including sketches, test data and/or repair procedures necessary to substantiate the recommendation; and

- Cause of the nonconformance and steps taken to prevent reoccurrence, indicating action(s) taken, positions or titles of persons contacted, letters written, and/or procedural changes proposed.

2.7.2 Initial Punch List

The QC Report records Punch List items (deficiencies) throughout the project and demonstrates that the contractor is correcting the Punch List item(s) in a timely manner. An Initial Punch List is developed as a result of initial inspections and then maintained throughout the project. The Punch List is consistently updated and

submitted to the Project Manager for corrective actions. Corrections are accomplished within the time stated. The QC Manager performs Follow-Up Inspections to ensure the deficiencies have been corrected before initiating a Prefinal Inspection.

2.7.3 Prefinal Inspection

After completing the Initial Punch List Inspection, the Construction Quality Manager and Construction Subcontractor representative conduct a Prefinal Inspection and develop a joint Punch List of noted deficiencies. The Punch List is formally documented along with the estimated date by which the deficiencies will be corrected. The Construction Quality Manager conducts Follow-Up Inspections to ensure that all deficiencies have been corrected before requesting a Final Inspection.

2.7.4 Final Inspection

Upon completion of the items listed in the Prefinal Inspection Punch List, the Construction Subcontractor notifies the Construction Quality Manager. This notification is made with the assurance that all items listed in the Prefinal Inspection and all other remaining work has been completed and will be acceptable by the date of the Final Inspection.

2.8 Reporting

QA/QC issues will be recorded and reported to interested parties in several ways. The Construction Subcontractor will prepare general daily, weekly, and monthly reports documenting construction progress and issues and submit them to the Prime Contractor. QA/QC test failures or nonconformances shall be noted on daily logs. Additionally, each test failure or nonconformance will be further reported on a special report documenting the issue and its resolution. Sample QA/QC test forms are included in Appendix A of this document. As required by 2 CCR 407-1 Rule 7.3.2(2), at the conclusion of the project the Prime Contractor will provide a certified verification by a professional engineer or other appropriately qualified professional that will confirm that the facility was constructed in accordance with the approved design plan.

At a minimum, the verification will contain the following information:

- Summaries of all construction activities within the scope of the QA/QC Plan performed.
- Observation logs and testing data sheets including sample location plans.
- Daily field reports including field personnel and activities completed.
- A discussion of any changes from the design requirements and material specifications.
- Record survey drawings of the areas where final construction occurred. The record survey drawings will be stamped by a Professional Land Surveyor registered in the State of Colorado.

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3 Earthwork, Riprap, and Concrete Construction

This section describes the QA/QC measures for all earthwork and channel construction to be performed. Table 3-1 summarizes the QA/QC tests for earthen materials, riprap, and concrete. The following field forms (Appendix A) shall be used to document the QA/QC activities for earthwork and channel construction:

- *Daily Construction Inspection Report,*
- *Construction Testing Services – Soils Compaction Testing by ASTM Standards*,
- *Concrete QC– Air and Slump Tests*, and
- *Subgrade Surface Acceptance*.

3.1 Quality Control Measures

QC measures for soils to be used for channel grading, riprap placement, and backfilling shall include visual inspection as well as in-place density and moisture content testing. All organic material, including roots, sticks, leaves, brush trash, and any other debris shall be removed before stockpiling or using excavated material. A visual inspection of the bedding material will be required to ensure there are no rocks or other objects greater than 1-inch in diameter in the top 3-inches of subgrade beneath the Geoweb material.

3.2 Quality Assurance Measures

The Prime Contractor's inspectors will perform QA testing to corroborate QC testing. In general, QA testing will use the same methods, standards, and rejection criteria as QC testing. Visual test methods will be performed continuously by inspectors. QC placement tests (i.e., in-place density) will be observed by the inspectors for QA. Additional QA placement tests may be performed at the Prime Contractor's discretion.

Prior to excavation of general fill, the Prime Contractor will verify and document that:

- Erosion controls have been installed in accordance with the permit for both the excavation area and the stockpile area.
- The limits of disturbance have been staked or otherwise suitably marked to delineate the area.
- The excavation equipment and personnel cited by the Construction Subcontractor for this activity are on site and available.
- The surface of the area to be excavated has been surveyed.

During excavation and stockpiling of soil, the Prime Contractor will verify and document that:

- The excavation is to the depth identified on the Drawings.
- Adequate erosion controls are placed around stockpiles.
- Soil not meeting the general fill requirements is segregated as defined in the Specifications.

3.3 Concrete

Concrete structure will be installed at the designated locations in the drawings as a capture structure for offsite flow. Prior to the construction of the concrete structure the Prime Contractor will verify the following:

- Bedrock has been exposed for the full length of the structure and is competent for connection of structure.
- The location is properly prepared and graded as shown in the Contract Documents.

During the construction of the concrete foundations the Prime Contractor will verify the following:

- Structure dimensions conform to Prime Contractor design.
- Appropriate number of samples are obtained and tested.

3.4 General Fill Grading and Compaction

Prior to the placement of general fill material, the Prime Contractor will verify and document that the underlying soil surface material is suitable and satisfies the requirements of the Specifications.

During placement of general fill, the Engineer will verify and document that:

- The general fill is suitable and satisfies the requirements of the Specifications as determined by the test methods and frequencies prescribed within Table 3-1.
- The general fill is moisture conditioned and compacted in accordance with the Specifications.
- Lift thicknesses meet the requirements of the Specifications.
- The surface is not fine-graded or compacted during periods of unfavorable weather conditions.
- General fill has been placed in accordance with the Specifications as determined by the test methods and frequencies prescribed in the attached Table 3-1.

3.5 Deficiencies

When deficiencies (field test results that do not meet the specified criteria) are discovered, the Prime Contractor will notify the Construction Subcontractor and Site Owner. The Prime Contractor will then determine the nature and extent of the deficient area by performing additional tests.

The deficient materials will be removed from the area of deficiency at the Prime Contractor's discretion. The corrected deficiency will then be re-tested before an additional lift is placed over the deficient area by the Construction Subcontractor. All re-tests and steps taken to correct the problem will be documented by the Prime Contractor.

The Prime Contractor will have the authority to reject borrow material that does not meet the Specification requirements. Unacceptable material, as judged visually, will be rejected by the Engineer prior to placement over the unacceptable material.

Table 3-1. Quality Assurance/Quality Control Tests for Earthen Materials, Riprap, and Concrete					
Material	**Test Description [1]**	**Test Method**	**Test Frequency**	**Standard**	**Test Rejection Criteria [2]**
Subgrade	Proof Rolling	Observation	Continuous	Rutting < 1 in.	No deviation from the standard
	Construction Oversight	Observation	Continuous	Firm, free of rocks or other protrusions, smooth rolled	No deviation from the standard
General Fill	Subgrade	Observation	Continuous	Scarify top 6 in.	No deviation from the standard
	Oversight	Observation	Continuous	Firm, free of rocks or other protrusions, adequate moisture to prevent desiccation.	No deviation from the standard
	USCS Soil Classification	ASTM D2487	1 per Project	Material shall be cohesive	No deviation from the standard
	Laboratory Compaction	ASTM D698	1 per Project per material type	Report	N/A
	Lift Thickness	Observation	Continuous	Maximum 12 in. lift	No deviation from the standard
	Dry Density	ASTM D6938	1 test for every 100-ft of channel	95% of Maximum Dry Density (ASTM D-698) Standard Proctor and ± 4% Optimum Moisture Content	No deviation from the standard
Concrete	Mix Design	Visual	100%	Collect and review tickets for each batch of concrete delivered; compare to submittal. Annotate water or admixtures added subsequent to batching. Water/cement ratio shall not exceed 0.45.	No deviation from the standard
	Strength	Field: ASTM C31, ASTM C143, and ASTM C172. Laboratory: ASTM C39 and ASTM 192.	Daily when concrete is being poured or test every 50 cubic yards	3,000 psi at 28 days	No deviation from the standard

Table 3-1. Quality Assurance/Quality Control Tests for Earthen Materials, Riprap, and Concrete					
Material	**Test Description [1]**	**Test Method**	**Test Frequency**	**Standard**	**Test Rejection Criteria [2]**
Riprap	Gradation	Visual	100%	D_{50} = 9-in. Collect and review tickets for each delivery; compare to submittal.	No deviation from the standard
Granular Material	Sieve Analysis	ASTM C136	1/Source per material	See Specification Section 312050	No deviation from standard

Note:

[1] Inspections shall be completed by the Construction Subcontractors quality control representatives, equipment operators, laborers, or other personnel.

[2] Unless otherwise specified, deviations shall be corrected by reworking material until the standard is met.

% = percent

± = plus or minus

ASTM = ASTM International

D_{50} = 50% point of diameter

ft = feet / foot

in = inch(es)

N/A = not applicable

psi = pounds per square inch

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4 Geoweb, Geomembrane, and Geotextile Channel Lining

This section describes the QA/QC measures for the Geoweb and geotextiles utilized to line the drainage channel. Table 4-1 summarizes the QA/QC tests for installing the non-woven geotextile, DuraSkrim, and Geoweb liner materials. The following field forms (Appendix A) shall be used to document the QA/QC activities for earthwork and channel construction:

- *Daily Construction Inspection Report,* and
- *Liner Inventory Checklist*.

Before shipping any material to the Site, the Construction Subcontractor shall submit the manufacturer's QA testing results to the Prime Contractor.

The Construction Subcontractor shall implement QC measures during installation. QC measures shall include visual inspection of the receiving surface, polyvinyl chloride (PVC) deadman trenches, earth anchors (if required), tendon placement, ATRA Key placements, and panel placement. Based on the result of the visual inspection of the Construction Subcontractor's QC testing, the Prime Contractor may perform the same tests as listed in Table 4-1 for confirmation.

4.1 Geoweb

4.1.1 Geoweb Installation

4.1.1.1 Surface Preparation

Prior to installation of the Geoweb, The Prime Contractor will verify that the following conditions exist:

- The geomembrane and geotextile cushion layers have been installed in accordance with the Drawings, Specifications, and this *Construction QA/QC Plan*.
- The as-built grades are acceptable and adequately match the lines and grades presented in the Drawings.

4.1.1.2 Geoweb Section Placement

During panel placement, the Prime Contractor will verify the following:

- The condition of the underlying layer has not changed detrimentally during installation. Any damage to the surface of the underlying layer will be repaired in accordance with the Specifications.

- No visual damage is present on each section. The Prime Contractor will advise which sections, or portions of sections, should be rejected, repaired, or accepted. Damaged sections or portions of damaged sections which have been rejected by the Prime Contractor will be marked, and their removal from the work area will be documented.

- Repair procedures are performed in accordance with the Specifications.

- All sections are expanded uniformly to required dimensions and that outer cells of each section are correctly aligned

- Upper surfaces of adjoining sections are flush at joint and adjoining cells are fully aligned at the cell wall slot.

- Check that pipe deadman, tendons, tendon clips, and keys are installed in accordance with the Specifications and Drawings.

4.2 Geotextile

4.2.1 Delivery, Storage, and Handling

The Prime Contractor will verify that all geotextile materials are delivered, handled, and stored in accordance with the Specifications and manufacturer's recommendations to avoid damage to the materials. The Prime Contractor will verify that the following activities are done:

- Care is taken to unload rolls using equipment that will not damage the product.

- Damage to protective covering due to mishandling or sampling is repaired immediately.

- Manufacturer's QC documentation for each roll is received.

- Each roll is marked and stored as required by the Specifications.

At the Prime Contractor's discretion, damaged rolls may be rejected. They will be removed from the site or stored at a location, separate from accepted rolls, designated by the Site Owner. All rolls without proper manufacturer's documentation will be rejected.

A Liner Inventory Checklist (Appendix A) will be prepared by the Engineer for all geosynthetic material delivered to the job site.

4.2.2 Geotextile Installation

4.2.2.1 Surface Preparation

Prior to geotextile installation, the Prime Contractor will verify that the following conditions exist:

- The subgrade as-built survey has been performed by a qualified surveyor to verify the design slopes have been achieved.
- The subgrade has been prepared in accordance with the earthwork specification.
- The supporting surface does not contain stones or other material that could damage the geotextile or, where applicable, an underlying geomembrane
- There are no excessively soft areas that could result in cover damage.
- All construction stakes and hubs have been removed and holes filled with soil compacted to the minimum requirements for the adjacent soil.
- Verify the anchor trench system has been excavated to the depth and width shown on the Drawings prior to placement. Trench corners should be slightly rounded. The trench should be clear of rocks, sticks, roots, and other debris.
- The certificate of soil subgrade acceptance has been completed and signed by the Installer.

4.2.2.2 Panel Placement

During panel placement, the Prime Contractor will verify the following:

- The condition of the underlying layer has not changed detrimentally during installation. Any damage to the surface of the underlying layer will be repaired in accordance with the Specifications.
- No visual damage is present on each panel. The Prime Contractor will advise which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected by the Prime Contractor will be marked, and their removal from the work area will be documented.
- Repair procedures are performed in accordance with the Specifications.

4.2.2.3 Seaming

During geotextile placement and seaming, the Prime Contractor will verify the following activities are completed:

- Geotextile panels are overlapped as required by the Specifications.
- Geotextile panels are joined by sewing geotextile panels together with a thread that conforms to the Specifications.

  Geotextile may also be heat seamed (with no open flame). Prime Contractor approval required prior to use of heat seaming.

4.3 GEOMEMBRANE

4.3.1 Delivery, Storage, and Handling

The Prime Contractor will review and document that geomembrane materials are delivered, handled, and stored in accordance with the Specifications and manufacturer's recommendations to avoid damage to the materials. The Prime Contractor will review and document the following activities:

- Care is taken to unload material using equipment that will not damage the product.
- Damage to protective covering due to mishandling or sampling is repaired immediately.
- Manufacturer's QC documentation for each roll is received.
- Each panel is marked and stored as required by the Specifications.

At the Prime Contractor's discretion, damaged material may be rejected. It will be removed from the site or stored at a location, separate from accepted material, designated by the Site Owner. All material without proper manufacturer's documentation will be rejected.

A Liner Inventory Checklist (Appendix A) will be prepared by the Prime Contractor for all geosynthetic material delivered to the job site.

4.3.2 Geomembrane Installation

4.3.2.1 Surface Preparation

Prior to the geomembrane installation, the Prime Contractor will verify that the following conditions exist:

- The surface is free of irregularities and protrusions.
- The geotextile cushion layer has been installed in accordance with the Drawings, Specifications, and this QA/QC Plan.

4.3.2.2 Panel Placement

During panel placement, the Engineer will perform the following activities:

- Observe the panel as it is deployed and record all panel defects and disposition of the defects (panel rejected, patch installed, etc.). Large sections of damaged material will be cut out and removed from the site. All repairs are to be made in accordance with the procedures given in this *Construction QA/QC Plan* and the Specifications.

- Verify that equipment used does not damage the geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.

- Verify that the surface on which geomembrane is to be placed has not deteriorated since acceptance by the Installer.

- Inspect the geomembrane for scratches if it has been pulled across an unprotected surface

- Record weather conditions including temperature, wind, and humidity. The geomembrane will not be deployed in the presence of excess moisture (fog, dew, mist, etc.).

- Verify that people working on the geomembrane do not smoke, wear shoes and/or engage in activities that could damage the geomembrane.

- Verify that the method used to deploy the sheet minimizes wrinkles and that the sheets are anchored to prevent movement by wind.

The Prime Contractor will inform both the Construction Subcontractor and Site Owner if the above conditions are not met.

4.3.2.3 Field Seaming

A seam numbering system will be agreed to by the Prime Contractor and Installer prior to the start of seaming operations. One methodology is to identify the seam by adjacent panels. For example, the seam located between Panel 1 and 2 would be Seam No. 1/2.

Prior to seaming, trial welds for each operator and seaming apparatus (welder) will be tested in accordance with the Specifications to determine if the equipment and operator are functioning properly.

The Prime Contractor will observe welding operations and the testing of the trial welds. Trial weld results will be recorded by the Prime Contractor and on the forms provided by the Installer. All trial welds are to be completed under conditions similar to those existing when the panel will be seamed. Trial welds will be completed at the beginning of each morning and afternoon shift, and at any time the Engineer believes that an operator or seaming apparatus is not functioning properly. If there are large changes in temperature, humidity, or wind speed, the testing is to be repeated.

During seaming operations, the Engineer will verify that the following conditions exist:

- The Installer has the number of seamers and spare parts agreed to in the pre-construction meeting.
- Equipment used for seaming does not damage the geomembrane.
- The weld is free of dust, dirt, moisture, or other contaminants.
- The seams overlap as required in the Specifications.
- No solvents or adhesives are present in the seam area.
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude QA/QC testing.
- The panels are seamed in accordance with this *Construction QA/QC Plan* and the Specifications,

The Prime Contractor will record all seaming activities on the Geomembrane Seaming Log provided in Appendix A.

4.3.3 Field Testing

Two non-destructive testing procedures will be utilized, depending on the type of welding procedure used. The testing procedures are set forth in the Specifications. For extrusion welded seams the vacuum box method will be employed for the full seam length. For the dual wedge (hot shoe) fusion welded seam, air pressure testing will be used for the full seam length. Spark testing may also be used to test extrusion welds that cannot be vacuum testing. Spark testing if used, will be done in accordance the Installer's QC manual.

4.3.3.1 Non-destructive Seam Testing

During non-destructive testing operations, the Prime Contractor will perform the following activities:

- Observe the non-destructive testing.
- Records the location, date, test number, technician name, and results of all non-destructive testing in accordance with the Installer's quality control manual.
- Mark the location of any defects requiring repairs and record on the Geomembrane Repair Log form provided in the Appendix A.
- Mark the failed areas with a waterproof marker compatible with the cover (spray paint should not be used) and inform the Prime Contractor of any required repairs.
- Verify that all testing covers the entire length of all field seams and is completed in accordance with the Specifications.

- Verify that all repairs are completed and then tested in accordance with the Specifications.

4.3.4 Repairs

Portions of the geomembrane with flaws will be repaired in accordance with the Specifications and manufacturer's recommendations. The Prime Contractor will locate and describe all repairs, including size.

- Patching is used to repair large holes, tears, large panel defects, and destructive testing sample locations.
- Extrusion is used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 3/8 inch in the largest dimension.
- Capping is used to repair failed welds or to cover seams where welds cannot be non-destructively tested.

- Removal is used to replace areas with large defects where the preceding methods are not appropriate. Removal is also used to remove excess material (wrinkles) from the installed geomembrane.

4.3.5 Wrinkles

Placing geotextile over the geomembrane, temperature changes, or creep may cause wrinkles to develop in the geomembrane. Any wrinkles that can fold over will be repaired either by cutting out excess material or, if possible, allowing the cover to contract due to temperature reduction. In no case will material be placed over the geomembrane that could result in the geomembrane folding.

4.3.6 Bridging

Unless approved by the Prime Contractor, bridging must be removed.

4.3.7 Folded Material

All folded geomembrane will be removed.

4.3.8 Geomembrane Acceptance

The Construction Subcontractor will retain all ownership and responsibility for the geomembrane until acceptance by the Site Owner. The Prime Contractor will recommend acceptance of the geomembrane to the Owner when the following activities have occurred:

- The installation is finished.

- Signed QC certificates for each roll of geomembrane have been supplied by the Installer and approved by the Engineer. Certificates will include resin identification, panel number, date of production, and test results for density, melt index, and tensile strength.

- All documentation, including warranties, required by the Specifications has been received.

- Cover material has been placed over the geomembrane.

Table 4-1. Quality Assurance/Quality Control Criteria for Geomembrane, Geoweb and Geotextile Channel Lining Materials				
Item	**Parameter**	**Test Method [1]**	**Frequency**	**Standard**
Geotextile	Material	Manufacturer's Cert	N/A	Nonwoven needle punched polypropylene or polyester
	Mass/Unit Area	ASTM D5261	1 per 100,000 SF	Minimum 8 oz/yd^2
	Grab Tensile Strength	ASTM D4632	1 per 100,000 SF	Minimum 205 lbs
	Elongation at Failure	ASTM D4632	1 per 100,000 SF	Minimum 50%
	Coefficient of Permittivity - k	ASTM D4491	1 per 540,000 SF	1.4 /second
	Apparent Opening Size	ASTMD D4751	1 per 540,000 SF	Minimum 80 mm
	CBR Puncture Strength	ASTM D6241	1 per 540,000 SF	Minimum 500 lbs
	Trapezoid Tear Strength	ASTM D4533	1 per 100,000 SF	Minimum 80 lbs
	Ultraviolet Light Resistance	ASTM D4355	per formulation	Minimum 70%
	Observation	Observation	N/A	Geotextile panels shall be overlapped a minimum of 3 in. before sewing
Geomembrane	Thickness	ASTM D5994	per roll	nominal 45 mils
	Asperity Height (min ave)	ASTM D7466	Every Second Roll	16 mils
	Weight	ASTM D751	1 per 20,000 lb	200 lbf/msf
	Tongue Tear Strength	ASTM D5884	1 per 45,000 lb	100 lbf
	Grab Tensile Strength	ASTM D7004	1 per 20,000 lb	275 lbf

Table 4-1. Quality Assurance/Quality Control Criteria for Geomembrane, Geoweb and Geotextile Channel Lining Materials				
Item	**Parameter**	**Test Method [1]**	**Frequency**	**Standard**
	Tensile Elongation at Break	ASTM D7004	1 per 45,000 lb	22%
	Puncture Resistance	ASTM 4833	1 per 45,000 lb	108 lbf
	Standard OIT or High Pressure OIT	ASTM D3895 or ASTM D5885	Per GRI-GM10	100 minutes or 400 minutes
	Subgrade	Observation	See Table 3-1	Firm, free of rocks, other protrusions, soft areas and desiccation and smooth rolled less than 1-in. ruts
	Trial Welds	ASTM D6392	Shift start up, 4 hours of continuous operation, geomembrane temperature increases by > 25°C	Minimum 5 peel meeting 50% minimum Elongation and 0% Separation
	Seam Overlap	Observation	Continuous	Minimum 4 in.es
	Nondestructive testing	GRI Test Method GM6	1 per continuous seam/repair	Air Channel: Fill to 30 psi and have less than a 2 psi drop over 5 minutes. Vacuum Box: Soapy water with 4 psi to check for soap bubbles.

Notes:

[1] Inspections shall be completed by the Construction Subcontractors quality control representatives, equipment operators, laborers, or other personnel.

> = greater than
% = percent
°C = degrees Celsius
in. = inch(es)
lb = pound(s)
lbf = pound-force
lbf / msf = pound(s) per thousand square feet
mm = millimeter
N/A = Not applicable
OIT = Oxidative induction time
oz/yd^2 = ounce(s) per square yard
psi = pound(s) per square inch
PVC = Polyvinyl chloride
SF = Square foot

5 Surveying

5.1 Compliance with Specifications

The Surveyor will perform the surveys and evaluate survey results in accordance with the Specifications and this Plan.

5.2 Control

The Surveyor will utilize the control points identified on the Drawings and utilize the same coordinate system and datums as the Drawings.

5.3 Field Work

The Surveyor will be scheduled by the Construction Subcontractor. The Surveyor will survey the completed areas identified by the Prime Contractor using generally accepted survey equipment and practices.

5.4 Record Drawings

The Surveyor will generate record drawings of the completed work. The Surveyor will generate the record drawings in a format acceptable to the Prime Contractor and provide the record drawings both electronically and in hard copy form to Owner and Prime Contactor.

At a minimum, record drawings are required for the following:

- Top of subgrade prior to geosynthetic material placement.
- The limits of the geosynthetic material (i.e., edge of anchor trench).
- Drainage channel locations and dimensions.

All record surveys will be stamped by a Professional Land Surveyor registered in the State of Colorado and submitted to the Prime Contractor in both electronic and hard copy form. Horizontal and vertical survey accuracies (i.e., as opposed to construction tolerances) will be as stated in the Specifications. Less stringent survey accuracies may be specified to identify test/sample locations.

Record survey of the drainage channel will include cross sections of the channels at maximum 100-foot intervals including points at top and toe of channel side slopes and along the channel flow line. Survey of pipe segments (e.g., at points located along top of pipe) should be performed at maximum 50-foot intervals, at changes in pipe direction and at the ends.

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6 References

ASTM International (ASTM) C-31, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens."

ASTM C-39, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens."

ASTM C-136, "Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates."

ASTM C-143, "Standard Test Method for Slump of Hydraulic-Cement Concrete."

ASTM C-172, "Standard Test Method for Slump of Hydraulic-Cement Concrete."

ASTM C-192, "Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory."

ASTM D-2487, "Standard Practice for Classification of Soils for Engineering Purposes."

ASTM D3895, "Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry."

ASTM D-4355, "Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc-Type Apparatus."

ASTM D-4491, "Standard Test Method for Water Permeability of Geotextiles by Permittivity."

ASTM D-4533, "Standard Test Method for Trapezoid Tearing Strength of Geotextiles."

ASTM D-4632, "Standard Test Method for Grab Break Load and Elongation of Geotextiles."

ASTM D-4751, "Standard Test Method for Determining Apparent Opening Size of a Geotextile."

ASTM D-5261, "Standard Test Method for Measuring Mass per Unit Area of Geotextiles."

ASTM D-5884, "Standard Test Method for Measuring Core Thickness of Textured Geomembranes."

ASTM D5885, "Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry."

ASTM D-5994, "Standard Test Method for Determining Tearing Strength of Internally Reinforced Geomembranes."

ASTM D-6241, "Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 55-mm Probe."

ASTM D6392, "Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Stems Produced Using Thermo-Fusion Methods."

ASTM D-698, "Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort."

ASTM D-6938, "Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)."

ASTM D-7004, "Standard Test Methods for Grab Tensile Properties of Reinforced Geomembranes."

ASTM D-7466, "Standard Test Methods for Measuring Asperity Height of Textured Geomembranes."

ASTM D-751, "Standard Test Methods for Coated Fabrics."

GRI Test Method GM6, "Test Method for Geotextile Pullout."

Appendix A – Typical Field Forms

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Daily Construction Inspection Report

CONTRACT NO.	DATE	REPORT NO
CONTRACTOR		
SHIFT	HOURS WORKED From: To:	WEATHER

CONTRACTOR MANPOWER (BY LABOR CLASS)	NO.	TOTAL HOURS	SUBCONTRACTOR MANPOWER	NO.	TOTAL HOURS

CONTRACTOR EQUIPMENT	NO.	TOTAL HOURS	SUBCONTRACTOR EQUIPMENT	NO.	TOTAL HOURS

DESCRIPTION OF WORK PERFORMED TODAY

REMARKS BY CONTRACTOR (Delays, Interruptions, Deviations, Extra Work Activities, Unusual Occurrence's, etc.)

INSPECTOR	TITLE	DATE

Construction Testing Services
Soils Compaction Testing by ASTM Standards

Project Number:	Project Name:	Client received copy of this report? ☐ Yes ☐ No	Page: 1 of 1
Date:	Client:	Location:	Technician/Engineer:
Daily Field Report Number:	Source of Fill: ☐ Native ☐ Import	Contractor/Representative:	Time Arrived:
Reviewed By:		Gauge Number: / Mileage:	Time Departed:
Date Reviewed:	General Location of Fill:	Results Reported To:	Travel Time (hours):
Density Std (DS): / Moisture Std (MS):	Specified Compaction:	Weather:	Total time (hours):
Soils Report Prepared by: / Soils Report Date:	Work activities observed: ☐ Compaction ☐ Excavation ☐ Earthwork		

Laboratory Compaction Curve A:
Soil Type (description):
Max. Laboratory Dry Density: (lbs/cu. ft)
Optimum Moisture Content (%):

Laboratory Compaction Curve B:
Soil Type (description):
Max. Laboratory Dry Density: (lbs/cu. ft)
Optimum Moisture Content (%):

Test Number	Test Location (i.e. Grid locations, etc.) ☐ See Map/Diagram/Plan attached	Probe Depth (in.)	Test Elev. (ft)	Ref. Curve Used	Test Dry Density (lbs/cu. ft)	Test Moisture %	% Compaction	Comments

Any unresolved test (date/number): _____

Observations/Remarks:

NOTES

1. Tests were conducted in general accordance with the generally accepted testing methodologies practiced within the site area at the time and locations the tests were performed. No warranty is expressed or implied.
2. Test results, pass/fail indications, and/or recommendations (if applicable) provided herein have not been reviewed by supervisory staff, therefore, should be considered preliminary and subject to change.
3. Please note that this report shall not be relied upon by others, as acceptance or guarantee of work. Even with diligent inspection techniques, the contractor is responsible for defects or failures to adhere to the code.

Inspector

☐ Continued next page

Concrete QC - Air and Slump Tests

Line No.: ______________________ **Page No.:** ______________________

Contractor: ______________________ **Category No.:** ______________________

Project No.: ______________________ **Contract ID:** ______________________

Date	Location	Mix Type	Air (%)	Witnessed Quality Control Test (X)	Slump (In)	Application	Remarks	By

Liner Inventory Check List Date: _____

Project: _____ Site Manager: _____

Project #: _____ QA Technician: _____ Page: _____of_____

Material	Roll #	Date Used	Material	Roll #	Date Used	Material	Roll #	Date Used	Material	Roll #	Date Used

SUBGRADE SURFACE ACCEPTANCE

Customer:_____ Date:_____

Project Name:_____ Project Number:_____

Location:_____ Partial:_____Final: _____

I, the undersigned duly authorized representative of Alexco Water and Environment, certify that upon visual inspection the subgrade surface described below meets criteria for installation of:

_____

By signing below, however, Alexco Water and Environment acknowledges no responsibility for the subgrade design, degree of moisture or compaction, integrity, elevation, or maintenance thereof, in any way.

Approximate size of area accepted:_____

Description of the area accepted: _____

_____

_____

_____

_____

_____

_____

_____ _____ _____

Alexco Wster andEnvironment Representative **Contractor** **Inspector**

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ATTACHMENT 4. CONSTRUCTION SPECIFICATIONS

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SECTION 013300
SUBMITTALS

PART 1 - GENERAL

1.01 Summary

A. This section includes definitions, descriptions, transmittal, and review of submittals identified in all Sections of these Specifications.

1.02 Related Work Specified Elsewhere

Not used

1.03 General Information

A. Definitions:

1. Shop Drawings and product data are technical submittals prepared by Contractor, Subcontractor, manufacturer, or Supplier and submitted by Contractor to Engineer as a basis for approval of the use of equipment and materials proposed for incorporation in the Work or needed to describe installation, operation, maintenance, or technical properties, as specified in each Division of the Specification section.

    a. Shop Drawings include custom-prepared data of all types including drawings, diagrams, performance curves, material schedules, templates, instructions, and similar information not in standard printed form applicable to other projects.

    b. Product data includes standard printed information on materials, products, and systems not custom-prepared for this Project, other than the designation of selections from available choices.

2. Informational submittals are those technical reports, administrative Submittals, certificates, and guarantees not defined as Shop Drawings or product data.

    a. Technical reports include laboratory reports, tests, technical procedures, technical records, and Contractor's design analysis.

    b. Administrative Submittals are those nontechnical Submittals required by the Contract Documents or deemed necessary for administrative records. These Submittals include maintenance agreements, Bonds, physical work records, statements of applicability, Project record data, schedules, and similar type Submittals.

B. Quality Requirements:

1. Submittals such as Shop Drawings and product data shall be of suitable quality for legibility and reproduction purposes. Every line, character, and letter shall be

clearly legible. Drawings such as reproducibles shall be useable for further reproduction to yield legible hard copy.

2. Documents submitted to Engineer that do not conform to specified requirements shall be subject to rejection by Engineer, and upon request by Engineer, Contractor shall resubmit conforming documents. If conforming submittals cannot be obtained, such documents shall be retraced, redrawn, or photographically restored as may be necessary to meet such requirements. Contractor's (or his Subcontractor's) failure to initially satisfy the legibility quality requirements will not relieve Contractor (or his Subcontractors) from meeting the required schedule for submittals.

C. Language and Dimensions: All words and dimensional units shall be in the English language.

D. Submittal Completeness:

1. Submittals shall be complete with respect to dimensions, design criteria, materials of construction, and other information specified to enable Engineer to review the information effectively.

2. Where standard Drawings are furnished which cover a number of variations of the general class of Equipment, each drawing shall be annotated to indicate exactly which parts of the drawing apply to the Equipment being furnished. Use hatch marks to indicate variations that do not apply to the Submittal. The use of "highlighting markers" will not be an acceptable means of annotating submittals. Annotation shall also include proper identification of the Submittal permanently attached to the drawing.

3. Reproductions or copies of Drawings or portions thereof will not be accepted as complete fabrication drawings. Contractor may use a reproduction of Contract Drawings to identify detail drawing references. Whenever the Drawings are revised to show this additional Contractor information, Engineer's title block shall be replaced with Contractor's title block, and Engineer's professional seal shall be removed from the drawing. The Contractor shall revise these drawings for subsequent Engineer revisions to the Drawings.

1.04 Technical Submittals

A. Items shall include, but not be limited to, the following:

1. Manufacturer's specifications.

2. Shop fabrication drawings.

3. Instruction books and operating manuals.

4. Material lists or schedules.

5. Performance tests on materials.

6. All drawings, catalogs or parts thereof, manufacturer's specifications and data, instructions, and other information specified or necessary for Engineer to determine that Materials conform with the design concept and comply with intent of the Contract Documents.

B. Schedule of Submittals:

1. Prepare for Engineer's concurrence, a schedule for submission of all Submittals specified or necessary for Engineer's approval of the materials proposed for incorporation in the Work or needed for proper installation, operation, or maintenance. Schedule submission of all submittals to permit review, fabrication, and delivery in time so as to not cause a delay in the Work of Contractor or his Subcontractors or any other contractors as described in the Contract Documents.

2. In establishing schedule for submittals, allow seven (7) days in Engineer's office for reviewing original submittals and four (4) days in Engineer's office for reviewing resubmittals.

3. The schedule shall indicate the anticipated dates of original submission for each item and Engineer's approval thereof, and shall be based upon at least one resubmission of each item.

4. Schedule all Submittals required prior to fabrication or manufacture for submission within 30 days of the Notice to Proceed. Schedule submittals pertaining to storage, installation, and operation at the Site for Engineer's approval prior to delivery of the Equipment and Materials.

5. Resubmit submittals the number of times necessary to obtain Engineer's "Submittal Approved." However, any need for resubmittals in excess of the number set forth in the accepted schedule, or any other delay in obtaining approval of submittals, will not be grounds for extension of the Contract times, provided Engineer completes his reviews within the times specified.

C. Transmittal of Submittals:

1. All submittals (Shop Drawings and product data) for Materials furnished by Contractor, Subcontractors, manufacturers, and Suppliers shall be submitted to Engineer by Contractor.

2. After checking and verifying all field measurements, transmit all submittals to Engineer for approval using the Submittal Transmittal supplied in the Project Manual.

3. Mark each submittal by Project name, Contract title and number, and applicable Specification section and article number. Include in the submittal an itemized list with identification number of submittal contents. Unidentifiable submittals will be returned for proper identification.

4. Check and include Contractor’s approval for submittals of Subcontractors, Suppliers, and manufacturers prior to transmitting them to Engineer.

Contractor's approval shall constitute a representation to Owner and Engineer that Contractor approves the submittals and has determined and verified all quantities, dimensions, field construction and installation criteria, materials, catalog numbers, compliance with Laws and Regulations, and similar data. Contractor assumes full responsibility for doing so; and Contractor has coordinated each submittal with the requirements of the Work and the Contract Documents.

5. At the time of each submission, call to the attention of Engineer in the letter of transmittal any deviations from requirements of the Contract Documents.

6. Make all modifications noted or indicated by Engineer and return the revised submittals until approved. Direct specific attention in writing, or on revised submittals, to changes other than the modifications called for by Engineer on previous submittals. After paper copy submittals have been approved, submit copies thereof for final distribution. Previously approved submittals transmitted for final distribution will not be further reviewed and are not to be revised. If errors are discovered during manufacture or fabrication, correct the submittal and resubmit for review.

7. Following completion of the Work and prior to final payment, furnish record documents and approved Shop Drawings necessary to indicate "as constructed" conditions, including field modifications, in the number of copies specified. All such copies shall be clearly marked "PROJECT RECORD."

8. Keep a copy or sample of each Submittal in good order at the Site.

D. Quantity Requirements:

1. Except as otherwise specified, transmit all Shop Drawings in either of the following quantities:

a. Initial Submittal:

i. Electronic - One copy to Engineer.

b. Resubmittals:

i. Electronic - One copy to Engineer.

c. As-constructed documents:

i. Electronic - One copy to Engineer.

2. Transmit submittals of product data as follows:

a. Initial Submittal:

i. Electronic - One copy to Engineer.

b. Resubmittals:

i. Electronic - One copy to Engineer.

3. Transmit Submittals of Equipment instruction books and operating manuals as follows:

a. Initial Submittal:

i. Electronic - One copy to Engineer.

b. Resubmittals:

i. Electronic - One copy to Engineer.

4. Transmit submittals for reference only:

a. Electronic – One to Engineer.

5. When all Submittals have been updated to "as-constructed" conditions, transmit to Engineer and to Owner in electronic format.

6. Owner may copy and use for internal operations and staff training purposes any and all document submittals required by this Contract and approved for final distribution, whether or not such documents are copyrighted, at no additional cost to Owner. If permission to copy any such Submittal for the purposes stated is unreasonably withheld from Owner by Contractor or any Subcontractor, manufacturer, or Supplier, Contractor shall provide to Engineer the number of copies required by Contractor at each final distribution issue.

E. Engineer's Review:

1. Engineer will review and take appropriate action on submittals in accordance with the accepted schedule of submittals. Engineer's review and approval will be only to determine if the Equipment and Materials items covered by the submittals compatible with the design concept and conform to information given in the Contract Documents.

2. Engineer's review and approval will not extend to design data reflected in submittals which is peculiarly within the special expertise of Contractor or Contractor's Subcontractors or Suppliers. Review and approval of a component item as such will not indicate approval of the assembly in which the item functions.

3. Engineer's review and approval of Shop Drawings or product data will not relieve Contractor of responsibility for any deviation from requirements of the Contract Documents unless Contractor has in writing called Engineer's attention to such deviation at the time of submission, and Engineer has given written concurrence in and approval of the specific deviation. Approval by Engineer shall not relieve Contractor from responsibility for errors or omissions in Submittals.

F. Review Action:

1. Engineer's review action, appropriately completed, will appear on all submittal transmittals when returned by Engineer. Review status designations listed on Engineer's action stamp are defined as follows:

    a. No Exception Taken: Signifies material represented by the Submittal conforms with the design concept and complies with the intent of the Contract Documents and is approved for incorporation in the Work. Contractor is to proceed with fabrication or procurement of the items and with related Work. Copies of the submittal are to be transmitted to Engineer for final distribution.

    b. Make Corrections as Noted: Signifies material represented by the submittal conforms with the design concept and complies with the intent of the Contract Documents and is approved for incorporation in the Work in accordance with Engineer's notations. Contractor is to proceed with fabrication or procurement of the items and with related Work in accordance with Engineer's notations and is to submit a revised submittal responsive to notations marked on the returned submittal or written in the letter of transmittal.

    c. Amend and Resubmit: Signifies material represented by the submittal appears to conform with the design concept and comply with the intent of the Contract Documents but information is either insufficient in detail or contains discrepancies which prevent Engineer from completing his review. Contractor is to resubmit revised information responsive to Engineer's annotations on the returned Submittal or written in the submittal transmittal. Fabrication or procurement of items represented by the submittal and related Work is not to proceed until the submittal is approved.

    d. REJECTED - RESUBMIT: Signifies material represented by the submittal does not conform with the design concept or comply with the intent of the Contract Documents and is disapproved for use in the Work. Contractor is to provide submittals responsive to the Contract Documents.

1.05 Informational Submittals

A. Informational submittals are comprised of technical reports, administrative submittals, and guarantees, which relate to the Work, but do not require Engineer approval prior to proceeding with the Work. Informational submittals include:

1. Field test reports.

2. Soil test reports.

3. Shipping or packing lists.

4. Job progress schedules.

5. Equipment and material delivery schedules.

6. Progress reports and photographs.

7. Warranties and guarantees.

B. Transmittal of Informational Submittals: All informational submittals furnished by Subcontractors, manufacturers, and Suppliers shall be submitted to Engineer by Contractor unless otherwise specified.

1. Identify each informational submittal by Project name and number, Contract title and number, and Specification section and article number marked thereon or in letter of transmittal. Unidentifiable submittals will be returned for proper identification.

2. At the time of each submission, call to the attention of Engineer in the submittal transmittal any deviations from requirements of the Contract Documents.

C. Quantity Requirements:

1. Technical reports, test reports, and administrative submittals except as otherwise specified:

(a) Electronic - One copy to Engineer.

2. Written Certificates and Guarantees:

(a) Paper - One copy to Engineer.

(b) Electronic - One copy to Engineer.

D. Engineer's Review:

1. Engineer will review informational submittals for indications of Work or Material deficiencies.

2. Engineer will respond to Contractor on those informational submittals, which indicate Work or Material deficiency.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

— END OF SECTION —

DIVISION 1 – GENERAL REQUIREMENTS
SECTION 017123
CONSTRUCTION LAYOUT AND SURVEYING

PART 1 - GENERAL

1.01 Summary

A. This section describes Contractor's construction survey responsibilities.

1. Contractor shall complete all necessary construction staking and surveys that may be required for execution of the Work, measurement for payment, and as outlined in the Contract Documents.

1.02 Related Work Specified Elsewhere:

A. Earthwork: Section 312050.

1.03 Submittals

A. All field notes required for determining progress pay estimates.

B. As-built survey data and plan drawings required to verify existing elevations. All as-built data shall be certified by a Professional Land Surveyor registered in the State of Colorado.

C. Copy of surveyor's registration demonstrating licensure in Colorado.

1.04 Quality Assurance

A. Surveyor Qualifications: Engage a land surveyor registered in the State of Colorado to perform required land surveying services.

B. Furnish competent men, equipment, tools, stakes, and other materials as required for properly staking out the Work.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.01 Examination

A. All Work shall be done to the lines, elevations, and grades indicated in the Drawings.

3.02 Performance

A. Contractor shall establish minimum three permanent benchmarks outside the limits of construction for survey control.

1. Benchmark monuments shall be iron pin, 5/8 inch diameter, minimum 24 inches long to prevent displacement.

B. Contractor shall complete the layout of the Work from the control points and shall be responsible for all measurements that may be required for execution of the Work to the location and limits prescribed in the Contract Documents, subject to such modification as may be required to meet changed conditions in the Work.

C. The existence and location of underground facilities, utilities, and other construction indicated as existing are not guaranteed by Engineer. Before beginning Site work, investigate and verify the existence and location of underground facilities and other construction.

D. Contractor shall be aware of all specified surveys and coordinate work with Owner to allow for surveying activities.

E. As-Built Surveys:

1. Contractor shall perform as-built surveys of all drainage channels and structures indicating vertical elevations and horizontal location to verify conformance with the Drawings.

a. Drainage Channels shall be surveyed at 50-foot intervals (maximum) to verify the appropriate geometry and slopes (shown on the Drawings) along the flow line. The results of the survey shall be reported to the Engineer.

b. Access Roadway shall be surveyed at 50-foot intervals (maximum). The results of the survey shall be reported to the Engineer.

c. Dissipater basin shall be surveyed at all grade breaks to verify the approximate geometry and slopes (shown on the Drawings). The results of the sruvey shall be reported to the Engineer.

d. Pipes invert elevations shall be surveyed at inlet and outlet locations. Top of pipes shall be surveyed at 50-foot spacings along the pipe length.

e. Vertical elevations shall be provided to the nearest 0.01 foot.

f. Contractor shall submit plan drawings, electronic files and other necessary documentation to Engineer indicating each grid point and the vertical elevations.

g. The as-built drawings shall be sealed by a Professional Land Surveyor registered in Colorado.

F. Vertical Tolerances:

Survey Item	Vertical Tolerance
Drainage Channels and Roads	+/- 0.20 feet and minimum
General site Grading (non-cap areas)	+/- 0.5 feet

3.03 Field Quality Assurance

A. Owner reserves the right to field check by survey the Work completed by the Contractor.

— END OF SECTION —

DIVISION 2 – EXISTING CONDITIONS
SECTION 026613
GEOTEXTILE

PART 1 - GENERAL

1.01 Summary

A. This Section includes requirements for all geotextile identifed on the Contract Drawings. It includes geotextile to be placed beneath the diversion channel.

1.02 Related Work Specified Elsewhere

B. Earthwork: Section 312050

C. Drainage Channels: Section 334100

1.03 References

D. Applicable Standards:

1. American Society for Testing and Materials (ASTM):

   a. D4354 – Sampling of Geosynthetics for Testing.

   b. D4355 – Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.

   c. D4491 – Test Method for Water Permeability of Geotextiles by Permittivity.

   d. D4533 – Test Method for Trapezoid Tearing Strength of Geotextiles.

   e. D4632 – Test Method for Grab Breaking Load and Elongation of Geotextiles.

   f. D4751 - Test Method for Determining the Apparent Opening Size of a Geotextile.

   g. D4759 – Determining the Specification Conformance of Geosynthetics

   h. D4833 – Test Method for Index Puncture Resistance of Geomembranes and Related Products.

   i. D5261 - Test Method for Measuring Mass per Unit Area of Geotextiles.

2. Raven Engineered Films, GTEX6-16 Nonwoven Needle-Punched Geotextile Data Sheet

1.04 Submittals

A. Product Data: Specifications, installation instructions, and general recommendations from materials manufacturer of geotextile filter fabric.Specification sheets shall give full details of minimum physical properties and test methods used.

B. Manufacturer's quality control certificates for each roll of geotextile delivered to the Site. The quality control certificates shall be submitted a minimum of 7 days prior to scheduled use and include material components listed in Paragraph 2.1 of this Section.

C. Manufacturer's and Installer's written warranties as outlined in Part 1.9 of this Section.

D. The Installer's quality control manual describing method of documenting placement, seaming, laps, and related items. Include results of quality control sampling and testing.

1.05 Qualifications

This section is not used.

1.06 Quality Assurance and Quality Control

A. The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. Documentation describing the quality control program shall be made available upon request. Perform manufacturing quality control sampling and testing in accordance with the manufacturer's approved quality control manual.

1.07 Operation Conditions

A. Do not expose the geotextile material to direct sunlight and ultraviolet rays.

B. High wind can occur at the Site.

1.08 Delivery, Storage and Handling

A. Geotextile rolls shall be packaged in an opaque, waterproof, protective plastic wrapping. The plastic wrapping shall not be removed until deployment. Geotextile or plastic wrapping damaged during storage or handling shall be repaired or replaced, as directed. Label each roll with the manufacturer's name, geotextile type, roll number, roll dimensions (length, width, gross weight), and date manufactured..

B. Protect rolls of geotextile from construction equipment, chemicals, sparks and flames, temperatures in excess of 160 degrees F, or any other environmental condition that may damage the physical properties of the geotextile. To protect geotextile from becoming saturated, either elevate rolls off the ground or place them on a sacrificial sheet of plastic in an area where water will not accumulate. Handle and unload geotextile rolls with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Rolls shall not be dragged along the ground, lifted by one end, or dropped to the ground.

C. Damaged material on rolls shall be cut out and removed from the Site.

1.09 Warranty

A. Material shall be warranted against defects for a period of 1-year from the date of the geotextile installation.

B. Installation shall be warranted against defects in workmanship for a period of 1-year from the date of geotextile completion.

PART 2 - PRODUCTS

2.01 Geotextile

A. Shall be manufactured of new, first quality products designed and manufactured specifically for the purpose of filtering out soil fines while maintaining good drainage characteristics.

B. Shall be so produced as to be free of tears, punctures, or any sign of contamination by foreign matter. Any such defect shall be repaired in accordance with the manufacturer's recommendations. Geotextile must be uniform in thickness with a maximum 10 percent deviation from the nominal thickness. Edges shall be straight and free of nicks and cuts.

C. Shall have a minimum roll width of 15-feet.

D. Shall be Mirafi 180N nonwoven needle-punched polypropylene or an approved alternate material which meets the following requirements:

1. Material: Nonwoven needle punched polypropylene.

2. Mass/Unit Area: ASTM D5261, 8 oz/yd^2.

3. Grab Tensile Strength: ASTM D4632, 205 pounds.

4. Elongation at Failure: ASTM D4632, 50 percent.

5. Coefficient of Permittivity-k: ASTM D4491, 1.4 sec^{-1}.

6. Apparent Opening Size: ASTM D4751, 80 mm.

7. CBR Puncture Strength: ASTM D6241, 500 pounds.

8. Trapezoid Tear Strength: ASTM D4533, 80 pounds.

9. Ultraviolet Light Resistance: ASTM D4355, 70 percent.

PART 3 - EXECUTION

3.01 Examination

A. Verify that all surfaces to be lined are smooth, free of all foreign material, sharp objects, or debris of any kind.

B. Verify that all surfaces to be lined provide a firm foundation with no sharp changes or abrupt breaks in grade.

C. Verify that there is no standing water or excessive moisture on prepared subgrade.

D. Certify in writing that the surface on which the geotextile is to be installed is acceptable before commencing work.

3.02 Installation

A. Install geotextile on prepared surface or within trench using careful procedures with minimum handling. Unroll panels as close to their final position as possible.

B. The geotextile shall be rolled down the slope in such a manner as to continuously keep the geotextile in tension by self weight. The geotextile shall be securely anchored in an anchor trench where applicable, or by other approved or specified methods.

C. Geotextile Overlaps:

1. Geotextile panels shall be overlapped a minimum of 12-inches before covering.

D. All holes, tears, burns, or other damage to geotextile shall be repaired by either heat bonding a patch over the damage area or by cutting out the damaged area and sewing in undamaged materials.

E. Adhere to the following stipulations while working on or near geotextile:

1. No smoking shall be allowed.

2. No glass or metal containers or other sharp objects shall be used.

3. No construction installation equipment shall pass over any exposed fabric surface.

4. Remove snow and water from the ground surface prior to fabric installation.

5. Cover the geotextile within 5 days after placement.

— END OF SECTION —

SECTION 026617
GEOMEMBRANE

PART 1 - GENERAL

1.01 Summary

A. This Section includes geomembrane liner and all necessary and incidental items as detailed or required to complete the installation of the reinforced polyethylene geomembrane underneath the diversion channel.

1. The geomembrane shall only be installed underneath the diversion channel when the channel is constructed over the waste rock pile.

1.02 Related Work Specified Elsewhere

A. Geotextile: Section 026613

B. Earthwork: Section 312050

C. Drainage Channels: Section 334100

1.03 References

A. Applicable Standards:

1. American Society for Testing and Materials (ASTM):

a. D5994 Standard Test Method for Measuring Core Thickness of Textured Geomembranes.

b. D7466 Standard Test Method for Measuring Asperity Height of Textured Geomembranes.

c. D751 Standard Test Methods for Coated Fabrics.

d. D5884 Standard Test Method for Determining Tearing Strength of Internally Reinforced Geomembranes.

e. D7004 Standard Test Method for Grab Tensile Properties of Reinforced Geomembranes.

f. D4833 Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

g. D3895 Standard Test Method for Determining Oxidative-Induction Time (OIT) of Polymeric Materials by Standard Differential Scanning Calorimetry.

h. D5885 Standard Test Method for Determining Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry.

2. The latest revision of the following standard of the Geosynthetic Research Institute (GRI) are hereby made a part of these specifications:

   a. GRI GM25 Standard Specification for Test Methods, Test Properties and Testing Frequency for Reinforced Linear Low-Density Polyethylene (LLDPE-R) Geomembranes.

1.04 Submittals

A. Prior to Reinforced Polyethylene Geomembrane installation, the Contractor shall submit the following:

1. Certificate of Conformance and Sample: Prior to shipping to the site, the Contractor shall submit a certificate or affidavit signed by a legally authorized official of the Manufacturer for the Reinforced Polyethylene Geomembrane attesting that the Reinforced Polyethylene Geomembrane meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample of the Reinforced Polyethylene Geomembrane to be used (sample may be of different color). The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Installer's QC manual to include, but not be limited to, deployment, wind ballast, seam sampling, testing, and documentation of all installation and testing activities required by this Section.

3. Certifications and calibration charts (current within 6 months prior to use on Project) for all testing apparatus and gauges to be used by Installer.

4. Submit installation procedures for carrying out the work. Installation procedures to be addressed shall include but not be limited to material installation, repair, and protection to be provided in the event of rain or strong winds.

5. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

B. Upon completion of the Reinforced Polyethylene Geomembrane installation, the Contractor shall submit a completed material performance warranty.

1.05 Qualifications

A. The Manufacturer shall have produced the proposed geomembrane sheets for at least 5 completed projects having a total minimum area of 10 million square feet.

B. The Installer is responsible for field handling, deploying, and field Quality Control (QC) testing of the geomembrane. The Installer shall have installed the proposed geomembrane material for at least 5 completed projects having a total minimum area of 2 million square feet.

C. The CQC Manager shall have provided CQC management during installation of the proposed geomembrane material for at least 5 completed projects having a total minimum area of 2 million square feet.

1. The QC laboratory shall have provided QC and/or Quality Assurance (QA) testing of the proposed geomembrane and geomembrane seams for at least five completed projects having a total minimum area of 2 million square feet. The QC laboratory shall be accredited via the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP) for the tests the QC laboratory will be required to perform.

1.06 Quality Assurance and Quality Control

A. Geomembrane manufacturer quality control testing shall meet or exceed requirements outlined in Tables 1 of this Section prior to installation. Materials that do not conform to these requirements shall be retested or rejected at the direction of Engineer.

B. Geomembrane that is rejected shall be removed from the Project Site and replaced at Contractor's expense. Sampling and conformance testing of geomembrane supplied to replace rejected material shall be performed by Engineer at Contractor's expense.

C. Contractor shall arrange for Geomembrane Installer to provide one or more Construction Quality Control (CQC) Managers to monitor installation, testing, and documentation of geomembrane installation. CQC Manager will coordinate all activities relating to the installation, testing, and documentation.

D. Installation documentation shall be recorded by the CQC Manager.

1.07 Operation Conditions

A. Geomembrane material will be exposed to direct sunlight and ultraviolet rays during the construction period.

B. Geomembrane may be exposed to high wind velocitoies.

C. Geomembrane shall not be deployed or field-seamed in the presence of excess moisture (i.e., rain, fog, dew), in areas of ponded water, or in the presence of excess wind. Unless authorized by the Engineer, no placement or seaming shall be attempted at ambient temperatures below 32°F or above 104°F. Ambient temperature shall be measured at a height no greater than 6 inches above the ground or geomembrane surface. If seaming is allowed below 32°F, the procedures outlined in GSI GRI GM9 shall be followed.

1.08 Delivery, Storage and Handling

A. Rolls and fabricated panels (accordion-folded in one direction, rolled in the other direction) will be unloaded from trucks in such a way that no damage occurs to the geomembrane.

B. Fabricated panels accordion folded in both directions shall not be used.

C. Rolls will be moved using sufficiently long stingers, spreader bars, or other equipment using at least two slings. Rolls will be lifted vertically off, and not dragged along, the truck bed.

D. Fabricated panels on pallets shall be moved by forklifts.

E. The folds of fabricated panels that are visible shall be examined for damage, particularly at kinks in the folds.

F. All material shall be stored on smooth clean dry level surfaces such that it shall not be damaged, become dirty, or get wet internally.

G. Rolls shall be stored no more than three high and with sufficient space between ends such that access is available to read identification labels.

H. Depending on the size of project, material shall be stored in a safe central location then staged at appropriate intermediate locations for deployment.

Fabricated panels shall ultimately be placed in the correct location and in the correct orientation for deployment as shown on the protective packaging or in contained deployment instructions.

1.09 Warranty

A. Furnish a written warranty from the geomembrane manufacturer for a useful life of not less than 20 years from the date of installation, covering the geomembrane liner material under the specified operating conditions.

B. Furnish as a minimum, a 2-year warranty from the Geomembrane Installer for the installation against defects.

C. Such written warranties shall provide for the repair and/or replacement of any defect or defective areas of geomembrane, or compensation for defective work, upon written notification and demonstration by Owner of the specific nonconformance of the geomembrane or installation with the Contract Specifications. Compensation for defective material shall be provided to Owner for the estimated cost to Owner at that time of supplying and installing material to a clean, dry, and unencumbered condition by a third-party Installer.

D. Contractor shall be responsible for obtaining any necessary guarantees or certifications from geomembrane manufacturer and Geomembrane Installer and submitting them to Engineer and Owner prior to installation of geomembrane liner.

PART 2 - PRODUCTS

2.01 Geomembrane Material

A. The material for the geomembrane shall be textured (both sides) 45-mil DuraSkrim® reinforced polyethylene, or Engineer approved alternate.

1. Reinforcement shall consist of a heavy encapsulated 9 X 9 weft inserted 1000 denier polyester.

B. Reinforced polyethylene geomembrane shall be manufactured to provide finished product free from holes, pin holes, bubbles, blisters, excessive gels, undispersed resins and/or carbon black, or contamination by foreign matter.

2.02 Geomembrane Manufacturing

A. The reinforced polyethylene geomembrane shall be supplied in panels, which shall be of maximum size to provide the largest manageable sheet for the fewest seams.

B. Factory seams are produced by thermal sealing methods and shall have a minimum seam width of 1 ½ inch scrim to scrim.

C. Factory seams are 100% visually inspected and destructive testing is done to verify quality compliance.

D. Labels on the panels shall identify the thickness, length, width, lot and panel numbers, and name of Manufacturer.

E. Factory pre-assembled panels are accordion folded and rolled on a cardboard core. Rolled panels are wrapped in a protective layer for shipment.

F. Table 1 lists required reinforced polyethylene geomembrane properties.

Table 1

REQUIRED PHYSICAL PROPERTIES OF 45 MIL TEXTURED REINFORCED GEOMEMBRANE

Property[(1)]	MQC Testing Frequency	Test Method	Requirement
Thickness	per roll	ASTM D5994	nominal 45 mils[(3)]
Asperity Height (min ave)	Every Second Roll	ASTM D7466	16 mils
Weight	Per 20,000 lb	ASTM D751	200 lbf/msf
Tongue Tear Strength	Per 45,000 lb	ASTM D5884	100 lbf
Grab Tensile Strength	Per 20,000 lb	ASTM D7004	275 lbf
Tensile Elongation at Break	Per 45,000 lb	ASTM D7004	22%
Puncture Resistance	Per 45,000 lb	ASTM D4833	108 lbf
Standard OIT or High Pressure HPOIT	per GRI-GM10	ASTM D3895 ASTM D5885	100 min 400 min

2.03 Tests, Inspections, and Verifcations

A. Sheet Material: Geomembrane sheets shall be tested in accordance with the approved MQC manual. As a minimum, MQC testing shall be conducted at the frequencies shown in Table 1. Sheets not meeting the minimum requirements specified in Table 1 shall not be sent to the site.

PART 3 - EXECUTION

3.01 Subgrade Preparation

A. The subgrade shall be constructed so as to cause minimimal stress on the geomembrane. It shall not be susceptible to differential settlement.

B. The Installer shall confirm that the subgrade is smooth, firm, and unyielding.

C. There shall be no step elevation changes exceeding 1 in. and no desiccation cracks exceeding 0.25 in. in width.

D. There shall be no rocks, roots, or any other protruding objects in the 2 in. surface layer. If there is any potential for vegetation growth a suitable sterilant shall be applied to the surface layer by the Contractor before final compaction. Such sterilant shall not be chemically incompatible with the geomembrane material.

E. The Installer shall approve the subgrade. Only as much subgrade that can be covered in one day should be approved.

F. It is the Contractor's responsibility to maintain the subgrade to the requirements of the Installer.

G. There shall be no standing water on the subgrade when liner is placed.

3.02 Material Deployment

A. General Requirements:

1. There shall be no smoking on the liner. Soft sole shoes shall be worn. Only hook blade knives with automatic blade retraction shall be used on the liner. Equipment such as generators are not allowed on the liner without a protective cushion. Fuel containers will only be allowed on the liner if they have leak-tight secondary containment.

2. Deployment shall not be done in strong winds, precipitation, lightning, or when there is standing water on the subgrade.

B. Material Deployment:

1. Rolls and panels shall be deployed in such a way that they are not damaged. Deployment shall not be done in strong or gusty winds or during precipitation events and lightning storms.

2. Rolls shall be suspended from a spreader bar and material pulled off the roll. Alternatively, the end of the roll shall be fixed and the roll unrolled manually.

3. Rolls shall not be allowed to unroll freely down slopes.

4. Vehicles shall not be used to carry and unroll the geomembrane as the vehicle traverses the subgrade unless the vehicle leaves no tire or track impressions in the subgrade. Any damaging rocks or roots, etc. seen in the subgrade during deployment shall be removed and not covered.

5. Final adjustments to the location of the panel can best be done by lifting and flapping the liner so it "floats" on air. In gusty conditions the panel shall be kept close to the ground.

6. In gusty conditions that might unexpectedly lift the liner no one shall walk on the liner until it has been effectively ballasted.

7. Large prefabricated panels shall be unrolled and unfolded as indicated in the deployment instructions included with the panel. Unfolding shall be done with a man every 15 to 30 ft. depending on the size/weight of the panel.

8. During deployment, folds and kinks in folds shall be carefully examined for thinning and cracking damage particularly at low temperatures.

9. Deployment will generally commence on side slopes and proceed down-gradient.

C. Anchor Trenches:

1. Geomembrane shall be placed down the front wall and across the bottom of anchor trenches. The geomembrane shall not be folded in the anchor trench.

2. The front edge of the anchor trench shall be rounded, with no sharp stones that might damage the liner. There shall be no loose stones/rocks in the anchor trench and no standing water. The Contractor shall be responsible for maintaining the anchor trenches in good condition for the installer.

3. The anchor trench shall be filled with soil that does not damage the liner and that will not damage the liner when compacted. The soil shall be compacted sufficiently to preclude standing water in the trench. If there are holes in the liner on the front face of the anchor trench, and the soil is not compacted such as to preclude standing water, water might seep through the holes and erode the slopes.

D. Welding / Joining

1. General

a. When the weld is sectioned there should not be a well-defined interface, nor should there be any particulates or voids along the weld line. There should be no crimps due to overheating. The adjacent geomembrane should not be overheated and oxidized such that it becomes brittle.

b. Acceptable field welding methods are thermal fusion and extrusion. The thermal energy for fusion welding can be provided by hot wedges, hot air, or a combination. Any other method (laser, ultrasonic, etc.) must be approved by the Manufacturer and the Engineer.

c. Chemical bonding is not acceptable.

d. Extrusion welding rod should be made from the same resin class as the bonding surface of the geomembrane surfaces being extruded to.

2. Trial Welding

a. Trial welding will be done at the start of every 4 hr. (approx.) shift, after the machine has been turned off and restarted, and when the geomembrane changes temperature by more than 25ºC.

b. Trial welds, at least 4 ft. long, shall be made on scraps of the same material as will be installed.

c. Welds will be made with sheet in the same orientation (flat floor, slope, wall etc.) and on the same substrate as the planned production welds. Trial welding conditions shall not be optimized.

d. Five specimens shall be tested in peel mode according to the parameters below. The minimum geomembrane tab elongation of 50% allows for scrim break but the polymer layers must not break.

e. Trial Seam Peel Test Parameters:

(1)	Width Specimen:	1 inch
(2)	Number of Specimens:	5
(3)	Grip/Specimen Distance:	1 inch
(4)	Crosshead Speed:	2 inches/min
(5)	Elongation:	50% min.
(6)	Separation:	0%

f. If three trial weld attempts fail, the equipment shall be put aside and repaired. When used again, two passing trial welds shall be made before that equipment can be used for production welding.

g. The cross sections of welds shall be examined for symmetry, lack of crimping (overheating), and the presence of voids and foreign particulates. If voids and particulates are present the weld will be rejected, even if the weld passes a peel test.

h. When geomembrane temperatures during welding are below 40ºF or above 100ºF 5 peel specimens will be tested for unreinforced material seams. All must pass.

3. Field Welding

a. Two types of weld geometry are acceptable:

(1) Double track fusion welding for long straight seams with free flaps on each side of the weld for peel and shear testing

(2) Extrusion welding for patches with a flap on the underside.

b. Sheet overlaps should be sufficient to facilitate seam peel testing, typically 4 in. for extrusion seams and 6 in. for fusion seams.

c. For double track fusion welds, the outer flap shall be wide enough to facilitate peel testing.

d. Welding shall not be done in strong winds, during precipitation, and during lightning storms, nor where there is standing water on the subgrade.

e. The surfaces to be bonded shall be dry and clean for fusion welding. Dry with a clean cloth, or carefully with a hot air gun. Clean with a cloth or carefully with isopropyl alcohol and water.

f. Reinforcement yarns shall not be exposed during grinding/abrasion, and all abrasion debris shall be removed.

g. Welding shall be done within 30 minutes of surface preparation.

h. Welding shall continue to the edge of the liner in the anchor trench.

i. Fishmouths in reinforced materials shall be cut along the peak, overlapped, laid flat, and extrusion welded along the full length. A minimum 6 in. diameter patch will be placed over the end of the cut. A keyhole shall be made at the end of the cut and the remainder of the overlap patched. The keyhole will minimize the potential for further propagation of the cut.

j. At the end of every weld write on the liner:

(1) Initials of operator

(2) Number of welding machine

(3) Machine speed, temperature, pressure settings

(4) Date

(5) Time started

4. Nondestructive Testing

a. Two test methods are available:

(1) center air channel pressure testing for double track fusion seams

(2) vacuum box testing for single track fusion and extrusion seams

b. Air Channel Testing

(1) Clamp or otherwise seal both ends of the seam to be tested – distance not to exceed 450 ft.

(2) Insert pressure feed needle into the air channel at one end and pressurize to 30 psi.

(3) Allow conditions to stabilize for 2 minutes.

(4) Note starting pressure.

(5) Note pressure after 5 minutes.

(6) Ensure pressure loss does not exceed 2 psi.

(7) If pressure cannot be generated or if pressure loss is excessive walk the length of the seam listening for the whistling noise at a leak. If a leak is found repair and re-test.

(8) If pressure loss is acceptable release seal at far end of seam and confirm loss of pressure.

(9) If pressure is not lost locate blockage in the channel and test the untested section.

(10) Repair needle hole with one extrusion bead.

(11) Write on the liner the tester's initials, date, start time/pressure, finish time/pressure, pressure drop, pass/fail.

c. Vacuum Box Testing

(1) Apply soapy solution to seam area to be tested.

(2) Place vacuum box with clean viewing glass along seam.

(3) Ensure sealing foam around bottom of box is well seated and provides a good seal.

(4) It may be necessary to "work" the box into place and to use some wet rags to get a good seal.

(5) Reduce pressure difference in the box to about 4 psi.

(6) Monitor the seam for soap bubbles for at least 5 seconds.

(7) Mark any locations where bubbles indicate leaks for repairs.

(8) If no bubbles occur after 5 seconds relieve vacuum and move to next seam section.

(9) Overlap sections tested by about 3 in. and re-test.

(10) Write on the liner the tester's initials, date, time tested, test pressure, and "VB pass/fail".

E. Seam Sample Failures

1. If any sample fails seam testing two new samples shall be taken about 10 ft. each side of the failing sample, and so on until two passing samples define the limits of the non-conforming seam.

2. The seam shall be repaired between the two passing samples.

F. Flaws and Repairs

1. All non-penetrating linear flaws less than 0.125 in. wide may be repaired with no more than one extrusion bead of the same base polymer as the geomembrane.

2. Penetrating holes less than 0.125 in. in diameter that do not expose scrim yarns may also be repaired with no more than one bead application.

3. Holes that expose scrim yarns and those that are more than 0.125 in. in diameter shall be patched with the same geomembrane with patch yarns oriented in the same direction as in the geomembrane. The patch shall extend at least 3 in. from the edge of the nearest damage if the damaged area is less than 1 in. in diameter. When damage exceeds 1 in. in diameter the patch shall extend at least 6 in. from the nearest damage.

4. Under no circumstances will parallel and overlapping beads be used to fill in a flawed area or a gap.

5. All corners on patches shall be rounded.

6. All patch extrusion welds shall be vacuum box tested and hot air patches can be either air lanced or vacuum tested and the results recorded.

7. All patches shall be numbered and their sizes and locations recorded

3.03 Geomembrane Acceptance

A. The Installer shall retain all ownership and responsibility for the geomembrane until acceptance by the Owner. In the event the Installer is responsible for placing a protective cover over the geomembrane, the Installer shall retain ownership and responsibility for the geomembrane until the protective cover is placed. The geomembrane will be accepted when the following activities have occurred:

1. The installation is finished.

2. Signed QC certificates for each roll/panel of geomembrane have been supplied by the Installer by the Engineer.

3. All documentation required by the specification has been received.

— END OF SECTION —

DIVISION 3 – CONCRETE
SECTION 033053
MISCELLANEOUS CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01 Summary

A. This Section includes concrete that will be used as infill material for the drainage channel lining material and for the capture structure.

1.02 Related Work Specified Elsewhere

A. Section 334100: Drainage Channels and Ponds.

1.03 References

A. Applicable Standards:

1. American Concrete Institute (ACI):

a. 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete.

b. 305R - Hot-Weather Concreting.

c. 306R - Cold-Weather Concreting.

d. 318 - Building Code Requirements for Structural Concrete.

e. SP-66 - Detailing Manual.

2. American Society for Testing and Materials (ASTM):

a. A82 - Steel Wire, Plain, for Concrete Reinforcement.

b. A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.

c. A185 - Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.

d. A312 - Seamless and Welded Austenitic Stainless Steel Pipe.

e. A615 - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

f. B370 - Copper Steel and Strip for Building Construction.

g. C31 - Practice for Making and Curing Concrete Test Specimens in the Field.

h. C33 - Concrete Aggregates.

i. C39 - Test Method for Compressive Strength of Cylindrical Concrete Specimens.

j. C94 - Ready-Mixed Concrete.

k. C143 - Test Method for Slump of Hydraulic Cement Concrete.

l. C150 - Portland Cement.

m. C172 - Practice for Sampling Freshly Mixed Concrete.

n. C192 - Practice of Making and Curing Concrete Test Specimens in the Laboratory.

o. C309 - Liquid Membrane-Forming Compounds for Curing Concrete.

p. C494 - Chemical Admixtures for Concrete.

q. C881 - Epoxy-Resin-Base Bonding Systems for Concrete.

r. C1107 - Packaged Dry, Hydraulic Cement Grout (Nonshrink).

s. C1315 - Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.

t. D1751 - Preformed Expansion Joint Filler for Concrete Paving and Structural Construction. (Nonextruding and Resilient Bituminous Types).

u. D1752 - Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.

v. F436 - Hardened Steel Washers.

w. F593 - Stainless Steel Bolts, Hex Cap Screws, and Studs.

x. F594 - Stainless Steel Nuts.

y. F1554 - Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

3. Concrete Reinforcing Steel Institute (CRSI):

a. Manual of Standard Practice.

4. Midwest Concrete Industry Board (MCIB).

1.04 Submittals

A. Include, but not limited to, the following:

1. Complete reinforcing-bar schedule, reinforcing-bar details, and erection drawings to conform to ACI SP-66.

2. Each type of reinforcing bar marked with identification corresponding to identification tag on bar.

3. Erection drawings clear, easily legible, and to a minimum scale of:

   a. 1/4 inch = 1 foot.

   b. 1/8 inch = 1 foot if bars in each face are shown in separate views.

4. Size and location of all openings.

5. Grade of steel.

6. Lap lengths.

B. Concrete Mix:

1. Submit proposed concrete-mix proportions for approval prior to placing concrete. Mix proportions shall be selected preferably on the basis of field experience.

2. Submit fine- and coarse-aggregate gradation data for approval prior to placing concrete.

1.05 Quality Assurance

Field Testing: Shall be performed by an ACI Concrete Field Testing Technician Grade 1.

PART 2 - PRODUCTS

2.01 Concrete Materials

A. Cement: Conform to ASTM C150. Portland cement Type II, or V.

B. Water: Clean and free from injurious amounts of oil, acids, alkalies, or other deleterious substances. Any potable drinking water will be acceptable.

C. Fine Aggregates: Clean natural sand. Manufactured sand may be used upon written approval of Engineer. Conform to ASTM C33.

D. Coarse Aggregates: Clean crushed stone or processed gravel, not containing organic materials. Conform to ASTM C33, size No. 57 or 67.

E. Air Entrainment: Conform to ASTM C260.

F. Water-Reducing Admixture: Conform to ASTM C494, Type A.

G. Admixtures shall not contain chloride ions.

2.02 Concrete Mix Proportions

A. 4,500 psi

1. Minimum Compressive Strength: 4,500 psi at 28 days.

2. Water/Cement Ratio: 0.45.

3. Air Content: 5% - 8%.

2.03 Concrete Reinforcement

A. Reinforcement Bars: Conform to ASTM A615, Grade 60 for all bars No. 4 or larger.

B. No. 3 Bars: Conform to ASTM A615, Grade 40.

C. Welded Wire Fabric: Conform to ASTM A185, using bright basic wire conforming to ASTM A82. Wire gage No. 11 or smaller shall be galvanized. Provide mats only.

D. Bolsters, Chairs, and Accessories: Conform to ACI SP-66 and CRSI Manual of Standard Practice.

2.04 Curing Agent

A. Apply to all concrete surfaces unless otherwise indicated or specified.

B. Curing agent shall conform as follows:

1. ASTM C309, Type 1: Use where concrete surface is not exposed to direct sunlight after placement.

2. ASTM C309, Type 1-D: Use where slabs are exposed to direct sunlight for a period of seven days minimum after placement. Curing and sealing agent with fugitive dye shall be readily distinguishable upon the concrete surface for at least four hours after application but shall be inconspicuous within seven days after application.

3. ASTM C309, Type 2: Use as specified in PART 3, ARTICLE 3.03 – PLACING OF CONCRETE, this Section.

4. Curing compound shall be VOC compliant with a maximum VOC content of 2.9 lbs/gal, or less where Project location regulations are more stringent.

PART 3 - EXECUTION

3.01 Field Testing

A. Field Testing of Concrete and Making of Concrete Test Cylinders:

1. Contractor shall furnish test equipment, test cylinder molds, and certified personnel to perform all required field tests, make the required concrete test

cylinders, and deliver test cylinders to the testing laboratory. The prescribed tests shall be made in the presence of or with the concurrence of Owner.

2. Test concrete and make test cylinders conforming to ASTM C31, C143, and C172. Samples shall be taken at random and at the point of truck discharge.

3. Perform slump and air content tests throughout any placement as required to maintain constant quality of fresh concrete, and when directed by Engineer.

4. Field testing personnel shall remain on Site throughout placement of concrete.

5. Make not less than four test cylinders for each 50 cubic yards of concrete or fraction thereof for each day concrete is placed. Deliver to testing laboratory within 24 hours after taking cylinders. Exercise care not to damage cylinders in transit.

3.02 Laboratory Testing

A. An independent testing laboratory will be selected and paid by the Owner to perform the required laboratory tests.

B. Laboratory will cure concrete cylinders conforming to ASTM C192.

C. Cylinders shall be tested conforming to ASTM C39. Average strength of two cylinders (same age) shall be used as result of the test. Break two cylinders at 7 days; two at 28 days; and one hold at Contractor's option.

3.03 Placing of Concrete

A. Preparation:

1. Clean bonding surfaces free from laitance and foreign materials.

2. Verify that all embedded items are accurately and securely installed.

3. Place concrete on properly prepared and unfrozen subgrade and only in dewatered excavations.

4. Do not deposit partially hardened concrete or concrete contaminated by foreign materials.

B. Placing Concrete:

1. Conform to ACI 304R.

2. Place within 45 minutes after mixing, except Engineer may extend the period to 90 minutes (maximum) dependent upon weather conditions.

3. Place in horizontal layers not exceeding 18 inches.

4. Vibrate concrete to produce solid mass without honeycomb or surface air bubbles.

C. Curing Concrete:

1. Cure with curing agent. Apply according to manufacturer's recommendations.

2. Apply curing compound to all exposed surfaces immediately after removing form or after finishing concrete.

3. Keep formwork wet until stripped.

D. Cold-Weather Placing: Conform to the practice recommended in ACI 306R when the temperature is below 40°F or is likely to fall below 40°F during 24-hour period after placing.

E. Hot-Weather Placing: Conform to practices recommended in ACI 305R when temperature is 90°F or above or is likely to rise above 90°F within 24-hour period after placing, or when there is a combination of high air temperature, low relative humidity, and wind velocity which would impair either concrete strength or quality.

3.04 Surface Finishes

A. Float Finish:

1. Compact, accurately screed, and wood-float all slabs to a true uniform surface.

2. Test surface with straightedge, and eliminate high and low spots of more than 1/8 inch in 10 feet.

3. Use this finish in addition to the finishes specified below for all surfaces as indicated.

4. Use as final finish for (slabs to receive ceramic or quarry tile or a finish topping.) (footing slabs not exposed.)

B. Broom Finish:

1. Finish surface as in "Float Finish" and, in addition, draw a stiff bristled broom across the previously floated surface.

2. Corrugations shall be uniform in appearance, not more than 1/16 inch in depth, and shall be perpendicular to direction of traffic.

3. Use this finish on all outdoor slabs subject to vehicular or pedestrian traffic.

C. Defective Surface Treatments:

1. After removal of forms, remove all fins, projections, and form ties.

2. Grout and cure all voids, damaged areas, and tie holes.

3. Remove concrete with defective surfaces and replace.

3.05 Steel Reinforcement:

A. Place all steel reinforcement before concrete is cast in accordance with approved erection drawings, ACI 117, Chapters 7 and 12 of ACI 318, and the CRSI Manual of Standard Practice.

B. Tie securely with 16-gage or larger annealed iron wire.

C. Splice steel reinforcement where indicated. Unless otherwise indicated, the minimum length of lap for tension lap splices shall be as required for Class B splices as defined by ACI 318.

D. Lap welded wire fabric not less than the length of one mesh.

3.06 Repair, Replacement, and Field Modifications

A. Embedded items and concrete that are misplaced or damaged during construction shall not be repaired, replaced, or field-modified without approval of Engineer.

— END OF SECTION —

DIVISION 31 EARTHWORK
SECTION 312050
EARTHWORK

PART 1 - GENERAL

1.01 Summary

A. This Section includes requirements for general fill, aggregate, and riprap, along with construction requirements for excavation, placement, compaction and grading necessary to complete the Work for the diversion channel.

1.02 Related work Specified Elsewhere

A. Section 026613: Geotextile

B. Section 334100: Drainage Channels

1.03 References

A. Applicable Standards (use latest published version):

1. American Society for Testing and Materials (ASTM) (Equivalent AASHTO standards may be substituted as approved):

a. C33 – Standard Specification for Concrete Aggregates

b. C88 – Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

c. C131 – Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

d. C127 – Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

e. D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3) (600 kN-m/m^3).

f. D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

2. Occupational Safety and Health Administration (OSHA):

a. 29 CFR Part 1926 - Safety and Health Regulations for Construction.

3. Colorado Department of Transportation (CDOT):

a. Standard Specifications for Road and Bridge Construction.

1.04 Submittals

A. Submit for Engineer's approval the following:

1. General Fill Samples: When requested or when new General Fill soil types are encountered, submit one five-gallon bucket of a representative sample of the soil to the Engineer for laboratory testing.

2. Material Test Results: Riprap and aggregate test results demonstrating that the materials comply with their respective ASTM standards, gradation and the requirements set forth herein.

3. Grading Plan: This plan shall identify the Contractor's planned means and methods for grading the drainage channels and rip rap basin. The plan shall include a list of the make and model of all planned equipment to be used, the planned sequence of events and associated procedures, and how deficiencies will be corrected.

1.05 Qualifications

Not used.

1.06 Quality Assurance and Quality Control

A. Sampling and Testing: Tests to determine conformance with all requirements of this Specification for quality and properties of all Contractor secured materials, including borrow materials (both on or off Site) proposed for use, shall be performed by an independent, commercial laboratory retained and compensated by Contractor, and approved by Engineer.

1.07 Operating Conditions

A. Lines and grades shall be as indicated. Owner will furnish benchmarks, base lines, and reference points as necessary to permit Contractor to lay out and construct the Work properly.

B. Carefully maintain all benchmarks, monuments, and other reference points and replace as directed by Engineer if disturbed or destroyed.

C. Temporary Erosion and Sediment Controls: Furnish, install, construct, and maintain temporary measures to control erosion and minimize the siltation of intermittent streams and the pollution of private properties. Temporary erosion and sediment control measures shall be constructed in substantial compliance with local, state, federal, and jurisdictional agency's regulations and Drawings. Temporary erosion and sediment control measures shall be maintained until completion of the Work.

D. Disposition of Utilities:

1. Contractor shall identify, locate and protect all underground utilities, which may be affected by the Work before starting excavation or other Site construction activities which could damage existing utilities.

2. Remove or relocate only as indicated, specified, or directed. Provide a minimum 48-hour notice to Engineer and Owner and receive written notice to proceed before interrupting any utility service.

3. Adequately protect from damage all active utilities and remove or relocate only as indicated or approved.

4. Contractor shall report active, inactive, and abandoned utilities encountered in excavating and grading operations that are not indicated on Drawings. Remove, plug, or cap as directed by Engineer.

5. Provide as-constructed drawings of underground utilities either not shown or found at locations that differ from those shown on Drawings.

E. Survey Work, to accurately determine locations, elevations, and quantities of Contract pay items as well as adherance to survey tolerances, shall be performed during the course of construction by Professional Surveyor registered in the state of Colorado. Surveyor shall be retained and compensated by Contractor. Contractor shall notify Engineer prior to commencing survey Work.

1.08 Delivery, Storage, and Handling:

Not used.

1.09 Warranty

Not used.

PART 2 - PRODUCTS

2.01 Definitions

A. Suitable Materials: Materials suitable for use in general fill include material that is free of debris, roots, organic matter, frozen matter:

1. Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands generally exclusive of clayey and silty material with the following properties: are free-draining; impact compaction will not produce a well-defined moisture-density relationship curve; maximum density by impact methods will generally be less than by vibratory methods; generally less than 15 percent by dry weight of soil particles pass a No. 200 square-mesh sieve.

2. Cohesive materials include materials made up predominately of silts and clays generally exclusive of sands and gravel with the following properties: impact compaction will produce a well-defined, moisture-density relationship curve; are not free draining.

B. Unsuitable Materials: Materials unsuitable for use in fill include all material that contains debris, roots, organic matter, frozen matter, shale particles, or material containing gravel or stone with any dimension greater than two inches, or other materials that are

determined by Engineer as too wet or otherwise unsuitable for providing a stable subgrade or stable foundation for structures.

2.02 Waste

A. Waste anticipated to be encountered during excavation consists of waste rock as defined by Colorado Reclamation, Mining and Safety Regulations.

2.03 General Fill

A. Obtain general fill from existing in place surficial soil located within the limits of construction shown on the Drawings.

B. General fill shall be free of waste, debris, and frozen material, suitable for embankment construction, and contain a maximum six inch stone size in any dimension. It shall be of such a nature and character that it can be compacted to the minimum specified dry density of 95 percent (measured as a percentage of the maximum dry density as determined by ASTM D698) with a reasonable compaction effort. Material shall be used as general site grading or backfill material.

C. Moisture content shall be that required to obtain specified compaction of the soil or as indicated.

D. Perform moisture curing by wetting or drying of the material as required to attain required compaction criteria.

2.04 Separation Geotextile

A. The geotextile separation fabric to be used under the aggregate road base shall be as indicated on the Drawings and shall meet the Specification in Section 026613 Geotextile.

2.05 Riprap

A. Riprap Material: The granular material used for the rip rap basin shall be Rip Rap (D_{50} = 9 inches) conforming to the following:

Sieve Size	Percent Passing
12”	85
9”	50
5”	15

B. Riprap shall consist of sound, durable rock, angular in shape, and shall be resistant to abrasion and freeze-thaw deterioration. No boulders or rounded stones will be accepted for this work.

C. All riprap stone shall have at least three (3) flat faces to enable the stones to be properly locked together to form a compact mass. Unacceptable rock includes mica schist, slate, micaceous or thinly-bedded sandstone, shale, coarse limestone, gypsiferous rock, poorly cemented sandstone and conglomerate or soft or closely jointed rock of any sort. The rock shall have the physical properties required by ASTM C 33 for quarry rock suitable for producing coarse aggregate for concrete, in accordance with ASTM C 88 and C 131,

respectively. The requirements of the Los Angeles Abrasion Test for all rock shall be a maximum loss of 40 percent (after 500 cycles). All stone shall not weigh less than 155 pounds per cubic foot, as determined by the standard test for apparent specific gravity (ASTM C 127), using representative chips about one inch in size taken from the stone as furnished. Stones shall have a loss not exceeding ten percent (10%) when subjected to five (5) cycles of the sulfate soundness test (ASTM C 88). Each load of riprap shall be reasonably well graded from the smallest to the maximum size specified.

D. The riprap stone to be used will be accepted only after its suitability has been established to the satisfaction of the Engineer. The riprap shall be composed of a well-graded mixture such that 50 percent of the mixture by weight shall be larger than D_{50} size as determined from the design procedure. A well-graded mixture as used herein is defined as a mixture composed primarily of the larger stone sizes, but with a sufficient mixture of other sizes to fill the progressively smaller voids between the stones. The diameter of the largest stone size in such a mixture shall be 1.5 times the D_{50} size.

2.06 Granular Material

A. Granular bedding material shall be used where shown on the Drawings. Granular bedding material shall consist of clean, inert, hard durable grains of rock free from vegetable matter, shale, and lumps or balls of clay, meet the requirements of No. 8 Coarse Aggregate as shown on Table 703-1 Concrete Aggregate Gradation Table in Section 703 of the CDOT Standard Specification for Road and Bridge Construction.

B. The aggregate road base material shall meet the Specifications for Class 6 material as referenced in Table 703-2 Classification For Aggregate Base Course in Section 703 of the CDOT Standard Specifications for Road and Bridge Construction.

PART 3 - EXECUTION

3.01 Preparation

A. Examine the areas and conditions under which filling, compacting and grading are to be performed and notify the Engineer of conditions detrimental to the proper and timely completion of the Work.

3.02 Site Preparation

A. Contractor shall be responsible for the installation and removal of all sediment controls required as a result of his/her activities. All equipment shall be installed in accordance with the Manufacturer's written instructions and recommendations, unless noted otherwise.

1. Contractors shall implement the best management practices (BMPs) as required. Additional BMPs shall be implemented as dictated by the Site conditions at no additional cost to Owner throughout all phases of construction.

2. Contractor shall minimize clearing to the maximum extent practical.

3. All wash water (concrete trucks, vehicle cleaning, equipment cleaning, etc.) shall be detained and properly treated or disposed.

4. Sufficient oil and grease absorbing materials shall be maintained onsite or readily available to contain and clean-up fuel or chemical spills and leaks.

5. Dust on the Site shall be controlled. The use of motor oils and other petroleum based or toxic liquids for dust suppression operations is prohibited.

6. Rubbish, trash, garbage, litter, or other such materials shall be deposited into sealed containers. Such materials shall be prevented from leaving the premises through the action of wind or storm water discharge into drainage ditches or waters of the state.

7. If the action of vehicles traveling over the gravel construction entrances is not sufficient to remove the majority of dirt or mud, then the tires must be washed before the vehicles enter onto a public road. If washing is used to remove mud, provisions must be made to intercept the wash water and trap the sediment before it is carried off the Site.

8. All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately. Contractor will be responsible for removing sediment in the sedimentation pond and any sediment that may have collected in the storm water drainage systems in conjunction with the stabilization of the site.

9. Soil stockpile areas shall be protected erosion and sedimentation through implementation of best management practices.

10. Slopes shall be left in a roughened condition during the grading phase to reduce runoff velocities and erosion.

11. Due to the grade changes during the development of the project, the contractor shall be responsible for adjusting the erosion control measures in order to prevent erosion.

B. Clearing and Grubbing

1. Perform only in areas where earthwork or other construction operations are to be performed.

2. Clear designated areas and dispose of other trees, brush, and vegetation before starting construction.

3. Contractor shall be responsible for the handling of the debris and transportation to the designated disposal area, as determined by the Owner.

3.03 General Excavation

A. Perform excavation within the limits of the Project to the lines, grades, and elevations of the subgrade as indicated on the Drawings.

B. Segregate unsatisfactory materials excavated and transport for placement within relocation area as indicated on the Drawings.

C. Surplus excavated material not required for achieving subgrade elevations shall be placed in areas approved for surplus material storage. Dispose surplus unsatisfactory excavated material in designated waste or spoil areas.

D. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times.

E. Excavate by hand in areas where space and access will not permit use of machines.

F. Over excavate and replace any localized zones of excessively wet, unstable, organic, yielding, or low bearing capacity materials as directed by Engineer. Restore bottom of excavation to proper elevation with compacted fill in areas over excavated. Correct at no additional cost to Owner when over excavated without authority or to stabilize bottom rendered unsuitable through negligence or improper dewatering or other operations.

3.04 Waste Rock Excavation:

A. Waste rock excavation may be necessary to achieve the design elevations. If waste rock is excavated the excavation shall be performed in a manner that will limit the potential for waste rock to be mixed with clean material.

B. Excavated waste rock shall be placed in the Minnesota Adit in accordance with the site-specific mine land reclamation permit.

3.05 General Fill

A. Proof roll all areas to receive general fill. Any areas showing deflections greater than one inch shall be overexcavated and backfilled with suitable material as determined by Engineer.

B. Perform earthwork for the cover subgrade to contours and elevations indicated, using material from excavations:

1. Place fill material in maximum 12-inch loose lifts.

2. Place embankment only on subgrades approved by Engineer.

3. Do not place snow, ice, or frozen earth in fill; do not place fill on a frozen surface.

C. Compact cohesive soils using compaction equipment approved by Engineer to a minimum 95 percent of maximum dry density. Maximum dry density shall be as determined by ASTM D698.

3.06 Subgrade Grading

A. Perform cut and fill activities to prepare the subgrade surface slope and grade as shown on the Drawings.

B. Independently verify the cut and fill locations and determine appriopriate excavation depths.

C. Aerate, dry, or add moisture if necessary to produce a finished subgrade that is nonyielding. Weak or compressible areas which cannot be satisfactorily compacted shall be removed and replaced with properly compacted soil material.

D. All prepared subgrade surfaces shall be smooth, free of all foreign, organic, or sharp objects; rock or gravel stone having any dimension less than one inch.; or debris of any kind.

E. Standing water or excessive moisture will not be allowed. Subgrades deemed to be too wet shall be dried and recompacted as required to meet specifications for subgrades.

F. Maintain prepared subgrade until geosynthetics are installed. Scarify, moisture condition, and recompact subgrade if damaged or shrinkage cracking occurs.

3.07 Site Grading

A. Grade and compact all areas within Project area, including adjacent transition areas, reasonably smooth, and free from irregular surface changes.

B. Degree of finish for rough grading shall be that ordinarily obtained from grader operations except as otherwise specified.

C. All minimum thicknesses shown on the Drawings shall be met.

D. Finish all ditches, swales, and gutters to drain readily.

E. Provide roundings at top and bottom of banks and at other breaks in grade.

F. Finished surfaces shall be uniformly graded and shall be free from depressions, mounds, or windrows. The top surface elevations shall be in accordance with the typical sections shown on the Drawings.

3.08 Riprap

A. Foundation Preparation:

1. Uniformly trim and dress areas on which rip rap is to be placed, conforming to cross sections indicated on the Drawings within an allowable tolerance from indicated slope lines and grades of subgrade. Fill areas below tolerance limit with satisfactory material and compact.

2. Place granular bedding within the limits shown and to the depths indicated on the Drawings.

B. Placement of Riprap:

1. Trim and dress areas requiring Riprap to conform with lines as indicated within an allowable tolerance of 3-inches from indicated slope lines and grades of granular bedding. When regrading is required, existing granular bedding shall be removed and then replaced when slope meets specified tolerance.

2. Place riprap to full course thickness in one operation and in a manner to avoid displacing underlying material .

3. Place Riprap on prepared base to produce a reasonably well-graded mass of stone in close contact and with a minimum of voids.

4. Place riprap within a tolerance of plus or minus 3 inches from the theoretical slope lines and grades.

5. Finished riprap shall be free from pockets of small stones and clusters of larger stones. Hand-place if necessary to secure the desired results.

6. Maintain riprap protection until accepted; replace any material displaced.

3.09 Maintenance

A. Protect newly graded and vegetated areas from actions of the elements.

B. Fill and repair settling or erosion occurring prior to acceptance of the Work, and re-establish grades to required elevations and slopes.

— END OF SECTION --

DIVISION 33 – SITE UTILITIES
SECTION 334100
DRAINAGE CHANNELS

PART 1 - GENERAL

1.01 Summary

A. For construction of a drainage channels, stilling basin, and a low water crossing at locations shown on the Drawings. All activities performed by the Contractor or any subcontractor at any tier shall be in accordance with all applicable Federal, State, and local laws and regulations.

1.02 Related Work Specified Elsewhere

A. Section 017123: Construction Layout and Surveying

B. Section 026613: Geotextile

C. Section 026617: Geomembrane

D. Section 312050: Earthwork

1.03 References

A. American Society of Testing and Materials (ASTM)

1. ASTM D 1505 - Density of Plastics by the Density-Gradient Technique.

2. ASTM D 1693 – Environmental Stress-Cracking of Ethylene Plastics.

3. ASTM D 5199 – Measuring Nominal Thickness of Geotextiles and Geomembranes.

4. ASTM E 41 – Terminology Relating to Conditioning.

1.04 Submittals

Submit for Engineer’s approval the following:

A. Geoweb:

1. Manufacturer's Certificate of Analysis: Manufacturer shall supply certificate of analysis containing the following test results for the celluar confinement material used for project: Base Resin Lot Number(s), Resin Density per ASTM-1505, Production Lot Number(s), Material Thickness, Short Term Seam Peel Strength, and percentage of Carbon Black.

2. Submit qualifications certifying the installer is experienced in the installation of the specified products.

B. Proposed Alternates: A minimum of 28 days prior to scheduled use, submit a 1 foot by 1 foot sample, manufacturer's specifications and installation specifications. Include permissible shear stress and velocity information. Also include any other information pertinent to the design performance of the proposed product.

C. Installation requirements: A minimum of 14 days prior to scheduled use, submit manufacturer's installation specifications for all erosion mat products. This submittal shall include requirements for storing, handling, subgrade preparation, anchor trenches, panel deployment, overlaps, staple patterns, repair, transitions, and protection.

1.05 Quality Assurance and Quality Control

A. The Geoweb material shall be provided from a single Manufacturer for the entire project.

B. The Manufacturer's Quality management system shall be certified and in accordance with ISO 9001:2015 and CE certification. Any substitute materials submitted shall provide a certification that their Geoweb manufacturing process is part of an ISO program and a certification will be required specifically stating that their testing facility is certified and in accordance with ISO. An ISO certification for the substitute material will not be acceptable unless it is proven it pertains specifically to the geocell manufacturing operations.

C. The Manufacturer shall provide certification of compliance to all applicable testing procedures and related specifications upon the customer's written request. Request for certification shall be submitted no later than the date of order placement.

D. Pre-Installation Meeting: Prior to installation of any materials, conduct a pre-installation meeting to discuss the scope of work and review installation requirements. The pre-installation meeting shall be attended by all parties involved in the installation of the Geoweb.

E. Manufacturer's Field Representative Qualifications:

1. Manufacturer shall provide a qualified field representative on site at the start of construction to ensure the system is installed in accordance with the Contract Documents.

2. Manufacturer’s field representative shall have a minimum 5 years installation experience with the specified products in the specified application.

1.06 Delivery, Handling and Storage

A. Deliver materials to site in Manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and Manufacturer.

B. The materials shall be stored in accordance with Manufacturer's instructions. The materials shall be protected from damage and out of direct sunlight.

C. The materials shall be delivered, unloaded and installed in a manner to prevent damage.

1.07 Warranty

A. The Manufacturer shall warrant each section that it ships to be free from defects in materials and workmanship at the time of manufacture. The Manufacturer's exclusive liability under this warranty or otherwise will be to furnish without charge to the original f.o.b. point a replacement for any section which proves to be defective under normal use and service during the 10-year period which begins on the date of shipment. The Manufacturer reserves the right to inspect any allegedly defective section in order to verify the defect and ascertain its cause.

B. This warranty shall not cover defects attributable to causes or occurrences beyond the Manufacturer's control and unrelated to the manufacturing process, including, but not limited to, abuse, misuse, mishandling, neglect, improper storage, improper installation, improper alteration or improper application.

C. In no event shall the Manufacturer be liable for any special, indirect, incidental or consequential damages for the breach of any express or implied warranty or for any other reason, including negligence, in connection with the Geoweb.

PART 2 - - PRODUCTS

2.01 Channel Earthwork

A. General Fill as described in Section 312050: Earthwork.

2.02 Geoweb

A. Approved manufacturers of Geoweb are:

1. Presto Geosystems;

2. Engineer approved alternate

B. Integral Components

1. Keys shall be used to connect Geoweb panels together at each interleaf and end to end connection

a. Keys shall be construction of polyethylene and provide a high strength connection with minimum pull-through of 275 lbs.

b. Keys shall be used to connect sections together at each interleaf and end to end connection.

C. Tendon Anchorage

1. Material shall be bright yellow, high-tenacity, industrial-continuous-filament, polypropylene yarn woven into a braided strap.

2. Minimum break strength shall be 1250 lbf

3. Type of Tendon Anchorage

a. Tendons, Tendon Clips and Deadman Pipe Anchorage as shown on the Drawings.

D. Cell Infill Materials

1. Cell infill material shall be concrete with a minimum strength of 3,000 psi and air content of 2 to 4% in accordance with ACI and ASTM standards.

E. Geotextile

1. Nonwoven geotextile for installation under the Geoweb channel shall meet the requirements of Section 026613 – Geotextile.

2. Woven geotextile for installation under the roadway crossing shall meet Tencate Mirafi HP570 high strength woven geotextile or approved alternate..

F. Geomembrane

1. Geomembrane shall meet the requirements of Section 026617 – Geomembrane.

2.03 Scour Protection

A. Riprap Basin

1. Riprap shall meet the requirements of Section 312050 – Earthwork.

PART 3 - EXECUTION

3.01 Drainage Channels

A. Construction:

1. Drainage channels shall be cut or filled to the dimensions and grades shown on the Drawings.

2. Drainage channel cross sections shall be surveyed in-place at 50-foot intervals (maximum) per Section 017123 Construction Layout and Surveying to verify the dimensions and slopes shown on the Drawings are achieved. The results of the survey shall be reported to the Engineer.

B. Compaction: Fill material shall be compacted as required in Section 312050: Earthwork. Soil compaction techniques shall be approved by the Engineer.

C. Finished Grade: The finished surface of the drainage channel shall be free of irregularities, depressions, loose soils, large rocks, roots, and debris, and shall conform to dimensions and grades shown on the Drawings.

3.02 Geotextile

A. Geotextile shall be installed in accordance with Section 026613 – Geotextile

3.03 Geomembrane

A. Geomembrane shall be installed in accordance with Section 026617 - Geomembrane

3.04 Geoweb:

A. Prepare subgrade and install the Geoweb in accordance with Manufacturer's instructions.

B. Subgrade Preparation:

1. Excavate and shape foundation soils as indicated on the Drawings.

2. Ensure foundation soil meets minimum strength requirements through proof rolling or other conventional method and is approved by the Engineer. If unacceptable foundation soils are encountered, excavate and replace with suitable quality material as directed by the Engineer.

C. Geosynthetics Installation:

1. Within the channel, install nonwoven geotextile and geomembrane layers in accordance with Section 026613 – Geotextile and Section 026617 – Geomembrane.

2. Under the road crossing, install the high strength woven geotextile layer on prepared surfaces ensuring required overlaps are maintained and outer edges of the geotextile are buried in accordance with the Manufacturer's recommendations.

D. Section Placement and Connection:

1. Place sections and verify all sections are expanded uniformly to required dimensions and that outer cells of each section are correctly aligned. Interleaf or overlap edges of adjacent sections. Ensure upper surfaces of adjoining sections are flush at joint and adjoining cells are fully aligned at the cell wall slot.

2. Connect the sections with keys at each interleaf and end to end connection. Insert the key through the cell wall slot before inserting through the adjacent cell. Turn the key 90 degrees to lock the panels together.

E. Anchorage – Tendons, Tendon Clips, and Pipe Deadman Anchorage

1. Excavate the anchor trench at the top of the channel slope to the depth as shown on the Contract Documents.

2. Install pipe Deadman in anchor trench. Pipe type, diameter and thickness shall be as shown on the Contract Documents.

3. Position the collapsed sections at the crest of the slope.

4. Measure and cut the tendon run lengths for each tendon location allowing extra length to connect to deadman anchor.

5. Mark the tendons with a black permanent marker per a tendon clip location chart.

6. Thread the tendons through the unexpanded section.

7. Starting from the first cell, count the number of cells to the next tendon clip location and repeat along that cell row.

8. Repeat this procedure for each additional cell row tendon/tendon clip run.

9. With all the tendon clips placed in the section, thread the tendons through the cell wall I-slots in the unexpanded section.

10. Locate the corresponding mark on the tendon and position it in front of the cell wall. Hold the tendon and connect to the tendon clip.

11. Repeat this process on each cell row tendon/tendon clip run.

12. Place the collapsed section in the anchor trench, connect tendons to the deadman anchor and expand down the slope.

13. Adjust the section (i.e. a shake or two of the expanded section works well for this) so that the section and tendons are uniformly taut.

14. Terminate the bottom of the tendons with tendon clips.

15. Fill the anchorage trench with the specified material and compact as required by the Contract Documents.

F. Concrete Infill Placement

1. Once placing operation commences, it shall be carried out as a continuous operation until a designated section is completed or as approved by the Engineer.

2. Limit the drop height of concrete to 3 feet to prevent panel distortion. Elephant trunks and/or tremies shall be used to prevent free fall of concrete.

3. Where concrete chutes are used, the end of the chute shall be baffled to prevent segregation of the concrete.

4. The concrete shall be thoroughly compacted by means of an approved vibrator. The period of vibration shall not be less than 2 seconds nor more than 5 seconds at any one point.

5. Concrete shall be flush with the top of the walls.

6. Apply specified finish.

3.05 Protection of Work

A. Protection of Work

1. The Contractor shall use all means necessary to protect all materials and the Work.

2. In the event of damage, the Engineer will identify areas requiring repair, and the Contractor shall make repairs and replacements necessary to the approval of the Engineer at no additional cost to the Owner.

— END OF SECTION --