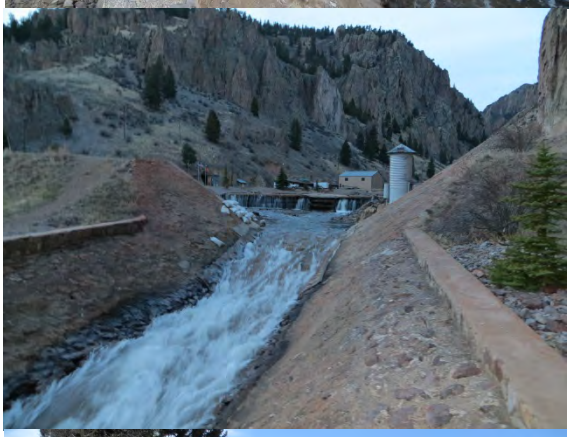
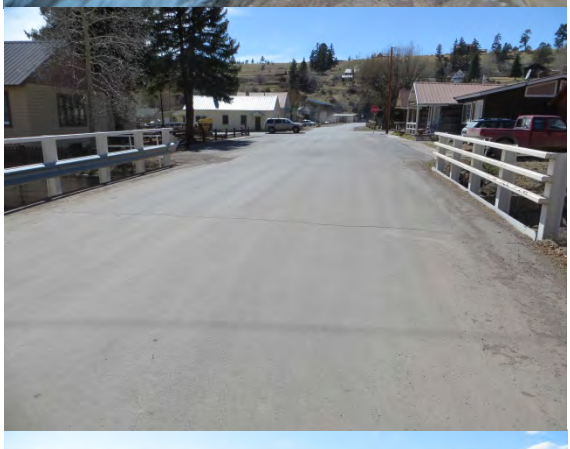
WILLOW CREEK FLUME REHABILITATION PROJECT

PRELIMINARY ENGINEERING REPORT

DRAFT

JULY 13, 2015

Prepared for:

City of Creede
2223 N Main St.
Creede, CO 88130

Prepared by:

Bohannan Huston
Engineering
Spatial Data
Advanced Technologies

PRELIMINARY ENGINEERING REPORT

FOR THE

WILLOW CREEK FLUME

REHABILITATION PROJECT

JULY 13, 2015

Prepared for:

CITY OF CREEDE

2223 N MAIN ST

CREEDE, CO 88130

Prepared by:

BOHANNAN HUSTON, INC.

COURTYARD I

7500 JEFFERSON STREET NE

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Kareem Saint-Lot, EI Date

Reviewed by:

_____ _____

Alandren Etlantus, PE Date Craig Hoover, PE Date

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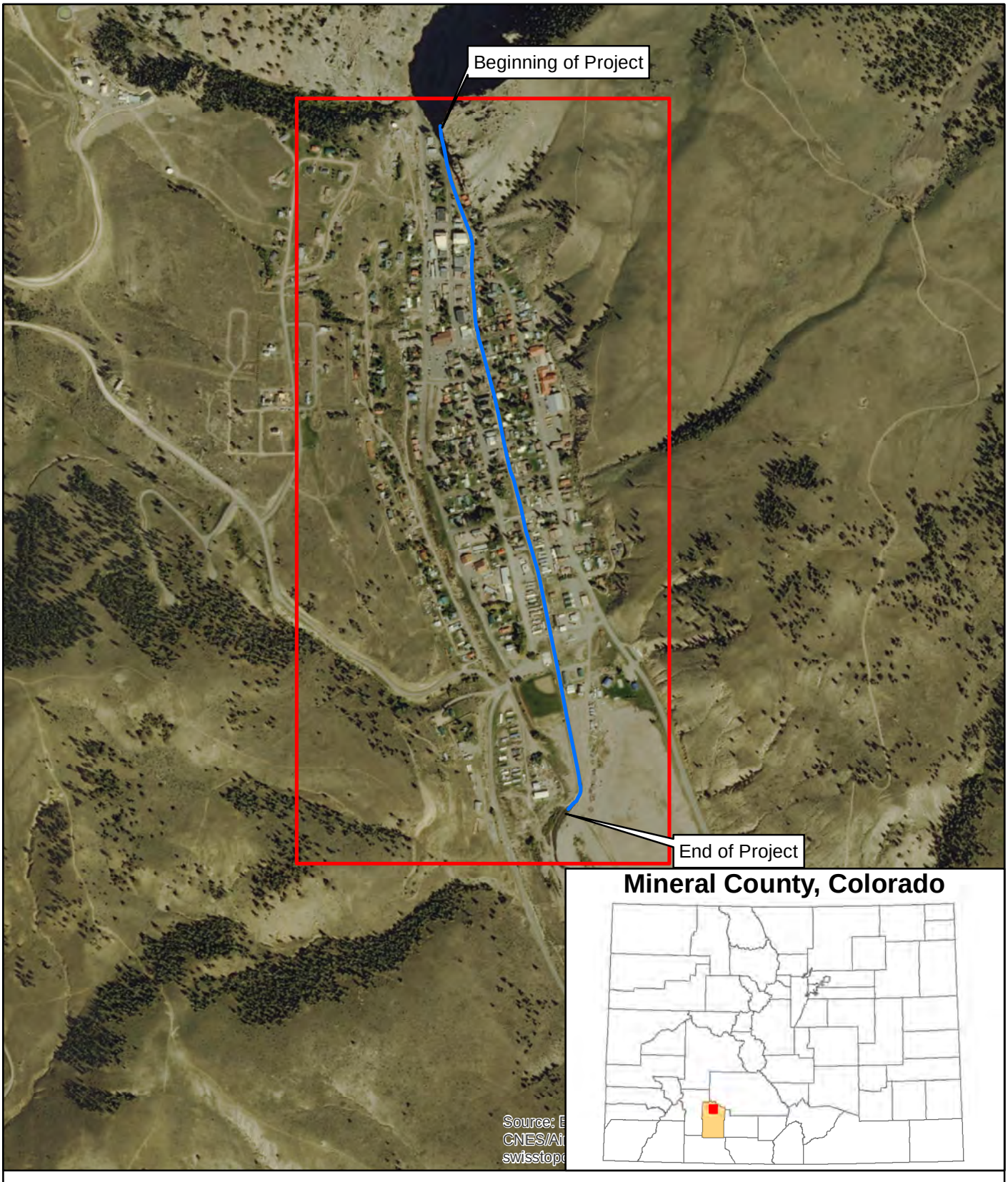
I. INTRODUCTION

This preliminary engineering report evaluates rehabilitation alternatives for the Willow Creek Flume located in Creede, Colorado. The Willow Creek Flume is the major drainage conveyance structure running North to South within the town of Creede. The intent of the rehabilitation project is to assess the existing grouted riprap flume and identify critical needs for repair, rehabilitation, and/or reconstruction. Three conceptual plan alternatives were considered and compared for the flume rehabilitation project and this report includes preliminary planning level cost estimates for the flume rehabilitation based on the alternatives presented.

The Willow Creek Flume is located in Creede, Colorado in north-central Mineral County, northeast of Durango, Colorado as shown in Figure 1. At a length of approximately 5,500 feet, the Willow Creek Flume was constructed in 1950 and has an average bottom width and depth of 8 feet and 7.5 feet, respectively, with 1.5H to 1V side slopes. Elevations within the project area range from approximately 8,882 feet at the upstream end to about 8,758 feet at the downstream end of the flume.

A. LITERATURE REVIEW

As a part of this project, the U.S. Army Corps of Engineers (USACE) *Willow Creek Channel Improvement Project Periodic Inspection Report* dated August 2012 was reviewed. The Willow Creek Flume deficiencies listed in the report include: spalling along the cut-off walls and parapet walls, several holes along the slopes, erosion along the left and right toes, several instances of caving, failure and mobilization of stone/riprap, and tension cracks along the grouted riprap slopes and parapet walls. Additionally, the inspection report identifies several structures and encroachments that were not part of the original project, and as such would require review and approval by the USACE. For the purpose of the Willow Creek Flume Rehabilitation Project this report focuses on resolving the visible deficiencies that are critical to the flume's structural integrity. Therefore, this report does not address the encroachments or the structures that require additional review and approval by the USACE. The 2012 USACE report states the Willow Creek Flume was designed for 1,800 cubic feet per second (cfs), lists peak flowrates from three different studies without establishing a 100-yr peak flowrate, and suggests updating the hydrology for the flume. The 100-yr peak flows listed are the USACE 1989 100-yr peak flow of 1,530 cfs, the USACE 1999 100-yr peak flow of 2,300 cfs, and National Resource Conservation Service (NRCS) 2002 100-yr peak flow of 1,073 cfs.



Legend

- Willow Creek Flume
- Study Area

N

0 500 1,000 2,000 Feet

Willow Creek Flume Rehabilitation Project

Vicinity Map

Figure 1

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P:\20150424\WR\Calculations\Programs\ArcGIS\Maps\Figure1VicinityMap.mxd
Author: gmaynard

June 2015

B. EXISTING CONDITIONS

Bohannan Huston, Inc. (BHI) conducted a flume inspection and survey in April 2015 to describe and catalog existing conditions and critical areas with the use of survey and photography. This visual inspection was helpful in identifying the surface deficiencies along the Willow Creek Flume but was limited in that a visual inspection cannot evaluate the underlying geotechnical issues or deficiencies associated with seepage. The most prominent deficiency along the flume was erosion along both the left and right toes (see Photo 1 below), as expected for a grouted riprap lined conveyance channel exposed to freeze thaw cycles. In some cases, erosion along the toe led to riprap mobilization creating voids near the toes and causing caving. Voids wider than four inches, measured along the slope, and longer than two feet, measured along the channel, were measured and surveyed.

Photo 1: Typical Erosion along the Left and Right Toes of the Willow Creek Flume

In addition to the voids and caving, several holes were identified and cataloged along the flume side slopes, and spalling was identified and most prominent near the downstream end of the flume along the left parapet wall. Table 1 below summarizes the type of

deficiencies identified during the inspection with the exception of voids. Voids were evident along the entire length of the flume and ranged in size from 0.25 to 4 feet in width, measured along the slope, and 0.33 to 2 feet in depth, measured into the void. Exhibits 1A-C are maps of all voids and deficiencies and their locations based on an approximate alignment. As shown in the exhibits, voids are concentrated in the upper two thirds portion of the flume with a majority of the voids centered between stations 17+00 to 34+00. Photos of selected voids and deficiencies are included in Appendix A.

Table 1 – Willow Creek Flume Deficiencies

Side of Channel	Approximate Station	Type of Deficiency
Right	45+98	Damaged Weep Hole
Right	40+47	Hole in Slope
Right	39+40 - 39+75	Spalling along top of Wall
Right	37+50 - 38+00	Spalling along top of Wall
Right	28+75	Spalling along the slope
Right	28+00	Caving
Right	27+25	Caving
Right	20+00	Caving
Right	16+45	Hole in Slope
Right	16+61	Hole in Slope
Right	10+60	Vegetation Growth along Channel Toe In Void/ Cracks In Channel Lining Left Bank
Left	50+17	Vertical Wall Resurfacing
Left	48+75 - 49+00	Spalling along top of Wall
Left	47+75 - 48+25	Spalling along top of Wall
Left	42+75 - 47+00	Spalling along top of Wall
Left	40+50 - 41+00	Spalling along top of Wall
Left	38+75 - 39+50	Spalling along top of Wall and Slope
Left	37+75 - 38+00	Spalling along top of Wall
Left	35+00 - 36+75	Spalling along top of Wall
Left	29+50	Vegetation Growth/ Spalling along the Slope/ Broken Concrete
Left	28+25	Crack/ Spalling along Slope
Left	28+14	Hole in Slope
Left	27+80	Crack/ Spalling near toe of slope
Left	26+25	Spalling along the Slope
Left	25+00	Shelf in Channel Bed
Left	20+25	Caving near upstream end of void
Left	18+70	1' deep hole in channel bed near center of void
Left	13+13	Caving
Left	8+75	Concrete pour causes a discontinuity in side slope

II. ALTERNATIVES ANALYSIS

Three alternatives were initially considered for rehabilitation of the flume including a natural channel and two alternative methods to fill in the existing voids and protect the flowline of the channel from further spalling and erosion. A natural channel was eliminated as a viable option as a result of the limited right of way and high channel velocities which lead to erosion in natural sand channels. Furthermore, adjacent development has resulted in severe encroachment, and in several cases cinderblock walls and chain link fences sit directly on top of the parapet wall. The other two alternatives, reinforced concrete curbs or concrete cloth, were selected to maximize the use of the existing Willow Creek Flume, while eliminating costs associated with the complete demolition and reconstruction of a conveyance channel. Both the reinforced concrete curb and concrete cloth alternatives protect the flowline of the channel and help maintain the life expectancy of the flume.

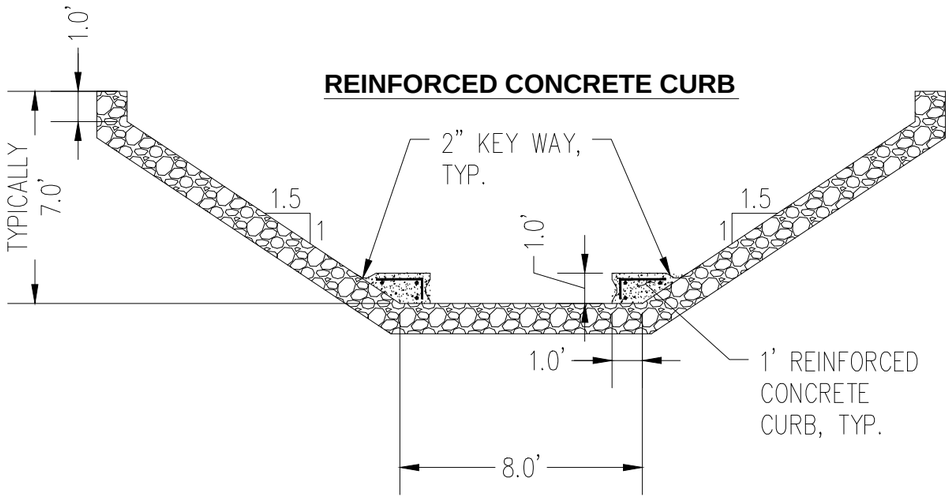
A. REINFORCED CONCRETE CURB

The reinforced concrete curb alternative consists of two curbs running along the entire length of both toes of the Willow Creek Flume. Each curb extends one foot horizontally from the toe towards the flume centerline and is one foot high. A typical section of the reinforced concrete curb is shown in Figure 2. It is recommended that all voids be filled with concrete prior to placement of the reinforced concrete curb on top of the voids. Loose rocks should be removed prior to filling the voids with concrete as shown in the typical section. Installation of the concrete curb requires water diversion to one side of the flume until concrete is cured sufficiently to ensure proper set and minimize loss of material when reintroduced to the active waterway. High-Early Strength Portland Cement Concrete is recommended to reduce the necessary curing time and decrease the project construction timeline.

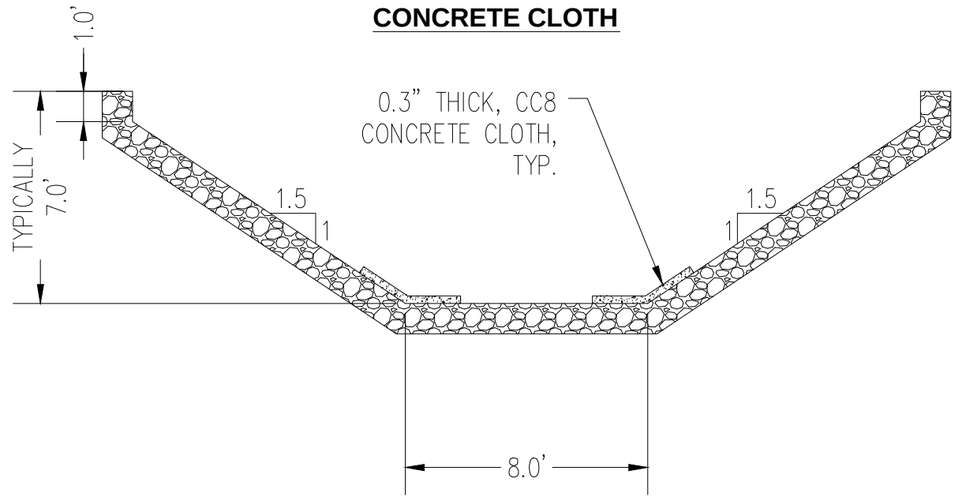
The reinforced concrete curb alternative is expected to crack and require annual inspections to identify and seal cracks. Annual inspections for cracks should be conducted during low flows when the reinforced concrete curb is visible above the water level. A localized diversion will be required to seal any cracks identified in the inspection and is assumed to be performed by a trained employee of the Town of Creede. The reinforced concrete curb provides protection of the flume side slopes up to a water depth of one foot. As shown in Figure 2, key ways are included in the design of the reinforced concrete curbs along the top and side edges to facilitate the addition of a new flume floor or side slopes to the existing flume.

REACHES WITH MINIMAL OR NO VOIDS

REINFORCED CONCRETE CURB

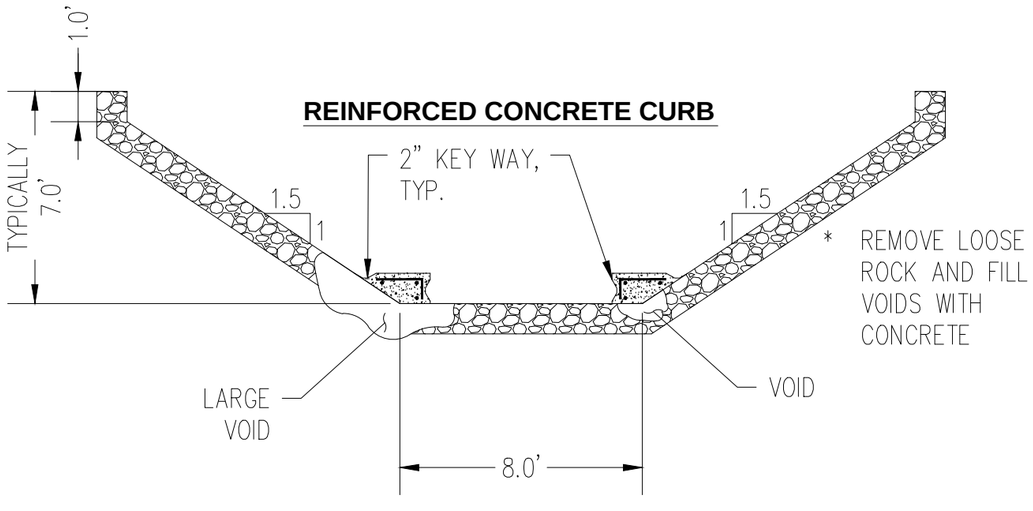


CONCRETE CLOTH

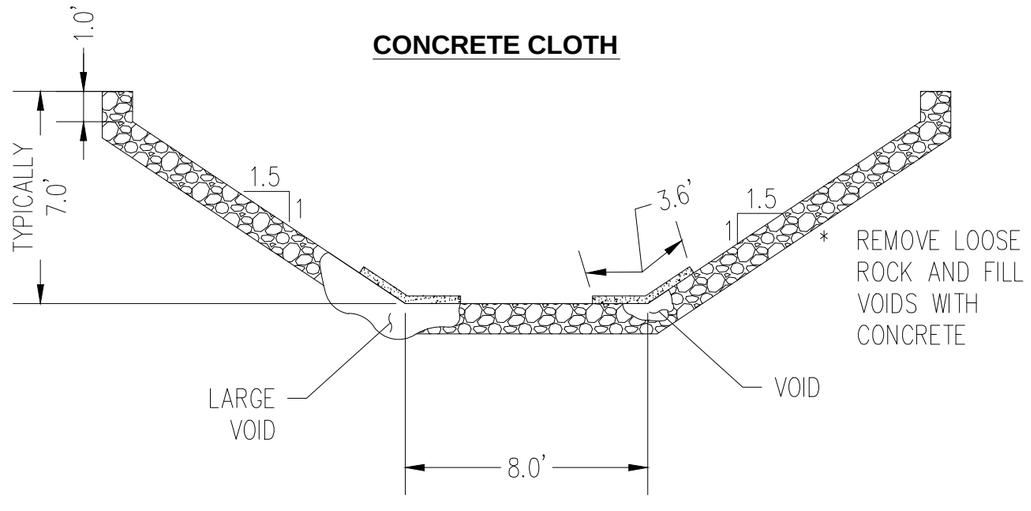


REACHES WITH VOIDS OR LARGE VOIDS

REINFORCED CONCRETE CURB



CONCRETE CLOTH



P:\20150424 WR\Design\workarea\Figure 2 - Typical Sections.dwg
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11x17

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WILLOW CREEK FLUME REHABILITATION PROJECT

FIGURE 2 - TYPICAL SECTIONS

DRAWN BY: J.J.G.	DATE: 07/2015
CHECKED BY: E.K.S.	PROJECT NO. 20150424 SHEET NO. C1

B. CONCRETE CLOTH

The Concrete Cloth alternative consists of a sheet of concrete cloth anchored along the entire length of both toes of the Willow Creek Flume. Concrete cloth is a flexible material that can be installed along a wide range of slopes, cut and bent to conform to channel sections, and then hydrated to form a hardened concrete liner. The material can be installed in wet or dry weather and does not require forms. CC8 concrete cloth is 3.6 feet wide and 0.3 inches thick and is recommended to be centered along the toe during installation. While it is possible to install the concrete cloth under flow conditions (within the running water) it is recommended that the water be diverted to one side of the flume to facilitate the removal of loose rock around the voids and filling of the voids with concrete, while also making installation of the concrete cloth easier. Anchors are required to attach the concrete cloth to the flume structure, and once attached the diversion would be removed to allow hydration of the concrete cloth. The concrete cloth may be immediately reintroduced to the active waterway after installation as the concrete cloth cannot be oversaturated. In places where there are large voids the recommendation is to fill the voids with concrete and place a longitudinal strip running along the toe running parallel to the flow.

Over time, concrete cloth is assumed to require patching in cracked, damaged, or torn areas. An annual inspection and patching of the concrete cloth is assumed to be performed by a trained employee of the Town of Creede. Annual inspections should be conducted during low flows, and localized diversion will be required during patching. At a width of 3.6 feet, the concrete cloth protects more surface area of the flume when compared to the 2.8 feet width of the reinforced concrete curb. However, because the cloth is centered along the flowline, it provides protection of the flume side slopes up to a water depth of 1 foot similar to that of the reinforced concrete curb. Concrete cloth can be added to the floor or side slopes of the flume at a later date with additional anchors.

C. LIMITED HYDRAULIC ANALYSIS

A limited open channel hydraulic analysis was conducted for the existing flume and both the reinforced concrete curb and the concrete cloth alternatives. The analysis was completed using the Hydraflow Express Extension of Civil 3D 2014 with an assumed Manning's roughness coefficient of 0.026 for one section at the critical slope. A channel slope of 1.37 percent, representing the mildest slope along the existing flume, was used in the analysis. Results of this limited hydraulic analysis reveal that the reinforced concrete curb and concrete cloth alternatives result in a 7.5 percent and 0.4 percent reduction

respectively in total channel capacity when compared to the original section. The Willow Creek Flume is capable of conveying the 100-yr storm event despite the reductions in channel capacity in both alternatives. Future major improvements were also analyzed for each alternative as described below:

- A one foot thick floor and 8 inch thick side slopes added to the reinforced concrete curb alternative
- Complete lining of the flume added to the concrete cloth alternative

Based on the hydraulic analysis of the future improvements considered, as listed above, at the mildest slope of 1.37 percent, the reinforced concrete curb and concrete cloth alternatives reduce the channel capacity by 20.0 percent and 1.1 percent, respectively. The future improvements added to the reinforced concrete curb alternative result in a larger reduction of the conveyance capacity of the flume. However, to understand the significance of this reduction, the 100-yr flowrate of the flume needs to be established through an updated hydrologic study incorporated into a hydraulic study to ensure the 100-yr storm event could be conveyed through the channel with adequate freeboard. As discussed in section I.A above, the USACE 2012 report lists three differing peak flowrates without establishing a 100-yr peak flow, and suggests updating the hydrology for the Willow Creek Flume. The hydraulic capacity calculations are included in Appendix B.

Hydraulic calculations for both alternatives with future improvements discussed above do not account for a hybrid alternative. An example hybrid alternative is where the reinforced concrete curb is used to rehabilitate the toes of the flume, a concrete slab is placed in the bottom of the flume, and the concrete cloth is used to line the remaining side slopes of the flume. A hybrid approach can be utilized to mitigate the reduction of conveyance capacity with any future improvements and allow such an alternative to convey the 100-yr peak flowrate. Additionally, step-outs can be added to the channel as part of future improvements to address safety concerns with individuals who may get into the flume. Although, step-outs are not anticipated to significantly affect the capacity of the flume, a hydraulic analysis may be necessary to account for future step-outs.

III. CONSTRUCTION COST ESTIMATES

Planning level construction cost estimates are presented below for both viable alternatives: the reinforced concrete curb and the concrete cloth. Both alternatives are expected to equally protect and maintain the life expectancy of the existing flume, for its remaining years and the options would not need replacing before the flume. Maintenance and repair costs for both alternatives have been estimated, projected for 25 years, and are included in the discussion below. The flume has operated as expected for a grouted riprap lined channel exposed to freeze thaw cycles, and both alternatives target the critical spalling and erosion deficiencies along both toes of the existing Willow Creek Flume.

A. REINFORCED CONCRETE CURB

The planning level cost estimate for the reinforced concrete curb alternative is presented in Table 2 below.

Table 2 – Construction Cost Estimate for the Reinforced Concrete Curb Alternative

Item No.	Description	Estimate Unit Price	Quantity	Unit	Estimate Amount
1	Construction Mobilization, compl.	$24,300.00	1	LS	$ 24,300.00
2	Construction Staking, compl.	$9,800.00	1	LS	$ 9,800.00
3	Flood Protection & Water Management, compl.	$75,000.00	1	LS	$ 75,000.00
4	NPDES Permitting, compl.	$10,000.00	1	LS	$ 10,000.00
5	Site Clearing and Grubbing, compl.	$1,540.00	1	AC	$ 1,540.00
6	Reinforced Concrete Curb	$45.50	10,150	LF	$ 461,830.00
7	Concrete for Voids	$400.00	39	CY	$ 15,600.00
8	Existing Channel Lining Remove and Reuse Rock	$170.00	39	CY	$ 6,630.00
		CONSTRUCTION SUBTOTAL			***$ 604,700.00***
				CONTINGENCY 20%	$ 121,000.00
				DESIGN 10%	$ 72,600.00
	CONSTRUCTION SURVEY, MATERIALS TESTING, OBSERVATION AND MANAGEMENT 10%				$ 72,600.00
		NON-CONSTRUCTION SUBTOTAL			***$ 266,200.00***
				GRAND TOTAL	**$ 870,900.00**

B. CONCRETE CLOTH

The planning level cost estimate for the CC8 concrete cloth alternative is presented in Table 3 below.

Table 3 – Construction Cost Estimate for the Concrete Cloth Alternative

Item No.	Description	Estimate Unit Price	Quantity	Unit	Estimate Amount
1	Construction Mobilization, compl.	$24,300.00	1	LS	$ 24,300.00
2	Construction Staking, compl.	$9,800.00	1	LS	$ 9,800.00
3	Flood Protection & Water Management compl.	$75,000.00	1	LS	$ 75,000.00
4	NPDES Permitting, compl.	$10,000.00	1	LS	$ 10,000.00
5	Site Clearing and Grubbing, compl.	$1,540.00	1	AC	$ 1,540.00
6	Concrete Cloth CC8 Material	$7.40	41,700	SF	$ 308,580.00
7	Concrete Cloth CC8 Roll Delivery	$355.00	31	EA	$ 11,010.00
8	Concrete Cloth CC8 Installation	$1.00	41,700	SF	$ 41,700.00
9	Concrete for Voids	$400.00	39	CY	$ 15,600.00
10	Existing Channel Lining Remove and Reuse	$170.00	39	CY	$ 6,630.00
		CONSTRUCTION SUBTOTAL			***$504,200.00***
				CONTINGENCY 20%	$ 100,900.00
				DESIGN 10%	$ 60,600.00
	CONSTRUCTION SURVEY, MATERIALS TESTING, OBSERVATION AND MANAGEMENT 10%				$ 60,600.00
		NON-CONSTRUCTION SUBTOTAL			***$222,100.00***
		GRAND TOTAL			**$726,300.00**

C. MAINTENANCE COST ANALYSIS

The maintenance costs presented in Table 4 below are for materials only as it is assumed an employee of the Town of Creede is conducting annual inspections and sealing cracks along the reinforced concrete curb or patching the concrete cloth. Maintenance for the reinforced concrete curb alternative is assumed to be 1 percent of the construction costs annually. Maintenance for the concrete cloth is assumed to be 1/3 of a bulk roll of CC8 concrete cloth required annually for patching. Both alternatives project the annual cost for 25 years using a 4.5 percent annual inflation rate and convert the total maintenance costs to present value. The maintenance costs are then added to the total construction and non-construction cost (capital cost) for the respective alternatives. Repairs and maintenance to the existing flume should be expected in addition to maintenance of the flume rehabilitation

alternatives. Repairs and maintenance of both the flume and either of the selected options are critical to maintaining the expected remaining life expectancy of the flume.

Table 4 – Maintenance Costs for the Willow Creek Flume Alternatives

Reinforced Concrete Curb						
Item #	**Item Description**	**Quantity**	**Unit**	**Unit Price**		**Amount**
1	Annual Maintenance (1% of Construction Costs)	$ 604,700	%	1%	$	6,100
				Total Annual Maintenance Cost	$	6,100
				Present Value of Maintenance Cost* (A)	$	91,000
				Estimated Total Capital Cost (B)**	$	870,900
				Estimated Total Capital Cost and Present Value of Maintenance Cost (A+B)	$	961,900
Concrete Cloth						
Item #	**Item Description**	**Quantity**	**Unit**	**Unit Price**		**Amount**
1	Annual Maintenance (1/3 Bulk Roll of Concrete Cloth Material and Delivery)	1	ROLL	$ 10,308.00	$	3,436
				Total Annual Maintenance Cost	$	3,436
				Present Value of Maintenance Cost* (A)	$	51,000
				Estimated Total Capital Cost (B)**	$	726,300
				Estimated Total Capital Cost and Present Value of Maintenance Cost (A+B)	$	777,300

D. PROJECT PHASING

If necessary, the Willow Creek Flume Rehabilitation Project can be broken up into three phases. Phasing is recommended to be split such that rehabilitation of the flume progresses from upstream to downstream, based on the current condition of the flume, with Phase 1 covering stations 0+00 to 17+00, Phase 2 covering stations 17+00 to 34+00, and Phase 3 covering station 34+00 to 50+75. Additionally, it is recommended that all voids in the upper 2/3 reach (Phase 1 and Phase 2 reaches) of the flume, stations 0+00 to 34+00, be filled and repaired as a part of Phase 1. The voids are mostly concentrated in the Phase 2 reach and then secondarily in the Phase 1 reach, which would allow approximately 90 percent of the voids to be repaired with the first phase and lessen additional growth of the existing voids. Cost estimates for project phasing are included in Appendix C and are summarized in Table 5 below. Phases 2 and 3 assume an additional two cubic yards of voids are formed over the time period between phases.

Table 5 – Cost Estimate Summaries for Phases 1, 2, and 3

	Phase	Construction Subtotal	Non-Construction Subtotal	Grand Total
Reinforced Concrete Curb Alternative	1	$242,300	$106,700	$349,000
	2	$221,700	$97,800	$319,500
	3	$224,100	$98,700	$322,800
Concrete Cloth Alternative	1	$216,300	$95,300	$311,600
	2	$183,900	$81,000	$264,900
	3	$186,400	$82,100	$268,500

IV. ALTERNATIVE EVALUATIONS AND RECOMMENDATIONS

An evaluation matrix was developed to aid in the decision making process for alternative selection. The evaluation matrix required each participant to weight the percentage of the decision that should be made based on each of five criteria: cost, constructability, aesthetics, maintenance and repair, and ease of future improvement. Each respondent then scored each criterion with a value from 1 to 5 with 1 being the lowest possible score and 5 being the highest. For example, the criterion cost would get a value of 5 for a low cost alternative and a value of 1 for a high cost alternative. All responses were compiled and weighted according to the weighting selected by each respondent then added together. The results are presented in Table 6 below and each matrix score is provided in Appendix D.

Table 6 – Alternative Evaluation Matrix Results

Alternative	Criteria					Total
	Cost	Constructability	Aesthetics	Maintenance & Repair	Ease of Future Major Improvement	
Reinforced Concrete Curb	5.8	4.2	3.1	3.5	3.4	20.0
Concrete Cloth	8.1	4.5	2.3	3.5	3.3	21.6

As presented in Table 6 above, the evaluation matrix concluded that both alternatives ranked statistically equal for selection in the Willow Creek Flume rehabilitation project. The evaluation matrix scores and discussions with the Town of Creede indicate that the Town of Creede has a preference for the reinforced concrete curb alternative; therefore, BHI recommends the use of reinforced concrete curb to line and protect the toes of the Willow Creek Flume. The reinforced concrete curb addresses the most prominent deficiency along the toes of the flume, maintains the life of the existing flume, and provides opportunity for future improvements. Selection of the concrete curb is contingent upon hydrologic and hydraulic studies to determine whether or not future improvements to the reinforced concrete curb alternative significantly limit the conveyance capacity of the flume. The contingency for the recommendation is such that the reinforced concrete curb alternative is only recommended if the alternative, with future improvements, will contain the 100-yr storm event within the rehabilitated flume with adequate freeboard, as defined by Federal Emergency Management Agency (FEMA).

V. CONCLUSION

Reinforced concrete curb and concrete cloth alternatives were developed to address the spalling, which was identified as the most critical deficiency, along both toes of the Willow Creek Flume. Both alternatives would protect the toe of the Willow Creek Flume and help maintain the life expectancy of the existing flume. The concrete cloth has less of an impact on the conveyance capacity of the flume resulting in a 0.4 percent reduction in conveyance capacity when compared to the reinforced concrete curb alternative, which reduces the capacity of the existing flume by 7.5 percent. Construction and maintenance costs were developed for both alternatives, and the reinforced concrete curb and concrete cloth alternatives were estimated to cost $961,900 and $777,300, respectively, to construct and maintain for 25 years. An evaluation matrix which rated each alternative based on five sets of criteria was prepared to aid in the decision making process. The matrix summary, provided in Table 6 above, reveals both alternatives rank almost equally based on the five criteria: cost, constructability, aesthetics, maintenance and repair, and ease of future improvement. Based on the evaluation matrix results and discussions with representatives of the Town of Creede, BHI contingently recommends the reinforced concrete curb alternative for the Willow Creek Flume rehabilitation project. The contingency for the recommendation is such that the reinforced concrete curb alternative with future improvements will contain the 100-yr storm event within the rehabilitated flume with adequate freeboard, as defined by FEMA. Additional hydrologic and hydraulic study is necessary to determine the 100-year flow rate and assess the hydraulic capacity of the flume in accordance with FEMA requirements.

VI. REFERENCES

U.S. Army Corps of Engineers. (August 2012). *Willow Creek Channel Improvement Project Periodic Inspection Report.*

EXHIBIT 1A – OVERALL VOID AND DEFICIENCY MAP

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EXHIBIT 1A

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1"=50'

WILLOW CREEK FLUME REHABILITATION PROJECT

OVERALL VOID AND DEFICIENCY MAP
EXHIBIT 1A

DRAWN BY: LSM	DATE: 07/08/15
CHECKED BY: CWH	PROJECT NO. 20150424 SHEET NO.

EXHIBIT 1B – OVERALL VOID AND DEFICIENCY MAP

LEGEND:

- HOLE
- RESURFACING
- WALL DAMAGE
- VEGETATION
- CAVING
- CHANNEL CAPACITY
- VOID

HOLE IN BOTTOM OF CHANNEL

CAVING

CAVING

SHELF IN CHANNEL BED

SLOPE RESURFACING

CRACK ON SLOPE RESURFACING NEAR TOE

HOLE IN SLOPE

VEGETATION GROWTH
SLOPE RESURFACING
BROKEN CONCRETE

CAVING

CAVING

SLOPE RESURFACING

CRACK ON SLOPE/
SLOPE RESURFACING

17+00 18+00 19+00 20+00 21+00 22+00 23+00 24+00 25+00 26+00 27+00 28+00 29+00 30+00 31+00 32+00 33+00 34+00

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1"=50'

WILLOW CREEK FLUME REHABILITATION PROJECT

OVERALL VOID AND DEFICIENCY MAP
EXHIBIT 1B

DRAWN BY: LSM	DATE: 07/08/15
CHECKED BY: CWH	PROJECT NO. 20150424 SHEET NO.

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EXHIBIT 1B

EXHIBIT 1C – OVERALL VOID AND DEFICIENCY MAP

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EXHIBIT 1C

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WILLOW CREEK FLUME REHABILITATION PROJECT

OVERALL VOID AND DEFICIENCY MAP
EXHIBIT 1C

DRAWN BY: LSM	DATE: 07/08/15
CHECKED BY: CWH	PROJECT NO. 20150424 SHEET NO.

APPENDIX A – PHOTO SUMMARY OF WILLOW CREEK FLUME DEFICIENCIES

Image 0284

Station 47+25

Void along Right Bank

Length – 14’

Width – 1’

Depth - 0.4’

Image 0294

Station 29+60

Void along Right Bank

Length – 9’

Width – 3’

Depth – 2’

Image 0300

Station 28+00

Caving along Right Bank

Length – 27’

Image 0307

Station 25+80

Significant Void and Loss of Channel Lining along Right Bank

Length – 10’

Width – 3’

Depth – 1’

Image 0320

Station 22+25

Void along Right Bank

Length – 21’

Width – 1.5’

Depth – 0.5’

Image 0335

Station 17+25

Void along Right Bank

Length – 8’

Width – 3’

Depth – 1’

Image 0346

Station 11+50

Void beneath Bridge along Right Bank

Length – 3’

Width – 2’

Depth – 2’

Image 0350

Station 10+60

Vegetation Growth near Channel Toe along Right Bank and Cracks in Channel Lining along Left Bank

Image 0367

Station 1+25

Void along Right Bank

Length – 72’

Width – 1’

Depth – 4”

Image 0370

Station 50+50

Void along Left Bank

Length – 14’

Width – 3’

Depth – 2’

Image 0374

Station 47+75 – 48+25

Spalling along Top of Wall and Slope of Left Bank

Length – 52’

Image 0379

Station 40+50 – 41+00

Spalling along Top of Wall of Left Bank

Length – 50’

Image 0388

Station 29+50

Void along Left Bank

Length – 32’

Width – 4’

Depth – 2’

Image 0389

Station 29+50

Vegetation Growth, Slope Resurfacing, and Broken Concrete along Left Bank

Length – 12’

Image 0393

Station 28+14

Hole in Slope along Left Bank

Length – 3”

Width – 3”

Depth – 1’

Image 0400

Station 26+25

Spalling along Slope of Left Bank

Length – 14’

Image 0401

Station 25+75

Void along Left Bank

Length – 38’

Width – 1.5’

Depth – 0.5’

Image 0411

Station 20+25

Large Void along Left Bank

Length – 26’

Width – 2’

Depth – 0.5’

Image 0414

Station 18+75

Void along Left Bank and 1’ Deep Hole in Channel Bed

Length – 12’

Width – 3’

Depth – 2’

Image 0417

Station 18+00

Large Void along Left Bank

Length – 15’

Width – 3’

Depth – 1.5’

Image 0418

Station 16+50

Void along Left Bank

Length – 25’

Width – 2’

Depth – 1.5’

Image 0423

Station 13+50

Large Void along Left Bank

Length – 6’

Width – 3’

Depth – 1’

APPENDIX B – LIMITED HYDRAULIC CALCULATIONS

Channel Report

Willow Creek Flume Typical Section

User-defined

Invert Elev (ft)	= 8778.86
Slope (%)	= 1.37
N-Value	= 0.026

Calculations

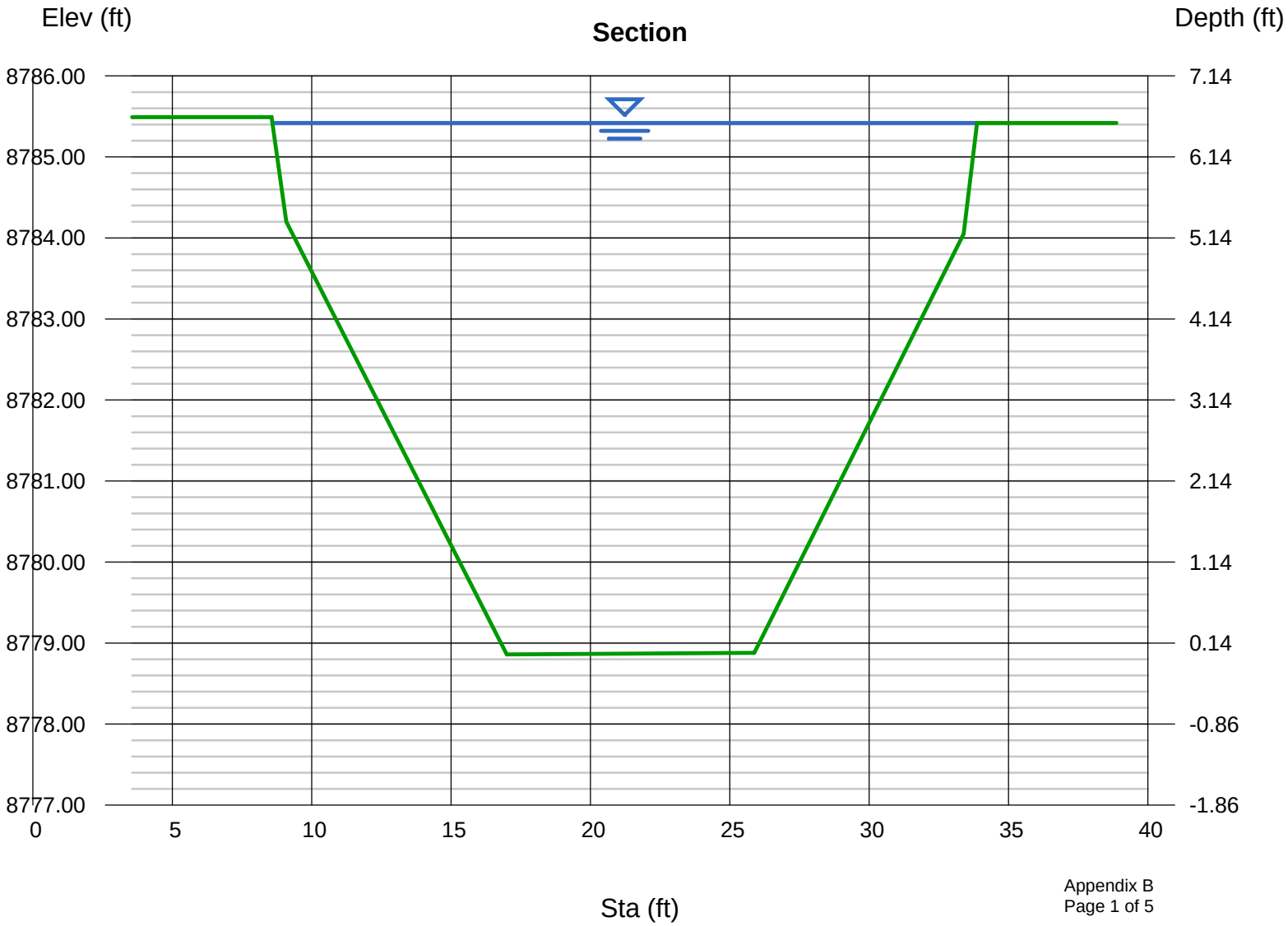
Compute by:	Known Depth
Known Depth (ft)	= 6.56

Highlighted

Depth (ft)	= 6.56
Q (cfs)	= 1,993
Area (sqft)	= 119.27
Velocity (ft/s)	= 16.71
Wetted Perim (ft)	= 30.31
Crit Depth, Yc (ft)	= 6.63
Top Width (ft)	= 25.28
EGL (ft)	= 10.90

(Sta, El, n)-(Sta, El, n)...

(8.56, 8785.49)-(9.09, 8784.20, 0.026)-(17.00, 8778.86, 0.026)-(25.88, 8778.88, 0.026)-(33.39, 8784.05, 0.026)-(33.87, 8785.42, 0.026)



Channel Report

Willow Creek Flume Concrete Curb Typical Section

User-defined

Invert Elev (ft)	= 8778.86
Slope (%)	= 1.37
N-Value	= 0.026

Calculations

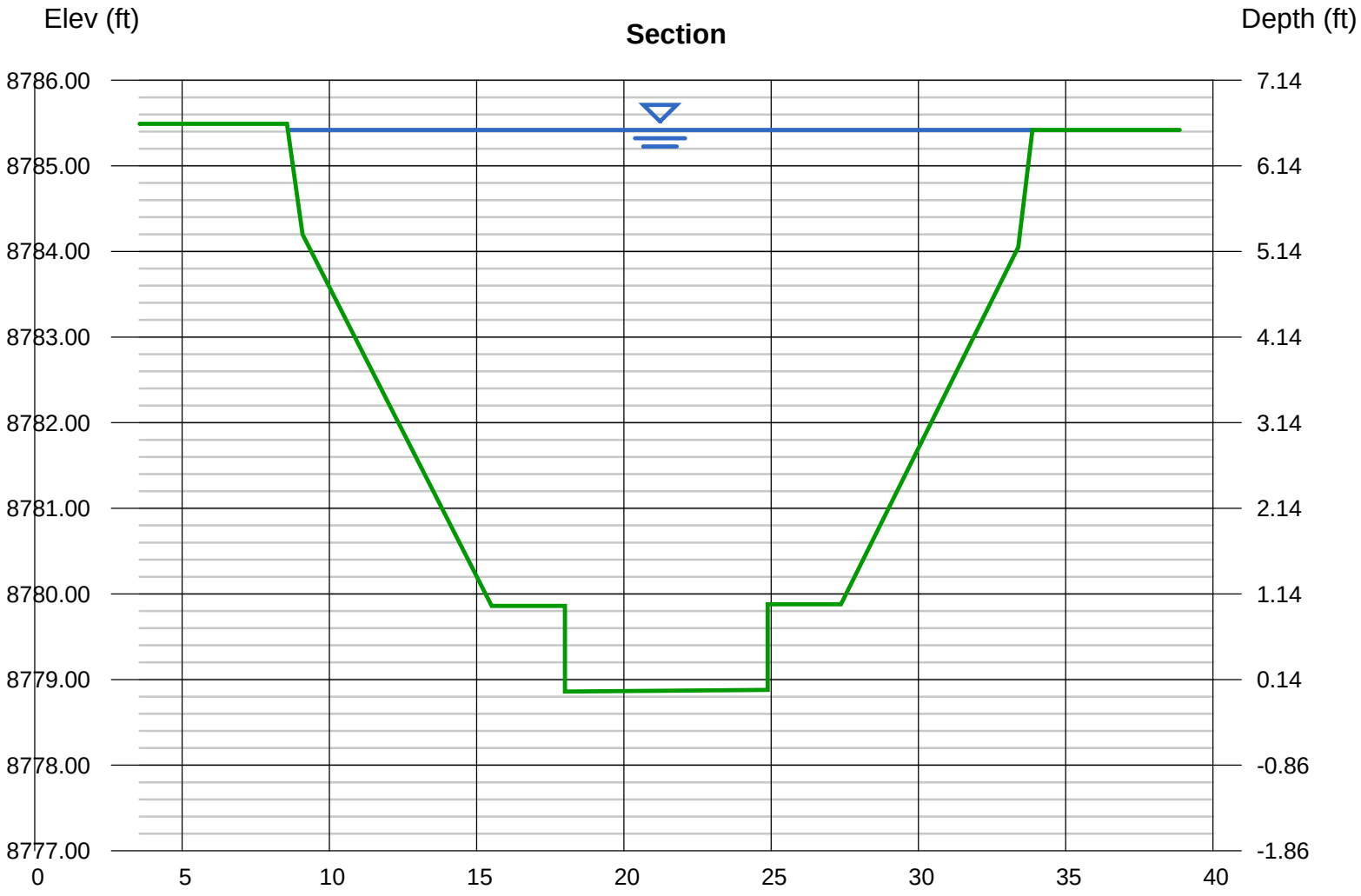
Compute by:	Known Depth
Known Depth (ft)	= 6.56

Highlighted

Depth (ft)	= 6.56
Q (cfs)	= 1,844
Area (sqft)	= 115.90
Velocity (ft/s)	= 15.91
Wetted Perim (ft)	= 31.70
Crit Depth, Yc (ft)	= 6.63
Top Width (ft)	= 25.28
EGL (ft)	= 10.50

(Sta, El, n)-(Sta, El, n)...

(8.56, 8785.49)-(9.09, 8784.20, 0.026)-(15.51, 8779.86, 0.026)-(18.00, 8779.86, 0.026)-(18.00, 8778.86, 0.026)-(24.88, 8778.88, 0.026)-(24.88, 8779.88, 0.026)-(27.37, 8779.88, 0.026)-(33.39, 8784.05, 0.026)-(33.87, 8785.42, 0.026)



Channel Report

Willow Creek Flume Concrete Curb Future Improvements Typical Section

User-defined

Invert Elev (ft)	= 8779.86
Slope (%)	= 1.37
N-Value	= 0.026

Calculations

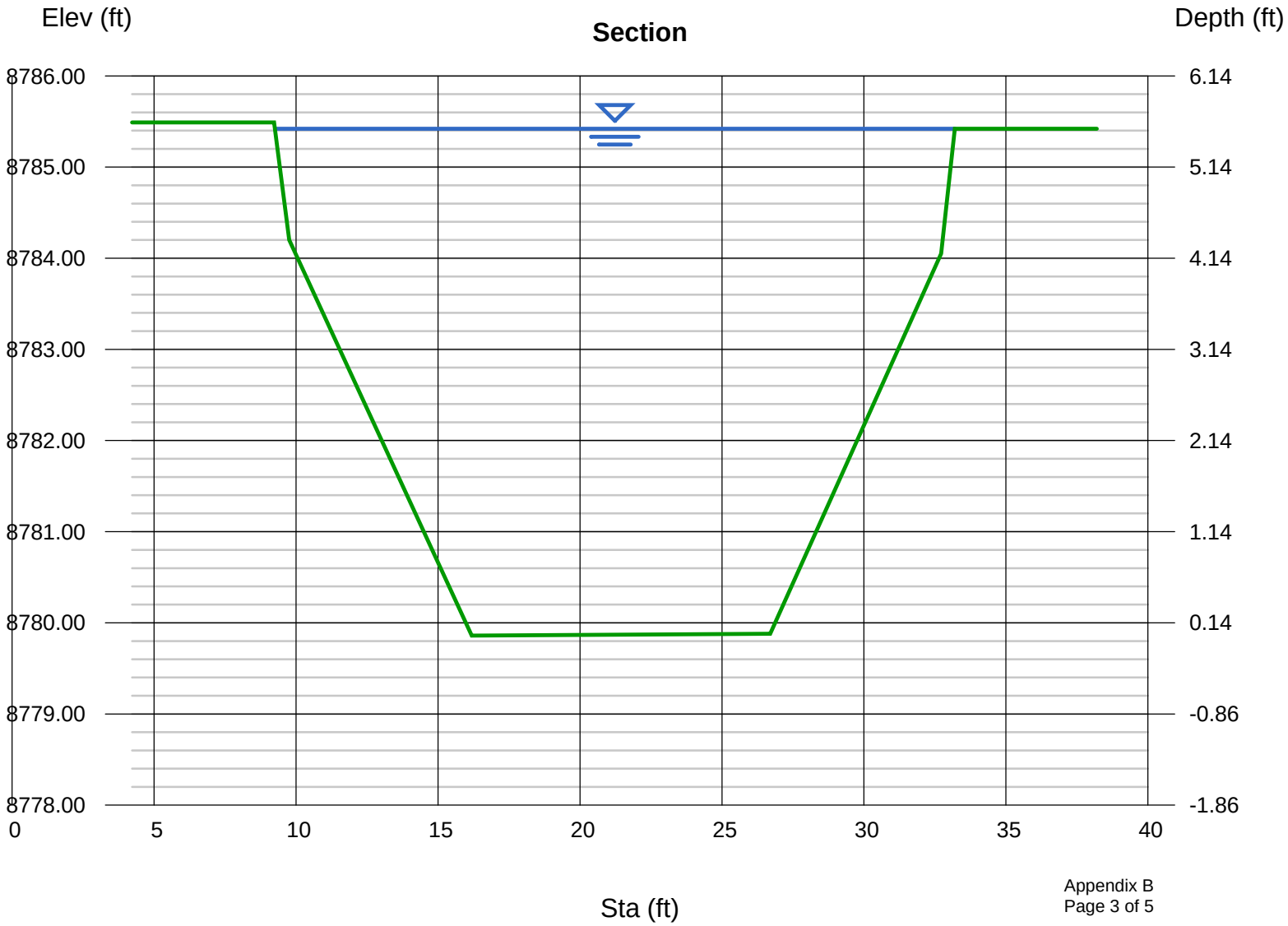
Compute by:	Known Depth
Known Depth (ft)	= 5.56

Highlighted

Depth (ft)	= 5.56
Q (cfs)	= 1,594
Area (sqft)	= 101.56
Velocity (ft/s)	= 15.69
Wetted Perim (ft)	= 28.36
Crit Depth, Yc (ft)	= 5.63
Top Width (ft)	= 23.94
EGL (ft)	= 9.39

(Sta, El, n)-(Sta, El, n)...

(9.23, 8785.49)-(9.76, 8784.20, 0.026)-(16.19, 8779.86, 0.026)-(26.70, 8779.88, 0.026)-(32.72, 8784.05, 0.026)-(33.20, 8785.42, 0.026)



Channel Report

Willow Creek Flume Concrete Cloth Typical Section

User-defined

Invert Elev (ft)	= 8778.86
Slope (%)	= 1.37
N-Value	= 0.026

Calculations

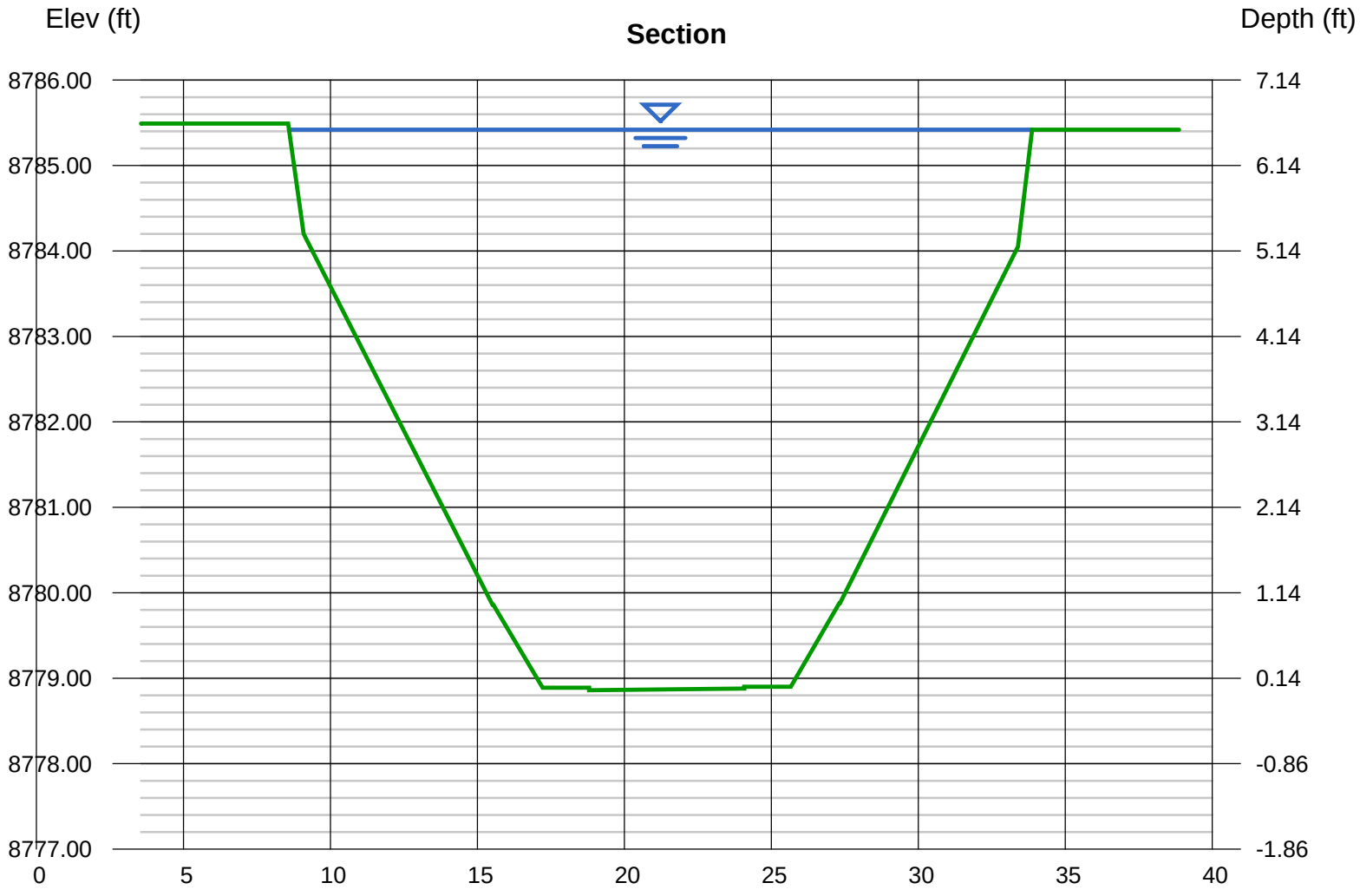
Compute by:	Known Depth
Known Depth (ft)	= 6.56

Highlighted

Depth (ft)	= 6.56
Q (cfs)	= 1,985
Area (sqft)	= 118.93
Velocity (ft/s)	= 16.69
Wetted Perim (ft)	= 30.27
Crit Depth, Yc (ft)	= 6.63
Top Width (ft)	= 25.28
EGL (ft)	= 10.89

(Sta, El, n)-(Sta, El, n)...

(8.56, 8785.49)-(9.09, 8784.20, 0.026)-(15.51, 8779.86, 0.026)-(15.54, 8779.86, 0.026)-(17.22, 8778.89, 0.026)-(18.80, 8778.89, 0.026)-(18.80, 8778.86, 0.026)
-(24.08, 8778.88, 0.026)-(24.08, 8778.90, 0.026)-(25.66, 8778.90, 0.026)-(27.31, 8779.88, 0.026)-(27.33, 8779.88, 0.026)-(33.39, 8784.05, 0.026)-(33.87, 8785.42, 0



Channel Report

Willow Creek Flume Concrete Cloth Future Improvements Typical Section

User-defined

Invert Elev (ft)	= 8778.88
Slope (%)	= 1.37
N-Value	= 0.026

Calculations

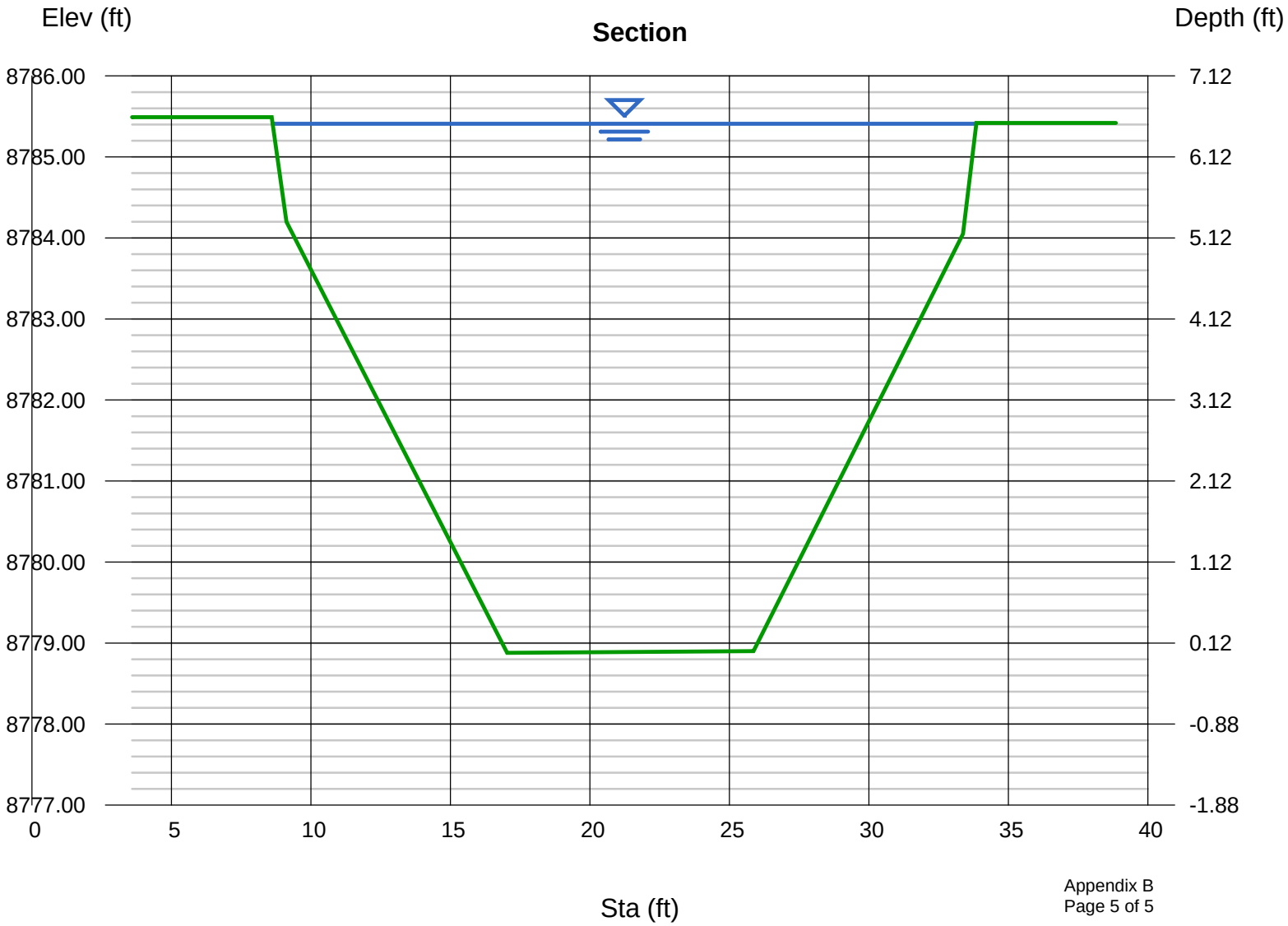
Compute by:	Known Depth
Known Depth (ft)	= 6.53

Highlighted

Depth (ft)	= 6.53
Q (cfs)	= 1,972
Area (sqft)	= 118.36
Velocity (ft/s)	= 16.66
Wetted Perim (ft)	= 30.22
Crit Depth, Yc (ft)	= 6.61
Top Width (ft)	= 25.22
EGL (ft)	= 10.85

(Sta, El, n)-(Sta, El, n)...

(8.59, 8785.49)-(9.12, 8784.20, 0.026)-(17.03, 8778.88, 0.026)-(25.86, 8778.90, 0.026)-(33.37, 8784.05, 0.026)-(33.85, 8785.42, 0.026)



APPENDIX C – DETAILED PHASING COST ESTIMATES

ENGINEER'S OPINION OF PROBABLE COSTS

Willow Creek Flume Reinforced Concrete Curb Phase 1 Station 0+00 to 17+00

Item No.	Description	Estimate Unit Price	Quantity	Unit		Estimate Amount
1	Construction Mobilization, compl.	$14,000.00	1	LS	$	14,000.00
2	Construction Staking, compl.	$3,500.00	1	LS	$	3,500.00
3	Flood Protection & Water Management, compl.	$40,000.00	1	LS	$	40,000.00
4	NPDES Permitting, compl.	$10,000.00	1	LS	$	10,000.00
5	Site Clearing and Grubbing, compl.	$1,540.00	0.34	AC	$	530.00
6	Reinforced Concrete Curb	$45.50	3,390	LF	$	154,250.00
7	Concrete for Voids	$400.00	35	CY	$	14,000.00
8	Existing Channel Lining Remove and Reuse Rock	$170.00	35	CY	$	5,950.00
				CONSTRUCTION SUBTOTAL	**$**	**242,300.00**
				CONTINGENCY 20%	$	48,500.00
				DESIGN 10%	$	29,100.00
				CONSTRUCTION SURVEY, MATERIALS TESTING, OBSERVATION AND MANAGEMENT 10%	$	29,100.00
				NON-CONSTRUCTION SUBTOTAL	**$**	**106,700.00**
				GRAND TOTAL	**$**	**349,000.00**

This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual Construction Costs will not vary from this opinion.

ENGINEER'S OPINION OF PROBABLE COSTS

Willow Creek Flume Reinforced Concrete Curb Phase 2 Station 17+00 to 34+00

Item No.	Description	Estimate Unit Price	Quantity	Unit		Estimate Amount
1	Construction Mobilization, compl.	$12,500.00	1	LS	$	12,500.00
2	Construction Staking, compl.	$3,200.00	1	LS	$	3,200.00
3	Flood Protection & Water Management, compl.	$40,000.00	1	LS	$	40,000.00
4	NPDES Permitting, compl.	$10,000.00	1	LS	$	10,000.00
5	Site Clearing and Grubbing, compl.	$1,540.00	0.34	AC	$	530.00
6	Reinforced Concrete Curb	$45.50	3,390	LF	$	154,250.00
7	Concrete for Voids	$400.00	2	CY	$	800.00
8	Existing Channel Lining Remove and Reuse Rock	$170.00	2	CY	$	340.00
				CONSTRUCTION SUBTOTAL	**$**	**221,700.00**
				CONTINGENCY 20%	$	44,400.00
				DESIGN 10%	$	26,700.00
				CONSTRUCTION SURVEY, MATERIALS TESTING, OBSERVATION AND MANAGEMENT 10%	$	26,700.00
				NON-CONSTRUCTION SUBTOTAL	**$**	**97,800.00**
				GRAND TOTAL	**$**	**319,500.00**

This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual Construction Costs will not vary from this opinion.

ENGINEER'S OPINION OF PROBABLE COSTS

Willow Creek Flume Reinforced Concrete Curb Phase 3 Station 34+00 to 50+75

Item No.	Description	Estimate Unit Price	Quantity	Unit		Estimate Amount
1	Construction Mobilization, compl.	$12,700.00	1	LS	$	12,700.00
2	Construction Staking, compl.	$3,200.00	1	LS	$	3,200.00
3	Flood Protection & Water Management, compl.	$40,000.00	1	LS	$	40,000.00
4	NPDES Permitting, compl.	$10,000.00	1	LS	$	10,000.00
5	Site Clearing and Grubbing, compl.	$1,540.00	0.34	AC	$	530.00
6	Reinforced Concrete Curb	$45.50	3,390	LF	$	154,250.00
7	Concrete for Voids	$400.00	6	CY	$	2,400.00
8	Existing Channel Lining Remove and Reuse Rock	$170.00	6	CY	$	1,020.00
				CONSTRUCTION SUBTOTAL	**$**	**224,100.00**
				CONTINGENCY 20%	$	44,900.00
				DESIGN 10%	$	26,900.00
				CONSTRUCTION SURVEY, MATERIALS TESTING, OBSERVATION AND MANAGEMENT 10%	$	26,900.00
				NON-CONSTRUCTION SUBTOTAL	**$**	**98,700.00**
				GRAND TOTAL	**$**	**322,800.00**

This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual Construction Costs will not vary from this opinion.

ENGINEER'S OPINION OF PROBABLE COSTS

Willow Creek Flume Concrete Cloth Option Phase 1 Station 0+00 to 17+00

Item No.	Description	Estimate Unit Price	Quantity	Unit	Estimate Amount
1	Construction Mobilization, compl.	$14,000.00	1	LS	$ 14,000.00
2	Construction Staking, compl.	$3,500.00	1	LS	$ 3,500.00
3	Flood Protection & Water Management, compl.	$40,000.00	1	LS	$ 40,000.00
4	NPDES Permitting, compl.	$10,000.00	1	LS	$ 10,000.00
5	Site Clearing and Grubbing, compl.	$1,540.00	0.34	AC	$ 530.00
6	Concrete Cloth CC8 Material	$7.40	14,800	SF	$ 109,520.00
7	Concrete Cloth CC8 Roll Delivery	$355.00	11	EA	$ 3,910.00
8	Concrete Cloth CC8 Installation	$1.00	14,800	SF	$ 14,800.00
9	Concrete for Voids	$400.00	35	CY	$ 14,000.00
10	Existing Channel Lining Remove and Reuse	$170.00	35	CY	$ 5,950.00

CONSTRUCTION SUBTOTAL	**$ 216,300.00**
CONTINGENCY 20%	$ 43,300.00
DESIGN 10%	$ 26,000.00
CONSTRUCTION SURVEY, MATERIALS TESTING, OBSERVATION AND MANAGEMENT 10%	$ 26,000.00
NON-CONSTRUCTION SUBTOTAL	**$ 95,300.00**
GRAND TOTAL	**$ 311,600.00**

This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual Construction Costs will not vary from this opinion.

ENGINEER'S OPINION OF PROBABLE COSTS
Willow Creek Flume Concrete Cloth Option Phase 2 Station 17+00 to 34+00

Item No.	Description	Estimate Unit Price	Quantity	Unit	Estimate Amount
1	Construction Mobilization, compl.	$12,500.00	1	LS	$ 12,500.00
2	Construction Staking, compl.	$3,200.00	1	LS	$ 3,200.00
3	Flood Protection & Water Management, compl.	$40,000.00	1	LS	$ 40,000.00
4	NPDES Permitting, compl.	$10,000.00	1	LS	$ 10,000.00
5	Site Clearing and Grubbing, compl.	$1,540.00	0.34	AC	$ 530.00
6	Concrete Cloth CC8 Material	$7.40	13,450	SF	$ 99,530.00
7	Concrete Cloth CC8 Roll Delivery	$355.00	10	EA	$ 3,550.00
8	Concrete Cloth CC8 Installation	$1.00	13,450	SF	$ 13,450.00
9	Concrete for Voids	$400.00	2	CY	$ 800.00
10	Existing Channel Lining Remove and Reuse	$170.00	2	CY	$ 340.00
				CONSTRUCTION SUBTOTAL	**$ 183,900.00**
				CONTINGENCY 20%	$ 36,800.00
				DESIGN 10%	$ 22,100.00
				CONSTRUCTION SURVEY, MATERIALS TESTING, OBSERVATION AND MANAGEMENT 10%	$ 22,100.00
				NON-CONSTRUCTION SUBTOTAL	**$ 81,000.00**
				GRAND TOTAL	**$ 264,900.00**

This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual Construction Costs will not vary from this opinion.

ENGINEER'S OPINION OF PROBABLE COSTS

Willow Creek Flume Concrete Cloth Option Phase 3 Station 34+00 to 50+75

Item No.	Description	Estimate Unit Price	Quantity	Unit	Estimate Amount
1	Construction Mobilization, compl.	$12,700.00	1	LS	$ 12,700.00
2	Construction Staking, compl.	$3,200.00	1	LS	$ 3,200.00
3	Flood Protection & Water Management, compl.	$40,000.00	1	LS	$ 40,000.00
4	NPDES Permitting, compl.	$10,000.00	1	LS	$ 10,000.00
5	Site Clearing and Grubbing, compl.	$1,540.00	0.34	AC	$ 530.00
6	Concrete Cloth CC8 Material	$7.40	13,450	SF	$ 99,530.00
7	Concrete Cloth CC8 Roll Delivery	$355.00	10	EA	$ 3,550.00
8	Concrete Cloth CC8 Installation	$1.00	13,450	SF	$ 13,450.00
9	Concrete for Voids	$400.00	6	CY	$ 2,400.00
10	Existing Channel Lining Remove and Reuse	$170.00	6	CY	$ 1,020.00
				CONSTRUCTION SUBTOTAL	**$ 186,400.00**
				CONTINGENCY 20%	$ 37,300.00
				DESIGN 10%	$ 22,400.00
				CONSTRUCTION SURVEY, MATERIALS TESTING, OBSERVATION AND MANAGEMENT 10%	$ 22,400.00
				NON-CONSTRUCTION SUBTOTAL	**$ 82,100.00**
				GRAND TOTAL	**$ 268,500.00**

This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual Construction Costs will not vary from this opinion.

APPENDIX D – EVALUATION MATRIX SCORES AND SUMMARY

Sean Melville											
Alternative	**Criteria**										**Total**
	Cost		**Constructability**		**Aesthetics**		**Maintenance & Repair**		**Ease of Future Major Improvement**		
Reinforced Concrete Curb	3	0.9	2	0.3	4	1.0	3	0.3	4	0.8	3.3
Concrete Cloth	4	1.2	4	0.6	2	0.5	5	0.5	4	0.8	3.6

*Score each alternative's criteria from 1 to 5 with 5 being the highest possible score. Scores can range between 1 and 5.

Criteria	%
Cost	30%
Constructability	15%
Aesthetics	25%
Maintenance and Repair	10%
Ease of Future Major Improvement	20%

*Rank the criteria with a percentage of decision weight. Combined total should add to 100%.

Key to Scoring:

Cost	
Low Cost	5
High Cost	1

Constructability	
Easy to construct and non-intrusive	5
Difficult to construct and intrusive	1

Aesthetics	
Aesthetically pleasing	5
Eye sore	1

Maintenance and Repair	
No maintenance and repair required	5
Excessive maintenance and repair required	1

Ease of Future Major Improvement	
No changes needed for future improvements	5
Removal required for future improvements	1

Craig Hoover											
Alternative	Criteria										Total
	Cost		Constructability		Aesthetics		Maintenance & Repair		Ease of Future Major Improvement		
Reinforced Concrete Curb	4	1.2	2	0.4	2	0.5	3	0.3	3	0.5	2.9
Concrete Cloth	5	1.5	4	0.8	4	1	4	0.4	4	0.6	4.3

*Score each alternative's criteria from 1 to 5 with 5 being the highest possible score. Scores can range between 1 and 5.

Criteria	%
Cost	30%
Constructability	20%
Aesthetics	25%
Maintenance and Repair	10%
Ease of Future Major Improvement	15%

*Rank the criteria with a percentage of decision weight. Combined total should add to 100%.

Key to Scoring:

Cost	
Low Cost	5
High Cost	1

Constructability	
Easy to construct and non-intrusive	5
Difficult to construct and intrusive	1

Aesthetics	
Aesthetically pleasing	5
Eye sore	1

Maintenance and Repair	
No maintenance and repair required	5
Excessive maintenance and repair required	1

Ease of Future Major Improvement	
No changes needed for future improvements	5
Removal required for future improvements	1

Alandren Etlantus											
Alternative	**Criteria**										**Total**
	Cost		**Constructability**		**Aesthetics**		**Maintenance & Repair**		**Ease of Future Major Improvement**		
Reinforced Concrete Curb	4	1.4	3	0.6	3	0.5	4	0.8	4	0.4	3.7
Concrete Cloth	5	1.8	4	0.8	2	0.3	4	0.8	5	0.5	4.2

*Score each alternative's criteria from 1 to 5 with 5 being the highest possible score. Scores can range between 1 and 5.

Criteria	**%**
Cost	35%
Constructability	20%
Aesthetics	15%
Maintenance and Repair	20%
Ease of Future Major Improvement	10%

*Rank the criteria with a percentage of decision weight. Combined total should add to 100%.

Key to Scoring:

Cost	
Low Cost	5
High Cost	1

Constructability	
Easy to construct and non-intrusive	5
Difficult to construct and intrusive	1

Aesthetics	
Aesthetically pleasing	5
Eye sore	1

Maintenance and Repair	
No maintenance and repair required	5
Excessive maintenance and repair required	1

Ease of Future Major Improvement	
No changes needed for future improvements	5
Removal required for future improvements	1

Kareem Saint-Lot											
Alternative	**Criteria**										**Total**
	Cost		**Constructability**		**Aesthetics**		**Maintenance & Repair**		**Ease of Future Major Improvement**		
Reinforced Concrete Curb	2	0.8	3	0.5	3	0.2	4	0.8	1	0.2	2.4
Concrete Cloth	4	1.6	4	0.6	2	0.1	3	0.6	4	0.8	3.7

*Score each alternative's criteria from 1 to 5 with 5 being the highest possible score. Scores can range between 1 and 5.

Criteria	**%**
Cost	40%
Constructability	15%
Aesthetics	5%
Maintenance and Repair	20%
Ease of Future Major Improvement	20%

*Rank the criteria with a percentage of decision weight. Combined total should add to 100%.

Key to Scoring:

Cost	
Low Cost	5
High Cost	1

Constructability	
Easy to construct and non-intrusive	5
Difficult to construct and intrusive	1

Aesthetics	
Aesthetically pleasing	5
Eye sore	1

Maintenance and Repair	
No maintenance and repair required	5
Excessive maintenance and repair required	1

Ease of Future Major Improvement	
No changes needed for future improvements	5
Removal required for future improvements	1

Clyde Dooley											
Alternative	**Criteria**										**Total**
	Cost		**Constructability**		**Aesthetics**		**Maintenance & Repair**		**Ease of Future Major Improvement**		
Reinforced Concrete Curb	4	0.8	4	0.4	4	0.8	4	1	5	1.3	4.3
Concrete Cloth	5	1	5	0.5	1	0.2	4	1	1	0.3	3.0

*Score each alternative's criteria from 1 to 5 with 5 being the highest possible score. Scores can range between 1 and 5.

Criteria	**%**
Cost	20%
Constructability	10%
Aesthetics	20%
Maintenance and Repair	25%
Ease of Future Major Improvement	25%

*Rank the criteria with a percentage of decision weight. Combined total should add to 100%.

Key to Scoring:

Cost	
Low Cost	5
High Cost	1

Constructability	
Easy to construct and non-intrusive	5
Difficult to construct and intrusive	1

Aesthetics	
Aesthetically pleasing	5
Eye sore	1

Maintenance and Repair	
No maintenance and repair required	5
Excessive maintenance and repair required	1

Ease of Future Major Improvement	
No changes needed for future improvements	5
Removal required for future improvements	1

Robert Schlough											
Alternative	Criteria										Total
	Cost		Constructability		Aesthetics		Maintenance & Repair		Ease of Future Major Improvement		
Reinforced Concrete Curb	2	0.7	5	2.0	4	0.2	3	0.3	3	0.3	3.5
Concrete Cloth	3	1.1	3	1.2	3	0.2	2	0.2	3	0.3	2.9

*Score each alternative's criteria from 1 to 5 with 5 being the highest possible score. Scores can range between 1 and 5.

Criteria	%
Cost	35%
Constructability	40%
Aesthetics	5%
Maintenance and Repair	10%
Ease of Future Major Improvement	10%

*Rank the criteria with a percentage of decision weight. Combined total should add to 100%.

Key to Scoring:

Cost	
Low Cost	5
High Cost	1

Constructability	
Easy to construct and non-intrusive	5
Difficult to construct and intrusive	1

Aesthetics	
Aesthetically pleasing	5
Eye sore	1

Maintenance and Repair	
No maintenance and repair required	5
Excessive maintenance and repair required	1

Ease of Future Major Improvement	
No changes needed for future improvements	5
Removal required for future improvements	1

Summary											
Alternative	Criteria										Total
	Cost		Constructability		Aesthetics		Maintenance & Repair		Ease of Future Major Improvement		
Reinforced Concrete Curb		5.8		4.2		3.1		3.5		3.4	20.0
Concrete Cloth		8.1		4.5		2.3		3.5		3.3	21.6

*Score each alternative's criteria from 1 to 5 with 5 being the highest possible score. Scores can range between 1 and 5.

Criteria	%
Cost	32%
Constructability	20%
Aesthetics	16%
Maintenance and Repair	16%
Ease of Future Major Improvement	17%

*Rank the criteria with a percentage of decision weight. Combined total should add to 100%.

Key to Scoring:

Cost	
Low Cost	5
High Cost	1

Constructability	
Easy to construct and non-intrusive	5
Difficult to construct and intrusive	1

Aesthetics	
Aesthetically pleasing	5
Eye sore	1

Maintenance and Repair	
No maintenance and repair required	5
Excessive maintenance and repair required	1

Ease of Future Major Improvement	
No changes needed for future improvements	5
Removal required for future improvements	1