TRUCKEE RIVER WATERSHED COUNCIL
HOKE MEADOWS CULVERT DESIGN

DRAINAGE REPORT
DECEMBER 2020

AUERBACH ENGINEERING CORPORATION

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I. Introduction

This Drainage Report is intended for submission with the construction drawings for review by Sierra County (County) for the Hoke Meadows Restoration Culvert Design Project (Project). This report has been prepared at the request of the Truckee River Watershed Council.

Hoke Meadows is on the northeast arm of Stampede Reservoir in the Truckee Ranger District of the Tahoe National Forest. Hoke Meadows is divided by Stampede Dam Road (a.k.a. County Route 270). The Project includes the embedment of an existing arch pipe culvert and the installation of four arch pipe culverts to aid in the restoration of functional floodplain processes in Hoke Meadows. The *Hoke Meadows Restoration Preliminary Design* report is included in Appendix F.

This report includes the following information.

- Review of background information
- Design criteria and assumptions
- Summary of the existing conditions
- Summary of the proposed conditions
- Summary and Recommendations

A. Background Information

Auerbach Engineering Corporation (AEC) reviewed the following documents associated with the site:

- Plumas Corporation (October 2020).

II. Design Criteria and Assumptions

Per Sierra County Code Chapter 12.08, "All drainage facilities shall be designed and engineered to carry surface and subsurface waters to the nearest adequate street, storm drain, natural watercourse, or other juncture, without unreasonably contributing to erosion or sedimentation problems or offsite drains or drainages in accordance with California Law". Hydrologic and Hydraulic methods are not included in Sierra County Code Chapter 12.08, therefore engineering standard of care is used to select the following methodology.

Peak flows for the existing culvert analysis and proposed design are determined from streamflow statistics as presented by Plumas Corp in the *Hoke Meadows Restoration Preliminary Design.* The AEC hydraulic analysis uses the streamflow statistics. The following table is a summary of the discharge data.

Table 1: Discharge Data

RECURRANCE INTERVAL	UNITS	FLOW
PK2	CFS	86.6
PK5	CFS	175
PK10	CFS	259
PK25	CFS	379
PK50	CFS	511
PK100	CFS	636
PK200	CFS	810
PK500	CFS	1040

Culvert hydraulics are modeled for the existing and proposed condition using HY-8[2], a Federal Highway Administration culvert hydraulic analysis program. The tailwater channel, roadway profile, culvert, and site geometric data are available from the survey prepared by AEC. Manning's n values for the floodplain and channel are selected based on the Placer County Stormwater Management Manual Table 8-1[1]. Manning's n values for the existing and proposed culverts are determined based on the auto-populated values from HY-8 that correlate to the arch pipe sections.

The riprap analysis for culvert outlet protection function of Hydraulic Toolbox[3], a Federal Highway Administration analysis program, is used to size proposed embedment riprap and outfall aprons. Equivalent diameters are used due to the inability to input arch pipe sizes. Manning's n values for the embedment material are determined based on Table 2.2 in HEC-15[4] per interpolation calculations in Appendix A.

III. Existing Conditions

The existing culvert under Stampede Dam Road measures 196" span by 122" rise. The nearest standard arch pipe section is an aluminum structural plate pipe arch of 196" span by 126" rise. The Manning's n-value for the culvert per HY-8 is 0.034. The culvert has no embedment depth and is straight with a projecting inlet. The tailwater floodplain and channel n-values used are 0.04 and 0.11, per calculations in Appendix A. Figure 1 depicts the tailwater channel section input and Figure 2 illustrates the resulting rating curve for the existing culvert. Appendix D includes HY-8 results for existing condition hydraulics.

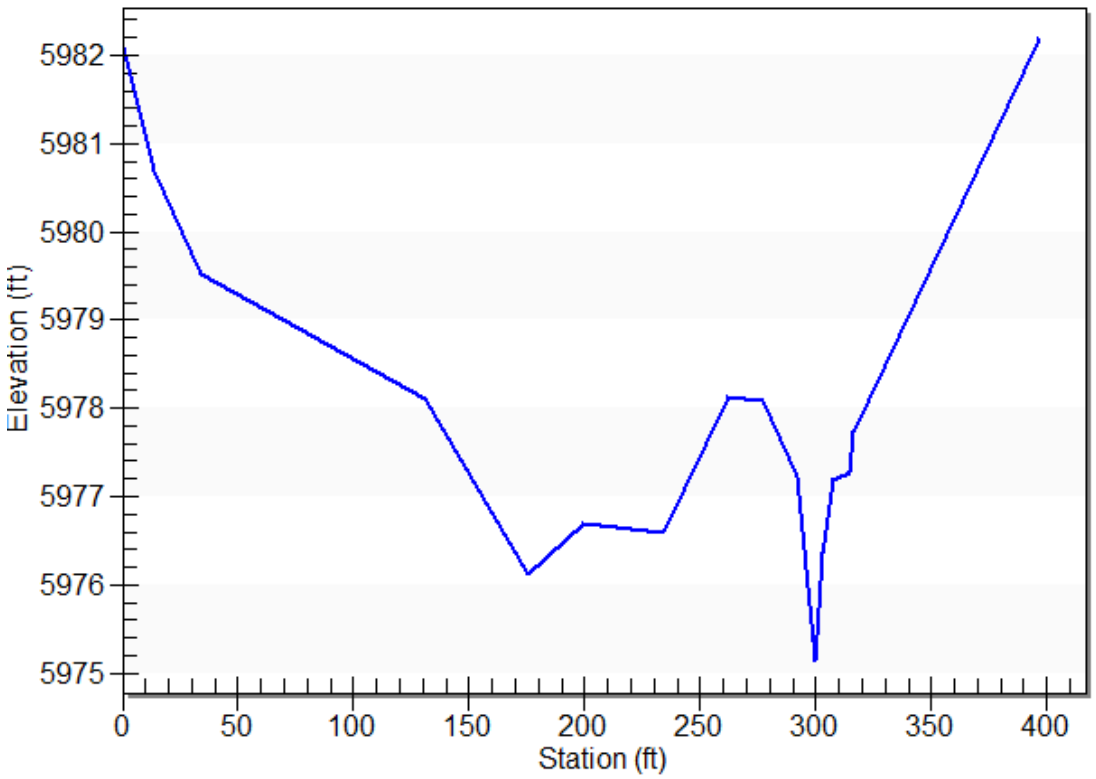

Figure 1: Tailwater/Channel Cross Section

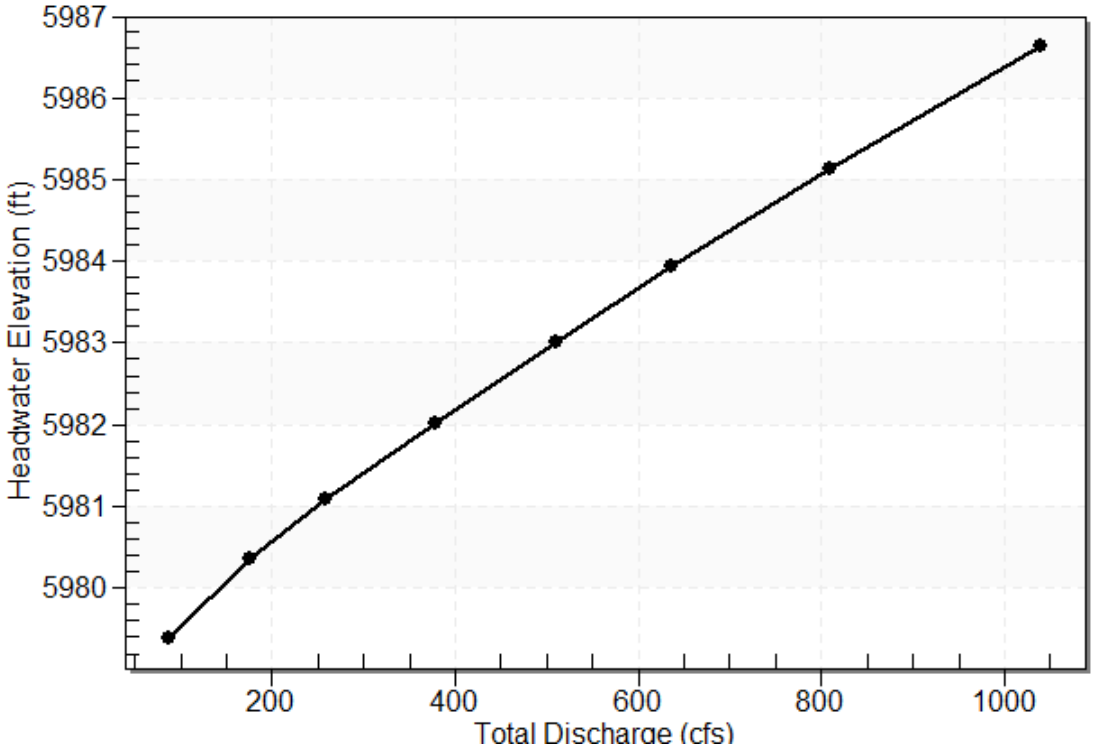

Figure 2: Existing Rating Curve

IV. Proposed Conditions

The Project includes installation of four new culverts with riprap aprons and embedment of the existing culvert under Stampede Dam Road. The Manning's n value for the existing culvert is 0.034 per HY-8 and the n value for the bottom is 0.080 per HEC-15 Table 2.2. The four new culverts are pipe arch 64" span by 43" rise. There is no embedment proposed in the new culverts, which have a Manning's n value of 0.024 per HY-8. The tailwater channel cross section is not proposed to be modified. The size of the new culverts is selected to maintain overtopping of the road at equal to or greater than 1612-cfs per the existing culvert analysis. Figure 3 illustrates the total rating curve for all culverts under the proposed condition. Appendix E includes HY-8 results for proposed hydraulics.

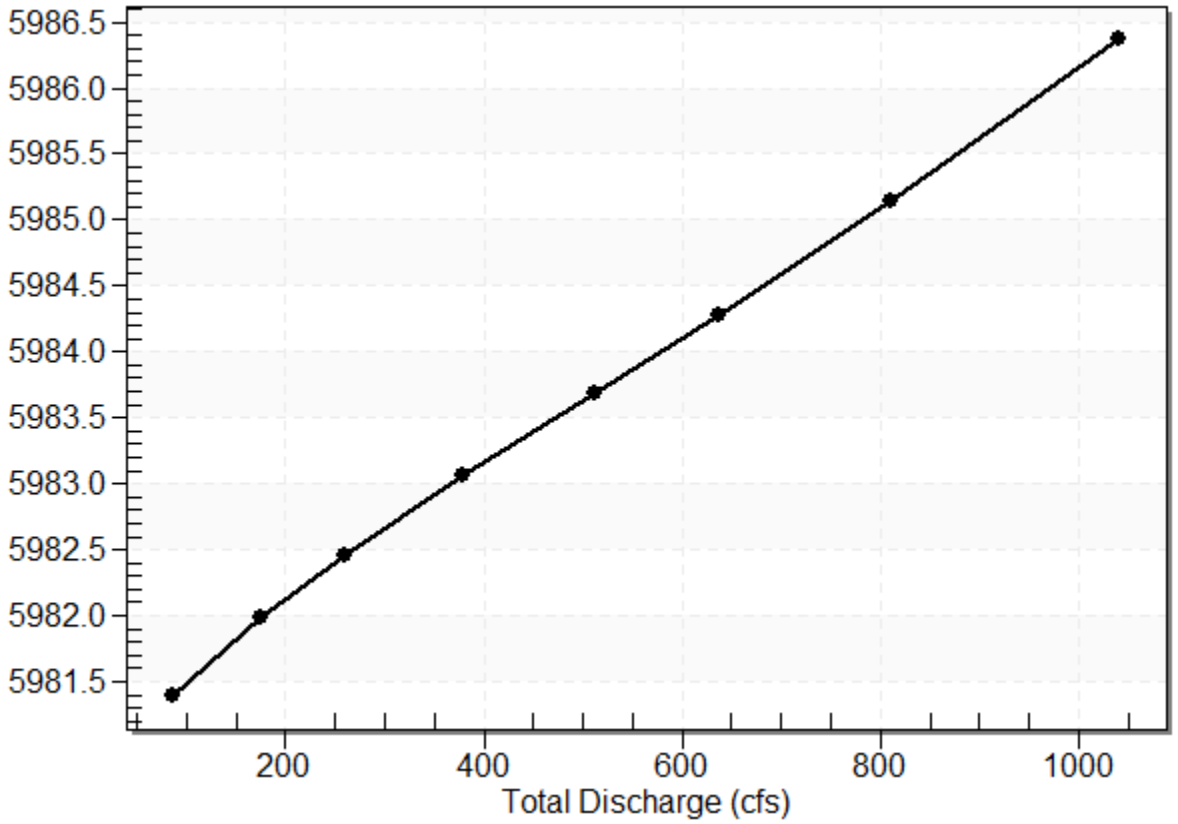

Figure 3: Proposed Rating Curve

The proposed riprap aprons for the new culverts are FHWA Class 3 riprap with a depth of 30-inches. FHWA Class I riprap is nearest in gradation to Caltrans Class 3 riprap. Appendix B includes the Hydraulic Toolbox results for apron sizing.

The proposed embedment for the existing culvert is FHWA Class 2 riprap with a depth of 34-inches. FHWA Class 2 riprap is nearest in gradation to Caltrans Class 2 riprap. Aquatic organism passage (AOP) design is not included in this AEC work. Appendix C includes the Hydraulic Toolbox results for embedment sizing.

V. Summary and Recommendations

The Project's drainage design conforms to the Sierra County criteria and engineering standard of care. The flow required to overtop the road in the existing condition (1612-cfs) is less than the flow required to overtop the road in the proposed condition (1699-cfs). The installation of the proposed improvements should not create adverse effects.

VI. References

1. Placer County. (September 1, 1990). *Placer County Stormwater Management Manual.* Retrieved from https://www.placer.ca.gov/DocumentCenter/View/1249/Stormwater-Management-Manual-PDF

2. USDOT Federal Highway Administration. (July 30, 2019). *HY-8 Version 7.60 Culvert Hydraulic Analysis Program.* Retrieved from https://www.fhwa.dot.gov/engineering/hydraulics/software/hy8/

3. USDOT Federal Highway Administration. (August 21, 2020). *Hydraulic Toolbox Version 5.0.* Retrieved from https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm

4. USDOT Federal Highway Administration. (September 2005) *Hydraulic Engineering Circular No. 1, Third Edition Design of Roadside Channels with Flexible Linings.* Retrieved from https://www.fhwa.dot.gov/engineering/hydraulics/pubs/05114/05114.pdf

APPENDICES

Appendix A: Manning's n Calculations

TABLE 8-1

MANNING N FOR STREAMS AND CHANNELS (24)

UNIFORM CHANNELS

Description	n
Concrete	0.012 - 0.016
Earth	0.017 - 0.022
Grass	0.020 - 0.025
Rock, Rubble	0.025 - 0.045

NATURAL STREAMS-CHANNELS

Channel n is a composite computed from the component n and k values in the table as follows:

$$n = k\,(n_1+n_2+n_3+n_4)$$

Component	Condition	n
Material involved (n_1)	Earth	0.020
	Rock Cut	0.025
	Fine Gravel	0.024
	Course Gravel	0.028
Degree of Irregularity (n_2)	Smooth	0.000
	Minor	0.005
	Moderate	0.010
	Severe	0.020
Relative effect of Obstructions (n_3)	Negligible	0.000
	Minor	0.010 - 0.015
	Appreciable	0.020 - 0.030
	Severe	0.040 - 0.060
Vegetation (n_4)	Low	0.005 - 0.010
	Medium	0.010 - 0.025
	High	0.025 - 0.050
	Very High	0.050 - 0.100
Degree of Meandering (k)	Minor	1.000
	Appreciable	1.150
	Severe	1.300

TABLE 8-1 (CONTINUED)
MANNING N FOR NATURAL STREAMS - FLOODPLAIN

Description	Condition	n
Pasture	Short Grass	0.025 - 0.035
	High Grass	0.030 - 0.050
Cultivated Areas	No Crop	0.020 - 0.040
	Mature Row Crops	0.025 - 0.045
	Mature Field Crops	0.030 - 0.050
Brush	Scattered brush, heavy weeds	0.035 - 0.070
	Light brush/trees, winter	0.035 - 0.060
	Light brush/trees, summer	0.040 - 0.080
	Medium to dense brush, winter	0.045 - 0.110
	Medium to dense brush, summer	0.070 - 0.160
Trees	Dense willows, summer, straight	0.110 - 0.200
	Cleared land with tree stumps, no sprouts	0.030 - 0.050
	Same as above, but with heavy growth of sprouts	0.050 - 0.080
	Heavy stand of timber a few down trees, little undergrowth, flood stage below branches	0.080 - 0.120
	As above, but with flood stage reaching branches	0.100 - 0.160

The effect of channel work on existing culverts, bridges, buried cables, pipelines, irrigation flumes, and inlet structures shall be evaluated to determine the need for modification or replacement.

f. Culverts and Brides Culverts and bridges that are modified or added as part of channel projects shall meet reasonable standards for the type of structure and shall have a minimum capacity equal to the design discharge or state agency design requirements, whichever is greater. Capacity of some culverts and bridges may need to be increased above the design discharge.

g. Disposition of spoil Spoil material from clearing, grubbing, and channel excavation shall be disposed of in a manner that will:

- Not confine or direct flows so as to cause instability when the discharge is greater than the bankfull flow.

- Provide for the free flow of water between the channel and flood plain unless the valley routing and water surface profile are based on continuous dikes being installed.

2. Natural Channels Natural waterways are important in conveying storm runoff in Placer County. The objectives of the

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civil engineering • land surveying • environmental planning

Project Name: Hoke Meadows Restoration Culvert Design Project No.: 419.01

Subject: Manning's n calculations

Date: 12/11/2020 By: Cindy Steele Page: 1 of 1

TAILWATER CHANNEL MANNING'S N

$n = k(n_1 + n_2 + n_3 + n_4)$

n_1 = 0.20 (earth)

n_2 = 0.01 (moderate irregularity)

n_3 = 0.025 (appreciable effect of obstructions)

n_4 = 0.04 (high vegetation)

k = 1.15 (appreciable meandering)

$n = 1.15(0.20 + 0.01 + 0.025 + 0.04)$

n = 0.11

Appendix B: Proposed Aprons Hydraulic Toolbox Results

(P) Apron

Structure type: Culvert Outlet Protection

Geotextile/Granular Filter Design...

Parameter	Value	Units	Notes
Channel Parameters			
Select Channel	PK500 Channel P		
	Channel Calculator...		
Design Flow	129.480	cfs	
Channel Depth	2.468	ft	
Slope	0.054	ft/ft	
Bottom Width	0.000	ft	
Area	116.767	ft^2	
Top Width	139.753	ft	
Wetted Perimeter	140.477	ft	
Hydraulic Radius	0.831	ft	
Input Parameters			
	Transfer Values From Channel Calculator		
Flow	129.480	cfs	
Culvert Diameter	4.500	ft	
Normal Depth in Culvert	2.468	ft	
Tailwater Depth	1.800	ft	If tailwater is unknown, use 0.4D
Flow Type	subcritical		
Results			
D50	11.621	in	
D50	0.968	ft	The sizing equation assumes a rock s.g.=2.65. If s.g. is not 2.65, rock size (D...
Riprap Shape	Riprap shape should be angular		
Riprap Class			
Riprap Class Name	CLASS III		
Riprap Class Order	3		
D15	9.00	in	This value is an 'average' of the size fraction range for the selected riprap class
D50	12.50	in	This value is an 'average' of the size fraction range for the selected riprap class
D85	17.00	in	This value is an 'average' of the size fraction range for the selected riprap class
D100	24.00	in	This value is an 'average' of the size fraction range for the selected riprap class
Layout			
Apron Length	22.500	ft	
Apron Thickness	2.500	ft	
Apron Width (at apron end)	28.500	ft	
Computation Variables			
Tailwater Depth Used in Computations	1.800	ft	
Culvert Diameter Used in Calculations	4.500	ft	

OK Cancel

Hydraulic Analysis Report

Project Data

Project Title: 419.01 TRWC Hoke Meadows Restoration Culvert Design

Designer: By: Cindy Steele; Checked: Chris Anderson

Project Date: Friday, November 13, 2020

Project Units: U.S. Customary Units

Notes:

Riprap Analysis: (P) Apron

Notes:

Input Parameters

Riprap Type: Culvert Outlet Protection

Flow: 129.48 cfs

Culvert Diameter: 4.5 ft

Normal Depth in Culvert: 2.46768 ft

Tailwater Depth: 1.8 ft

If tailwater is unknown, use 0.4D

flow is sbcritical

Result Parameters

Tailwater Depth Used in Computations: 1.8 ft

Culvert Diameter Used in Computations: 4.5 ft

Computed D50: 11.6213 in

Riprap Class

Riprap Name: CLASS III

Riprap Class: III

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 24 in

d85: 17 in

d50: 12.5 in

d15: 9 in

Layout Recommendations

Apron Length: 22.5 ft

Apron Depth: 2.5 ft

Apron Width (at end): 28.5 ft

Name of Selected Channel: PK500 Channel P

No channel used in calculations

Channel Analysis: PK500 Channel P

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
0.00	5982.10	0.2753
13.78	5980.69	0.2753
34.35	5979.52	0.2753
131.12	5978.10	0.2753
175.26	5976.12	0.2753
200.00	5976.70	0.2753
233.96	5976.70	0.2753
262.18	5978.12	0.2753
277.03	5978.08	0.2753
291.80	5977.22	0.2753
300.09	5975.13	0.2753
302.75	5976.35	0.2753
307.18	5977.18	0.2753
314.49	5977.27	0.2753
315.96	5977.71	0.2753
396.74	5982.19	-----

Longitudinal Slope: 0.0540 ft/ft

Flow: 129.4800 cfs

Result Parameters

Depth: 2.4677 ft

Area of Flow: 116.7666 ft^2

Wetted Perimeter: 140.4775 ft

Hydraulic Radius: 0.8312 ft

Average Velocity: 1.1089 ft/s

Top Width: 139.7526 ft

Froude Number: 0.2138

Critical Depth: 1.7724 ft

Critical Velocity: 3.5553 ft/s

Critical Slope: 1.5223 ft/ft

Critical Top Width: 92.80 ft

Calculated Max Shear Stress: 8.3151 lb/ft^2

Calculated Avg Shear Stress: 2.8009 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.2753

Selected Profile: FHWA Profile (read-only)

Culvert Assessment Profiles

Culvert Assessment Profile Name: Standard (read-only)

Maximum Excavation Depth: 20 ft

Maximum Shallow Cover: 4 ft

Maximum Small Pipe Size: 36 in

Minimum Manned Entry Size: 48 in

Riprap Classes

Riprap Name: CLASS I

Riprap Class: I

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 12 in

d85: 9 in

d50: 6.5 in

d15: 4.5 in

Riprap Name: CLASS II

Riprap Class: II

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 18 in

d85: 13 in

d50: 9.5 in

d15: 7 in

Riprap Name: CLASS III

Riprap Class: III

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 24 in

d85: 17 in

d50: 12.5 in

d15: 9 in

Riprap Name: CLASS IV

Riprap Class: IV

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 30 in

d85: 21 in

d50: 15.5 in

d15: 10.5 in

Riprap Name: CLASS V

Riprap Class: V

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 36 in

d85: 25.5 in

d50: 18.5 in

d15: 13 in

Riprap Name: CLASS VI

Riprap Class: VI

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 42 in

d85: 30 in

d50: 21.5 in

d15: 15 in

Riprap Name: CLASS VII

Riprap Class: VII

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 49.5 in

d85: 35 in

d50: 25.5 in

d15: 17.5 in

Riprap Name: CLASS VIII

Riprap Class: VIII

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 60 in

d85: 42.5 in

d50: 31.5 in

d15: 22 in

Riprap Name: CLASS IX

Riprap Class: IX

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 72 in

d85: 51 in

d50: 38 in

d15: 26 in

Riprap Name: CLASS X

Riprap Class: X

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 84 in

d85: 59.5 in

d50: 44.5 in

d15: 31 in

Appendix C: Proposed Embedment Hydraulic Toolbox Results

(E) Embedment

Structure type: Culvert Outlet Protection

Geotextile/Granular Filter Design...

Parameter	Value	Units	Notes
Channel Parameters			
Select Channel	PK500 Channel E		
	Channel Calculator...		
Design Flow	523.370	cfs	
Channel Depth	3.622	ft	
Slope	0.054	ft/ft	
Bottom Width	0.000	ft	
Area	339.322	ft^2	
Top Width	248.033	ft	
Wetted Perimeter	248.846	ft	
Hydraulic Radius	1.364	ft	
Input Parameters			
	Transfer Values From Channel Calculator		
Flow	523.370	cfs	
Culvert Diameter	13.400	ft	
Normal Depth in Culvert	3.622	ft	
Tailwater Depth	5.200	ft	If tailwater is unknown, use 0.4D
Flow Type	subcritical		
Results			
D50	5.866	in	
D50	0.489	ft	The sizing equation assumes a rock s.g.=2.65. If s.g. is not 2.65, rock size (D...
Riprap Shape	Riprap shape should be angular		
Riprap Class			
Riprap Class Name	CLASS I		
Riprap Class Order	1		
D15	4.50	in	This value is an 'average' of the size fraction range for the selected riprap class
D50	6.50	in	This value is an 'average' of the size fraction range for the selected riprap class
D85	9.00	in	This value is an 'average' of the size fraction range for the selected riprap class
D100	12.00	in	This value is an 'average' of the size fraction range for the selected riprap class
Layout			
Apron Length	53.600	ft	
Apron Thickness	1.896	ft	
Apron Width (at apron end)	75.933	ft	
Computation Variables			
Tailwater Depth Used in Computations	5.360	ft	
Culvert Diameter Used in Calculations	13.400	ft	

OK Cancel

Hydraulic Analysis Report

Project Data

Project Title: 419.01 TRWC Hoke Meadows Restoration Culvert Design

Designer: By: Cindy Steele; Checked: Chris Anderson

Project Date: Friday, November 13, 2020

Project Units: U.S. Customary Units

Notes:

Riprap Analysis: (E) Embedment

Notes:

Input Parameters

Riprap Type: Culvert Outlet Protection

Flow: 523.37 cfs

Culvert Diameter: 13.4 ft

Normal Depth in Culvert: 3.62167 ft

Tailwater Depth: 5.2 ft

If tailwater is unknown, use 0.4D

flow is sbcritical

Result Parameters

Tailwater Depth Used in Computations: 5.36 ft

Culvert Diameter Used in Computations: 13.4 ft

Computed D50: 5.86564 in

Riprap Class

Riprap Name: CLASS I

Riprap Class: I

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 12 in

d85: 9 in

d50: 6.5 in

d15: 4.5 in

Layout Recommendations

Apron Length: 53.6 ft

Apron Depth: 1.89583 ft

Apron Width (at end): 75.9333 ft

Name of Selected Channel: PK500 Channel E

No channel used in calculations

Channel Analysis: PK500 Channel E

Notes:

Input Parameters

Channel Type: Custom Cross Section

Cross Section Data

Elevation (ft)	Elevation (ft)	Manning's n
0.00	5982.10	0.2753
13.78	5980.69	0.2753
34.35	5979.52	0.2753
131.12	5978.10	0.2753
175.26	5976.12	0.2753
200.00	5976.70	0.2753
233.96	5976.70	0.2753
262.18	5978.12	0.2753
277.03	5978.08	0.2753
291.80	5977.22	0.2753
300.09	5975.13	0.2753
302.75	5976.35	0.2753
307.18	5977.18	0.2753
314.49	5977.27	0.2753
315.96	5977.71	0.2753
396.74	5982.19	-----

Longitudinal Slope: 0.0540 ft/ft

Flow: 523.3700 cfs

Result Parameters

Depth: 3.6217 ft

Area of Flow: 339.3219 ft^2

Wetted Perimeter: 248.8460 ft

Hydraulic Radius: 1.3636 ft

Average Velocity: 1.5424 ft/s

Top Width: 248.0325 ft

Froude Number: 0.2324

Critical Depth: 2.3781 ft

Critical Velocity: 5.0086 ft/s

Critical Slope: 1.2096 ft/ft

Critical Top Width: 134.14 ft

Calculated Max Shear Stress: 12.2036 lb/ft^2

Calculated Avg Shear Stress: 4.5947 lb/ft^2

Composite Manning's n Equation: Lotter method

Manning's n: 0.2753

Selected Profile: FHWA Profile (read-only)

Culvert Assessment Profiles

Culvert Assessment Profile Name: Standard (read-only)

Maximum Excavation Depth: 20 ft

Maximum Shallow Cover: 4 ft

Maximum Small Pipe Size: 36 in

Minimum Manned Entry Size: 48 in

Riprap Classes

Riprap Name: CLASS I

Riprap Class: I

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 12 in

d85: 9 in

d50: 6.5 in

d15: 4.5 in

Riprap Name: CLASS II

Riprap Class: II

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 18 in

d85: 13 in

d50: 9.5 in

d15: 7 in

Riprap Name: CLASS III

Riprap Class: III

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 24 in

d85: 17 in

d50: 12.5 in

d15: 9 in

Riprap Name: CLASS IV

Riprap Class: IV

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 30 in

d85: 21 in

d50: 15.5 in

d15: 10.5 in

Riprap Name: CLASS V

Riprap Class: V

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 36 in

d85: 25.5 in

d50: 18.5 in

d15: 13 in

Riprap Name: CLASS VI

Riprap Class: VI

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 42 in

d85: 30 in

d50: 21.5 in

d15: 15 in

Riprap Name: CLASS VII

Riprap Class: VII

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 49.5 in

d85: 35 in

d50: 25.5 in

d15: 17.5 in

Riprap Name: CLASS VIII

Riprap Class: VIII

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 60 in

d85: 42.5 in

d50: 31.5 in

d15: 22 in

Riprap Name: CLASS IX

Riprap Class: IX

The following values are an 'average' of the size fraction range for the selected riprap class.

d100: 72 in

d85: 51 in

d50: 38 in

d15: 26 in

Riprap Name: CLASS X

Riprap Class: X

The following values are an 'average' of the size fraction range for the selected riprap class.

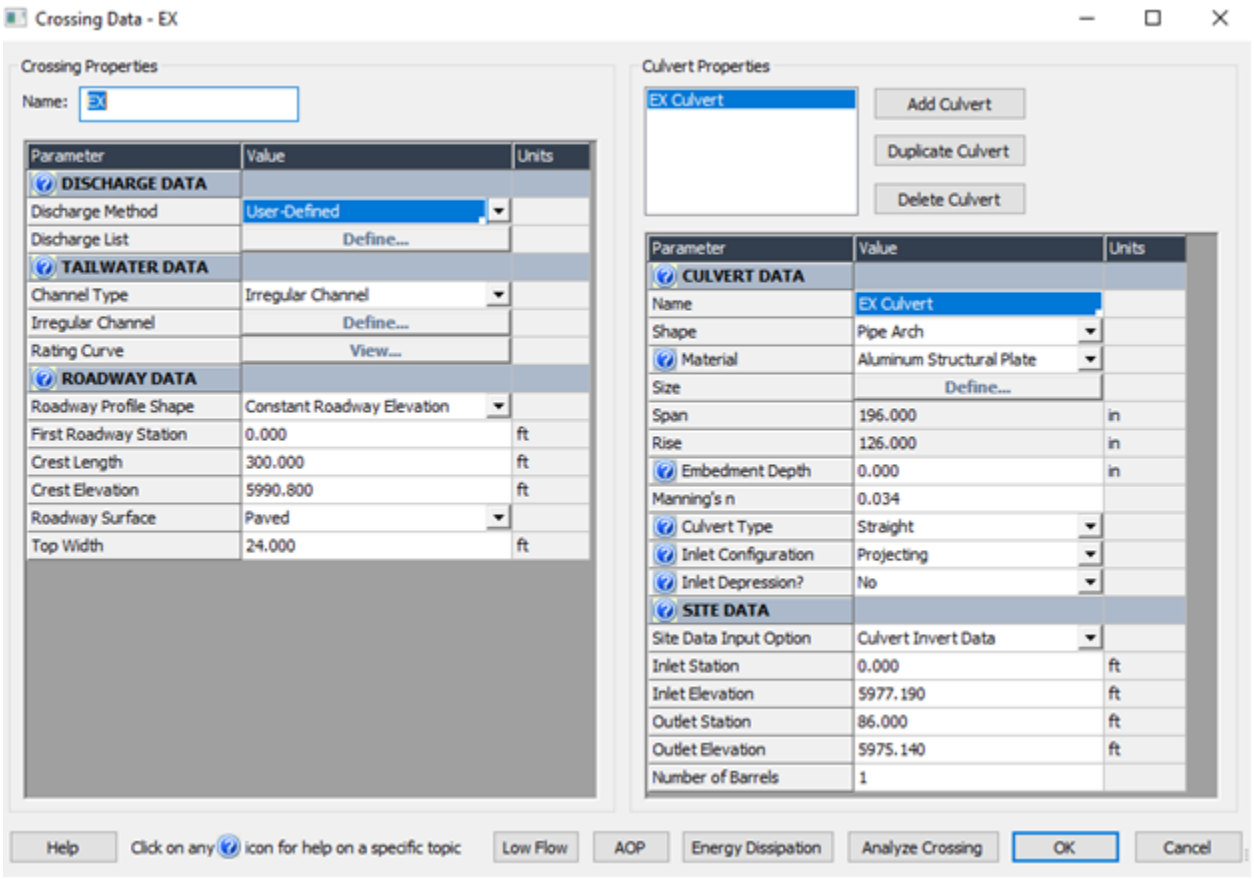
d100: 84 in

d85: 59.5 in

d50: 44.5 in

d15: 31 in

Appendix D: Existing Conditions HY-8 Results


Crossing Data - EX
Crossing Properties
Name: EX
Parameter
Value
Units
DISCHARGE DATA
Discharge Method
User-Defined
Discharge List
Define...
TAILWATER DATA
Channel Type
Irregular Channel
Irregular Channel
Define...
Rating Curve
View...
ROADWAY DATA
Roadway Profile Shape
Constant Roadway Elevation
First Roadway Station
0.000
ft
Crest Length
300.000
ft
Crest Elevation
5990.800
ft
Roadway Surface
Paved
Top Width
24.000
ft
Culvert Properties
EX Culvert
Add Culvert
Duplicate Culvert
Delete Culvert
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Name
EX Culvert
Shape
Pipe Arch
Material
Aluminum Structural Plate
Size
Define...
Span
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in
Rise
126.000
in
Embedment Depth
0.000
in
Manning's n
0.034
Culvert Type
Straight
Inlet Configuration
Projecting
Inlet Depression?
No
SITE DATA
Site Data Input Option
Culvert Invert Data
Inlet Station
0.000
ft
Inlet Elevation
5977.190
ft
Outlet Station
86.000
ft
Outlet Elevation
5975.140
ft
Number of Barrels
1
Help
Click on any icon for help on a specific topic
Low Flow
AOP
Energy Dissipation
Analyze Crossing
OK
Cancel

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: EX

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	EX Culvert Discharge (cfs)	Roadway Discharge (cfs)	Iterations
5979.39	PK2	86.60	86.60	0.00	1
5980.35	PK5	175.00	175.00	0.00	1
5981.10	PK10	259.00	259.00	0.00	1
5982.01	PK25	379.00	379.00	0.00	1
5983.01	PK50	511.00	511.00	0.00	1
5983.93	PK100	636.00	636.00	0.00	1
5985.12	PK200	810.00	810.00	0.00	1
5986.63	PK500	1040.00	1040.00	0.00	1
5990.80	Overtopping	1612.46	1612.46	0.00	Overtopping

Rating Curve Plot for Crossing: EX

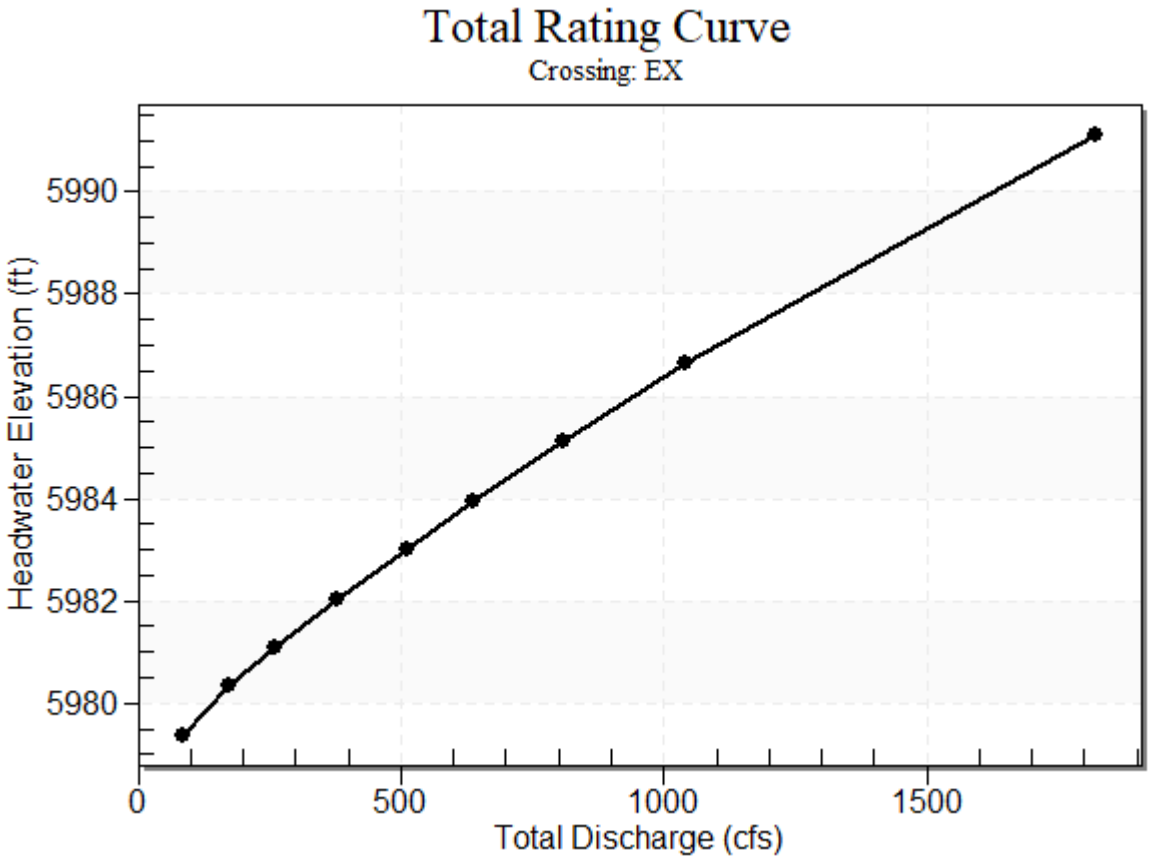


Table 2 - Culvert Summary Table: EX Culvert

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
PK2	86.60	86.60	5979.39	2.196	0.0*	1-S2n	1.450	1.571	1.450	1.651	6.581
PK5	175.00	175.00	5980.35	3.165	0.246	1-S2n	2.011	2.227	2.011	1.814	8.268
PK10	259.00	259.00	5981.10	3.908	0.821	1-S2n	2.429	2.720	2.429	1.935	9.407
PK25	379.00	379.00	5982.01	4.825	1.591	1-S2n	2.932	3.316	2.932	2.082	10.678
PK50	511.00	511.00	5983.01	5.816	2.424	1-S2n	3.421	3.885	3.421	2.222	11.774
PK100	636.00	636.00	5983.93	6.741	3.231	1-S2n	3.850	4.368	3.850	2.333	12.623
PK200	810.00	810.00	5985.12	7.934	4.407	1-S2n	4.416	4.976	4.430	2.469	13.542
PK500	1040.00	1040.00	5986.63	9.441	6.100	1-S2n	5.146	5.708	5.165	2.627	14.542

* Full Flow Headwater elevation is below inlet invert.

****

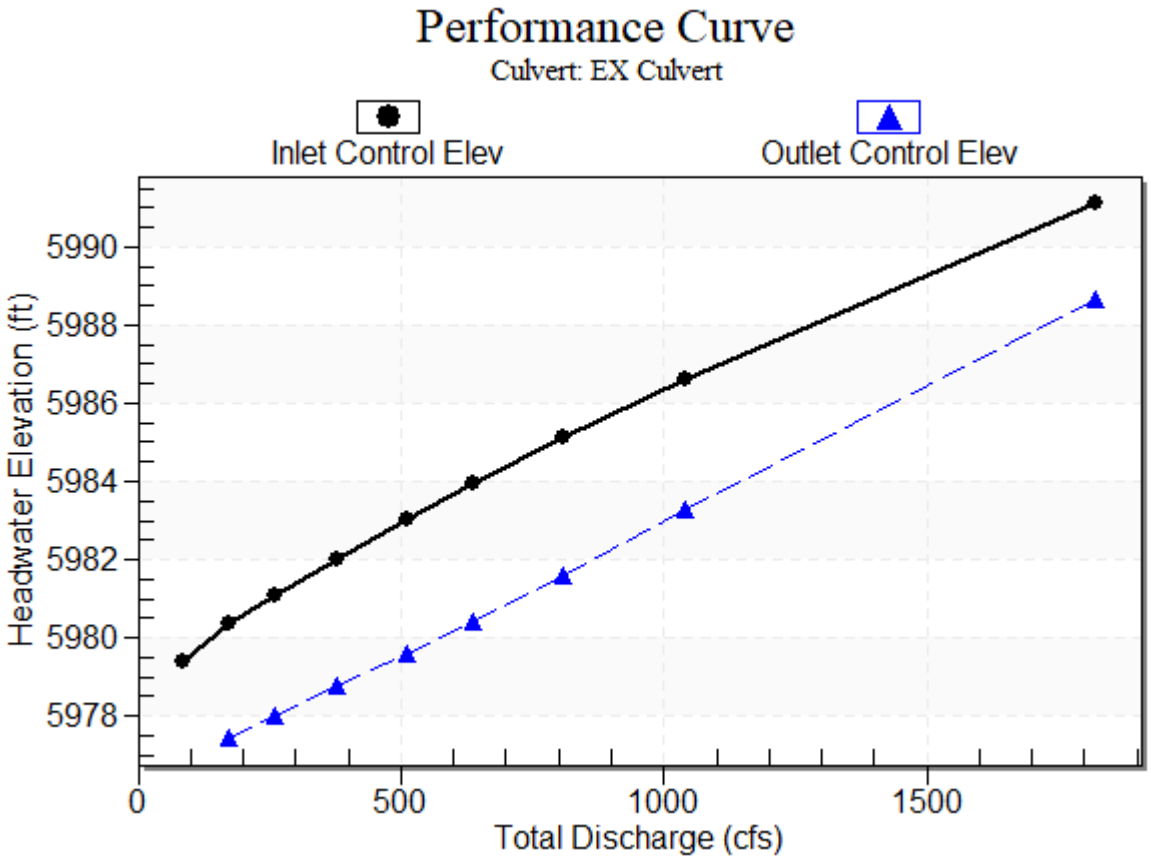
Straight Culvert

Inlet Elevation (invert): 5977.19 ft, Outlet Elevation (invert): 5975.14 ft

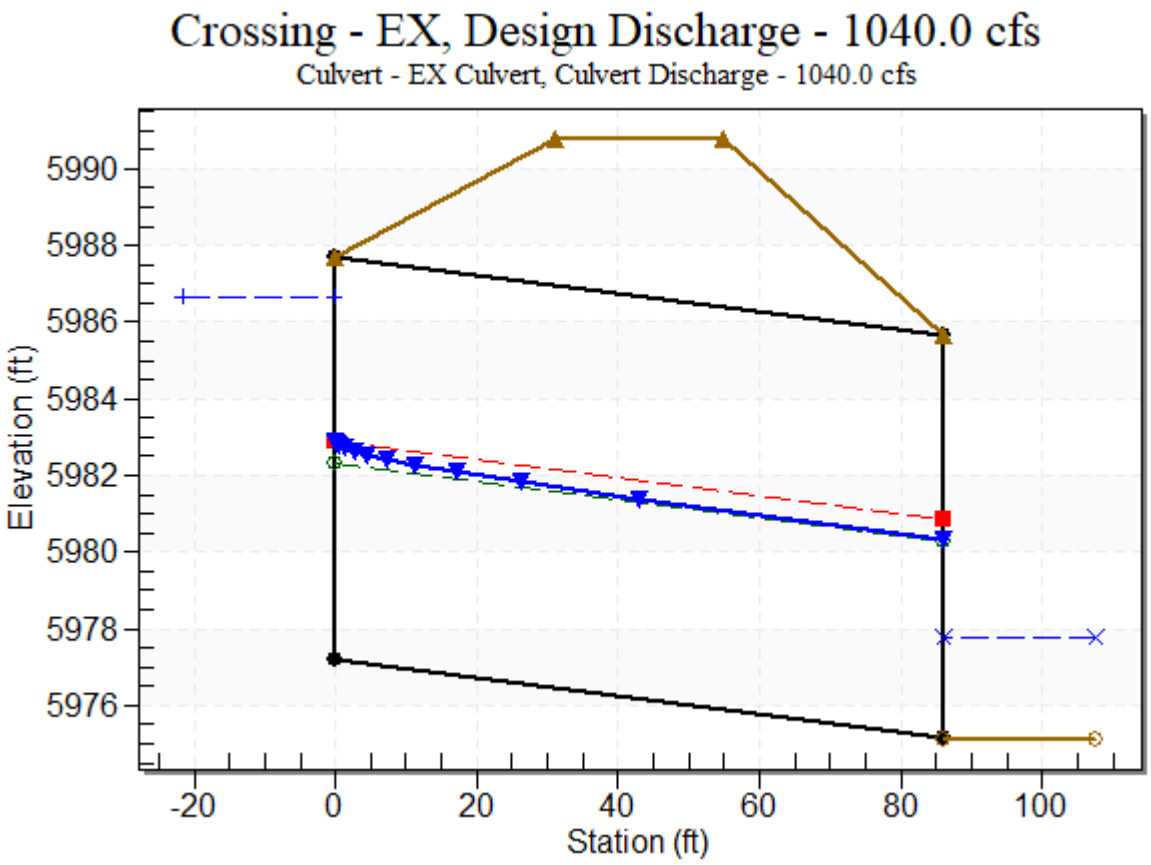
Culvert Length: 86.02 ft, Culvert Slope: 0.0238

****

Culvert Performance Curve Plot: EX Culvert



Water Surface Profile Plot for Culvert: EX Culvert



Site Data - EX Culvert

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 5977.19 ft

Outlet Station: 86.00 ft

Outlet Elevation: 5975.14 ft

Number of Barrels: 1

Culvert Data Summary - EX Culvert

Barrel Shape: Pipe Arch

Barrel Span: 196.00 in

Barrel Rise: 126.00 in

Barrel Material: Aluminum Structural Plate

Embedment: 0.00 in

Barrel Manning's n: 0.0340

Culvert Type: Straight

Inlet Configuration: Projecting

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: EX)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
86.60	5976.78	1.65	3.13	5.56	0.98
175.00	5976.94	1.81	4.09	6.11	1.08
259.00	5977.06	1.93	4.73	6.52	1.14
379.00	5977.21	2.08	5.38	7.01	1.20
511.00	5977.35	2.22	5.85	7.49	1.24
636.00	5977.46	2.33	6.26	7.86	1.26
810.00	5977.60	2.47	6.74	8.32	1.28
1040.00	5977.76	2.63	7.27	8.85	1.32

Tailwater Channel Data - EX

Tailwater Channel Option: Irregular Channel

Roadway Data for Crossing: EX

Roadway Profile Shape: Constant Roadway Elevation

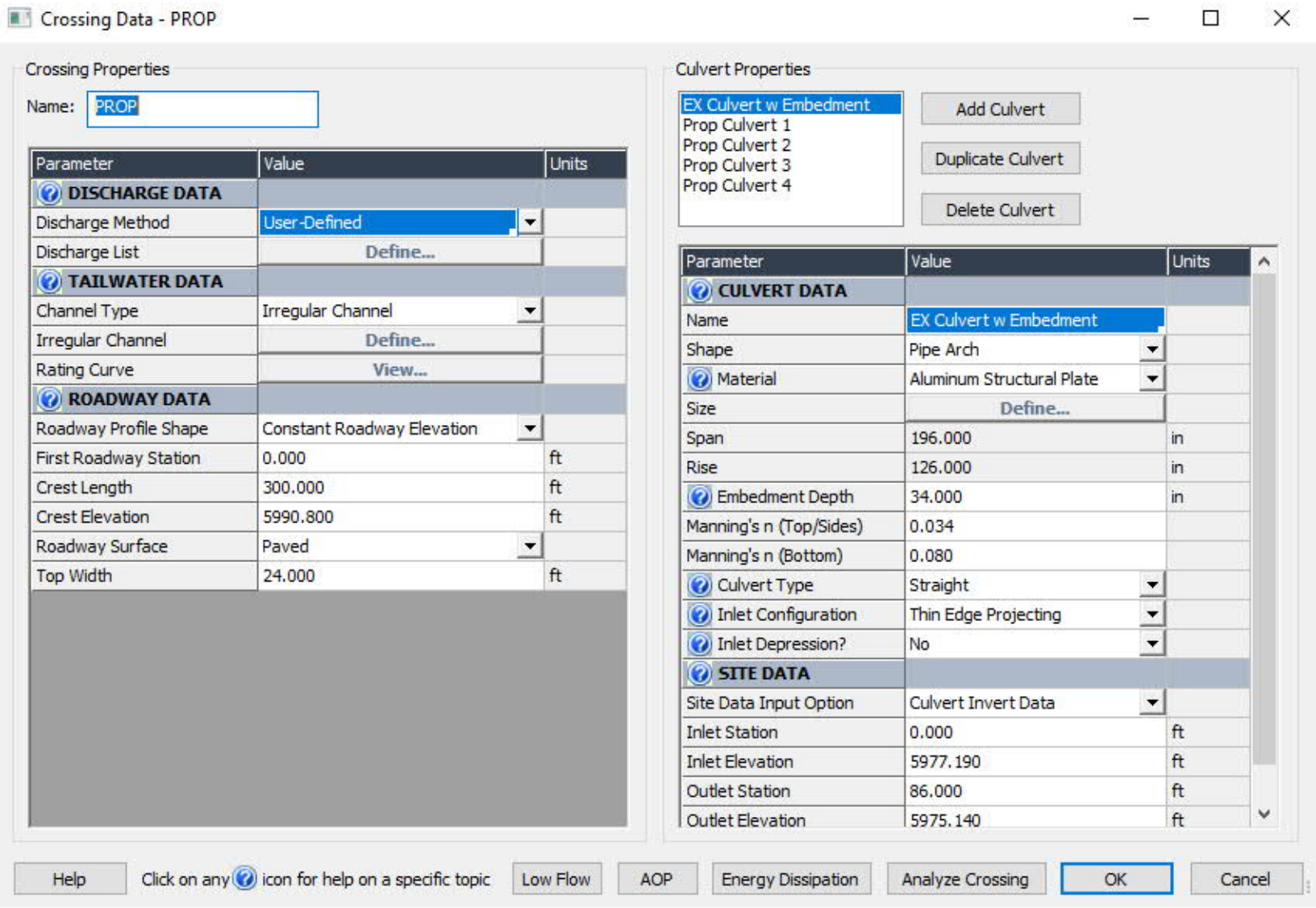
Crest Length: 300.00 ft

Crest Elevation: 5990.80 ft

Roadway Surface: Paved

Roadway Top Width: 24.00 ft

Appendix E: Proposed Conditions HY-8 Results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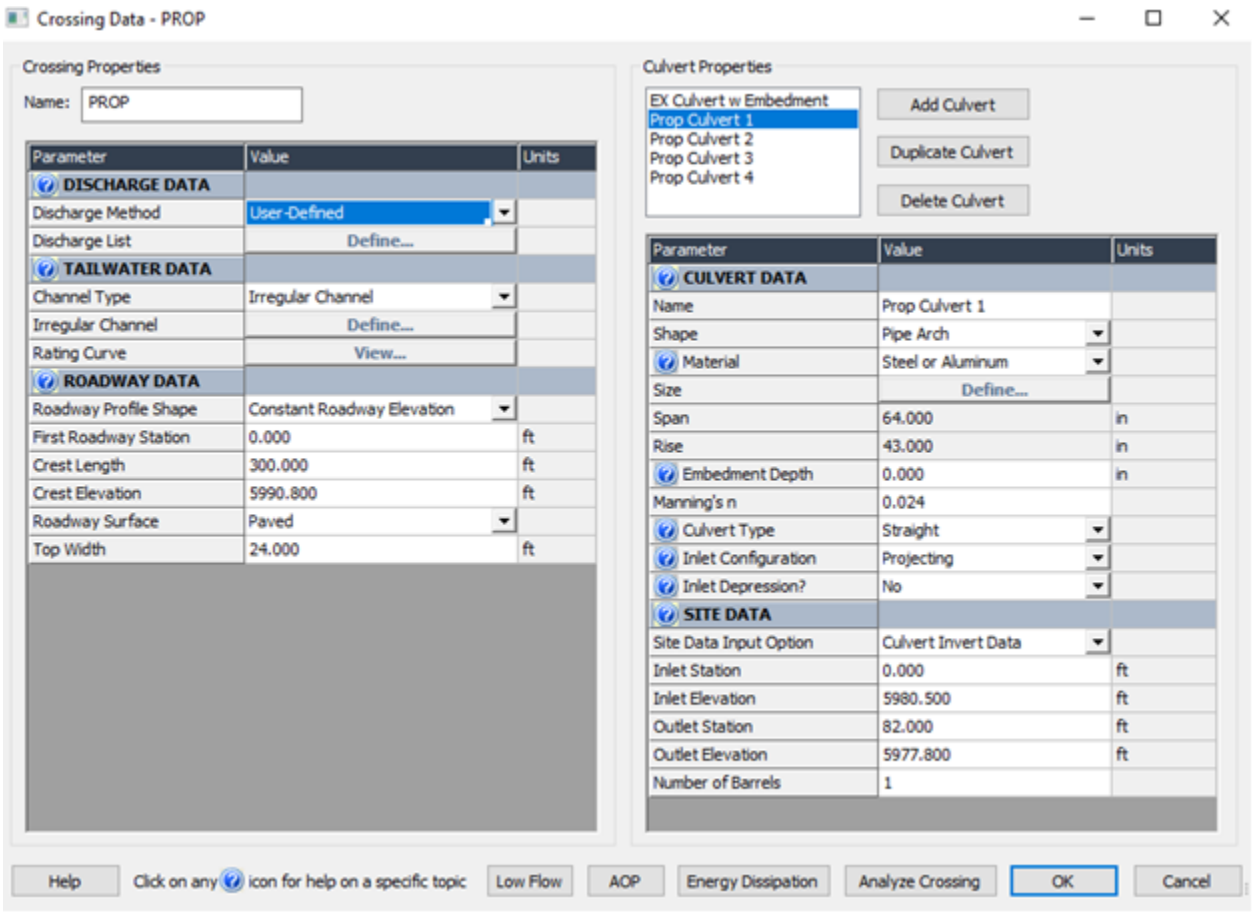
Crossing Properties
Name: PROP
Parameter
Value
Units
DISCHARGE DATA
Discharge Method
User-Defined
Discharge List
Define...
TAILWATER DATA
Channel Type
Irregular Channel
Irregular Channel
Define...
Rating Curve
View...
ROADWAY DATA
Roadway Profile Shape
Constant Roadway Elevation
First Roadway Station
0.000
ft
Crest Length
300.000
ft
Crest Elevation
5990.800
ft
Roadway Surface
Paved
Top Width
24.000
ft
Culvert Properties
EX Culvert w Embedment
Prop Culvert 1
Prop Culvert 2
Prop Culvert 3
Prop Culvert 4
Add Culvert
Duplicate Culvert
Delete Culvert
Parameter
Value
Units
CULVERT DATA
Name
EX Culvert w Embedment
Shape
Pipe Arch
Material
Aluminum Structural Plate
Size
Define...
Span
196.000
in
Rise
126.000
in
Embedment Depth
34.000
in
Manning's n (Top/Sides)
0.034
Manning's n (Bottom)
0.080
Culvert Type
Straight
Inlet Configuration
Thin Edge Projecting
Inlet Depression?
No
SITE DATA
Site Data Input Option
Culvert Invert Data
Inlet Station
0.000
ft
Inlet Elevation
5977.190
ft
Outlet Station
86.000
ft
Outlet Elevation
5975.140
ft
Help
Click on any icon for help on a specific topic
Low Flow
AOP
Energy Dissipation
Analyze Crossing
OK
Cancel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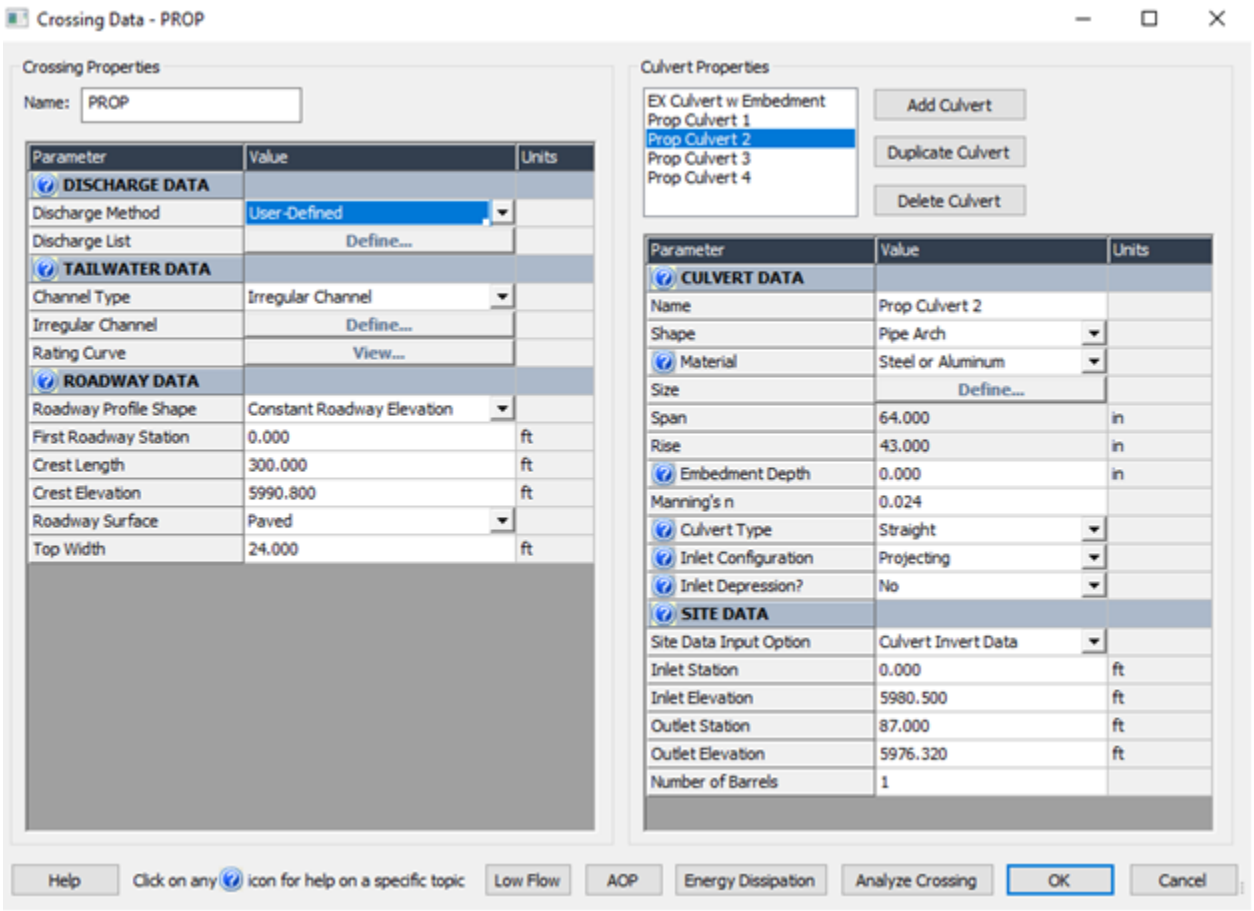
Crossing Properties
Name: PROP
Parameter
Value
Units
DISCHARGE DATA
Discharge Method
User-Defined
Discharge List
Define...
TAILWATER DATA
Channel Type
Irregular Channel
Irregular Channel
Define...
Rating Curve
View...
ROADWAY DATA
Roadway Profile Shape
Constant Roadway Elevation
First Roadway Station
0.000
ft
Crest Length
300.000
ft
Crest Elevation
5990.800
ft
Roadway Surface
Paved
Top Width
24.000
ft
Culvert Properties
EX Culvert w Embedment
Prop Culvert 1
Prop Culvert 2
Prop Culvert 3
Prop Culvert 4
Add Culvert
Duplicate Culvert
Delete Culvert
Parameter
Value
Units
CULVERT DATA
Name
Prop Culvert 1
Shape
Pipe Arch
Material
Steel or Aluminum
Size
Define...
Span
64.000
in
Rise
43.000
in
Embedment Depth
0.000
in
Manning's n
0.024
Culvert Type
Straight
Inlet Configuration
Projecting
Inlet Depression?
No
SITE DATA
Site Data Input Option
Culvert Invert Data
Inlet Station
0.000
ft
Inlet Elevation
5980.500
ft
Outlet Station
82.000
ft
Outlet Elevation
5977.800
ft
Number of Barrels
1
Help
Click on any icon for help on a specific topic
Low Flow
AOP
Energy Dissipation
Analyze Crossing
OK
Cancel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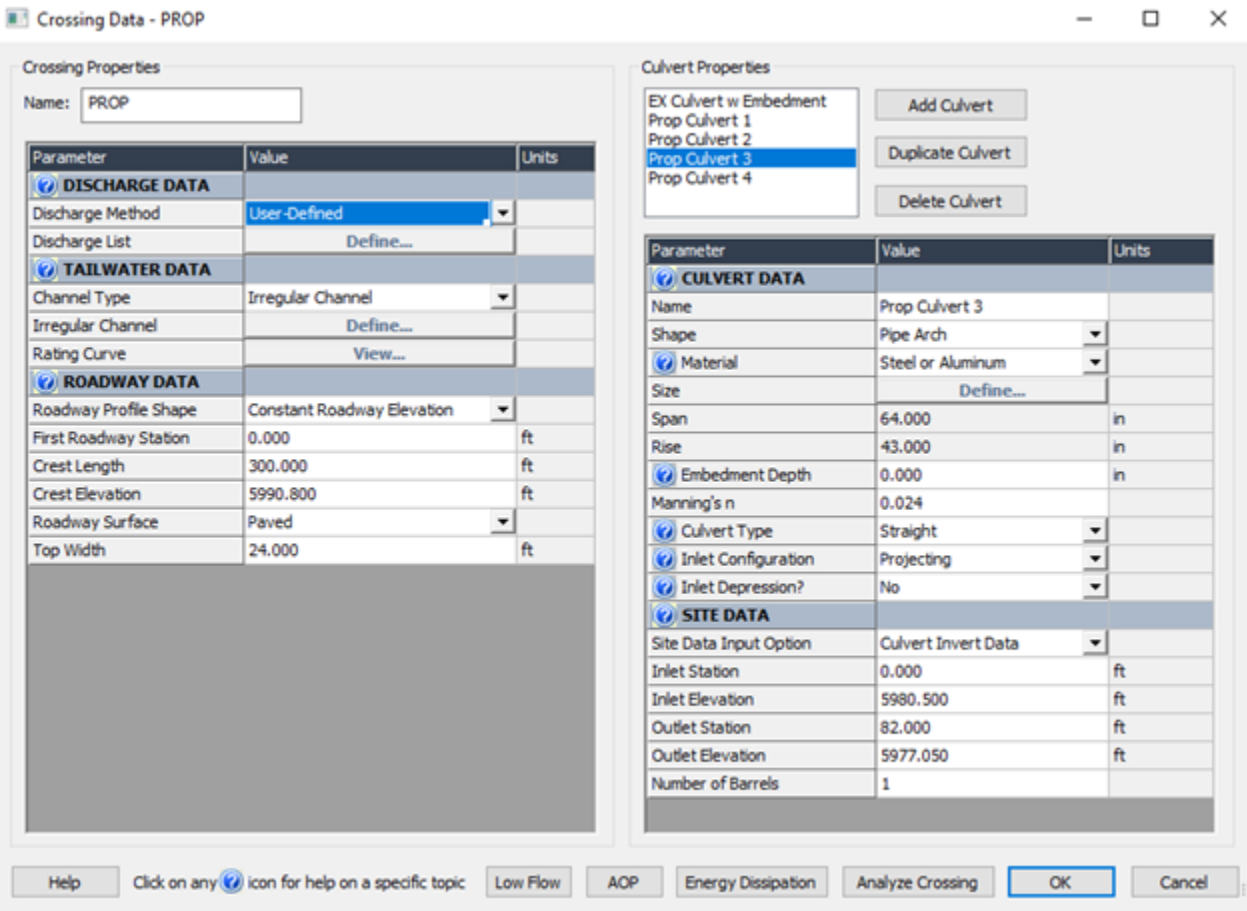
Crossing Properties
Name: PROP
Parameter | Value | Units
DISCHARGE DATA
Discharge Method | User-Defined
Discharge List | Define...
TAILWATER DATA
Channel Type | Irregular Channel
Irregular Channel | Define...
Rating Curve | View...
ROADWAY DATA
Roadway Profile Shape | Constant Roadway Elevation
First Roadway Station | 0.000 | ft
Crest Length | 300.000 | ft
Crest Elevation | 5990.800 | ft
Roadway Surface | Paved
Top Width | 24.000 | ft
Culvert Properties
EX Culvert w Embedment
Prop Culvert 1
Prop Culvert 2
Prop Culvert 3
Prop Culvert 4
Add Culvert
Duplicate Culvert
Delete Culvert
Parameter | Value | Units
CULVERT DATA
Name | Prop Culvert 2
Shape | Pipe Arch
Material | Steel or Aluminum
Size | Define...
Span | 64.000 | in
Rise | 43.000 | in
Embedment Depth | 0.000 | in
Manning's n | 0.024
Culvert Type | Straight
Inlet Configuration | Projecting
Inlet Depression? | No
SITE DATA
Site Data Input Option | Culvert Invert Data
Inlet Station | 0.000 | ft
Inlet Elevation | 5980.500 | ft
Outlet Station | 87.000 | ft
Outlet Elevation | 5976.320 | ft
Number of Barrels | 1
Help
Click on any icon for help on a specific topic
Low Flow
AOP
Energy Dissipation
Analyze Crossing
OK
Cancel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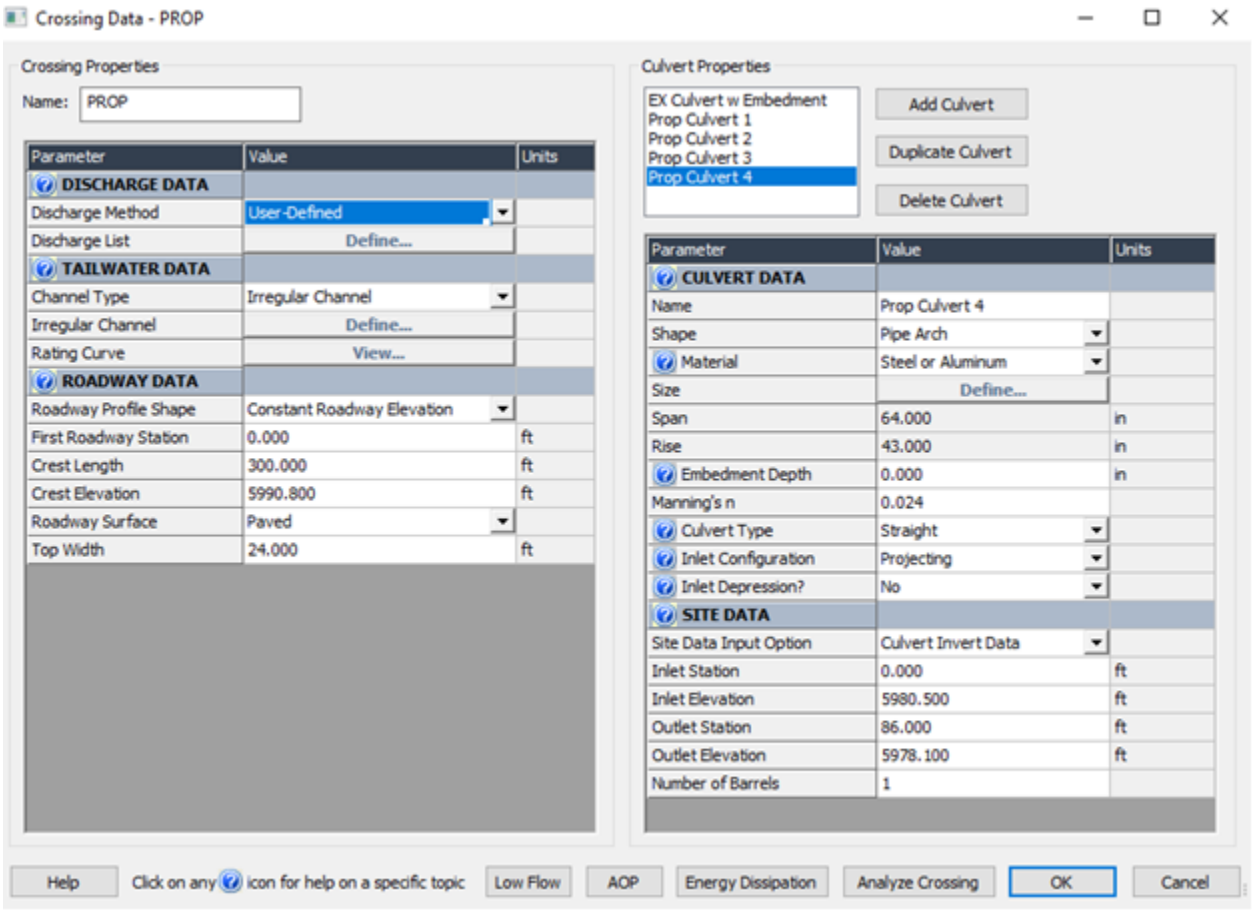
Crossing Properties
Name: PROP
Parameter | Value | Units
DISCHARGE DATA
Discharge Method | User-Defined
Discharge List | Define...
TAILWATER DATA
Channel Type | Irregular Channel
Irregular Channel | Define...
Rating Curve | View...
ROADWAY DATA
Roadway Profile Shape | Constant Roadway Elevation
First Roadway Station | 0.000 | ft
Crest Length | 300.000 | ft
Crest Elevation | 5990.800 | ft
Roadway Surface | Paved
Top Width | 24.000 | ft
Culvert Properties
EX Culvert w Embedment
Prop Culvert 1
Prop Culvert 2
Prop Culvert 3
Prop Culvert 4
Add Culvert
Duplicate Culvert
Delete Culvert
Parameter | Value | Units
CULVERT DATA
Name | Prop Culvert 3
Shape | Pipe Arch
Material | Steel or Aluminum
Size | Define...
Span | 64.000 | in
Rise | 43.000 | in
Embedment Depth | 0.000 | in
Manning's n | 0.024
Culvert Type | Straight
Inlet Configuration | Projecting
Inlet Depression? | No
SITE DATA
Site Data Input Option | Culvert Invert Data
Inlet Station | 0.000 | ft
Inlet Elevation | 5980.500 | ft
Outlet Station | 82.000 | ft
Outlet Elevation | 5977.050 | ft
Number of Barrels | 1
Help
Click on any icon for help on a specific topic
Low Flow
AOP
Energy Dissipation
Analyze Crossing
OK
Cancel


Crossing Data - PROP
Crossing Properties
Name: PROP
Parameter
Value
Units
DISCHARGE DATA
Discharge Method
User-Defined
Discharge List
Define...
TAILWATER DATA
Channel Type
Irregular Channel
Irregular Channel
Define...
Rating Curve
View...
ROADWAY DATA
Roadway Profile Shape
Constant Roadway Elevation
First Roadway Station
0.000
ft
Crest Length
300.000
ft
Crest Elevation
5990.800
ft
Roadway Surface
Paved
Top Width
24.000
ft
Culvert Properties
EX Culvert w Embedment
Prop Culvert 1
Prop Culvert 2
Prop Culvert 3
Prop Culvert 4
Add Culvert
Duplicate Culvert
Delete Culvert
Parameter
Value
Units
CULVERT DATA
Name
Prop Culvert 4
Shape
Pipe Arch
Material
Steel or Aluminum
Size
Define...
Span
64.000
in
Rise
43.000
in
Embedment Depth
0.000
in
Manning's n
0.024
Culvert Type
Straight
Inlet Configuration
Projecting
Inlet Depression?
No
SITE DATA
Site Data Input Option
Culvert Invert Data
Inlet Station
0.000
ft
Inlet Elevation
5980.500
ft
Outlet Station
86.000
ft
Outlet Elevation
5978.100
ft
Number of Barrels
1
Help
Click on any icon for help on a specific topic
Low Flow
AOP
Energy Dissipation
Analyze Crossing
OK
Cancel

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: User Defined

Table 1 - Summary of Culvert Flows at Crossing: PROP

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	EX Culvert w Embedment Discharge (cfs)	Prop Culvert 1 Discharge (cfs)	Prop Culvert 2 Discharge (cfs)	Prop Culvert 3 Discharge (cfs)	Prop Culvert 4 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
5981.39	PK2	86.60	52.53	8.44	8.64	8.56	8.38	0.00	6
5981.98	PK5	175.00	92.02	20.59	21.07	20.88	20.43	0.00	4
5982.46	PK10	259.00	128.21	32.45	33.15	32.87	32.23	0.00	4
5983.06	PK25	379.00	180.48	49.37	50.17	49.86	49.10	0.00	4
5983.68	PK50	511.00	237.90	68.01	68.81	68.50	67.75	0.00	2
5984.27	PK100	636.00	296.52	84.65	85.38	85.08	84.41	0.00	3
5985.14	PK200	810.00	387.61	105.42	106.00	105.77	105.22	0.00	3
5986.37	PK500	1040.00	523.37	129.01	129.48	129.29	128.86	0.00	4
5990.80	Overtopping	1698.55	943.89	188.57	188.87	188.75	188.47	0.00	Overtopping

Rating Curve Plot for Crossing: PROP

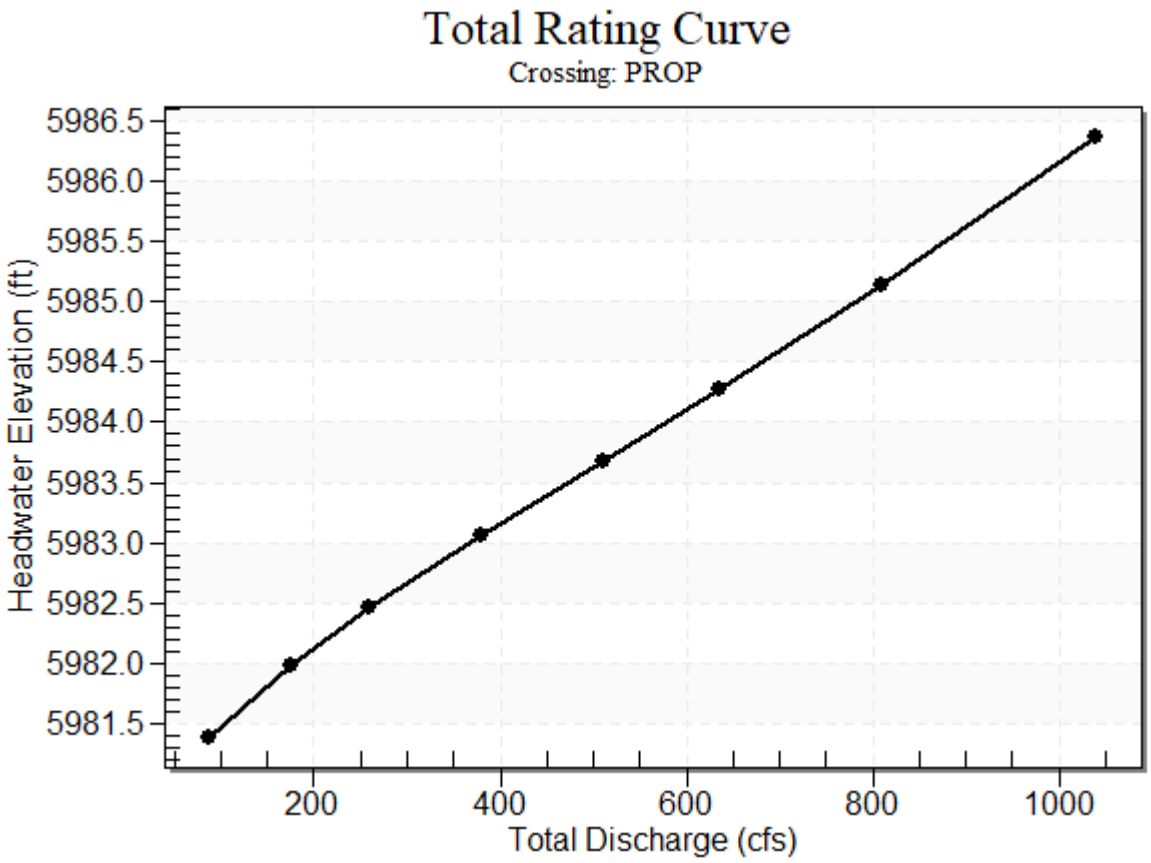


Table 2 - Culvert Summary Table: EX Culvert w Embedment

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
PK2	86.60	52.53	5981.39	1.207	1.368	2-M2c	1.119	0.694	0.694	1.651	4.701
PK5	175.00	92.02	5981.98	1.749	1.960	2-M2c	1.576	1.006	1.006	1.814	5.662
PK10	259.00	128.21	5982.46	2.180	2.432	2-M2c	1.935	1.251	1.251	1.935	6.329
PK25	379.00	180.48	5983.06	2.739	3.041	2-M2c	2.402	1.567	1.567	2.082	7.110
PK50	511.00	237.90	5983.68	3.300	3.659	2-M2c	2.875	1.879	1.879	2.222	7.827
PK100	636.00	296.52	5984.27	3.832	4.249	2-M2c	3.331	2.172	2.172	2.333	8.458
PK200	810.00	387.61	5985.14	4.683	5.117	2-M2c	4.016	2.590	2.590	2.469	9.326
PK500	1040.00	523.37	5986.37	5.953	6.351	2-M2c	5.049	3.160	3.160	2.627	10.429

****

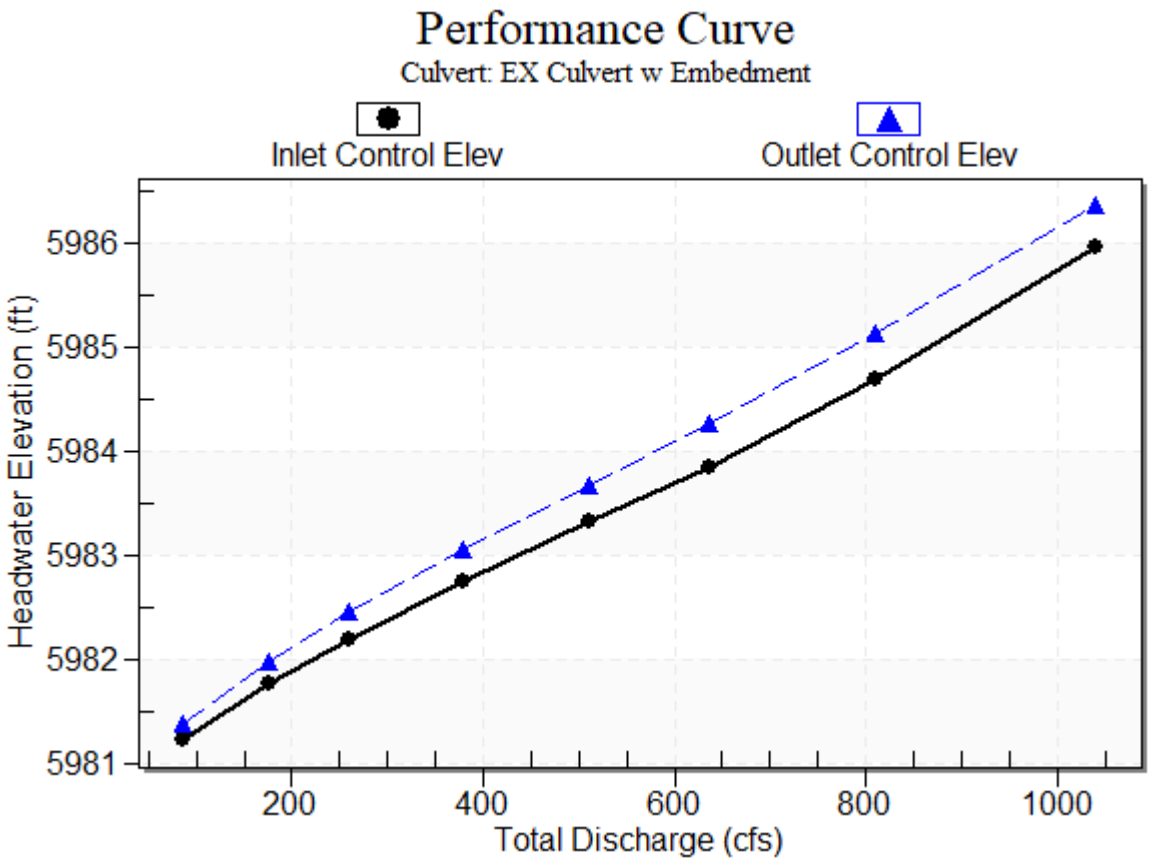
Straight Culvert

Inlet Elevation (invert): 5980.02 ft, Outlet Elevation (invert): 5977.97 ft

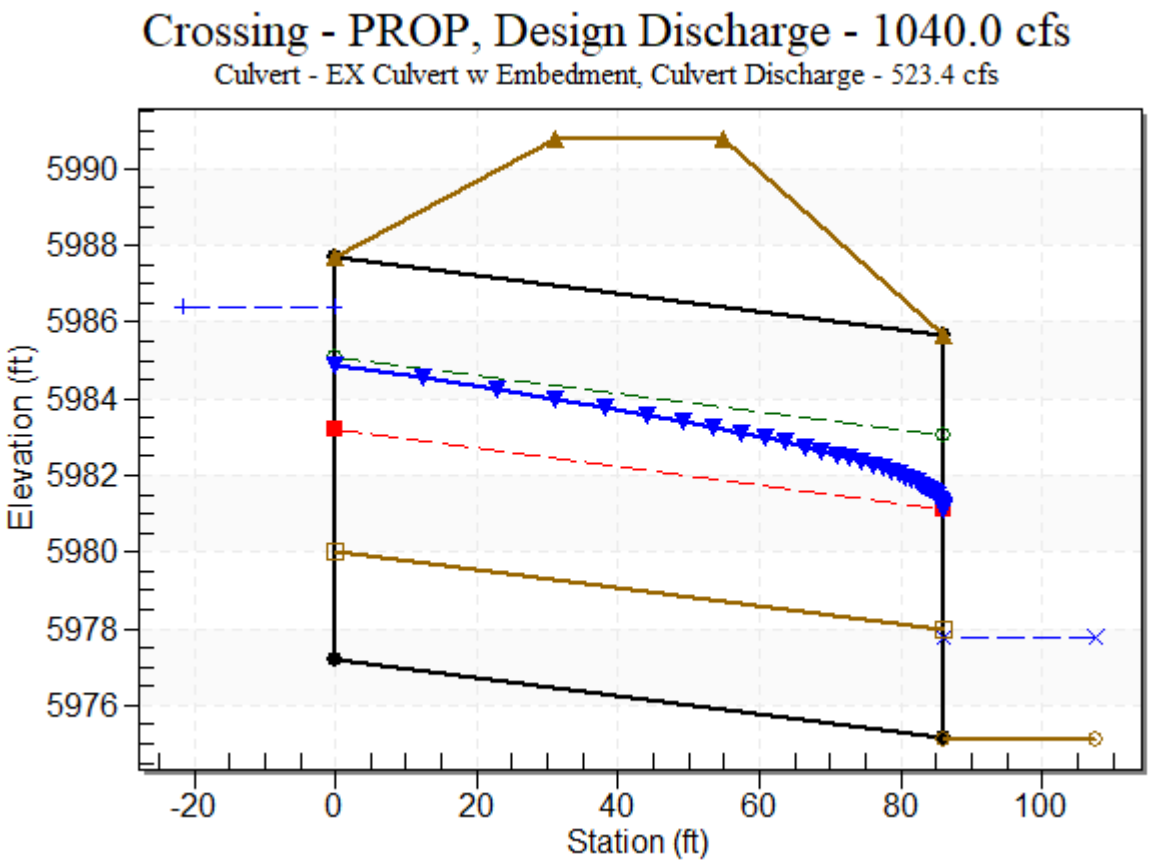
Culvert Length: 86.02 ft, Culvert Slope: 0.0238

****

Culvert Performance Curve Plot: EX Culvert w Embedment



Water Surface Profile Plot for Culvert: EX Culvert w Embedment



Site Data - EX Culvert w Embedment

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 5977.19 ft

Outlet Station: 86.00 ft

Outlet Elevation: 5975.14 ft

Number of Barrels: 1

Culvert Data Summary - EX Culvert w Embedment

Barrel Shape: Pipe Arch

Barrel Span: 196.00 in

Barrel Rise: 126.00 in

Barrel Material: Aluminum Structural Plate

Embedment: 34.00 in

Barrel Manning's n: 0.0340 (top and sides)

Manning's n: 0.0800 (bottom)

Culvert Type: Straight

Inlet Configuration: Thin Edge Projecting

Inlet Depression: None

Table 3 - Culvert Summary Table: Prop Culvert 1

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
PK2	86.60	8.44	5981.39	0.893	0.0*	1-S2n	0.457	0.590	0.457	1.651	5.349
PK5	175.00	20.59	5981.98	1.484	0.0*	1-S2n	0.714	0.960	0.714	1.814	7.263
PK10	259.00	32.45	5982.46	1.957	0.0*	1-S2n	0.909	1.238	0.909	1.935	8.451
PK25	379.00	49.37	5983.06	2.564	0.0*	1-S2n	1.146	1.569	1.146	2.082	9.685
PK50	511.00	68.01	5983.68	3.183	0.189	1-S2n	1.384	1.887	1.384	2.222	10.693
PK100	636.00	84.65	5984.27	3.773	0.993	5-S2n	1.588	2.141	1.601	2.333	11.296
PK200	810.00	105.42	5985.14	4.640	2.133	5-S2n	1.839	2.427	1.869	2.469	11.896
PK500	1040.00	129.01	5986.37	5.873	4.051	5-S2n	2.132	2.711	2.161	2.627	12.542

* Full Flow Headwater elevation is below inlet invert.

****

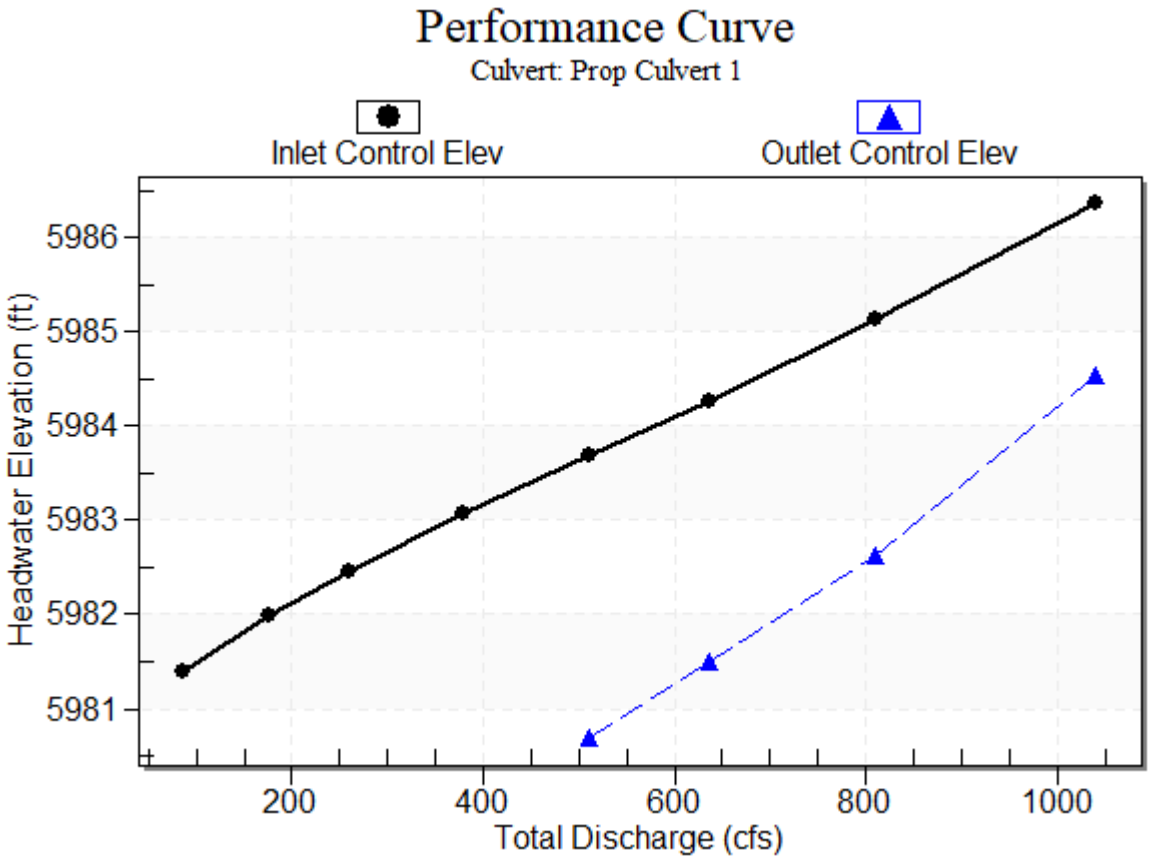
Straight Culvert

Inlet Elevation (invert): 5980.50 ft, Outlet Elevation (invert): 5977.80 ft

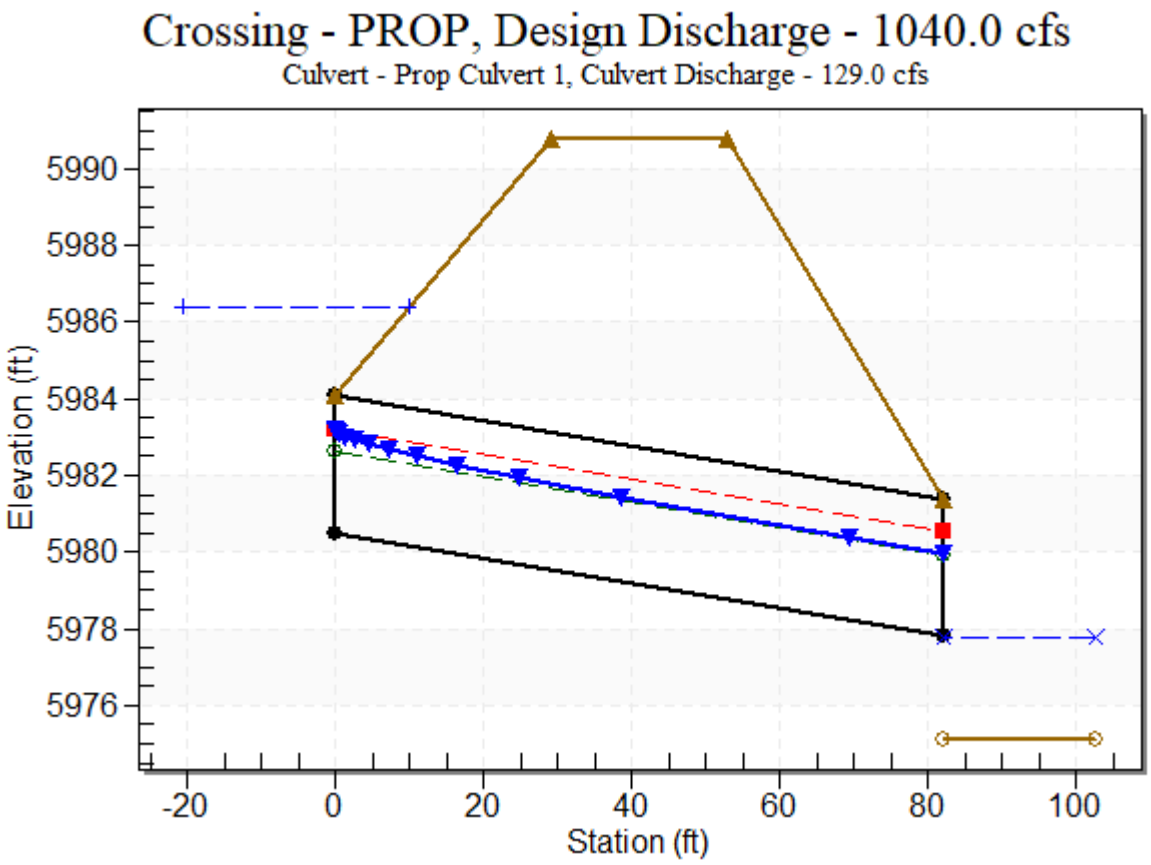
Culvert Length: 82.04 ft, Culvert Slope: 0.0329

****

Culvert Performance Curve Plot: Prop Culvert 1



Water Surface Profile Plot for Culvert: Prop Culvert 1



Site Data - Prop Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 5980.50 ft

Outlet Station: 82.00 ft

Outlet Elevation: 5977.80 ft

Number of Barrels: 1

Culvert Data Summary - Prop Culvert 1

Barrel Shape: Pipe Arch

Barrel Span: 64.00 in

Barrel Rise: 43.00 in

Barrel Material: Steel or Aluminum

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Projecting

Inlet Depression: None

Table 4 - Culvert Summary Table: Prop Culvert 2

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
PK2	86.60	8.64	5981.39	0.893	0.0*	1-S2n	0.420	0.597	0.420	1.651	6.133
PK5	175.00	21.07	5981.98	1.484	0.0*	1-S2n	0.656	0.972	0.656	1.814	8.292
PK10	259.00	33.15	5982.46	1.956	0.0*	1-S2n	0.831	1.253	0.831	1.935	9.653
PK25	379.00	50.17	5983.06	2.564	0.0*	1-S2n	1.040	1.584	1.041	2.082	11.063
PK50	511.00	68.81	5983.68	3.183	0.0*	1-S2n	1.245	1.900	1.245	2.222	12.237
PK100	636.00	85.38	5984.27	3.774	0.0*	5-S2n	1.417	2.152	1.446	2.333	12.775
PK200	810.00	106.00	5985.14	4.640	0.748	5-S2n	1.625	2.434	1.654	2.469	13.643
PK500	1040.00	129.48	5986.37	5.873	2.690	5-S2n	1.860	2.716	1.901	2.627	14.348

* Full Flow Headwater elevation is below inlet invert.

****

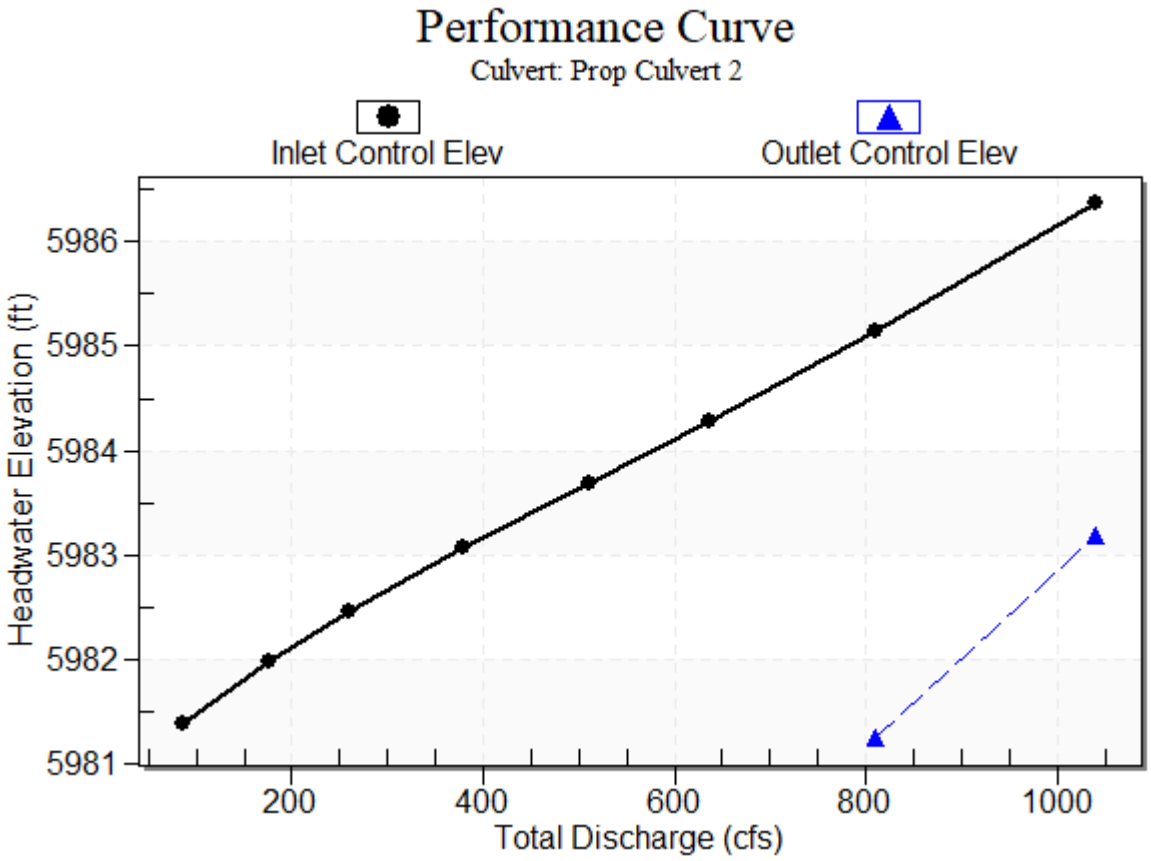
Straight Culvert

Inlet Elevation (invert): 5980.50 ft, Outlet Elevation (invert): 5976.32 ft

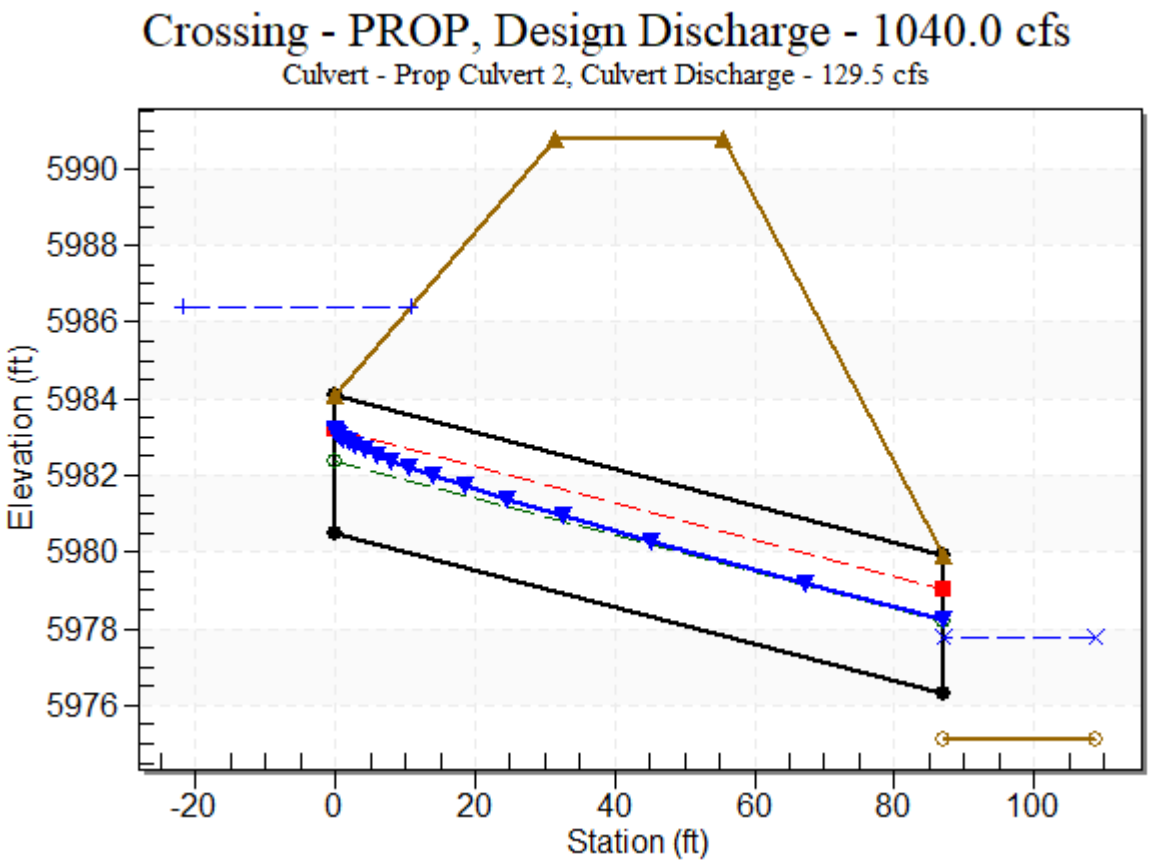
Culvert Length: 87.10 ft, Culvert Slope: 0.0480

****

Culvert Performance Curve Plot: Prop Culvert 2



Water Surface Profile Plot for Culvert: Prop Culvert 2



Site Data - Prop Culvert 2

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 5980.50 ft

Outlet Station: 87.00 ft

Outlet Elevation: 5976.32 ft

Number of Barrels: 1

Culvert Data Summary - Prop Culvert 2

Barrel Shape: Pipe Arch

Barrel Span: 64.00 in

Barrel Rise: 43.00 in

Barrel Material: Steel or Aluminum

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Projecting

Inlet Depression: None

Table 5 - Culvert Summary Table: Prop Culvert 3

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
PK2	86.60	8.56	5981.39	0.893	0.0*	1-S2n	0.432	0.594	0.432	1.651	5.847
PK5	175.00	20.88	5981.98	1.484	0.0*	1-S2n	0.675	0.967	0.675	1.814	7.918
PK10	259.00	32.87	5982.46	1.956	0.0*	1-S2n	0.856	1.247	0.856	1.935	9.216
PK25	379.00	49.86	5983.06	2.564	0.0*	1-S2n	1.076	1.578	1.076	2.082	10.560
PK50	511.00	68.50	5983.68	3.183	0.0*	1-S2n	1.292	1.895	1.299	2.222	11.595
PK100	636.00	85.08	5984.27	3.773	0.265	5-S2n	1.474	2.148	1.474	2.333	12.455
PK200	810.00	105.77	5985.14	4.640	1.405	5-S2n	1.696	2.432	1.728	2.469	12.979
PK500	1040.00	129.29	5986.37	5.873	3.319	5-S2n	1.949	2.714	1.988	2.627	13.679

* Full Flow Headwater elevation is below inlet invert.

****

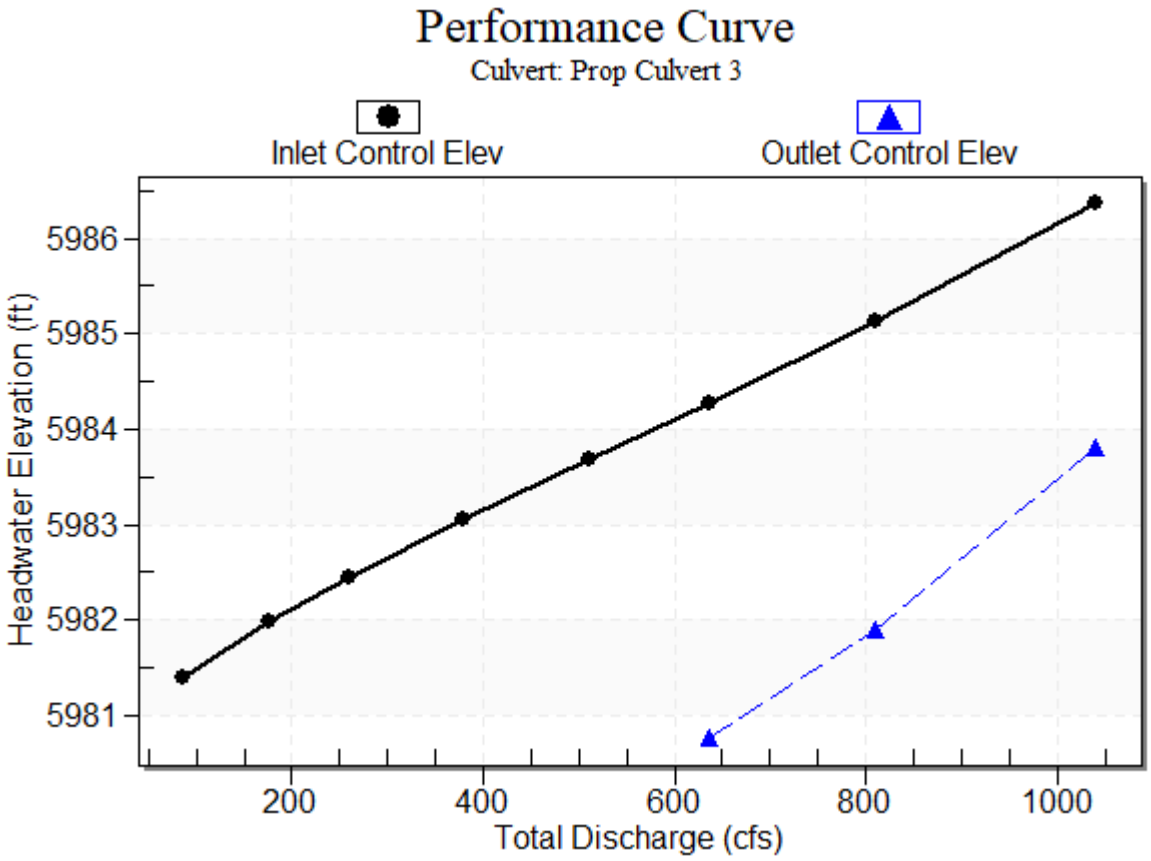
Straight Culvert

Inlet Elevation (invert): 5980.50 ft, Outlet Elevation (invert): 5977.05 ft

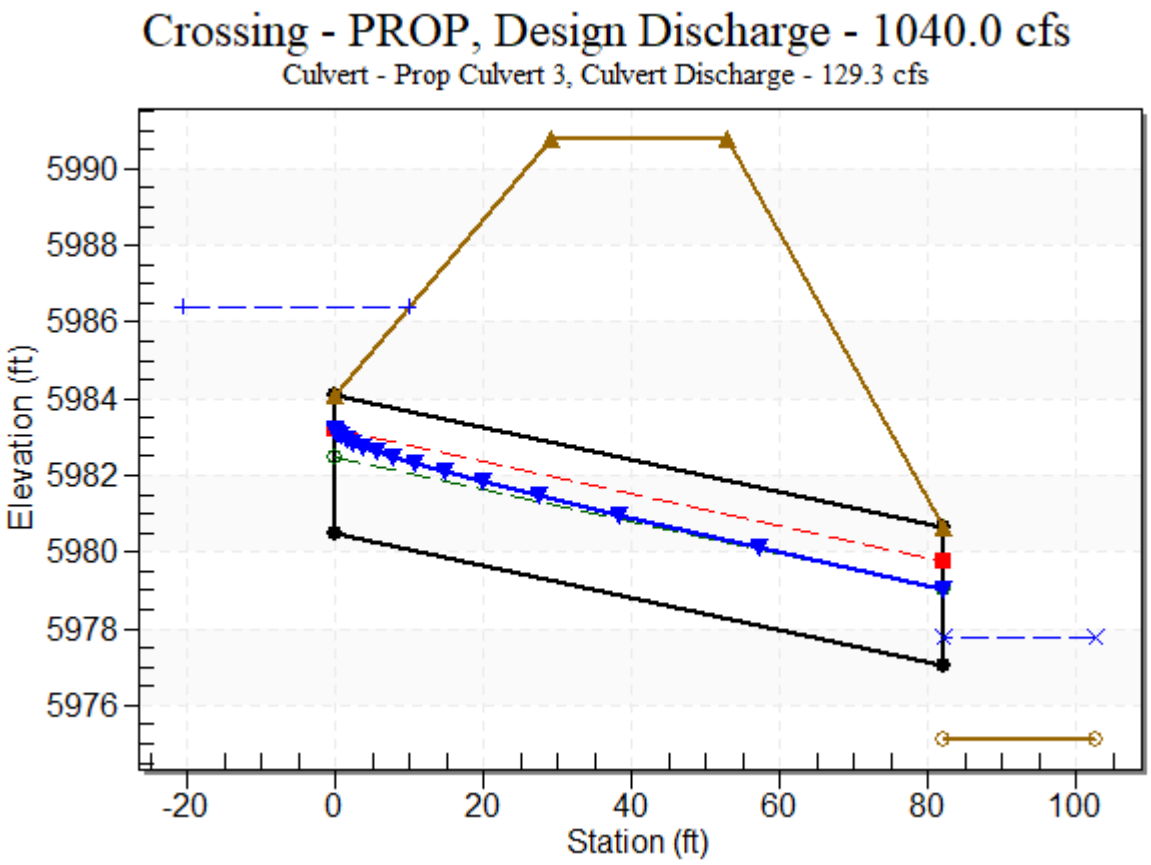
Culvert Length: 82.07 ft, Culvert Slope: 0.0421

****

Culvert Performance Curve Plot: Prop Culvert 3



Water Surface Profile Plot for Culvert: Prop Culvert 3



Site Data - Prop Culvert 3

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 5980.50 ft

Outlet Station: 82.00 ft

Outlet Elevation: 5977.05 ft

Number of Barrels: 1

Culvert Data Summary - Prop Culvert 3

Barrel Shape: Pipe Arch

Barrel Span: 64.00 in

Barrel Rise: 43.00 in

Barrel Material: Steel or Aluminum

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Projecting

Inlet Depression: None

Table 6 - Culvert Summary Table: Prop Culvert 4

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
PK2	86.60	8.38	5981.39	0.893	0.0*	1-S2n	0.473	0.587	0.473	1.651	5.062
PK5	175.00	20.43	5981.98	1.484	0.0*	1-S2n	0.743	0.956	0.743	1.814	6.854
PK10	259.00	32.23	5982.46	1.957	0.0*	1-S2n	0.947	1.233	0.947	1.935	7.979
PK25	379.00	49.10	5983.06	2.564	0.0*	1-S2n	1.199	1.564	1.199	2.082	9.134
PK50	511.00	67.75	5983.68	3.183	0.496	1-S2n	1.453	1.883	1.479	2.222	9.875
PK100	636.00	84.41	5984.27	3.773	1.311	5-S2n	1.673	2.138	1.673	2.333	10.731
PK200	810.00	105.22	5985.14	4.640	2.469	5-S2n	1.947	2.424	1.947	2.469	11.372
PK500	1040.00	128.86	5986.37	5.873	4.412	5-S2n	2.275	2.709	2.303	2.627	11.769

* Full Flow Headwater elevation is below inlet invert.

****

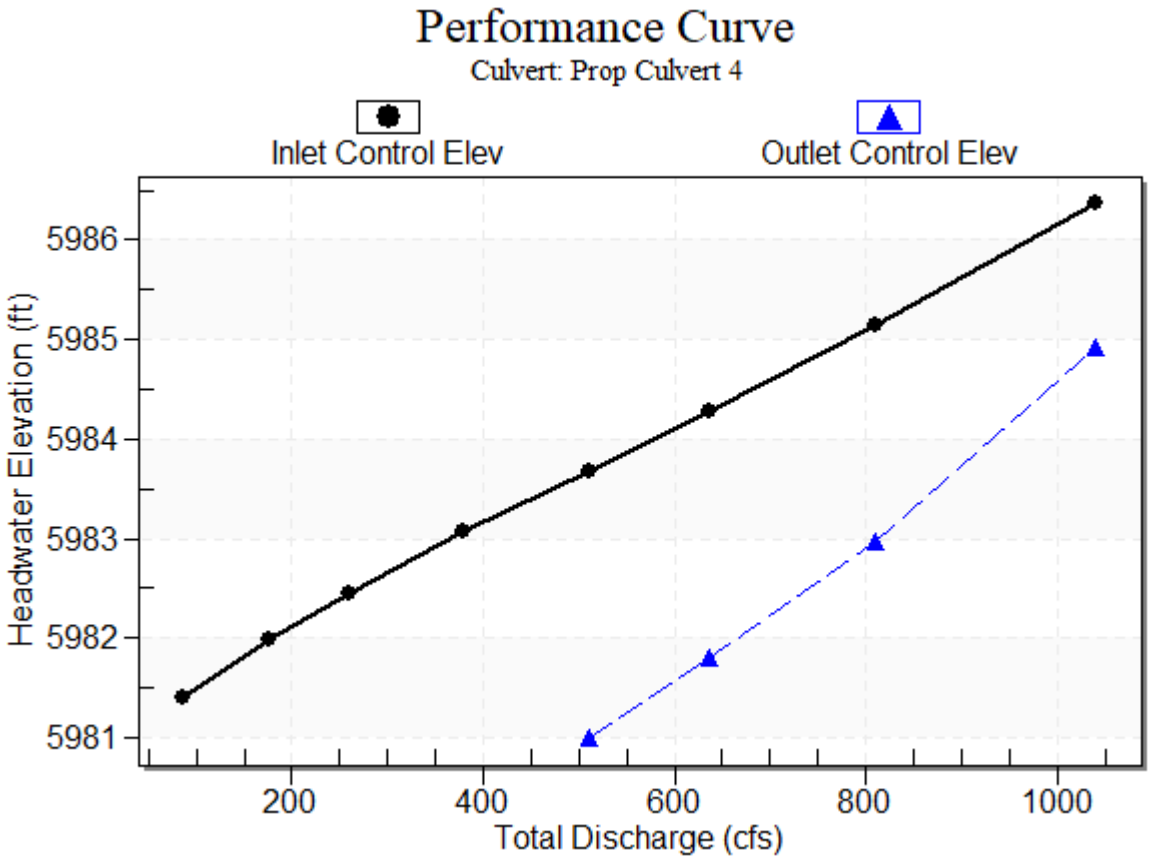
Straight Culvert

Inlet Elevation (invert): 5980.50 ft, Outlet Elevation (invert): 5978.10 ft

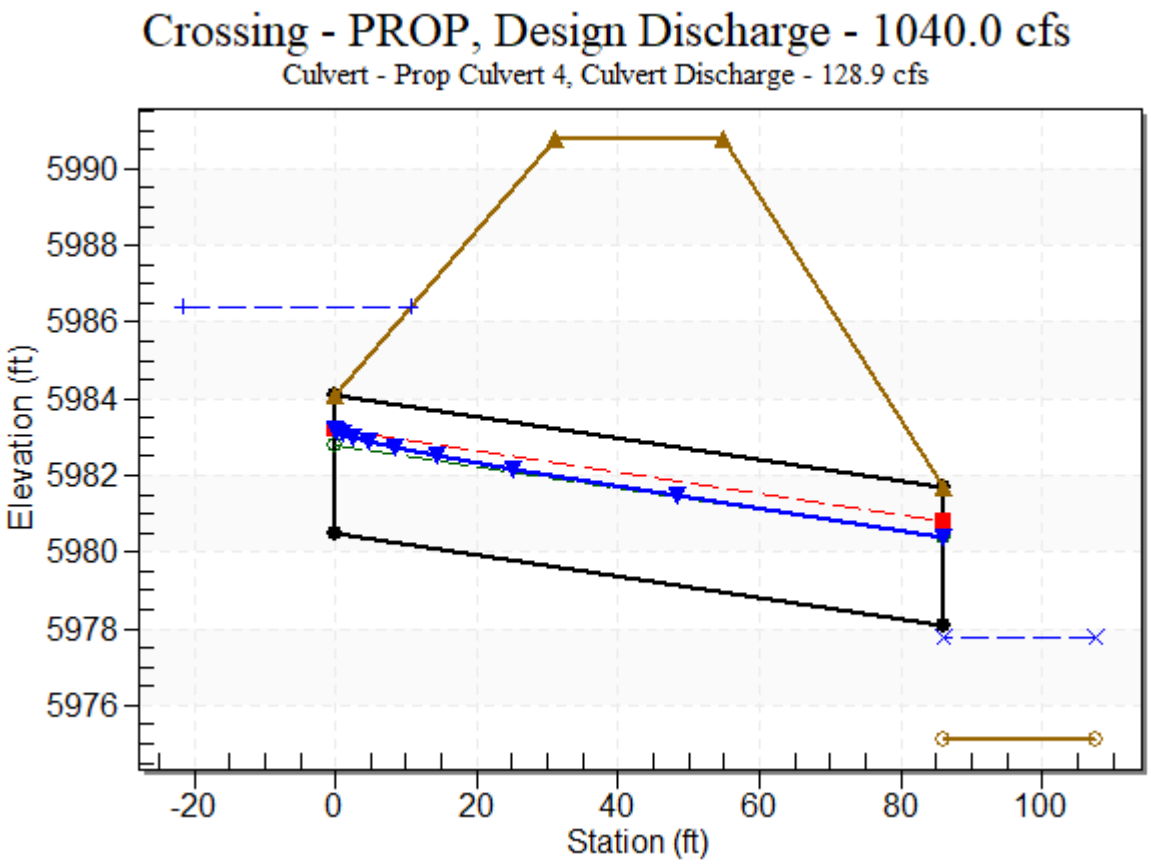
Culvert Length: 86.03 ft, Culvert Slope: 0.0279

****

Culvert Performance Curve Plot: Prop Culvert 4



Water Surface Profile Plot for Culvert: Prop Culvert 4



Site Data - Prop Culvert 4

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 5980.50 ft

Outlet Station: 86.00 ft

Outlet Elevation: 5978.10 ft

Number of Barrels: 1

Culvert Data Summary - Prop Culvert 4

Barrel Shape: Pipe Arch

Barrel Span: 64.00 in

Barrel Rise: 43.00 in

Barrel Material: Steel or Aluminum

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Projecting

Inlet Depression: None

Table 7 - Downstream Channel Rating Curve (Crossing: PROP)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
86.60	5976.78	1.65	3.13	5.56	0.98
175.00	5976.94	1.81	4.09	6.11	1.08
259.00	5977.06	1.93	4.73	6.52	1.14
379.00	5977.21	2.08	5.38	7.01	1.20
511.00	5977.35	2.22	5.85	7.49	1.24
636.00	5977.46	2.33	6.26	7.86	1.26
810.00	5977.60	2.47	6.74	8.32	1.28
1040.00	5977.76	2.63	7.27	8.85	1.32

Tailwater Channel Data - PROP

Tailwater Channel Option: Irregular Channel

Roadway Data for Crossing: PROP

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 300.00 ft

Crest Elevation: 5990.80 ft

Roadway Surface: Paved

Roadway Top Width: 24.00 ft

Appendix F: Hoke Meadows Restoration Preliminary Design

Hoke Meadow Restoration Preliminary Design

Characterization

The 59.8 acre Hoke Meadow Restoration Project is located on an unnamed tributary to Stampede Reservoir on the Truckee Ranger District of the Tahoe National Forest. The meadow and associated channel is actively degrading. The channel is currently four to ten feet below the surface of the meadow floodplain. Headcuts at the bottom of the meadow indicate an active degradation trend that is likely to result in a deeper channel, leading to further soil erosion, loss of herbaceous meadow vegetation and expansion of sagebrush. Several features on the landscape have synergistically contributed to channel degradation. A primary cause of channel incision is County Road 270 that crosses the meadow and bounds the downstream end of the project area. Where the channel intersects the road, it is directed into one single culvert, with an invert elevation approximately two feet below the meadow floodplain. All flood flows travelling down the valley must either pass through this culvert or breach the road berm, which has no additional flood flow culverts. A railroad grade near the top of the project area also likely concentrated the flow into one single culvert (all that is left of the railroad crossing is the bermed railroad grade on either side of the large entrenchment). An unimproved crossing of FS Road 72 (the up-valley boundary of the project area) is contributing to minor channelization further up-valley. An underground petroleum pipeline and telephone line cross the meadow and channel. There are numerous berms on the meadow floodplain that appear to have been constructed to direct overland flood flows. The Emigrant Trail crossed the meadow, and there is an existing non-system road along the toe of the northwest slope in the lower portion of the meadow. The valley was also historically grazed, however, the intensity of grazing is unknown. Over-grazing can compromise the erosion resistance of vegetative ground cover. All of these features and land uses likely had some contribution to channel incision in the project area. The meadow below the county road is in relatively good condition, with flood flows that can access the adjacent meadow floodplain.

Several attempts have been made to address channel conditions in Hoke Valley, although the time frame of the work is unknown. There are approximately five gabion basket structures in the channel. The gabion baskets do not meet in the bottom of the channel, and so have not induced channel aggradation; they may have been an attempt only at bank stabilization. Some of the berms on the meadow floodplain appear to have been an attempt to spread out overland flows. Approximately four rock sills in the channel above the culvert and a berm appear to be an attempt to treat culvert-induced channel degradation, and to direct a meandering channel into the single culvert. Headcuts continue to move up-valley, both within the gully, and on the floodplain. Prior to disturbances in the meadow, surface flows likely occupied multiple small channel features. In the lower half of the valley, the gully is located on a slightly higher crown feature in the middle of the valley, which is indicative of human intervention, and that the existing channel did not evolve naturally.

The drainage area into Hoke Valley just above Stampede Reservoir is 5.9 square miles, with mean annual precipitation of 33.9 inches. The channel in the upper half of the valley was dry during the field survey work in October 2016, with tributary flow from the east totaling less than 0.1 cfs in the lower half of the valley. Table 1 displays peak flow statistics from the USGS Streamstats website.

Table 1. Streamflow statistics for Hoke Valley from Streamstats for the two- to 500- year return interval flows.

Statistic	Value	Unit	Prediction Error (percent)	90-Percent Prediction Interval	
				Min	Max
PK2	86.6	ft3/s	98	22.4	334
PK5	175	ft3/s	83	53.2	575
PK10	259	ft3/s	78	83.1	809
PK25	379	ft3/s	76	125	1150
PK50	511	ft3/s	76	170	1530
PK100	636	ft3/s	77	205	1970
PK200	810	ft3/s	79	256	2570
PK500	1040	ft3/s	83	317	3410

Table 2 below displays analysis of the 17 cross-sections generated from the LiDAR data. The valley slope within the project area is 2.1%, and is fairly uniform from the top to the bottom of the project area. The incised channel dimensions average 76 feet wide and six feet deep. Erosion of the incised channel within the project area has resulted in the loss of approximately 38,000 yds^3 of soil. This channel can contain flood flows up to approximately the 25 year event, with infrequent floodplain inundation. It will require approximately 19,000 yds^3 of fill to eliminate the existing gully and restore flow to channels on the meadow floodplain surface. Flows would be restored into the remnant multiple channel system that overbanks every year, resulting in restored floodplain function.

Table 2. Valley-wide cross-section summary.

Cross-section	Gully			Remnant Channel			Floodplain width
	width	max depth	area	width	max depth	area	
4	68	4.8	125	26	1.5	25	220
5	84	6.3	340	20	0.4	6	187
6	115	7	570	65	0.7	20	270
7	101	6	395	23	0.4	10	300
8	75	7	300	33	1	23	298
9	72	6	235	23	0.6	10	310
10	118	7	540	remnant lost in gully erosion			283
11	82	7	360	23	0.4	10	260
12	76	10	433	19	0.9	10	300
13	65.4	5.9	200	32	0.5	12	335
14	56	5	100	36	2.2	20	442
15	59	4	130	33	0.5	9	475
16	20	1.7	20	32	0.5	10	335
17	not applicable due to county road berm across valley						410
Average	**76**	**6**	**288**	**30**	**0.8**	**14**	**316**

Methods

The objective of this restoration design is to restore functional floodplain processes that would restore a wet meadow ecosystem and balanced deposition/erosion floodplain processes, while still protecting the county road causeway across the project area bottom. The design considered the fluvial geomorphological process that formed the channel and meadow floodplain system, as well the existing infrastructure in the meadow, and possible causes of degradation. The meadow survey utilized data from June 2014 LiDAR data (completed by Dr. Qinghua Guo of UC Merced for the Tahoe National Forest). The LiDAR elevations are accurate to about six inches. 17 valley-wide cross-sections were generated using ArcGIS 3-D Analyst, and were used to help determine where restored floodplain flow would likely occur. A laser level was used to verify predicted floodplain flow paths, and to determine gully plug locations. Borrow sites for gully plug material were identified on the slopes adjacent to the floodplain. Off-channel borrow areas were identified to minimize the area of ponded water in the restored meadow. Watershed statistics were generated from a query on the USGS Streamstats website for Hoke Valley just above Stampede Reservoir. A rough estimate of flow containment in the incised channel was calculated using the Slope-Area method at cross-section 13.

Design Discussion

Hoke Valley

The mainstem incised channel would be partially filled with 26 gully plug structures (2.8 acres), filled to floodplain elevation. Gaps between the plugs would appear as ponds that would seasonally rise and fall with groundwater levels. These ponds would not be excavated, except for eight shallow excavation locations listed below. Excavations would remain shallow. Two tributaries near the top of the project area would also be plugged, as would an incised floodplain meander bend just above the culvert at the downstream end of the project area. Borrow material would primarily come from the slopes adjacent to the valley, as well as eight small must-cut areas that are required to protect the adjacent downstream plug (plugs 2, T2, 4, 9, 11, 16, 19 & 20). Rock would be used to protect the surface of three plugs that are likely to see overland flow each year (17, 22 & 23). Rock would also be used for 30 riffles. 22 riffles would be placed on the remnant channel, including the exit of pond 4. Eight riffles would be placed to step tributary flow from the east floodplain down to the culvert elevation. Some of the rock for these riffles would be available by dismantling the gabion baskets (about 20 cu yds), and the rest would have to be imported (about 200 cu yds). Rock size would be 4-12", increasing in size toward the bottom of the project.

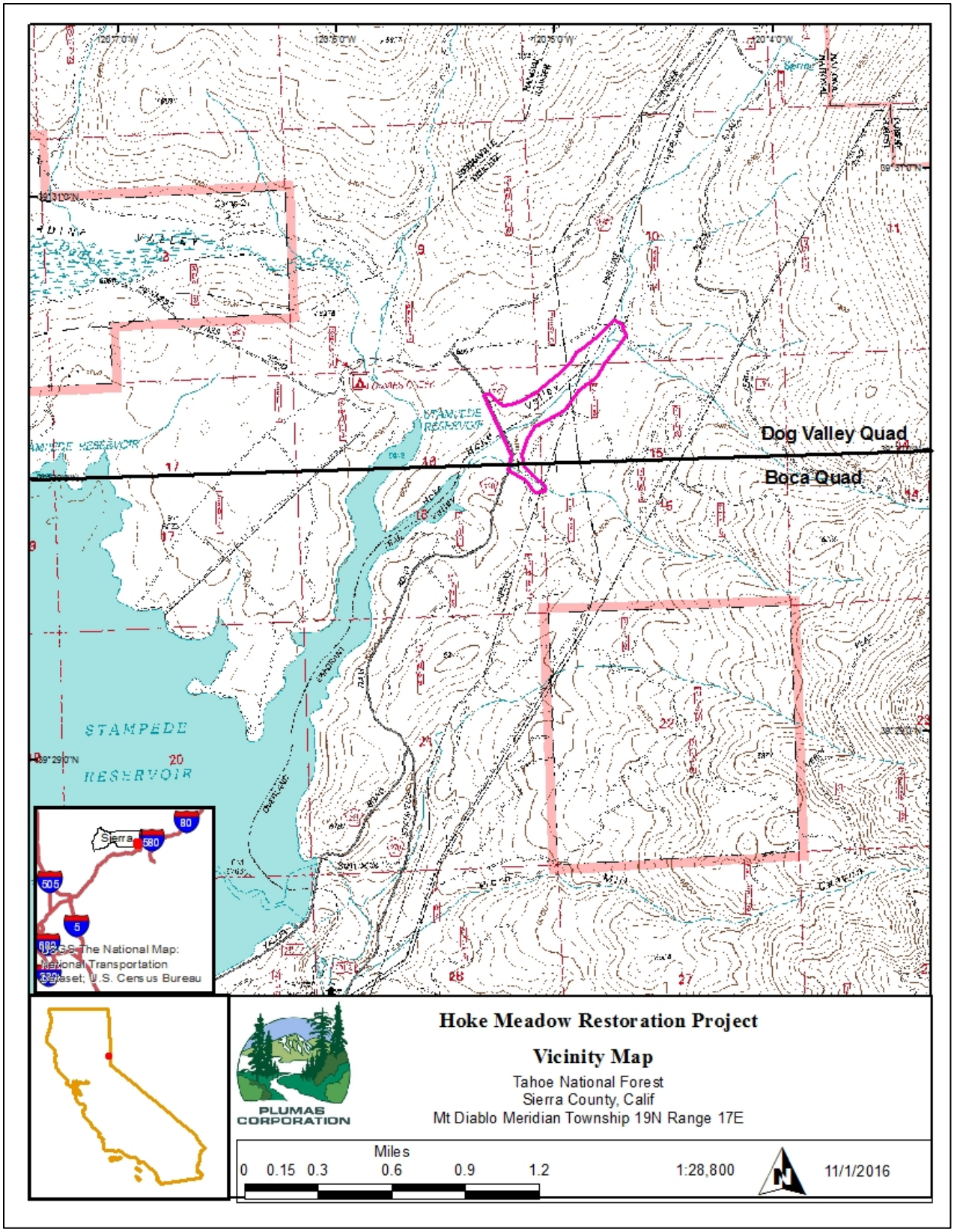
The project proposal also includes some road work: a) rock 113 feet of the Forest Service Road 72 where it crosses the meadow at the upper project boundary; and b) remove 2,448 feet of non-system road along the NW edge of Hoke Valley, or re-route the road further up the slope. This road on the meadow surface was once closed by berms that have since degraded and now allow pickup truck access from the county road. While the road is not contributing to water quality degradation at this time, the re-activation of the floodplain would make this road impassable for most of the year, with a high likelihood of damage to the floodplain from stuck vehicles.

The ponded water features are likely to maintain year-round surface water in the meadow. Habitat complexity features such as varying water depths, islands, peninsulas, basking logs, etc., would be incorporated into these features as much as is practicable. For plug construction, topsoil would be removed and stockpiled adjacent to the plug fill zone to top dress completed plugs. All plugs and borrow ponds are sited and configured to accommodate surface and subsurface through flow as well as adjacent hillslope surface and groundwater inflows. Plug compaction is intended to match the porosity/transmissivity of the native meadow soils. This allows moisture to move freely within the plug soil profile and support erosion resistant meadow vegetation for long term durability as well as preventing preferential pathways for subsurface flows either in the plug or the native material. All vegetation and larger woody material (lodgepole pine) from either the borrow ponds or the plug fill areas would be salvaged and used for habitat features in the borrow ponds and added surface roughness in key areas of plug fill. Meadow sod and willow transplants would be planted into the plug surfaces, with particular emphasis on seams and velocity reduction of overland flows.

Plug surfaces would be ripped to a depth of 12" to facilitate precipitation infiltration, with the recovered topsoil spread and seeded with native seed. All native vegetation recovered from fill and borrow sites would be transplanted to plug edges, surfaces and key locations on the remnant channel. Equipment transport of material from the slopes to the plugs would be perpendicular to the valley slope.

Unnamed Tributary

The unnamed tributary appears relatively stable at this time, but the removal of six berms and addition of 13 rocked riffles would help maintain stability. The berm removals and one borrow site would supply all of the necessary material to construct the riffles.


Dog Valley Quad
Boca Quad
STAMPEDE RESERVOIR
Sierra
80
580
505
5
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PLUMAS CORPORATION
Hoke Meadow Restoration Project
Vicinity Map
Tahoe National Forest
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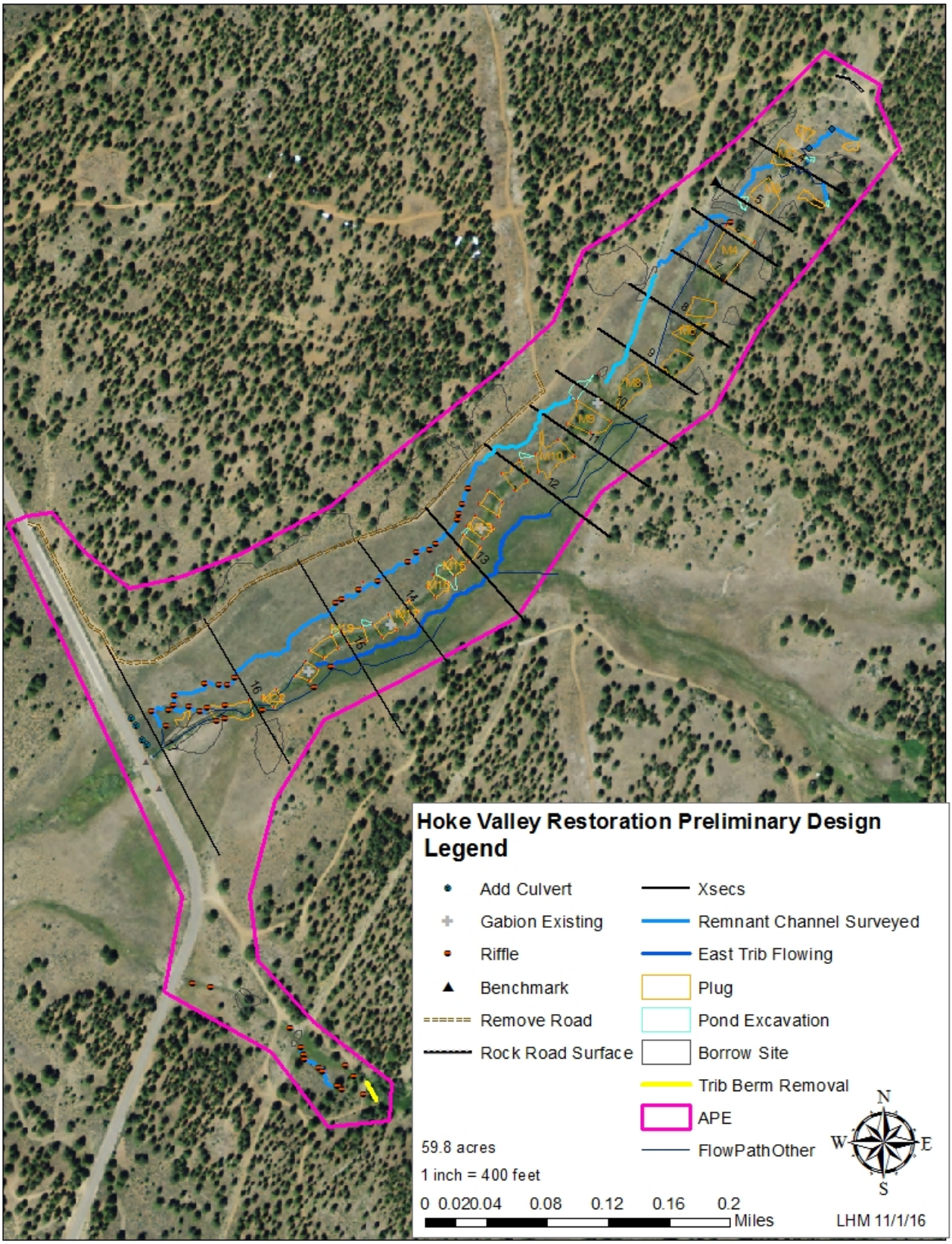
11/1/2016


Hoke Valley Restoration Preliminary Design
Legend
Add Culvert
Gabion Existing
Riffle
Benchmark
Remove Road
Rock Road Surface
Xsecs
Remnant Channel Surveyed
East Trib Flowing
Plug
Pond Excavation
Borrow Site
Trib Berm Removal
APE
FlowPathOther
59.8 acres
1 inch = 400 feet
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Miles
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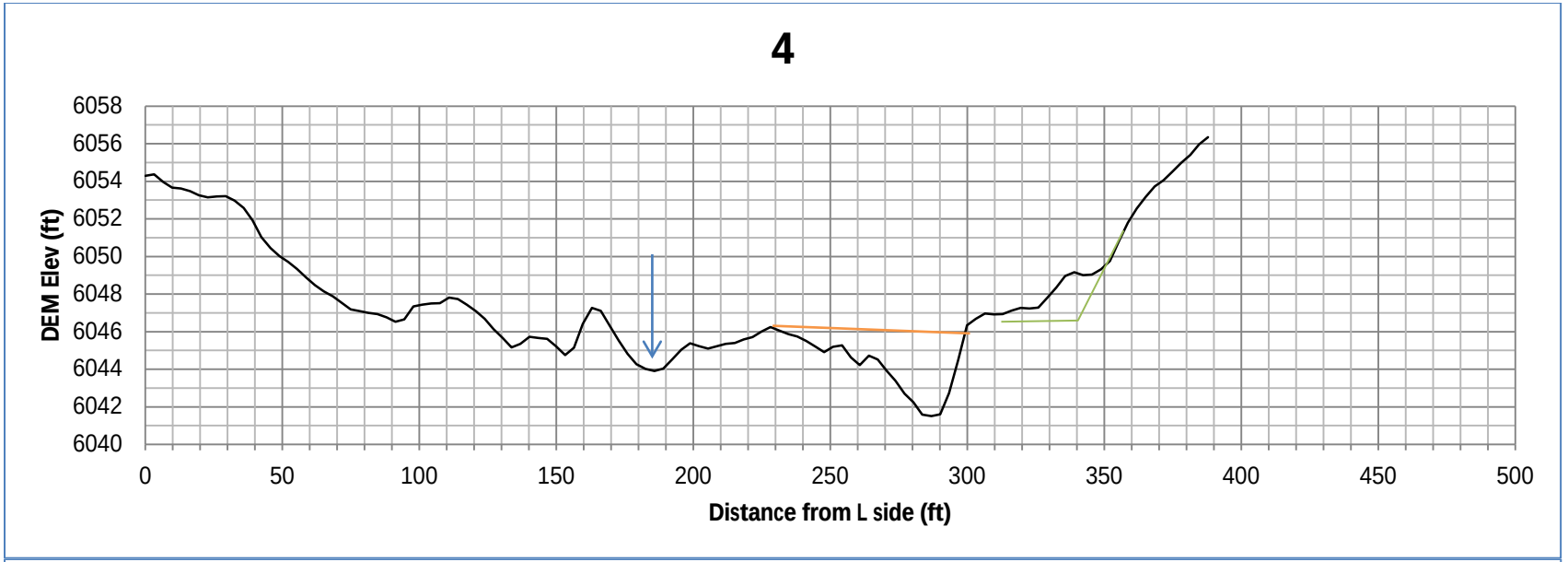
LHM 11/1/16

APPENDIX A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500
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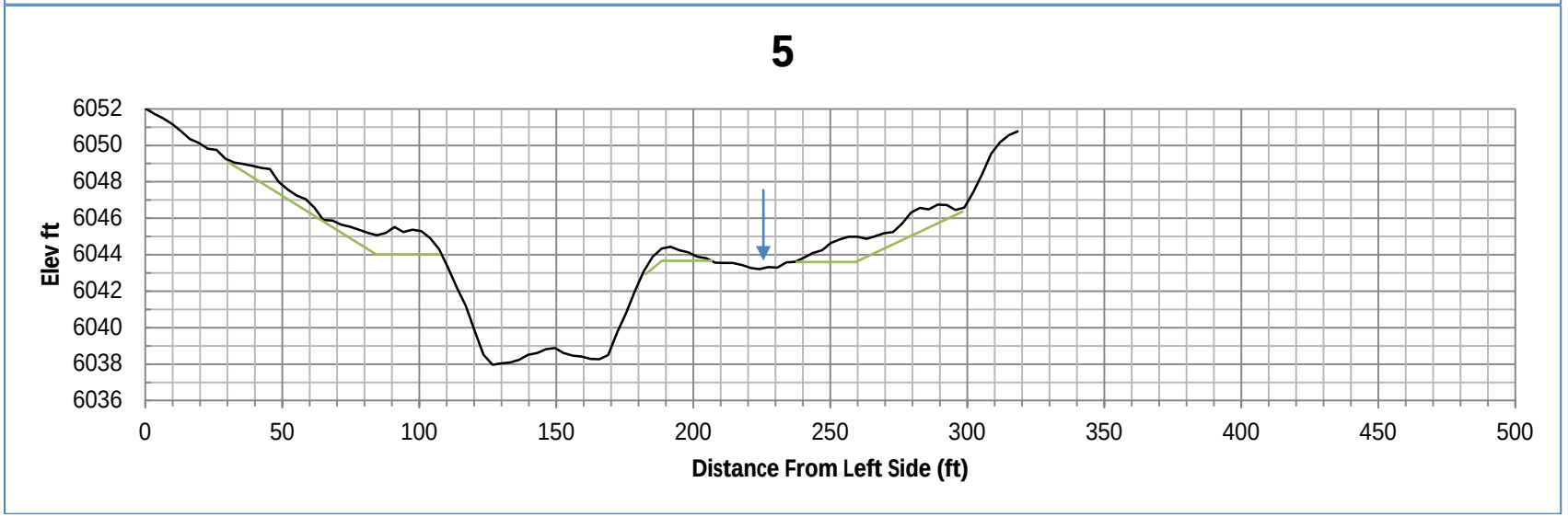
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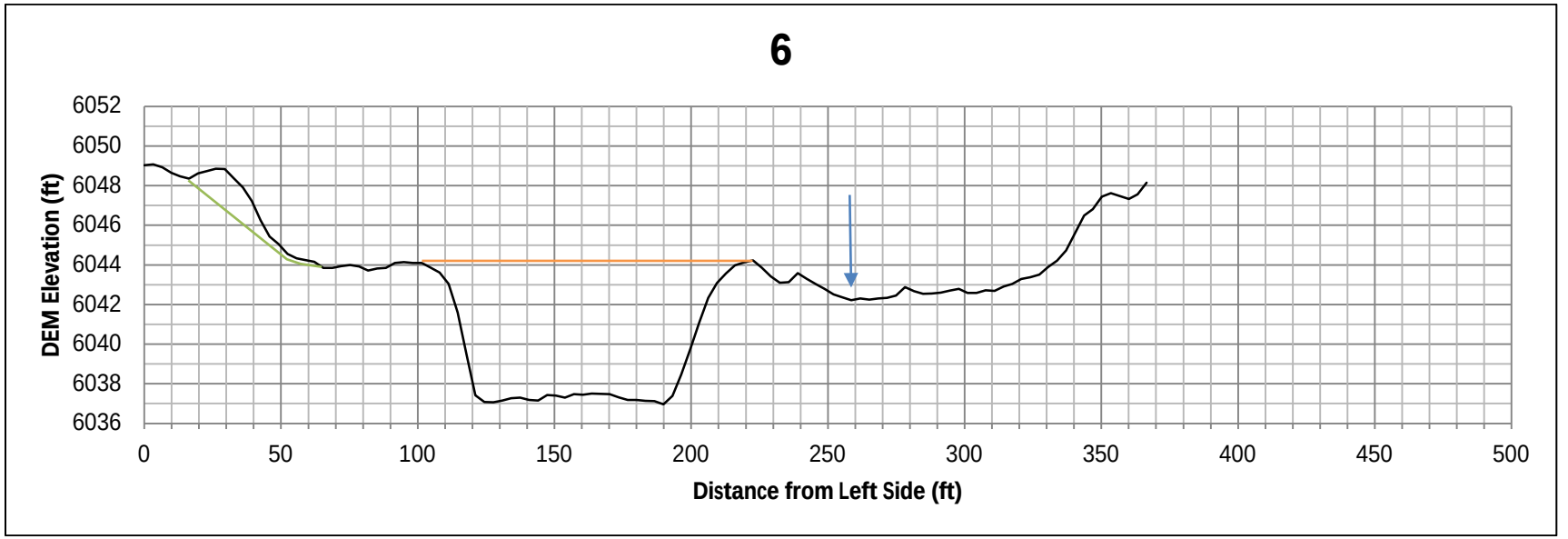
Distance From Left Side (ft)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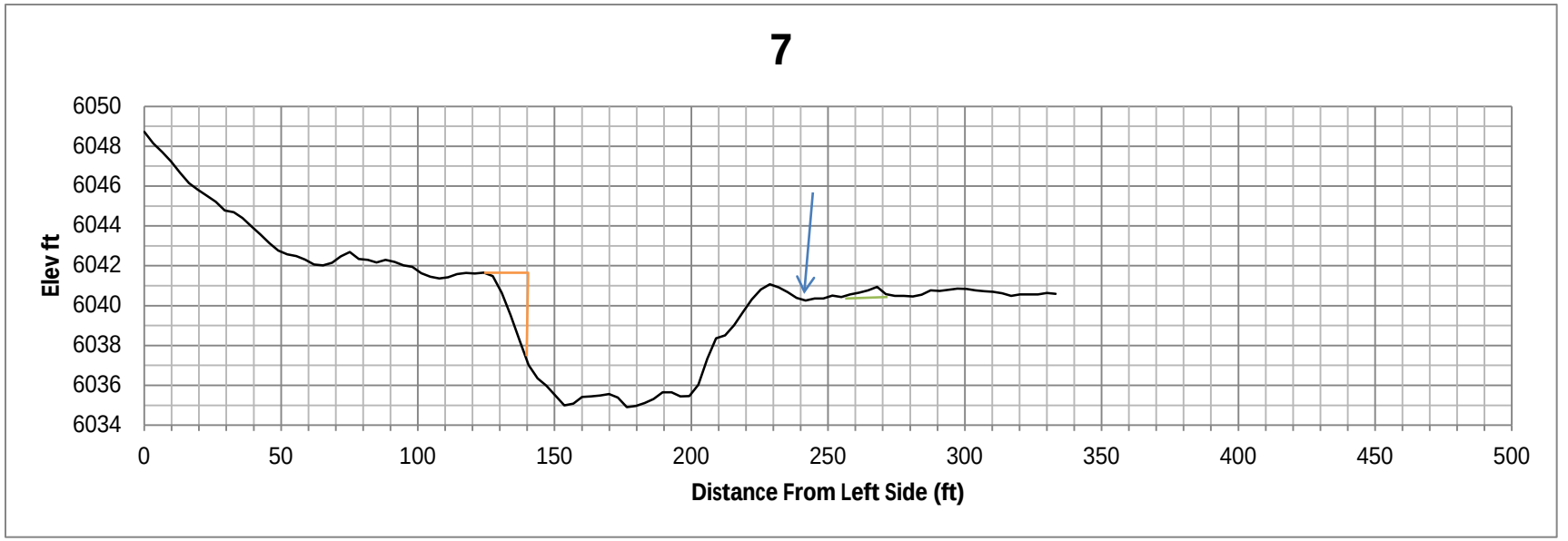
Distance from Left Side (ft)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Elev ft
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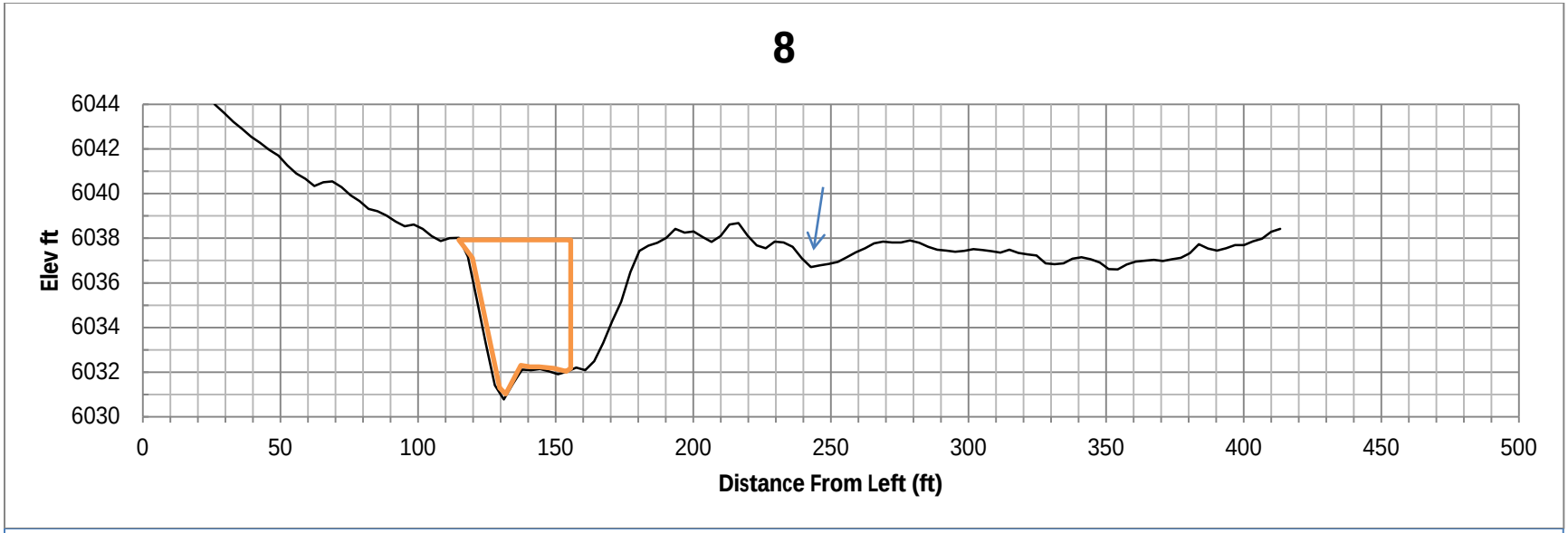
Distance From Left Side (ft)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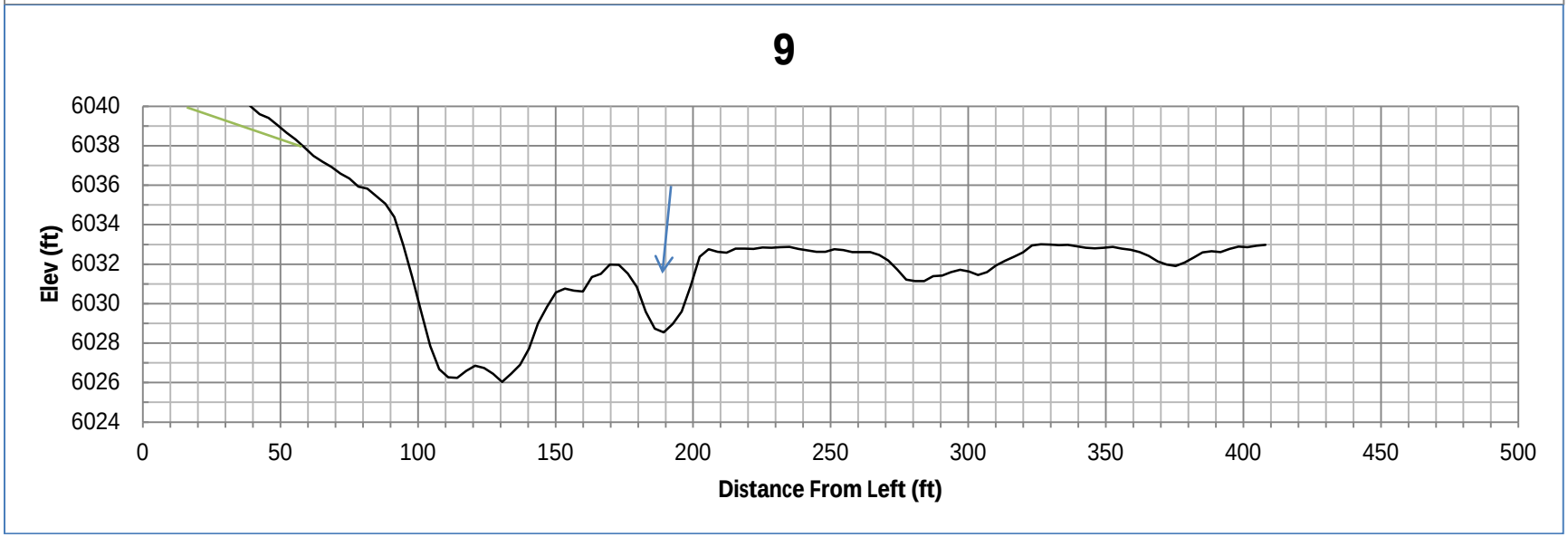
Distance From Left (ft)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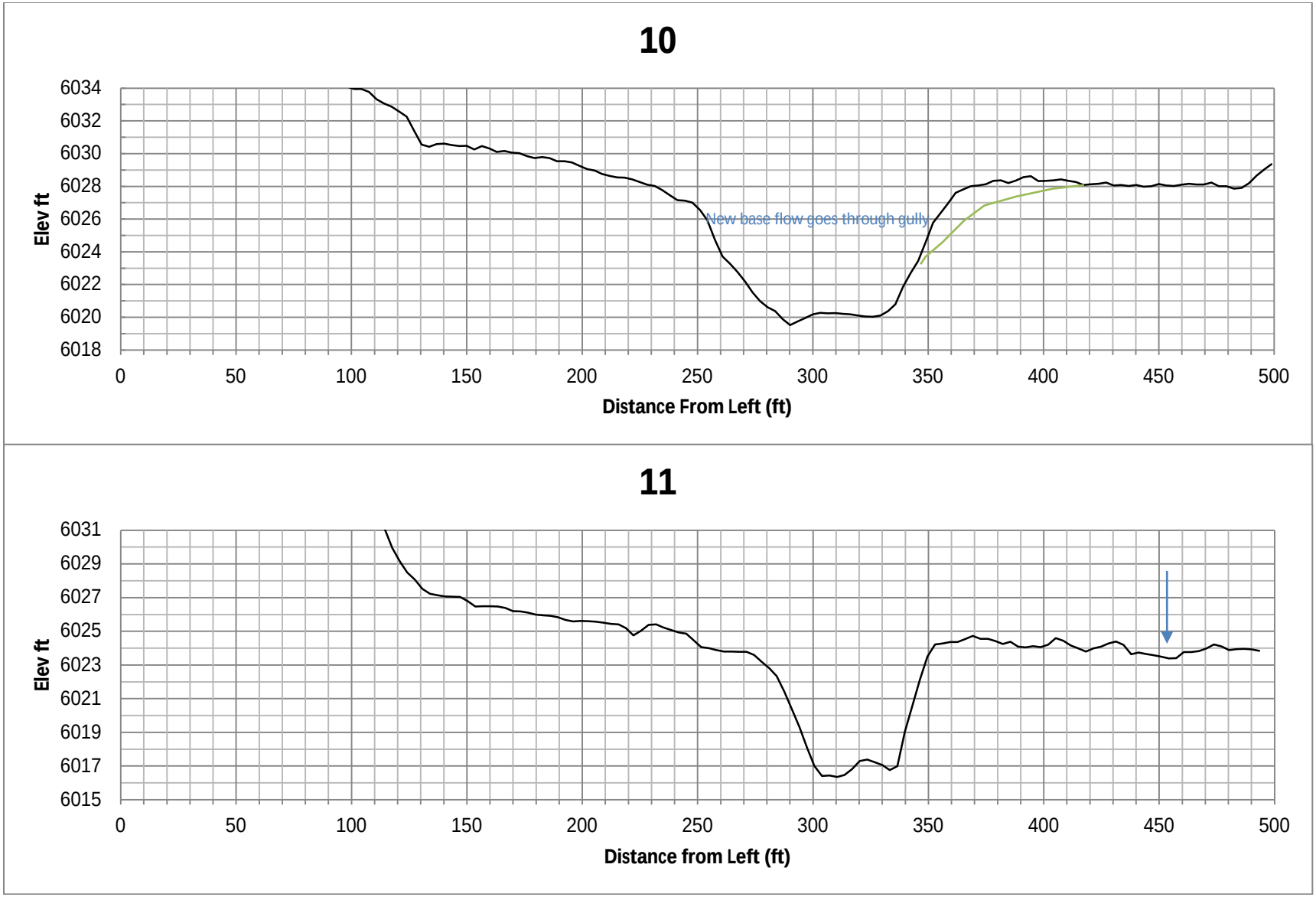
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New base flow goes through gully
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200
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Distance From Left (ft)
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Elev ft
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6025
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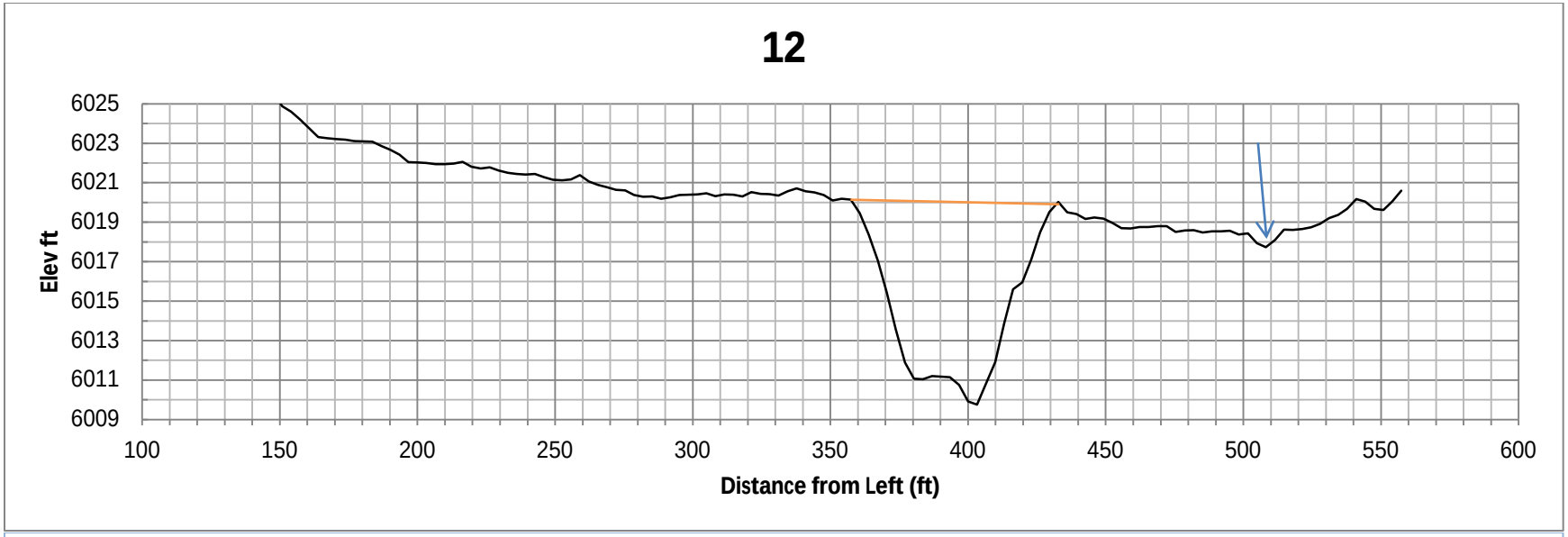
Distance from Left (ft)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Elev ft
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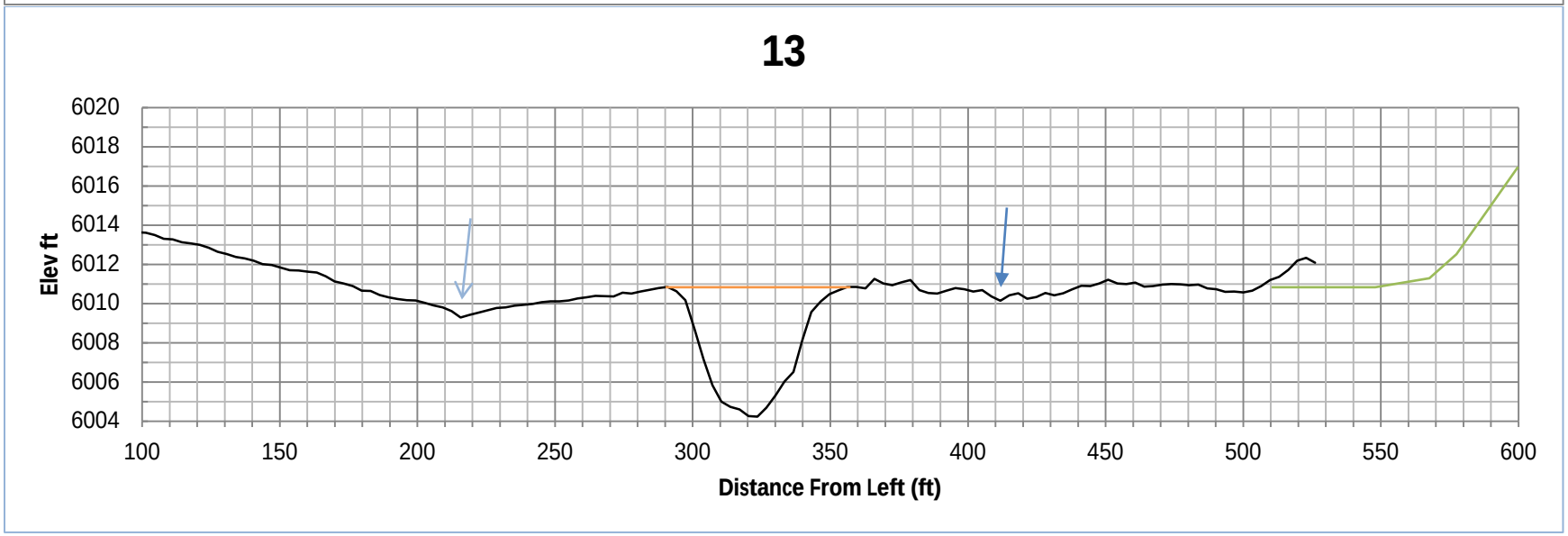
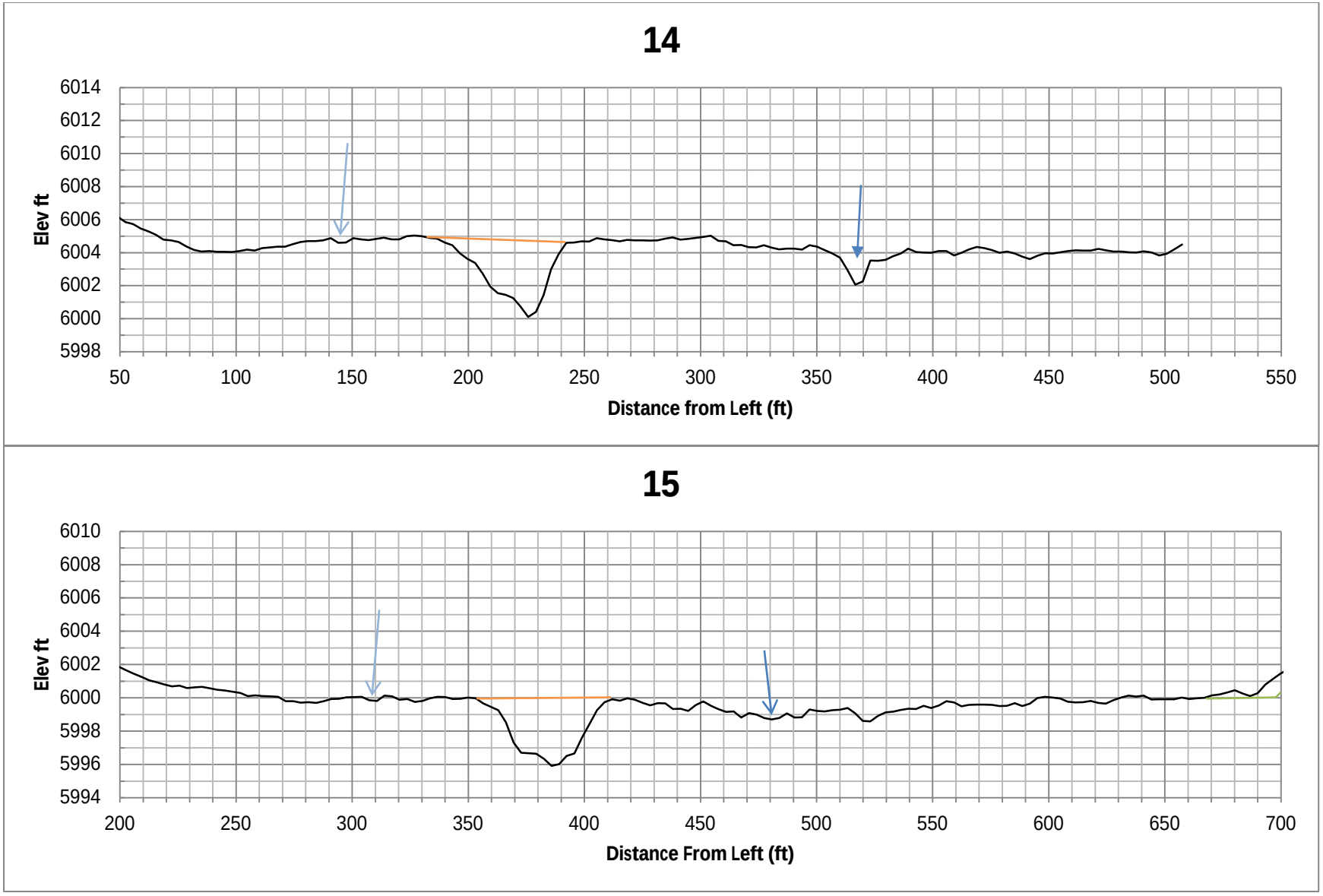
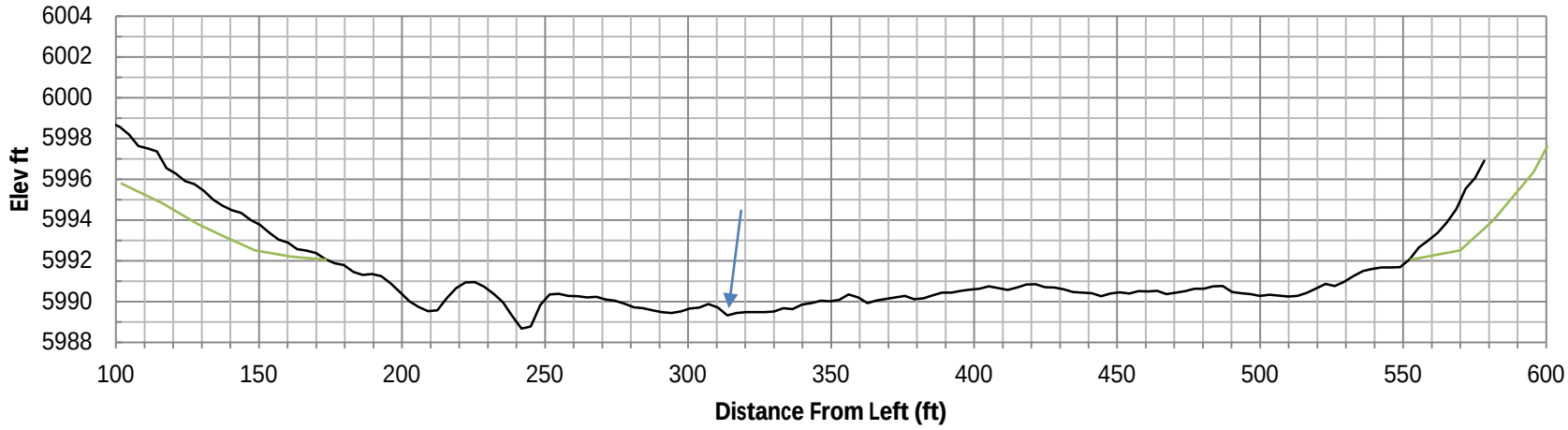
500
550
600
Distance from Left (ft)

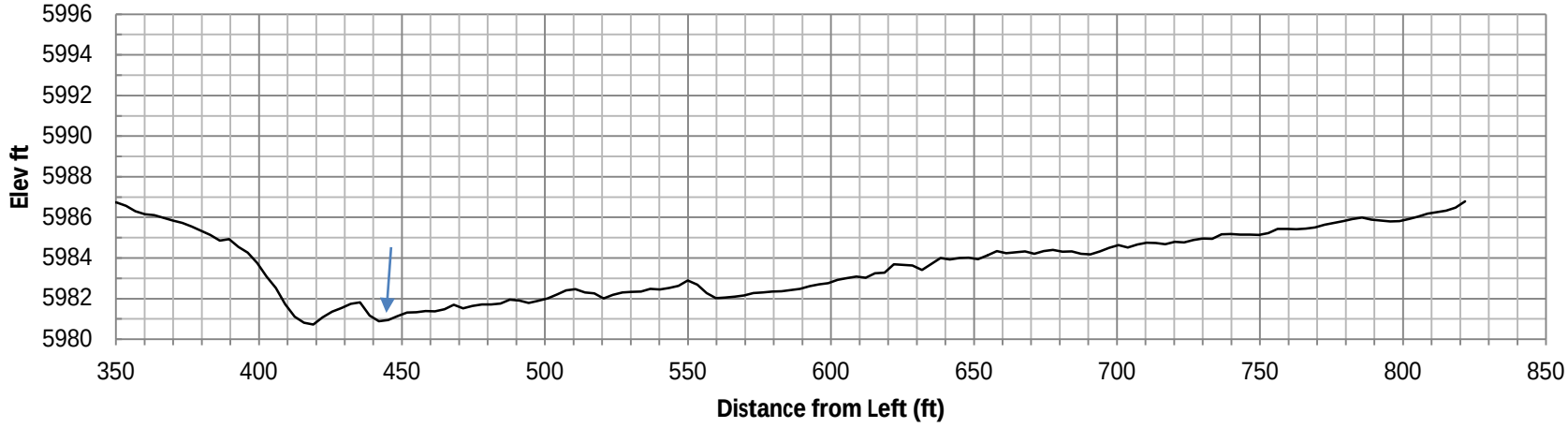

13
6020
6018
6016
6014
6012
6010
6008
6006
6004
Elev ft
100
150
200
250
300
350
400
450
500
550
600
Distance From Left (ft)

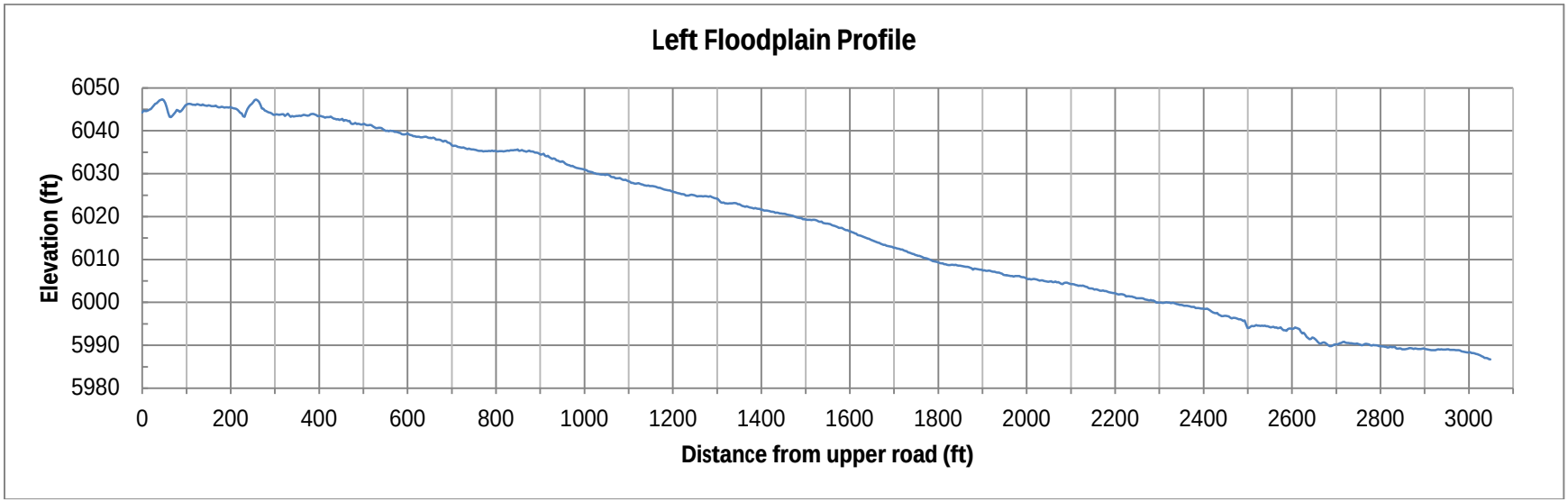

14
6014
6012
6010
6008
6006
6004
6002
6000
5998
Elev ft
50
100
150
200
250
300
350
400
450
500
550
Distance from Left (ft)
15
6010
6008
6006
6004
6002
6000
5998
5996
5994
Elev ft
200
250
300
350
400
450
500
550
600
650
700
Distance From Left (ft)

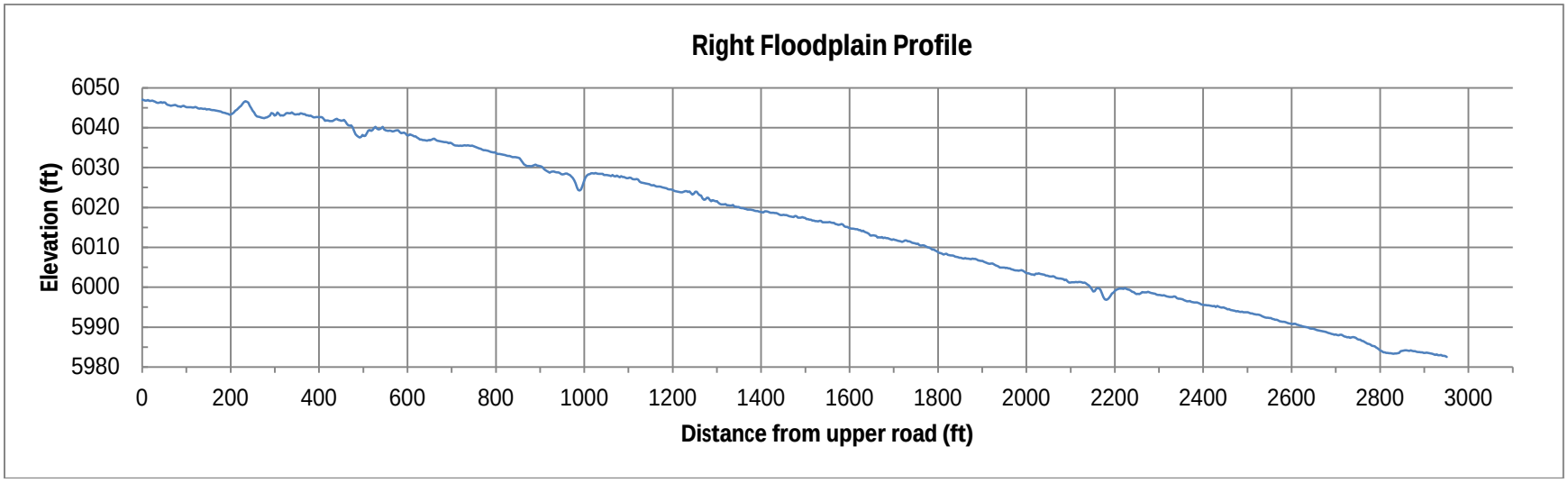
16


6004
6002
6000
5998
5996
5994
5992
5990
5988
Elev ft
100
150
200
250
300
350
400
450
500
550
600
Distance From Left (ft)

17


5996
5994
5992
5990
5988
5986
5984
5982
5980
Elev ft
350
400
450
500
550
600
650
700
750
800
850
Distance from Left (ft)


Left Floodplain Profile
Elevation (ft)
6050
6040
6030
6020
6010
6000
5990
5980
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
Distance from upper road (ft)


Right Floodplain Profile
Elevation (ft)
6050
6040
6030
6020
6010
6000
5990
5980
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
Distance from upper road (ft)

Plug corner elevations. Elevations are based on assumed elevation of 6051.69 feet at the project nail benchmark (see plan view map for benchmark location at the top of the project area). Empty cells are missing data. All units are in feet.

Plug Number	ELEV Top Right	ELEV Top Left	ELEV Btm Right	Elev Btm Left	Drop-off 0
T1	6052.98	6053.08	6050.68	6050.63	
M1	6049.48	6049.48	6048.48	6048.28	
M2	6048.25	6048.22	6046.65	6046.65	
T2	6049.95	6050.25			0
M3	6046.64		6045.44	6045.54	1.9
M4	6044.04	6044.24	6042.04	6042.14	2.16
M5	6040.18	6040.48	6038.38	6039.68	2.1
M6	6037.98	6039.28	6037.3	6037.68	1.81
M7	6036.07	6036.17	6033.57	6034.77	
M8	6036.47	6036.37	6031.2	6031.2	0.41
M9	6031.19	6031.09	6028.59	6028.29	1.6
M10	6027.26	6028.16	6024.76	6024.76	1.5
M11	6023.56	6023.66	6022.06	6022.06	1.4
M12	6020.99	6021.09	6019.19	6019.09	
M13	6018.29	6018.59	6016.39	6016.89	1.2
M14	6016.07	6016.07	6014.37	6014.37	1
M15	6013.47	6013.87	6012.37	6012.37	1.1
M16	6011.67	6011.57	6010.27	6009.87	0.9
M17	6008.95	6008.95	6007.75	6007.35	0.9
M18	6007.45	6007.05	6006.05	6005.65	
M19	6005.33	6004.73	6003.63	6003.63	0.7
M20	6003.13	6003.13	6000.93	6001.33	1.2
M21	6000.43	6001.03	5998.18	5998.08	
M22	5996.98	5997.38	5995.28	5995.38	0
M23	5994.18	5994.28	5988.96	5988.96	0
Btm1 RemPlug	5986.93	5986.83	5984.93	5984.93	0