COUNTY OF EL DORADO
DEPARTMENT OF TRANSPORTATION

INTEROFFICE MEMORANDUM

Date: 10/4/2010

To: File

From: Chandra Ghimire, PE Chandra Ghimire 10/4/'10

Subject: **Ellis Creek Crossing Bridge Drainage Design Report, 77117**

REGISTERED PROFESSIONAL ENGINEER
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1. Introduction

1.1. General

The Project is located in the Sierra Nevada mountain range in northeastern El Dorado County, in the Eldorado National Forest (see Figure 1). The Project consists of a 16 ft wide by 70 ft long bridge over the perennial Ellis Creek. A prefabricated steel truss bridge is proposed to replace the existing low water crossing. The Rubicon Trail at Ellis Creek Bridge Project (Project) is a federally funded project through the Federal Highway Administration (FHWA).

The Rubicon Trail is used by off-highway vehicles (OHVs). The increase in the numbers and types of vehicles using the Rubicon Trail has resulted in a need for greater management in order to provide both environmental protection and visitor safety. Vehicles currently cross Ellis Creek by fording. A bridge crossing will reduce the amount of sediment and contaminants that enter Ellis Creek from vehicle crossings. A bridge crossing will also reduce the turbidity of the creek from tires disturbing the streambed.

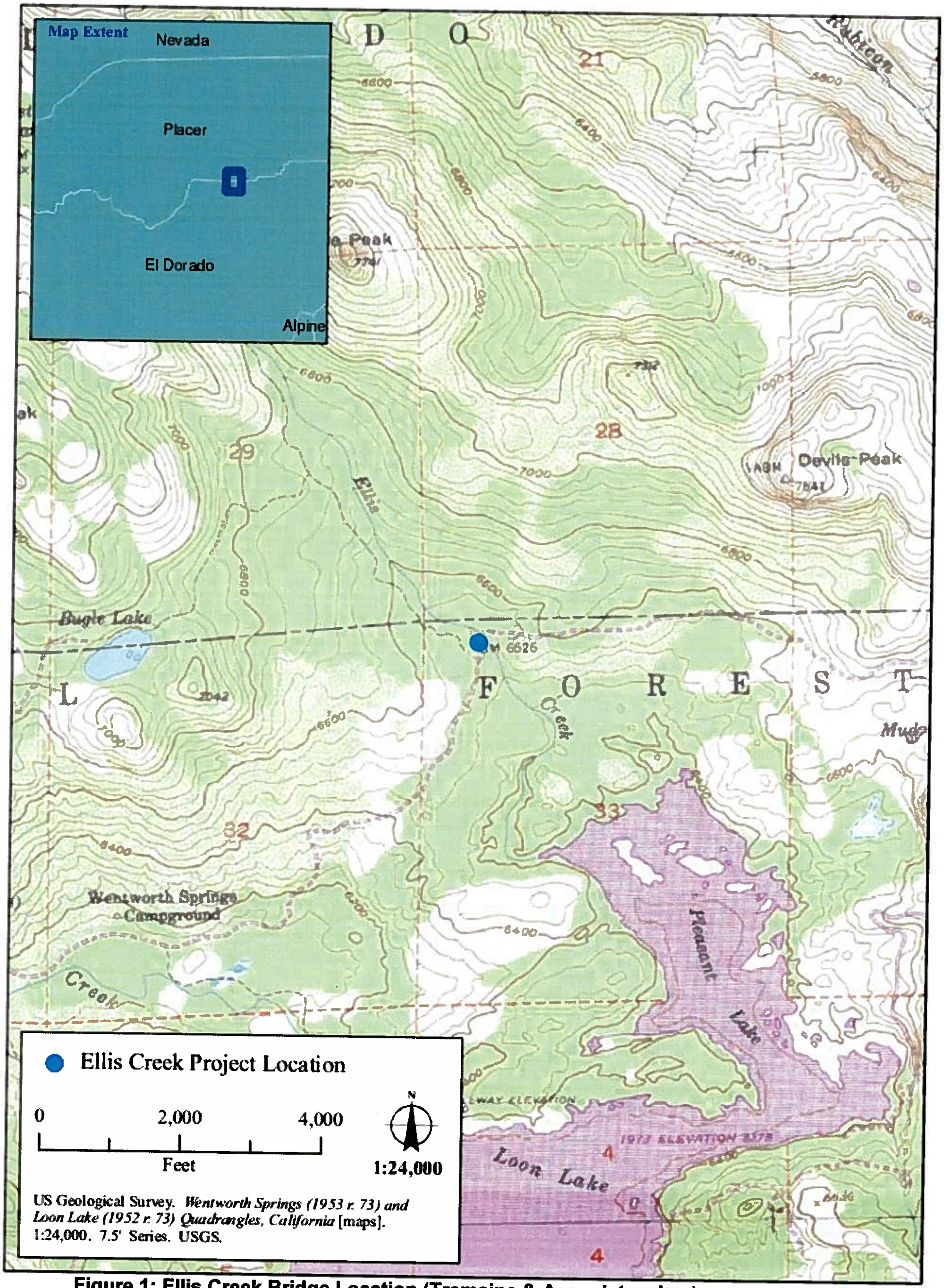
1.2. Purpose

The purpose of this drainage analysis is to develop 10-year, 50-year and 100-year peak flows to provide a hydraulic evaluation for the proposed bridge location. This report is intended to detail and document the hydrologic parameters and assumptions used to forecast the flows applicable to design a bridge at Ellis Creek. The report also summarizes the potential scour condition for the proposed bridge location.

2. Background

The drainage analysis is necessary to ensure that the proposed bridge will meet the specific design standards provided by El Dorado County Department of Transportation (EDCDOT) and California Department of Transportation (Caltrans). EDCDOT does not provide specific freeboard design criteria. However, the County has a practice of designing 3 ft minimum freeboard for 50-year event flood and 2 ft minimum freeboard for 100-year event flood. The proposed bridge design will satisfy the following standard:

1. County of El Dorado Drainage Manual, dated March 1995



US Geological Survey. *Wentworth Springs (1953 r. 73) and Loon Lake (1952 r. 73) Quadrangles, California* [maps]. 1:24,000. 7.5' Series. USGS.

Figure 1: Ellis Creek Bridge Location (Tremaine & Associates, Inc.)

2. Caltrans Local Assistance Procedure Manual, Chapter 11, dated July 23, 2006
    - The basic rule for hydraulic design of bridges is that; they should be designed to pass the two percent (2%) probability flood or tide (Q50) or the flood-of-record, whichever is greater without causing objectionable backwater, excessive flow velocities, or encroaching on through traffic lanes. Sufficient freeboard, the vertical clearance between the lowest structural member, and the water surface elevation of the design flood should be provided. A minimum freeboard of 2 feet is often assumed for preliminary bridge design.
    - The bridge should be able to withstand the effects of the base flood, Q_{100} without failure.
3. Caltrans Memo to Designers 1-23 dated October 2003
    - Adequate freeboard should be provided above the design flood to pass anticipated drift. A site specific drift evaluation must be performed to determine the horizontal (clear span) and vertical drift way requirement.
    - Convey a flood having a one percent (1%) chance of being exceeded in any given year (base flood designation Q100). No freeboard added to the base flood.
    - Bridge foundation should not fail due to scour from base flood (Q100).
    - Footings on piles may be located above the lowest anticipated scour level provided the piles are designed for this condition.

3. Previous Studies and Reference Documents

No previous studies in the vicinity exist. The gauge data recorded and provided by SMUD was used to check the reasonableness of the study. Frequency analysis was performed based on twenty-five year gauge data recorded less than a mile downstream of the proposed bridge. No known Federal Emergency Management Agency published map has been found in the project vicinity.

4. Hydrology

4.1. Basin Characteristics

The Ellis Creek Basin is approximately 1.31 square miles upstream from the proposed bridge location (Rubicon Trail location). The watershed is around 1.4 miles in length and 1.0 miles in width with concentrated shape. In general, the basin consists of hilly terrain which is located in Eldorado National Forest at elevation ranges from 6600 ft to 7400 ft. This basin is aligned north to south with an average slope of the watershed of approximately 12 percent (see Figure 2).

4.2. Soil Characteristics

According to the Foundation Investigation Report prepared by Taber Consultants, dated December 2009, the surface and subsurface soil in the project area are as follows:

- Topsoil/Alluvium was encountered at each sounding location and interpreted to be 5 to 7 ft in thickness. Surface material generally consists of tree litter including bark, needles and branches forming a spongy surface layer on the order of 1 ft thick underlain by sandy soil. It is likely that cobble and boulder size clasts exist within the Topsoil/Alluvium unit.
- Weathered rock is interpreted as beginning at approximately 5 to 7.5 ft depth at both abutment locations. Highly weathered to decomposed rock is capable of generating support for heavy concentrated foundation loads, however the upper 1 to 3 feet of the decomposed rock is not considered erosion/scour resistant.

- The ground appears to be adequately stable and capable of providing foundation support for the proposed bridge.

4.3. Climate

The average temperatures in the vicinity of the project are 60°F in June and 32°F in winter. Within last five years, the maximum and the minimum recorded temperatures at Loon Lake are 85°F and 8°F respectively. Winter storm season extends from November to April, and generally moves from west to south-west and travel in a northeasterly to easterly direction.

4.4. Rainfall Data

Generally, the project area receives precipitation in the form of snow and most of the runoff is from the snowmelt. Precipitation data used for model input was obtained from the County of El Dorado Drainage Manual. The Mean Annual Precipitation (MAP) for the project vicinity is 49 inches.

4.5. Time of Concentration

Time of concentration estimations were performed per the County of El Dorado Drainage Manual. Sheet flow is assumed to occur for maximum of 300 ft length and sheet flow travel time is calculated based on the following equation:

$$T_t = \frac{0.007(nL)^{0.08}}{(P_2)^{0.5}S^{0.4}}$$

Where:
T_t = sheet flow travel time, in hr
n = overland-flow roughness coefficient, 0.7 was chosen for this project
L = length of overland flow surface, in ft (maximum 300 ft.)
P_2 = 2-yr, 24-hr rainfall depth in inches
S = land slope, in ft/ft.

The velocity of shallow flow over an unpaved surface is estimated based on the following equation:

$V = 16.1345(\sqrt{S_o})$
Where, V = shallow-concentrated flow velocity, in ft./sec;
S_o = slope, in ft/ft.

Shallow Concentrated Flow travel time is the flow path length divided by the velocity.

The USGS regression equation was used to estimate for 2-year event flow. The channel-flow travel time is the channel length divided by the velocity. See Table 1 for summary of time of concentration. Appendix A provides sheet flow, shallow concentrated flow, channel flow travel times, and total time of concentration.

5. Hydrologic Model Development

Runoff from snowmelt (rain on snow condition-energy budget) was used to achieve the depth of precipitation which then was utilized to USACOE HEC-HMS Program Version 3.4 to develop hydrologic model for Ellis Creek watershed. Figure 2 provides the Ellis Creek basin delineation.

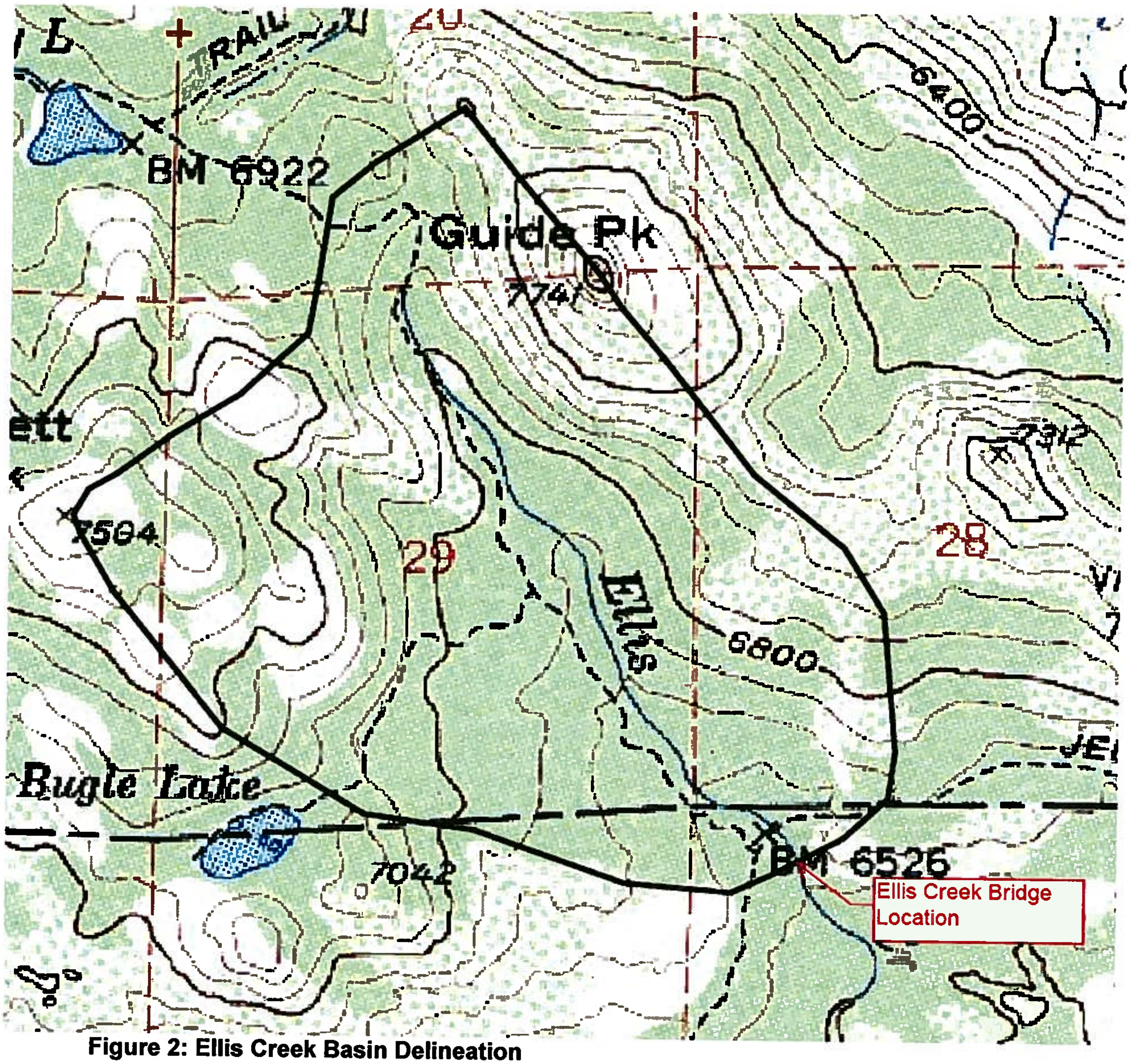


Figure 2: Ellis Creek Basin Delineation

5.1. Hydrologic Parameters

Appendix A provides the HMS model diagram and Mean Annual Precipitation for Ellis Creek shed. Also included in Appendix A are Table A-1 (precipitation depth), Table A-2 (melted precipitation), Table A-3 (sheet and shallow concentrated flow), Table A-4 (channel flow travel time), and Table A-5 (total time of concentrated). Parameters used in the hydrologic model were based on concept of the Soil Conservation Service (SCS) Curve Number (CN) method. CN used for the snow condition is higher than the actual soil CN on the ground. The hydrograph used for hydrologic modeling was based on SCS type 1A temporal distribution consistent with the County of El Dorado Drainage Manual. These guidelines recommend using type 1A temporal distribution for projects located an elevation above 1640 ft.

Because the HEC-HMS snowmelt model requires data that is not available in the vicinity of the Project, snow melt has been calculated based on the average temperature, wind velocity and forest cover. A generalized Energy Budget method applicable to partly forested area was chosen from Engineer Manual 1110-2-1406 (USACOE-Runoff from Snowmelt).

The design storms were based on 24-hour duration for 10-year, 50-year and 100 year storm frequency using:

- Rainfall depth provided by the County of El Dorado Drainage Manual dated March 1995, updated August 2008, See Appendix A.
- Hydrologic parameters presented in the County of El Dorado Drainage Manual dated March 1995.

Table 1 summarizes input parameters used for the HEC-HMS hydrologic modeling, including curve number, conveyance and rainfall (rain on snow condition).

Table 1: Hydrologic Model Summary Parameters for Ellis Creek

Parameter	**Ellis Creek**
Basin	
Watershed Area (mi^2)	1.31
Loss Rate	SCS Curve Number
Transform method	SCS Unit Hydrograph
Loss Rates	
Initial Abstraction (in)	0
Curve Number	95
Impervious Area (%)	0
Transformation	
Graph Type	Standard
Time of Concentration (min)	78.52
Lag Time (min)	47.1
Precipitation	
Hydrograph Duration	24 hour
Temporal Distribution	Type 1A
Mean Annual Precipitation (in)	49
100-year precipitation (in/day)	8.95
50-year precipitation (in/day)	8.2
10-year precipitation (in/day)	6.33
Snowmelt	
100-year (in/day)	3.76
50-year (in/day)	2.83
10-year (in/day)	1.53

5.2. *Land Use/Hydrologic Soil Type/Curve Number*

Land use was evaluated using Google Earth image which indicates that the watershed consists of forested areas with some open areas and dirt road. The ground is assumed fully saturated after rain and snow. The SCS curve number used in the model is 95 for rain on snow and frozen soil conditions.

5.3. *Peak Discharges*

Peak discharges were analyzed by both HEC-HMS and USGS regression equation. Appendix B provides the peak flow hydrographs developed from the HEC-HMS models for 10-year, 50-year and 100-year peak flows. Table 2 provides HEC-HMS peak discharge based on hydrologic model parameter listed on Table 1.

Table 2: Hydrograph Analysis Summary Results from HEC-HMS Model

HEC-HMS Node Location	Sub-basin Area (mi^2)	Cumulative Sub-basin Area (mi^2)	10-year Peak Flow (cfs)	50-year Peak Flow (cfs)	100-year Peak Flow (cfs)
Ellis Creek	1.31	1.31	140	317	443

USGS regression equations are useful for relatively large drainage areas (greater than 0.5 square miles) that experience a significant proportion of storm runoff from snowmelt (USACOE, 2005). Hydrologic input parameters applicable to the USGS regression equations are watershed area (mi^2), altitude index (thousands ft) and mean annual precipitation (inch). Table 3 provides the results from the USGS regression equations. The USGS regression equations are attached in Appendix C.

Table 3: USGS regression equation output

Area (mi^2)	1.31	Input
Mean Annual Precipitation (in)	49	
Altitude index (in thousands ft)	6.76	
Return Period	**Flow (cfs)**	
2-year, Q_2	31	Output
5-year Q_5	91	
10-year, Q_{10}	140	
25-year, Q_{25}	235	
50-year, Q_{50}	317	
100-year, Q_{100}	450	

Table 3 and Table 4 indicate that the USGS equation for Sierra Region produced higher flows than HEC-HMS output flows. The higher flows between HEC-HMS output and USGS regression equation method were chosen as inputs into the HEC-RAS model. Table 4 provides the peak discharge results used to analyze the proposed bridge hydraulics.

Table 4: Project Location Peak Discharge

Location	Peak Discharge		
	10% Annual Chance (10-year)	2% Annual Chance (50-year)	1% Annual Chance (100-year)
Ellis Creek	140 cfs	317 cfs	450 cfs

5.4. Model Reasonableness

There is a SMUD stream gauge less than a mile downstream of the study area. Data from the gauge allowed the hydrologic models to be calibrated to the specific events. Though the frequency of the event is unknown, the base flood is greater than the observed event flow which verifies the reasonableness of the model output. A twenty-five year yearly peak flow gauge record is included in Figure 3.

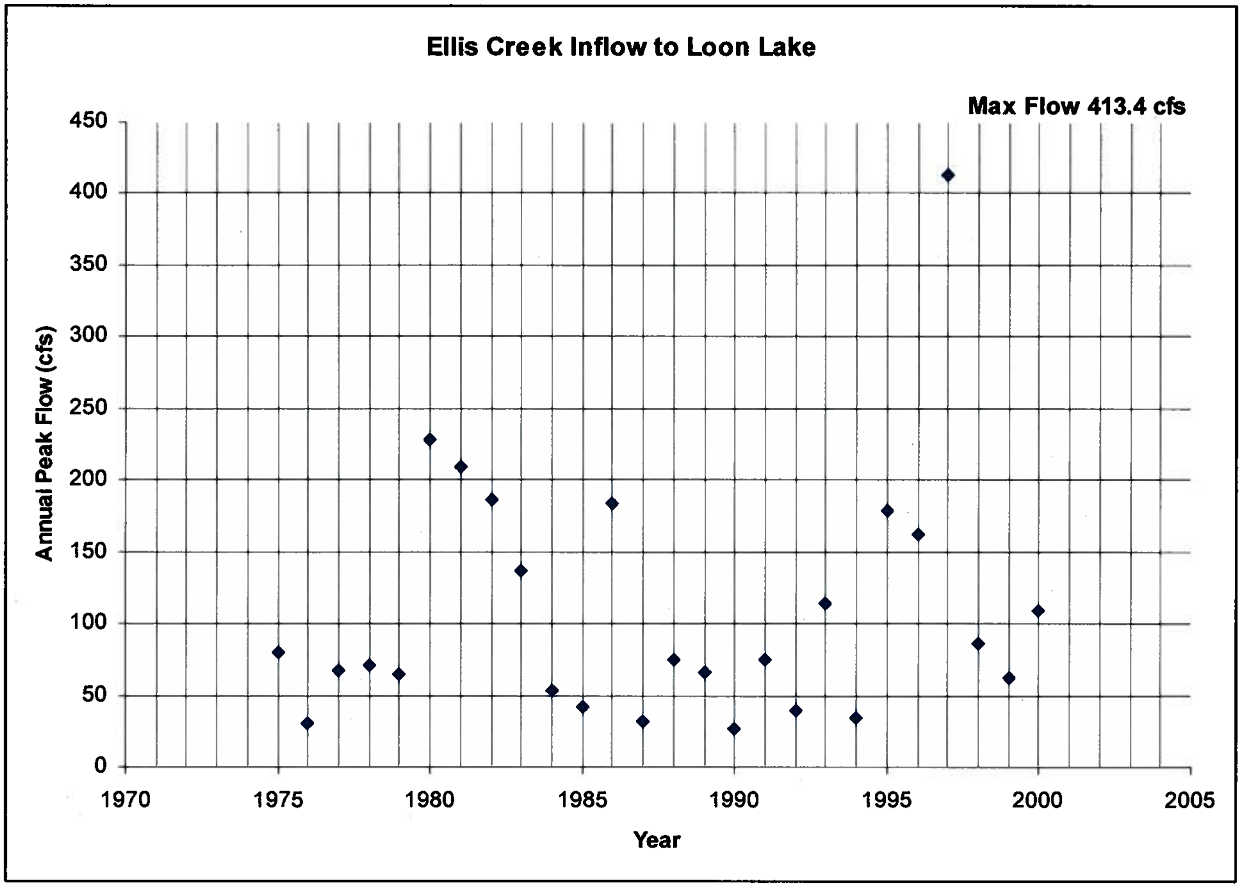


Figure 3: Yearly Peak Flow Recorded Data (1975-2000)

6. Hydraulic Model Development

The hydraulic model was extended approximately 500 ft upstream and 400 ft downstream of the proposed bridge location. A steady-flow model was developed using HEC-RAS version 4.0. Three water surface profiles, corresponding to 10-year, 50-year and 100-year peak discharges were developed.

6.1. Stream Channel Geometry Development

Information used for hydraulic modeling was derived using AutoCAD Civil 3D 2010. For each stream reach four sets of data were used to develop HEC-RAS geometry: 1) stream centerline, 2) cross section cut lines, 3) lines representing left and right banks, and 4) flow paths. AutoCAD surface data are based on an actual topographic survey performed by the County of El Dorado Department of Transportation. Cross sections were developed for the proposed project locations upstream and downstream of the bridge.

During the hydraulic modeling and preparation of this document, only local area coordinate data was available. Since then, conversion to NAD83 has been completed. It has been determined the local area elevation datum of 1000.00 ft is equivalent to an actual elevation of 6527.58 ft above mean sea level.

6.2. Bridge Modeling

The bridge scenarios were modeled using user defined cross sections for computation of energy losses. Table 5 summarizes the proposed bridge dimensions used in HEC-RAS model.

Table 5: Bridge parameters

Bridge Crossing	HEC-RAS River Station	Bridge Length (ft)	Bridge Width (ft)	No of Piers	Proposed Low Chord Elevation (ft)	Approximate Angle of Attack Against the Abutment (deg)
Proposed	14.1	70	16	0	995.70	N/A

Proposed construction includes wing walls connecting into the interior corners of the bridge abutments, see drawing included in Appendix D.

6.3. Boundary Condition

Steady flow boundary condition was used for proposed bridge to represent the general channel hydraulics.

- **Proposed Bridge Downstream Boundary Condition:** Normal depth was used and normal depth slope of 0.047 was utilized based existing average ground slope. No FEMA flood elevations are available for the study area.

6.4. Losses

Selection of an appropriate value for Manning's *n* is very significant to the accuracy of the computed water surface profiles. The value of Manning's *n* is highly variable and depends on a number of factors including: surface roughness, vegetation, channel irregularities, channel alignment, scour and deposition, obstruction, sizes and shape of the channel, stage and discharge, seasonal changes, temperature, suspended materials, and bedload.

There are many factors that affect the selection of *n* value for the channel. The most important factors that affect that selection of the channel *n* values are: 1) the type and size of the materials that compose the bed and banks of a channel, and 2) the shape of the channel. Manning's *n* values were estimated by analyzing existing land and aerial photographs of the study area. The estimated roughness coefficients utilized for Ellis Creek and overbank reaches for this report are summarized in Table 6.

Table 6: Estimated Manning's n values for Ellis Creek Hydraulic Model

Reach	Left Overbank *n*	Channel *n*	Right Overbank *n*
Ellis Creek Entire Reach	0.08	0.04	0.08

6.5. Ineffective Flow Location

The proposed bridge location does not result in any pooling of water immediately downstream and upstream. Because of the steepness and narrowness of the creek, no ineffective area is identified.

7. Ellis Creek Hydraulic Analysis

- **Proposed Bridge**: There is no record of any existing bridge at Ellis Creek. The bridge has been proposed as a new structure which replaces the low water crossing.

8. Hydraulic Model Results

8.1. General

The summary of HEC-RAS output table is included in Appendix E.

8.2. Hydraulic Findings

Table 7 summarizes the hydraulic model results.

Table 7: Summary of the Results at the Bridge Location (Station 14.1).

Profile	Peak Flow (cfs)	WSE	U/S Velocity (ft/s)	Freeboard Requirement
10-year	140	991.6	5	-
50-year	317	992.7	6.8	Minimum 3 ft
100-year	450	993.5	7.7	Minimum 2 ft

The cross section provided in Appendix E from hydraulic modeling indicates that the 100-year and 50-year event water surfaces are 993.50 ft and 992.70 ft respectively. To maintain minimum 3 ft freeboard for design (50-year event) flood, the low chord elevation of the bridge shall be located at or above an elevation of 996.00 ft. This elevation also satisfies the County required minimum freeboard (2 ft) for base (100-year event) flood.

9. Scour Analysis

9.1. General

Flow velocities at the bridge location were reviewed for purpose of determining scour potential. The minimum design standard for bridge scour is the base flood (100-year event flood). Scour analysis has been performed using the methodology described in Hydraulic Engineering Circular No 18, Evaluating Scour at Bridge (May 2001).

Scour is the result of the erosive action of flowing water, excavating and carrying away materials from the bed and the bank of the stream and from around the piers and abutments of the bridges. The most common cause of the bridge failure is scouring of bed materials around bridge foundations. It should be noted that scour rates are dependent on the particular materials. Loose granular soils are prone to rapid erosion by flowing water while cohesive or cemented soils are more scour resistant.

9.2. Scour Analysis Methodology

Field seismic refraction testing indicates that 5 to 7.5 ft of topsoil/alluvium exists above the layer of weathered rock at both abutment locations. [Neither detail soil information nor soil test data from boring is available for the proposed Ellis Creek Bridge site].

Highly weathered to decomposed rock is capable of generating support for heavy concentrated foundation loads, however the upper 1 to 3 feet of the decomposed rock is not considered erosion/scour resistant (Taber 2009). The ground appears to be adequately stable and capable of providing foundation support for the proposed bridge (Taber 2009).

A preliminary scour analysis has been computed using the hydraulic model developed and soil data from Gerle Creek Bridge. Particle size distribution report by Taber Consultant approximates the value of mean size fraction of the bed material (D_{50}) to be 0.2 mm for gravelly sand with cobbles, small boulders and silt.

9.3. Long Term Aggradation and Degradation

Long-term aggradation and degradation may be the result of natural or anthropogenic forces. The streambed may be aggrading, degrading, or in relative equilibrium in the vicinity of the bridge crossing. No long term degradation and aggradation data is available at the proposed Ellis Creek bridge location. However some degradation was observed approximately 70 ft upstream of the proposed bridge location. It is assumed that this degradation occurred because of the vehicular movement along the Rubicon Trail. It is believed that degradation will cease after the trail is re-routed. No degradation was noted at the proposed bridge location during past field visits. There is no visible sign of long term aggradation or degradation at the proposed bridge location; therefore, long term aggradation and degradation is assumed to be negligible. Since both abutments are designed to be outside the base floodplain, the overall bridge scour will be minimally affected by streambed degradation or aggradation.

9.4. Contraction Scour

Contraction scour occurs when the flow area of the stream is reduced by natural features or by a bridge. The HEC-RAS program offer options to either manually input one these forms of contraction or to select the default option where the program automatically determines the form of contraction to be used based on critical velocities and mean flow velocities in the channel and overbanks.

As stated before, a value of 0.2 mm was assigned for D_{50} and water temperature was assumed to be 40°F. Contraction scour was computed for the 100-year flood event. Results of the contraction scour are presented in Table 8.

Table 8: Summary of Contraction Scour at the Proposed Bridge

Parameters	100-year Flood Left Overbank	 Channel	 Right Overbank
Contraction Scour			
Scour Depth Ys (ft)	0	0.12	0
Critical Velocity (ft/s)	1.03	1.20	1.03
Equation	Live	Live	Live

9.5. Local Scour

Local scour consists of pier and abutment scour. Since there are no piers in the proposed bridge, only scour at the abutment is a concern. Scour occurs when the abutment and the embankment obstruct the flow.

Since the proposed abutments are located outside the base floodplain, the abutment scour calculation by HEC-RAS is not applicable to Ellis Creek Bridge design.

9.6. Total Scour

Total scour is the combination of long-term elevation changes (aggradation and degradation), contraction scour, and local scour at each individual pier and abutment location. Since long term bed elevation changes were assumed to be negligible and local scour is not applicable, total scour computed is the contraction scour. The total scour of the proposed bridge is presented in Table 9.

Table 9: Summary of Total Scour at the Proposed Bridge

Parameters	100-year Flood		
	Left Overbank	**Channel**	**Right Overbank**
Total Scour Depth (ft)	0	0.12	0

Total scour is negligible for the abutments based on the assumption that the scoured materials are erodible sediment and the abutments are outside the base floodplain. It is recommended the foundations of the bridge be embedded into a sufficient depth of competent rock in order to ensure scour protection and stability, as specified in the foundation investigation report.

Rip-rap is recommended for both bank and abutment protection. Based on the upstream velocity from the proposed bridge location, the size of the designed rock is 75 lbs consistent to the Caltrans Highway Design Manual and USACOE EM 1110-2-1601. It is recommended that the designed rocks will be of number one (1) backing class and shall be placed by method B.

10. Conclusion

To satisfy Caltrans hydraulic design requirements and the County design practice for both 50-year and 100-year computed peak flows, it is advised to follow the recommendations below. Table 10 summarizes the recommendations based on Caltrans and the County of El Dorado design criteria.

Table 10: Recommendation

Caltrans Design Criteria	Summary/Recommendations
• **The proposed bridge will be able to pass the two percent (2%) probability flood or tide (Q_{50}) or the flood-of-record, whichever is greater without causing objectionable backwater, excessive flow velocities, or encroaching on through traffic lanes. Sufficient freeboard, typically a minimum freeboard of 2 feet is often assumed for bridge design.**	• **To meet the minimum requirement of 3 ft freeboard for 50-year event flood and 2 ft freeboard for 100-year event flood, the low chord elevation of the proposed bridge is recommended to be set at or above an elevation of 996.00.** • **The foundations of the bridge will be set a sufficient depth of competent rock in order to ensure scour protection and stability.** • **Banks and abutments shall be protected with a minimum of 75 lbs rip-rap, number one (1) backing class, method B placement.**

11. References

1. SMUD (July 2007) Proposed Ellis and Gerle Creek Bridge-SMUD Hydrology Information Request, Fax Communication
2. SMUD (2007), Ellis Creek Inflow to Loon Lake, Gauge Data
3. SMUD (May 2005), Hydrology Technical Report, SMUD Upper American River Project and PG&E Company Chili Bar Project, Version 3
4. FEMA, Current FEMA Issued Flood Maps http://www.msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1 retrieved on 8/23/2010
5. USGS, http://water.usgs.gov/software/NFF/manual/ca/index.html retrieved on 6/15/2010
6. USACOE (March 2008), Hydrologic Engineering Center-River Analysis System 4.0
7. USACOE (September 2008), Hydrologic Engineering Center-Hydrologic Modeling System version 3.4
8. USACOE (March 1998), Engineer Manual 1110-2-1406, Runoff from Snowmelt.
9. USACOE (30 June 1994), Engineer Manual 1110-2-1601, Hydraulic Design of Flood Control Channels
10. USACOE (April 2005), Recommended Watershed Modeling Techniques for Hydrologic Design and Best Management Practice, Lake Tahoe, California and Nevada.
11. Bedient, B. Philip & Huber, C. Wayne (2002), Hydrology and Floodplain Analysis, Third Edition
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13. Caltrans (October, 2003) Memo to Designer 1-23
14. Caltrans (July 23, 2006) Local Assistance Procedure Manual, Page 11-18
15. Caltrans (September, 2006), Highway Design Manual Sixth Edition
16. Taber Consultants (December 2009), Ellis Creek Foundation Investigation Report
17. Sycamore Environmental Consultants Inc (April 2010), Natural Environment Study and Jurisdictional Delineation Report, Rubicon Trail at Ellis Creek Bridge Project
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19. AutoCAD (2010) Civil 3D
20. Tremaine & Associates, Inc (March 2010), Draft Archaeological Survey Report, Rubicon at Ellis Creek Bridge Project
21. Department of Water Resources, California Data Exchange Center http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=LON&dur_code=D&sensor_num=&start_date=01/10/1997+00:00&end_date=08/06/2010+12:36 retrieved on 9/28/2010

Attachments

Appendix A: HEC-HMS Model

Appendix B: HEC-HMS Model Results

Appendix C: USGS Equations

Appendix D: Bridge Plans and Sections

Appendix E: Summary of HEC-RAS Output

Appendix A: HEC-HMS Model

HEC-HMS

Project : Rubicon

Basin Model : DP-1

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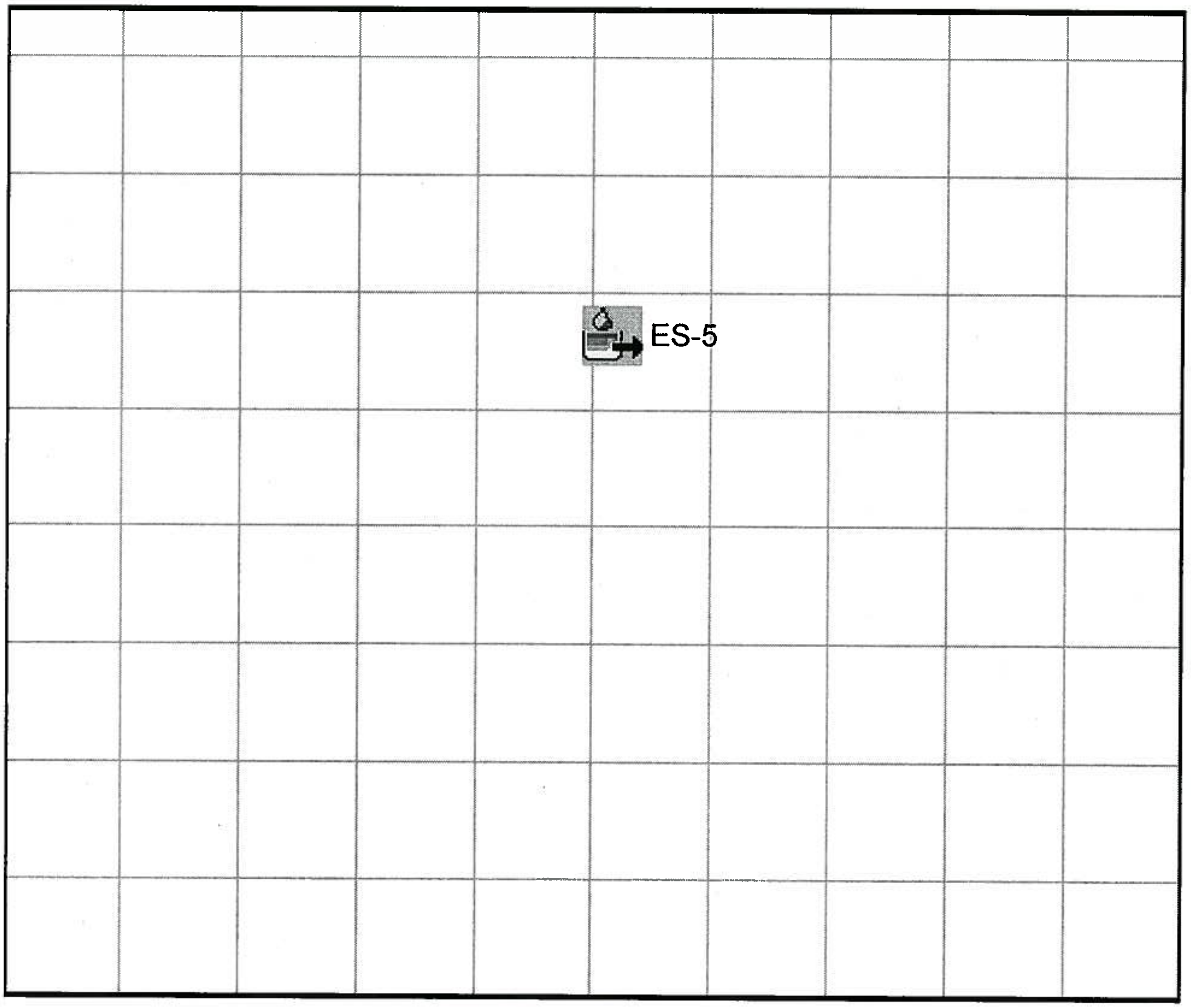


Project: Rubicon Simulation Run: Run 10 year

Start of Run:	01Jan2009, 00:00	Basin Model:	DP-1
End of Run:	03Jan2009, 00:00	Meteorologic Model:	10 year 49"
Compute Time:	26Aug2010, 14:21:31	Control Specifications:	DP-1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak
ES-5	1.31	140.2	01Jan2009, 08:4

Project: Rubicon Simulation Run: Run 50

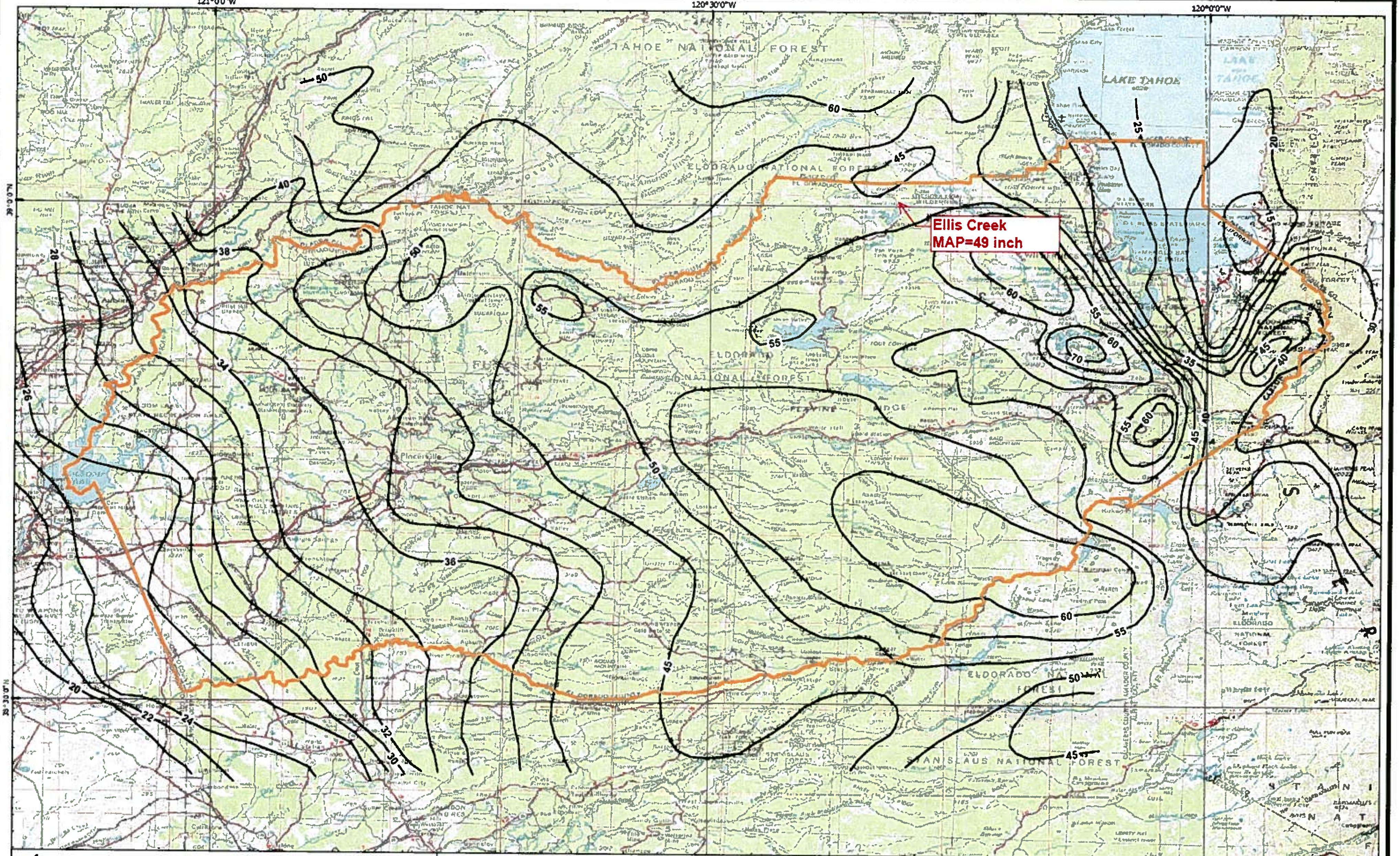
Start of Run:	01Jan2009, 00:00	Basin Model:	DP-1
End of Run:	03Jan2009, 00:00	Meteorologic Model:	50 year 49"
Compute Time:	26Aug2010, 14:43:35	Control Specifications:	DP-1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak
ES-5	1.31	316.9	01Jan2009, 08:4

Project: Rubicon Simulation Run: Run 100

Start of Run:	01Jan2009, 00:00	Basin Model:	DP-1
End of Run:	03Jan2009, 00:00	Meteorologic Model:	100 year 49"
Compute Time:	26Aug2010, 14:14:41	Control Specifications:	DP-1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak
ES-5	1.31	443.1	01Jan2009, 08:4



Units are inches per year

— Mean annual precipitation for El Dorado County, CA

▭ County boundary

Note:

Source: Report on El Dorado County design rainfall.
Prepared by Jim Goodridge, August 2008.

El Dorado County drainage manual

MAP mapping

NAD 83

Table A-1: Total Precipitation and Snowmelt Depth

Type/Event	2 yrs	5 yrs	10 yrs	25 yrs	50 yrs	100 yrs
P_r (inch/d)	3.99	5.43	6.33	7.43	8.2	8.95
M (inch/d)	0.63	1.11	1.53	2.24	2.83	3.76

Table A-2: Hydrologic Parameters for Snowmelt

Event	Basin Wind Coeff. (k)	Wind Velocity v (mph)	Saturated Air Temp (T_a°F)	Snowmelt M (inch/day)
2 yrs	0.7	9	37	0.63
5 yrs	0.7	14	39	1.11
10 yrs	0.7	19	40	1.53
25 yrs	0.7	24	42	2.24
50 yrs	0.7	29	43	2.83
100 yrs	0.7	34	45	3.76

Table A-3: Sheet and Shallow Concentrated Flow Travel Time

		Sheet Flow (L =300 ft)				Shallow Concentrated Flow				
Watershed	Sheet L_s (ft)	Δelev /ΔLs Slope	P_2 (in.)	Overland Rough. n	T_{sheet} (min)	Length L (ft)	Δelev /ΔLs Slope	*Unpaved V (ft/s)	**Paved V (ft/s)	T_{conc} (min)
Ellis	300	0.10	5.43	0.7	32.63	750	0.14	6.04		2.07

Table A-4: Channel Flow Travel Time

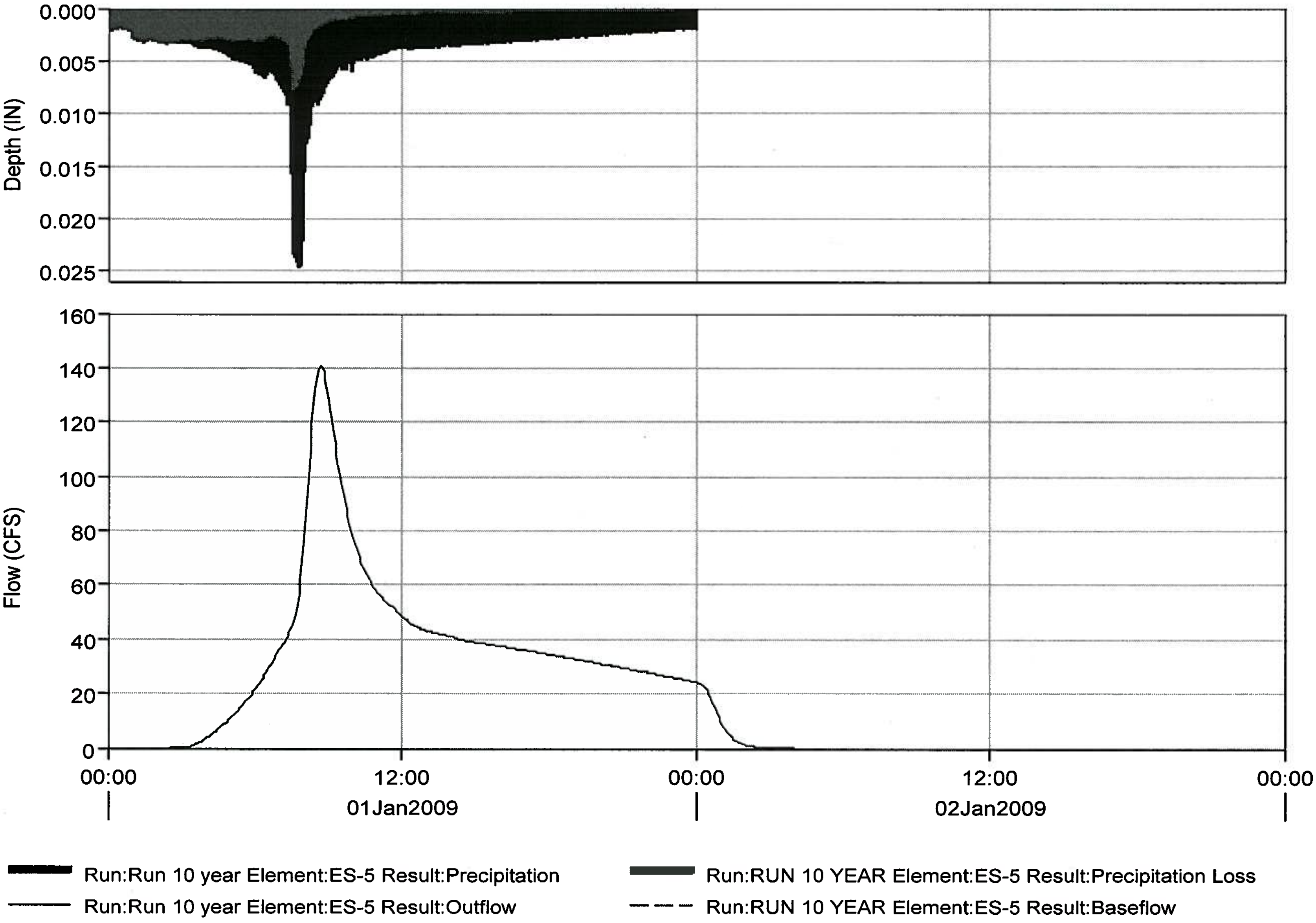
Basin	Length (ft)	Slope	Manning's *n*	T_c (min)	Velocity (ft/s)
Ellis	8150	0.06	0.05	43.8	3.1

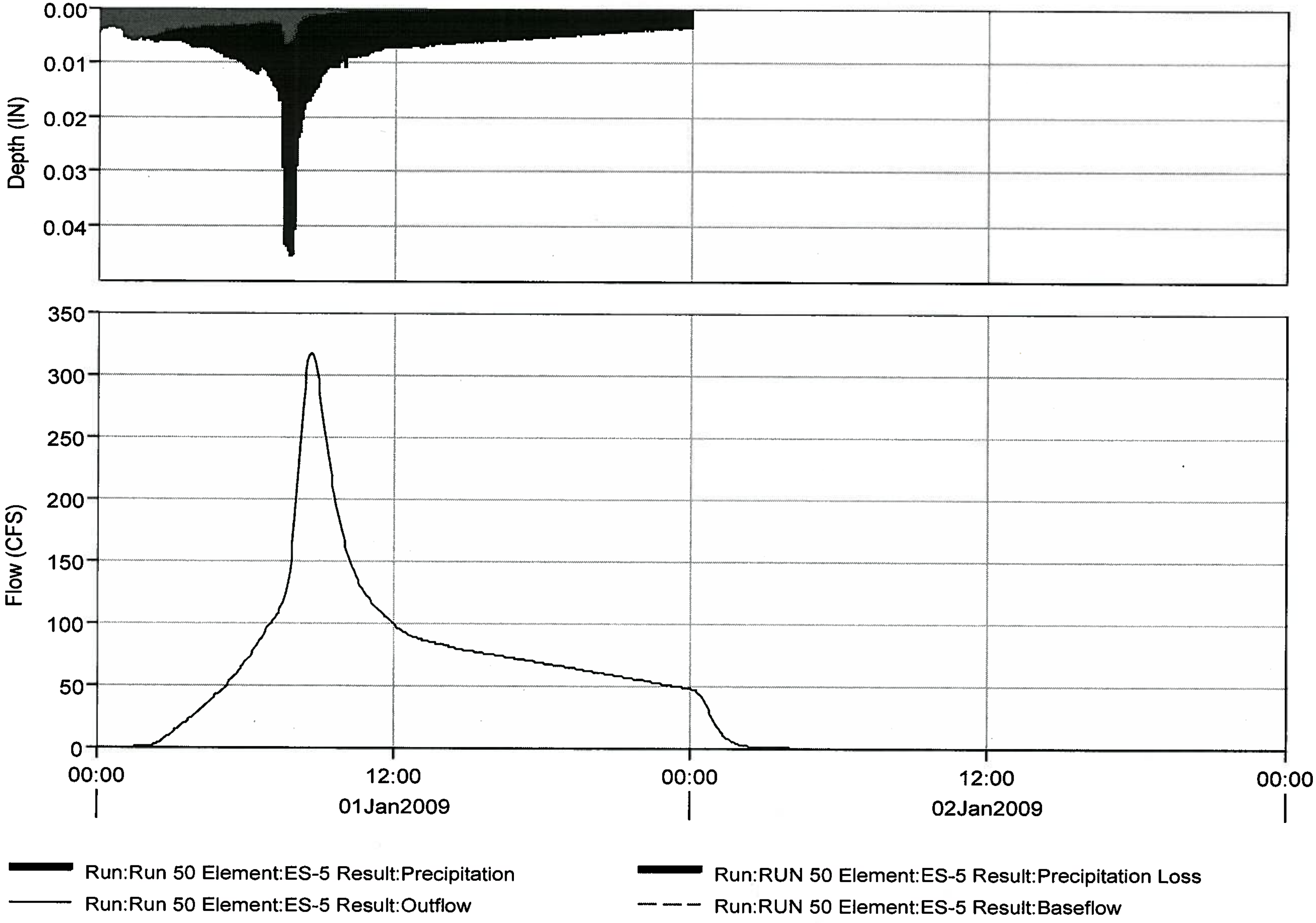
Table A-5: Time of Concentration

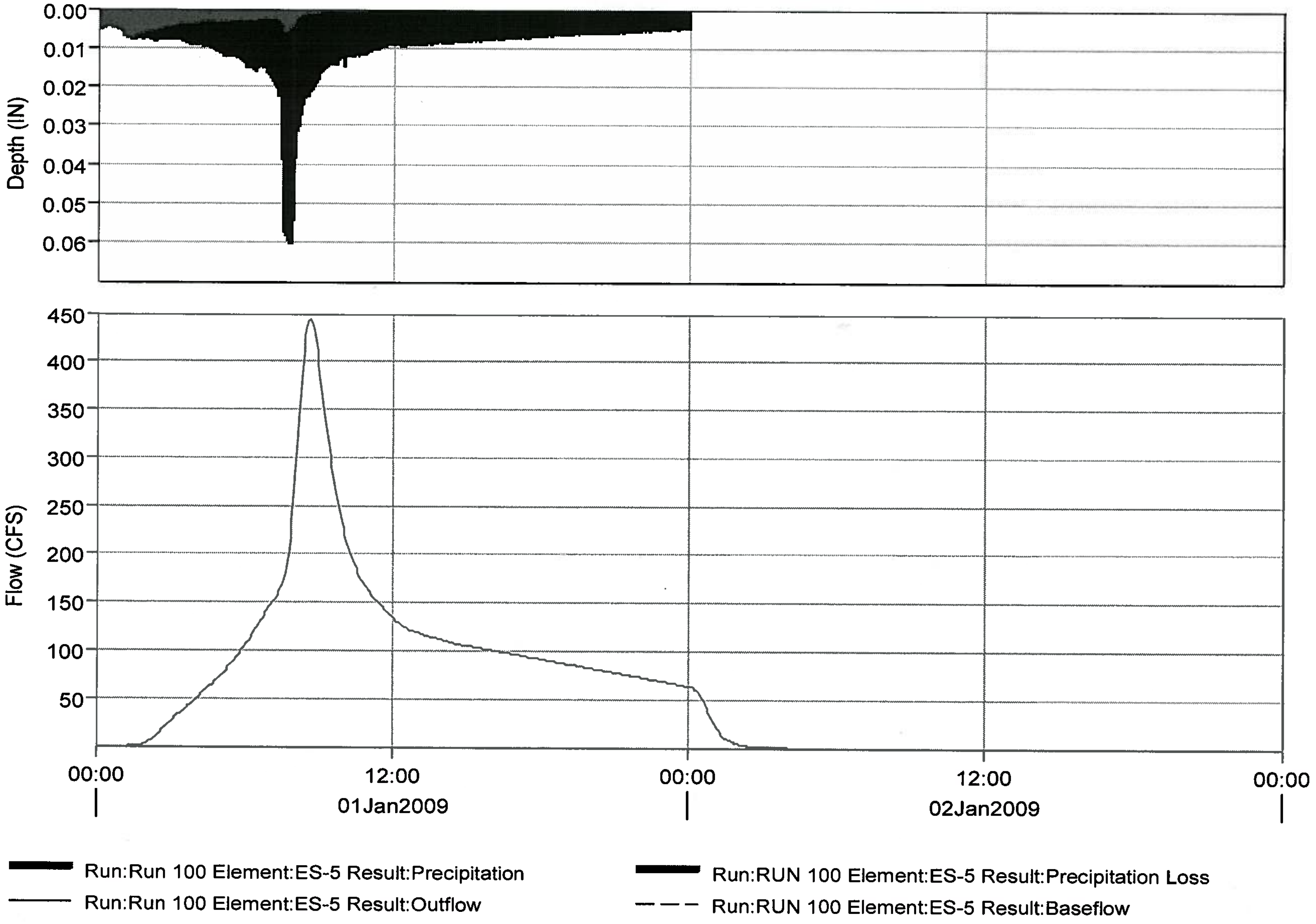
Total Flow Length (ft)	Basin	Tc,channel flow (min)	Tc,sheet flow (min)	Tc,shallow flow (min)	Total Tc (min)	Tlag=0.6*Tc (min)
9200	Ellis	43.8	32.63	2.07	78.52	47.1

Appendix B: HEC-HMS Model Results

Subbasin "ES-5" Results for Run "Run 10 year"




Subbasin "ES-5" Results for Run "Run 50"



Subbasin "ES-5" Results for Run "Run 100"

Appendix C: USGS Equations

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The following documentation was taken from:

U.S. Geological Survey Water-Resources Investigations Report 94-4002: *Nationwide summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1993*

CALIFORNIA

STATEWIDE RURAL

Summary

California is divided into six hydrologic regions (fig. 1). The regression equations developed for these regions are for estimating peak discharges (QT) having recurrence intervals T that range from 2 to 100 years. The explanatory basin variables used in the equations are drainage area (A), in square miles; mean annual precipitation (P), in inches; and an altitude index (H), which is the average of altitudes in thousands of feet at points along the main channel at 10 percent, and 85 percent of the distances from the site to the divide. The variables A and H may be measured from topographic maps. Mean annual precipitation (P) is determined from a map in Rantz (1969). The regression equations were developed from peak-discharge records of 10 years or longer, available as of 1975, at more than 700 gaging stations throughout the State. The regression equations are applicable to unregulated streams but are not applicable to some parts of the State (see fig. 1). The standard errors of estimate for the regression equations for various recurrence intervals and regions range from 60 to over 100 percent. The report by Waananen and Crippen (1977) includes an approximate procedure for increasing a rural discharge to account for the effect of urban development. The influences of fire and other basin changes on flood magnitudes are also discussed.

Procedure

Topographic maps, the hydrologic regions map (fig. 1), the mean annual precipitation from Rantz (1969), and the following equations are used to estimate the needed peak discharges QT, in cubic feet per second, having selected recurrence intervals T.

North Coast Region

$Q2 = 3.52\, A^{0.90}\, P^{0.89}\, H^{-0.47}$
$Q5 = 5.04\, A^{0.89}\, P^{0.91}\, H^{-0.35}$
$Q10 = 6.21\, A^{0.88}\, P^{0.93}\, H^{-0.27}$
$Q25 = 7.64\, A^{0.87}\, P^{0.94}\, H^{-0.17}$
$Q50 = 8.57\, A^{0.87}\, P^{0.96}\, H^{-0.08}$
$Q100 = 9.23\, A^{0.87}\, P^{0.97}$

Northeast Region

$Q2 = 22\ A^{0.40}$
$Q5 = 46\ A^{0.45}$
$Q10 = 61\ A^{0.49}$
$Q25 = 84\ A^{0.54}$
$Q50 = 103\ A^{0.57}$
$Q100 = 125\ A^{0.59}$

Sierra Region

$Q2 = 0.24\ A^{0.88}\ P^{1.58}\ H^{-0.80}$
$Q5 = 1.20\ A^{0.82}\ P^{1.37}\ H^{-0.64}$
$Q10 = 2.63\ A^{0.80}\ P^{1.25}\ H^{-0.58}$
$Q25 = 6.55\ A^{0.79}\ P^{1.12}\ H^{-0.52}$
$Q50 = 10.4\ A^{0.78}\ P^{1.06}\ H^{-0.48}$
$Q100 = 15.7\ A^{0.77}\ P^{1.02}\ H^{-0.43}$

Central Coast Region

$Q2 = 0.0061\ A^{0.92}\ P^{2.54}\ H^{-1.10}$
$Q5 = 0.118\ A^{0.91}\ P^{1.95}\ H^{-0.79}$
$Q10 = 0.583\ A^{0.90}\ P^{1.61}\ H^{-0.64}$
$Q25 = 2.91\ A^{0.89}\ P^{1.26}\ H^{-0.50}$
$Q50 = 8.20\ A^{0.89}\ P^{1.03}\ H^{-0.41}$
$Q100 = 19.7\ A^{0.88}\ P^{0.84}\ H^{-0.33}$

South Coast Region

$Q2 = 0.14\ A^{0.72}\ P^{1.62}$
$Q5 = 0.40\ A^{0.77}\ P^{1.69}$
$Q10 = 0.63\ A^{0.79}\ P^{1.75}$
$Q25 = 1.10\ A^{0.81}\ P^{1.81}$
$Q50 = 1.50\ A^{0.82}\ P^{1.85}$
$Q100 = 1.95\ A^{0.83}\ P^{1.87}$

South Lahontan-Colorado Desert Region

$Q2 = 7.3A^{0.30}$
$Q5 = 53A^{0.44}$
$Q10 = 150A^{0.53}$
$Q25 = 410A^{0.63}$
$Q50 = 700A^{0.68}$
$Q100 = 1080A^{0.71}$

In the North Coast region, use a minimum value of 1.0 for the altitude index (H). Equations are defined only for basins of 25 mi² or less in the Northeast and South Lahontan-Colorado Desert regions.

Reference

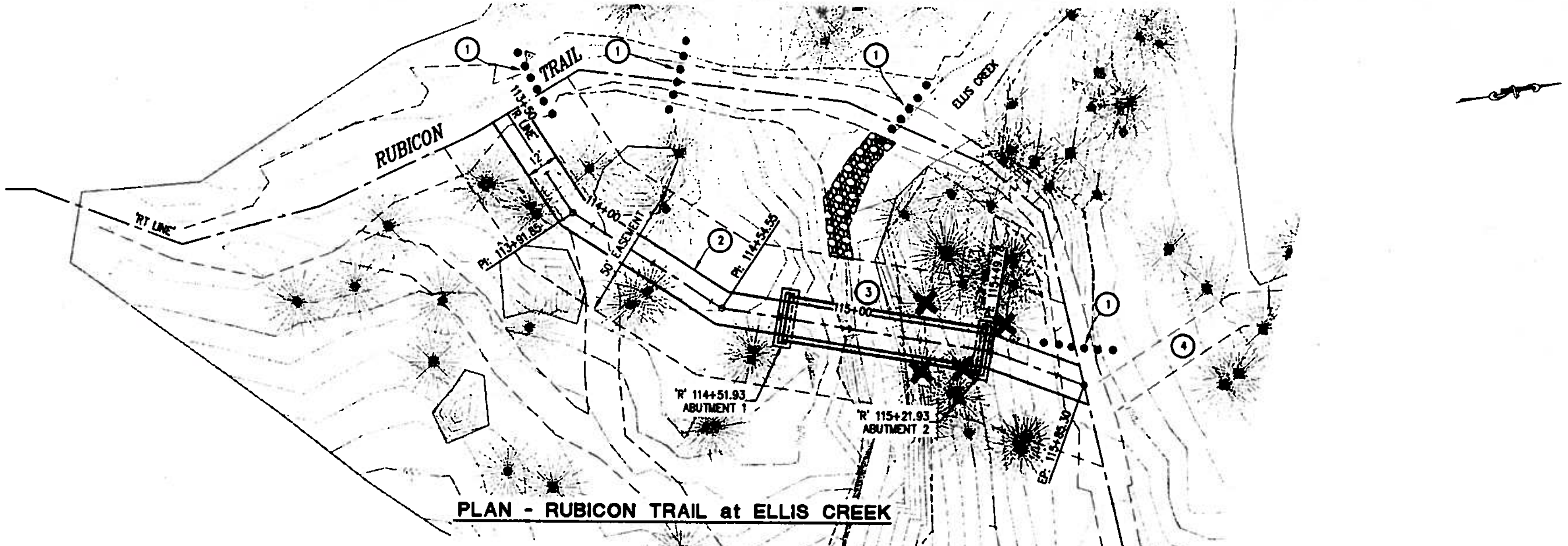
Waananen, A.O., and Crippen, J.R., 1977, Magnitude and frequency of floods in California: U.S. Geological Survey Water-Resources Investigations Report 77-21, 96 p.

Additional Reference

Rantz, S.E., 1969, Mean annual precipitation in the California region: U.S. Geological Survey Open-File Map (Reprinted 1972, 1975).

Figure 1. Flood-frequency region map for California. (PostScript file of Figure 1.)

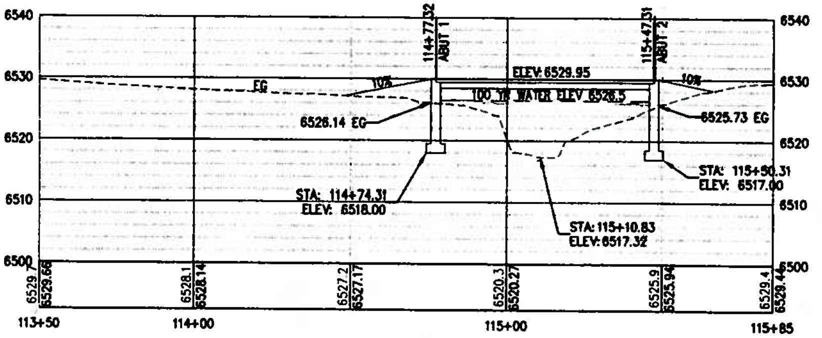
Appendix D: Bridge Plans and Sections



PLAN - RUBICON TRAIL at ELLIS CREEK

CONSTRUCTION NOTES:

① - BOULDERS PLACED TO BLOCK EXISTING TRAIL
② - ESTABLISH 12' WIDE TRAIL. CONTRACTOR TO REMOVE FALLEN LOGS, TREE STUMPS AND ROCKS.
③ - 16'x70' BRIDGE (SEE BRIDGE DETAIL SHEETS).
④ - ACCESS TO 14N05
✕ TREES TO BE REMOVED



5' [illegible]

To be Updated

PROFILE - RUBICON TRAIL at ELLIS CREEK

SCALE: 1"=10'V,20'H

LAYOUT
SCALE : 1" = 20'

REVISION			
NUMBER	DATE	DESCRIPTION	BY

PREPARED UNDER THE SUPERVISION OF
REGISTERED CIVIL ENGINEER
DATE

DESIGNED	DRAWN
DH	RR
CHECKED	DATE
DH	2/25/10
ROAD NUMBER	

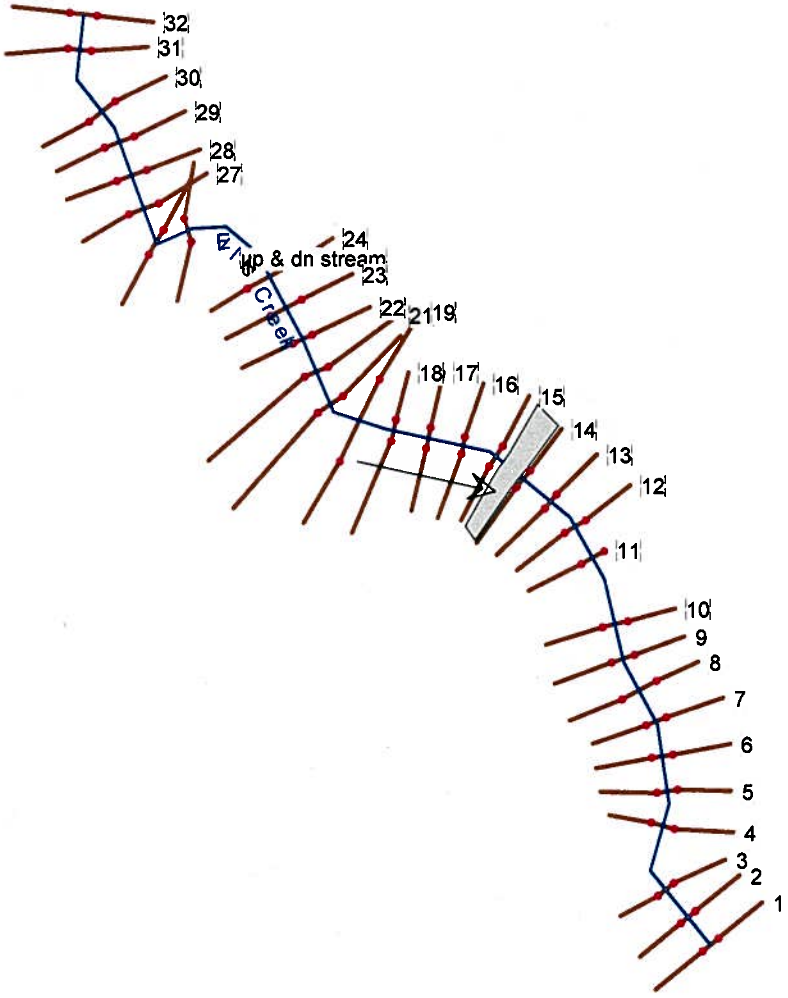
EL DORADO COUNTY
DEPARTMENT OF TRANSPORTATION

RUBICON TRAIL at ELLIS CREEK
BRIDGE REPLACEMENT

SHEET
L-1
3 OF 15
W.O. No. 77117

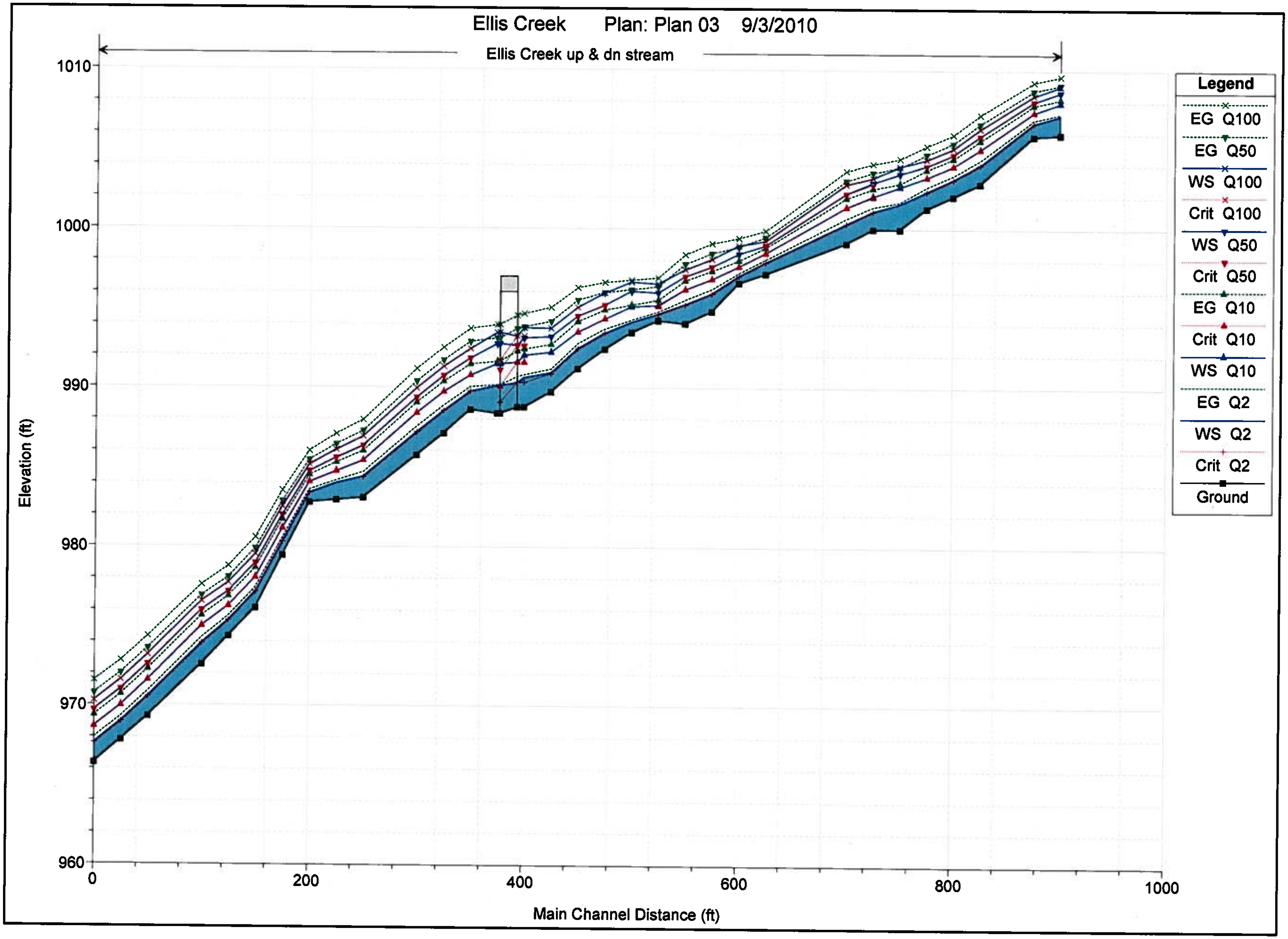
Drawing name: C:\Civil 3D Projects\77117 Ellis Creek\CADD Files\Sheets\L-1.dwg Layout Tab: L-1 Feb 25,2010 - 2:50pm BRichards

Appendix E: Summary of HEC-RAS Output



Some schematic data outside default extents (see View/Set Schematic Plot Extents...)

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



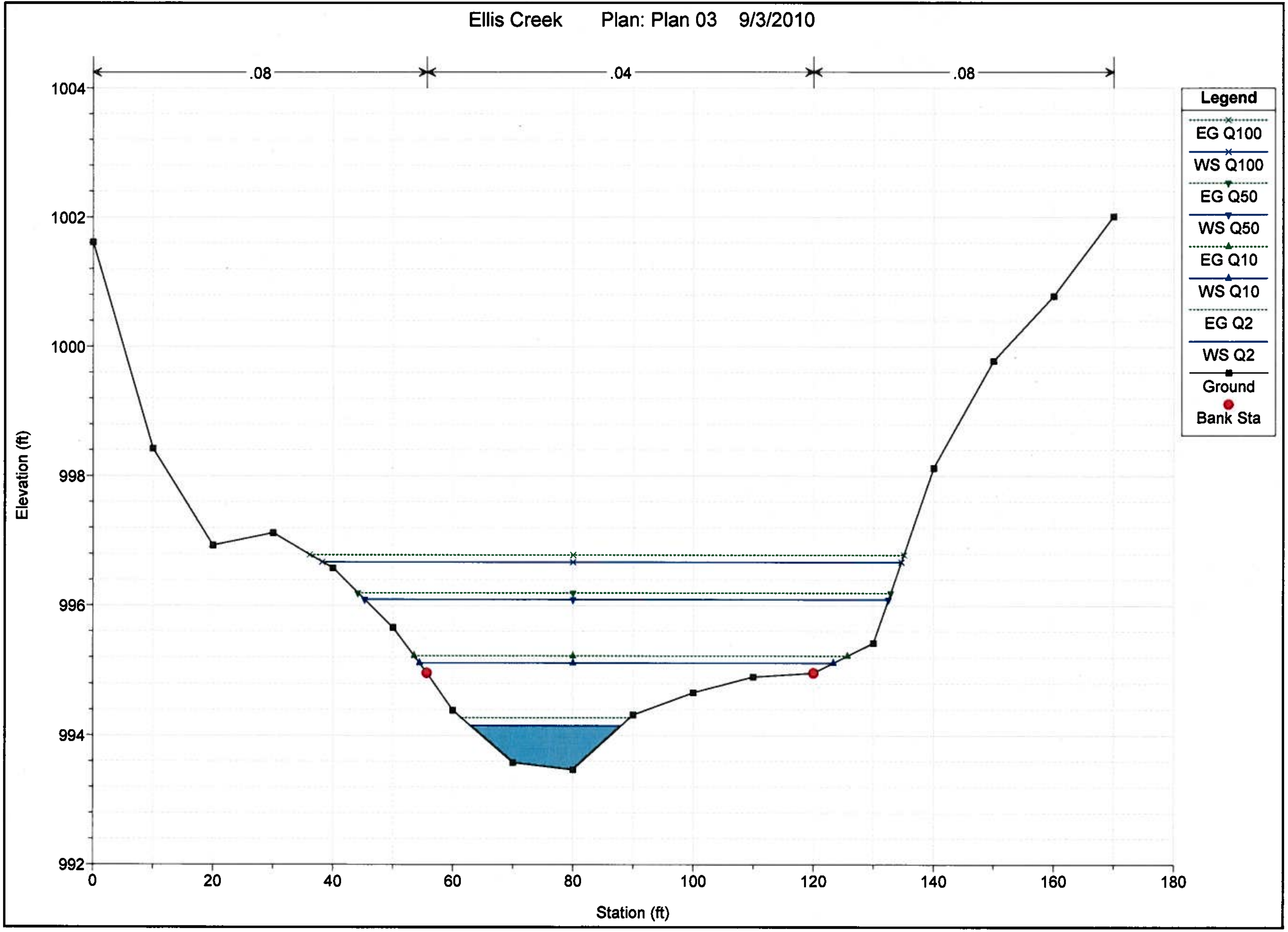
Ellis Creek Plan: Plan 03 9/3/2010

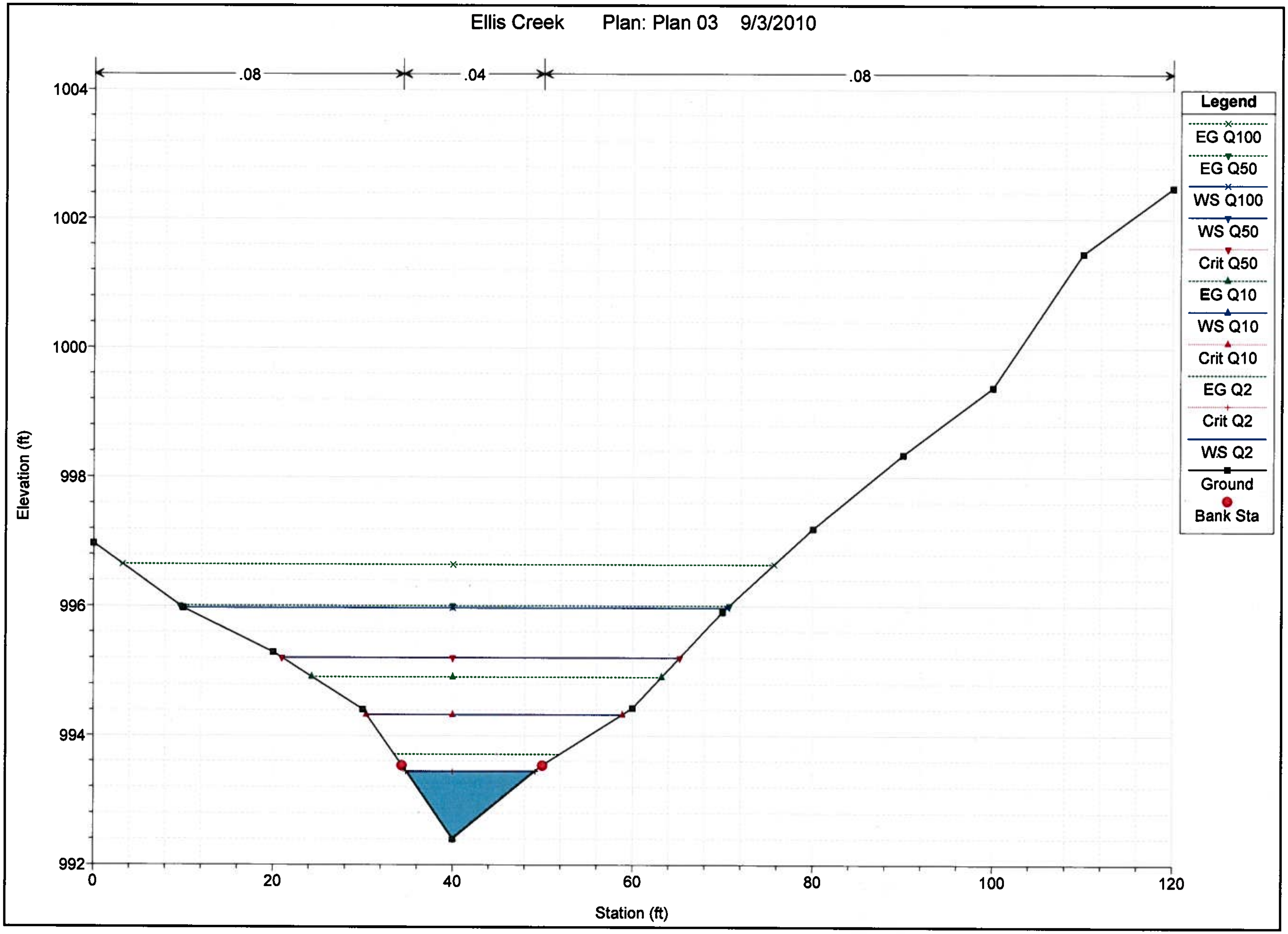
HEC-RAS Plan: Plan 02 River: Ellis Creek Reach: up & dn stream

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
up & dn stream	32	Q2	20.00	1005.95	1007.19		1007.27	0.007849	2.36	8.46	13.68	0.53
up & dn stream	32	Q10	88.00	1005.95	1007.96		1008.21	0.010055	3.99	22.24	21.09	0.66
up & dn stream	32	Q50	200.00	1005.95	1008.64		1009.12	0.010483	5.58	37.84	24.80	0.73
up & dn stream	32	Q100	283.00	1005.95	1009.02		1009.65	0.010847	6.45	47.69	26.89	0.77
up & dn stream	31	Q2	20.00	1005.85	1006.69	1006.69	1006.91	0.032510	3.74	5.34	12.68	1.02
up & dn stream	31	Q10	88.00	1005.85	1007.36	1007.36	1007.82	0.023112	5.47	16.88	21.22	0.98
up & dn stream	31	Q50	200.00	1005.85	1008.04	1008.04	1008.75	0.018353	6.96	33.42	27.06	0.96
up & dn stream	31	Q100	283.00	1005.85	1008.43	1008.43	1009.29	0.017129	7.75	44.53	30.08	0.96
up & dn stream	30	Q2	20.00	1002.86	1004.07	1004.07	1004.37	0.029797	4.43	4.52	7.48	1.00
up & dn stream	30	Q10	88.00	1002.86	1005.04	1005.04	1005.59	0.024852	5.99	14.69	13.49	1.01
up & dn stream	30	Q50	200.00	1002.86	1005.88	1005.88	1006.66	0.022289	7.07	28.30	18.70	1.01
up & dn stream	30	Q100	283.00	1002.86	1006.33	1006.33	1007.22	0.021254	7.58	37.34	21.43	1.01
up & dn stream	29	Q2	20.00	1002.06	1003.15	1003.12	1003.39	0.026566	3.95	5.06	9.33	0.95
up & dn stream	29	Q10	88.00	1002.06	1003.97	1003.97	1004.46	0.025300	5.62	15.65	16.41	1.01
up & dn stream	29	Q50	200.00	1002.06	1004.71	1004.71	1005.43	0.021947	6.83	29.30	20.47	1.01
up & dn stream	29	Q100	283.00	1002.06	1005.10	1005.10	1005.97	0.021112	7.49	37.78	22.61	1.01
up & dn stream	28	Q2	20.00	1001.31	1002.39	1002.39	1002.66	0.030763	4.22	4.74	8.81	1.01
up & dn stream	28	Q10	88.00	1001.31	1003.26	1003.26	1003.76	0.025111	5.67	15.52	15.94	1.01
up & dn stream	28	Q50	200.00	1001.31	1004.00	1004.00	1004.73	0.022366	6.83	29.29	20.78	1.01
up & dn stream	28	Q100	283.00	1001.31	1004.40	1004.40	1005.26	0.021202	7.45	38.00	23.14	1.01
up & dn stream	27	Q2	20.00	1000.00	1001.62		1001.71	0.005621	2.35	8.52	10.52	0.46
up & dn stream	27	Q10	88.00	1000.00	1002.67		1002.90	0.007551	3.80	23.17	17.35	0.58
up & dn stream	27	Q50	200.00	1000.00	1003.50		1003.90	0.008967	5.04	39.71	22.41	0.66
up & dn stream	27	Q100	283.00	1000.00	1003.96		1004.46	0.008369	5.66	50.62	25.06	0.66
up & dn stream	26	Q2	20.00	1000.00	1001.15	1001.13	1001.42	0.027578	4.16	4.81	8.37	0.97
up & dn stream	26	Q10	88.00	1000.00	1002.07	1002.04	1002.56	0.023053	5.63	15.62	15.09	0.98
up & dn stream	26	Q50	200.00	1000.00	1002.94	1002.83	1003.57	0.017524	6.37	31.43	21.41	0.91
up & dn stream	26	Q100	283.00	1000.00	1003.23	1003.23	1004.11	0.019630	7.57	37.95	23.63	0.99
up & dn stream	25	Q2	20.00	999.12	1000.37	1000.37	1000.69	0.030514	4.55	4.40	7.06	1.02
up & dn stream	25	Q10	88.00	999.12	1001.38	1001.38	1001.95	0.024896	6.10	14.42	12.79	1.01
up & dn stream	25	Q50	200.00	999.12	1002.24	1002.24	1003.06	0.022003	7.27	27.63	19.22	1.01
up & dn stream	25	Q100	283.00	999.12	1002.81	1002.81	1003.66	0.015367	7.44	43.00	39.58	0.89
up & dn stream	24	Q2	20.00	997.18	997.91	997.91	998.09	0.034623	3.46	5.78	15.99	1.02
up & dn stream	24	Q10	88.00	997.18	998.49	998.49	998.83	0.028165	4.64	18.96	28.97	1.01
up & dn stream	24	Q50	200.00	997.18	998.99	998.99	999.50	0.024032	5.76	34.73	34.05	1.00
up & dn stream	24	Q100	283.00	997.18	999.26	999.26	999.89	0.022870	6.39	44.31	36.19	1.01
up & dn stream	23	Q2	20.00	996.59	997.05	997.05	997.23	0.033212	3.41	5.87	16.35	1.00
up & dn stream	23	Q10	88.00	996.59	997.65	997.64	998.02	0.025996	4.87	18.07	24.57	1.00
up & dn stream	23	Q50	200.00	996.59	998.45		998.87	0.011307	5.25	39.71	29.33	0.74
up & dn stream	23	Q100	283.00	996.59	998.98		999.43	0.008182	5.44	56.23	32.85	0.67
up & dn stream	22	Q2	20.00	994.80	995.95	995.93	996.22	0.028278	4.20	4.76	8.29	0.98
up & dn stream	22	Q10	88.00	994.80	996.85	996.85	997.37	0.024207	5.78	15.22	14.82	1.00
up & dn stream	22	Q50	200.00	994.80	997.63	997.63	998.47	0.019037	7.42	28.91	20.54	0.97
up & dn stream	22	Q100	283.00	994.80	998.11	998.11	999.10	0.016569	8.11	39.75	24.13	0.94
up & dn stream	21	Q2	20.00	994.03	995.26	995.23	995.54	0.026553	4.24	4.72	7.68	0.95
up & dn stream	21	Q10	88.00	994.03	996.20	996.20	996.76	0.024946	5.99	14.69	13.55	1.01
up & dn stream	21	Q50	200.00	994.03	997.03	997.03	997.82	0.022252	7.14	28.05	19.00	1.02
up & dn stream	21	Q100	283.00	994.03	997.45	997.45	998.41	0.019414	7.86	37.13	23.30	0.99
up & dn stream	20	Q2	20.00	994.23	994.66	994.64	994.79	0.029752	2.98	6.74	21.91	0.93
up & dn stream	20	Q10	88.00	994.23	995.20	995.15	995.53	0.019823	4.71	20.30	28.33	0.90
up & dn stream	20	Q50	200.00	994.23	995.98		996.38	0.010361	5.26	46.35	37.92	0.72
up & dn stream	20	Q100	283.00	994.23	996.55		996.94	0.007072	5.30	70.20	45.90	0.63
up & dn stream	19	Q2	31.00	993.47	994.15		994.28	0.017093	2.81	11.05	25.11	0.75
up & dn stream	19	Q10	140.00	993.47	995.11		995.22	0.006716	2.66	52.97	68.90	0.52
up & dn stream	19	Q50	317.00	993.47	996.09		996.20	0.002326	2.65	131.08	87.21	0.35
up & dn stream	19	Q100	450.00	993.47	996.68		996.79	0.001765	2.78	184.30	96.42	0.32
up & dn stream	18	Q2	31.00	992.40	993.45	993.45	993.71	0.029607	4.12	7.52	14.37	1.00
up & dn stream	18	Q10	140.00	992.40	994.33	994.33	994.91	0.019149	6.26	26.31	28.46	0.95
up & dn stream	18	Q50	317.00	992.40	995.20	995.20	996.01	0.015125	7.75	58.07	44.24	0.91
up & dn stream	18	Q100	450.00	992.40	995.97		996.65	0.009335	7.41	98.24	60.51	0.75
up & dn stream	17	Q2	31.00	991.18	992.47	992.47	992.79	0.028728	4.59	6.76	10.51	1.01
up & dn stream	17	Q10	140.00	991.18	993.50	993.50	994.17	0.021246	6.62	21.90	18.80	0.99
up & dn stream	17	Q50	317.00	991.18	994.50	994.50	995.52	0.016195	8.30	44.87	26.75	0.94
up & dn stream	17	Q100	450.00	991.18	995.06	995.06	996.30	0.015335	9.28	60.98	31.80	0.95
up & dn stream	16	Q2	31.00	989.71	990.94	990.87	991.18	0.019872	3.89	7.99	12.47	0.84

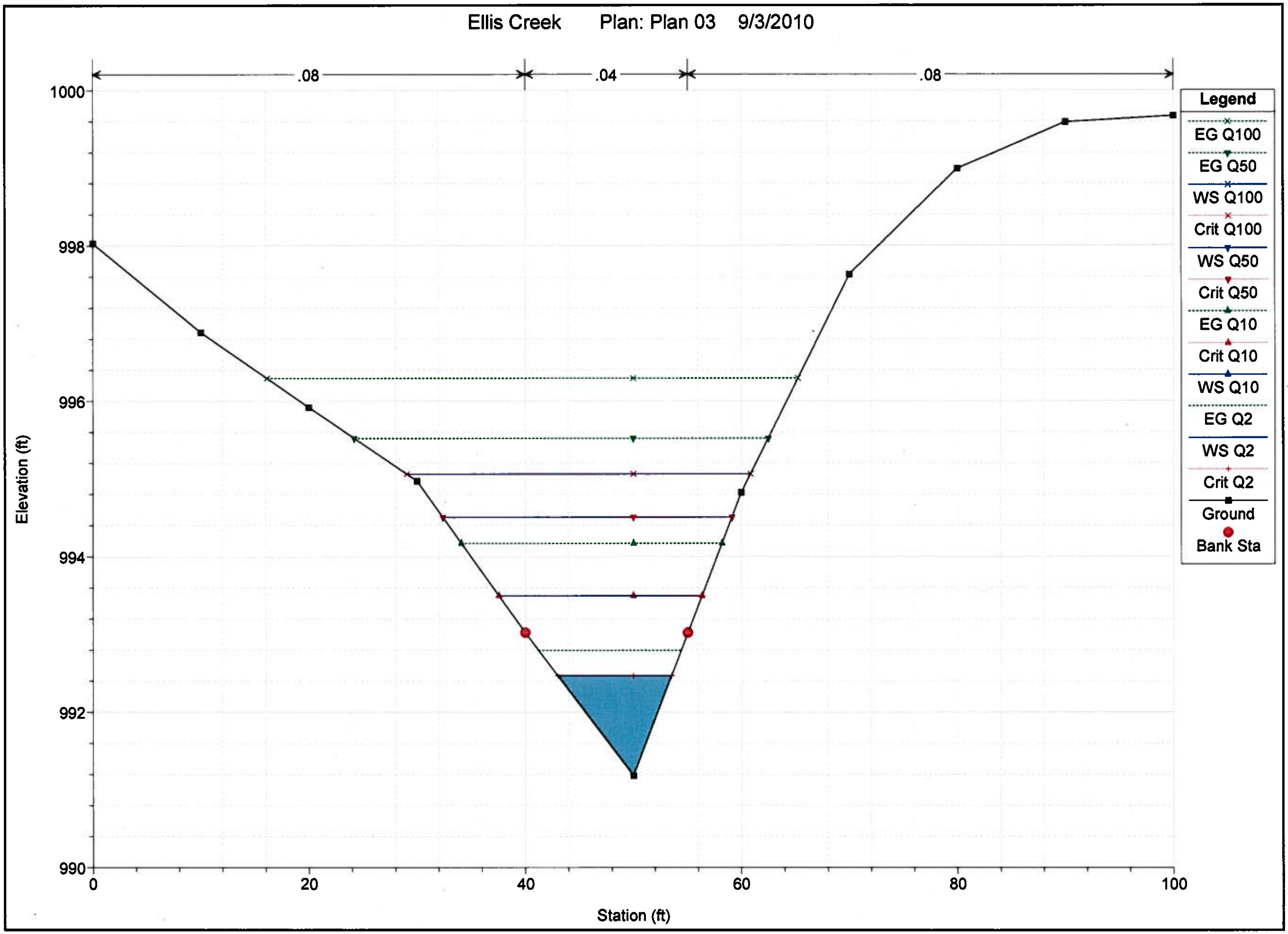
HEC-RAS Plan: Plan 02 River: Ellis Creek Reach: up & dn stream (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
up & dn stream	16	Q10	140.00	989.71	992.23		992.72	0.010161	5.72	27.48	17.86	0.72
up & dn stream	16	Q50	317.00	989.71	993.20		994.19	0.012369	8.27	46.86	21.95	0.85
up & dn stream	16	Q100	450.00	989.71	993.74		995.06	0.013571	9.69	59.19	24.20	0.92
up & dn stream	15	Q2	31.00	988.76	990.64	990.30	990.82	0.010012	3.40	9.12	9.70	0.62
up & dn stream	15	Q10	140.00	988.76	992.03	991.58	992.43	0.010642	5.07	27.61	16.88	0.70
up & dn stream	15	Q50	317.00	988.76	993.13	992.62	993.83	0.009643	6.76	49.32	22.67	0.72
up & dn stream	15	Q100	450.00	988.76	993.76	993.24	994.65	0.009361	7.66	64.86	26.77	0.74
up & dn stream	14.1		Bridge									
up & dn stream	14	Q2	31.00	988.36	990.13		990.17	0.000960	1.41	21.95	15.61	0.21
up & dn stream	14	Q10	140.00	988.36	991.49		991.66	0.002076	3.24	46.13	19.95	0.34
up & dn stream	14	Q50	317.00	988.36	992.76		993.12	0.002901	4.91	74.04	24.00	0.43
up & dn stream	14	Q100	450.00	988.36	993.46		993.96	0.003347	5.85	91.49	26.41	0.47
up & dn stream	13	Q2	31.00	988.60	989.77	989.77	990.07	0.029456	4.39	7.07	12.07	1.01
up & dn stream	13	Q10	140.00	988.60	990.78	990.78	991.48	0.019503	6.84	22.54	18.48	0.97
up & dn stream	13	Q50	317.00	988.60	991.84	991.84	992.91	0.015521	8.65	45.72	24.98	0.94
up & dn stream	13	Q100	450.00	988.60	992.43	992.43	993.73	0.014897	9.69	61.43	28.77	0.95
up & dn stream	12	Q2	31.00	987.10	988.54	988.54	988.90	0.028065	4.83	6.42	8.91	1.00
up & dn stream	12	Q10	140.00	987.10	989.73	989.73	990.39	0.023207	6.56	21.34	16.25	1.01
up & dn stream	12	Q50	317.00	987.10	990.73	990.73	991.74	0.017385	8.14	41.73	24.67	0.96
up & dn stream	12	Q100	450.00	987.10	991.31	991.31	992.52	0.015621	8.99	57.63	31.15	0.94
up & dn stream	11	Q2	31.00	985.73	987.19	987.19	987.56	0.028131	4.88	6.36	8.70	1.01
up & dn stream	11	Q10	140.00	985.73	988.39	988.39	989.08	0.023326	6.63	21.13	15.86	1.01
up & dn stream	11	Q50	317.00	985.73	989.37	989.37	990.41	0.019440	8.18	39.69	21.51	1.00
up & dn stream	11	Q100	450.00	985.73	989.95	989.95	991.20	0.017097	9.02	52.83	24.13	0.97
up & dn stream	10	Q2	31.00	983.06	984.40	984.35	984.68	0.023627	4.28	7.24	10.80	0.92
up & dn stream	10	Q10	140.00	983.06	985.40	985.40	986.02	0.023631	6.32	22.17	18.97	1.02
up & dn stream	10	Q50	317.00	983.06	986.34	986.34	987.28	0.017058	7.87	44.39	29.69	0.95
up & dn stream	10	Q100	450.00	983.06	986.91	986.91	987.98	0.014592	8.53	63.48	37.25	0.91
up & dn stream	9	Q2	31.00	982.91	983.99		984.15	0.016925	3.27	9.49	17.47	0.77
up & dn stream	9	Q10	140.00	982.91	984.71	984.71	985.29	0.020006	6.19	25.47	26.06	0.96
up & dn stream	9	Q50	317.00	982.91	985.56	985.56	986.44	0.016492	7.88	51.45	35.05	0.95
up & dn stream	9	Q100	450.00	982.91	986.07	986.07	987.09	0.015211	8.71	70.36	40.54	0.94
up & dn stream	8	Q2	31.00	982.76	983.37	983.37	983.58	0.032080	3.67	8.45	20.57	1.01
up & dn stream	8	Q10	140.00	982.76	984.04	984.04	984.50	0.023667	5.45	26.19	31.18	0.99
up & dn stream	8	Q50	317.00	982.76	984.72	984.72	985.46	0.018932	7.00	49.50	38.05	0.97
up & dn stream	8	Q100	450.00	982.76	985.13	985.13	986.02	0.017155	7.76	66.06	42.26	0.96
up & dn stream	7	Q2	31.00	979.41	980.27	980.27	980.52	0.029615	4.04	7.80	17.08	1.00
up & dn stream	7	Q10	140.00	979.41	981.12	981.12	981.69	0.019369	6.31	26.72	26.82	0.96
up & dn stream	7	Q50	317.00	979.41	981.96	981.96	982.86	0.016956	8.14	52.62	35.00	0.97
up & dn stream	7	Q100	450.00	979.41	982.49	982.49	983.52	0.015237	8.92	72.99	41.86	0.95
up & dn stream	6	Q2	31.00	976.12	977.15	977.15	977.41	0.030004	4.10	7.56	14.68	1.01
up & dn stream	6	Q10	140.00	976.12	978.04	978.04	978.65	0.019540	6.41	24.79	24.05	0.96
up & dn stream	6	Q50	317.00	976.12	978.94	978.94	979.87	0.016140	8.15	50.39	32.24	0.95
up & dn stream	6	Q100	450.00	976.12	979.49	979.49	980.56	0.014641	8.95	69.47	37.56	0.94
up & dn stream	5	Q2	31.00	974.34	975.34	975.34	975.60	0.030686	4.14	7.49	14.88	1.02
up & dn stream	5	Q10	140.00	974.34	976.24	976.24	976.86	0.019174	6.44	25.23	24.43	0.95
up & dn stream	5	Q50	317.00	974.34	977.15	977.15	978.07	0.016014	8.19	51.24	32.58	0.95
up & dn stream	5	Q100	450.00	974.34	977.69	977.69	978.77	0.014673	9.02	70.29	37.61	0.94
up & dn stream	4	Q2	31.00	972.56	973.90	973.90	974.25	0.028821	4.71	6.58	9.80	1.01
up & dn stream	4	Q10	140.00	972.56	975.00	975.00	975.65	0.023188	6.47	21.71	18.55	1.01
up & dn stream	4	Q50	317.00	972.56	975.98	975.98	976.91	0.016089	7.90	46.85	31.97	0.93
up & dn stream	4	Q100	450.00	972.56	976.55	976.55	977.60	0.014017	8.57	67.30	39.99	0.90
up & dn stream	3	Q2	31.00	969.28	970.54	970.54	970.86	0.029126	4.56	6.79	10.78	1.01
up & dn stream	3	Q10	140.00	969.28	971.56	971.56	972.24	0.020476	6.65	22.36	19.66	0.98
up & dn stream	3	Q50	317.00	969.28	972.58	972.58	973.58	0.015761	8.32	46.82	28.54	0.94
up & dn stream	3	Q100	450.00	969.28	973.17	973.17	974.33	0.014273	9.14	65.11	33.56	0.92
up & dn stream	2	Q2	31.00	967.81	968.98	968.98	969.28	0.029109	4.37	7.10	12.12	1.01
up & dn stream	2	Q10	140.00	967.81	969.97	969.97	970.66	0.019410	6.74	23.07	19.86	0.96
up & dn stream	2	Q50	317.00	967.81	970.99	970.99	972.02	0.015626	8.52	47.33	27.55	0.94
up & dn stream	2	Q100	450.00	967.81	971.58	971.58	972.79	0.014454	9.41	64.84	31.80	0.94
up & dn stream	1	Q2	31.00	966.35	967.62	967.62	967.95	0.029180	4.59	6.75	10.62	1.01
up & dn stream	1	Q10	140.00	966.35	968.65	968.65	969.35	0.020805	6.72	21.87	18.38	0.98
up & dn stream	1	Q50	317.00	966.35	969.68	969.68	970.74	0.016141	8.47	44.53	25.56	0.95
up & dn stream	1	Q100	450.00	966.35	970.27	970.27	971.53	0.015016	9.40	60.70	29.76	0.95


Ellis Creek Plan: Plan 03 9/3/2010
.08
.04
.08
Elevation (ft)
1004
1002
1000
998
996
994
992
Station (ft)
0
20
40
60
80
100
120
140
160
180
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q10
WS Q10
EG Q2
WS Q2
Ground
Bank Sta



Ellis Creek   Plan: Plan 03   9/3/2010


Ellis Creek Plan: Plan 03 9/3/2010
.08
.04
.08
Elevation (ft)
1000
998
996
994
992
990
0
20
40
60
80
100
Station (ft)
Legend
EG Q100
EG Q50
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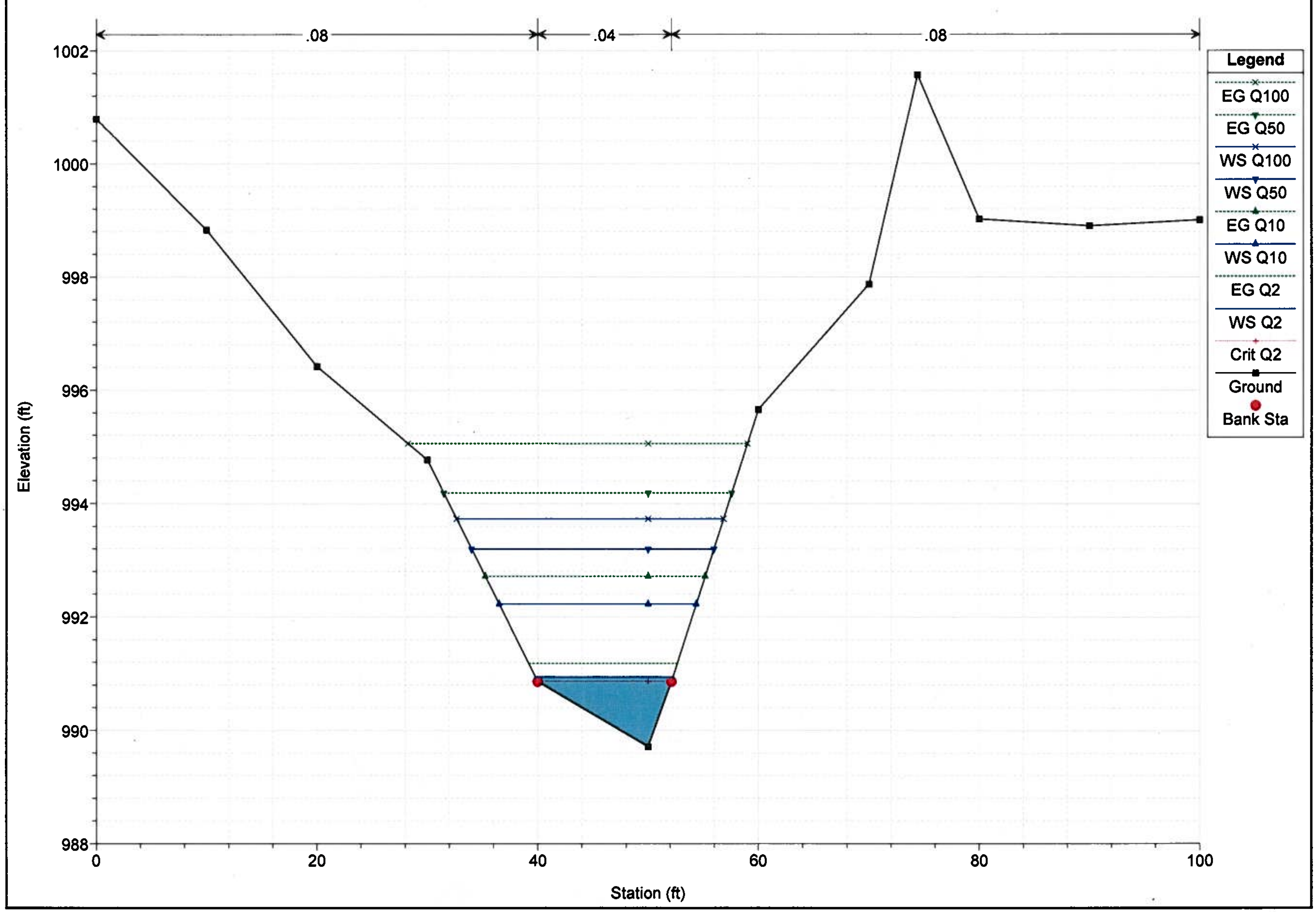
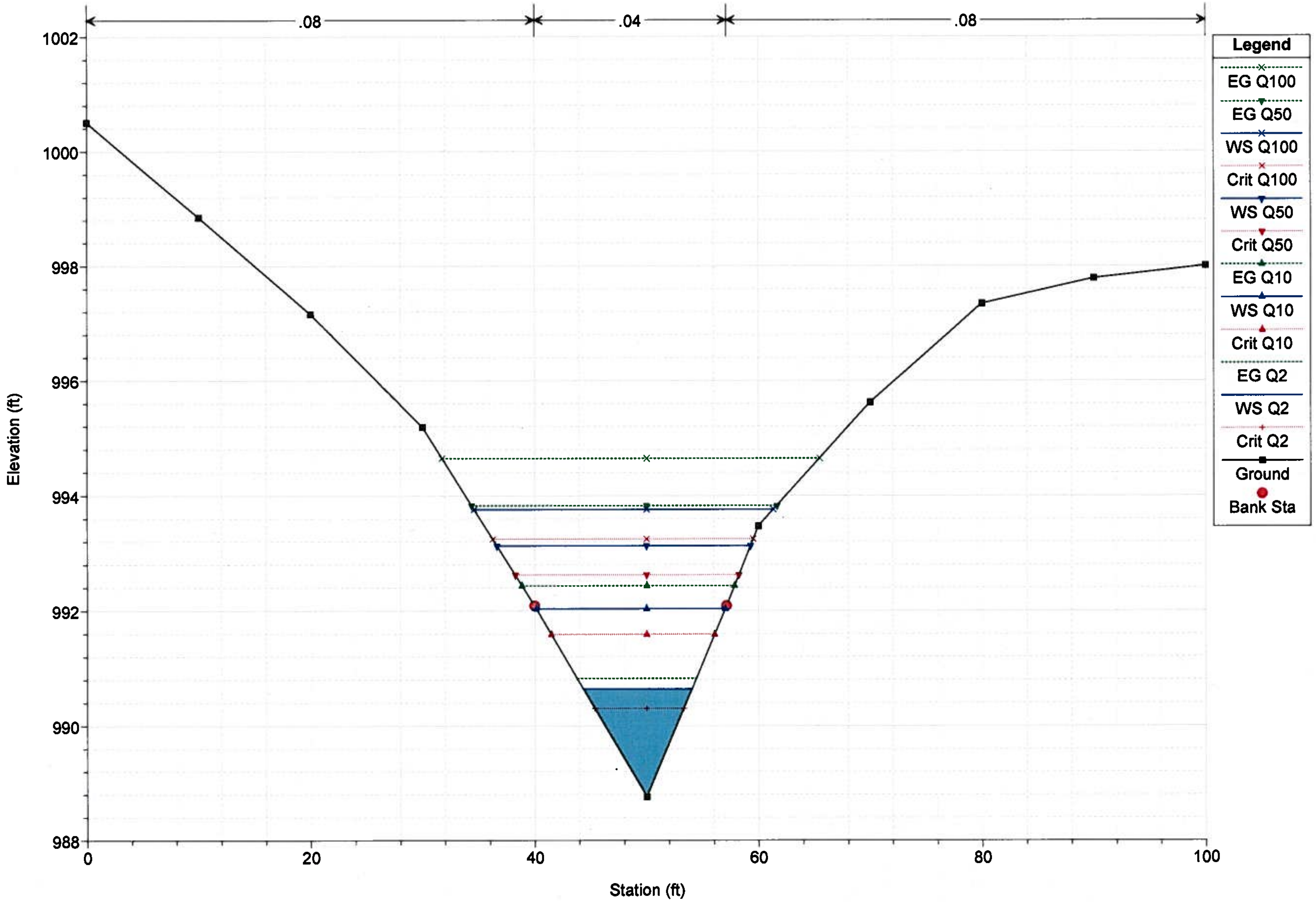
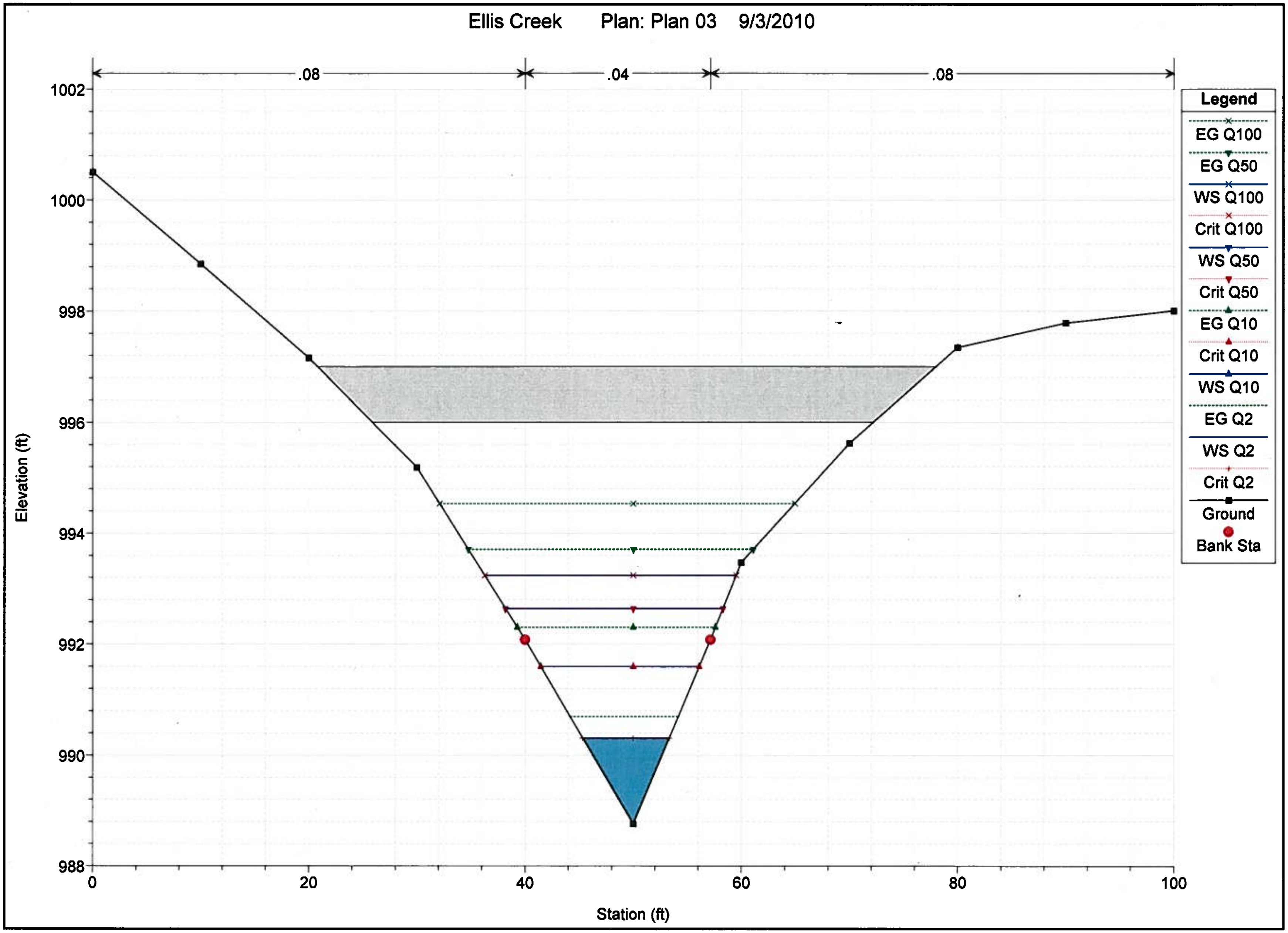
EG Q2
WS Q2
Crit Q2
Ground
Bank Sta



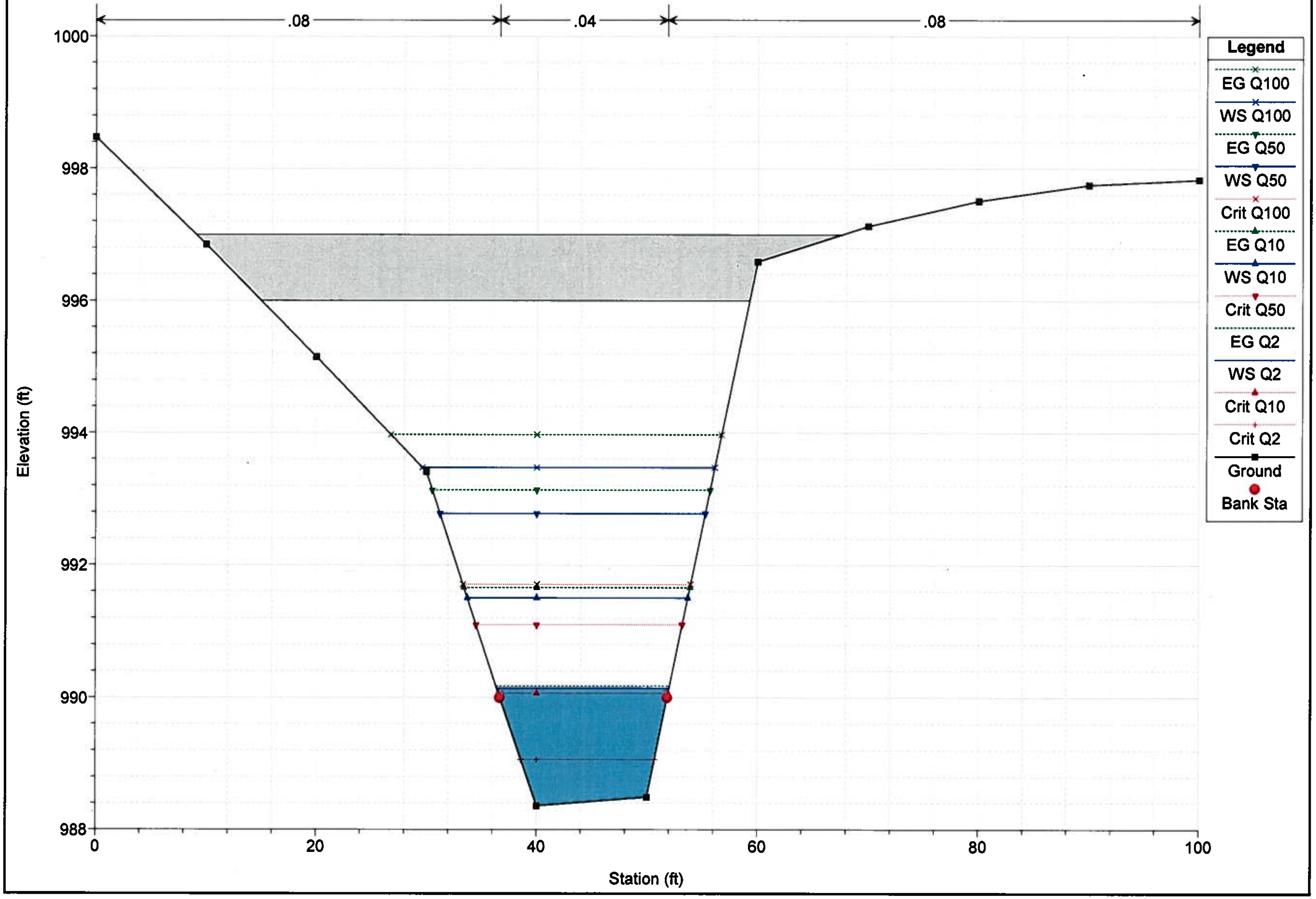
Ellis Creek Plan: Plan 03 9/3/2010

Ellis Creek Plan: Plan 03 9/3/2010

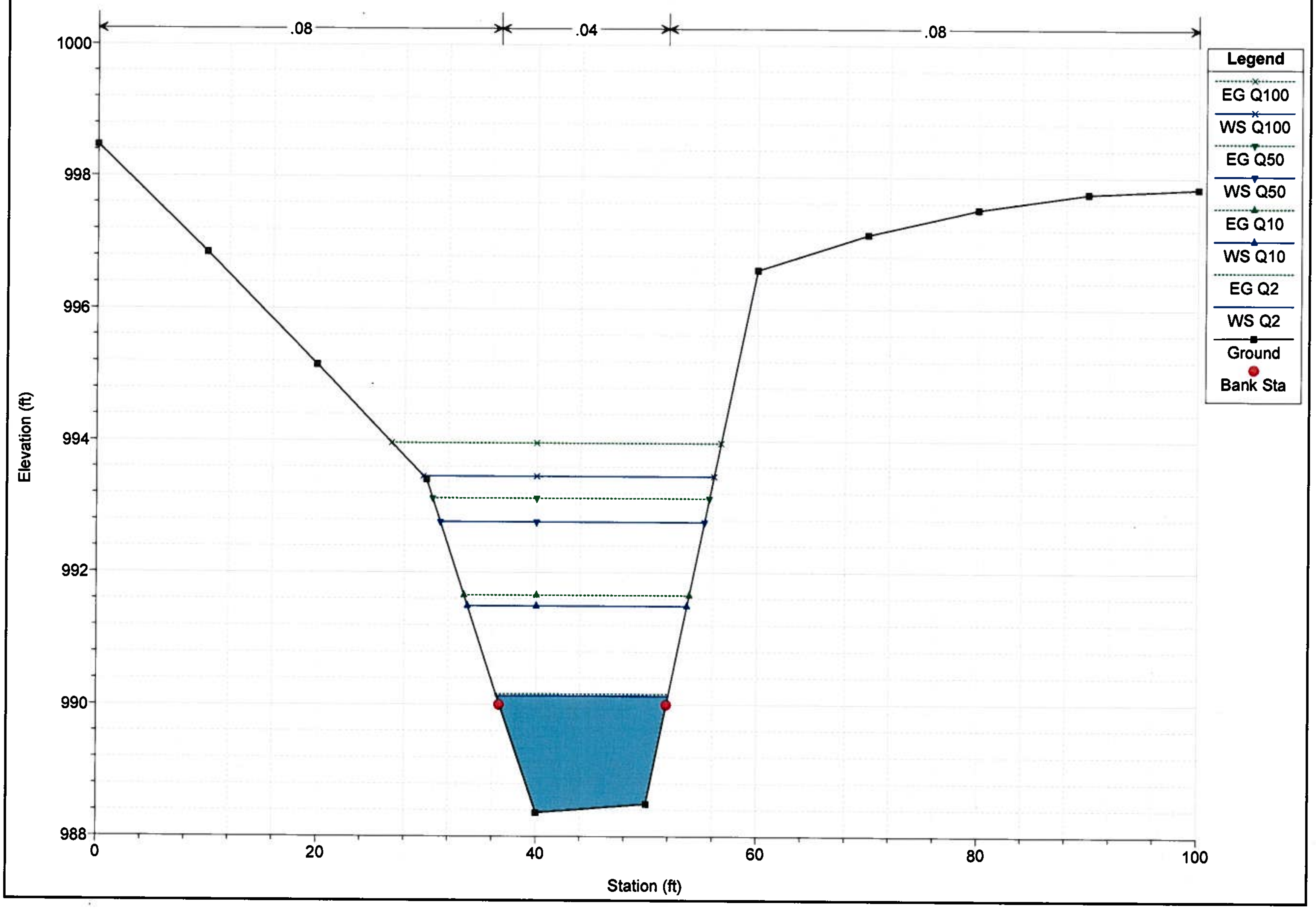



Ellis Creek Plan: Plan 03 9/3/2010

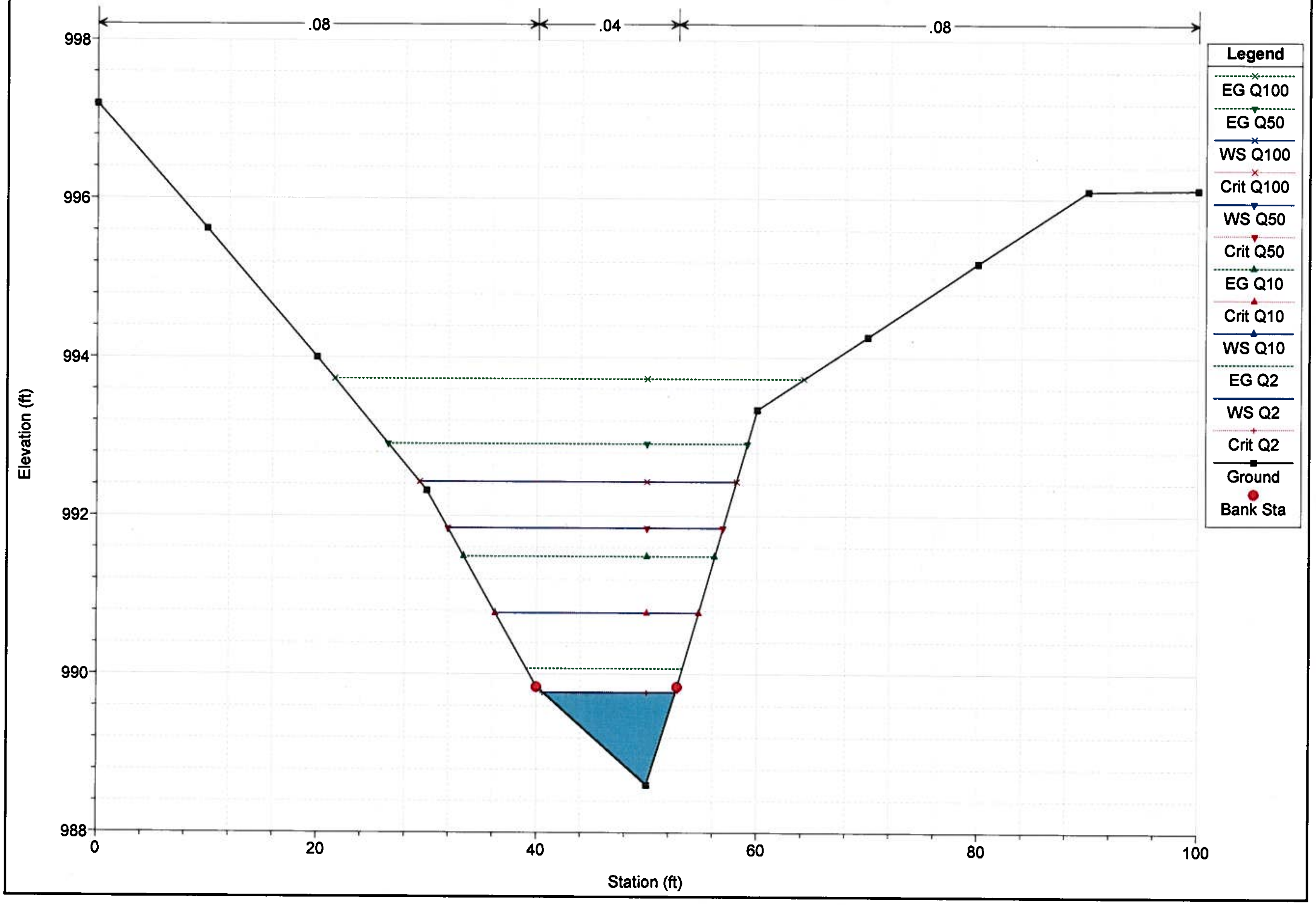
Ellis Creek   Plan: Plan 03   9/3/2010

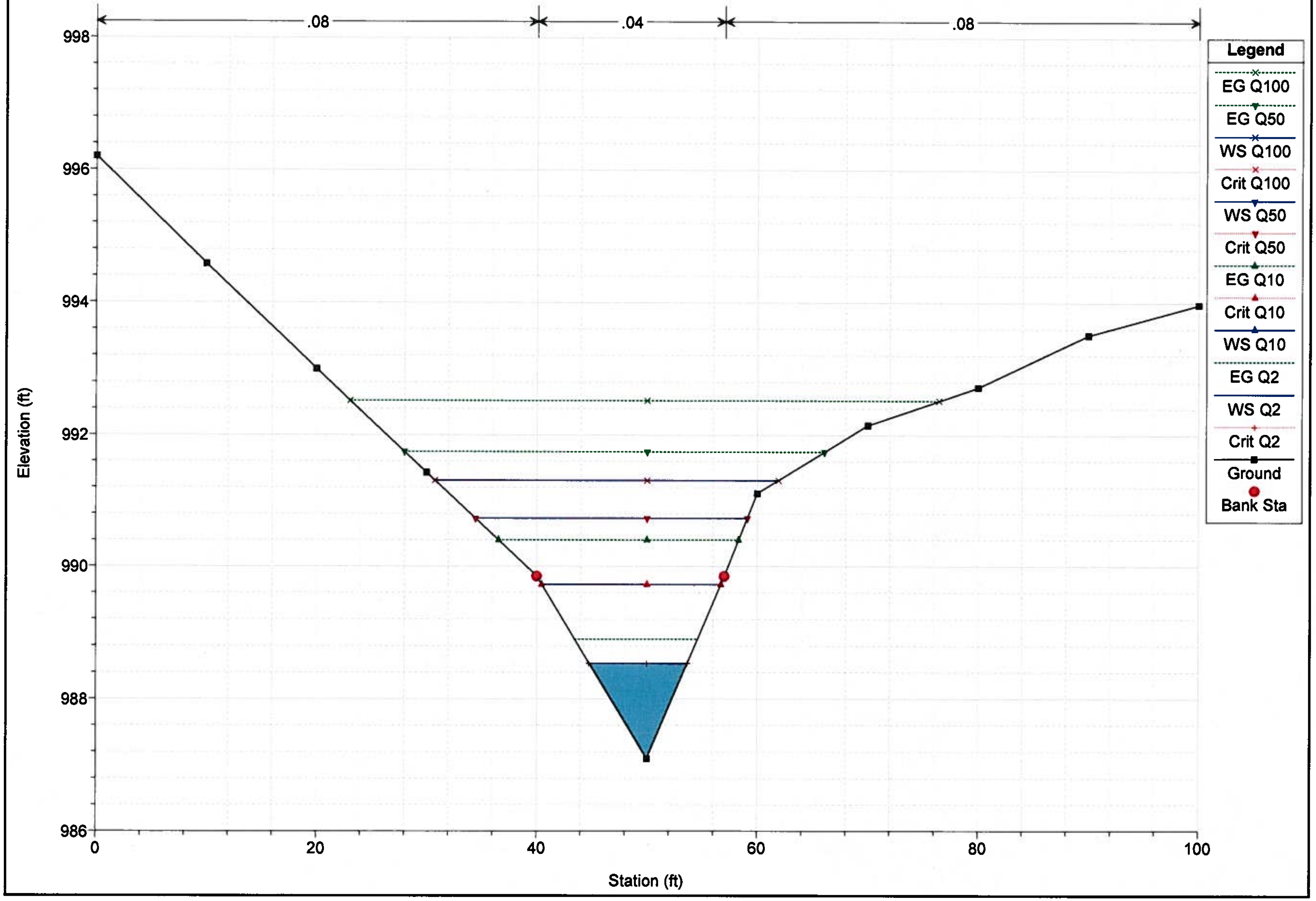


Ellis Creek Plan: Plan 03 9/3/2010



Ellis Creek Plan: Plan 03 9/3/2010





Ellis Creek Plan: Plan 03 9/3/2010