Appendix P

Draft Bridge Design Hydraulic Study For the State Route 32 Widening Between Fir Street and Yosemite Drive at Dead Horse Slough and South Fork Dead Horse Slough in the City of Chico, California

Draft

Bridge Design Hydraulic Study

For the State Route 32 Widening
Between Fir Street and Yosemite Drive
At Dead Horse Slough and South Fork Dead Horse Slough
in the City of Chico, California

Prepared for

City of Chico
Department of Public Works

Mark Thomas and Company, Inc

Prepared By

WRECO

August 2006

Draft

Bridge Design Hydraulic Study

For the State Route 32 Widening Between Fir Street and Yosemite Drive Over Dead Horse Slough and South Fork Dead Horse Slough in the City of Chico, California

Submitted to

City of Chico
Department of Public Works
&
Mark Thomas and Company, Inc

This report has been prepared by or under the supervision of the following Registered Engineer. The Registered Civil Engineer attests to the technical information contained herein and has judged the qualifications of any technical specialists providing engineering data upon which recommendations, conclusions, and decisions are based.

_____
Han-Bin Liang, Ph.D., P.E.
Registered Civil Engineer

WRECO

April 2006

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PHOTOS

LIST OF FIGURES

APPENDICES

EXECUTIVE SUMMARY

This study presents the hydrologic and hydraulic assessment of Dead Horse Slough and South Fork Dead Horse Slough crossings of State Route 32 (SR 32) in the existing and proposed conditions. The city of Chico is proposing to widen SR 32 from 2 lanes to 4 lanes between Fir Street to just east of Yosemite Drive in the city of Chico, California.

The widening project is necessary to accommodate major development projects planned for the area. The project is in the city's General Plan and is planned to go to construction in 2008. The proposed improvements include widening the stream crossings which will affect the hydraulics of the Dead Horse Slough and South Fork Dead Horse Slough.

The South Fork Dead Horse Slough flows north-north-west under SR 32 through a box culvert just east of Bruce Road (and just downstream of California Park Lake). Just north of SR 32, South Fork Dead Horse Slough joins the main Dead Horse Slough then flows west under Bruce Road and roughly parallels SR 32 on the north side for 450 feet (ft) until the slough turns south and passes under SR 32 beneath the Dead Horse Slough Bridge (CT Bridge No. 12C-0138). Dead Horse Slough flows into Little Chico Creek 740 ft downstream of the SR 32 crossing.

The proposed improvement to the main Dead Horse Slough crossing is to widen the existing bridge by approximately 49 feet to the north to make the total bridge width 81.5 ft. The widening will include extension of the 3 pile bents and 2 abutments. The existing bridge will not be lengthened.

The proposed improvement to the South Fork Dead Horse Slough crossing is to extend the existing 8'x6' box culvert. This will be done by extending the culvert 14 feet to the south, and 39.5 feet to the North with new headwalls.

The water surface elevations and flow velocities in *Table 1* are located at the modeled cross-section just upstream of the proposed SR 32 Bridge over Dead Horse Slough. The downstream controlling water surface elevation is based on the FEMA 100-year flood elevation. This information was obtained from the current FEMA Flood Insurance Study (FIS) for Butte Count and Incorporated Areas (2000), and the 2005 FEMA issued Letter of Map Revision (LOMR) for the area. The proposed bridge design has 2.21 ft above the Q200 flood. This does not meet the city of Chico's stringent freeboard design criteria of 3 ft above the 200-year flood, but does meet Federal Highway Administration's (FHWA) and Caltrans design criteria for bridges on State highways. The Caltrans' criteria are 100-year without freeboard and 50-year plus 2 ft of freeboard for bridges.

Table 1 - Hydraulic Summary – Dead Horse Slough at SR 32

Design Flow Return Period	Design Flow (ft^3/s)	Bridge Soffit Elevation (est.) (ft)	Water Surface Elevation (ft)	Freeboard (ft)	Velocity (ft/s)
200-year	2,200	~240.7	238.49	2.21	5.72
100-year	1,900	~240.7	237.96	2.74	5.45
50-year	1,500	~240.7	237.24	3.46	5.07

The water surface elevations in *Table 2* are at the modeled cross-section just upstream of the proposed RCB culvert under SR 32 along South Fork Dead Horse Slough. The culvert design meets Caltrans' design criteria of the culvert not causing objectionable backwater during 100-year event", and the 100-year water surface will not spread into the travel way.

Table 2 - Hydraulic Summary – South Fork Dead Horse Slough at SR 32

Return Period	Design Flow (ft^3/s)	Edge of Travel Way Elev. (ft)	RCB Top Elev. (est.) (ft)	Water Surface Elevation (ft)	Upstream Velocity** (ft/s)	Downstream Velocity*** (ft/s)
100-year	470	~255.8	252.3	254.55	0.54	18.97
50-year	430	~255.8	252.3	254.13	0.57	18.65
25-year	360	~255.8	252.3	253.26	0.64	17.93
10-year	290	~255.8	252.3	252.31	0.70	17.07

*the 10-year water surface as indicated is at the cross-section upstream of the culvert opening. The 10-year water surface elevation at the culvert opening is 249.73 feet as indicated in Appendix B.
**the Upstream Velocities as indicated are at the cross-section upstream of the culvert opening
***the Downstream Velocities as indicated are at the downstream culvert opening (not the downstream cross-section)

The scour analysis performed in this study follows the FHWA recommended methodology. *Table 3* summarizes the estimated potential total scour depth at the abutments and pile bents for the SR 32 Bridge over Dead Horse Slough.

Table 3. Potential Scour Depths for SR 32 Bridge Widening over Dead Horse Slough (below grade)

Location	Long-Term Bed Change	Contraction Scour	Local Scour	Total Scour Depth
Abutment 1	Negligible	0.32 ft	3.31 ft	3.63 ft
Bent 2	Negligible	0.32 ft	7.02 ft	7.34 ft
Bent 3	Negligible	0.32 ft	6.68 ft	7.00 ft
Bent 4	Negligible	0.32 ft	5.35 ft	5.67 ft
Abutment 5	Negligible	0.00 ft	0.00 ft	0.00 ft

The foundation of the proposed bridge abutments and pile bents should be constructed below the calculated total potential scour to avoid structural damage and/or undermining. Protection measures such as rock slope protection (RSP), are also recommended for the abutments of the proposed bridge widening.

For the South Fork Dead Horse Slough culvert extension, we recommend the installation of Rock Slope Protection ¼ ton (RSP) at the downstream end of the culvert extension. This RSP will help dissipate the high flow velocities (as indicated in *Table 2*) at the outfall the culvert, and protect the channel from scour.

I. INTRODUCTION

Background: The purpose of this study is to provide hydrologic and hydraulic data for the design of State Route 32 (SR 32) at Dead Horse Slough and South Fork Dead Horse Slough. The city of Chico proposes to widen SR 32 from east of Fir Street to Yosemite Drive. The project extends through the Bruce Road/SR 32 intersection. The widening will occur to the north between Fir Street and Bruce Road, where available right-of-way exists. SR 32 between Bruce Road to Yosemite Street will be symmetrically widened. The scope of this project is to prepare a Caltrans Project Study Report for the four-lane widening within the project limits. Major development projects are being planned for the area and the city needs planning complete to make sure developers know the ultimate geometry. The project is in the city's General Plan as a four-lane roadway. The anticipated horizon for construction is three to four years. The confluence of Dead Horse Slough with Little Chico Creek is approximately 0.2 mile downstream of the SR 32 crossing. The bridge and box culvert will be designed by Mark Thomas and Company, Inc.

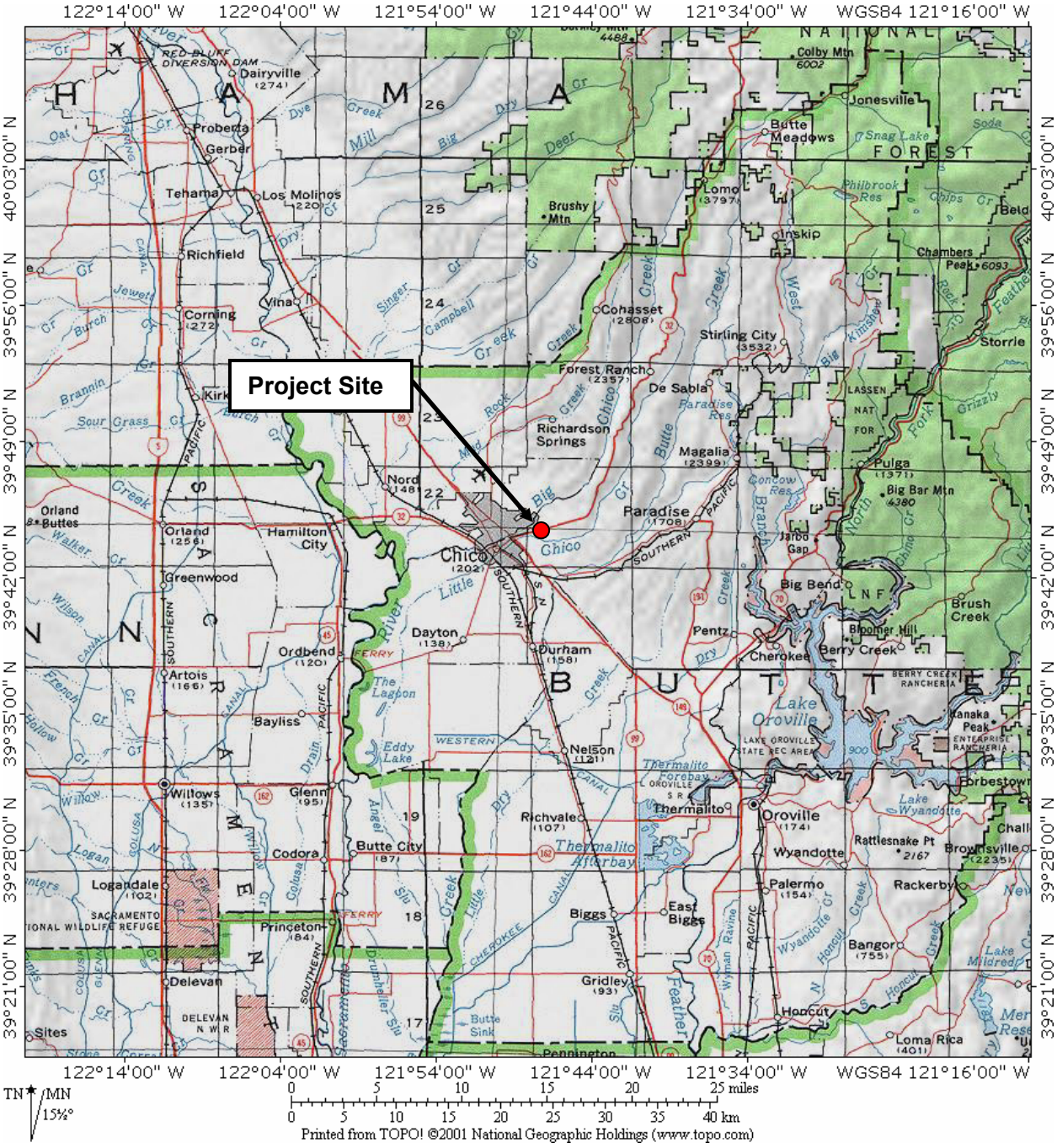
Project Location: The project location is in the city of Chico, Butte County, California. The proposed bridge is located along SR 32 approximately 0.1 mile east of the SR 32/Forest Avenue intersection. The proposed RCB extension is located just east of the SR 32/ Bruce Road intersection. See *Figure 1* for the Project Location Map, and *Figure 2* for the Project Vicinity Map.

Photo 1: SR 32 Bridge Over Dead Horse Slough (Looking East)

Key Tasks: The key tasks performed for the project included 1) investigation into previous hydrologic and hydraulic studies of Dead Horse Slough, 2) HEC-HMS hydrologic analysis of the South Fork Dead Horse Slough watershed to determine design flows, 3) hydraulic analyses to determine the water surface elevations and flow velocities at both the Dead Horse Slough and the South Fork Dead Horse Slough crossings, and 4) scour analysis to determine potential scour depths and countermeasures at the Dead Horse Slough crossing.

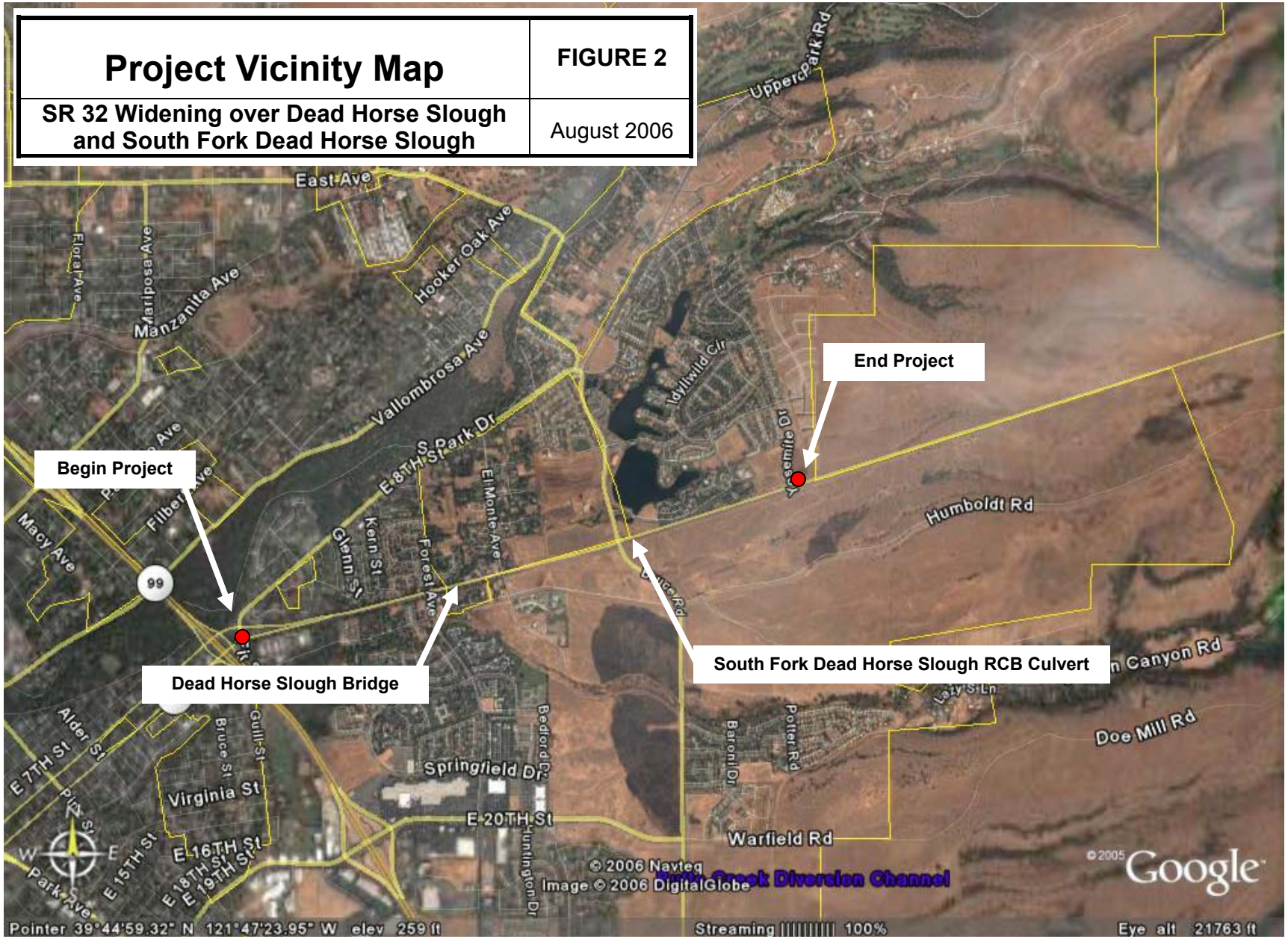
Design Criteria: Per the Federal Highway Administration (FHWA) and Caltrans design criteria, the basic criterion for hydraulic design of bridges is that they should be designed to pass the two percent (2%) probability flood (50-year flood or Q_{50}) with 2 ft of freeboard and the one percent (1%) probability flood (100-year flood or Q_{100}) without causing objectionable backwater, excessive flow velocities or encroaching on through traffic lanes. The design criteria for the RCB is the water surface of the Q_{100} not causing objectionable backwater, and not spreading into the travel way.

Photo 2: SR 32 RCB at South Fork Dead Horse Slough (Upstream Face)



Project Location Map	FIGURE 1
SR 32 Widening at Dead Horse Slough and South Fork Dead Horse Slough	August 2006

Project Vicinity Map	FIGURE 2
SR 32 Widening over Dead Horse Slough and South Fork Dead Horse Slough	August 2006



II. DESCRIPTION OF WATERSHED

Geographic Location: The project site is located in the Dead Horse Slough Watershed adjacent to the Little Chico Creek Watershed (See *Figure 3*). Dead Horse Slough begins approximately 5.1 miles upstream of the project site. South Fork Dead Horse Slough begins approximately 3.2 miles upstream of the project site. Dead Horse Slough and its south fork drain a segment of the western slopes of Sierra foothills between Musty Buck and Doe Mill Ridges. The highest point in the watershed is at elevation 1,300 ft.

Watershed Size: The Dead Horse Slough watershed is about 5.2 square miles at the SR 32 Bridge. The South Fork Dead Horse watershed is about 0.9 square miles at the SR 32 RCB.

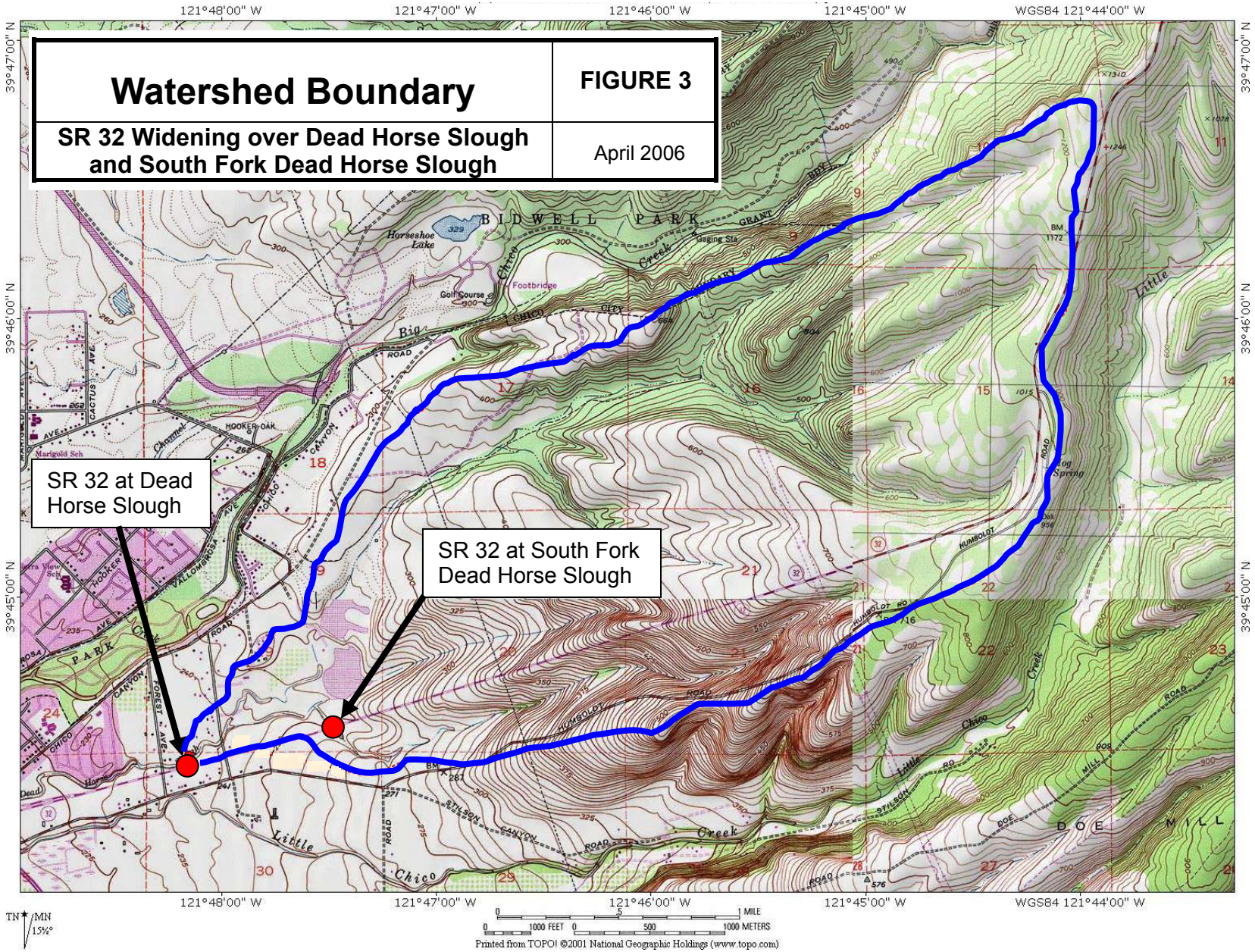
Receiving Waters: South Fork Dead Horse Slough is a tributary to Dead Horse Slough. Dead Horse Slough is a tributary to Little Chico Creek. Little Chico Creek flows southwest to join Angel Slough. Angel Slough in turn flows south to join Butte Creek just upstream of where Butte Creek joins the Sacramento River. The Sacramento River flows south to the city of Sacramento then west into San Francisco Bay and the Pacific Ocean.

Precipitation: Mean annual precipitation at the project site is approximately 30 inches, which is based on the Spatial Climate Analysis Service (SCAS) Oregon State University (OSU) *1961-1990 Average Annual Precipitation, CA.*

Land Use: The lower watershed of Dead Horse Slough is currently zoned mostly residential at the California Park development, some community commercial at Bruce Road and SR 32, and mixed-use neighborhood core at the intersection of Bruce Road/8th Street and at California Park Drive/Chico Canyon Road. The upper watershed of Dead Horse Slough is rural residential, parks, open space for environmental conservation/safety, and open space for agriculture/resource management. The California Park development surrounds California Park Lake, except at the upstream end, which is a park. The uppermost part of the watershed is located in Bidwell Park's Upper Park.

Vegetation: Dead Horse Slough and its south fork upstream of the project site has hilly terrain that is well covered with various grasses. Some chaparral vegetation is found along the slough banks, and at the higher elevations of the watershed.

Photo 3.
Downstream End of South Fork Dead Horse Slough Along SR 32, Looking West


Watershed Boundary
FIGURE 3
SR 32 Widening over Dead Horse Slough and South Fork Dead Horse Slough
April 2006
SR 32 at Dead Horse Slough
SR 32 at South Fork Dead Horse Slough
121°48'00" W
121°47'00" W
121°46'00" W
121°45'00" W
WGS84 121°44'00" W
39°47'00" N
39°46'00" N
39°45'00" N
BIDWELL PARK
Horseshoe Lake
Big Chico Creek
Little Chico Creek
Footbridge
Golf Course
Gaging Sta
HOOKER OAK
Marigold Sch
PARK CANYON
STILSON CANYON
DOE MILL
HUMBOLDT ROAD
Log Spring
TN 15½° MN
0 1000 FEET 0 500 1000 METERS
0 .5 MILE
Printed from TOPO! ©2001 National Geographic Holdings (www.topo.com)

III. DESCRIPTION OF STREAM AND SITE

Dead Horse Slough:

At the project site, Dead Horse Slough occupies a well-defined, vegetated channel with medium thick riparian growth along the embankments. The slough channel crosses SR 32 at approximately 41° from perpendicular. The existing and proposed bridges have a 41° skew to the slough flow direction.

Photo 4.
SR 32 Bridge looking downstream

South Fork Dead Horse Slough:

Upstream of the South Fork Dead Horse Slough (South Fork) crossing the slough channel is located in a gravel and cobble laden swale with mild embankment slopes. The embankments are almost exclusively vegetated with grasses, with very few shrubs or trees. Downstream of the crossing the gravel and cobble channel is mostly clear of vegetation with heavy foliage on the banks.

Photo 5.
SR 32 RCB looking upstream

Soil and Bed Material:

According to the Caltrans *Bridge Inspection Reports* (5/7/2004 and 10/4/2001), the bed material at the Dead Horse Slough crossing is described as silt and gravel. Based on field observation, the bed material at the South Fork crossing is silty gravel with some cobbles.

Proposed Action: The existing bridge over Dead Horse Slough will be widened to the upstream side.

The existing RCB culvert along South Fork Dead Horse Slough under SR 32 will be extended both upstream and downstream.

Existing Dead Horse Slough Bridge:	Type:	Reinforced concrete (RC) slab with RC pile bents and RC open diaphragm abutments on piles
	Pier Bents:	Three circular concrete pier bents (four-span)
	Span:	123.5 ft (normal – 87.5 ft)
	Width:	32.5 ft (normal – 46 ft)
	Deck elev.:	242.10 ft – 242.50 ft
	Soffit elev.:	240.85 ft
Proposed Dead Horse Slough Bridge:	Type:	Reinforced concrete (RC) slab with RC pile bents and RC open diaphragm abutments on piles
	Pier Bents:	Three circular concrete pier bents (four-span)
	Span:	123.5 ft (normal – 87.5 ft)
	Width:	73.33 ft (normal – 111 ft)
	Deck elev.:	242.68 ft – 242.98 ft
	Soffit elev.:	240.49-240.79 ft

See *Appendix C* for detailed schematic of the proposed bridge.

Existing South Fork RCB:	Type:	Reinforced Concrete Box Culvert
	Length:	88 feet
	Size:	8 feet x 6 feet
Proposed RCB:	Type:	Reinforced Concrete Box Culvert
	Length:	141.5 feet
	Size:	8 feet x 6 feet

IV. HYDROLOGY

Dead Horse Slough Hydrology:

The Federal Emergency Management Agency's (FEMA) FIS for the area dated April 2000 and FEMA Letter of Map Revision (LOMR) dated March 31, 2005 for the Dead Horse Slough have been used to develop design flows for the Dead Horse Slough crossing. Furthermore, *Proposed Husa Ranch Development Flood Mitigation Analysis* (2001) from Borcalli and Associates was reviewed for comparison. The LOMR flows for Dead Horse Slough at the confluence with Little Chico Creek were used to extrapolate a 200-year design flow for hydraulic analysis using the city's criteria. The 200-year flow of 2,200 cfs was extrapolated logarithmically as shown in *Figure 4* below.

Figure 4: Dead Horse Slough Extrapolated Flows

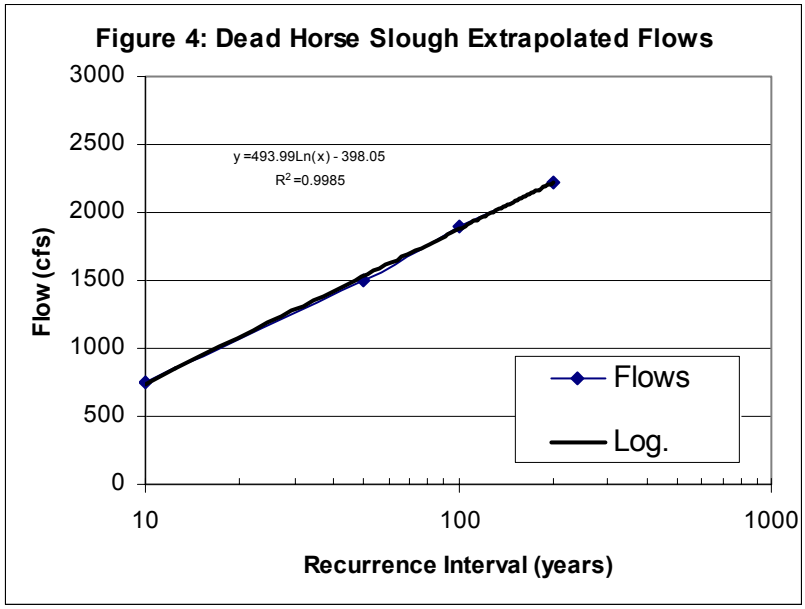


Table 4 below summarizes the design flows for Dead Horse Slough based on the FEMA LOMR and our extrapolation of the 200-year flow.

Table 4 – Dead Horse Slough Design Flows

Design Storm Frequency	Design Storm Flow
10-year	750 cfs
50-year	1,500 cfs
100-year	1,900 cfs
200-year	2,200 cfs

See Appendix D for detailed excerpts from the FEMA LOMR and calculations of Dead Horse Slough flows.

Hydrologic Stability of Dead Horse Slough:

California Park Lake is located approximately 0.7 miles upstream of the Dead Horse Slough crossing. The lake is unregulated and can only handle low flows as shown in *Photo 6*. There appear to be no significant changes in basin hydrology in recent years. Although there is some development around California Park Lake, most of the watershed is located in a rural

setting with primarily open space.

Photo 6.
California Park Lake Outlet

South Fork Hydrologic Analysis Tool:

A hydrograph transform method was applied using the U.S. Army Corps of Engineers' HEC-HMS computer program (Version 2.2.2). The HEC-HMS Hydrologic analysis of the South Fork Dead Horse Slough watershed at the RCB culvert crossing included the use of the SCS Transform method with SCS curve number loss calculations. The hydrologic model considers the limited future land use changes shown on the city of Chico General Plan Diagram provided for this project.

Photo 7 illustrates the existing downstream headwall and wingwalls of the South Fork Dead Horse Slough RCB. This is located immediately north of SR 32 and just east of Bruce Road.

Photo 7.
Downstream Headwall of South Fork RCB

Hydrologic Analysis of South Fork:

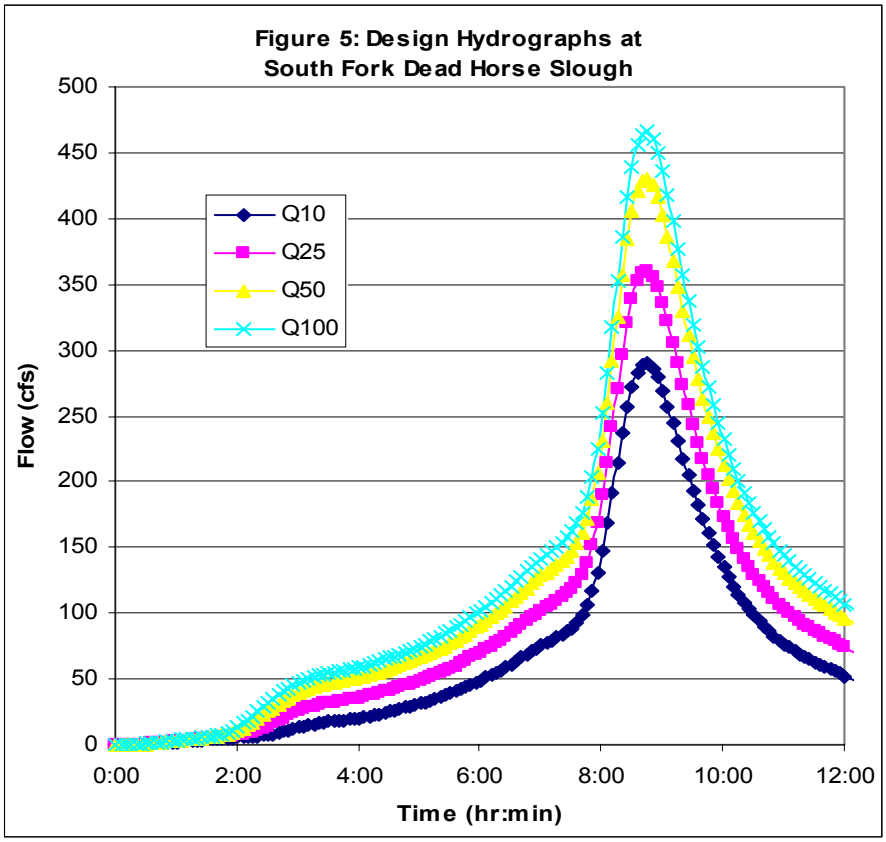
24-hour storm hydrographs for the various storm frequencies were developed by HEC-HMS based on the SCS Hypothetical Storm Type 1A. Return period rainfall depths were obtained from the National Oceanic and Atmospheric Administration's *Isopluvial Maps* (Reference 3). *Table 5* shows the peak design flows for the South Fork Dead Horse Slough.

Table 5 – South Fork Dead Horse Slough Design Flows

Design Storm Frequency	Design Storm Flow
10-year	290 cfs
25-year	360 cfs
50-year	430 cfs
100-year	470 cfs
200-year	530 cfs

Initial abstraction rates and constant rate infiltration were used to simulate abstractions. These values were estimated by an evaluation of the soil types present in the area. Lag time was estimated from the empirical relationship to Time of Concentration. Time of concentration was estimated based on shallow concentrated flow velocities and reach length.

The various design storm hydrographs are shown in *Figure 6* below.



See Appendix D for detailed HEC-HMS modeling data.

V. HYDRAULIC ANALYSIS

Design Tool: The hydraulic analysis for Dead Horse Slough and the South Fork involved standard step backwater calculations using the U.S. Army Corps of Engineers' HEC-RAS computer program (Version 3.1.3) to provide flow characteristics.

Cross-section Data: For the Dead Horse Slough analysis, a total of eight cross-sections, distributed over an 880 ft reach of Dead Horse Slough were obtained from Mark Thomas and Company, Inc. The cross-sections included three upstream of the SR 32 crossing and five downstream of the crossing.

The South Fork model was developed from six surveyed cross-sections along South Fork Dead Horse Slough. Three cross-sections were taken downstream and 3 were taken upstream.

Manning's 'n': Manning's 'n' values were used in the hydraulic model to estimate energy losses in the flow due to friction. The Manning's 'n' value for the main channel was 0.035 and 0.040. For the left and right banks, a Manning's 'n' value of 0.05 to 0.045 was used. The 'n' values for the South Fork are 0.03 in the main channel and 0.045 for the overbanks. These Manning's 'n' values were selected to best describe the friction characteristics of the existing and proposed site under the design storm conditions.

Expansion and Contraction Coefficients: For both the Dead Horse Slough and South Fork models, the expansion and contraction coefficients used to represent the channel were 0.3 and 0.1, respectively. These values describe a creek or slough with gradual transitions between cross-sections. The expansion and contraction coefficients used in the vicinity of the bridge and culvert were 0.5 and 0.3, respectively. These values were used because the abutments of the bridge intrude slightly into the channel.

Dead Horse Slough High Water Elevations: The calculated water surface elevation for the peak discharge of the design storms for the existing and proposed alternatives are listed in *Table 6*.

Table 6 – Dead Horse Slough Water Surface Elevations at River Station 10762 (Just upstream of proposed bridge)

Design flow return period	Existing Condition (ft)	Proposed Condition (ft)
Soffit Elevation	~240.7	~240.7
200-year	238.11	238.49
100-year	237.59	237.96
50-year	236.89	237.24

Our hydraulic analysis indicated that, in both the existing and proposed condition, the water surface elevation just upstream of the project site is below the soffit elevation of the bridge during the 200-year, 100-year, and 50-year events. There is more then 3 feet of freeboard between the soffit and the 50-year event water surface.
The proposed bridge does not significantly impact the water surface

elevations upstream of the bridge. Both the existing and proposed condition meet the standard Caltrans/FHWA criteria of passing the 100-year flow and passing the 50-year flow with at least 2 feet of freeboard. Neither the existing condition nor the proposed condition meets the city criteria of passing the 200-year flow with 3 feet of freeboard.

South Fork Dead Horse Slough High Water Elevations:

The calculated water surface elevation for the peak discharge of the design storms for the existing and proposed alternatives are listed in *Table 7*.

Table 7 – South Fork Dead Horse Slough Water Surface Elevations at River Station 1485.7 (Just upstream of RCB)

Design flow return period	Existing Condition (ft)	Proposed Condition (ft)
RCB Top Elevation	252.00	255.30
200-year	255.24	255.27
100-year	254.26	254.55
50-year	253.84	254.13
25-year	252.97	253.26
10-year	252.02	252.31

*the 10-year water surface at indicated is at the cross-section upstream of the culvert opening. The 10-year water surface elevation at the culvert opening is 249.73 feet as indicated in the Appendix B.

We assumed the that the proposed condition will extend the RCB by the same amount the roadway will be widened in the direction of the existing RCB: 14 ft upstream and 39.5 ft downstream. The proposed condition hydraulic model assumed that the culvert will be extended at the same slope as the existing culvert. Our hydraulic analysis indicated that the proposed condition will slightly increase the water surface elevations from the existing condition. This is due to head losses associated with the extended RCB, which result in slightly decreased flow velocities and slightly increase water surface elevations.

Dead Horse Slough Flow Velocities:

The calculated Dead Horse Slough flow velocities in the main channel are shown in *Table 8* for the existing and proposed conditions.

Table 8 – Flow Velocities in Main Channel at River Station 10762 (Just upstream of proposed bridge)

Design flow return period	Existing Condition (ft/s)	Proposed Condition (ft/s)
200-year	5.98	5.72
100-year	5.70	5.45
50-year	5.32	5.07

Per *Table 8*, the proposed project acts as a minor impediment to the flow. Because of this, the flow velocities decrease slightly in the proposed condition. The impediment is a result of energy losses due to the lengthier abutment and pile bents.

South Fork Dead Horse

The flow in the RCB is entirely supercritical. This is due to the steep slope of the RCB flowline. The calculated South Fork Dead Horse Slough flow

Slough Flow Velocities: velocities in the main channel are shown in *Table 9* for the existing and proposed conditions:

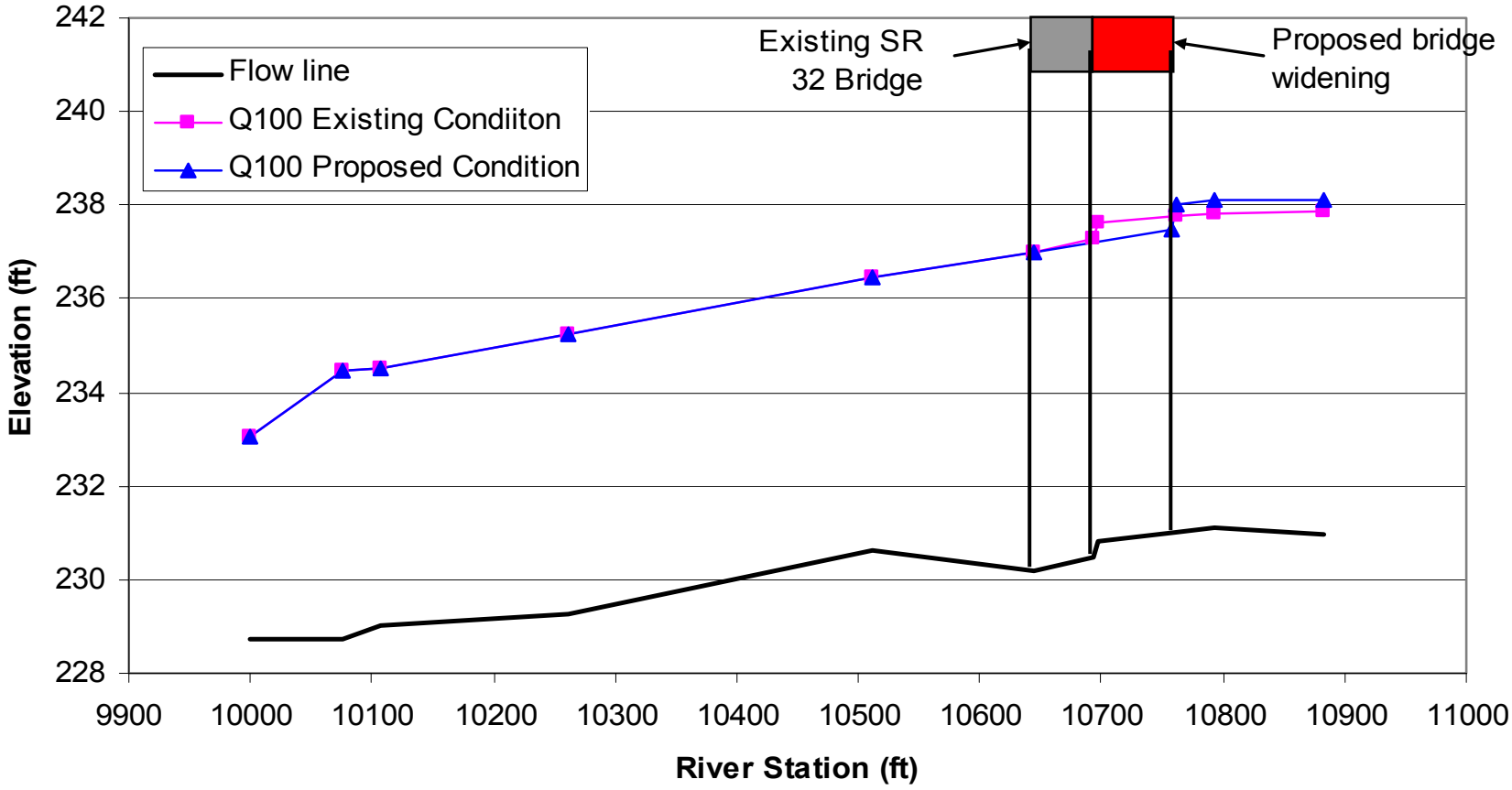
Table 9 – Flow Velocities in Main Channel at Upstream and Downstream Ends of Culvert

Design flow return period	Existing Condition (upstream) (ft/s)	Proposed Condition (upstream) (ft/s)	Existing Condition (downstream)* (ft/s)	Proposed Condition (downstream)* (ft/s)
100-year	0.60	0.54	17.79	18.97
50-year	0.63	0.57	17.48	18.65
25-year	0.70	0.64	16.79	17.93
10-year	0.77	0.70	15.98	17.07

*the Downstream Velocities as indicated are at the downstream culvert opening (not the downstream cross-section)

Per *Table 9*, the proposed project slightly decreases the flow velocities of South Fork Dead Horse Slough upstream of the culvert, which is due to the head loss from the extended RCB. The downstream flow velocities in the RCB range 15.98 ft/s to 17.79 ft/s in the existing condition and 17.07 ft/s to 18.97 ft/s in the proposed condition. This represents a slight increase in downstream erosive forces. Although there is no evidence of significant erosion at the downstream end of the RCB, we recommend energy dissipating countermeasures such as rock slope protection to protect against potential scour from the high flow velocities outfalling into the slough channel.

Figure 6: Profile of Dead Horse Slough at SR 32



VI. SCOUR ANALYSIS

Design Criteria: The local scour at the abutments and piers was evaluated at the proposed SR 32 Bridge over Dead Horse Slough per the criteria described in the Federal Highway Administration Manual HEC-18, *Evaluating Scour at Bridges (Fourth Edition)*. The minimum design criteria for bridge scour is the 100-year flood. The scour analysis is based on hydraulic data taken from the HEC-RAS (Version 3.1.3) analysis of the bridge site with 41° skew angle.

Caltrans Bridge Inspection Report: The Caltrans Structure Maintenance & Investigations' *Bridge Inspection Report* (October 4, 2001) indicates the following:

> Erosion of the slope protection at Abutment #1 is still occurring. According to a 1983 inspection report, the rock slope protection was put in place in either 1969 or 1970 to arrest erosion at the abutments. However, the report mentions that the rock slope protection at Abutment #1 had sloughed down the slope shortly after placement and bank erosion was still occurring and is still slowly occurring at this location to this date. Additional rock slope protection should be placed at Abutment #1 to prevent further erosion.

Existing Channel Bed: The bed material is predominantly silt and gravel (Caltrans, 2001). According to the *Civil Engineering Reference Manual*, AASHTO's (1970) classification of soil particle sizes defines gravel size as 2 mm –75 mm and defines silt size as 0.002 mm – 0.075 mm. We assumed a D_{50} grain size of 0.05 mm.

Long-term Bed Change: Our field observations did not indicate severe creek bed degradation. We assumed the long-term bed elevation change to be negligible. Further research will be done to finalize our long-term bed change analysis. These results will be determined in the final version of this report.

Contraction Scour: Contraction scour occurs when the flow area of a stream is reduced significantly, either by a natural contraction or by a bridge. There is contraction that occurs at the proposed bridge site due to the proposed bridge structure.

For the proposed bridge replacement, the flow area of Dead Horse Slough is reduced from about 350 square feet; about 30 ft upstream of the bridge to about 320 square feet at the upstream face of the bridge. This corresponds to a 9% reduction in flow area in approximately 30 ft. Using the Live-Bed Contraction Scour Equation at the channel, the calculated contraction scour at the channel is 0.32 ft.

Pier Scour: The basic mechanism causing local scour at piers is the formation of vortices (known as horseshoe vortex) at their base. The horseshoe vortex results from the pileup of water on the upstream surface of the pier and subsequent acceleration of the flow around the base of the pier. The action of the vortex removes bed material from around the base of the

pier. The CSU equation was utilized to determine pier scour.

For the proposed bridge replacement, pier scour at Bent 2 (HEC-RAS Pier #3) is 7.02 ft. Pier scour at Bent 3 (HEC-RAS Pier #2) is 6.68 ft. And pier scour at Bent 4 (HEC-RAS Pier #1) is 5.35 ft. Pier scour at Bent 2 is greater than pier scour at Bents 3 and 4, because the flow velocity is greater at Bent 2 (6.30 ft/s) than at Bent 3 (5.86 ft/s) and Bent 4 (4.07 ft/s).

Abutment Scour: Scour occurs at abutments when the abutment and embankment obstruct the flow. The flow obstructed by the abutment and approach highway embankment forms a horizontal vortex starting at the upstream end of the abutment and running along the toe of the abutment, and a vertical wake vortex at the downstream end of the abutment. To determine abutment scour, the Froelich equation was utilized to determine abutment scour.

For the proposed bridge replacement project, abutment scour at Abutment 1 (HEC-RAS Right Bank) is 3.31 ft. Scour was not calculated at Abutment 4 (HEC-RAS Left Bank) because the 100-year water surface elevation does not reach this abutment. We assumed abutment scour at Abutment 4 is negligible.

Total Scour: Total scour is the sum of local scour (pier and abutment scour), contraction scour, and long-term bed degradation. The itemized total scour depth for the piers/abutments of the proposed bridge alternatives are shown in *Table 10.* The detailed calculations for total scour are available in *Appendix E*. HEC-18 was used in performing the detailed calculations to estimate scour.

Table 10 – Summary of Scour

Location	Long-term Bed Change	Contraction Scour	Local Scour	Total Scour Depth
Abutment 1	Negligible	0.32 ft	3.31 ft	3.63 ft
Bent 2	Negligible	0.32 ft	7.02 ft	7.34 ft
Bent 3	Negligible	0.32 ft	6.68 ft	7.00 ft
Bent 4	Negligible	0.32 ft	5.35 ft	5.67 ft

The 100-year water surface elevation does not reach Abutment 4 (Left Abutment), and therefore, abutment scour was not evaluated there. The potential for local scour and contraction scour should be considered in setting abutment/pier foundation depths in and near the main channel of Dead Horse Slough. The foundation of the proposed bridge piers should be designed and constructed to below the estimated total scour depth to avoid structural damage, and/or undermining. Otherwise, protection measures, such as rock slope protection, are recommended for the abutments of the proposed bridge.

According to the Caltrans *Highway Design Manual*, protection of the proposed abutments and pier bents do not require the placement of rock slope protection. See chart in *Appendix E*.

VII. REFERENCES

1. Borcalli & Associates, Inc., February 2001. *Proposed Husa Ranch Development Flood Mitigation Analysis*.

2. California Department of Transportation, 1995 (with updates). *Highway Design Manual (Fifth Edition)*.

3. California Department of Transportation, Structure Maintenance & Investigations, Oct 14, 1993 to May 7, 2004. Various *Bridge Inspection Report, Bridge Number 12 0135*.

4. City of Chico, March 3, 2003 (with updates). *City of Chico Design Standards*.

5. Federal Emergency Management Agency, April 2000. *Flood Insurance Study, Butte County and Incorporated Areas.*

6. Federal Emergency Management Agency, March 31, 2005. *LOMR, Butte County Unincorporated Areas, Husa Ranch Subdivision.*

7. United States Army Corps of Engineers, January 2001. *HEC-HMS Hydrologic Modeling System User Manual.*

8. United States Army Corps of Engineers, March 2000. *HEC-HMS Technical Reference Manual.*

9. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, J.F. Miller, R.H. Frederick, R.J. Tracey, 1973. *NOAA Atlas 2: Precipitation Frequency Atlas of the Western United States, Volume 11 - California:*

10. United States Army Corps of Engineers, January 2001. *HEC-RAS River Analysis System Hydraulic Reference Manual.*

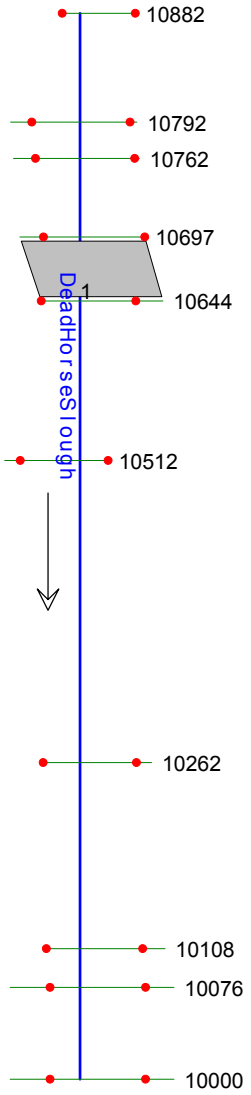
11. United States Army Corps of Engineers, January 2001. *HEC-RAS River Analysis System User Manual.*

APPENDIX A

HEC-RAS Hydraulic Analysis – Existing Condition

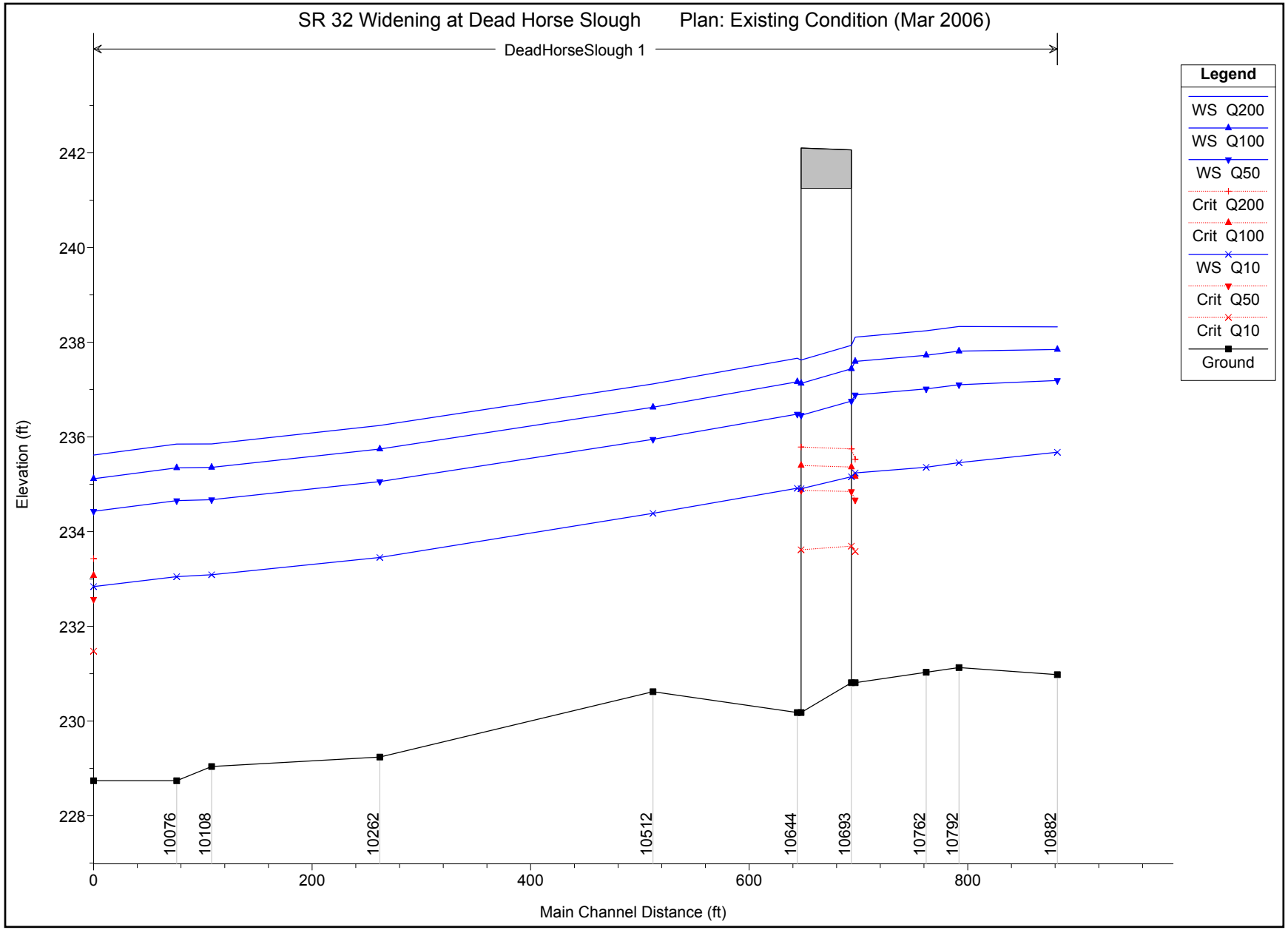
DRAFT BRIDGE DESIGN HYDRAULIC STUDY REPORT FOR
THE SR32 BRIDGE OVER DEAD HORSE SLOUGH
CITY OF CHICO, CALIFORNIA

EXISTING CONDITION HEC-RAS MODEL

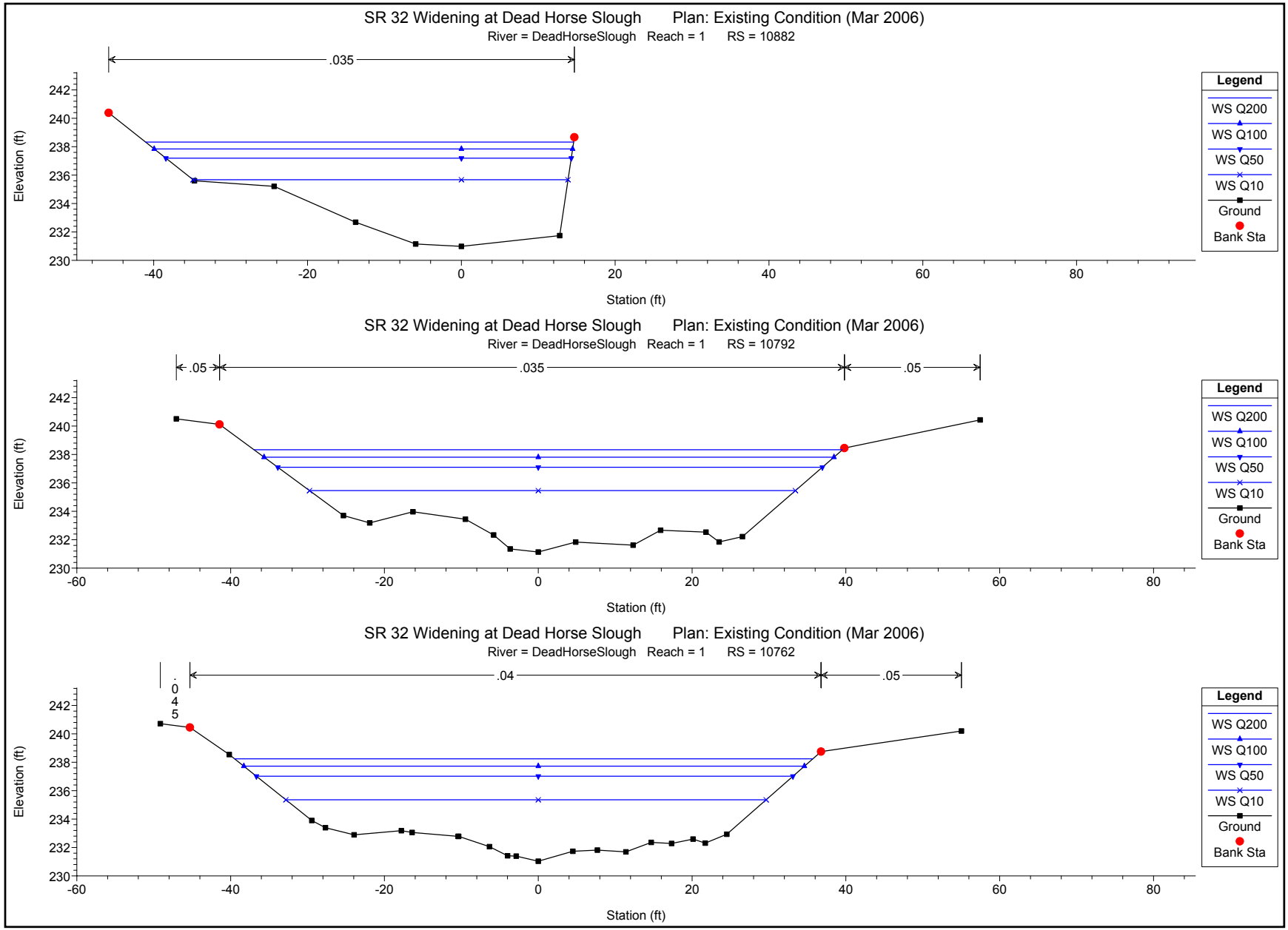


HEC-RAS Plan: Existing River: DeadHorseSlough Reach: 1

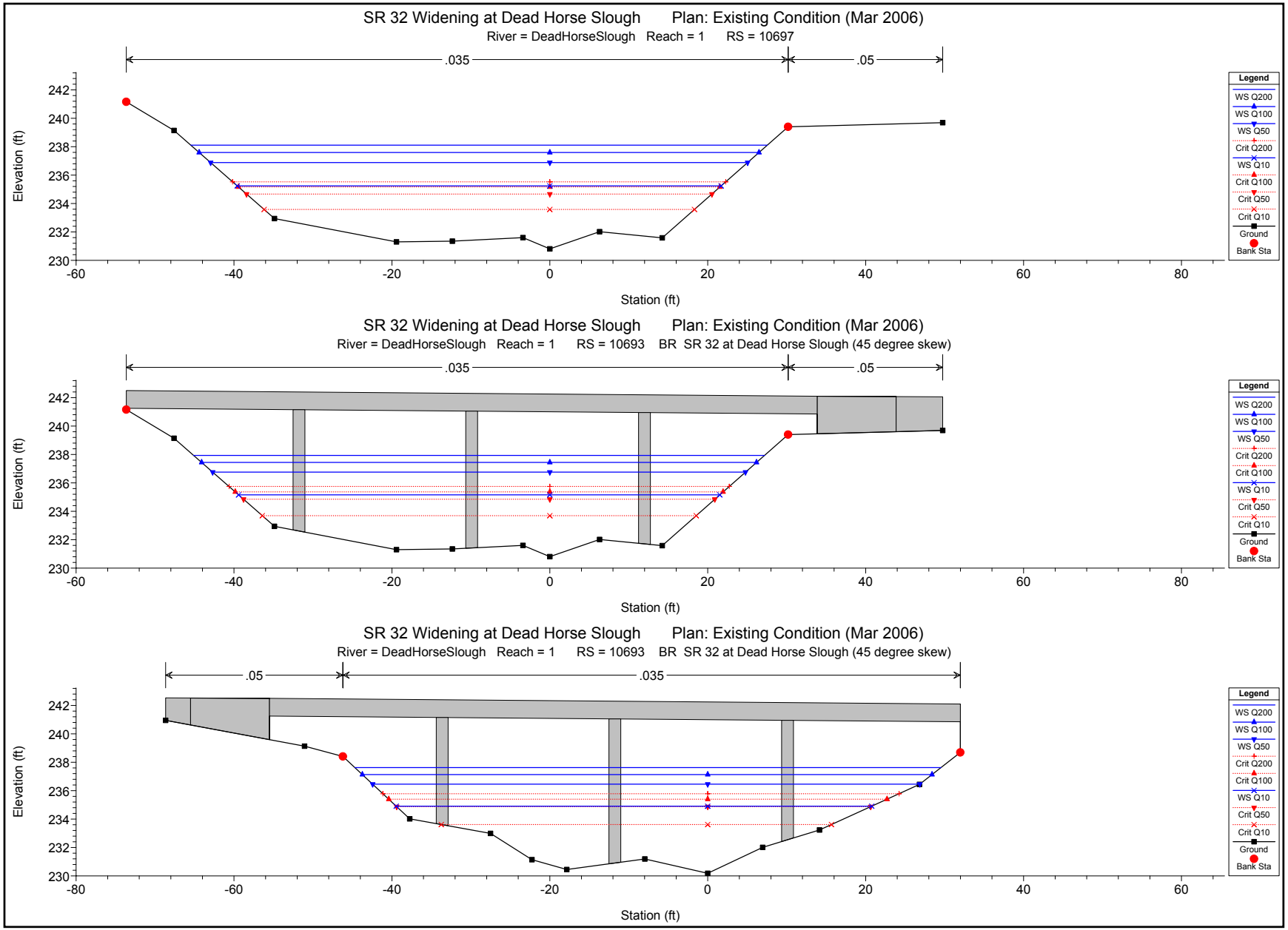
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	10000	Q200	2220.00	228.74	235.62	233.43	236.17	0.002501	5.97	371.82	77.23	0.48
1	10000	Q100	1900.00	228.74	235.12	233.07	235.62	0.002504	5.69	334.02	74.32	0.47
1	10000	Q50	1500.00	228.74	234.43	232.57	234.86	0.002501	5.28	284.08	70.79	0.46
1	10000	Q10	750.00	228.74	232.84	231.47	233.11	0.002501	4.21	177.96	62.65	0.44
1	10076	Q200	2220.00	228.74	235.85		236.35	0.002168	5.70	389.97	79.49	0.45
1	10076	Q100	1900.00	228.74	235.35		235.80	0.002165	5.41	351.21	75.49	0.44
1	10076	Q50	1500.00	228.74	234.65		235.04	0.002130	5.00	300.11	71.94	0.43
1	10076	Q10	750.00	228.74	233.05		233.29	0.002014	3.92	191.29	63.73	0.40
1	10108	Q200	2220.00	229.04	235.85		236.46	0.002708	6.26	354.40	71.48	0.50
1	10108	Q100	1900.00	229.04	235.36		235.91	0.002662	5.94	319.66	68.96	0.49
1	10108	Q50	1500.00	229.04	234.67		235.14	0.002590	5.48	273.70	65.46	0.47
1	10108	Q10	750.00	229.04	233.09		233.37	0.002298	4.25	176.62	56.89	0.42
1	10262	Q200	2220.00	229.24	236.24		236.97	0.003504	6.84	324.60	69.81	0.56
1	10262	Q100	1900.00	229.24	235.74		236.41	0.003508	6.54	290.58	66.97	0.55
1	10262	Q50	1500.00	229.24	235.06		235.63	0.003512	6.10	245.88	63.03	0.54
1	10262	Q10	750.00	229.24	233.45		233.83	0.003505	4.93	152.16	53.86	0.52
1	10512	Q200	2220.00	230.62	237.12		237.84	0.003471	6.82	325.56	70.01	0.56
1	10512	Q100	1900.00	230.62	236.63		237.29	0.003512	6.51	291.67	67.91	0.55
1	10512	Q50	1500.00	230.62	235.95		236.52	0.003599	6.08	246.59	65.01	0.55
1	10512	Q10	750.00	230.62	234.39		234.77	0.004023	5.00	150.14	58.33	0.55
1	10644	Q200	2220.00	230.18	237.66		238.26	0.002748	6.21	357.66	74.39	0.50
1	10644	Q100	1900.00	230.18	237.16		237.71	0.002764	5.91	321.22	72.29	0.49
1	10644	Q50	1500.00	230.18	236.48		236.95	0.002799	5.50	272.90	69.41	0.49
1	10644	Q10	750.00	230.18	234.92		235.21	0.002718	4.38	171.29	60.28	0.46
1	10693		Bridge									
1	10697	Q200	2220.00	230.81	238.11	235.53	238.62	0.002098	5.75	386.25	73.01	0.44
1	10697	Q100	1900.00	230.81	237.59	235.16	238.05	0.002062	5.44	349.29	70.91	0.43
1	10697	Q50	1500.00	230.81	236.89	234.67	237.27	0.002005	5.00	300.24	68.02	0.42
1	10697	Q10	750.00	230.81	235.24	233.58	235.47	0.001860	3.87	193.67	61.28	0.38
1	10762	Q200	2220.00	231.03	238.24		238.80	0.003282	6.01	369.35	75.19	0.48
1	10762	Q100	1900.00	231.03	237.72		238.24	0.003315	5.74	331.04	72.90	0.47
1	10762	Q50	1500.00	231.03	237.01		237.46	0.003378	5.35	280.33	69.76	0.47
1	10762	Q10	750.00	231.03	235.36		235.66	0.003749	4.39	170.96	62.45	0.47
1	10792	Q200	2220.00	231.13	238.33		238.89	0.002581	6.00	369.79	76.51	0.48
1	10792	Q100	1900.00	231.13	237.81		238.32	0.002625	5.75	330.63	74.10	0.48
1	10792	Q50	1500.00	231.13	237.10		237.55	0.002699	5.37	279.14	70.81	0.48
1	10792	Q10	750.00	231.13	235.46		235.76	0.003070	4.44	168.87	63.17	0.48
1	10882	Q200	2220.00	230.98	238.32		239.35	0.005026	8.12	273.40	55.66	0.65
1	10882	Q100	1900.00	230.98	237.85		238.76	0.004966	7.69	247.14	54.41	0.64
1	10882	Q50	1500.00	230.98	237.19		237.97	0.004885	7.07	212.11	52.70	0.62
1	10882	Q10	750.00	230.98	235.68		236.15	0.004797	5.54	135.27	48.75	0.59



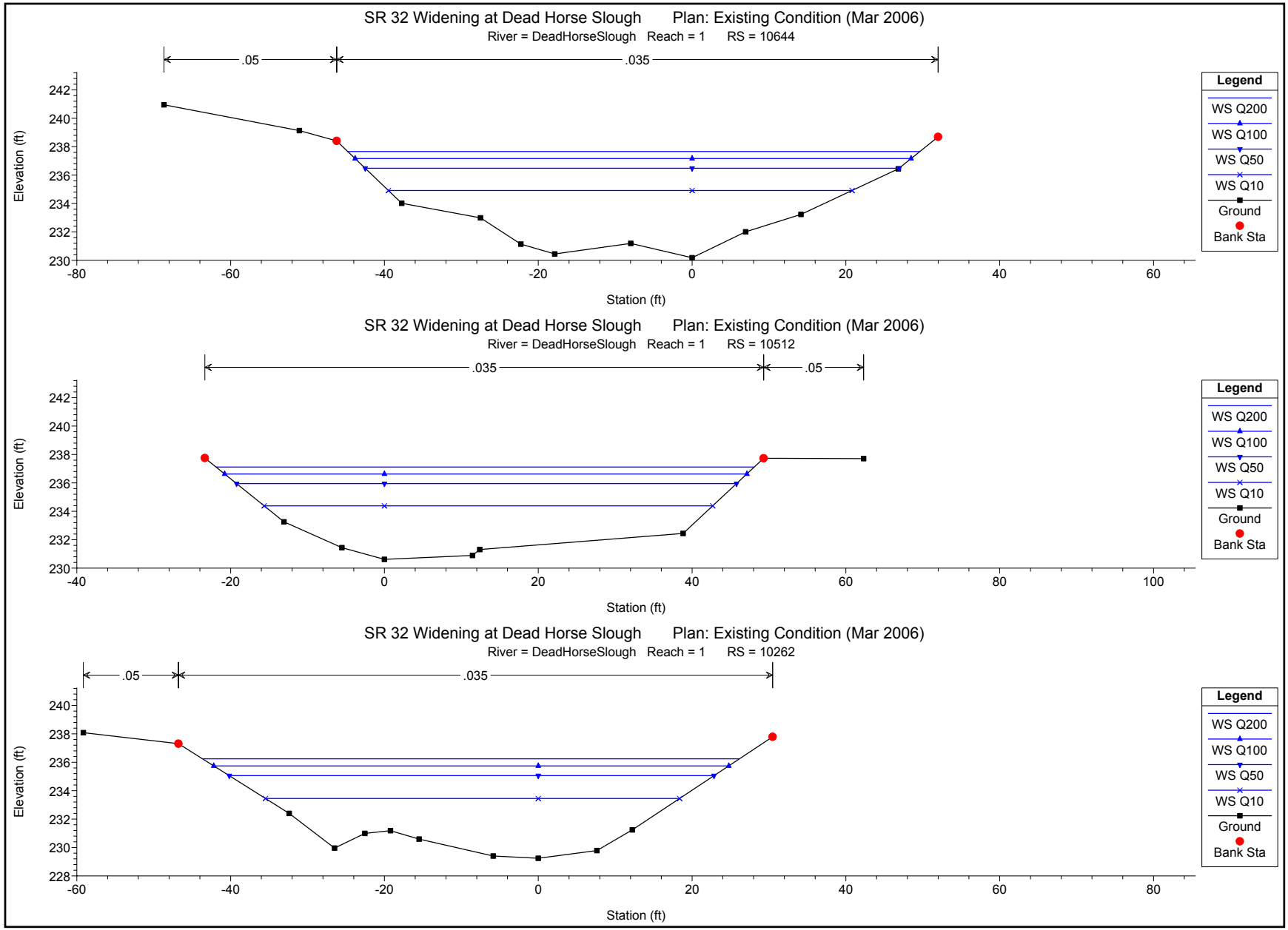
1 in Horiz. = 130 ft 1 in Vert. = 3 ft



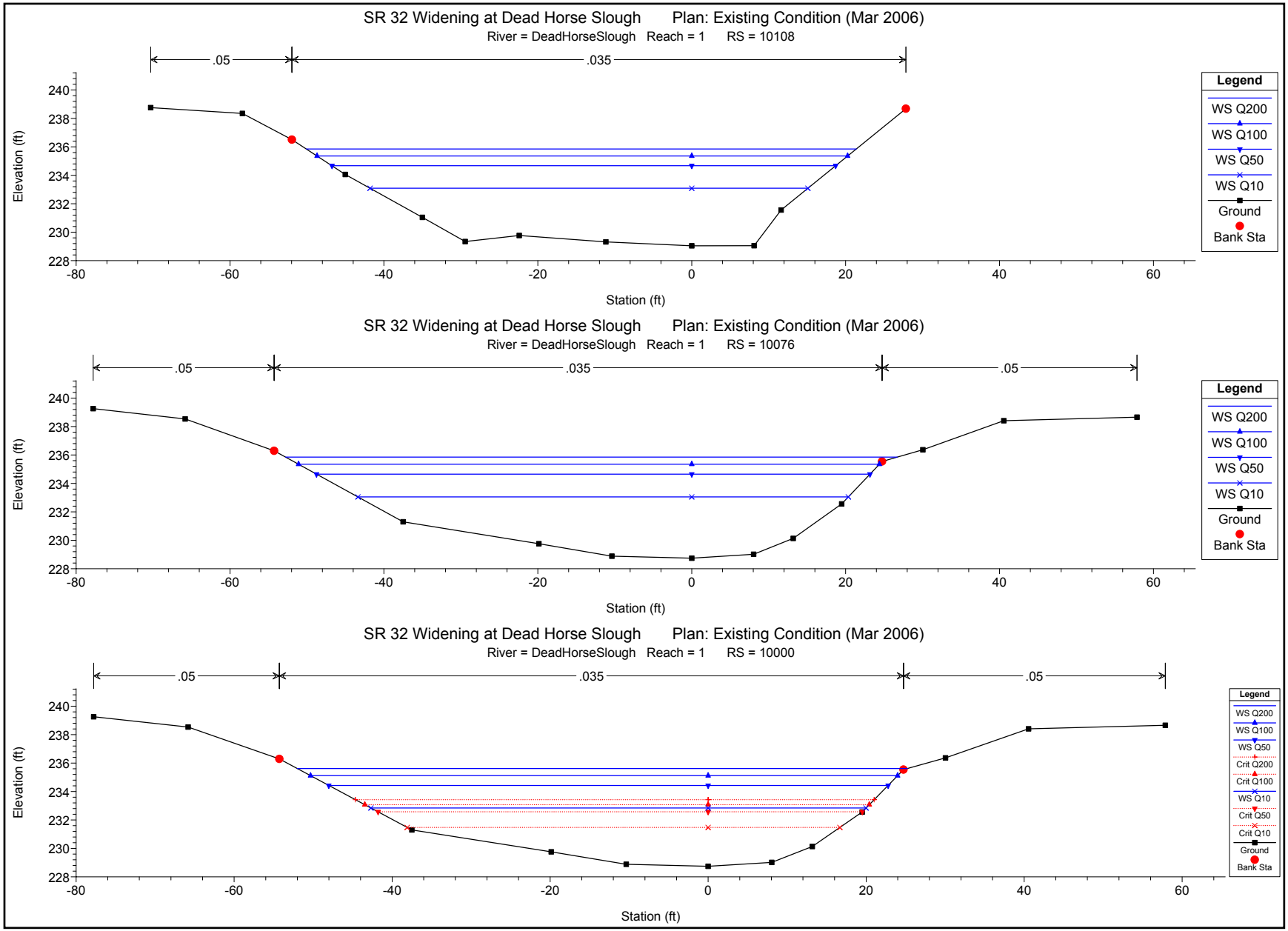
1 in Horiz. = 18 ft 1 in Vert. = 10 ft



1 in Horiz. = 18 ft 1 in Vert. = 10 ft



1 in Horiz. = 18 ft 1 in Vert. = 10 ft



1 in Horiz. = 18 ft 1 in Vert. = 10 ft

```
                    HEC-RAS Version 3.1.3 May 2005
                     U.S. Army Corp of Engineers
                    Hydrologic Engineering Center
                          609 Second Street
                          Davis, California


           X     X  XXXXXX    XXXX        XXXX       XX      XXXX
           X     X  X        X    X       X   X     X  X    X
           X     X  X        X            X   X    X    X   X
           XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
           X     X  X        X            X  X     X    X        X
           X     X  X        X    X       X   X    X    X        X
           X     X  XXXXXX    XXXX        X    X   X    X   XXXXX



PROJECT DATA
Project Title: SR 32 Widening at Dead Horse Slough
Project File : DeadHorse.prj
Run Date and Time: 3/6/2006 3:12:11 PM

Project in English units


PLAN DATA

Plan Title: Existing Condition (Mar 2006)
Plan File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.p03

          Geometry Title: Survey (December 2005)
          Geometry File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.g01

          Flow Title    : City of Chico Q - Normal Depth
          Flow File     : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.f02

Plan Summary Information:
Number of:  Cross Sections =   10    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =    0
            Bridges        =    1    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow



FLOW DATA

Flow Title: City of Chico Q - Normal Depth
Flow File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.f02

Flow Data (cfs)

  River           Reach          RS                Q200           Q100           Q50            Q10
  DeadHorseSlough 1              10882             2220           1900           1500           750


Boundary Conditions

  River           Reach          Profile                    Upstream              Downstream

  DeadHorseSlough 1              Q200                   Normal S = 0.0057     Normal S = 0.0025
  DeadHorseSlough 1              Q100                   Normal S = 0.0057     Normal S = 0.0025
  DeadHorseSlough 1              Q50                    Normal S = 0.0057     Normal S = 0.0025
  DeadHorseSlough 1              Q10                    Normal S = 0.0057     Normal S = 0.0025



GEOMETRY DATA

Geometry Title: Survey (December 2005)
Geometry File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.g01

CROSS SECTION


RIVER: DeadHorseSlough
```

```
REACH: 1                  RS: 10882

INPUT
Description:
Station Elevation Data    num=       8
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -45.85  240.38   -34.7   235.6  -24.35  235.21  -13.75  232.68   -5.94  231.15
       0  230.98   12.78  231.74    14.7  238.67

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -45.85     .05  -45.85    .035    14.7     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -45.85    14.7               90      90      90             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10792

INPUT
Description:
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -47.07  240.51  -41.44  240.12  -25.33   233.7  -21.91  233.18  -16.29  233.97
   -9.47  233.44   -5.81  232.33   -3.65  231.35       0  231.13    4.87  231.83
   12.33  231.62   15.91  232.67    21.8  232.53   23.51  231.84   26.55  232.22
   39.81  238.45   57.46  240.43

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -47.07     .05  -41.44    .035   39.81     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -41.44   39.81              30      30      30             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10762

INPUT
Description:
Station Elevation Data    num=      24
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -49.14  240.72  -45.29  240.45  -40.18  238.54  -29.44   233.9  -27.68  233.39
  -23.95  232.89   -17.8  233.18   -16.4  233.06  -10.43  232.78  -10.35  232.78
   -6.35  232.06   -3.99  231.42   -2.87  231.39       0  231.03     4.5  231.73
    7.68  231.82   11.39  231.69   14.69  232.36   17.34  232.28   20.13  232.59
   21.71  232.31   24.52  232.93   36.77  238.75   55.03   240.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -49.14    .045  -45.29     .04   36.77     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -45.29   36.77              65      65      65             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10697

INPUT
Description:
Station Elevation Data    num=      11
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -53.64  241.16  -47.59  239.14  -34.87  232.94  -19.42   231.3  -12.35  231.35
    -3.4   231.6       0  230.81     6.3  232.02   14.23  231.58   30.18   239.4
   49.76  239.69

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -53.64     .05  -53.64    .035   30.18     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -53.64   30.18              53      53      53             .3       .5

BRIDGE


RIVER: DeadHorseSlough
REACH: 1                  RS: 10693

INPUT
Description: SR 32 at Dead Horse Slough (45 degree skew)
Distance from Upstream XS =     3.5
Deck/Roadway Width        =      46
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
```

```
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
    -200   242.9       0  -53.65   242.5       0  -53.64   242.5  241.25
   33.86   242.1  240.85   33.87   242.1       0     330   241.4       0

Upstream Bridge Cross Section Data
Station Elevation Data    num=      11
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -53.64  241.16  -47.59  239.14  -34.87  232.94  -19.42   231.3  -12.35  231.35
    -3.4   231.6       0  230.81     6.3  232.02   14.23  231.58   30.18   239.4
   49.76  239.69

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -53.64     .05  -53.64    .035   30.18     .05

Bank Sta: Left   Right    Coeff Contr.   Expan.
        -53.64   30.18             .3       .5

Downstream  Deck/Roadway Coordinates
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
    -200   242.9       0  -55.52   242.5       0  -55.51   242.5  241.25
   31.99   242.1  240.85      32   242.1       0     330   241.4       0

Downstream Bridge Cross Section Data
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -68.66  240.95  -51.07  239.13  -46.21  238.41  -37.75  234.02  -27.51  232.99
  -22.26  231.14  -17.86  230.45   -7.97  231.19       0  230.18    6.96  232.01
   14.15  233.23   26.82  236.44   31.99  238.69

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -68.66     .05  -46.21    .035   31.99     .05

Bank Sta: Left   Right    Coeff Contr.   Expan.
        -46.21   31.99             .1       .3

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       2
     Sta    Elev     Sta    Elev
  -63.64  242.52  -53.64   242.5
Downstream     num=       2
     Sta    Elev     Sta    Elev
  -65.51  242.52  -55.51   242.5

Abutment Data
Upstream     num=       2
     Sta    Elev     Sta    Elev
   33.86   242.1   43.86  242.08
Downstream     num=       2
     Sta    Elev     Sta    Elev
   31.99   242.1   41.99  242.08

Number of Piers =  3

Pier Data
Pier Station     Upstream=  -31.77    Downstream=  -33.64
Upstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242
Downstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242

Pier Data
Pier Station     Upstream=  -9.895    Downstream= -11.765
Upstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242
Downstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242

Pier Data
Pier Station     Upstream=   11.98    Downstream=   10.11
Upstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242
Downstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242
```

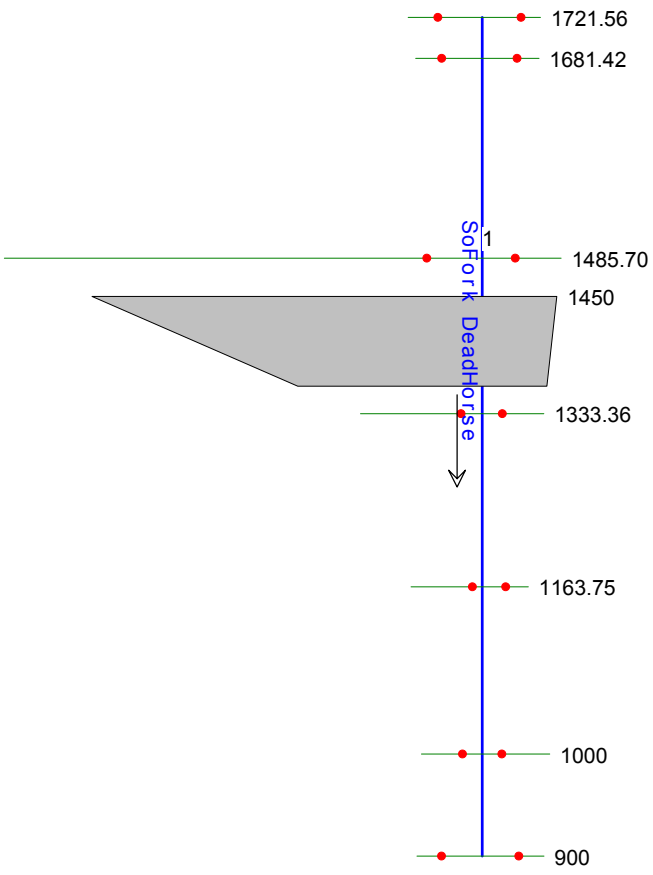
```
Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10644

INPUT
Description:
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -68.66  240.95  -51.07  239.13  -46.21  238.41  -37.75  234.02  -27.51  232.99
  -22.26  231.14  -17.86  230.45   -7.97  231.19       0  230.18    6.96  232.01
   14.15  233.23   26.82  236.44   31.99  238.69

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -68.66     .05  -46.21    .035   31.99     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -46.21   31.99              132     132     132             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10512

INPUT
Description:
Station Elevation Data    num=       9
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -23.36  237.75  -13.06  233.26   -5.54  231.44       0  230.62   11.45  230.89
   12.39  231.31   38.84  232.44   49.31  237.73   62.31  237.71

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -23.36     .05  -23.36    .035   49.31     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -23.36   49.31              250     250     250             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10262

INPUT
Description:
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -59.16  238.08  -46.79  237.31  -32.38   232.4  -26.49  229.96  -22.55  230.99
  -19.22  231.18  -15.49  230.59   -5.86   229.4       0  229.24    7.63  229.78
   12.22  231.24   30.47  237.79

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -59.16     .05  -46.79    .035   30.47     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -46.79   30.47              154     154     154             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10108

INPUT
Description:
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -70.32  238.76   -58.4  238.35  -51.96  236.51  -45.02  234.06     -35  231.04
  -29.44  229.34  -22.42  229.77  -11.16  229.32       0  229.04    8.11  229.05
   11.61  231.56   27.83  238.68

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
```

```
  -70.32     .05  -51.96    .035   27.83     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -51.96   27.83               32      32      32             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10076

INPUT
Description:
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -77.78  239.26  -65.83  238.53  -54.27  236.29  -37.51   231.3  -19.86  229.76
  -10.37  228.88       0  228.74    8.05  229.02   13.18  230.13   19.49  232.56
   24.73  235.54   30.04  236.37   40.56  238.41   57.87  238.66

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -77.78     .05  -54.27    .035   24.73     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -54.27   24.73               76      76      76             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10000

INPUT
Description:
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -77.78  239.26  -65.83  238.53  -54.27  236.29  -37.51   231.3  -19.86  229.76
  -10.37  228.88       0  228.74    8.05  229.02   13.18  230.13   19.49  232.56
   24.73  235.54   30.04  236.37   40.56  238.41   57.87  238.66

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -77.78     .05  -54.27    .035   24.73     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -54.27   24.73                0       0       0             .1       .3


SUMMARY OF MANNING'S N VALUES

River:DeadHorseSlough

      Reach          River Sta.       n1        n2        n3

 1                    10882             .05      .035       .05
 1                    10792             .05      .035       .05
 1                    10762            .045       .04       .05
 1                    10697             .05      .035       .05
 1                    10693        Bridge
 1                    10644             .05      .035       .05
 1                    10512             .05      .035       .05
 1                    10262             .05      .035       .05
 1                    10108             .05      .035       .05
 1                    10076             .05      .035       .05
 1                    10000             .05      .035       .05


SUMMARY OF REACH LENGTHS

River: DeadHorseSlough

      Reach          River Sta.      Left     Channel    Right

 1                    10882              90        90        90
 1                    10792              30        30        30
 1                    10762              65        65        65
 1                    10697              53        53        53
 1                    10693        Bridge
 1                    10644             132       132       132
 1                    10512             250       250       250
 1                    10262             154       154       154
 1                    10108              32        32        32
 1                    10076              76        76        76
 1                    10000               0         0         0


SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: DeadHorseSlough
```

Reach	River Sta.	Contr.	Expan.
1	10882	.1	.3
1	10792	.1	.3
1	10762	.1	.3
1	10697	.3	.5
1	10693	Bridge	
1	10644	.1	.3
1	10512	.1	.3
1	10262	.1	.3
1	10108	.1	.3
1	10076	.1	.3
1	10000	.1	.3

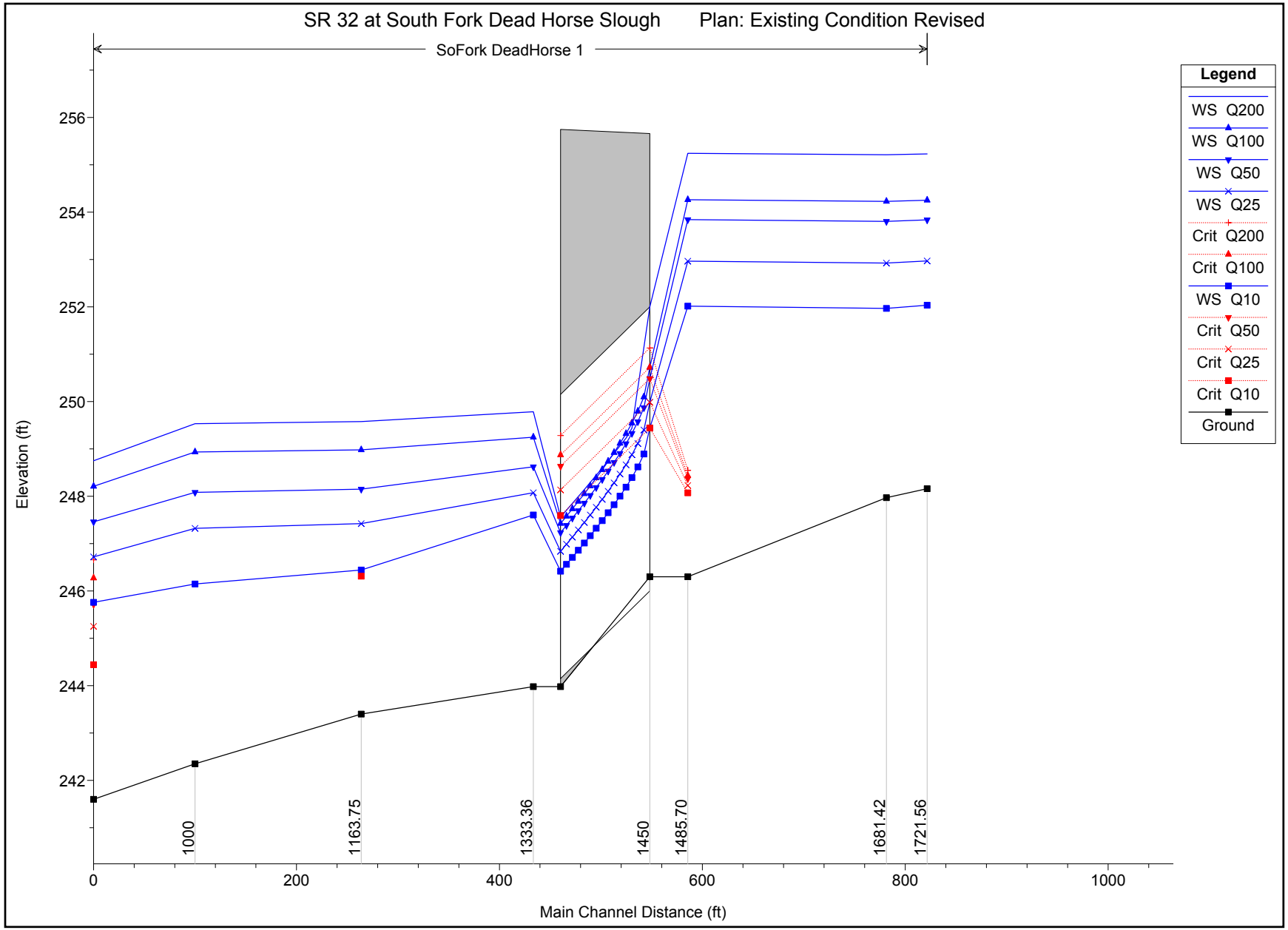
DRAFT BRIDGE DESIGN HYDRAULIC STUDY REPORT FOR
THE SOUTH FORK DEAD HORSE SLOUGH CULVERT UNDER SR32
CITY OF CHICO, CALIFORNIA

EXISTING CONDITION HEC-RAS MODEL

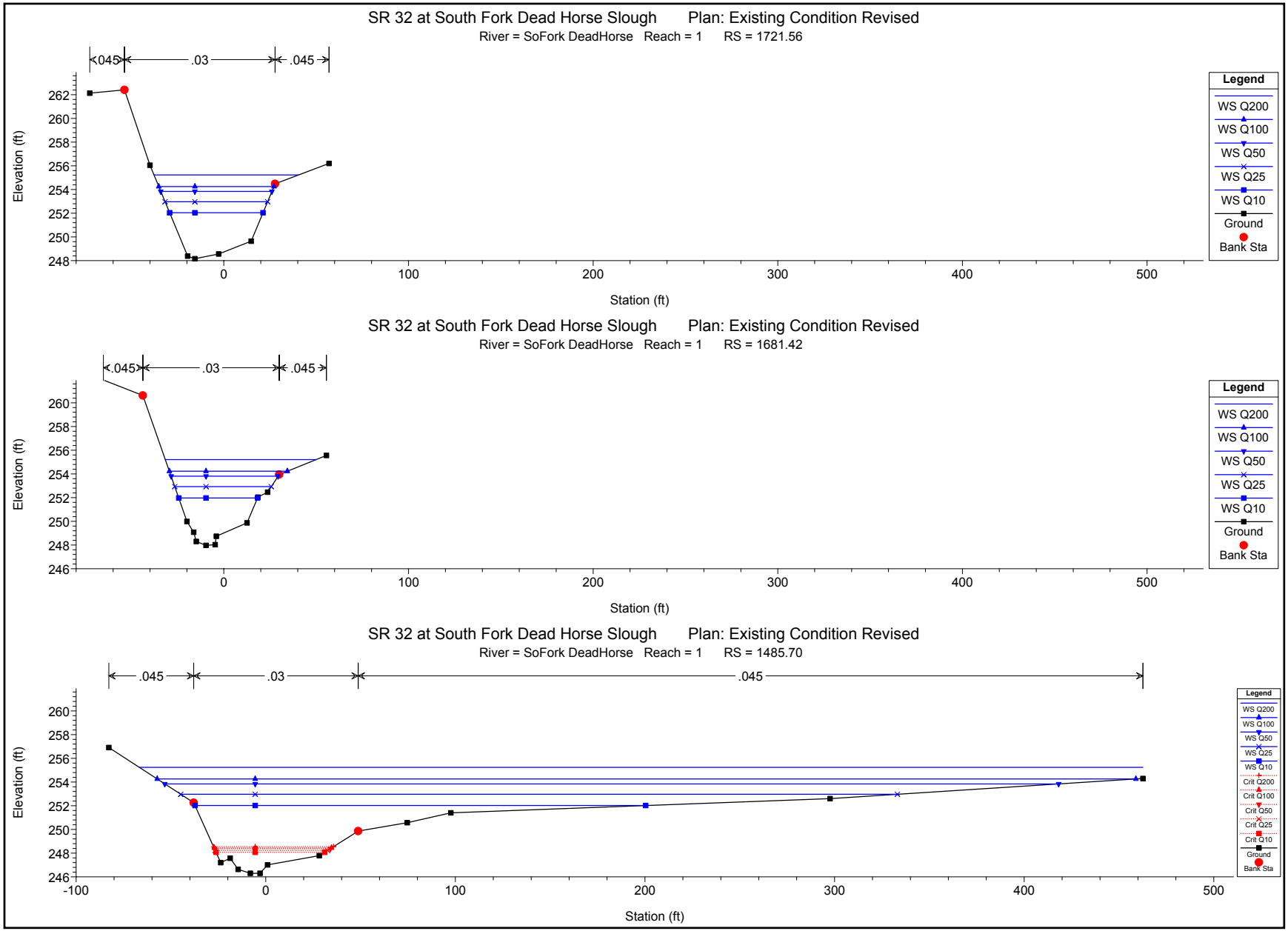


HEC-RAS Plan: Exist River: SoFork DeadHorse Reach: 1

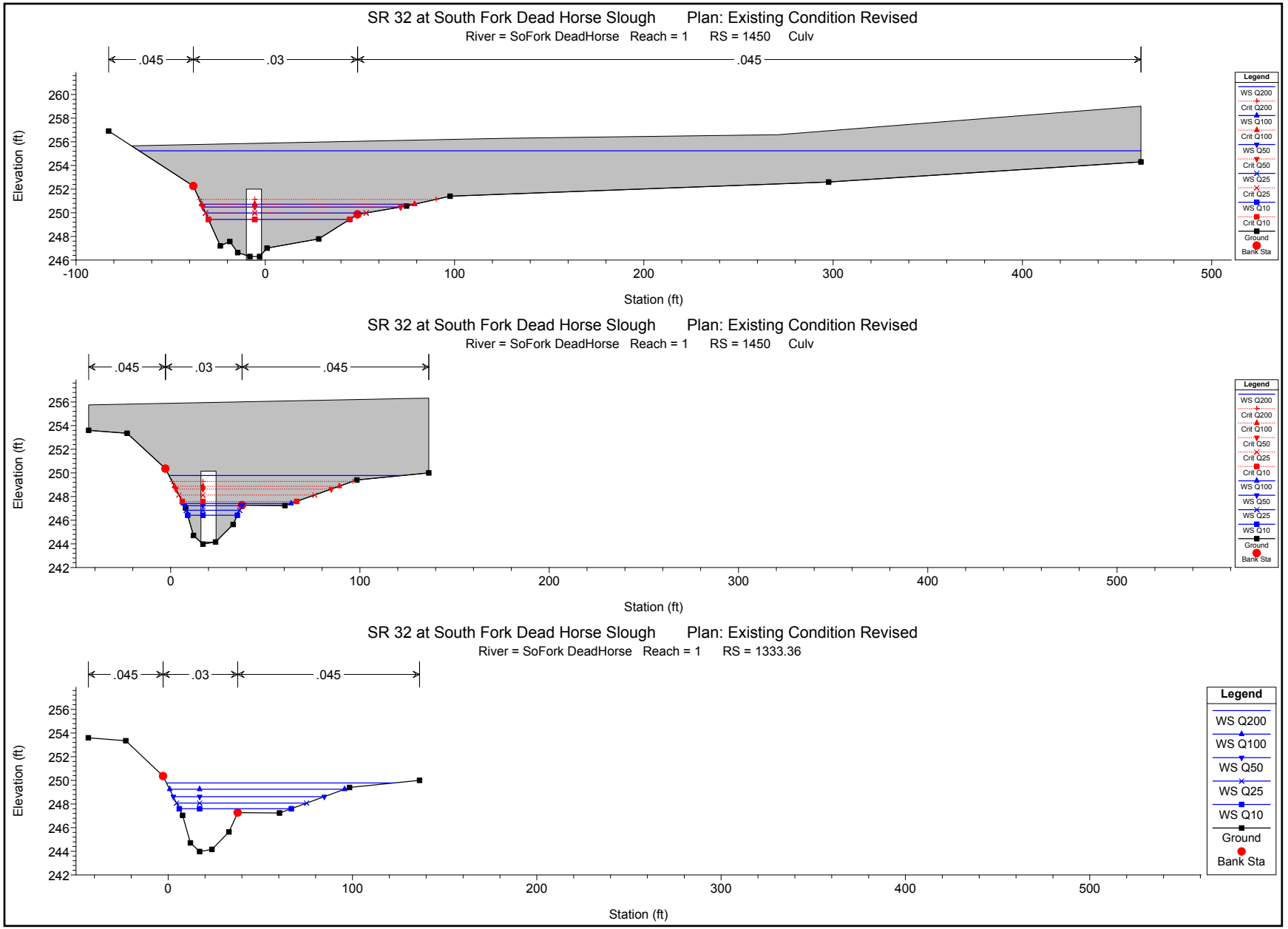
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	900	Q200	2220.00	241.60	248.75	246.66	249.43	0.002215	6.61	335.62	68.02	0.52
1	900	Q100	1900.00	241.60	248.21	246.27	248.83	0.002231	6.34	299.66	65.17	0.52
1	900	Q50	1500.00	241.60	247.46	245.72	248.01	0.002263	5.95	252.27	61.21	0.52
1	900	Q25	1200.00	241.60	246.72	245.25	247.23	0.002498	5.76	208.41	57.30	0.53
1	900	Q10	750.00	241.60	245.76	244.44	246.12	0.002260	4.81	155.84	52.23	0.49
1	1000	Q200	528.00	242.35	249.53		249.63	0.000461	2.60	227.80	69.83	0.20
1	1000	Q100	466.00	242.35	248.93		249.04	0.000541	2.65	189.17	58.98	0.21
1	1000	Q50	431.00	242.35	248.08		248.22	0.000867	3.04	144.97	44.94	0.27
1	1000	Q25	361.00	242.35	247.32		247.47	0.001135	3.13	115.48	33.32	0.30
1	1000	Q10	290.00	242.35	246.15		246.36	0.002226	3.69	78.54	29.66	0.40
1	1163.75	Q200	528.00	243.40	249.58		249.76	0.000865	3.63	185.69	80.65	0.31
1	1163.75	Q100	466.00	243.40	248.98		249.20	0.001165	3.90	142.20	64.92	0.36
1	1163.75	Q50	431.00	243.40	248.15		248.51	0.002319	4.86	95.76	46.90	0.49
1	1163.75	Q25	361.00	243.40	247.42		247.87	0.003775	5.39	67.42	31.14	0.60
1	1163.75	Q10	290.00	243.40	246.44	246.31	247.18	0.009582	6.90	42.04	23.70	0.91
1	1333.36	Q200	528.00	243.98	249.78		249.88	0.000497	2.72	272.33	123.59	0.24
1	1333.36	Q100	466.00	243.98	249.25		249.35	0.000621	2.85	214.96	94.85	0.26
1	1333.36	Q50	431.00	243.98	248.62		248.78	0.001038	3.39	159.80	81.88	0.33
1	1333.36	Q25	361.00	243.98	248.08		248.27	0.001405	3.61	118.18	70.53	0.38
1	1333.36	Q10	290.00	243.98	247.60		247.81	0.001695	3.64	87.27	60.74	0.41
1	1450		Culvert									
1	1485.70	Q200	528.00	246.30	255.24	248.55	255.24	0.000007	0.50	1848.68	529.36	0.03
1	1485.70	Q100	466.00	246.30	254.26	248.44	254.27	0.000013	0.60	1334.62	516.21	0.04
1	1485.70	Q50	431.00	246.30	253.84	248.37	253.85	0.000015	0.63	1127.26	471.41	0.05
1	1485.70	Q25	361.00	246.30	252.97	248.23	252.97	0.000024	0.70	755.13	377.92	0.06
1	1485.70	Q10	290.00	246.30	252.02	248.07	252.03	0.000038	0.77	456.08	237.66	0.07
1	1681.42	Q200	528.00	247.97	255.21		255.26	0.000179	1.81	301.94	81.74	0.15
1	1681.42	Q100	466.00	247.97	254.23		254.29	0.000291	2.03	230.18	63.89	0.18
1	1681.42	Q50	431.00	247.97	253.81		253.87	0.000352	2.11	204.74	57.94	0.20
1	1681.42	Q25	361.00	247.97	252.93		253.01	0.000528	2.31	156.25	52.25	0.24
1	1681.42	Q10	290.00	247.97	251.97		252.07	0.000836	2.63	110.14	42.69	0.29
1	1721.56	Q200	528.00	248.16	255.23		255.27	0.000129	1.61	332.13	78.36	0.13
1	1721.56	Q100	466.00	248.16	254.25		254.30	0.000192	1.76	264.63	62.43	0.15
1	1721.56	Q50	431.00	248.16	253.84		253.89	0.000219	1.80	239.06	60.20	0.16
1	1721.56	Q25	361.00	248.16	252.97		253.03	0.000302	1.91	188.88	55.57	0.18
1	1721.56	Q10	290.00	248.16	252.04		252.10	0.000471	2.08	139.35	50.58	0.22



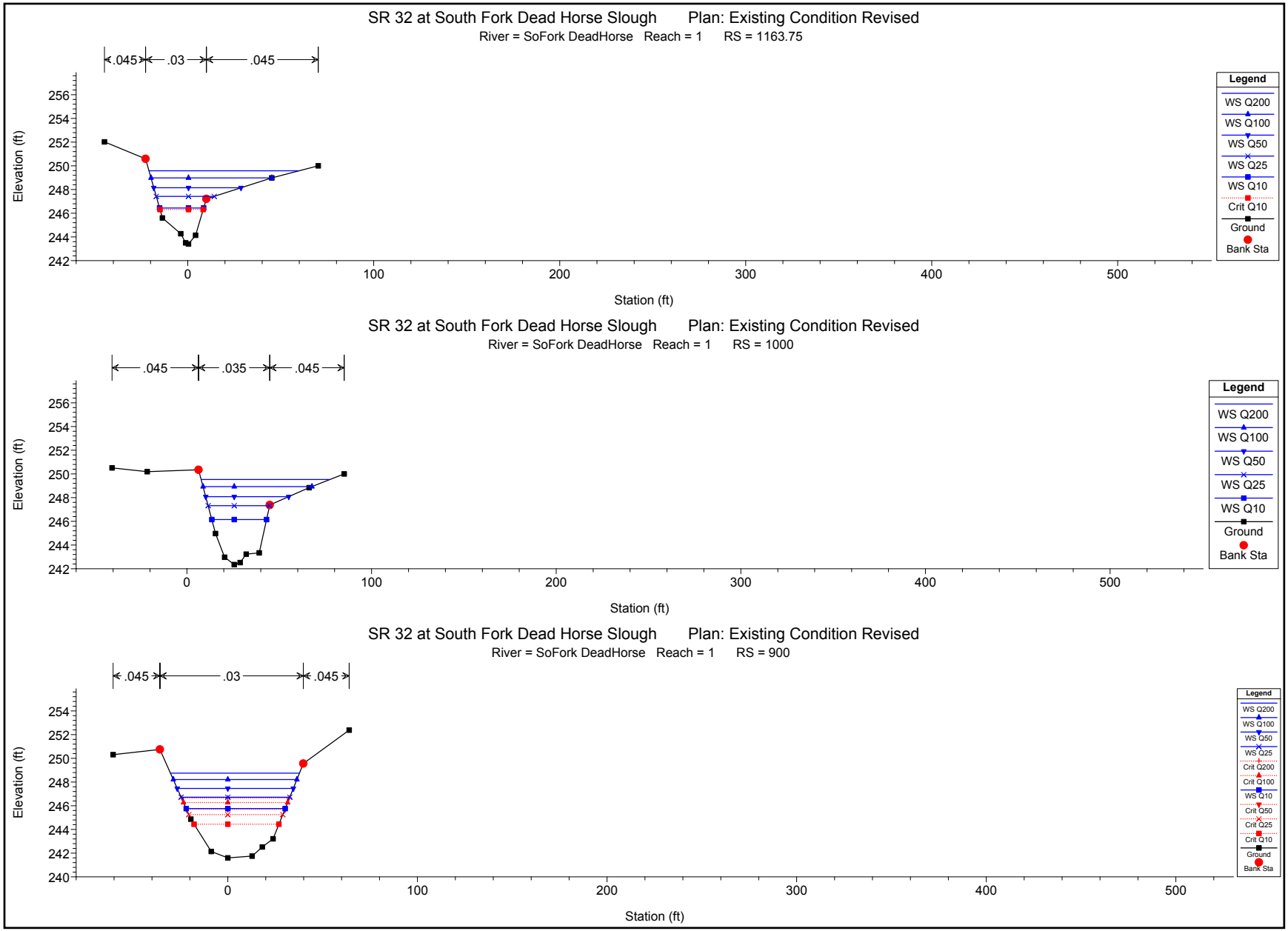
1 in Horiz. = 140 ft 1 in Vert. = 3 ft



1 in Horiz. = 75 ft 1 in Vert. = 12 ft



1 in Horiz. = 75 ft 1 in Vert. = 12 ft



1 in Horiz. = 75 ft 1 in Vert. = 12 ft

```
                    HEC-RAS Version 3.1.3 May 2005
                     U.S. Army Corp of Engineers
                    Hydrologic Engineering Center
                          609 Second Street
                          Davis, California

           X     X  XXXXXX    XXXX        XXXX       XX      XXXX
           X     X  X        X    X       X   X     X  X    X
           X     X  X        X            X   X    X    X   X
           XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
           X     X  X        X            X  X     X    X        X
           X     X  X        X    X       X   X    X    X        X
           X     X  XXXXXX    XXXX        X    X   X    X   XXXXX


PROJECT DATA
Project Title: SR 32 at South Fork Dead Horse Slough
Project File : SFDeadHorse.prj
Run Date and Time: 3/15/2006 3:38:10 PM

Project in English units


PLAN DATA

Plan Title: Existing Condition Revised
Plan File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.p06

          Geometry Title: WRECO Existing revised
          Geometry File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.g04

          Flow Title    : City of Chico-Husa Ranch Development WSE
          Flow File     : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.f01

Plan Summary Information:
Number of:  Cross Sections =    7    Multiple Openings  =    0
            Culverts       =    1    Inline Structures  =    0
            Bridges        =    0    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow



FLOW DATA

Flow Title: City of Chico-Husa Ranch Development WSE
Flow File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.f01

Flow Data (cfs)

  River           Reach          RS                Q200          Q100          Q50           Q25           Q10
  SoFork DeadHorse1              1721.56            528           466           431           361           290
  SoFork DeadHorse1              900               2220          1900          1500          1200           750


Boundary Conditions

  River           Reach          Profile                   Upstream              Downstream

  SoFork DeadHorse1              Q200                  Normal S = 0.011      Known WS = 248.75
  SoFork DeadHorse1              Q100                  Normal S = 0.011      Known WS = 248.21
  SoFork DeadHorse1              Q50                   Normal S = 0.011      Known WS = 247.46
  SoFork DeadHorse1              Q25                   Normal S = 0.011      Known WS = 246.72
  SoFork DeadHorse1              Q10                   Normal S = 0.011      Known WS = 245.76



GEOMETRY DATA

Geometry Title: WRECO Existing revised
Geometry File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.g04

CROSS SECTION
```

```
RIVER: SoFork DeadHorse
REACH: 1                  RS: 1721.56

INPUT
Description:
Station Elevation Data    num=       9
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -72.65  262.13  -53.81  262.41  -40.03  256.05  -19.63  248.38  -15.67  248.16
   -2.79  248.56   14.78  249.64   27.79  254.48   56.98   256.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -72.65    .045  -53.81     .03   27.79    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -53.81   27.79            40.14   40.14   40.14             .1       .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1681.42

INPUT
Description:
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -65.21  261.92  -43.87  260.62  -19.98  249.99  -16.32  249.08  -14.92   248.3
   -9.66  247.97   -4.74  248.03    -4.1  248.74   12.53  249.87   18.47  252.04
   23.71  252.46      30  253.95   55.55  255.56

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -65.21    .045  -43.87     .03      30    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -43.87      30           195.72  195.72  195.72             .1       .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1485.70

INPUT
Description:
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -82.78  256.91     -38  252.26  -23.73   247.2  -18.78  247.57  -14.58  246.63
   -8.13   246.3   -2.99   246.3     .93  247.01   28.28  247.79   48.76  249.86
   74.65  250.57   97.65   251.4  297.65   252.6  462.65   254.3

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -82.78    .045     -38     .03   48.76    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           -38   48.76           152.34  152.34  152.34             .3       .5

CULVERT


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1450

INPUT
Description:
Distance from Upstream XS =    37.5
Deck/Roadway Width        =      88
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=       5
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
    -233   255.3       0    -120   255.5       0     128   256.3       0
     271   256.6       0     470   259.1       0

Upstream Bridge Cross Section Data
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -82.78  256.91     -38  252.26  -23.73   247.2  -18.78  247.57  -14.58  246.63
   -8.13   246.3   -2.99   246.3     .93  247.01   28.28  247.79   48.76  249.86
   74.65  250.57   97.65   251.4  297.65   252.6  462.65   254.3

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -82.78    .045     -38     .03   48.76    .045

Bank Sta: Left   Right    Coeff Contr.   Expan.
           -38   48.76             .3       .5

Downstream  Deck/Roadway Coordinates
    num=       4
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
```

```
    -233   255.3       0    -120   255.5       0     128   256.3       0
     271   256.6       0

Downstream Bridge Cross Section Data
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -43.31   253.6     -23  253.35   -2.73  250.36    7.86  247.04   12.09  244.71
   17.07  243.98   23.77  244.16      33  245.64   37.76  247.27   60.38  247.24
   98.38   249.4  136.38     250

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -43.31    .045   -2.73     .03   37.76    .045

Bank Sta: Left   Right    Coeff Contr.   Expan.
         -2.73   37.76             .1       .3

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Culverts =  1

Culvert Name     Shape      Rise    Span
Culvert #1           Box       6       8
FHWA Chart # 11- Skewed headwall; Chamfered or beveled Inlet
FHWA Scale # 3 - Headwall skewed 15 deg.; inlet edges chamfered 3/4 inch
Solution Criteria = Highest U.S. EG
Culvert Upstrm Dist  Length    Top n  Bottom n  Depth Blocked  Entrance Loss Coef   Exit Loss Coef
              37.5      88     .013     .013        0                    .5              1
Upstream   Elevation =  246
           Centerline Station = -6
Downstream Elevation =  244.15
           Centerline Station =  20

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1333.36

INPUT
Description:
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -43.31   253.6     -23  253.35   -2.73  250.36    7.86  247.04   12.09  244.71
   17.07  243.98   23.77  244.16      33  245.64   37.76  247.27   60.38  247.24
   98.38   249.4  136.38     250

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -43.31    .045   -2.73     .03   37.76    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         -2.73   37.76           169.61  169.61  169.61             .1       .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1163.75

INPUT
Description:
Station Elevation Data    num=      10
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -44.78  252.02  -22.68  250.59  -13.62   245.6   -3.75  244.27   -1.14   243.5
      .4   243.4    4.23  244.14    9.99  247.21   45.18  248.98   70.18     250

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -44.78    .045  -22.68     .03    9.99    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -22.68    9.99           163.75  163.75  163.75             .1       .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1000

INPUT
Description:
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -40.58  250.51  -21.47  250.19    6.33  250.35    15.5  244.97   20.41  242.97
   25.61  242.35   28.86  242.52   32.12  243.23   39.18  243.34   44.89  247.38
   66.19  248.84   85.19     250
```

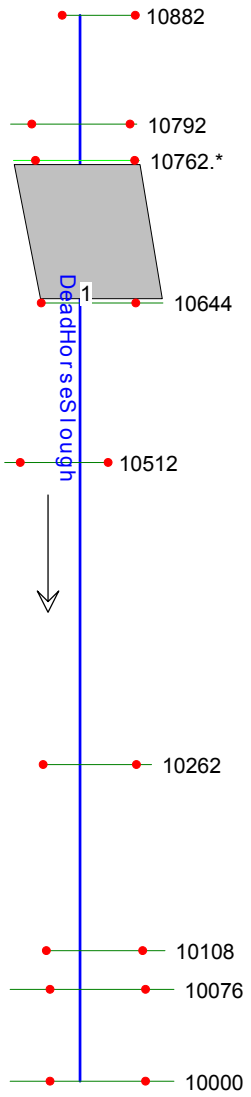
```
Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -40.58    .045    6.33    .035   44.89    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          6.33   44.89              100     100     100             .1      .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 900

INPUT
Description:
Station Elevation Data    num=      10
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -60.52  250.31   -35.8  250.75   -19.5  244.87   -8.77  242.14       0   241.6
    12.8  241.75   18.19  242.52   23.87  243.21    39.8  249.56   64.03  252.38

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -60.52    .045   -35.8     .03    39.8    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         -35.8    39.8                0       0       0             .1      .3


SUMMARY OF MANNING'S N VALUES

River:SoFork DeadHorse

      Reach          River Sta.       n1        n2        n3

 1                    1721.56          .045       .03      .045
 1                    1681.42          .045       .03      .045
 1                    1485.70          .045       .03      .045
 1                    1450         Culvert
 1                    1333.36          .045       .03      .045
 1                    1163.75          .045       .03      .045
 1                    1000             .045      .035      .045
 1                    900              .045       .03      .045



SUMMARY OF REACH LENGTHS

River: SoFork DeadHorse

      Reach          River Sta.      Left     Channel    Right

 1                    1721.56          40.14     40.14     40.14
 1                    1681.42         195.72    195.72    195.72
 1                    1485.70         152.34    152.34    152.34
 1                    1450         Culvert
 1                    1333.36         169.61    169.61    169.61
 1                    1163.75         163.75    163.75    163.75
 1                    1000               100       100       100
 1                    900                  0         0         0



SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: SoFork DeadHorse


      Reach          River Sta.     Contr.    Expan.

 1                    1721.56          .1        .3
 1                    1681.42          .1        .3
 1                    1485.70          .3        .5
 1                    1450     Culvert
 1                    1333.36          .1        .3
 1                    1163.75          .1        .3
 1                    1000             .1        .3
 1                    900              .1        .3
```

APPENDIX B

HEC-RAS Hydraulic Analysis – Proposed Condition

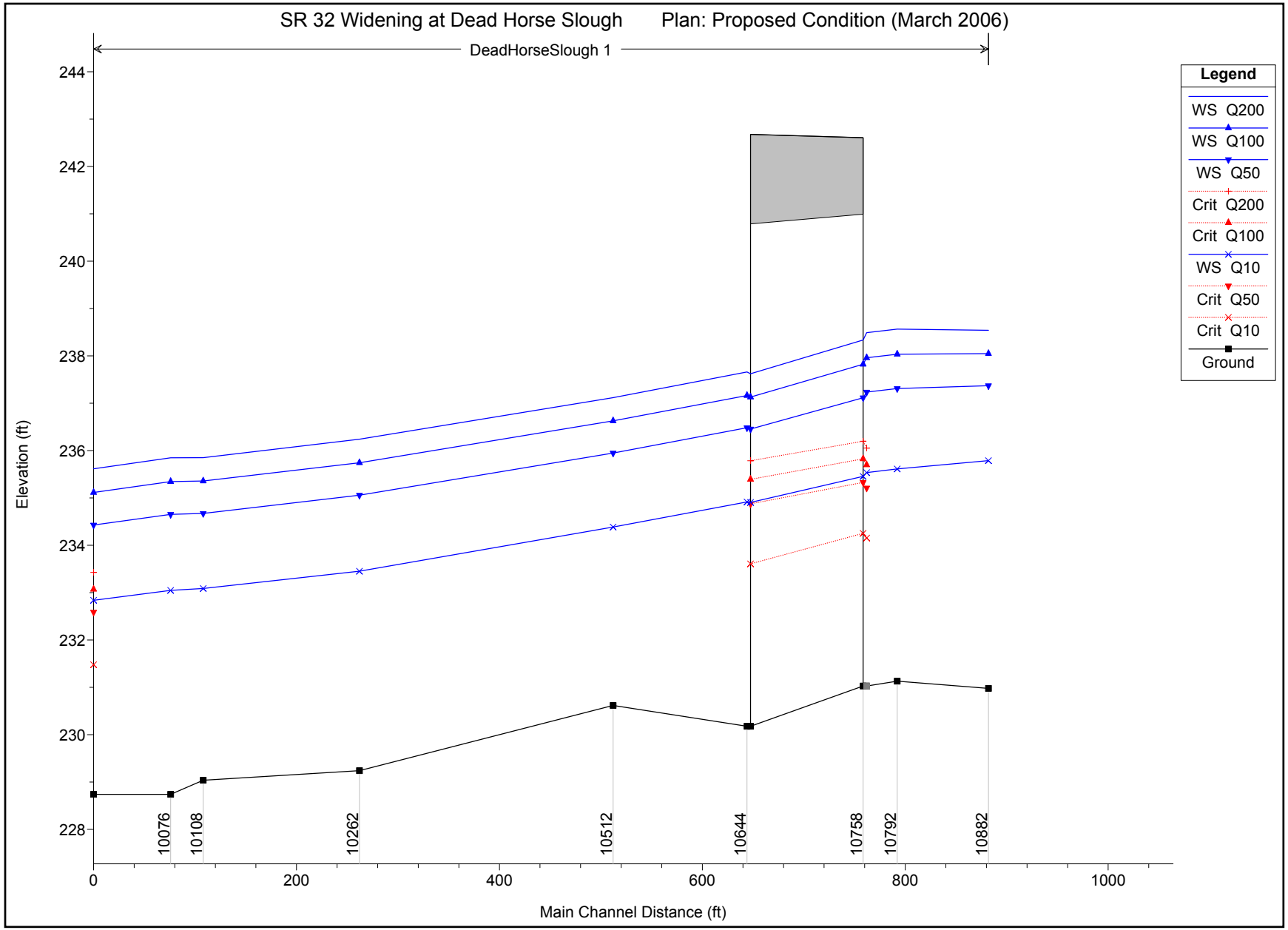
DRAFT BRIDGE DESIGN HYDRAULIC STUDY REPORT FOR
THE SR32 BRIDGE OVER DEAD HORSE SLOUGH
CITY OF CHICO, CALIFORNIA

PROPOSED CONDITION HEC-RAS MODEL

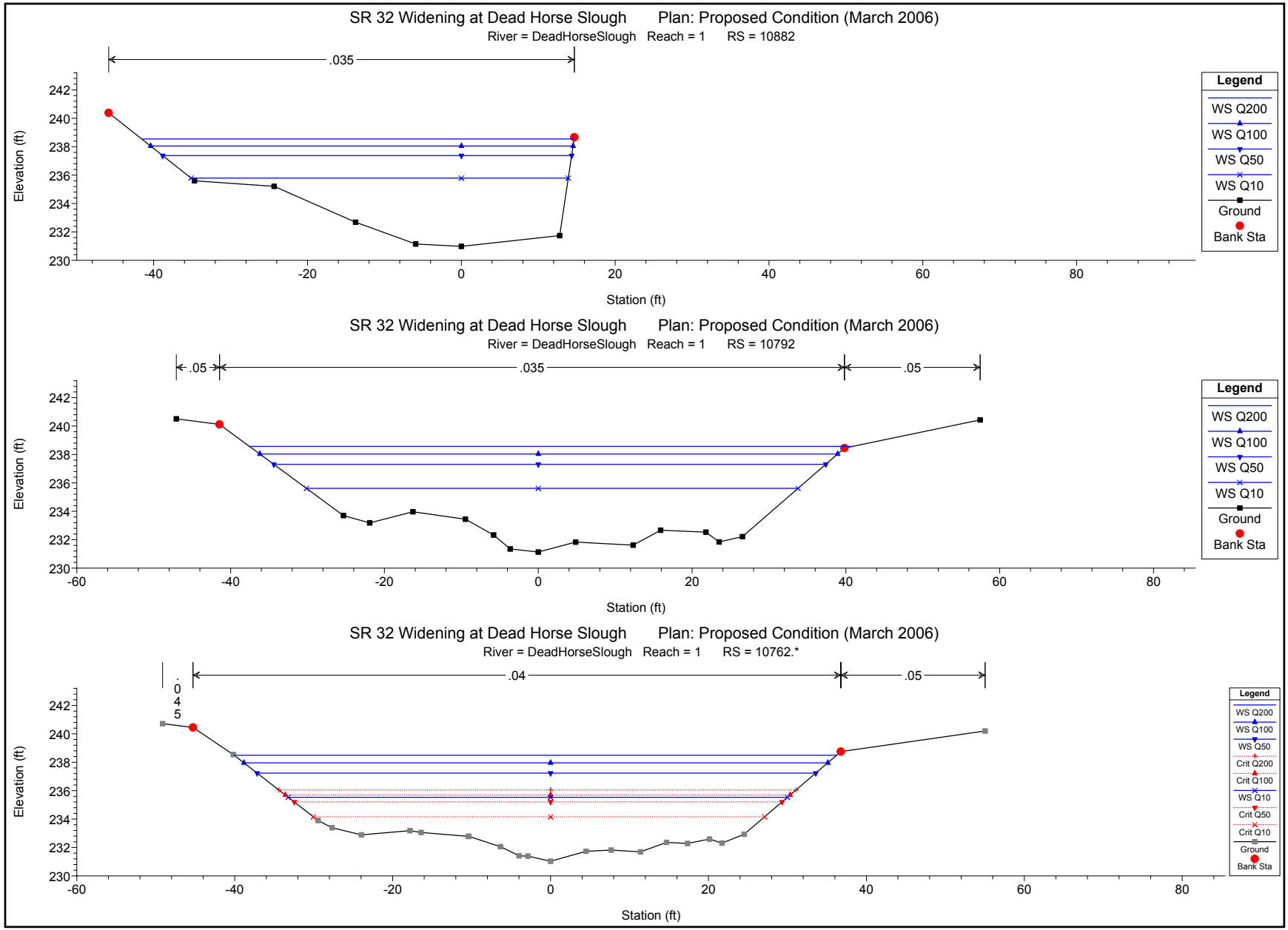


HEC-RAS Plan: Proposed River: DeadHorseSlough Reach: 1

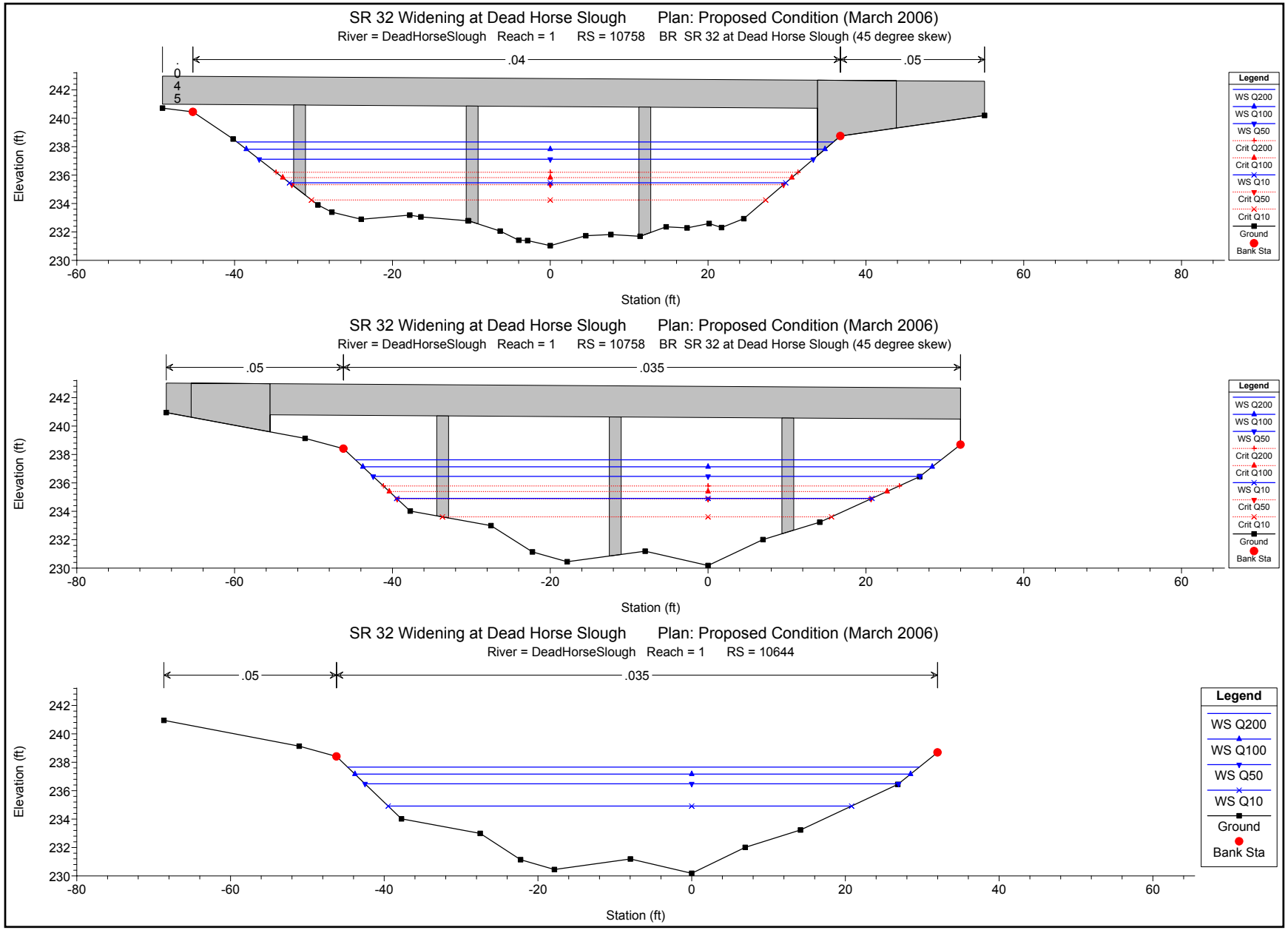
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	10000	Q200	2220.00	228.74	235.62	233.43	236.17	0.002501	5.97	371.82	77.23	0.48
1	10000	Q100	1900.00	228.74	235.12	233.07	235.62	0.002504	5.69	334.02	74.32	0.47
1	10000	Q50	1500.00	228.74	234.43	232.59	234.86	0.002501	5.28	284.08	70.79	0.46
1	10000	Q10	750.00	228.74	232.84	231.48	233.11	0.002501	4.21	177.96	62.65	0.44
1	10076	Q200	2220.00	228.74	235.85		236.35	0.002168	5.70	389.97	79.49	0.45
1	10076	Q100	1900.00	228.74	235.35		235.80	0.002165	5.41	351.24	75.49	0.44
1	10076	Q50	1500.00	228.74	234.65		235.04	0.002128	5.00	300.20	71.95	0.43
1	10076	Q10	750.00	228.74	233.05		233.29	0.002013	3.92	191.33	63.74	0.40
1	10108	Q200	2220.00	229.04	235.85		236.46	0.002708	6.26	354.40	71.48	0.50
1	10108	Q100	1900.00	229.04	235.36		235.91	0.002661	5.94	319.69	68.96	0.49
1	10108	Q50	1500.00	229.04	234.67		235.14	0.002588	5.48	273.77	65.47	0.47
1	10108	Q10	750.00	229.04	233.09		233.37	0.002297	4.25	176.66	56.89	0.42
1	10262	Q200	2220.00	229.24	236.24		236.97	0.003504	6.84	324.60	69.81	0.56
1	10262	Q100	1900.00	229.24	235.74		236.41	0.003507	6.54	290.60	66.97	0.55
1	10262	Q50	1500.00	229.24	235.06		235.64	0.003510	6.10	245.93	63.04	0.54
1	10262	Q10	750.00	229.24	233.45		233.83	0.003504	4.93	152.18	53.86	0.52
1	10512	Q200	2220.00	230.62	237.12		237.84	0.003471	6.82	325.56	70.01	0.56
1	10512	Q100	1900.00	230.62	236.63		237.29	0.003511	6.51	291.68	67.91	0.55
1	10512	Q50	1500.00	230.62	235.95		236.52	0.003598	6.08	246.61	65.02	0.55
1	10512	Q10	750.00	230.62	234.39		234.77	0.004022	5.00	150.15	58.33	0.55
1	10644	Q200	2220.00	230.18	237.66		238.26	0.002748	6.21	357.66	74.39	0.50
1	10644	Q100	1900.00	230.18	237.16		237.71	0.002764	5.91	321.23	72.29	0.49
1	10644	Q50	1500.00	230.18	236.48		236.95	0.002798	5.50	272.91	69.41	0.49
1	10644	Q10	750.00	230.18	234.92		235.21	0.002718	4.38	171.29	60.28	0.46
1	10758		Bridge									
1	10762.*	Q200	2220.00	231.03	238.49	236.05	239.00	0.002835	5.72	388.32	76.30	0.45
1	10762.*	Q100	1900.00	231.03	237.96	235.70	238.42	0.002850	5.45	348.51	73.95	0.44
1	10762.*	Q50	1500.00	231.03	237.24	235.21	237.64	0.002874	5.07	296.04	70.75	0.44
1	10762.*	Q10	750.00	231.03	235.54	234.15	235.80	0.003093	4.12	182.09	63.23	0.43
1	10792	Q200	2220.00	231.13	238.57		239.08	0.002236	5.72	387.88	78.39	0.45
1	10792	Q100	1900.00	231.13	238.04		238.50	0.002272	5.47	347.32	75.14	0.45
1	10792	Q50	1500.00	231.13	237.31		237.71	0.002314	5.10	294.01	71.77	0.44
1	10792	Q10	750.00	231.13	235.61		235.89	0.002573	4.19	178.93	63.91	0.44
1	10882	Q200	2220.00	230.98	238.54		239.48	0.004419	7.77	285.59	56.22	0.61
1	10882	Q100	1900.00	230.98	238.05		238.89	0.004359	7.36	258.24	54.94	0.60
1	10882	Q50	1500.00	230.98	237.37		238.08	0.004282	6.77	221.66	53.17	0.58
1	10882	Q10	750.00	230.98	235.79		236.23	0.004245	5.33	140.75	49.04	0.55



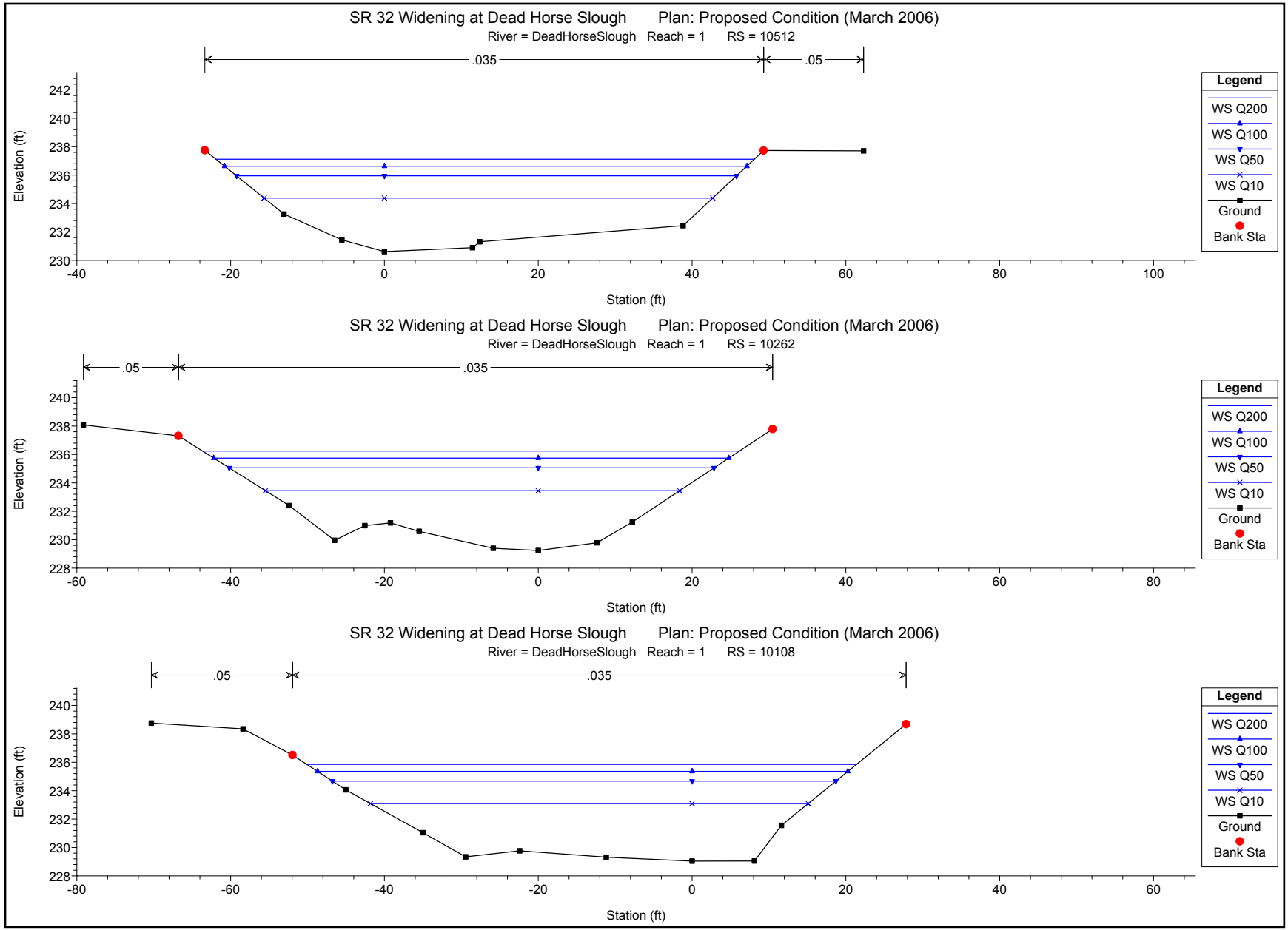
1 in Horiz. = 140 ft 1 in Vert. = 3 ft



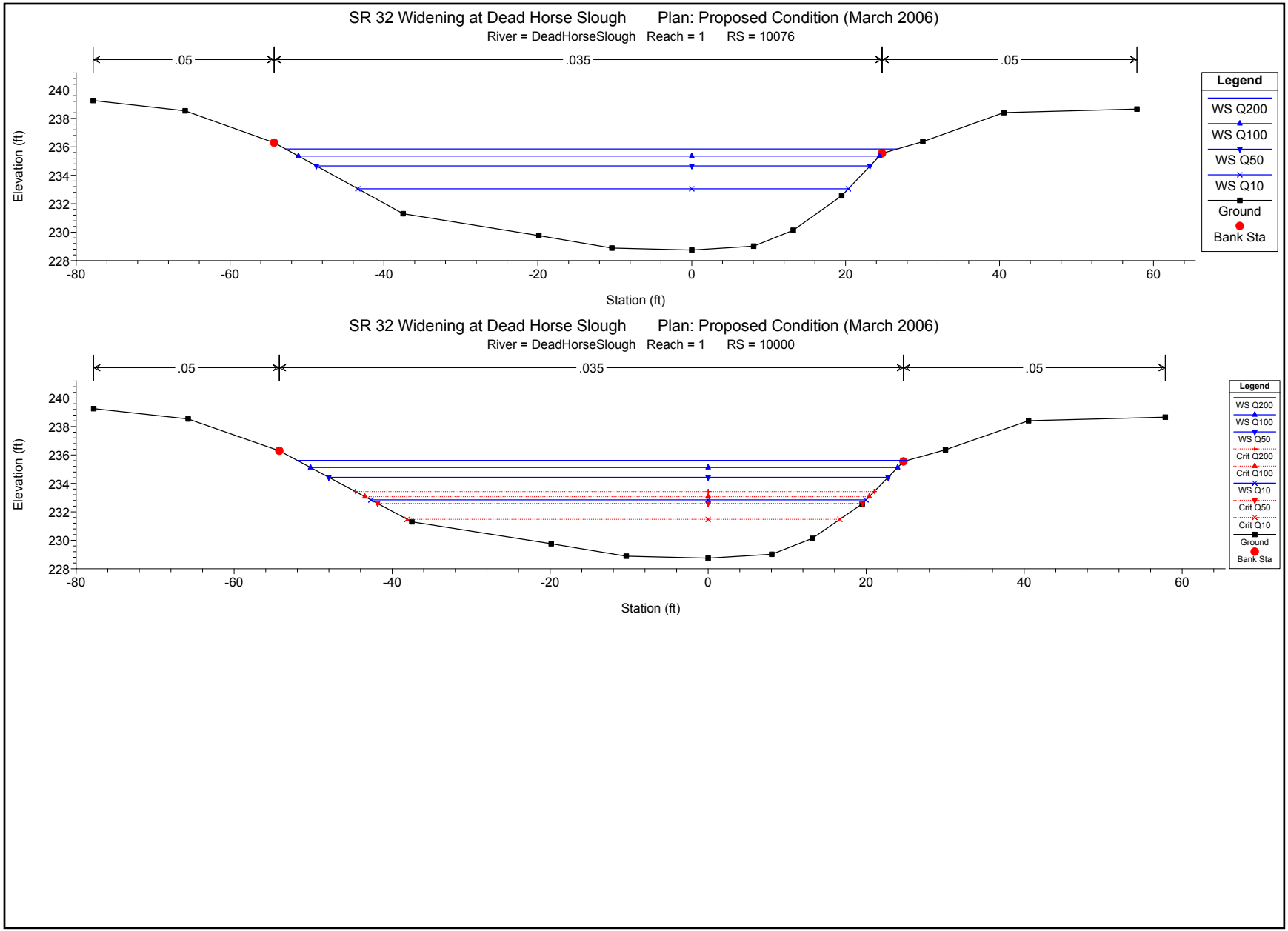
1 in Horiz. = 18 ft 1 in Vert. = 10 ft



1 in Horiz. = 18 ft 1 in Vert. = 10 ft



1 in Horiz. = 18 ft 1 in Vert. = 10 ft



1 in Horiz. = 18 ft 1 in Vert. = 10 ft

```
                    HEC-RAS Version 3.1.3 May 2005
                     U.S. Army Corp of Engineers
                    Hydrologic Engineering Center
                          609 Second Street
                          Davis, California


           X     X  XXXXXX    XXXX        XXXX       XX      XXXX
           X     X  X        X    X       X   X     X  X    X
           X     X  X        X            X   X    X    X   X
           XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
           X     X  X        X            X  X     X    X        X
           X     X  X        X    X       X   X    X    X        X
           X     X  XXXXXX    XXXX        X    X   X    X   XXXXX


PROJECT DATA
Project Title: SR 32 Widening at Dead Horse Slough
Project File : DeadHorse.prj
Run Date and Time: 3/6/2006 3:12:01 PM

Project in English units


PLAN DATA

Plan Title: Proposed Condition (March 2006)
Plan File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.p04

          Geometry Title: Prop Widen Bridge (Feb 2006)
          Geometry File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.g02

          Flow Title    : City of Chico Q - Normal Depth
          Flow File     : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.f02

Plan Summary Information:
Number of:  Cross Sections =    9    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =    0
            Bridges        =    1    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow



FLOW DATA

Flow Title: City of Chico Q - Normal Depth
Flow File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.f02

Flow Data (cfs)

  River           Reach           RS                  Q200            Q100            Q50             Q10
  DeadHorseSlough 1               10882               2220            1900            1500            750


Boundary Conditions

  River           Reach           Profile                     Upstream                Downstream

  DeadHorseSlough 1               Q200                    Normal S = 0.0057       Normal S = 0.0025
  DeadHorseSlough 1               Q100                    Normal S = 0.0057       Normal S = 0.0025
  DeadHorseSlough 1               Q50                     Normal S = 0.0057       Normal S = 0.0025
  DeadHorseSlough 1               Q10                     Normal S = 0.0057       Normal S = 0.0025



GEOMETRY DATA

Geometry Title: Prop Widen Bridge (Feb 2006)
Geometry File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\Dead Horse Slough\DeadHorse.g02

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                 RS: 10882
```

```
INPUT
Description:
Station Elevation Data    num=       8
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -45.85  240.38   -34.7   235.6  -24.35  235.21  -13.75  232.68   -5.94  231.15
       0  230.98   12.78  231.74    14.7  238.67

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -45.85     .05  -45.85    .035    14.7     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -45.85    14.7              90      90      90             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10792

INPUT
Description:
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -47.07  240.51  -41.44  240.12  -25.33   233.7  -21.91  233.18  -16.29  233.97
   -9.47  233.44   -5.81  232.33   -3.65  231.35       0  231.13    4.87  231.83
   12.33  231.62   15.91  232.67    21.8  232.53   23.51  231.84   26.55  232.22
   39.81  238.45   57.46  240.43

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -47.07     .05  -41.44    .035   39.81     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -41.44   39.81              30      30      30             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10762.*

INPUT
Description:
Station Elevation Data    num=      24
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -49.14  240.72  -45.29  240.45  -40.18  238.54  -29.44   233.9  -27.68  233.39
  -23.95  232.89   -17.8  233.18   -16.4  233.06  -10.43  232.78  -10.35  232.78
   -6.35  232.06   -3.99  231.42   -2.87  231.39       0  231.03     4.5  231.73
    7.68  231.82   11.39  231.69   14.69  232.36   17.34  232.28   20.13  232.59
   21.71  232.31   24.52  232.93   36.77  238.75   55.03   240.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -49.14    .045  -45.29     .04   36.77     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -45.29   36.77              118     118     118             .3       .5

BRIDGE


RIVER: DeadHorseSlough
REACH: 1                  RS: 10758

INPUT
Description: SR 32 at Dead Horse Slough (45 degree skew)
Distance from Upstream XS =     3.5
Deck/Roadway Width        =     111
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
    -350     244       0  -53.65  242.98       0  -53.64  242.98  241.01
   33.86  242.68  240.71   33.87  242.68       0     145   242.3       0

Upstream Bridge Cross Section Data
Station Elevation Data    num=      24
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -49.14  240.72  -45.29  240.45  -40.18  238.54  -29.44   233.9  -27.68  233.39
  -23.95  232.89   -17.8  233.18   -16.4  233.06  -10.43  232.78  -10.35  232.78
   -6.35  232.06   -3.99  231.42   -2.87  231.39       0  231.03     4.5  231.73
    7.68  231.82   11.39  231.69   14.69  232.36   17.34  232.28   20.13  232.59
   21.71  232.31   24.52  232.93   36.77  238.75   55.03   240.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -49.14    .045  -45.29     .04   36.77     .05

Bank Sta: Left   Right    Coeff Contr.   Expan.
        -45.29   36.77             .3       .5

Downstream  Deck/Roadway Coordinates
```

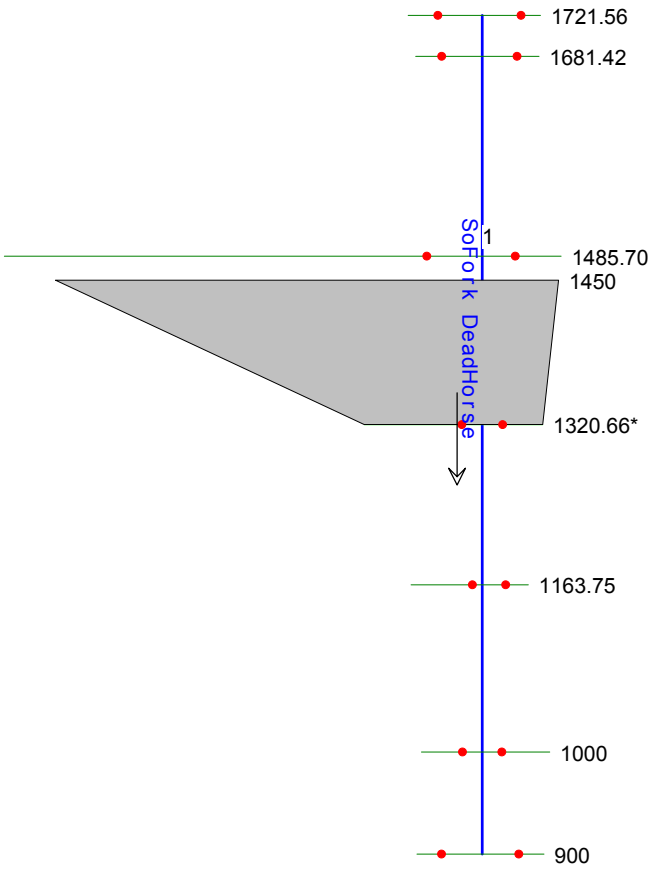
```
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
    -350     244       0  -55.52  242.98       0  -55.51  242.98  240.79
   31.99  242.68  240.49      32  242.68       0     145   242.3       0

Downstream Bridge Cross Section Data
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -68.66  240.95  -51.07  239.13  -46.21  238.41  -37.75  234.02  -27.51  232.99
  -22.26  231.14  -17.86  230.45   -7.97  231.19       0  230.18    6.96  232.01
   14.15  233.23   26.82  236.44   31.99  238.69

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -68.66     .05  -46.21    .035   31.99     .05

Bank Sta: Left   Right    Coeff Contr.   Expan.
        -46.21   31.99             .1       .3

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       2
     Sta    Elev     Sta    Elev
  -63.64 243.014  -53.64  242.98
Downstream     num=       2
     Sta    Elev     Sta    Elev
  -65.51 243.014  -55.51  242.98

Abutment Data
Upstream     num=       2
     Sta    Elev     Sta    Elev
   33.86  242.68   43.86 242.646
Downstream     num=       2
     Sta    Elev     Sta    Elev
   31.99  242.68   41.99 242.646

Number of Piers =  3

Pier Data
Pier Station     Upstream=  -31.77    Downstream=  -33.64
Upstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242
Downstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242

Pier Data
Pier Station     Upstream=  -9.895    Downstream= -11.765
Upstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242
Downstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242

Pier Data
Pier Station     Upstream=   11.98    Downstream=   10.11
Upstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242
Downstream     num=       2
    Width   Elev    Width   Elev
     1.5       0     1.5     242

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: DeadHorseSlough
```

```
REACH: 1                  RS: 10644

INPUT
Description:
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -68.66  240.95  -51.07  239.13  -46.21  238.41  -37.75  234.02  -27.51  232.99
  -22.26  231.14  -17.86  230.45   -7.97  231.19       0  230.18    6.96  232.01
   14.15  233.23   26.82  236.44   31.99  238.69

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -68.66     .05  -46.21    .035   31.99     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -46.21   31.99             132     132     132             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10512

INPUT
Description:
Station Elevation Data    num=       9
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -23.36  237.75  -13.06  233.26   -5.54  231.44       0  230.62   11.45  230.89
   12.39  231.31   38.84  232.44   49.31  237.73   62.31  237.71

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -23.36     .05  -23.36    .035   49.31     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -23.36   49.31             250     250     250             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10262

INPUT
Description:
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -59.16  238.08  -46.79  237.31  -32.38   232.4  -26.49  229.96  -22.55  230.99
  -19.22  231.18  -15.49  230.59   -5.86   229.4       0  229.24    7.63  229.78
   12.22  231.24   30.47  237.79

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -59.16     .05  -46.79    .035   30.47     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -46.79   30.47             154     154     154             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10108

INPUT
Description:
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -70.32  238.76   -58.4  238.35  -51.96  236.51  -45.02  234.06     -35  231.04
  -29.44  229.34  -22.42  229.77  -11.16  229.32       0  229.04    8.11  229.05
   11.61  231.56   27.83  238.68

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -70.32     .05  -51.96    .035   27.83     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -51.96   27.83              32      32      32             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                  RS: 10076

INPUT
Description:
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -77.78  239.26  -65.83  238.53  -54.27  236.29  -37.51   231.3  -19.86  229.76
  -10.37  228.88       0  228.74    8.05  229.02   13.18  230.13   19.49  232.56
   24.73  235.54   30.04  236.37   40.56  238.41   57.87  238.66

Manning's n Values        num=       3
```

```
     Sta   n Val     Sta   n Val     Sta   n Val
  -77.78     .05  -54.27    .035   24.73     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -54.27   24.73               76      76      76             .1       .3

CROSS SECTION


RIVER: DeadHorseSlough
REACH: 1                 RS: 10000

INPUT
Description:
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -77.78  239.26  -65.83  238.53  -54.27  236.29  -37.51   231.3  -19.86  229.76
  -10.37  228.88       0  228.74    8.05  229.02   13.18  230.13   19.49  232.56
   24.73  235.54   30.04  236.37   40.56  238.41   57.87  238.66

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -77.78     .05  -54.27    .035   24.73     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -54.27   24.73                0       0       0             .1       .3


SUMMARY OF MANNING'S N VALUES

River:DeadHorseSlough

      Reach          River Sta.       n1        n2        n3

 1                    10882             .05      .035       .05
 1                    10792             .05      .035       .05
 1                    10762.*          .045       .04       .05
 1                    10758        Bridge
 1                    10644             .05      .035       .05
 1                    10512             .05      .035       .05
 1                    10262             .05      .035       .05
 1                    10108             .05      .035       .05
 1                    10076             .05      .035       .05
 1                    10000             .05      .035       .05



SUMMARY OF REACH LENGTHS

River: DeadHorseSlough

      Reach          River Sta.      Left     Channel    Right

 1                    10882              90        90        90
 1                    10792              30        30        30
 1                    10762.*           118       118       118
 1                    10758        Bridge
 1                    10644             132       132       132
 1                    10512             250       250       250
 1                    10262             154       154       154
 1                    10108              32        32        32
 1                    10076              76        76        76
 1                    10000               0         0         0



SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: DeadHorseSlough


      Reach          River Sta.     Contr.    Expan.

 1                    10882           .1        .3
 1                    10792           .1        .3
 1                    10762.*         .3        .5
 1                    10758    Bridge
 1                    10644           .1        .3
 1                    10512           .1        .3
 1                    10262           .1        .3
 1                    10108           .1        .3
 1                    10076           .1        .3
 1                    10000           .1        .3
```

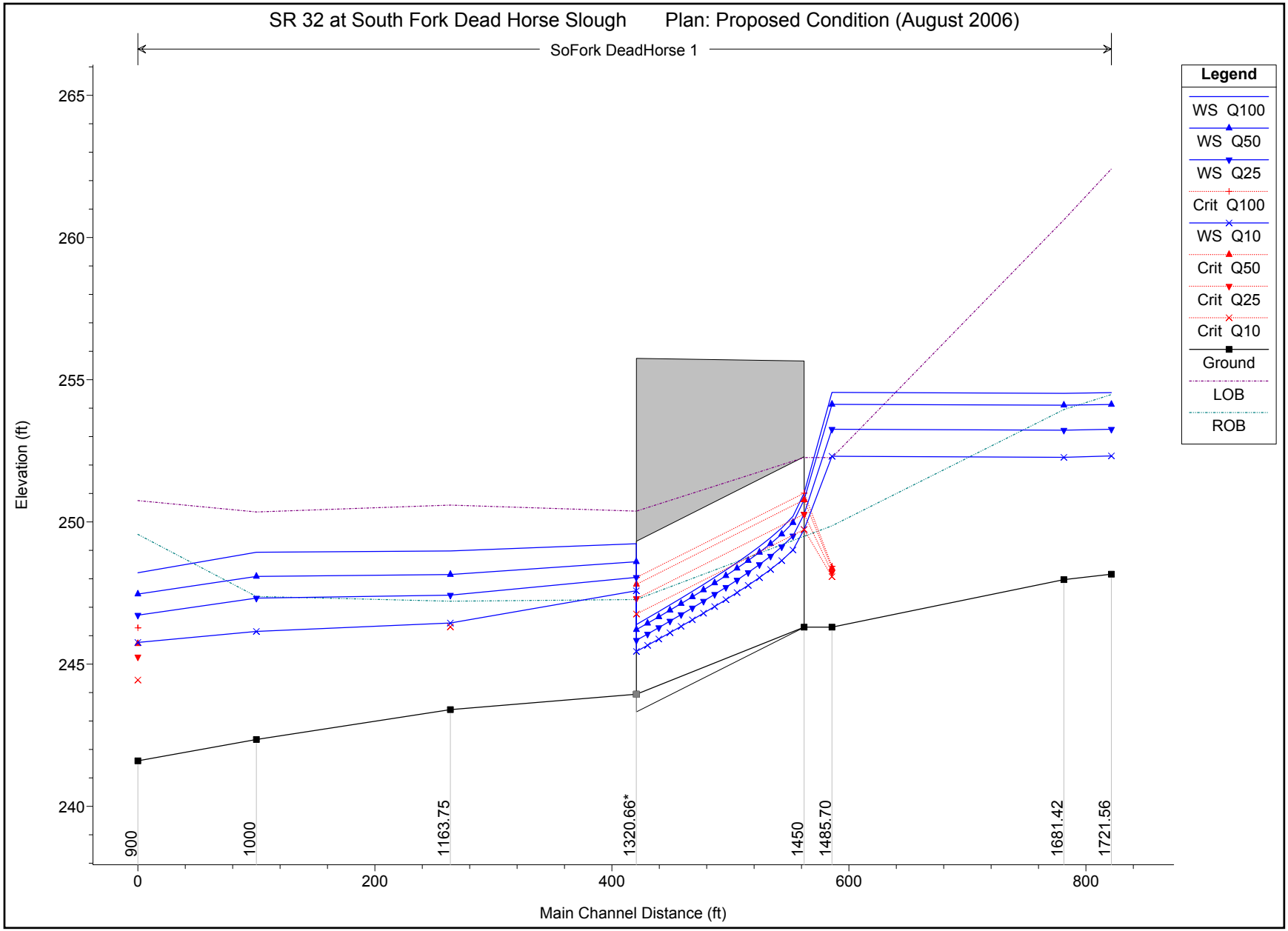
DRAFT BRIDGE DESIGN HYDRAULIC STUDY REPORT FOR
THE SOUTH FORK DEAD HORSE SLOUGH CULVERT UNDER SR32
CITY OF CHICO, CALIFORNIA

PROPOSED CONDITION HEC-RAS MODEL

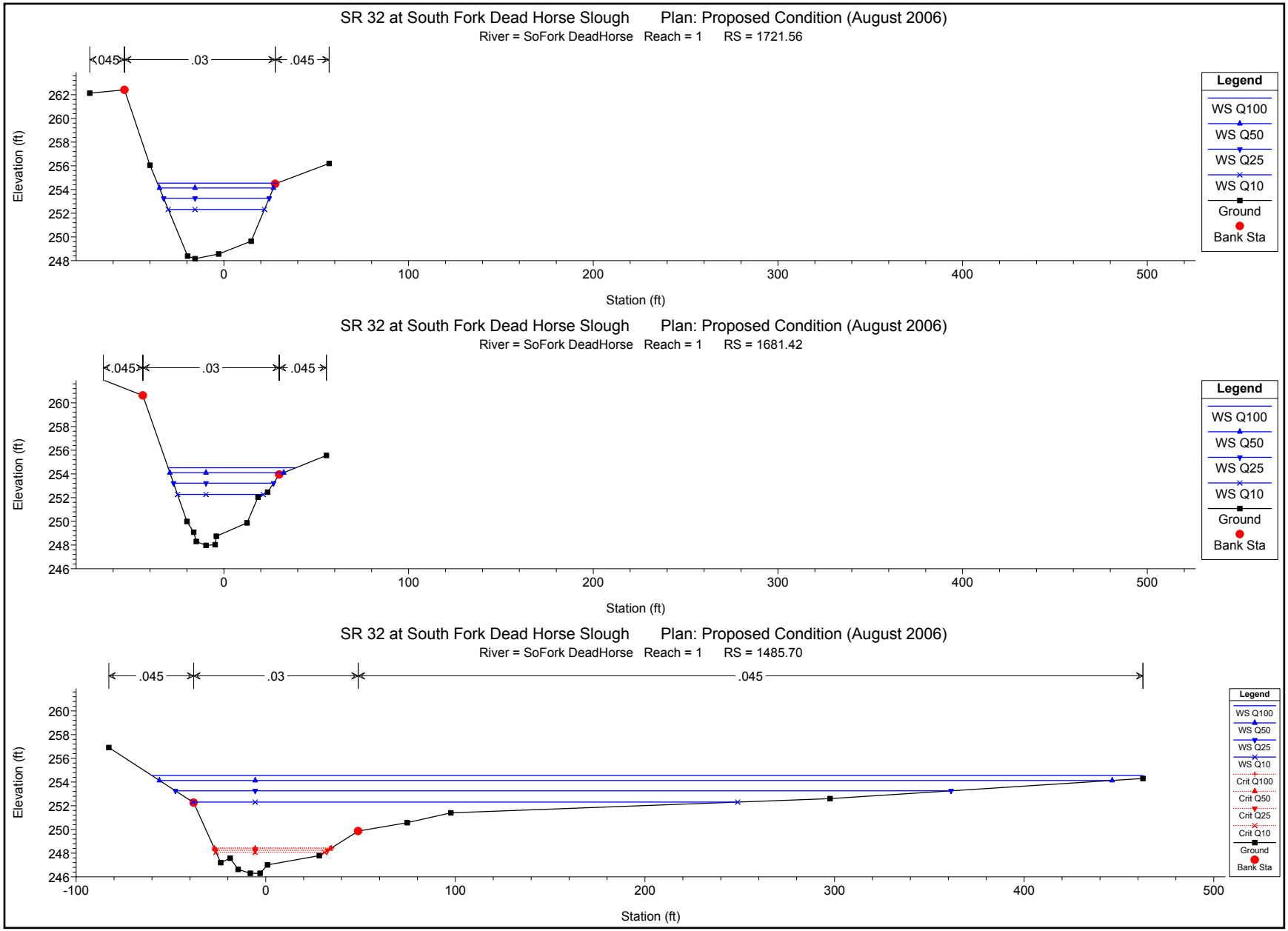


HEC-RAS Plan: PrAug06 River: SoFork DeadHorse Reach: 1

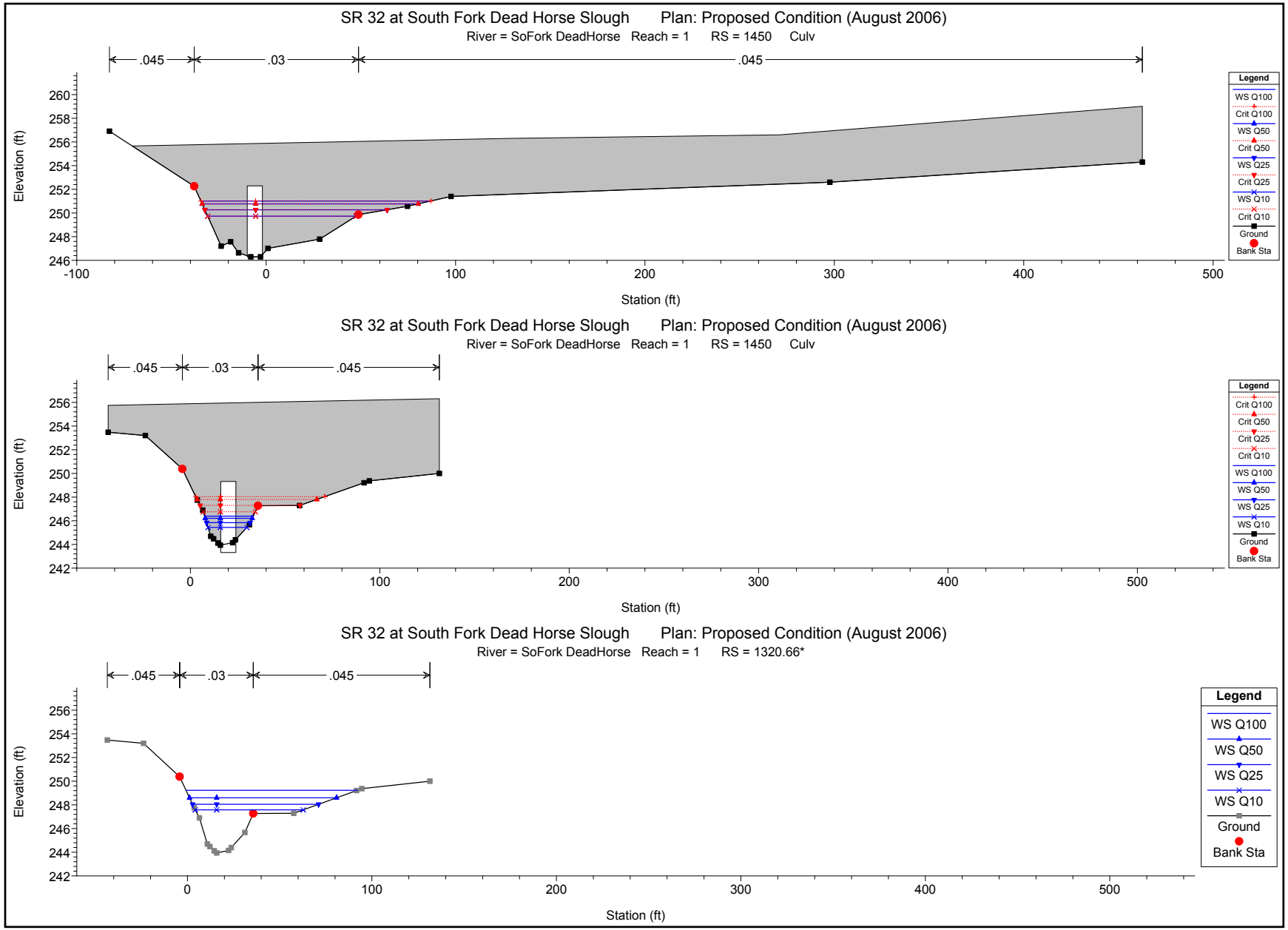
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	1721.56	Q100	466.00	248.16	254.54		254.59	0.000158	1.65	282.99	64.89	0.14
1	1721.56	Q50	431.00	248.16	254.13		254.17	0.000179	1.68	256.71	61.75	0.15
1	1721.56	Q25	361.00	248.16	253.26		253.31	0.000238	1.76	205.07	57.10	0.16
1	1721.56	Q10	290.00	248.16	252.32		252.38	0.000352	1.88	153.96	52.10	0.19
1	1681.42	Q100	466.00	247.97	254.52		254.58	0.000230	1.88	249.82	69.24	0.16
1	1681.42	Q50	431.00	247.97	254.10		254.16	0.000276	1.94	222.29	61.61	0.18
1	1681.42	Q25	361.00	247.97	253.22		253.29	0.000402	2.10	172.07	54.17	0.21
1	1681.42	Q10	290.00	247.97	252.27		252.35	0.000637	2.35	123.50	46.42	0.25
1	1485.70	Q100	466.00	246.30	254.55	248.44	254.56	0.000010	0.54	1486.17	522.73	0.04
1	1485.70	Q50	431.00	246.30	254.13	248.37	254.14	0.000012	0.57	1268.91	502.45	0.04
1	1485.70	Q25	361.00	246.30	253.26	248.23	253.26	0.000018	0.64	869.77	409.01	0.05
1	1485.70	Q10	290.00	246.30	252.31	248.07	252.32	0.000029	0.70	532.62	287.42	0.06
1	1450		Culvert									
1	1320.66*	Q100	466.00	243.94	249.23		249.35	0.000653	2.92	208.94	92.86	0.27
1	1320.66*	Q50	431.00	243.94	248.60		248.77	0.001103	3.48	154.39	79.76	0.34
1	1320.66*	Q25	361.00	243.94	248.05		248.25	0.001509	3.72	113.60	68.35	0.39
1	1320.66*	Q10	290.00	243.94	247.58		247.79	0.001831	3.74	83.61	58.50	0.42
1	1163.75	Q100	466.00	243.40	248.98		249.20	0.001165	3.90	142.20	64.92	0.36
1	1163.75	Q50	431.00	243.40	248.15		248.51	0.002319	4.86	95.76	46.90	0.49
1	1163.75	Q25	361.00	243.40	247.42		247.87	0.003775	5.39	67.42	31.14	0.60
1	1163.75	Q10	290.00	243.40	246.44	246.31	247.18	0.009582	6.90	42.04	23.70	0.91
1	1000	Q100	466.00	242.35	248.93		249.04	0.000541	2.65	189.17	58.98	0.21
1	1000	Q50	431.00	242.35	248.08		248.22	0.000867	3.04	144.97	44.94	0.27
1	1000	Q25	361.00	242.35	247.32		247.47	0.001135	3.13	115.48	33.32	0.30
1	1000	Q10	290.00	242.35	246.15		246.36	0.002226	3.69	78.54	29.66	0.40
1	900	Q100	1900.00	241.60	248.21	246.27	248.83	0.002231	6.34	299.66	65.17	0.52
1	900	Q50	1500.00	241.60	247.46	245.72	248.01	0.002263	5.95	252.27	61.21	0.52
1	900	Q25	1200.00	241.60	246.72	245.25	247.23	0.002498	5.76	208.41	57.30	0.53
1	900	Q10	750.00	241.60	245.76	244.44	246.12	0.002260	4.81	155.84	52.23	0.49



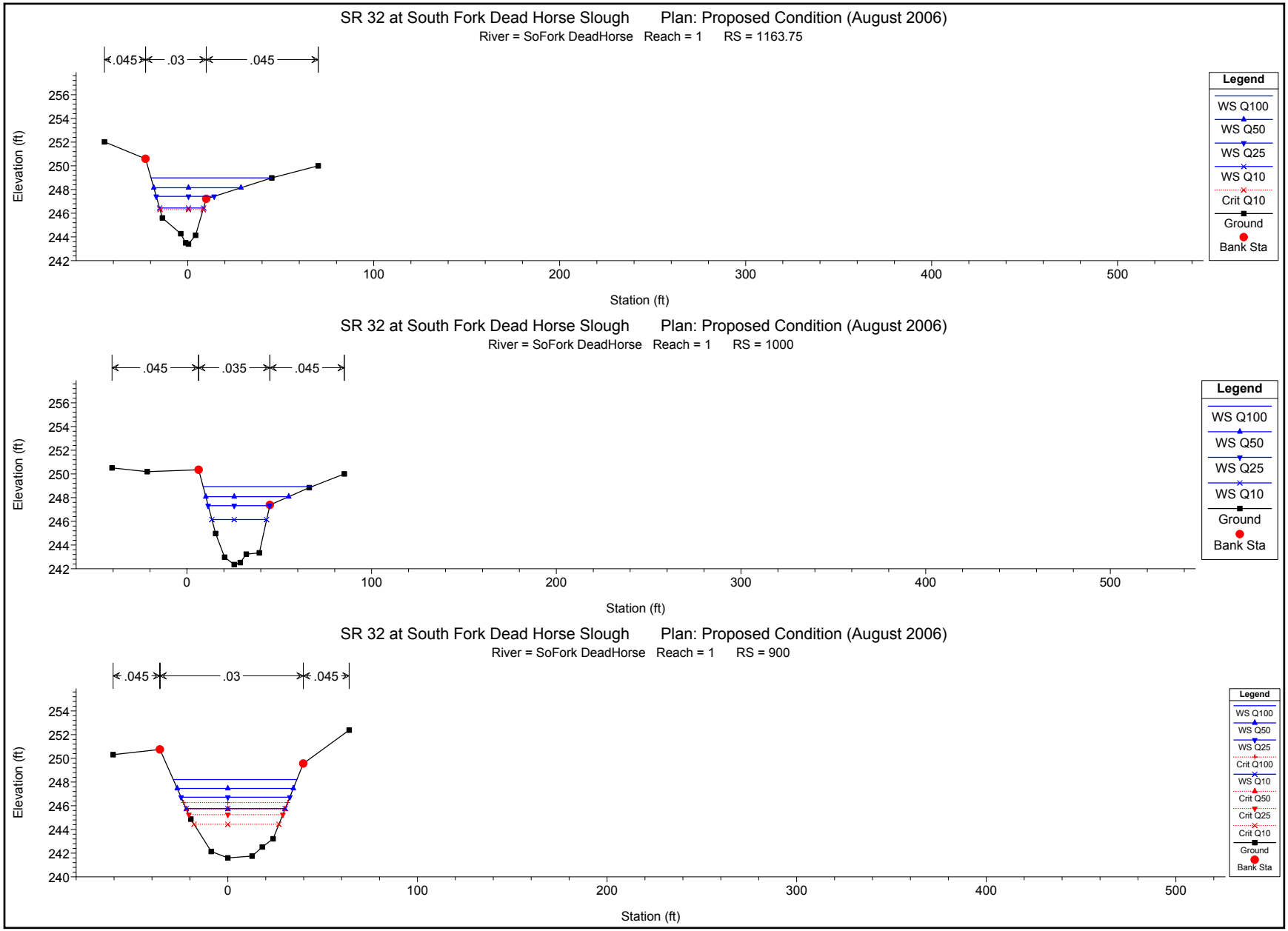
1 in Horiz. = 120 ft 1 in Vert. = 5 ft



1 in Horiz. = 75 ft 1 in Vert. = 12 ft



1 in Horiz. = 75 ft 1 in Vert. = 12 ft



1 in Horiz. = 75 ft 1 in Vert. = 12 ft

```
                    HEC-RAS Version 3.1.3 May 2005
                     U.S. Army Corp of Engineers
                    Hydrologic Engineering Center
                          609 Second Street
                          Davis, California

           X     X  XXXXXX    XXXX        XXXX       XX      XXXX
           X     X  X        X    X       X   X     X  X    X
           X     X  X        X            X   X    X    X   X
           XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
           X     X  X        X            X  X     X    X        X
           X     X  X        X    X       X   X    X    X        X
           X     X  XXXXXX    XXXX        X    X   X    X   XXXXX


PROJECT DATA
Project Title: SR 32 at South Fork Dead Horse Slough
Project File : SFDeadHorse.prj
Run Date and Time: 8/14/2006 10:06:44 AM

Project in English units


PLAN DATA

Plan Title: Proposed Condition (August 2006)
Plan File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.p08

          Geometry Title: WRECO Proposed revised2
          Geometry File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.g05

          Flow Title    : City of Chico-Husa Ranch Development WSE
          Flow File     : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.f01

Plan Summary Information:
Number of:  Cross Sections =    7    Multiple Openings  =    0
            Culverts       =    1    Inline Structures  =    0
            Bridges        =    0    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Subcritical Flow



FLOW DATA

Flow Title: City of Chico-Husa Ranch Development WSE
Flow File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.f01

Flow Data (cfs)

  River           Reach           RS                  Q200            Q100            Q50             Q25             Q10
  SoFork DeadHorse1               1721.56              528             466             431             361             290
  SoFork DeadHorse1               900                 2220            1900            1500            1200             750


Boundary Conditions

  River           Reach           Profile                     Upstream                Downstream

  SoFork DeadHorse1               Q200                    Normal S = 0.011        Known WS = 248.75
  SoFork DeadHorse1               Q100                    Normal S = 0.011        Known WS = 248.21
  SoFork DeadHorse1               Q50                     Normal S = 0.011        Known WS = 247.46
  SoFork DeadHorse1               Q25                     Normal S = 0.011        Known WS = 246.72
  SoFork DeadHorse1               Q10                     Normal S = 0.011        Known WS = 245.76



GEOMETRY DATA

Geometry Title: WRECO Proposed revised2
Geometry File : g:\Projects\Y2005\P0513 SR32 Chico\HEC-RAS\South Fork Dead Horse Slough\SFDeadHorse.g05

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                 RS: 1721.56

INPUT
Description:
Station Elevation Data    num=       9
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -72.65  262.13  -53.81  262.41  -40.03  256.05  -19.63  248.38  -15.67  248.16
   -2.79  248.56   14.78  249.64   27.79  254.48   56.98   256.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -72.65    .045  -53.81     .03   27.79    .045
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -53.81   27.79            40.14   40.14   40.14             .1       .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1681.42

INPUT
Description:
Station Elevation Data    num=      13
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
  -65.21  261.92  -43.87  260.62  -19.98  249.99  -16.32  249.08  -14.92   248.3
   -9.66  247.97   -4.74  248.03    -4.1  248.74   12.53  249.87   18.47  252.04
   23.71  252.46      30  253.95   55.55  255.56

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -65.21    .045  -43.87    .03      30    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -43.87      30           195.72  195.72  195.72             .1       .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1485.70

INPUT
Description:
Station Elevation Data    num=      14
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
  -82.78  256.91      -38  252.26  -23.73   247.2  -18.78  247.57  -14.58  246.63
   -8.13   246.3   -2.99   246.3     .93  247.01   28.28  247.79   48.76  249.86
   74.65  250.57   97.65   251.4  297.65   252.6  462.65   254.3

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -82.78    .045     -38    .03   48.76    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           -38   48.76           165.04  165.04  165.04              .3       .5

CULVERT


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1450

INPUT
Description:
Distance from Upstream XS =    23.5
Deck/Roadway Width        =   141.5
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=       5
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
    -233   255.3       0    -120   255.5       0     128   256.3       0
     271   256.6       0     470   259.1       0

Upstream Bridge Cross Section Data
Station Elevation Data    num=      14
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
  -82.78  256.91      -38  252.26  -23.73   247.2  -18.78  247.57  -14.58  246.63
   -8.13   246.3   -2.99   246.3     .93  247.01   28.28  247.79   48.76  249.86
   74.65  250.57   97.65   251.4  297.65   252.6  462.65   254.3

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -82.78    .045     -38    .03   48.76    .045

Bank Sta: Left   Right    Coeff Contr.   Expan.
           -38   48.76             .3       .5

Downstream  Deck/Roadway Coordinates
    num=       4
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
    -233   255.3       0    -120   255.5       0     128   256.3       0
     271   256.6       0

Downstream Bridge Cross Section Data
Station Elevation Data    num=      17
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
  -43.42  253.48   -23.8   253.2   -4.22  250.38    3.65  247.75     6.5   246.9
   10.78  244.69   12.22  244.48   14.48  244.12   15.82  243.94   22.25  244.15
   23.75  244.39   31.11  245.67   35.68  247.27   57.64  247.29   91.66  249.21
   94.53  249.37  131.42     250

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -43.42    .045   -4.22    .03   35.68    .045

Bank Sta: Left   Right    Coeff Contr.   Expan.
         -4.22   35.68             .1       .3

Upstream Embankment side slope             =       0 horiz. to 1.0 vertical
Downstream Embankment side slope           =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins        =
Energy head used in spillway design        =
Spillway height used in design             =
Weir crest shape                           = Broad Crested

Number of Culverts =  1
```

```
Culvert Name     Shape      Rise    Span
Culvert #1          Box       6       8
FHWA Chart # 11- Skewed headwall; Chamfered or beveled Inlet
FHWA Scale # 3 - Headwall skewed 15 deg.; inlet edges chamfered 3/4 inch
Solution Criteria = Highest U.S. EG
Culvert Upstrm Dist  Length    Top n  Bottom n  Depth Blocked  Entrance Loss Coef   Exit Loss Coef
              23.5   141.5     .013     .013        0                  .5              1
Upstream   Elevation =  246.29
           Centerline Station = -6
Downstream Elevation =  243.32
           Centerline Station =  20

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1320.66*

INPUT
Description:
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -43.42  253.48   -23.8   253.2   -4.22  250.38    3.65  247.75     6.5   246.9
   10.78  244.69   12.22  244.48   14.48  244.12   15.82  243.94   22.25  244.15
   23.75  244.39   31.11  245.67   35.68  247.27   57.64  247.29   91.66  249.21
   94.53  249.37  131.42     250

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -43.42    .045   -4.22     .03   35.68    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         -4.22   35.68           156.91  156.91  156.91             .1       .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1163.75

INPUT
Description:
Station Elevation Data    num=      10
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -44.78  252.02  -22.68  250.59  -13.62   245.6   -3.75  244.27   -1.14   243.5
      .4   243.4    4.23  244.14    9.99  247.21   45.18  248.98   70.18     250

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -44.78    .045  -22.68     .03    9.99    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        -22.68    9.99           163.75  163.75  163.75             .1       .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 1000

INPUT
Description:
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -40.58  250.51  -21.47  250.19    6.33  250.35    15.5  244.97   20.41  242.97
   25.61  242.35   28.86  242.52   32.12  243.23   39.18  243.34   44.89  247.38
   66.19  248.84   85.19     250

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -40.58    .045    6.33    .035   44.89    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          6.33   44.89            100     100     100             .1       .3

CROSS SECTION


RIVER: SoFork DeadHorse
REACH: 1                  RS: 900

INPUT
Description:
Station Elevation Data    num=      10
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -60.52  250.31   -35.8  250.75   -19.5  244.87   -8.77  242.14       0   241.6
    12.8  241.75   18.19  242.52   23.87  243.21    39.8  249.56   64.03  252.38

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -60.52    .045   -35.8     .03    39.8    .045

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         -35.8    39.8              0       0       0             .1       .3


SUMMARY OF MANNING'S N VALUES

River:SoFork DeadHorse

      Reach          River Sta.       n1        n2        n3

 1                    1721.56          .045       .03      .045
 1                    1681.42          .045       .03      .045
 1                    1485.70          .045       .03      .045
 1                    1450         Culvert
```

1	1320.66*	.045	.03	.045
1	1163.75	.045	.03	.045
1	1000	.045	.035	.045
1	900	.045	.03	.045

SUMMARY OF REACH LENGTHS

River: SoFork DeadHorse

Reach	River Sta.	Left	Channel	Right
1	1721.56	40.14	40.14	40.14
1	1681.42	195.72	195.72	195.72
1	1485.70	165.04	165.04	165.04
1	1450	Culvert		
1	1320.66*	156.91	156.91	156.91
1	1163.75	163.75	163.75	163.75
1	1000	100	100	100
1	900	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: SoFork DeadHorse

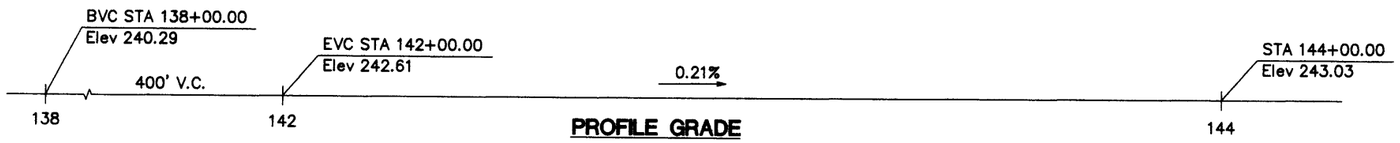
Reach	River Sta.	Contr.	Expan.
1	1721.56	.1	.3
1	1681.42	.1	.3
1	1485.70	.3	.5
1	1450	Culvert	
1	1320.66*	.1	.3
1	1163.75	.1	.3
1	1000	.1	.3
1	900	.1	.3

APPENDIX C

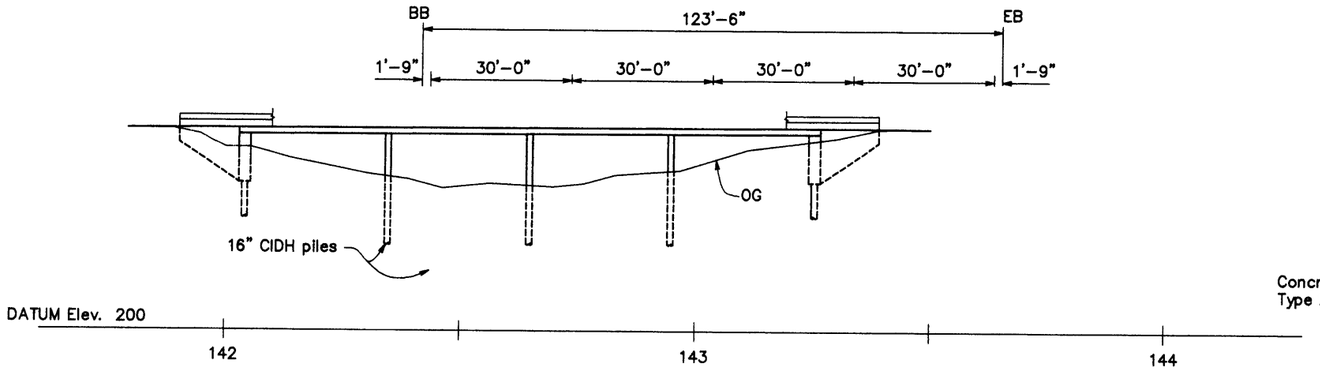
PROPOSED BRIDGE PLANS

PREPARED FOR THE STATE OF CALIFORNIA — DEPARTMENT OF TRANSPORTATION

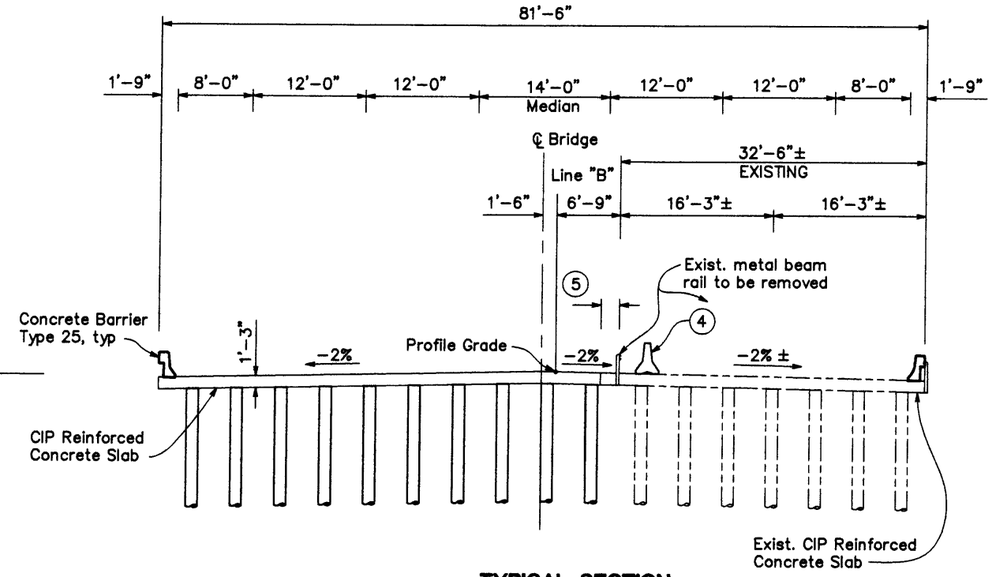
DIST.	COUNTY	ROUTE	POST MILE
03	But	32	11.08



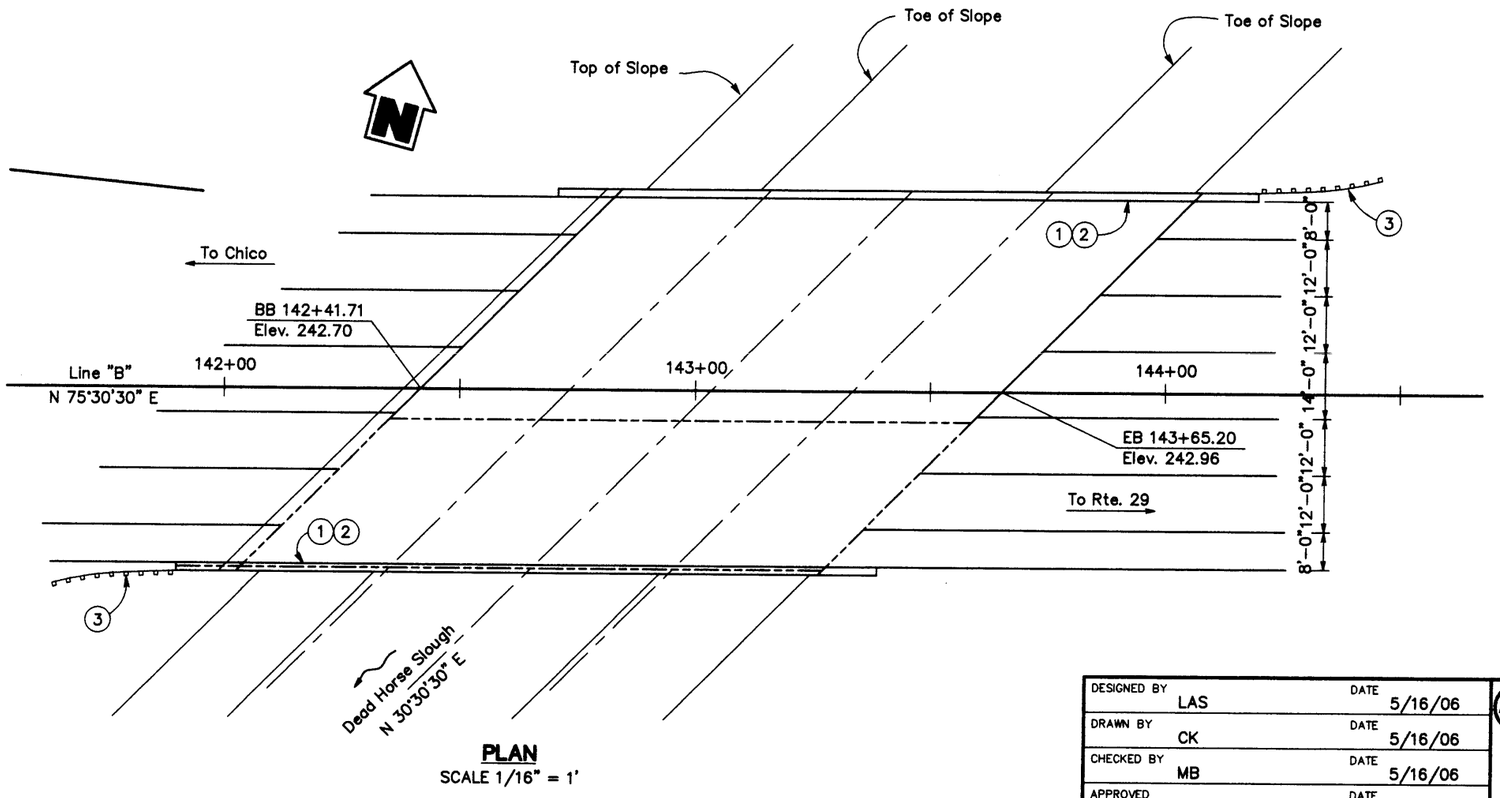
PROFILE GRADE
NO SCALE



ELEVATION
SCALE 1/16" = 1'



TYPICAL SECTION
SCALE 1/8" = 1'



PLAN
SCALE 1/16" = 1'

Date of Estimate	=	May. 2006
Str Depth	=	1'-3"
Length	=	123.5 ft
Width	=	49.0 ft
Area	=	6052 ft²
Cost/Sq.ft including 10% Mobilization 25% Contingency	=	140.00 $/ft²
Total Cost	=	$847,210

Notes:

1. Paint Bridge Number
2. Paint Bridge Name
3. MBGR, see "Road Plans"
4. Temporary Rail Type K
5. 2'-0" Closure Pour

DESIGNED BY	LAS	DATE	5/16/06
DRAWN BY	CK	DATE	5/16/06
CHECKED BY	MB	DATE	5/16/06
APPROVED		DATE	

FILE => $REQUEST

MARK THOMAS & COMPANY, INC.
7300 FOLSOM BOULEVARD,
SUITE 203
SACRAMENTO, CALIFORNIA 95826
(916) 381-9100

PLANNING STUDY

RTE. 32 / DEAD HORSE SLOUGH (WIDEN)

BRIDGE NO.	12-0135	CU
SCALE:	AS NOTED	EA

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

APPENDIX D

HYDROLOGIC ANALYSES

Federal Emergency Management Agency

Washington, D.C. 20472

NOV 29 2004

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

The Honorable Robert J. Beeler
Chairman, Butte County
Board of Supervisors
Butte County Administration Center
25 County Center Drive
Oroville, CA 95965

IN REPLY REFER TO:
Case No.: 04-09-0415P
Follows Conditional
Case No.: 02-09-0348X
Community Name: Butte County, CA
Community No.: 060017
Effective Date of
This Revision: **MAR 31 2005**

Dear Mr. Beeler:

The Flood Insurance Study report and Flood Insurance Rate Map for your community have been revised by this Letter of Map Revision (LOMR). Please use the enclosed annotated map panel(s) revised by this LOMR for floodplain management purposes and for all flood insurance policies and renewals issued in your community.

Additional documents are enclosed which provide information regarding this LOMR. Please see the List of Enclosures below to determine which documents are included. Other attachments specific to this request may be included as referenced in the Determination Document. If you have any questions regarding floodplain management regulations for your community or the National Flood Insurance Program (NFIP) in general, please contact the Consultation Coordination Officer for your community. If you have any technical questions regarding this LOMR, please contact the Director, Federal Insurance and Mitigation Division of the Department of Homeland Security's Federal Emergency Management Agency (FEMA) in Oakland, California, at (510) 627-7103, or the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP). Additional information about the NFIP is available on our website at http://www.fema.gov/nfip.

Sincerely,

Max H. Yuan, P.E., Project Engineer
Hazard Identification Section
Mitigation Division
Emergency Preparedness
and Response Directorate

For: Doug Bellomo, P.E., CFM, Chief
Hazard Identification Section
Mitigation Division
Emergency Preparedness
and Response Directorate

List of Enclosures:
Letter of Map Revision Determination Document
Annotated Flood Insurance Rate Map
Annotated Flood Insurance Study Report

cc: The Honorable Maureen Kirk
Mayor, City of Chico

[redacted] P.E.
Wood Rogers, Inc.

Ms. Yvonne Christopher
Floodplain Administrator
Department of Public Works
Butte County

 | Issue Date: NOV 29 2004 | Effective Date: MAR 31 2005 | Case No.: 04-09-0415P | LOMR-APP

Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION DETERMINATION DOCUMENT

COMMUNITY AND REVISION INFORMATION		PROJECT DESCRIPTION	BASIS OF REQUEST
COMMUNITY	Butte County California (Unincorporated Areas)	FILL LEVEE DETENTION BASIN	BASE MAP CHANGES HYDROLOGIC ANALYSIS HYDRAULIC ANALYSIS NEW TOPOGRAPHIC DATA
	COMMUNITY NO.: 060017		
IDENTIFIER	Husa Ranch Subdivision	APPROXIMATE LATITUDE & LONGITUDE: 39.744, -121.796 SOURCE: USGS QUADRANGLE DATUM: NAD 83	
FLOODING SOURCE(S) & REVISED REACH(ES)	Dead Horse Slough – from State Highway 32 to Bruce Road		

SUMMARY OF REVISIONS

Effective Flooding:	Zone A	Zone A	No BFEs*	Zone X (unshaded)
Revised Flooding:	Zone AE	Zone A	BFEs	Zone X (shaded)
Increases:	YES	YES	YES	YES
Decreases:	YES	YES	NONE	NONE

* BFEs – Base Flood Elevations

ANNOTATED MAPPING ENCLOSURES	ANNOTATED STUDY ENCLOSURES
TYPE: FIRM* NO.: 06007C0510 D Date: April 20, 2000	DATE OF EFFECTIVE FLOOD INSURANCE STUDY REPORT: April 20, 2000 SUMMARY OF DISCHARGES TABLE: 1 PROFILE: 61P

* FIRM – Flood Insurance Rate Map; ** FBFM – Flood Boundary and Floodway Map; *** FHBM – Flood Hazard Boundary Map

DETERMINATION

This document provides the determination from the Department of Homeland Security's Federal Emergency Management Agency (FEMA) regarding a request for a Letter of Map Revision (LOMR) for the area described above. Using the information submitted, we have determined that a revision to the flood hazards depicted in the Flood Insurance Study (FIS) report and/or National Flood Insurance Program (NFIP) map is warranted. This document revises the effective NFIP map, as indicated in the attached documentation. Please use the enclosed annotated map panels revised by this LOMR for floodplain management purposes and for all flood insurance policies and renewals in your community.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2677 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional information about the NFIP is available on our website at http://www.fema.gov/nfip.

Max H. Yuan, P.E., Project Engineer
Hazard Identification Section
Mitigation Division
Emergency Preparedness and Response Directorate

102426 D.A04090415E 102IAC

Federal Emergency Management Agency
Washington, D.C. 20472

LETTER OF MAP REVISION DETERMINATION DOCUMENT (CONTINUED)

OTHER COMMUNITIES AFFECTED BY THIS REVISION

CID Number: 060746 **Name:** City of Chico, California

AFFECTED MAP PANELS	AFFECTED PORTIONS OF THE FLOOD INSURANCE STUDY REPORT
TYPE: FIRM NO.: 06007C0345 C Date: June 8, 1998 TYPE: FIRM NO.: 06007C0510 D Date: April 20, 2000	DATE OF EFFECTIVE FLOOD INSURANCE STUDY REPORT: April 20, 2000 SUMMARY OF DISCHARGES TABLE: 1 PROFILE: 61P

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2677 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional information about the NFIP is available on our website at http://www.fema.gov/nfip.

Max H. Yuan, P.E., Project Engineer
Hazard Identification Section
Mitigation Division
Emergency Preparedness and Response Directorate

Federal Emergency Management Agency
Washington, D.C. 20472

LETTER OF MAP REVISION DETERMINATION DOCUMENT (CONTINUED)

COMMUNITY INFORMATION

APPLICABLE NFIP REGULATIONS/COMMUNITY OBLIGATION

We have made this determination pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (P.L. 93-234) and in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, P.L. 90-448), 42 U.S.C. 4001-4128, and 44 CFR Part 65. Pursuant to Section 1361 of the National Flood Insurance Act of 1968, as amended, communities participating in the NFIP are required to adopt and enforce floodplain management regulations that meet or exceed NFIP criteria. These criteria, including adoption of the FIS report and FIRM, and the modifications made by this LOMR, are the minimum requirements for continued NFIP participation and do not supersede more stringent State/Commonwealth or local requirements to which the regulations apply.

COMMUNITY REMINDERS

We based this determination on the 1-percent-annual-chance discharges computed in the submitted hydrologic model. Future development of projects upstream could cause increased discharges, which could cause increased flood hazards. A comprehensive restudy of your community's flood hazards would consider the cumulative effects of development on discharges and could, therefore, indicate that greater flood hazards exist in this area.

Your community must regulate all proposed floodplain development and ensure that permits required by Federal and/or State/Commonwealth law have been obtained. State/Commonwealth or community officials, based on knowledge of local conditions and in the interest of safety, may set higher standards for construction or may limit development in floodplain areas. If your State/Commonwealth or community has adopted more restrictive or comprehensive floodplain management criteria, those criteria take precedence over the minimum NFIP requirements.

We will not print and distribute this LOMR to primary users, such as local insurance agents or mortgage lenders; instead, the community will serve as a repository for the new data. We encourage you to disseminate the information in this LOMR by preparing a news release for publication in your community's newspaper that describes the revision and explains how your community will provide the data and help interpret the NFIP maps. In that way, interested persons, such as property owners, insurance agents, and mortgage lenders, can benefit from the information.

This revision has met our criteria for removing an area from the 1-percent-annual-chance floodplain to reflect the placement of fill. However, we encourage you to require that the lowest adjacent grade and lowest floor (including basement) of any structure placed within the subject area be elevated to or above the Base (1-percent-annual-chance) Flood Elevation.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2677 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional information about the NFIP is available on our website at http://www.fema.gov/nfip.

Max H. Yuan, P.E., Project Engineer
Hazard Identification Section
Mitigation Division
Emergency Preparedness and Response Directorate

Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)

COMMUNITY INFORMATION (CONTINUED)

We have designated a Consultation Coordination Officer (CCO) to assist your community. The CCO will be the primary liaison between your community and FEMA. For information regarding your CCO, please contact:

Ms. Sally M. Ziolkowski
Director, Federal Insurance and Mitigation Division
Federal Emergency Management Agency, Region IX
1111 Broadway Street, Suite 1200
Oakland, CA 94607-4052
(510) 627-7103

STATUS OF THE COMMUNITY NFIP MAPS

We will not physically revise and republish the FIRM and FIS report for your community to reflect the modifications made by this LOMR at this time. When changes to the previously cited FIRM panel and FIS report warrant physical revision and republication in the future, we will incorporate the modifications made by this LOMR at that time.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2677 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional information about the NFIP is available on our website at http://www.fema.gov/nfip.

Max H. Yuan, P.E., Project Engineer
Hazard Identification Section
Mitigation Division
Emergency Preparedness and Response Directorate

Federal Emergency Management Agency
Washington, D.C. 20472

LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)

PUBLIC NOTIFICATION OF REVISION

Within 90 days of the second publication in the local newspaper, a citizen may request that we reconsider this determination. Any request for reconsideration must be based on scientific or technical data. Therefore, this letter will be effective only after the 90-day appeal period has elapsed and we have resolved any appeals that we receive during this appeal period. Until this LOMR is effective, the revised BFEs presented in this LOMR may be changed.

A notice of changes will be published in the *Federal Register*. This information also will be published in your local newspaper on or about the dates listed below.

LOCAL NEWSPAPER Name: *Chico Enterprise-Record*
Dates: 12/23/2004 12/30/2004

PUBLIC NOTIFICATION

FLOODING SOURCE	LOCATION OF REFERENCED ELEVATION	BFE (FEET NGVD)		MAP PANEL NUMBER(S)
		EFFECTIVE	REVISED	
Dead Horse Slough	Just upstream of El Monte Avenue	None	240	06007C0510 D
	Just downstream of Bruce Road*	None	245	06007C0510 D

*City of Chico

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2677 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional information about the NFIP is available on our website at http://www.fema.gov/nfip.

Max H. Yuan, P.E., Project Engineer
Hazard Identification Section
Mitigation Division
Emergency Preparedness and Response Directorate 102426D.A04090415E 102IAC

CHANGES ARE MADE IN DETERMINATIONS OF BASE FLOOD ELEVATIONS FOR THE CITY OF CHICO AND THE UNINCORPORATED AREAS OF BUTTE COUNTY, CALIFORNIA, UNDER THE NATIONAL FLOOD INSURANCE PROGRAM

On April 20, 2000, the Department of Homeland Security's Federal Emergency Management Agency identified Special Flood Hazard Areas (SFHAs) in the City of Chico and in the unincorporated areas of Butte County, California, through issuance of a Flood Insurance Rate Map (FIRM). The Mitigation Division has determined that modification of the elevations of the flood having a 1-percent chance of being equaled or exceeded in any given year (base flood) for certain locations in these communities is appropriate. The modified Base Flood Elevations (BFEs) revise the FIRM for the communities.

The changes are being made pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (Public Law 93-234) and are in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, Public Law 90-448), 42 U.S.C. 4001-4128, and 44 CFR Part 65.

A hydraulic analysis was performed to incorporate updated topographic information and the effects of construction of the Husa Ranch subdivision, which included detention basins, levees, and placement of fill along Dead Horse Slough from approximately 1,000 feet upstream to approximately 2,500 feet upstream of El Monte Avenue. This has resulted in increases and decreases in SFHA width and the establishment of BFEs for Dead Horse Slough from State Highway 32 to Bruce Road. The table below indicates existing and modified BFEs for selected locations along the affected lengths of the flooding source(s) cited above.

Location	Existing BFE (feet)*	Modified BFE (feet)*
[2]Just upstream of El Monte Avenue	None	240
[1]Just downstream of Bruce Road	None	245

*National Geodetic Vertical Datum, rounded to nearest whole foot
[1]City of Chico
[2]Unincorporated areas of Butte County

Under the above-mentioned Acts of 1968 and 1973, the Mitigation Division must develop criteria for floodplain management. To participate in the National Flood Insurance Program (NFIP), the community must use the modified BFEs to administer the floodplain management measures of the NFIP. These modified BFEs will also be used to calculate the appropriate flood insurance premium rates for new buildings and their contents and for the second layer of insurance on existing buildings and contents.

Upon the second publication of notice of these changes in this newspaper, any person has 90 days in which he or she can request, through the Chief Executive Officer of the community, that the Mitigation Division reconsider the determination. Any request for reconsideration must be based on knowledge of changed conditions or new scientific or technical data. All interested parties are on notice that until the 90-day period elapses, the Mitigation Division's determination to modify the BFEs may itself be changed.

Any person having knowledge or wishing to comment on these changes should immediately notify:

The Honorable Robert J. Beeler
Chairman, Butte County
Board of Supervisors
Butte County Administration Center
25 County Center Drive
Oroville, CA 95965

OR

The Honorable Maureen Kirk
Mayor, City of Chico
P.O. Box 3420
Chico, CA 95927

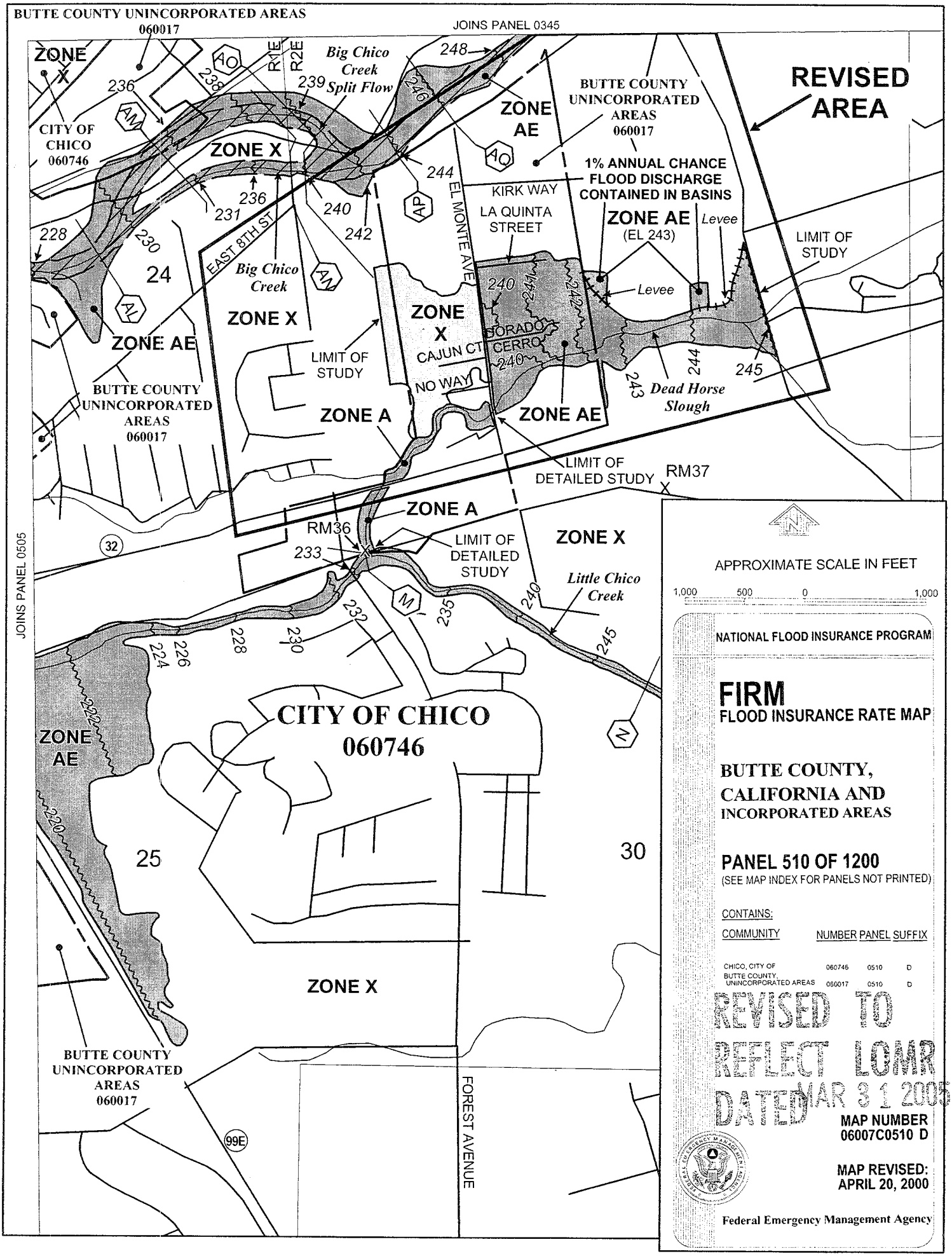
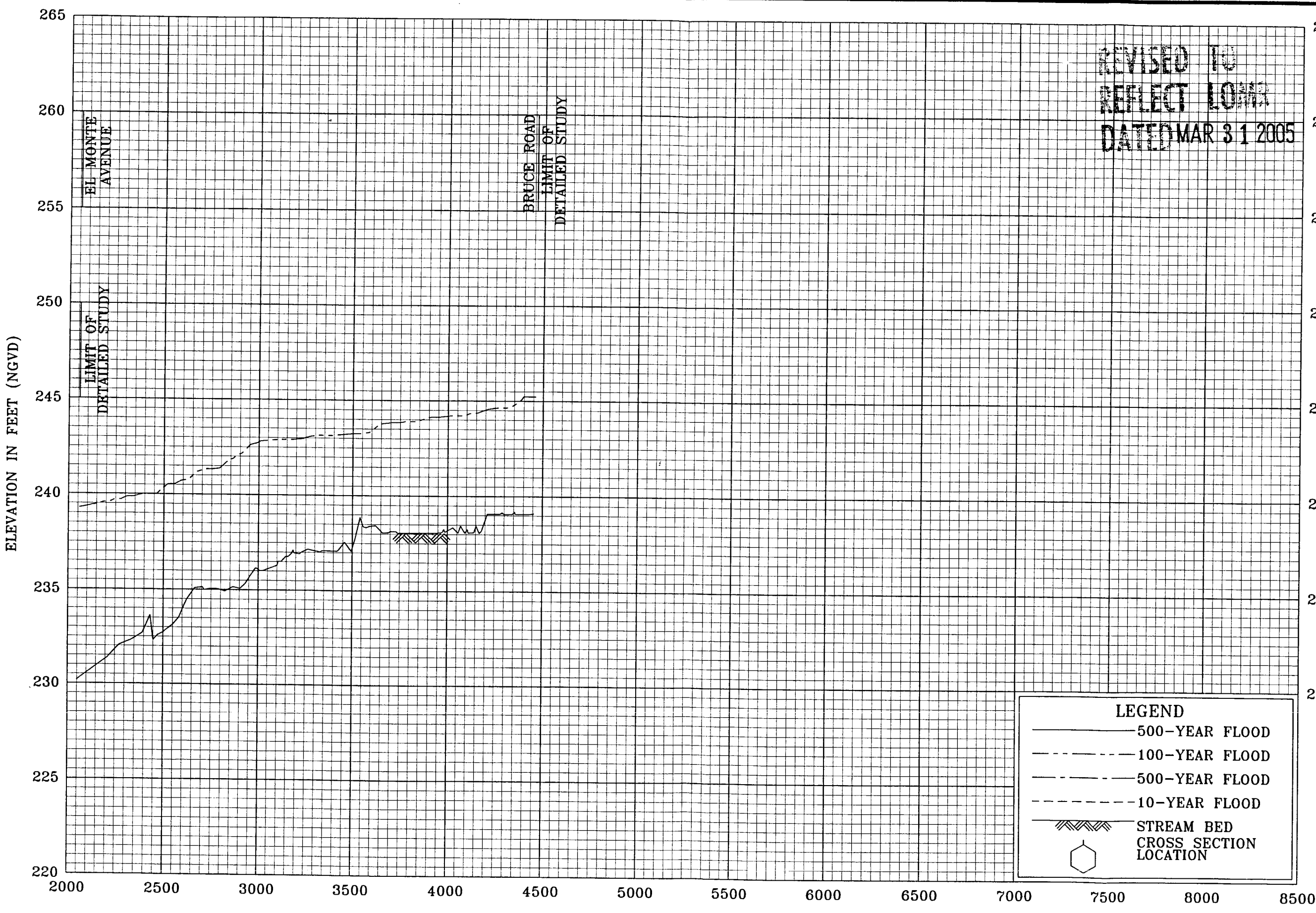

BUTTE COUNTY UNINCORPORATED AREAS
060017
JOINS PANEL 0345
JOINS PANEL 0505
ZONE X
CITY OF CHICO 060746
Big Chico Creek Split Flow
ZONE AE
BUTTE COUNTY UNINCORPORATED AREAS 060017
REVISED AREA
1% ANNUAL CHANCE FLOOD DISCHARGE CONTAINED IN BASINS
KIRK WAY
LA QUINTA STREET
EL MONTE AVE
EAST 8TH ST
Big Chico Creek
ZONE AE (EL 243)
Levee
LIMIT OF STUDY
CAJUN CT
CERRO
NO WAY
ZONE A
Dead Horse Slough
LIMIT OF DETAILED STUDY
RM37
RM36
Little Chico Creek
CITY OF CHICO 060746
24
25
30
FOREST AVENUE
APPROXIMATE SCALE IN FEET
1,000 500 0 1,000
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
BUTTE COUNTY, CALIFORNIA AND INCORPORATED AREAS
PANEL 510 OF 1200
(SEE MAP INDEX FOR PANELS NOT PRINTED)
CONTAINS:
COMMUNITY NUMBER PANEL SUFFIX
CHICO, CITY OF 060746 0510 D
BUTTE COUNTY, UNINCORPORATED AREAS 060017 0510 D
REVISED TO REFLECT LOMR DATED MAR 31 2005
MAP NUMBER 06007C0510 D
MAP REVISED: APRIL 20, 2000
Federal Emergency Management Agency

Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cubic feet per second) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
Dead Horse Slough					
At confluence with Little Chico Creek	5.36	750	1,500	1,900	--[1]

[1]Data Not Available

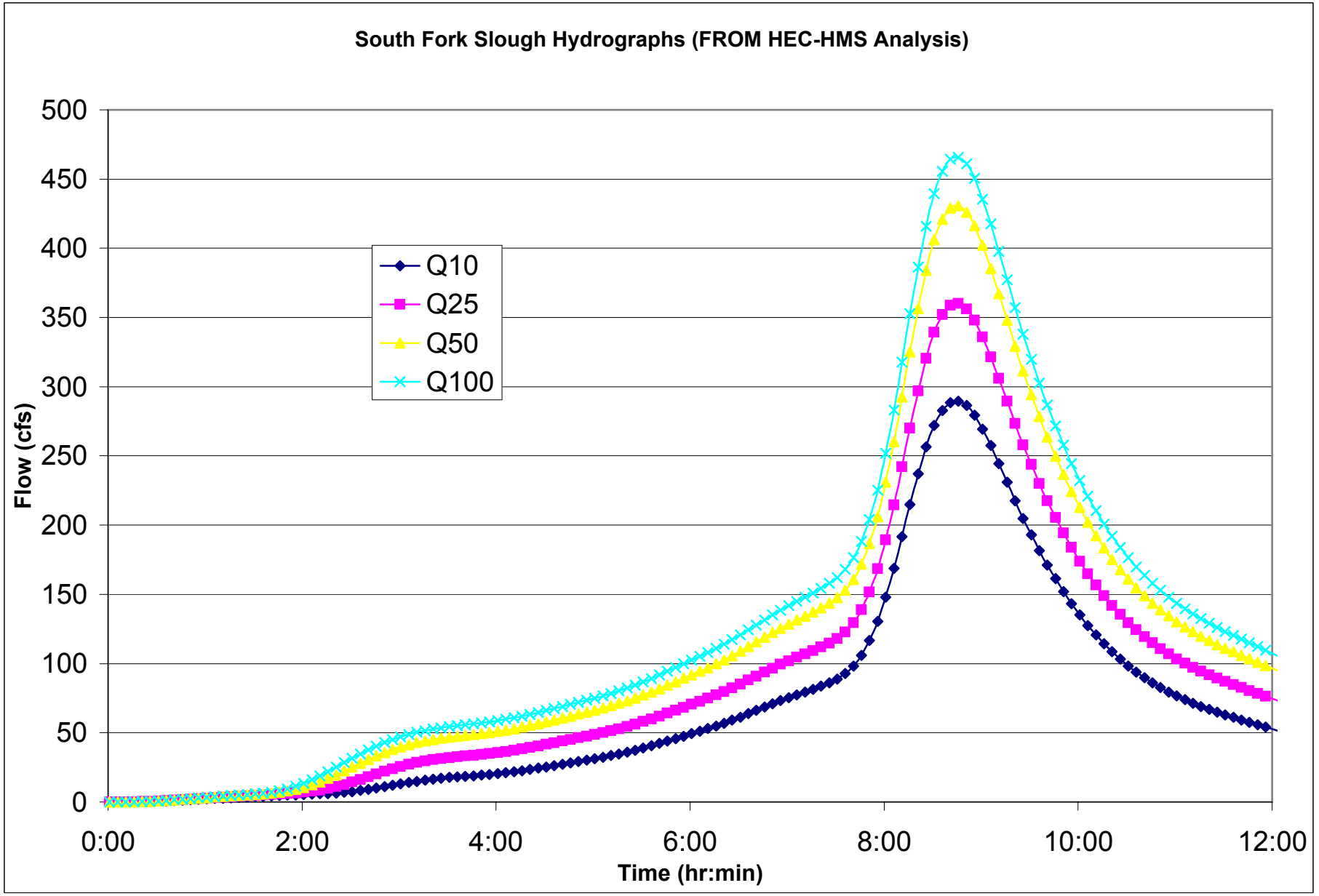


FLOOD PROFILES

DEAD HORSE SLOUGH

FEDERAL EMERGENCY MANAGEMENT AGENCY

BUTTE COUNTY, CA
AND INCORPORATED AREAS


South Fork Slough Hydrographs (FROM HEC-HMS Analysis)
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
Q10
Q25
Q50
Q100
0:00
2:00
4:00
6:00
8:00
10:00
12:00
Time (hr:min)

Catchment Name: **Sheep Hollow Creek at Cohasset Road Bridge**

Mean Annual Precipitation 28 in
Source: OSU Corvallis, PRISM Project California Mean Annual Precipitation Plot

Topographic Parameters

	sq ft	acres	sq mi	sq km
Size:	245,371,237	5,633	8.801482	

Total flowline length	34,883	ft
10% flowline length:	3,488	ft
Elevation at 10% flowline length	205	m
85% flowline length:	29,651	ft
Elevation at 85% flowline length	910	m

Source: "\Projects\Y2004\P0436 Cohasset\DWG\sheep hollow catchment.dwg"
Based on USGS 7.5' quadrangle excerpted using TOPO! Software application

Average of 10% and 85% elevatio	558	m
Altitude Index	1.83	ft * 1000

Discharges by Return Period	**Sierra Region Coefficients**					
Q2	0.24	0.88	1.58	-0.80	194	cfs
Q5	1.20	0.82	1.37	-0.64	466	cfs
Q10	2.63	0.80	1.25	-0.58	680	cfs
Q25	6.55	0.79	1.12	-0.52	1,114	cfs
Q50	10.40	0.78	1.06	-0.48	1,452	cfs
Q100	15.70	0.77	1.02	-0.43	1,934	cfs

Source: Caltrans Highway Design Manual, Figure 819.2C from USGS, "Magnitude and Frequency of Floods in California", June 1977.

	Latitude					**Longitude**				
	D	**M**	**S**	**DD**	**Radians**	**D**	**M**	**S**	**DD**	**Radians**
Crossing Location:	39	47	11.8	39.78661	0.694407	121	50	37.9	-121.8439	-2.126577

CALIFORNIIA

A N N U A L P R E C I P I T A T I O N S U M M A R Y (INCHES)

		PRECIPITATION						SNOWFALL			NUMBER OF DAYS			
	PERIOD OF RECORD	MEAN	MAX YEAR	YR	MIN YEAR	YR	MAX DAY	YEARMODY	MEAN	MAX YEAR	YR	>= .01	>= .10	>= .50	>= 1.0
CHICO EXPERIMENT STN	1906-2004	25.84	45.54	41	10.40	76	5.73	19160103	0.1	4.3	72	63	43	18	7

http://www.wrcc.dri.edu/htmlfiles/ca/ca.ppt.ext.html

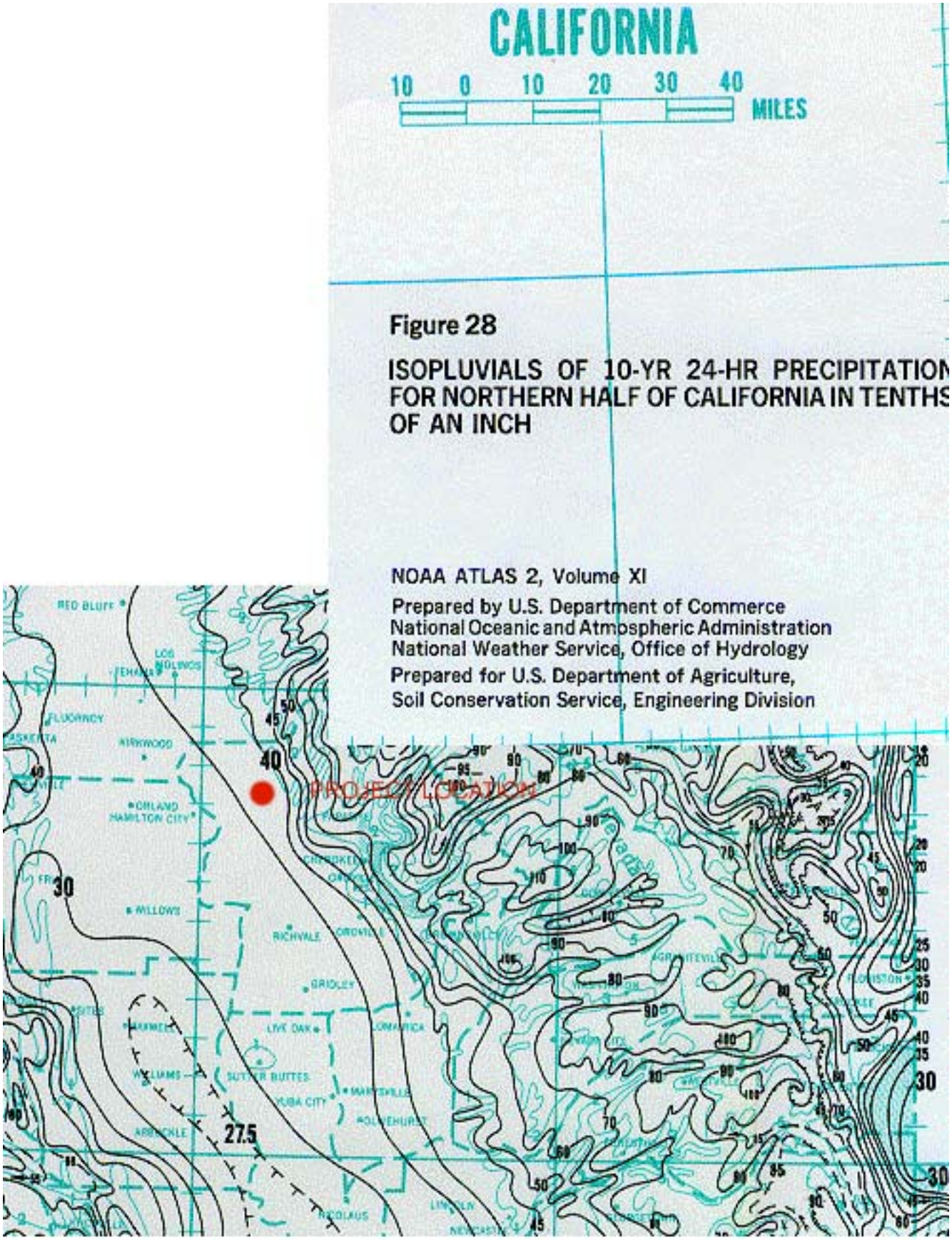


Figure 28

ISOPLUVIALS OF 10-YR 24-HR PRECIPITATION FOR NORTHERN HALF OF CALIFORNIA IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume XI

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

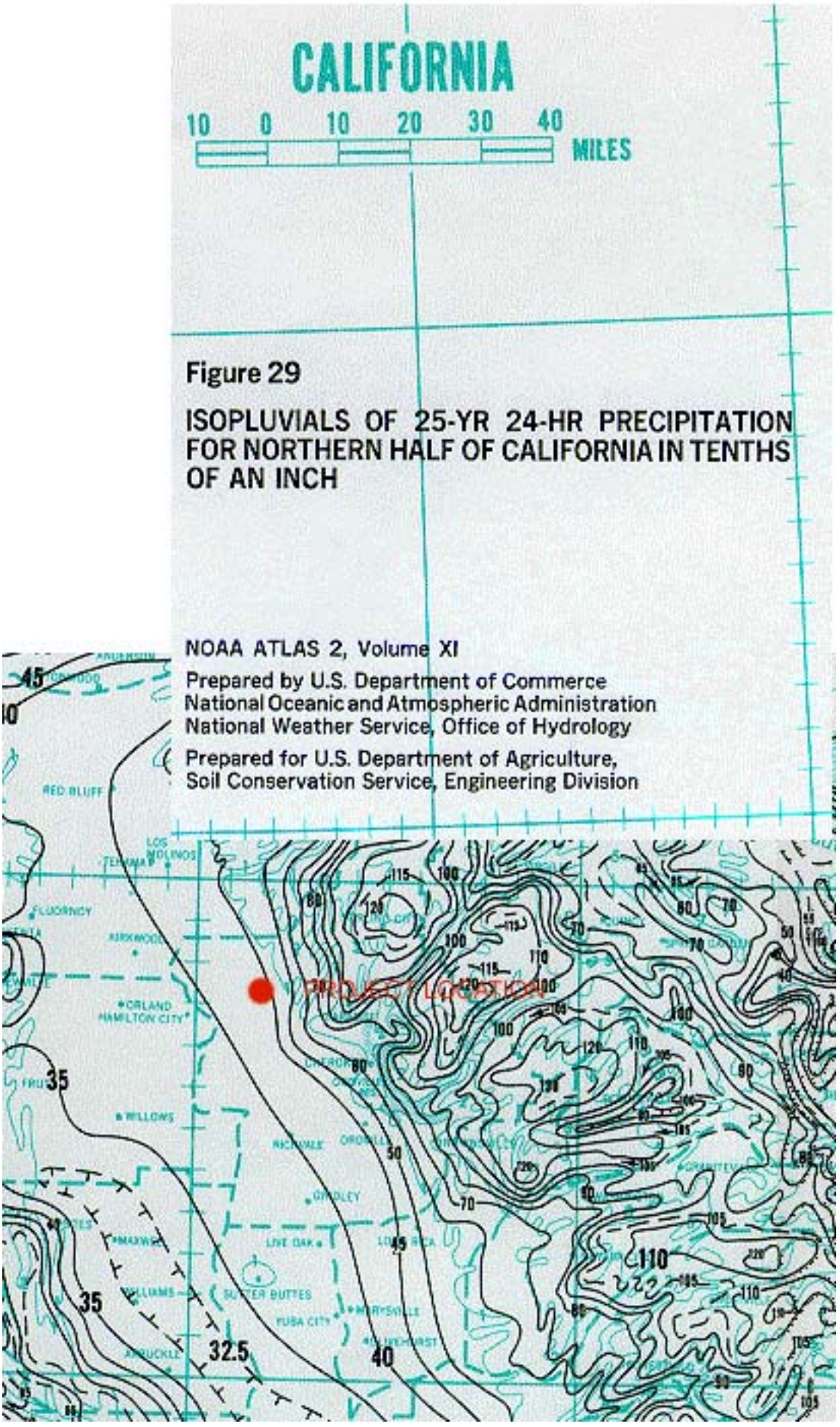


Figure 29

ISOPLUVIALS OF 25-YR 24-HR PRECIPITATION FOR NORTHERN HALF OF CALIFORNIA IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume XI

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

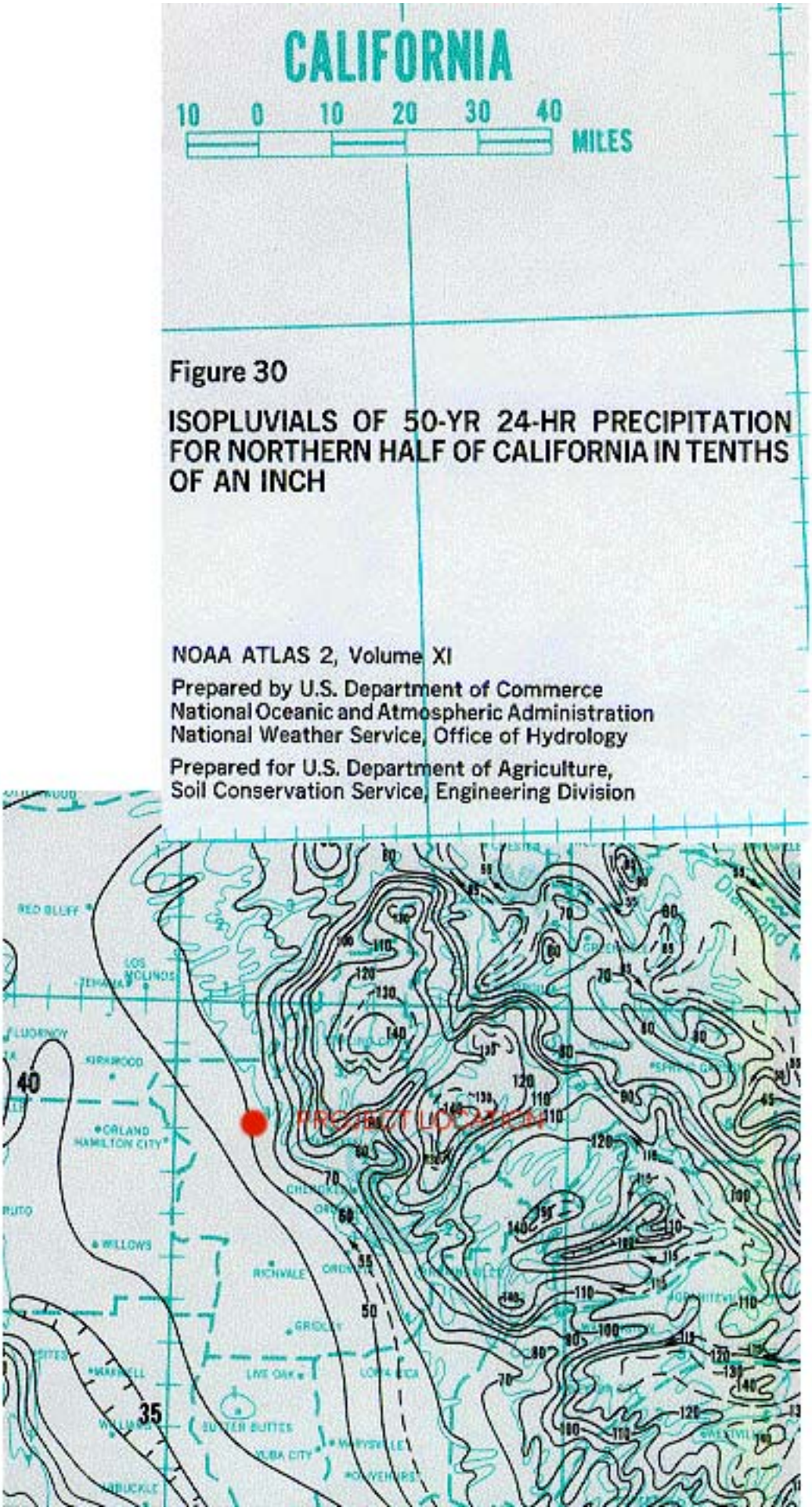


Figure 30

ISOPLUVIALS OF 50-YR 24-HR PRECIPITATION FOR NORTHERN HALF OF CALIFORNIA IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume XI

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

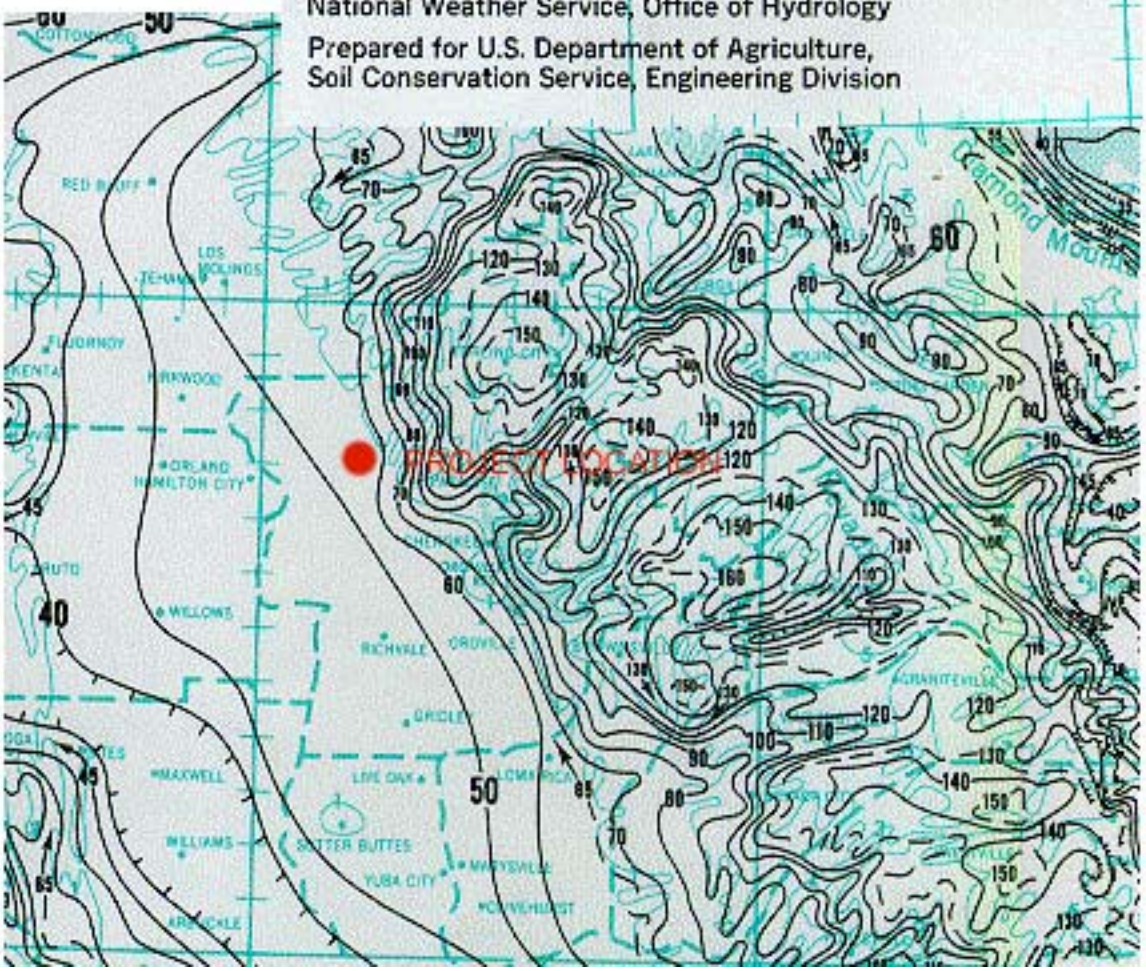


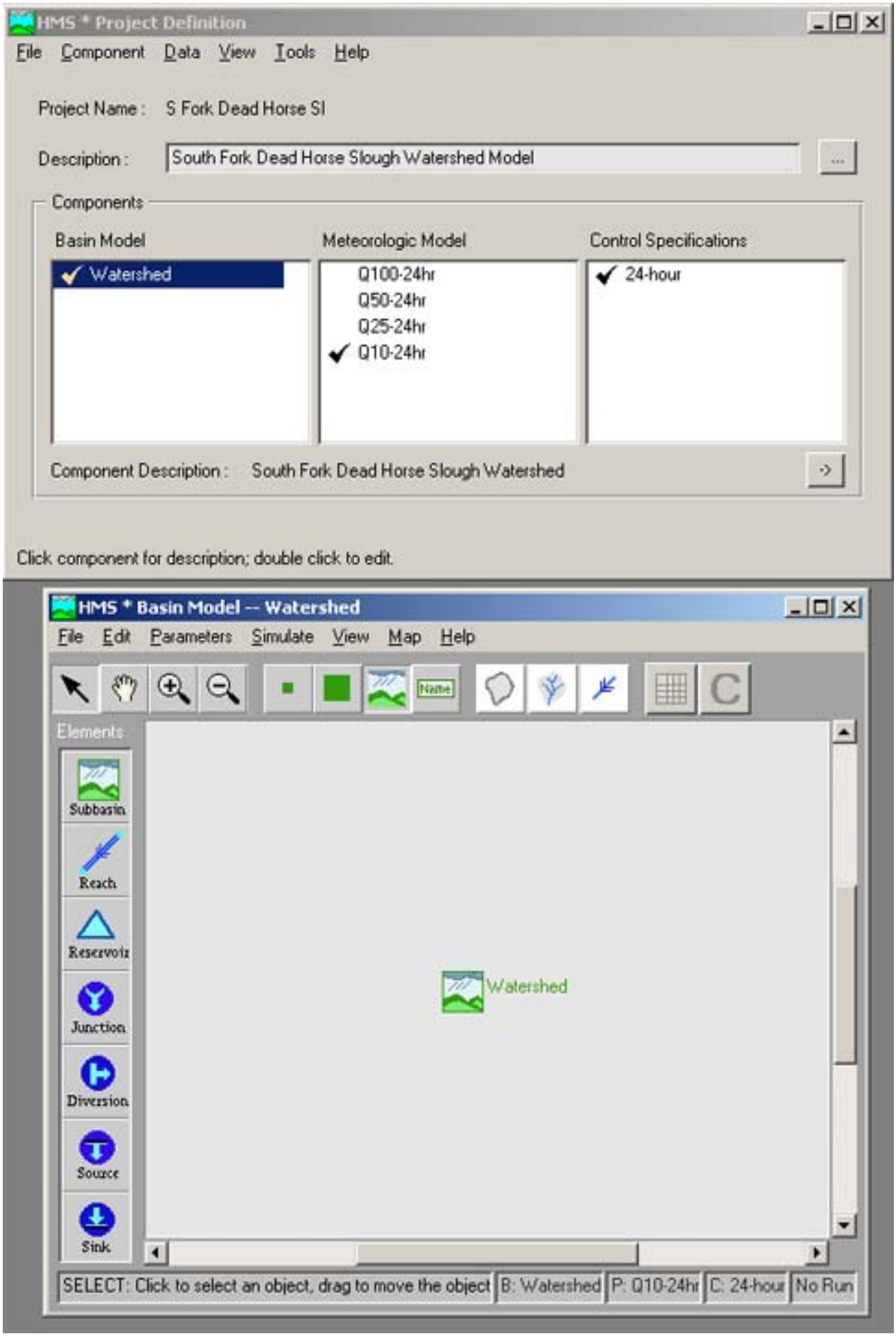
Figure 31

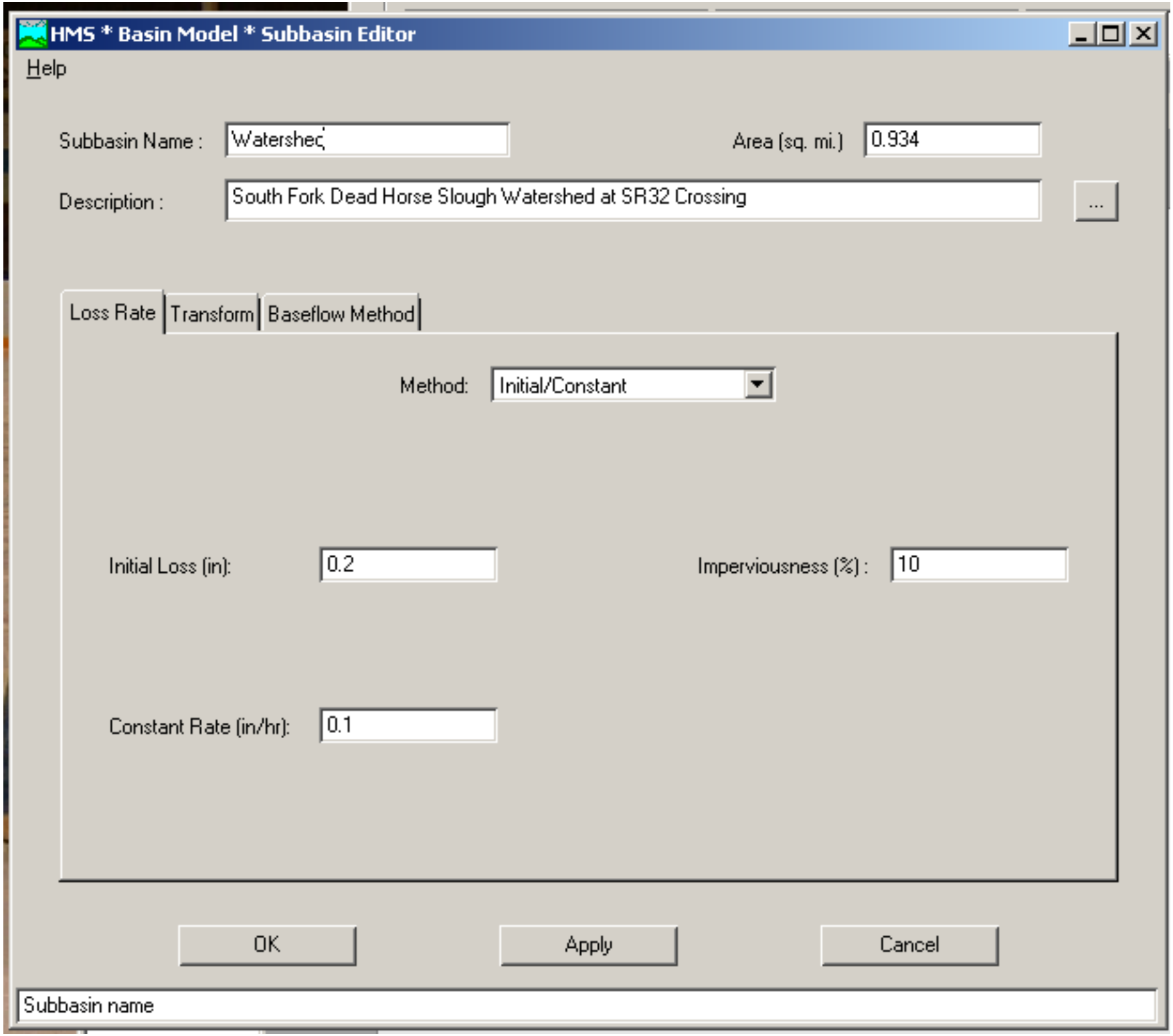
ISOPLUVIALS OF 100-YR 24-HR PRECIPITATION FOR NORTHERN HALF OF CALIFORNIA IN TENTHS OF AN INCH

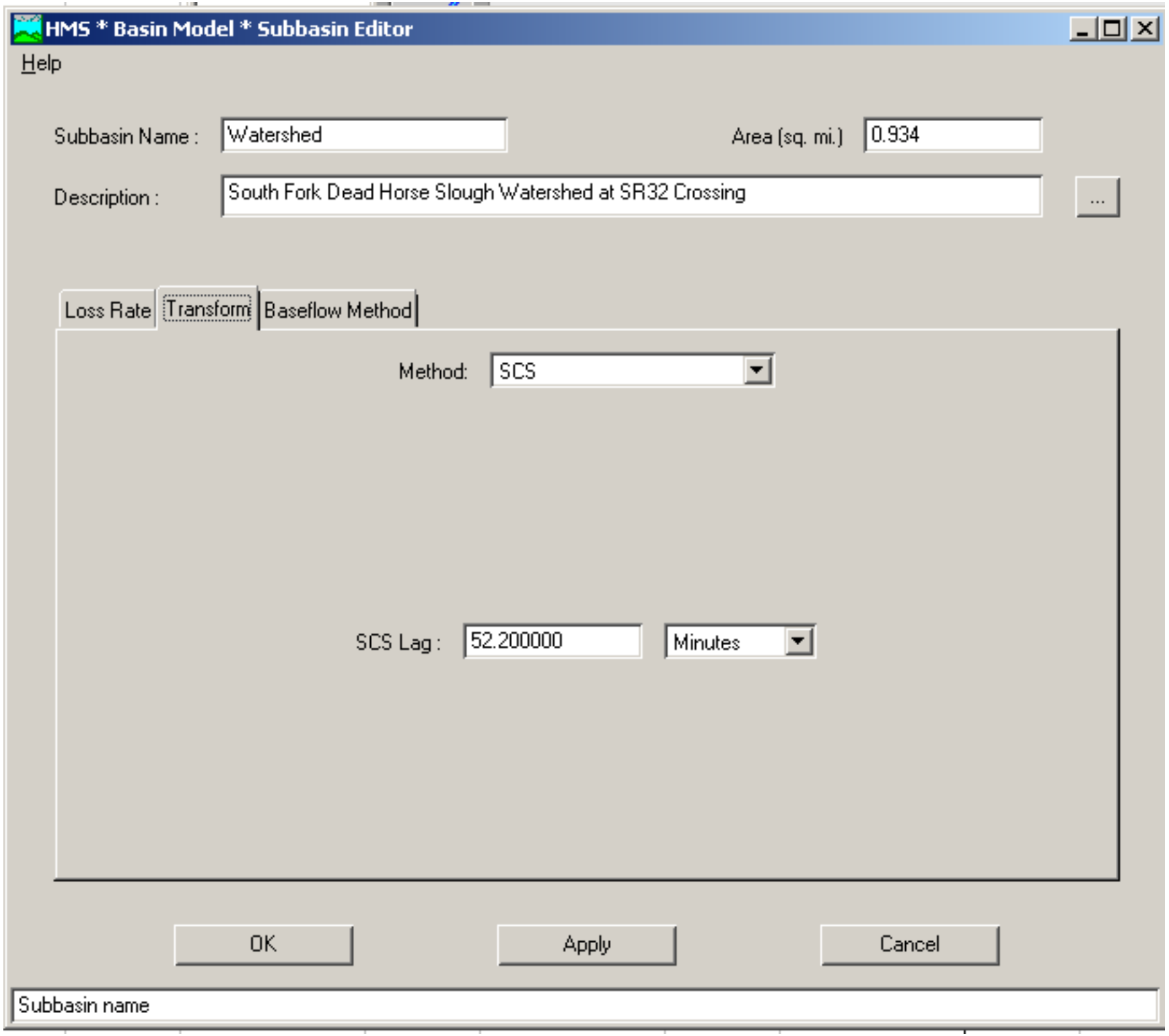
NOAA ATLAS 2, Volume XI

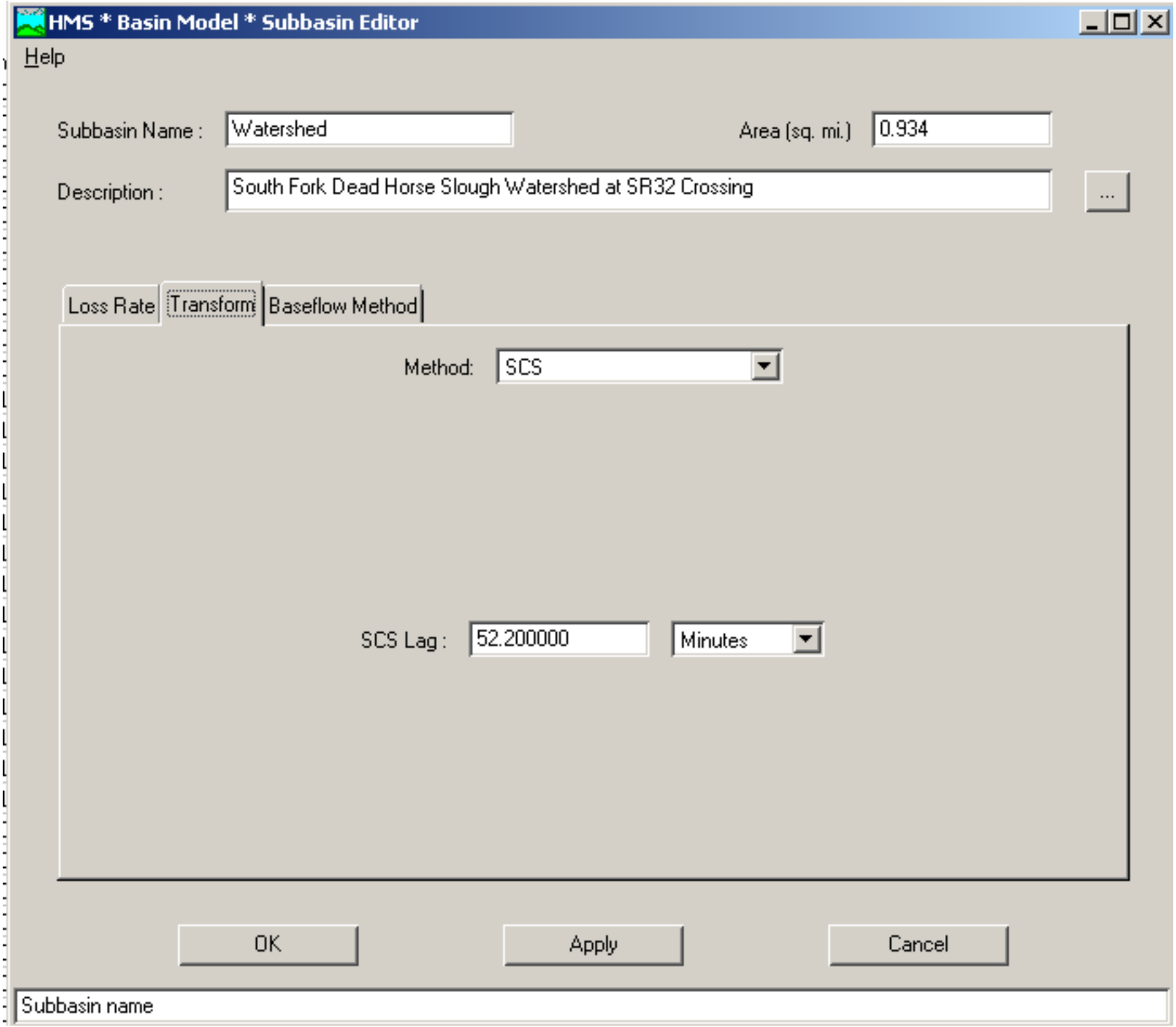
Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

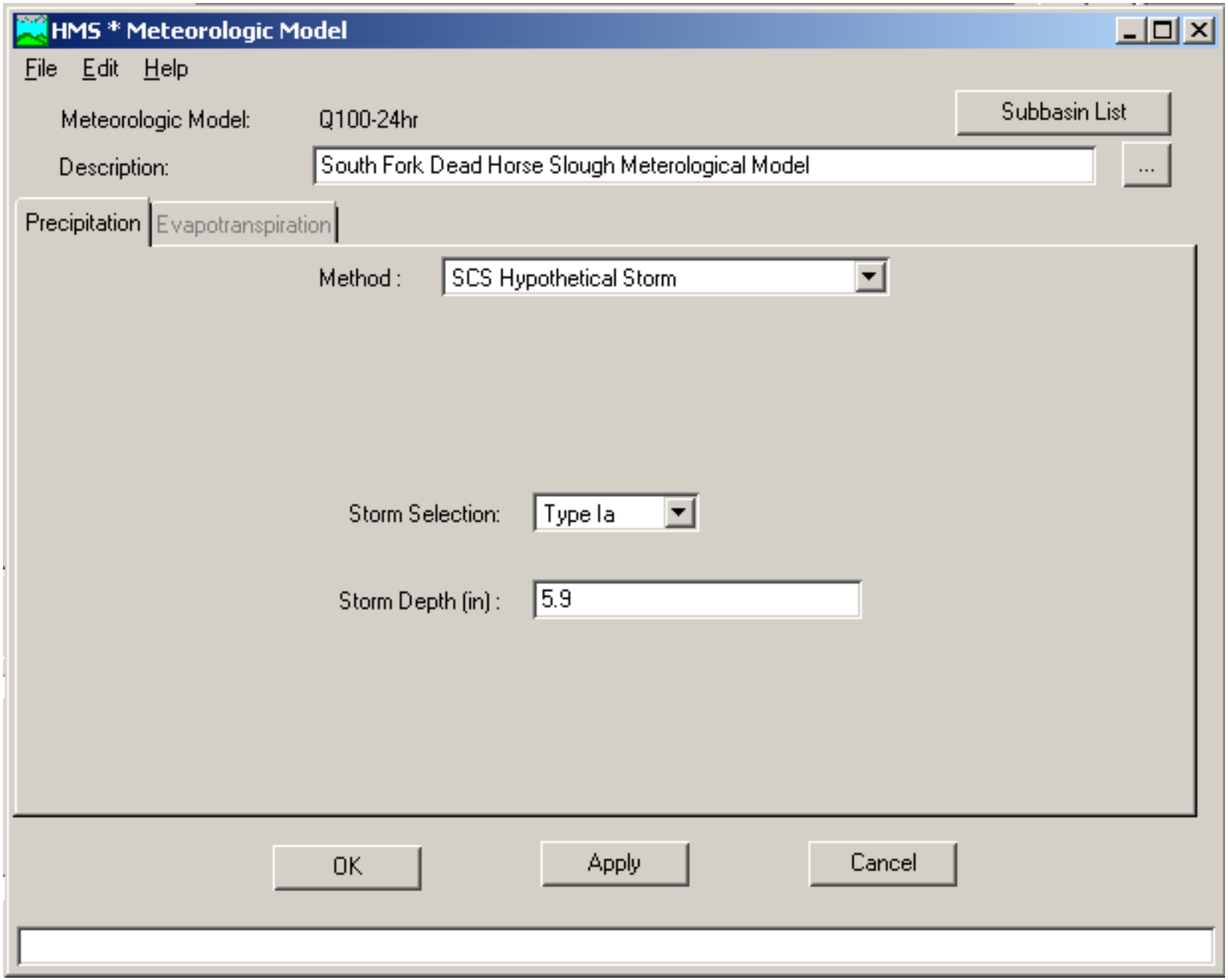
Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

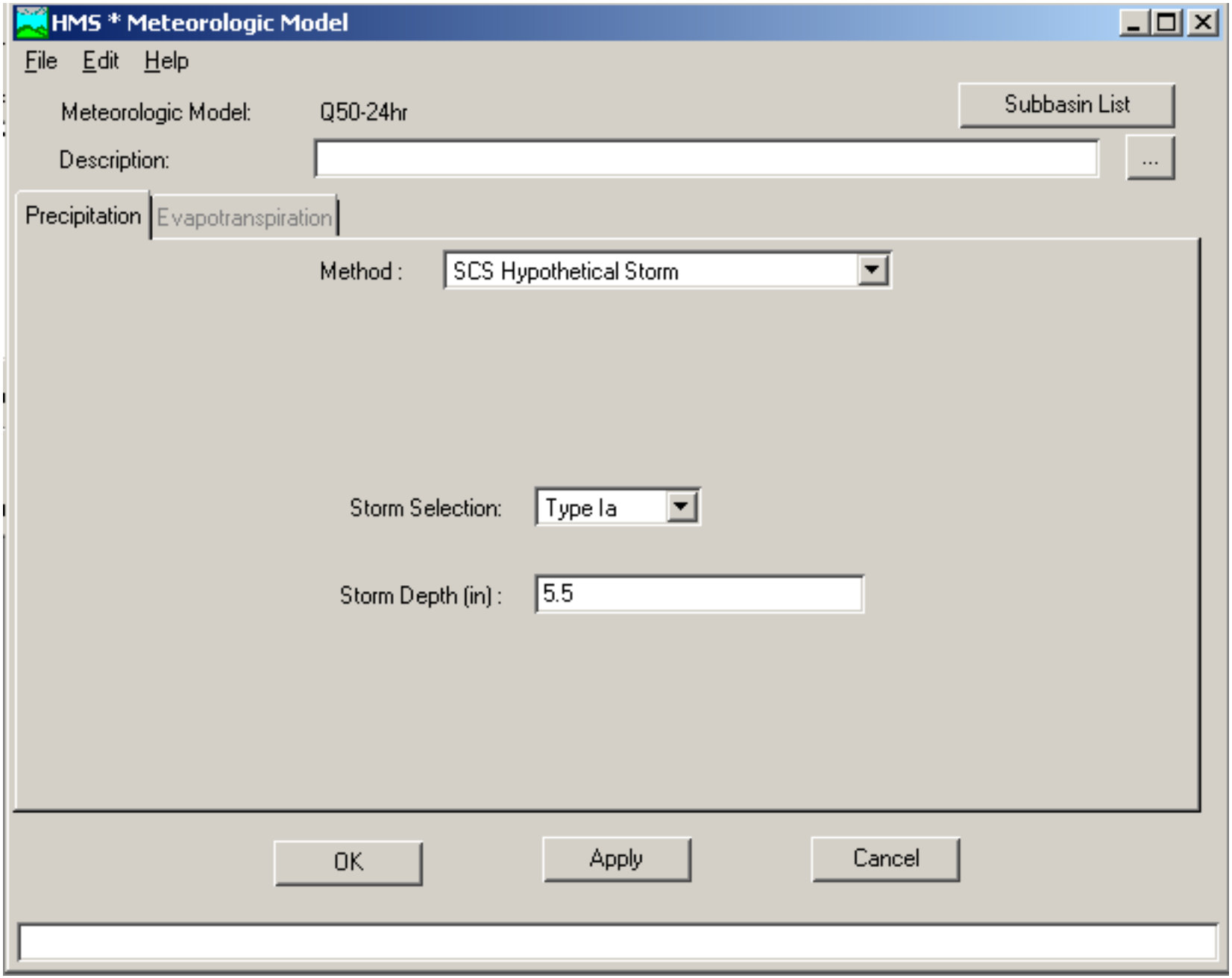

HMS * Project Definition
File Component Data View Tools Help
Project Name : S Fork Dead Horse Sl
Description : South Fork Dead Horse Slough Watershed Model
Components
Basin Model
Meteorologic Model
Control Specifications
Watershed
Q100-24hr
Q50-24hr
Q25-24hr
Q10-24hr
24-hour
Component Description : South Fork Dead Horse Slough Watershed
Click component for description; double click to edit.
HMS * Basin Model -- Watershed
File Edit Parameters Simulate View Map Help
Elements
Subbasin
Reach
Reservoir
Junction
Diversion
Source
Sink
Watershed
SELECT: Click to select an object, drag to move the object
B: Watershed
P: Q10-24hr
C: 24-hour
No Run

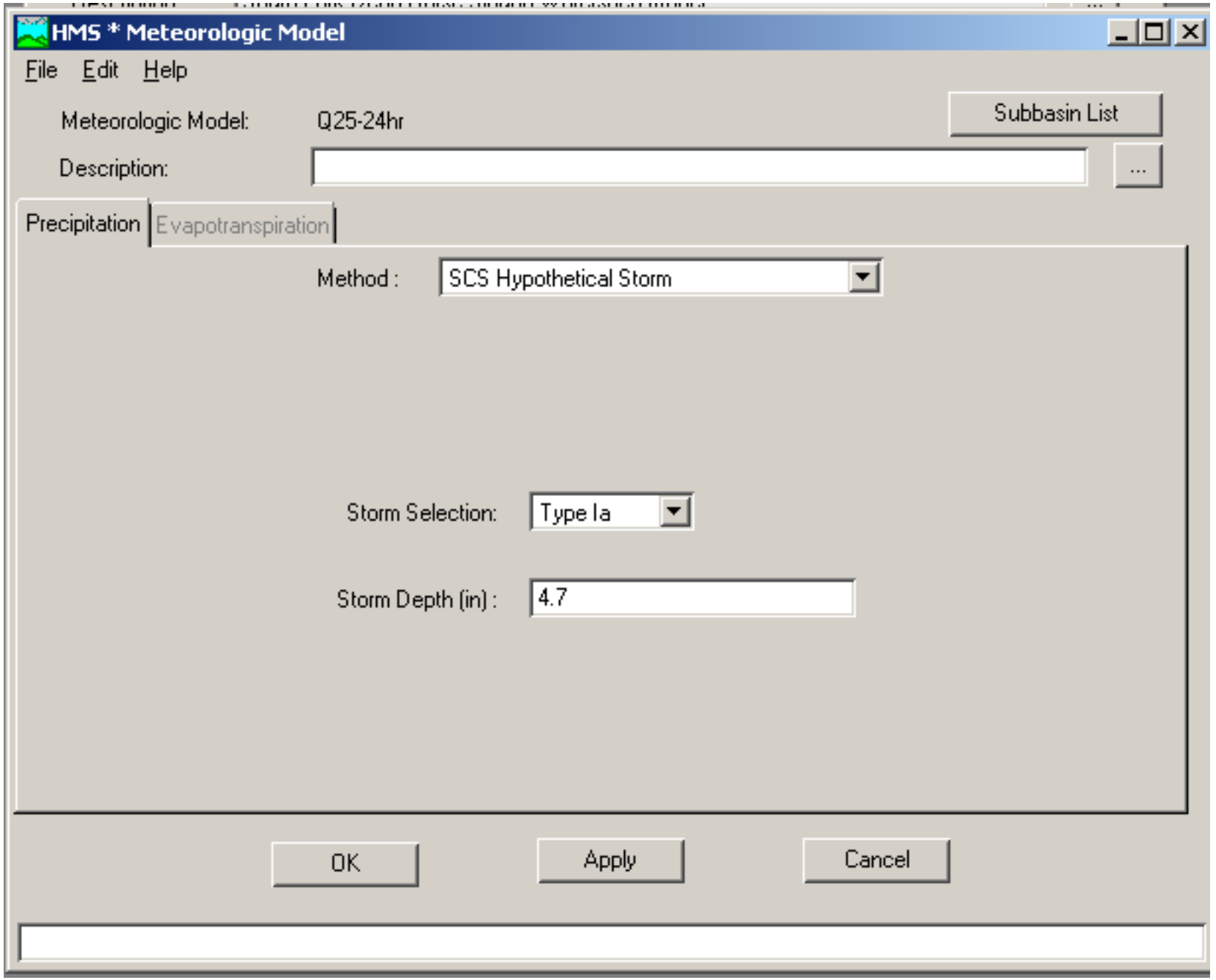

HMS * Basin Model * Subbasin Editor
Help
Subbasin Name :
Watershed
Area (sq. mi.)
0.934
Description :
South Fork Dead Horse Slough Watershed at SR32 Crossing
...
Loss Rate
Transform
Baseflow Method
Method:
Initial/Constant
Initial Loss (in):
0.2
Imperviousness (%) :
10
Constant Rate (in/hr):
0.1
OK
Apply
Cancel
Subbasin name

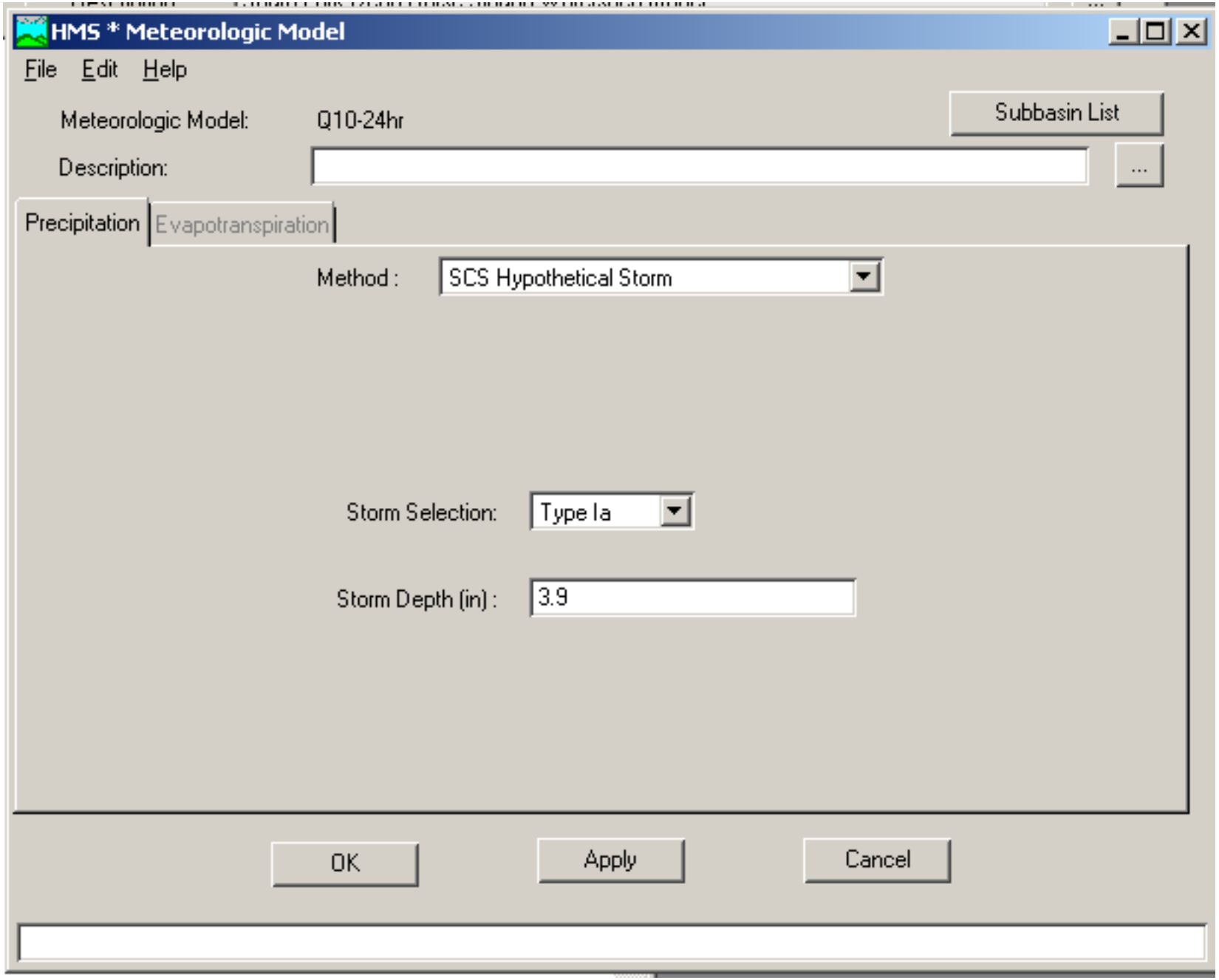

HMS * Basin Model * Subbasin Editor
Help
Subbasin Name :
Watershed
Area (sq. mi.)
0.934
Description :
South Fork Dead Horse Slough Watershed at SR32 Crossing
...
Loss Rate
Transform
Baseflow Method
Method:
SCS
SCS Lag :
52.200000
Minutes
OK
Apply
Cancel
Subbasin name

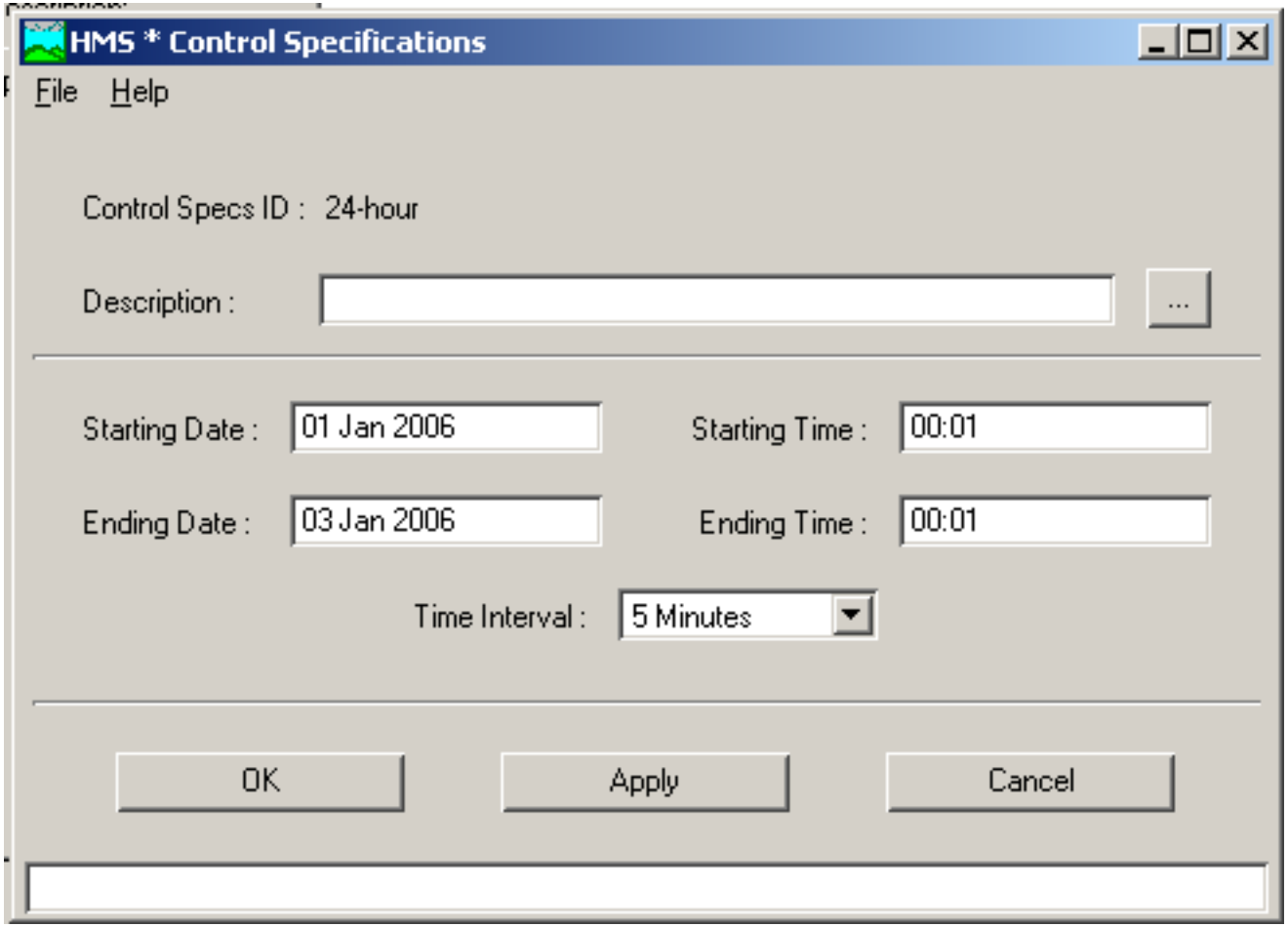

HMS * Basin Model * Subbasin Editor
Help
Subbasin Name :
Watershed
Area (sq. mi.)
0.934
Description :
South Fork Dead Horse Slough Watershed at SR32 Crossing
...
Loss Rate
Transform
Baseflow Method
Method:
SCS
SCS Lag :
52.200000
Minutes
OK
Apply
Cancel
Subbasin name

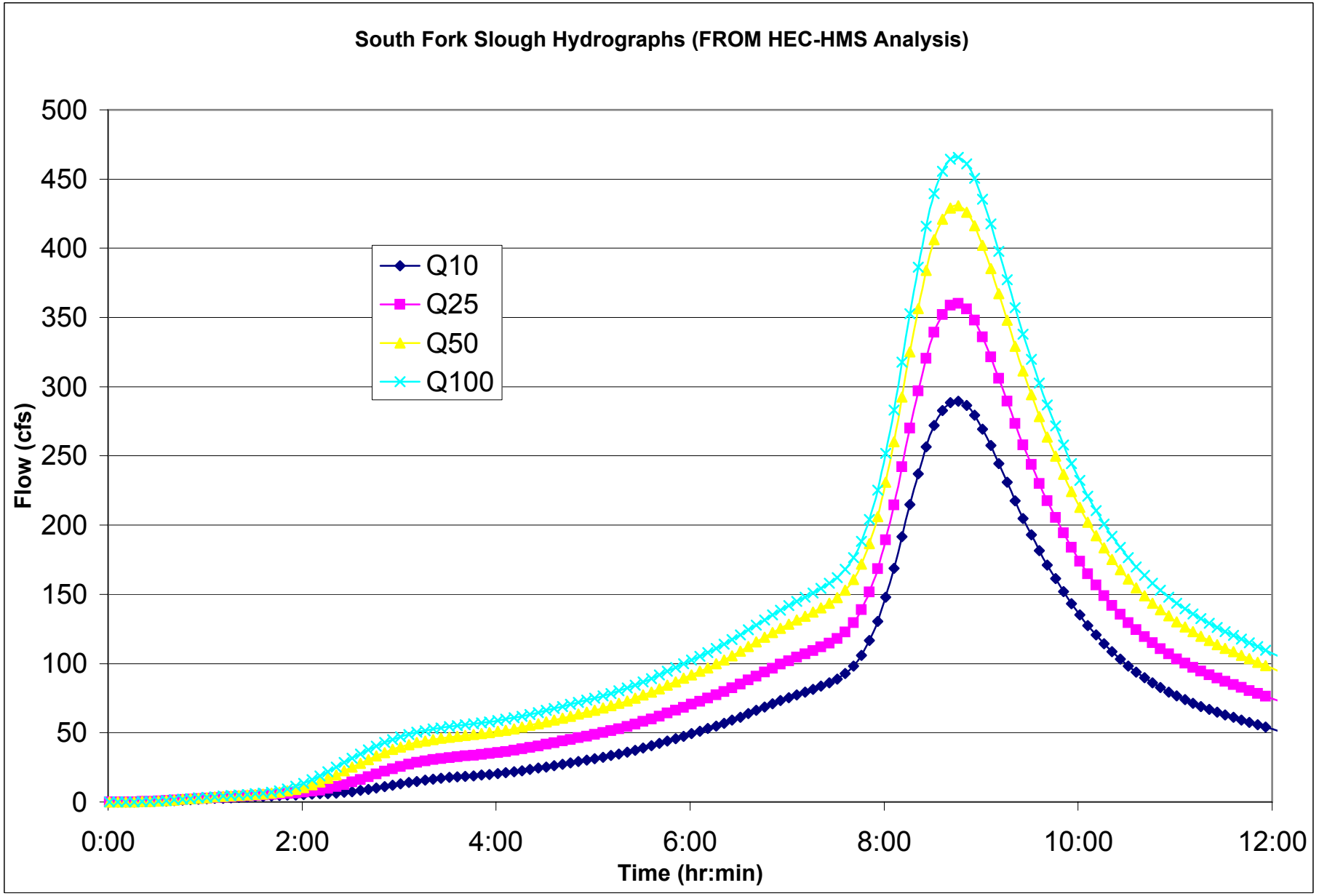

HMS * Meteorologic Model
File
Edit
Help
Meteorologic Model:
Q100-24hr
Subbasin List
Description:
South Fork Dead Horse Slough Meterological Model
...
Precipitation
Evapotranspiration
Method :
SCS Hypothetical Storm
Storm Selection:
Type Ia
Storm Depth (in) :
5.9
OK
Apply
Cancel


HMS * Meteorologic Model
File
Edit
Help
Meteorologic Model:
Q50-24hr
Subbasin List
Description:
...
Precipitation
Evapotranspiration
Method :
SCS Hypothetical Storm
Storm Selection:
Type Ia
Storm Depth (in) :
5.5
OK
Apply
Cancel


HMS * Meteorologic Model
File Edit Help
Meteorologic Model: Q25-24hr
Subbasin List
Description:
...
Precipitation
Evapotranspiration
Method :
SCS Hypothetical Storm
Storm Selection:
Type Ia
Storm Depth (in) :
4.7
OK
Apply
Cancel


HMS * Meteorologic Model
File Edit Help
Meteorologic Model: Q10-24hr
Subbasin List
Description:
...
Precipitation
Evapotranspiration
Method :
SCS Hypothetical Storm
Storm Selection:
Type Ia
Storm Depth (in) :
3.9
OK
Apply
Cancel


HMS * Control Specifications
File
Help
Control Specs ID : 24-hour
Description :
...
Starting Date : 01 Jan 2006
Starting Time : 00:01
Ending Date : 03 Jan 2006
Ending Time : 00:01
Time Interval : 5 Minutes
OK
Apply
Cancel

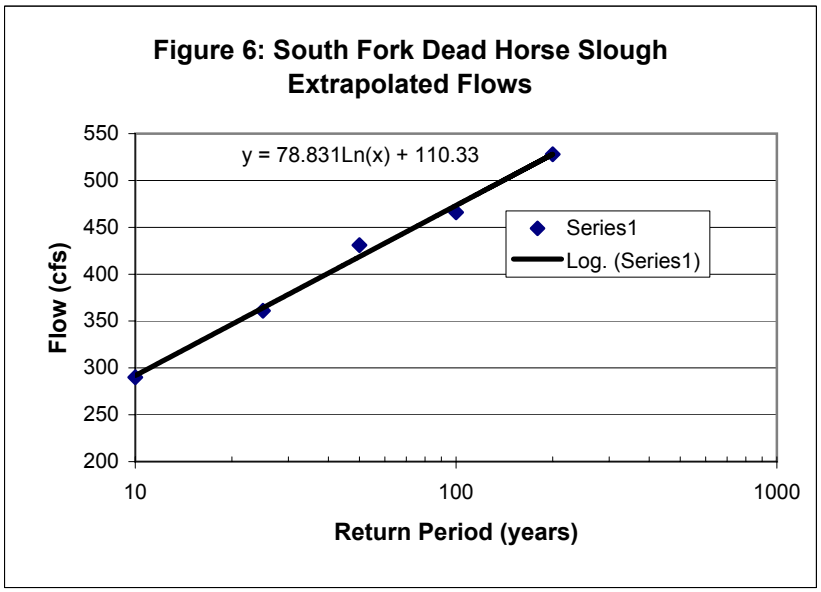

South Fork Slough Hydrographs (FROM HEC-HMS Analysis)
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
Q10
Q25
Q50
Q100
0:00
2:00
4:00
6:00
8:00
10:00
12:00
Time (hr:min)

P0513: SR 32 Widening
South Fork Dead Horse Slough Flows

From HEC-HMS Analysis

Q200 =	200	528.0017	cfs	(FROM GRAPH)
Q100 =	100	466	cfs	(FROM HEC-HMS model)
Q50 =	50	431	cfs	(FROM HEC-HMS model)
Q25 =	25	361	cfs	(FROM HEC-HMS model)
Q10 =	10	290	cfs	(FROM HEC-HMS model)

Q200 =	200	528.0017	cfs	(FROM GRAPH)



APPENDIX E

SCOUR ANALYSIS CALCULATIONS

Local Pier Scour – To determine pier scour, an equation based on the CSU equation is recommended within the HEC-18 manual for both live-bed and clear-water scour. The equation predicts maximum pier scour depths. The equation is:

$$\frac{Y_s}{Y_1} = 2.0\,K_1 K_2 K_3 K_4 \left(\frac{a}{Y_1}\right)^{0.65} Fr^{0.43}$$

where: Y_s = Scour depth
Y_1 = Flow depth directly upstream of the pier
K_1 = Coefficient factor for pier nose shape (from HEC-18)
K_2 = Coefficient factor for angle of attack of flow (from HEC-18)
K_3 = Correction factor for bed condition (from HEC-18)
K_4 = Correction factor for armoring by bed material size (from HEC-18)
a = Pier width
V_1 = Mean velocity of flow directly upstream of the pier
Fr = Froude number directly upstream of the pier= $V_1/(gY_1)^{0.5}$

After using HEC-RAS to analyze the flow at the proposed SR 32 Bridge at Dead Horse Slough, the factors in the above equation were determined to be:

Bridge Widening

Bent 2 (HEC-RAS Pier #3)

Y_1 = 6.68 ft (from HEC-RAS)
K_1 = 1.0 (for round nose pier shape) (from HEC-18)
K_2 = 1.0 (for angle of attack = 0 degrees) (from HEC-18)
K_3 = 1.1 (for clear-water scour) (from HEC-18)
K_4 = 1.0 (for D_{50} < 2mm or D_{95} < 20mm) (from HEC-18)
a = 3.75 ft.
Fr_1 = 0.43 (from HEC-RAS)

The Pier scour, calculated using the CSU equation is:

$$\frac{Y_s}{6.68} = 2.0(1.0)(1.0)(1.1)(1.0)\left(\frac{3.75}{6.68}\right)^{0.65} (0.43)^{0.43}$$

Y_s = 7.02 ft

Bent 3 (HEC-RAS Pier #2)

Y_1 = 5.79 ft (from HEC-RAS)
K_1 = 1.0 (for round nose pier shape) (from HEC-18)
K_2 = 1.0 (for angle of attack = 0 degrees) (from HEC-18)
K_3 = 1.1 (for clear-water scour) (from HEC-18)
K_4 = 1.0 (for D_{50} < 2mm or D_{95} < 20mm) (from HEC-18)

a = 3.75 ft.
Fr_1 = 0.43 (from HEC-RAS)

The Pier scour, calculated using the CSU equation is:

$$\frac{Y_s}{5.79} = 2.0(1.0)(1.0)(1.1)(1.0)\left(\frac{3.75}{5.79}\right)^{0.65}(0.43)^{0.43}$$

Y_s = 6.68 ft

Bent 4 (HEC-RAS Pier #1)

Y_1 = 3.59 ft (from HEC-RAS)
K_1 = 1.0 (for round nose pier shape) (from HEC-18)
K_2 = 1.0 (for angle of attack = 0 degrees) (from HEC-18)
K_3 = 1.1 (for clear-water scour) (from HEC-18)
K_4 = 1.0 (for D_{50} < 2mm or D_{95} < 20mm) (from HEC-18)
a = 3.75 ft.
Fr_1 = 0.38 (from HEC-RAS)

The Pier scour, calculated using the CSU equation is:

$$\frac{Y_s}{3.59} = 2.0(1.0)(1.0)(1.1)(1.0)\left(\frac{3.75}{3.59}\right)^{0.65}(0.38)^{0.43}$$

Y_s = 5.35 ft

Live-Bed Scour at abutments – As a check on the potential depth of scour to aid in the design of the foundation and placement of rock riprap and/or guide banks, either Froelich's live-bed scour equation or the HIRE equation can be used. Use the live-bed equations even if clear-water scour dominates.

Froelich's Abutment Scour Equation is:

$$\frac{Y_s}{Y_a} = 2.27\,K_1 K_2\left(\frac{L'}{Y_a}\right)^{0.43} Fr^{0.61} + 1$$

The HIRE Live-Bed Abutment Scour Equation is:

$$\frac{Y_s}{Y_1} = 4Fr^{0.33}\left(\frac{k_1}{0.55}\right)$$

where: Y_s = Scour depth
Y_a = Average depth of flow on floodplain
Y_1 = Depth of flow at the abutment on the overbank or in the main channel
K_1 = Coefficient for abutment shape (from HEC-18)
K_2 = Coefficient for angle of embankment to flow (from HEC-18)
L' = Length of active flow obstructed by the embankment and abutment
V_1 = Hypothetical approach velocity of flow obstructed by embankment
Fr = Froude number = $V_1/(gY_1)^{0.5}$

The HIRE equation should be used when L'/Y_1 is greater than 25; otherwise the Froelich equation applies.

After using HEC-RAS to analyze the flow at the proposed SR 32 Bridge at Dead Horse Slough, the factors in the above equation were determined for each abutment to be:

Bridge Widening

Abutment 1 (HEC-RAS Right Abutment)

Y_a = 1.04 ft (from HEC-RAS)
Y_1 = 1.12 ft (from HEC-RAS)
L' = 3.95 ft
L'/Y_1 = 3.95 ft / 1.12 ft < 25: therefore use Froelich's equation
K_1 = 1.0 (vertical abutment) (from HEC-18)
K_2 = 1.0 (flow perpendicular to embankment) (from HEC-18)
Fr_1 = 0.36 (from HEC-RAS)

The Abutment scour, calculated using Froelich's equation is:

$$\frac{Y_s}{1.04} = 2.27(1.0)(1.0)\left(\frac{3.95}{1.04}\right)^{0.43}(0.36)^{0.61}+1$$

Y_s = 3.31 ft

Abutment 2 (Left Bank)

The 100-year water surface elevation does not reach Abutment 2 (HEC-RAS Left Abutment), and therefore, abutment scour was not evaluated at Abutment 2.

Clear-Water Contraction Scour - Contraction scour typically occurs where the bridge opening is smaller than the flow area of the upstream channel and/or flood plain. Clear-Water contraction scour occurs when there is little or no transport of bed material. Also use a Clear-Water Contraction Scour Equation if transported material is mostly suspended and will be washed through the contracted section reach. The Laursen's Clear-Water Contraction Scour Equation can be used:

$$y_2 = \left(\frac{K_U Q^2}{D_m^{2/3} W^2} \right)^{3/7}$$

where: Y_2 = Average equilibrium depth in the contracted section (after scour)
D_m = 1.25xD_{50}
Q_1 = Flow in the upstream channel transporting sediment
Q = Flow in the contracted channel
W = Bottom width of the contracted section (minus pier widths)
K_U = Exponent: 0.025 SI units, 0.0077 English Units (from HEC-18)

Live Bed Contraction Scour - Contraction scour typically occurs where the bridge opening is smaller than the flow area of the upstream channel and/or flood plain. Live-bed contraction scour occurs when there is transport of bed material in the upstream reach into the bridge cross section. With live bed contraction scour the area of the contracted section increases until, in the limit, the transport of sediment out of the contracted section equals the sediment transported in. The modified Laursen's Live-Bed Contraction Scour Equation can be used:

$$\frac{Y_2}{Y_1} = \left(\frac{Q_2}{Q_1} \right)^{6/7} \left(\frac{W_1}{W_2} \right)^{k_1}$$

$$Y_s = Y_2 - Y_o$$

where: Y_2 = Average depth in the contracted section (after scour)
Y_1 = Average depth in the upstream main channel
Y_o = Existing depth in the contracted section
Q_1 = Flow in the upstream channel transporting sediment
Q_2 = Flow in the contracted channel
W_1 = Bottom width of the upstream main channel
W_2 = Bottom width of the contracted section (minus pier widths)

The critical velocity equation is applied to determine whether Clear Water Contraction Scour or Live Bed Contraction Scour is occurring. If the flow velocity at the site is greater than the critical velocity, based on the average particle size present at the site, then the Live Bed Contraction Scour equation is used to determine scour.

$$V_C = K_U y^{1/6} D^{1/3}$$

where: V_C = Critical velocity above which bed material of size D and smaller will be transported, m/s (ft/s)
y = Average depth of flow upstream of the bridge, m (ft)

D = Particle size for V_C, m (ft)
D_{50} = Average particle size, m (ft)

$$V_C = 11.17(5.01)^{1/6}(0.00016)^{1/3}$$

K_U = Exponent: 6.19 SI units, 11.17 English Units (from HEC-18)

V_C = 0.8 ft/s

After using HEC-RAS to analyze the flow at the proposed SR 32 Bridge at Dead Horse Slough, it is determined that Live Bed Contraction Scour is occurring. The factors for Laursen's Live-Bed Contraction Scour Equation were determined to be:

Bridge Widening

Y_o = 5.10 ft
Y_1 = 5.01 ft
Q_1 = 2,200 cfs
Q_2 = 2,200 cfs
W_1 = 77.35 ft
W_2 = 69.07 ft
K_1 = 0.69

The live-bed contraction scour calculated using Laursen's Equation is:

$$\frac{Y_2}{5.01} = \left(\frac{2200}{2200}\right)^{6/7}\left(\frac{77.35}{69.07}\right)^{0.69}$$

$$Y_2 = 5.42$$
$$Y_s = 5.42 - 5.10$$
$$Y_s = 0.32 \text{ ft}$$

Long Term Bed Elevation Change (long-term scour) – Long-term bed elevation change is the trend of a reach of stream bed to degrade or aggrade. The purpose of the evaluation is to estimate the changes that will occur during the life of the structure. A long term trend may change during the life of the bridge. These long-term changes are the result of modifications to the stream or watershed. Such changes may be a result of natural processes or human activities. The equation for evaluating long term bed change is:

$$\Delta = \frac{E_1 - E_2}{A_1 - A_2}$$

where*:* Δ = long-term bed elevation change per year (ft/yr)
E_1 = bed elevation in year *x (ft)*
E_2 = bed elevation in year *y (ft)*
A_1 = year *x*
A_2 = year *y*

Our field observations did not indicate severe creek bed degradation. We assumed the long-term bed elevation change to be negligible. Further research will be done to finalize our long-term bed change analysis. These results will be determined in the final version of this report.

Table 873.3B
Rock Slope Protection Design Guide

Mean Stream Velocity V_M	PARALLEL FLOW ALONG TANGENT BANK					IMPINGEMENT FLOW AGAINST CURVED BANK				
	Bank Velocity V_A	Minimum Stone W	Protection Class W_C	Placement Method	Section Thickness T	Bank Velocity VB	Minimum Stone W	Protection Class W_C	Placement Method	Section Thickness T
fps	fps	lb		A or B	ft	fps	lb or T		A or B	ft
4.5	3		None			6	3 lb	None		
6	4		None			8	15	Facing	B	1.8
7.5	5	1	None			10	57	1/4 ton	B	3.3
9	6	3	None			12	170	1/4 ton	B	3.3
10.5	7	7	Facing	B	1.8	14	430	1/2 ton	A	3.3
									B	4.2
12	8	15	Facing	B	1.8	16	950	1 ton	A	4.2
									B	5.3
13.5	9	30	Light	B	2.5	18	1.0 T	2 ton	A	5.3
15	10	57	1/4 ton	B	3.3	20	1.8	4 ton	A	6.7
18	12	170	1/4 ton	B	3.3	24	5.5	8 ton	A	8.3
21	14	430	1/2 ton	A	3.3	28	13.7	Special		
				B	4.2					
24	16	950	1 ton	A	4.2	32	30.4	Special		
				B	5.3					

NOTES:

1. **All Values in Figure 873.3A and Table 873.3B are in U.S. Customary Units. Conversions to the S.I. System are; 1 ft. = 0.305 m**

   1 lb. = 0.454 kg
   1 ton = 0.907 tonne

2. See Section 72 of the Standard Specifications for Gradations of the Protection Classes (W_C) indicated.

From the Caltrans *Highway Design Manual* (1995, with updates)