Clover Creek Bridge Replacement at First Street
Lake County, California
Federal-Aid Project No. BRLO-5914(079)
Proposed Bridge No. 14C0134; Existing Bridge No. 14C0015

Location Hydraulic Study Report

Prepared for:

Prepared by:

May 2018

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Submitted to:
County of Lake Public Works Department

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

5/22/2018
Date

May 2018

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Executive Summary

The County of Lake (County) is proposing to replace the First Street bridge (existing Bridge No. 14C0015 and proposed Bridge No. 14C0134) over Clover Creek. The Clover Creek Bridge Replacement Project at First Street (Project) is located near the community of Upper Lake approximately 8.3 miles north of the City of Lakeport, Lake County, California.

The existing First Street Bridge, constructed in 1930, is a 39-feet (ft)-long, 31.5-ft-wide two-lane bridge with a speed limit of 25 miles per hour. The California Department Transportation's (Caltrans) Structure Inventory and Appraisal Report classified the existing bridge as "functionally obsolete" because the existing concrete structure for the bridge is too narrow for the roadway's Functional Classification. The existing bridge has concrete bridge railing with no approach railings.

The primary objective of the Project is to replace a temporary functionally obsolete structure to improve public safety and to provide for a permanent structure that has long-term value for the County. The Project proposes to replace the existing bridge with a new triple 12 ft by 8 ft reinforced box culvert (the culvert meets the definition of a bridge). The existing bridge would be widened from 31.5 ft to 43.5 ft to accommodate two 10-ft-wide traffic lanes, two 5-ft-wide shoulders, two 5-ft-wide sidewalks, and two concrete barriers.

The purpose of this study is to examine and analyze the existing base (100-year) floodplain within the Project limits, to document any potential impacts to or encroachments upon the floodplain, and to recommend any avoidance, minimization, or mitigation measures that may be required.

The design flow of Clover Creek for the design of the proposed bridge was based on the rational method outlined in Caltrans' *Highway Design Manual*. The 100-year flow is 628 cubic feet per second (cfs).

The hydraulics of the existing and proposed conditions were analyzed using the Hydrologic Engineering Center's River Analysis System (HEC-RAS) Version 4.1.0, which is hydraulic modeling software developed by the United States Army Corps of Engineers (USACE). The existing and proposed water surface elevations (WSEs) in the Project vicinity with the design flow are summarized in the following table. In general, the WSEs would not be significantly different in the existing versus proposed conditions because the design flow through the Project site is limited by the conveyance capacity of the channel.

Hydraulic Summary, 100-year Storm Event

River Station	Description/Distance from Existing Bridge Centerline	Existing WSE (ft NAVD 88)	Proposed Culvert WSE (ft NAVD 88)	Elevation Change (ft)
3976.7	518 feet upstream	1,347.2	1,347.2	0.0
3484.9	26 feet upstream	1,346.3	1,346.3	0.0
3474.9	16 feet upstream	1,346.3	--	--
3461.7 BR U	Upstream face of First Street Bridge	1,346.0	1,346.1	0.1
3461.7 BR D	Downstream face of First Street Bridge	1,346.0	1,345.9	-0.1
3442.9	16 feet downstream	1,346.3	--	--
3432.9	26 feet downstream	1,346.2	1,346.3	<0.1
3155	304 feet downstream	1,345.8	1,345.8	0.0

Notes:

- NAVD 88 = North American Vertical Datum of 1988
- Elevations are rounded to the nearest 0.1 ft.
- RS 3474.9 and RS 3442.9 would be inside the footprint of the proposed bridge.

The risk associated with the Project was assessed by evaluating whether the Project would result in changes to land use, changes in impervious surface, and added fill within the 100-year floodplain. The qualitative impacts resulting from the Project were assessed by analyzing the hydraulics using HEC-RAS to compare the existing and proposed conditions.

Due to the nature of the work, the Project would not result in an overall change in land use within the watershed. The new bridge would result in added impervious areas. When compared to the total watershed of Clover Creek at the Project site, the added impervious areas would be insignificant. There will be fill inside the floodplain with the placement of the new culvert, and the associated rock slope protection at the culvert entrance and exit. The hydraulic models of the existing and proposed conditions indicate that the proposed condition would result in insignificant increases in the base flood elevation at the upstream face of the bridge. The risk associated with the Project is considered to be low.

Potential short-term adverse effects to the natural and beneficial floodplain values include temporary loss of vegetation from construction, potential effects to habitats within the Project area during construction and/or maintenance activities, and potential impacts to water quality. Temporary environmental impacts resulting from construction activities for the proposed Project can be minimized with standard measures such as revegetation, best management practices (BMPs), seasonal work restrictions, implementation of erosion control measures, and other activities that meet the requirements of the Project permit conditions.

The County will coordinate with local, state, and federal water resources and floodplain management agencies as necessary during all aspects of the proposed Project. The

following regulatory permits and approvals would be required when the Project enters into the final design and construction phases: a 1602 Streambed Alteration Agreement from the California Department of Fish and Wildlife (CDFW), a Section 404 Nationwide Permit from the USACE, Central Valley Flood Protection Board Encroachment Permit, and a 401 Water Quality Certification from the Regional Water Quality Control Board (RWQCB).

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ADT	average daily traffic
BFE	base flood elevation
BIR	Bridge Inspection Report
BMP	Best Management Practice
Caltrans	California Department of Transportation
CFR	Code of Federal Regulations
cfs	cubic feet per second
CVFPB	Central Valley Flood Protection Board
DWR	Department of Water Resources
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
ft	foot, feet
HDM	Highway Design Manual
HEC-RAS	Hydrologic Engineering Center's River Analysis System
LRFD	Load and Resistance Factor Design
mi	mile
NAVD 88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NGVD 29	National Geodetic Vertical Datum of 1929
Project	Clover Creek Bridge Replacement Project at First Street
RS	river station
RWQCB	Regional Water Quality Control Board
SR	State Route
USACE	United States Army Corps of Engineers
WSE	water surface elevation

LOCATION HYDRAULIC STUDY FORM

Dist. 1 Co. Lake Rte. First Street Project ID
Federal-Aid Project Number: BRLO-5914(079)

Floodplain Description:
The Project site is located in unshaded Zone X, which represents an area of minimal flood hazard, which is outside of the Special Flood Hazard Areas and higher than the elevation of the 0.2-percent-annual-chance flood. In the area just downstream (south) of the Project site and south of State Highway 20, the floodplain associated with Clover Creek is in Zone AE where base flood elevations have been determined.

1. Description of Proposal *(include any physical barriers i.e. concrete barriers, sound walls, etc. and design elements to minimize floodplain impacts)*
The existing bridge will be replaced with a wider bridge approximately along the same alignment.

2. ADT: Current 400 (2016) Projected 600 (2036)

3. Hydraulic Data: Base Flood Q100= 628 CFS
WSE100= existing: 1,346.0 ft, proposed: 1,346.1 ft *The flood of record, if greater than Q100:*
Q= N/A CFS WSE= N/A
Overtopping flood Q= N/A CFS WSE= N/A

Are NFIP maps and studies available? NO ____ YES ✓

4. Is the highway location alternative within a regulatory floodway?
NO ✓ YES ____

5. Attach map with flood limits outlined showing all buildings or other improvements within the base floodplain. See Figure 7 for the floodplain map.

Potential Q100 backwater damages:

A.	Residences?	NO ✓	YES ____
B.	Other Bldgs?	NO ✓	YES ____
C.	Crops?	NO ✓	YES ____
D.	Natural and beneficial Floodplain values?	NO ✓	YES ____

"Natural and beneficial flood-plain values" shall include but are not limited to fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and groundwater recharge.

6. Type of Traffic:

A. Emergency supply or evacuation route?	NO ____	YES ✓
B. Emergency vehicle access?	NO ____	YES ✓
C. Practicable detour available?	NO ____	YES ✓
D. School bus or mail route?	NO ____	YES ✓

7. Estimated duration of traffic interruption for 100-year event hours: N/A

8. Estimated value of Q100 flood damages (if any) – moderate risk level.

A.	Roadway	$ N/A
B	Property	$ N/A
	Total	$ N/A

9. Assessment of Level of Risk
Low ✓
Moderate ____
High ____

For High Risk projects, during design phase, additional Design Study Risk Analysis may be necessary to determine design alternative.

LOCATION HYDRAULIC STUDY FORM cont.

Dist. 1 Co. Lake Rte. First Street P.M.
Federal-Aid Project Number: BRLO-5914(079)
Project ID Bridge No. 14C0015 (existing), 14C0134 (proposed)

PREPARED BY:

Signature:
I certify that I have conducted a Location Hydraulic Study consistent with 23 CFR 650 and that the information summarized in items numbers 3, 4, 5, 7, and 9 of this form is accurate.

Date

District Hydraulic Engineer *(capital and 'on' system projects)*

Date 5/22/2018

Local Agency/Consulting Hydraulic Engineer *(local assistance projects)*

Is there any longitudinal encroachment, significant encroachment, or any support of incompatible Floodplain development? NO ✓ YES

If yes, provide evaluation and discussion of practicability of alternatives in accordance with 23 CFR 650.113

Information developed to comply with the Federal requirement for the Location Hydraulic Study shall be retained in the project files.

I certify that item numbers 1, 2, 6 and 8 of this Location Hydraulic Study Form are accurate and will ensure that Final PS&E reflects the information and recommendations of said report:

Date

District Project Engineer *(capital and 'on' system projects)*

Date 5/24/18

Local Agency Project Engineer *(local assistance projects)*

CONCURRED BY:
I have reviewed the quality and adequacy of the floodplain submittal consistent with the attached checklist, and concur that the submittal is adequate to meet the mandates of 23 CFR 650.

Date

District Project Manager *(capital and 'on' system projects)*

Date 5/24/18

Local Agency Project Manager *(Local Assistance projects)*

Date 6/18/18

District Local Assistance Engineer *(or District Hydraulic Branch for very complex projects or when required expertise is unavailable. Note: District Hydraulic Branch review of local assistance projects shall be based on reasonableness and concurrence with the information provided).*

I concur that the natural and beneficial floodplain values are consistent with the results of other studies prepared pursuant to 23 CFR 771, and that the NEPA document or determination includes environmental mitigation consistent with the Floodplain analysis.

Date 06/18/18

District Senior Environmental Planner *(or Designee)*

Note: If a significant floodplain encroachment is identified as a result of floodplains studies, FHWA will need to approve the encroachment and concur in the Only Practicable Alternative Finding.

SUMMARY FLOODPLAIN ENCROACHMENT REPORT

Dist. 1 Co. Lake Rte. First Street K.P.
Federal-Aid Project Number *(Local Assistance)* BRLO-5914(079)
Project No.: Bridge No. 14C0015 (existing), 14C0134 (proposed)
Limits: The existing roadway alignment will be maintained. The replacement structure will be wider than the existing bridge. The limit of the proposed work will be at the approach roadways to accommodate the bridge widening.
Floodplain Description: The Project site is located in unshaded Zone X, which represents an area of minimal flood hazard, which is outside of the Special Flood Hazard Areas and higher than the elevation of the 0.2-percent-annual-chance flood. In the area just downstream (south) of the Project site and south of State Highway 20, the floodplain associated with Clover Creek is in a Zone AE where BFEs have been determined.

		No	Yes
1.	Is the proposed action a longitudinal encroachment of the base floodplain?	✓	
2.	Are the risks associated with the implementation of the proposed action significant?	✓	
3.	Will the proposed action support probable incompatible floodplain development?	✓	
4.	Are there any significant impacts on natural and beneficial floodplain values?	✓	
5.	Routine construction procedures are required to minimize impacts on the floodplain. Are there any special mitigation measures necessary to minimize impacts or restore and preserve natural and beneficial floodplain values? If yes, explain.	✓	
6.	Does the proposed action constitute a significant floodplain encroachment as defined in 23 CFR, Section 650.105(q).	✓	
7.	Are Location Hydraulic Studies that document the above answers on file? If not explain.		✓

PREPARED BY:

_____ *Date* _____
District Project Engineer *(capital and 'on' system projects)*

_____ *Date* 5/22/2018
Local Agency/Consulting Hydraulic Engineer *(local assistance projects)*

CONCURRED BY:

_____ *Date* _____
District Project Manager *(capital and 'on' system projects)*

_____ *Date* 6/18/18
District Local Assistance Engineer *(Local Assistance projects)*

I concur that impacts to natural and beneficial floodplain values are consistent with the results of other studies prepared pursuant to 23 CFR 771, and that the NEPA document or determination includes environmental mitigation consistent with the Floodplain analysis.

_____ *Date* 06/18/18
District Senior Environmental Planner *(or Designee)*

Note: If a significant floodplain encroachment is identified as a result of floodplains studies, FHWA will need to approve the encroachment and concur in the Only Practicable Alternative Finding.

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1 GENERAL DESCRIPTION

The County of Lake (County) is proposing to replace the First Street bridge over Clover Creek. The Clover Creek Bridge Replacement Project at First Street (Project) is located near the community of Upper Lake approximately 8.3 miles (mi) north of the City of Lakeport, Lake County, California. See Figure 1 for the Project Location Map, Figure 2 for the Project Vicinity Map, and Figure 3 for the Project Aerial Map. The Project site is located at latitude 39°09'51.62" North and longitude 122°54'32.89" West.

1.1 Project Description

The Project consists of the replacement of an existing single span reinforced concrete haunched T-girder (existing Bridge No. 14C0015 and proposed Bridge No. 14C0134) over Clover Creek. The existing bridge is located on First Street approximately 0.10 mi east of Main Street and approximately 0.16 mi north of State Route (SR) 20, near the community of Upper Lake.

The existing concrete structure is too narrow for the roadway's Functional Classification and is considered "functionally obsolete." The existing bridge has concrete bridge railing with no approach railings. The Project need is to provide a safe permanent crossing over Clover Creek on First Street since the existing structure is considered functionally obsolete.

The primary objective is to replace a temporary functionally obsolete structure to improve public safety and to provide for a permanent structure that has long term value for the County. The entire existing roadway is within County right-of-way, which has a minimum width of 50 feet (ft). It is anticipated that any additional need for right-of-way acquisition, rights-of-entry, or temporary construction easements will be minimized by maintaining the existing roadway alignment.

It is assumed that the roadway for one block will be closed during construction and traffic will be redirected onto other local streets. It is anticipated that excavators, dozers, cranes, dump trucks, concrete trucks, concrete pumps, and pile driving or drilling equipment may be required to construct the new bridge. Construction is anticipated to be completed within one construction season.

The existing bridge crosses Clover Creek upstream of its confluence with Middle Creek and the flow is primarily controlled by the upstream Clover Creek Diversion structure and seasonal runoff. The flows were reduced by the diversion structure from 8,500 cubic feet per second (cfs) to 500 cfs. The channel appears to have a good alignment with the current bridge configuration.

1.2 Study Purpose

The purpose of this study is to examine and analyze the existing base (100-year) floodplain within the Project limits, to document any potential impacts to or encroachments upon the floodplain, and to recommend any avoidance, minimization, or mitigation measures that may be required.

Figure 1. Project Location Map

Source: Environmental Systems Research Institute (ESRI)

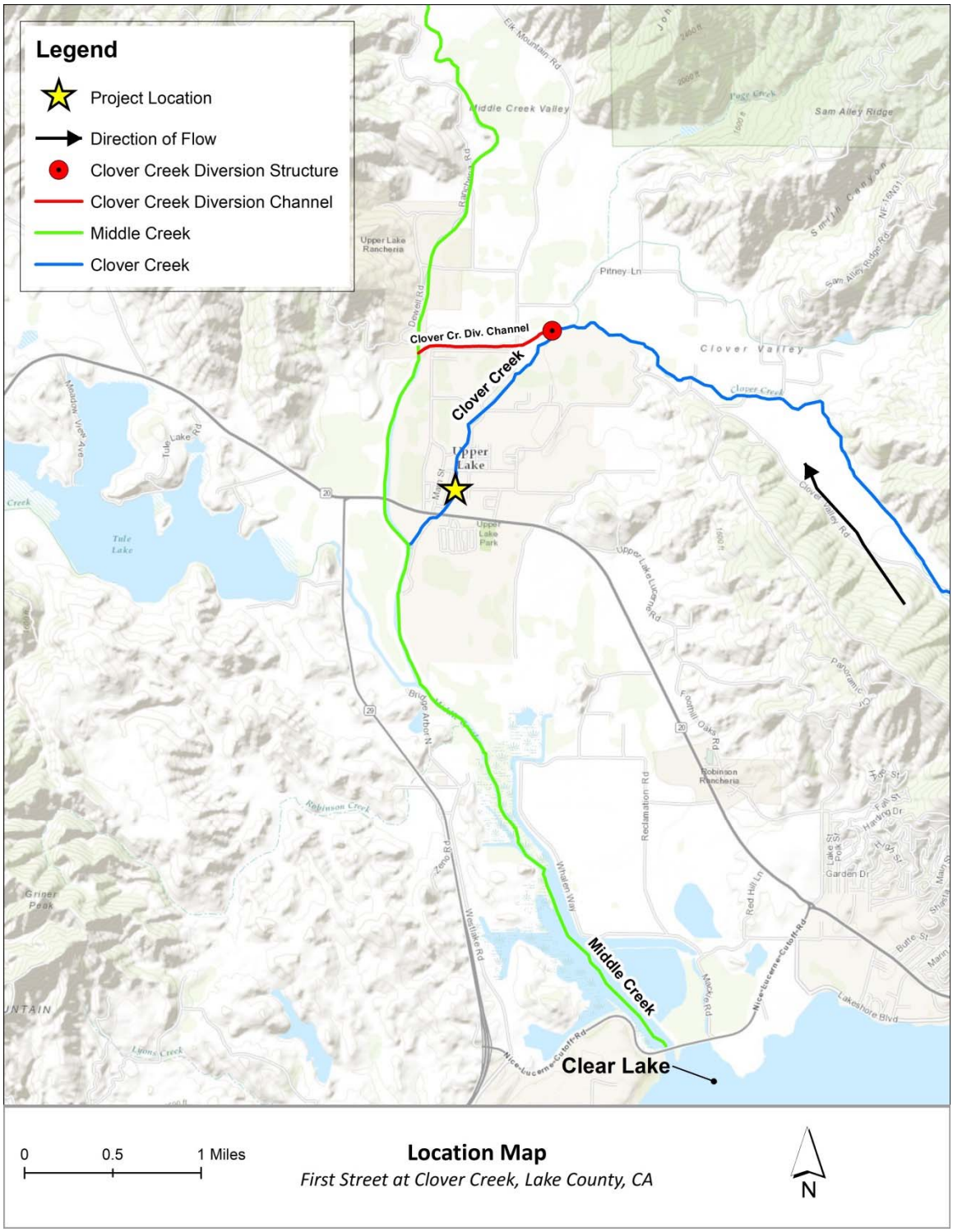

Figure 2. Project Vicinity Map

Source: ESRI

Figure 3. Project Aerial Map

Source: ESRI

1.3 Existing Bridge

The existing First Street Bridge, constructed in 1930, is a 39-ft-long, 31.5-ft-wide, two-lane bridge with speed limit of 25 miles per hour. A warning sign indicating that existing bridge is "Narrow Bridge" is present at both approaches to the existing bridge (see Photo 1). According to the California Department Transportation's (Caltrans) Structure Inventory and Appraisal Report included in the Bridge Inspection Report (BIR) of the existing First Street Bridge dated February 23, 2016, the item 68 "Deck Geometry" of existing First Street Bridge is appraised as Code 2, "Basically intolerable requiring high priority of replacement." Because of this rating, the existing First Street Bridge is classified as functionally obsolete.

Photo 1. Existing Bridge Approach, Looking East

Source: Caltrans

1.4 Proposed Bridge

The Project proposes to replace the existing bridge with new triple 12 ft x 8 ft reinforced concrete box culvert (see Figure 4). The existing bridge would be widened to 43.5 ft to accommodate two 10-ft-wide traffic lanes, two 5-ft-wide shoulder, two 5-ft-wide sidewalks, and two concrete barriers.

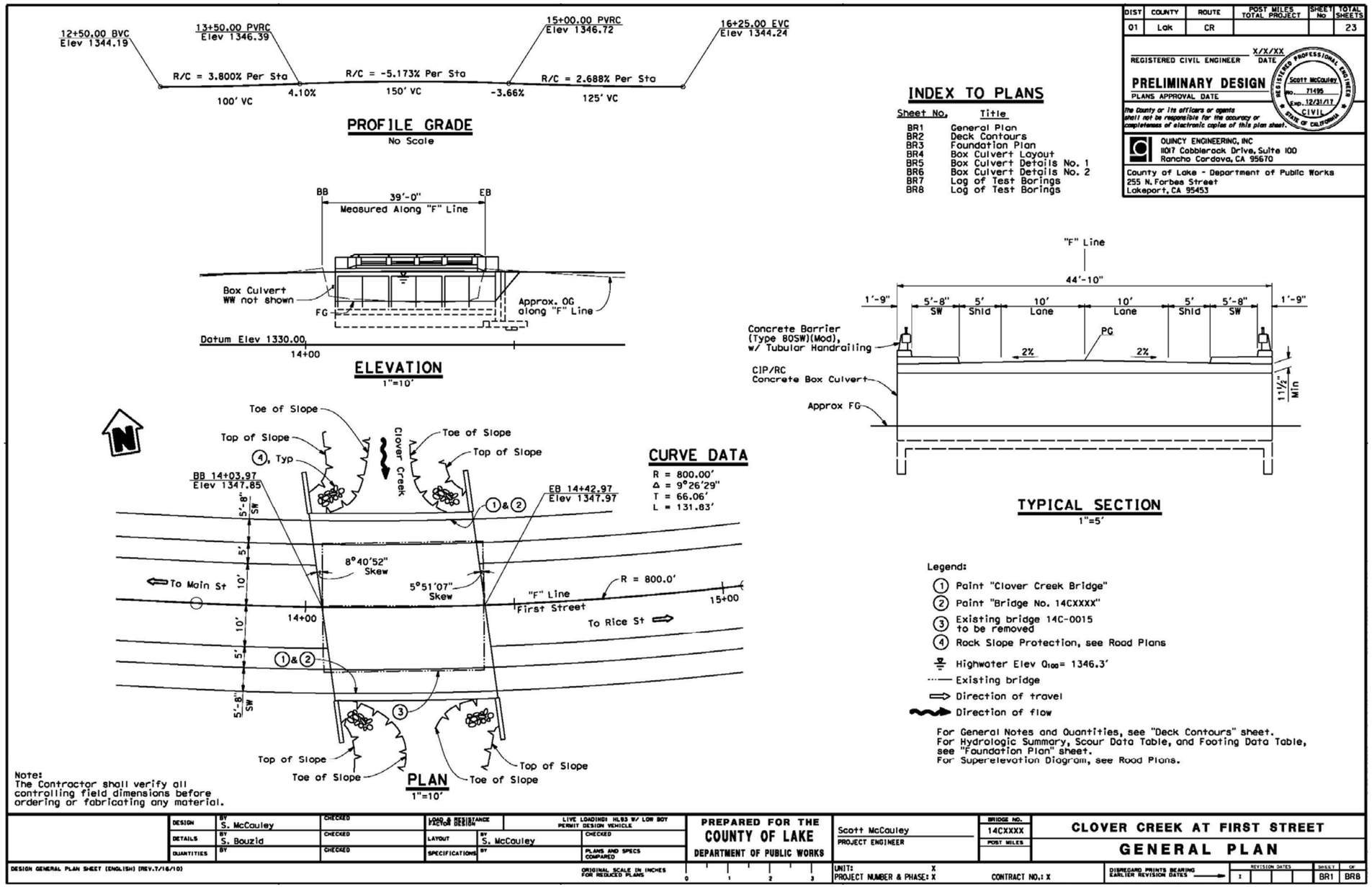

Figure 4. Proposed General Plan: RCB Culvert

Source: Quincy Engineering, Inc.

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1.5 Regulatory Setting

1.5.1 Executive Order 11988 (Floodplain Management, 1977)

Executive Order 11988 (Floodplain Management) directs all federal agencies to avoid, to the extent possible, long- and short-term adverse impacts associated with the occupancy and modification of floodplains, and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. Requirements for compliance are outlined in Title 23, Code of Federal Regulations, Part 650, Subpart A (23 CFR 650A) titled "Location and Hydraulic Design of Encroachment on Floodplains" (2015).

If the preferred alternative involves significant encroachment onto the floodplain, the final environmental document (final Environmental Impact Statement or finding of no significant impact) must include:

- The reasons why the proposed action must be located in the floodplain;
- The alternatives considered and why they were not practicable; and
- A statement indicating whether the action conforms to applicable state or local floodplain protection standards.

1.5.2 California's National Flood Insurance Program

The Federal Emergency Management Agency (FEMA) is the nationwide administrator of the National Flood Insurance Program (NFIP), which is a program that was established by the National Flood Insurance Act of 1968 to protect lives and property, and to reduce the financial burden of providing disaster assistance. Under the NFIP, FEMA has the lead responsibility for flood hazard assessment and mitigation, and it offers federally backed flood insurance to homeowners, renters, and business owners in communities that choose to participate in the program. FEMA has adopted the 100-year floodplain as the base flood standard for the NFIP. FEMA is also concerned with construction that would be within a 500-year floodplain for proposed projects that are considered "critical actions," which are defined as any activities where even a slight chance of flooding is too great. FEMA issues the Flood Insurance Rate Maps (FIRMs) for communities that participate in the NFIP. These FIRMs present delineations of flood hazard zones.

In California, nearly all of the State's flood-prone communities participate in the NFIP, which is locally administered by the California Department of Water Resources' (DWR) Division of Flood Management. Under California's NFIP, communities have a mutual agreement with the State and federal governments to regulate floodplain development according to certain criteria and standards, which are further detailed in the NFIP.

1.5.3 Lake County Floodplain Data

As part of the NFIP, typically, each county (or community) has a Flood Insurance Study (FIS), which is used to locally develop FIRMs and Base Flood Elevations (BFEs). The FIS for Lake County, California and Incorporated Areas (FIS Number 06033CV000A) presents hydrologic data for Clover Creek for areas within Lake County (FEMA 2005).

The FIS includes a frequency discharge drainage area curve for Clover Creek. Flood profiles for Clover Creek are also included in the FIS. The bridge at the Project site is outside of the limits of the detailed study of Clover Creek.

1.6 Design Standards

1.6.1 FEMA Standards

FEMA standards are employed for design, construction, and regulation to reduce flood loss and to protect resources. Two types of standards are often employed: design criteria and performance standards.

A design criteria or specified standard dictates that a provision, practice, requirement, or limit be met; e.g., using the 1% flood and establishing floodway boundaries so as not to cause more than a 1-ft increase in flood stages.

A performance standard dictates that a goal is to be achieved, leaving it to the individual application as to how to achieve the goal; e.g., providing protection to the regulatory flood, keeping post-development stormwater runoff the same as pre-development, or maintaining the present quantity and quality of water in a wetland.

The 1% annual chance flood and floodplain have been adopted as a common design and regulatory standard in the United States. The NFIP adopted it in the early 1970s, and it was adopted as a standard for use by all federal agencies with the issuance of Executive Order 11988. States or local agencies are free to impose a more stringent standard within their jurisdiction.

1.6.2 Hydraulic Design Criteria

1.6.2.1 Federal Highway Administration (FHWA) Standards

The FHWA criterion refers to the California Amendments to American Association of State Highway and Transportation Officials (AASHTO) *Load and Resistance Factor Design* (LRFD) *Bridge Design Specifications* (2014), which indicates that the proposed bridge profile should provide adequate freeboard to pass anticipated drift for the 50-year design flood, to pass the 100-year base flood without freeboard, or the flood of record without freeboard, whichever is greater.

1.6.2.2 Caltrans Standards

The Caltrans criteria for the hydraulic design of bridges is they be designed to pass the 2% probability of annual exceedance flow (50-year design discharge) with adequate freeboard to pass anticipated drift, and the 1% probability of annual exceedance flow (100-year design discharge, or base flood) without freeboard.

1.6.2.3 Central Valley Flood Protection Board Standards

Streams regulated by the Central Valley Flood Protection Board (CVFPB) must adhere to the design criteria from the California Code of Regulations, Title 23 Waters, Division 1, Central Valley Flood Protection Board. Clover Creek is included in the list of streams regulated by the CVFPB (see Appendix A).

1.6.2.4 Lake County Design Standards

According to *Lake County Hydrology Design Standards* (1999), the proposed bridge may not increase the base flood elevation by more than 1 ft (see Appendix B). In addition, the design of the proposed bridge needs to conform to Chapter 820 of the Caltrans *Highway Design Manual* (HDM).

1.7 Traffic

According to the 2016 Caltrans BIR, the bridge is functionally classified as a local urban road. The average daily traffic (ADT) was 400 vehicles per day in 2016 and the future ADT projected for the year 2036 is 600 vehicles per day (Lake County 2016). The existing bridge is used as an emergency supply or evacuation route. It is used as an emergency vehicle access route. A practicable detour is available. It is used as a school bus or mail route. It is expected that the proposed replacement bridge will maintain these traffic uses.

1.8 Vertical Datum

The Project references the North American Vertical Datum of 1988 (NAVD 88). A conversion factor of 2.84 ft from the Preliminary FIS for Lake County, California and Incorporated Areas was used to convert the elevations referencing the National Geodetic Vertical Datum of 1929 (NGVD 29) to NAVD 88 (FEMA 2014).

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2 AFFECTED ENVIRONMENT

2.1 Watershed Description

Clover Creek is a tributary to Middle Creek, which is a sub-watershed of the Clear Lake Basin and flows into the north end of Clear Lake. The Middle Creek Watershed lies almost entirely within the boundaries of Lake County, with only a small portion located within Mendocino County. Clover Creek drains the southern portion of the Middle Creek watershed.

The Federal Middle Creek Flood Control Project in 1958-1961 rerouted the majority of the flows of Clover Creek around Upper Lake through the leveed Clover Creek Diversion Channel, while maintaining a short section of the historic Clover Creek channel through the community of Upper Lake. Only a minimal amount of the Clover Creek flow is permitted to flow through the historic Clover Creek channel. The First Street bridge is located within this section of the historic Clover Creek channel. The watershed area of Clover Creek downstream of the diversion channel is approximately 227 acres, which contributes to the peak flow that reaches the Project site (see Figure 5). The point of confluence between the historic Clover Creek and Middle Creek is located approximately 2,400 ft downstream of the Project site.

2.2 Receiving Waterbody

Approximately 4.0 mi downstream of the Project location, Middle Creek outfalls into Clear Lake. The outfall from Clear Lake flows into Cache Creek, which flows east in Lake and Yolo counties. Cache Creek outfalls into Yolo Bypass, the bypass channel of the Sacramento River, approximately 76 mi southeast of the Project location.

2.3 Land Use

The existing land uses within the watershed of Clover Creek identified in the *Lake County General Plan* (2008) are Agricultural, Low and Medium Density Residential, Rural Residential, Suburban Residential Reserve, Commercial, and Public Facilities (see Figure 6 and Appendix C). The detailed definition of the land use designations is included in the *Lake County General Plan* (2008).

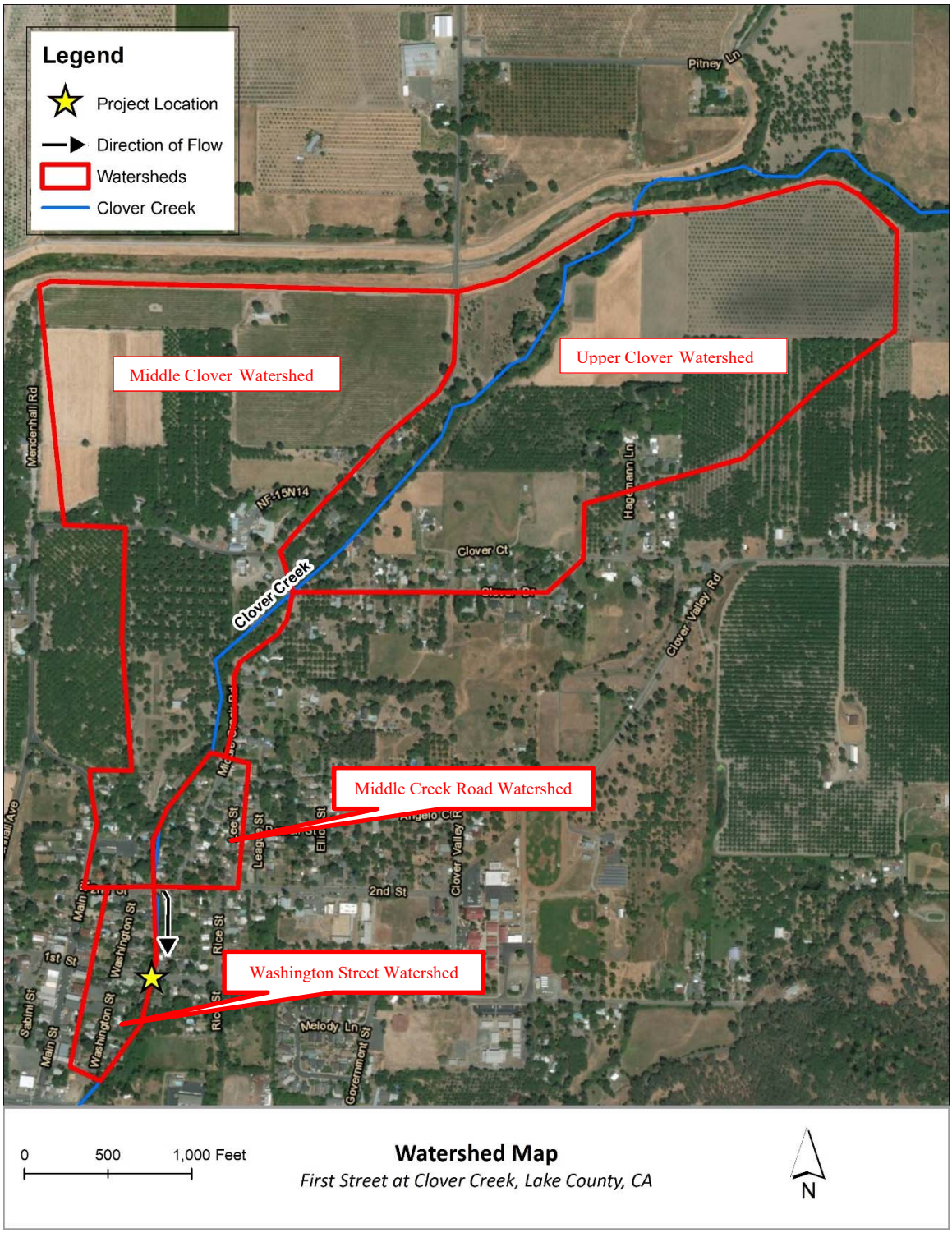

Figure 5. Project Watershed Map

Source: ESRI

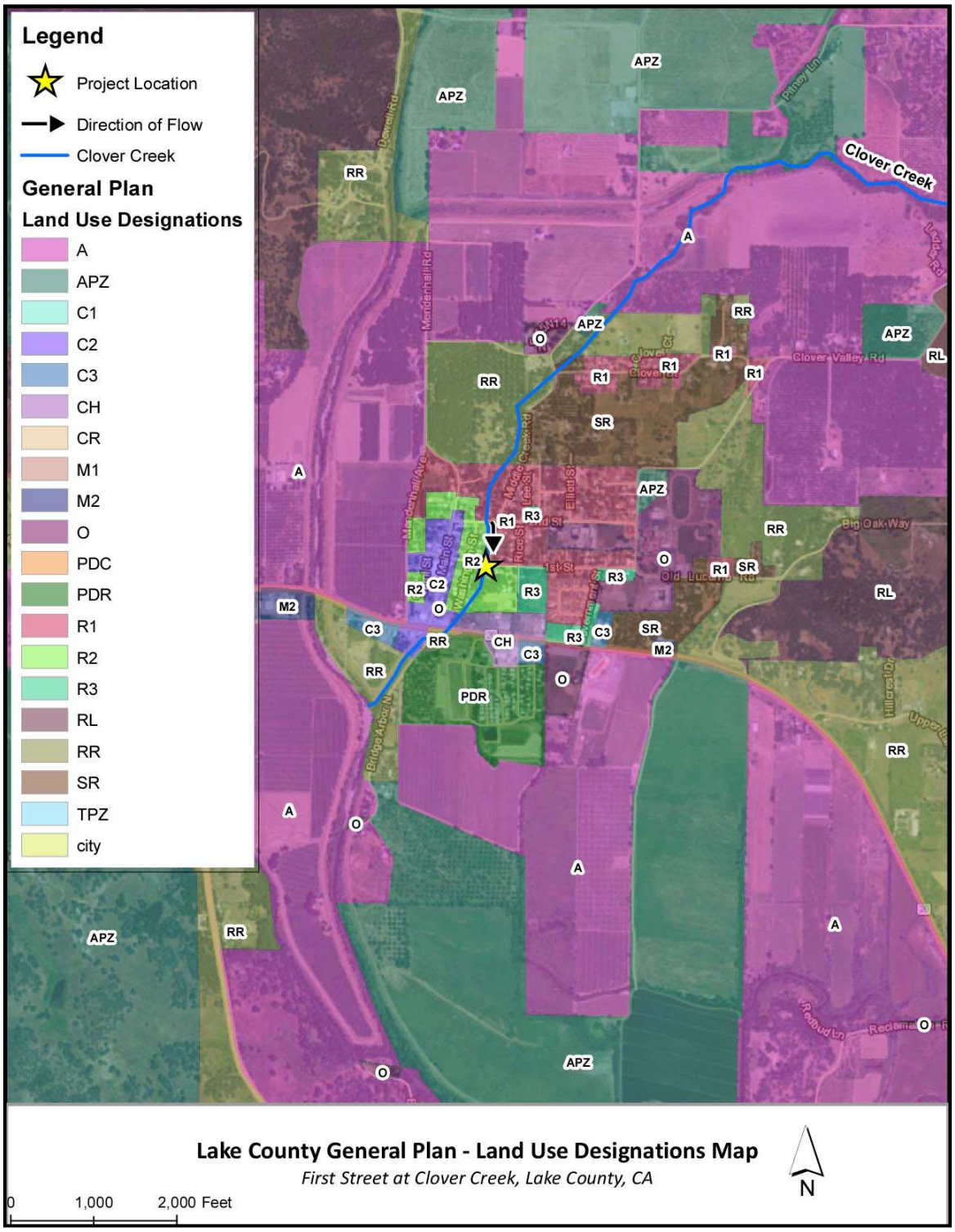

Figure 6. Land Use Map for Project Vicinity

Source: ESRI and Lake County

2.4 FEMA Floodplains

FIRM 06033C0341D presents flood hazard data for Lake County, California, and Incorporated Areas (FEMA 2005) at the Project vicinity. The FIRM at the Project site is shown in Figure 7. The Project site is located in unshaded Zone X, which represents an area of minimal flood hazard, which is outside of the Special Flood Hazard Areas and higher than the elevation of the 0.2-percent-annual-chance flood. In the area just downstream (south) of the Project site and south of State Highway 20, the floodplain associated with Clover Creek is in a Zone AE Special Flood Hazard Area where base flood elevations have been determined. The water surface elevation just downstream of State Highway 20 is 1,342 feet NGVD 29.

Figure 7. FIRMette of Project Vicinity

Source: FEMA

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3 HYDROLOGY AND HYDRAULICS

3.1 Hydrologic Assessment

The downstream limit of the study reach is at Middle Creek downstream of its confluence with Clover Creek. Flows for both Clover Creek and Middle Creek were obtained or calculated using the following sources and methods.

3.1.1 Hydrologic Design Sources and Methods

The peak flows at the Project location were computed using the rational method following the procedures from the Caltrans HDM and the United States Geological Survey's (USGS) gaging station analysis. The FEMA FIS also included peak flood flows of Middle Creek in the Project vicinity. The following sections describe the flows based on the various methods and sources.

3.1.2 Rational Method – Clover Creek

The peak flow at the Project site was based on the rational method and following the procedures specified in the Caltrans HDM. With rational method, the 100-year storm peak flow was calculated to be approximately 128 cfs. Because Clover Creek is controlled by the diversion structure upstream of the Project location, the 100-year flow at the Project site would be the sum of the peak flows from the rational method and the diverted flow in Clover Creek, which is approximately 628 cfs. See Appendix D for the detailed calculations.

3.1.3 USGS Gaging Station Analysis

The 100-year peak flow for Clover Creek at Project location was estimated using the stream flows from the USGS gaging stations 11384400 and 11461400 and applying a basin transfer. The information for the gaging stations is summarized in Table 1. The 100-year peak flow at the Project location was calculated based on the average values of the 100-year peak flows per drainage area at each gaging station. Based on the watershed area at the Project site (see Section 2.1), the 100-year based on the nearby gaging station was calculated to be approximately 182 cfs. With the 500 cfs diverted flow in Clover Creek, the 100-year peak flow at the Project location is approximately 682 cfs. Figure 8 shows the location of the gaging stations nearest to the Project site.

Table 1. Gaging Station Data

USGS Station Number	11384400	11461400
Station Name	SF STONY C NR STONYFORD CA	EF RUSSIAN R TRIB NR POTTER VAL CA
Latitude (NAD 83)	39.29599674	39.26099991
Longitude (NAD 83)	-122.7530474	-123.1163915
Drainage Area (sq. mi)	2.52	0.24
100-Year Peak Flow (cfs)	1050	136
Begin Date of Record	10/1/1969	10/1/1958
End Date of Record	9/30/1980	9/30/1973

3.1.4 FEMA – Middle Creek

The FEMA FIS for Lake County provided the frequency discharge, drainage area curve for Middle Creek at the confluence with Clover Creek (2014). The 100-year flow from the FEMA FIS was 19,000 cfs (see Appendix E).

3.1.5 Selected Design Discharges

Because the gaging stations are not located on Clover Creek and have a limited number of years of records, the flow based on the rational method was selected as the design flow for the hydraulic analysis. The 100-year flow of Clover Creek at the First Street bridge location is 628 cfs. This flow will be used in the upstream limit of the hydraulic model for Clover Creek. The channel does not have the capacity to convey the design flow, which overtops the channel banks upstream of the Project site.

The 100-year flow from FEMA FIS was selected as the design flow for Middle Creek. The FEMA flow was used to be consistent with the flood profiles of Middle Creek, which was used as the downstream control water surface elevation (WSE) for the hydraulic analysis.

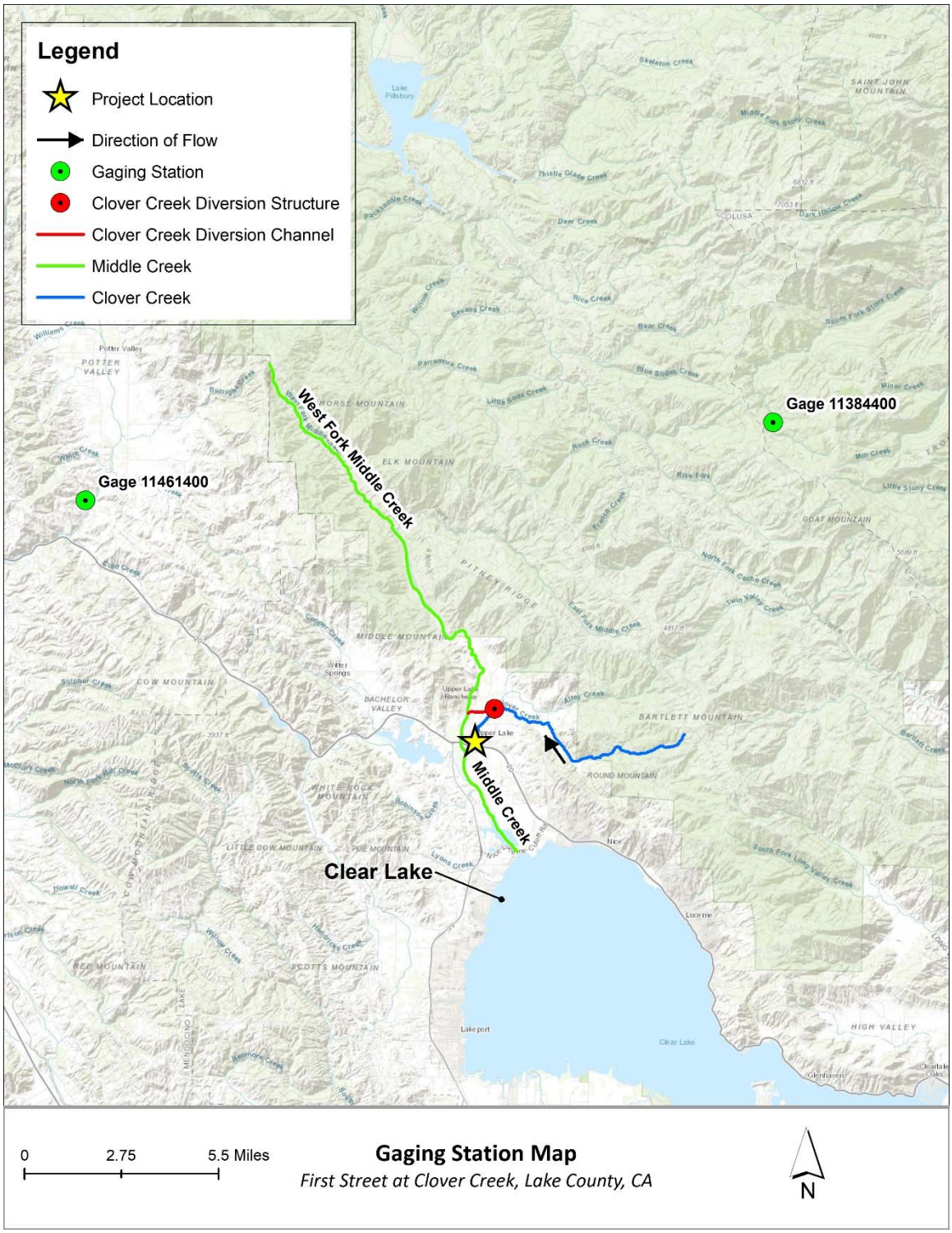

Figure 8. Gaging Station Map

Source: ESRI and USGS

3.2 Hydraulic Assessment

The following sections discuss the development of the hydraulic models and summarize the results for the existing and proposed conditions.

3.2.1 Design Tools

The hydraulic analyses were performed for the existing and proposed conditions using the United States Army Corps of Engineers' (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) modeling software, Version 4.1.0.

3.2.2 Cross Section Data

The channel cross sections of Clover Creek and Middle Creek were used to develop the hydraulic model using survey point elevations provided by Quincy Engineering on August 2017. The existing condition hydraulic model includes a total of 13 cross sections for Clover Creek and 5 cross sections for Middle Creek within a 3,972-ft-long reach. The cross section naming convention is by river stations (RS) starting with RS 3977.6 at the upstream limit of the model in Clover Creek and RS 5.2 at the downstream limit of the model in Middle Creek (see Figure 9).

3.2.3 Modeled Hydraulic Structures

3.2.3.1 Bridges and Culverts

The hydraulic models that represent the existing and proposed conditions include three bridges: First Street Bridge, State Route 20 Bridge, and Bridge Arbor North Bridge. The input parameters for the three existing bridges were based on the information available from the survey file, field visit, Caltrans BIR, and the preliminary HEC-RAS model from Lake County. The input parameters for the proposed culvert are based on the bridge general plan (see Figure 4).

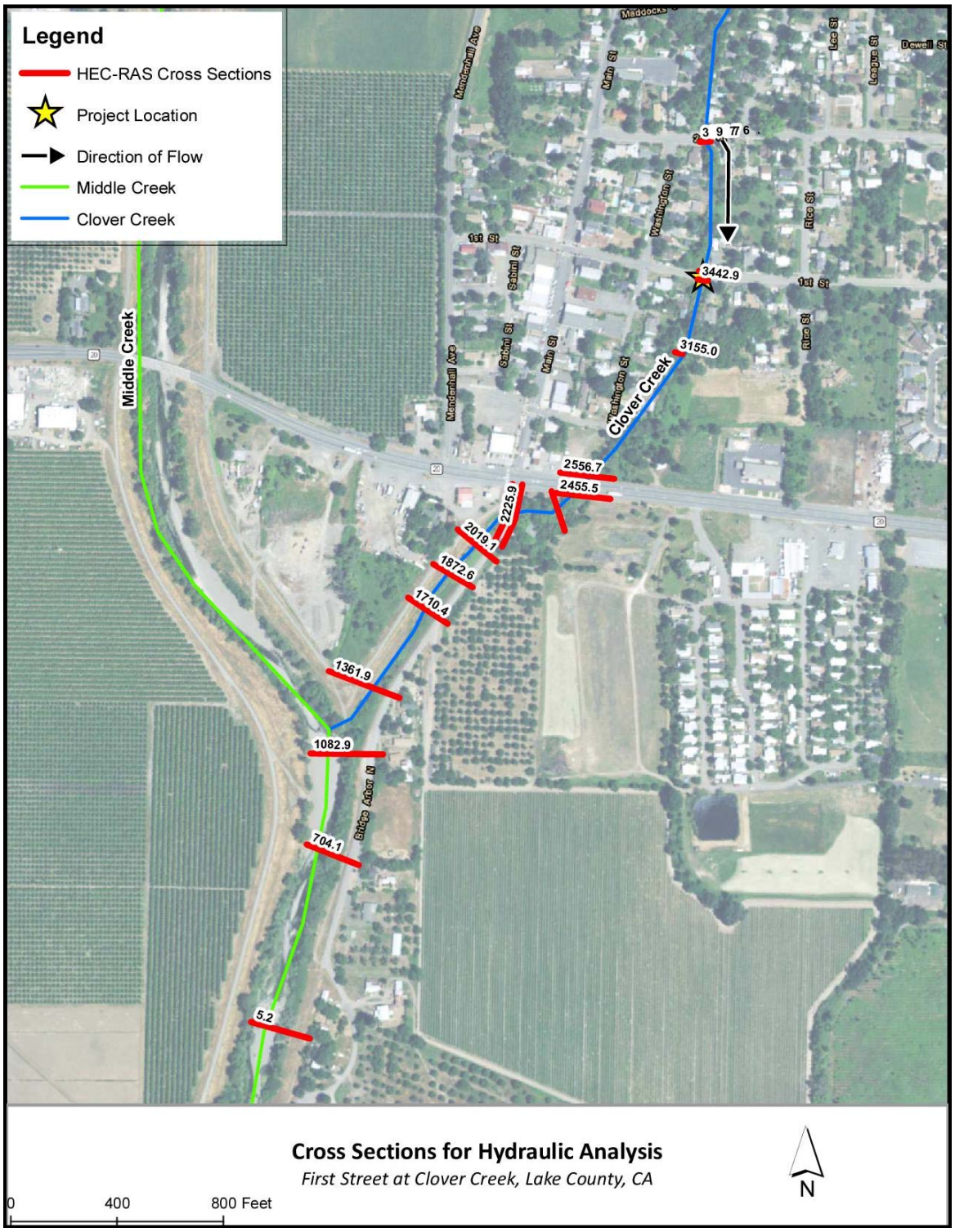

Figure 9. Cross Section Locations

Source: ESRI

3.2.3.2 Escape Flows

The HEC-RAS model of Clover Creek provided by Lake County showed that Clover Creek in the Project vicinity would not have the capacity to convey the 100-year flow, and the flood flows would potentially overtop the east and west banks of Clover Creek. The lateral structure function in HEC-RAS was used to represent the flood flows escaping from the main channel of Clover Creek, which cannot be conveyed within the main channel.

3.2.4 Model Boundary Condition

The confluence of the historic Clover Creek and Middle Creek is located approximately 2,400 ft downstream of the First Street bridge. The downstream limit of the hydraulic model is at Middle Creek, and is located approximately 3,450 ft downstream of the First Street bridge. The 100-year WSEs of Middle Creek from the FEMA FIS flood profile was utilized as the downstream control WSE for the hydraulic analysis. The elevation from the flood profile referenced the NGVD 29 vertical datum, and was converted to the NAVD 88 vertical datum (see Section 1.8 for the conversion factor).

3.3 Manning's Roughness Coefficients

Manning's roughness coefficients were used in the hydraulic model to estimate energy losses in the flow due to friction. A roughness coefficient in the main channel varied from 0.035 to 0.080 to describe the engineered, clean trapezoidal channel for Middle creek, engineered trapezoidal channel with modest vegetation growth for Clover Creek between Bridge Arbor North and the confluence with Middle Creek, and channel with dense vegetation for Clover Creek north of Bridge Arbor North. A roughness coefficient of 0.050 was used to describe the overbank areas.

3.4 Expansion and Contraction Coefficients

Expansion and contraction coefficients were used in the hydraulic model to represent energy losses in the channel. An expansion coefficient of 0.3 and a contraction coefficient of 0.1 were used to represent the channel. These values represent a channel with gradual transitions between cross sections. The expansion and contraction coefficients used in the vicinity of the bridge and culvert structures were 0.5 and 0.3, respectively. These values represent the flow interference caused by the bridges and culvert.

3.5 Water Surface Elevations

The water surface profiles along the studied stream reach are presented in Figure 10 for the 100-year storm. The upstream face cross section of the existing and proposed conditions are presented in Figure 11and Figure 12, respectively. The Clover Creek WSEs in the vicinity of the First Street bridge are presented in Table 2 for the 100-year storm. In general, the WSEs would not significantly differ in the existing versus proposed conditions because the design flow through the Project site is limited by the conveyance capacity of the channel.

Table 2. 100-Year WSEs

River Station	Description/Distance from Existing Bridge Centerline	Existing WSE (ft NAVD 88)	Proposed Culvert WSE (ft NAVD 88)	Elevation Change (ft)
3976.7	518 feet upstream	1,347.2	1,347.2	0.0
3484.9	26 feet upstream	1,346.3	1,346.3	0.0
3474.9	16 feet upstream	1,346.3	--	--
3461.7 BR U	Upstream face of First Street Bridge	1,346.0	1,346.1	0.1
3461.7 BR D	Downstream face of First Street Bridge	1,346.0	1,345.9	-0.1
3442.9	16 feet downstream	1,346.3	--	--
3432.9	26 feet downstream	1,346.2	1,346.3	<0.1
3155	304 feet downstream	1,345.8	1,345.8	0.0

Notes:

- Elevations are rounded to the nearest 0.1 ft.
- RS 3474.9 and RS 3442.9 would be inside the footprint of the proposed bridge.

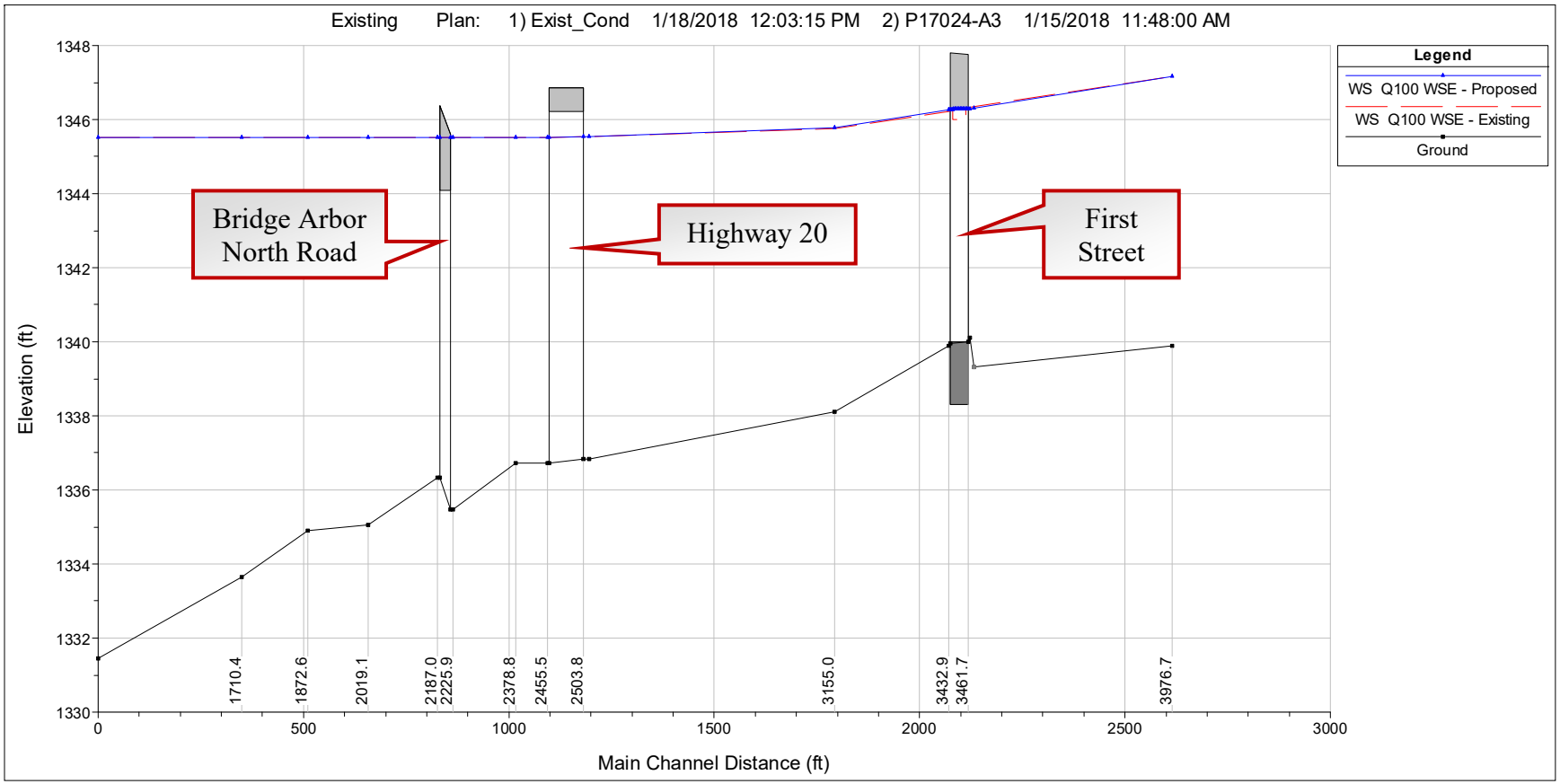

Figure 10. 100-Year Water Surface Profile

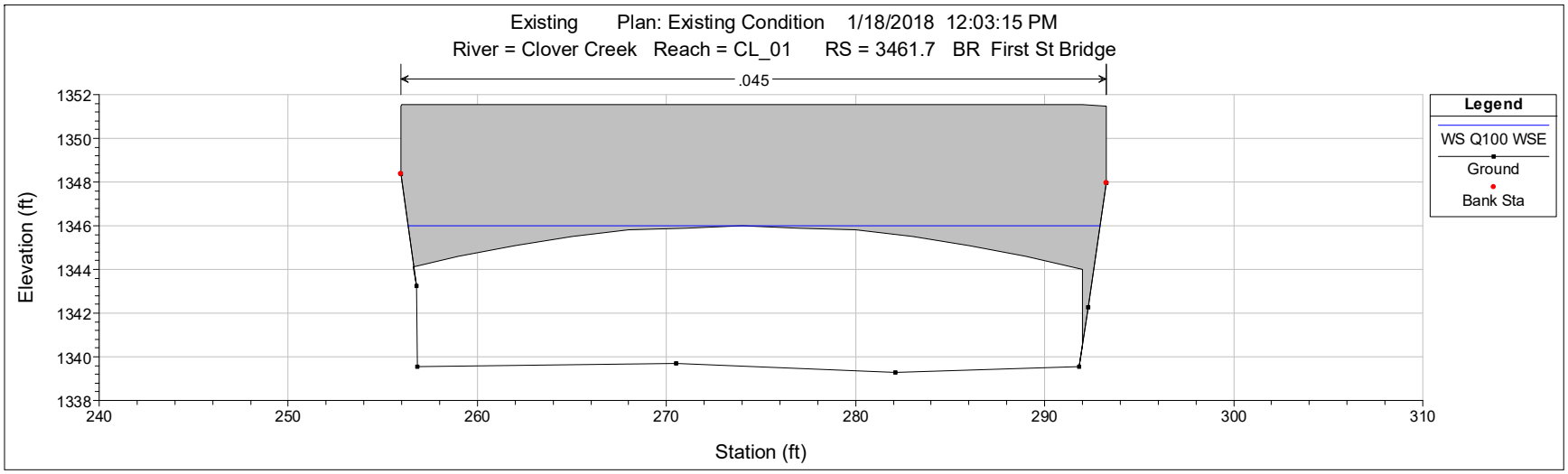

Figure 11. Upstream Face of Existing Bridge, Looking Downstream (South)

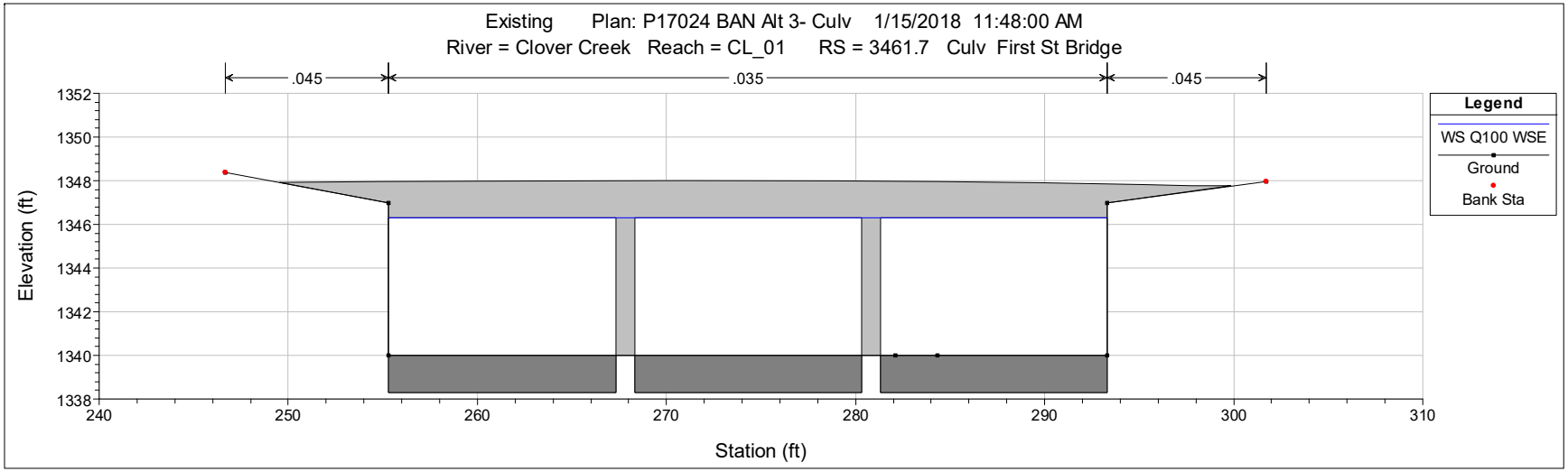

Figure 12. Upstream Face of Proposed Culvert, Looking Downstream (South)

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4 PROJECT EVALUATION

Executive Order 11988 requires federal agencies to avoid to the maximum extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. This section analyzes the impacts associated with this Project.

4.1 Risk Associated with the Proposed Action

As defined by the FHWA, risk shall mean the consequences associated with the probability of flooding attributable to an encroachment. It shall include the potential for property loss and hazard to life during the service life of the bridge and roadway.

The potential risk associated with the implementation of the proposed action includes, but is not limited to: 1) change in land use, 2) change in impervious surface area, 3) fill inside the floodplain, or 4) change in the 100-year water surface elevation. The measures to minimize the potential floodplain impacts associated with the action are summarized in Section 5.

4.1.1 Change in Land Use

The Project proposes to remove the existing bridge and replace it with a structure at roughly the same location that is wider than the existing bridge. With the exception of the bridge and associated approach roadway widening, changes in the land use in the Project vicinity are not anticipated to occur from the proposed Project. The County is not proposing to change the overall land uses within the watershed as a part of this Project.

4.1.2 Change in Impervious Surface Area

The widening of the bridge and roadway approach area will not significantly increase the impervious surface area within the Clover Creek watershed at the Project site. The added impervious area resulting from the proposed Project would be insignificant compared to the watershed of Clover Creek at the Project location.

4.1.3 Fill Inside the Floodplain

The Project proposes to construct a wider bridge consisting of three box culvert cells and therefore, the Project would introduce fill within the floodplain.

4.1.4 Change in the 100-Year Water Surface Elevation

The results of the steady-state hydraulic modeling indicated that the proposed alternative would result in insignificant changes in the 100-year WSEs with a localized increase of 0.1 ft (relative to the existing condition) at the bridge location. The proposed action would not significantly modify the characteristics of the existing 100-year floodplain.

4.2 Summary of Potential Encroachments

FHWA defines a significant encroachment as a highway encroachment, and any direct support of likely base floodplain development, that would involve one or more of the following construction or flood-related impacts: 1) significant potential for interruption or termination of a transportation facility that is needed for emergency vehicles or provides a community's only evacuation route, 2) a significant risk, or 3) a significant adverse impact on the natural and beneficial floodplain values (FHWA 1994). The following sections discuss the potential impacts to the floodplain that may result from the proposed action. The risk associated with implementation of the action is discussed in Section 4.1.

4.2.1 Potential Traffic Interruptions for the Base Flood

The existing bridge is under pressure flow during the 100-year storm, but not overtopped. Therefore, traffic interruptions are not anticipated for the existing bridge during the base flood. Based on the results of the hydraulic analysis, the new structure would pass the 100-year flow. Therefore, traffic interruptions for the base flood are not anticipated for the proposed action.

4.2.2 Potential Impacts on Natural and Beneficial Floodplain Values

Natural and beneficial floodplain values include, but are not limited to: fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and groundwater recharge.

According to the Natural Environmental Study for the Project (Northwest Biosurvey 2015), Clover Creek and its riparian corridor provides a migration and travel corridor for fish and wildlife. Clear Lake hitch is a California Threatened Species that is seasonally present at the Project site and western pond turtle also pass through the Project vicinity. The proposed Project is not likely to adversely affect federally listed species, and no wetlands will be impacted by this Project. Vegetation along the Clover Creek corridor within the Project vicinity includes Red Willow Thicket, Valley Oak Woodland, and Blackberry Bramble. Other plant and wildlife species and habitats of concern are listed in the Natural Environmental Study.

The proposed action would result in environmental impacts from the removal of the existing bridge structure and construction of the new bridge. Potential short-term adverse effects during the construction of the new bridge to the natural and beneficial floodplain values include: 1) the loss of vegetation during construction activity; and 2) temporary disturbance of wildlife and aquatic habitat. Permanent potential impacts include, modification of vegetation at the new bridge structure at the locations of the new approaches and culvert.

4.2.3 Support of Probable Incompatible Floodplain Development

As defined by the FHWA, the support of incompatible base floodplain development will encourage, allow, serve, or otherwise facilitate incompatible base floodplain development such as commercial development or urban growth.

The Project is proposing to replace the existing bridge with a wider new bridge at approximately the same location. The Project is not proposing to create a new access route to developed or undeveloped lands. The Project would not trigger incompatible floodplain development of Clover Creek within the existing floodplain.

4.2.4 Longitudinal Encroachments

As defined by the FHWA, a longitudinal encroachment is an action within the limits of the base floodplain that is longitudinal to the normal direction of the floodplain.

A longitudinal encroachment is "[a]n encroachment that is parallel to the direction of flow (i.e. A highway that runs along the edge of a river is usually considered a longitudinal encroachment). The requirement for consideration of avoidance alternatives must be included in a Location Hydraulic Study by including an evaluation and a discussion of the practicability of alternatives to any significant encroachment or any support of incompatible floodplain development.

The alignment of the proposed bridge is not parallel to the direction of flow in Clover Creek and therefore, the proposed action would not be a longitudinal encroachment to the existing floodplain.

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5 AVOIDANCE, MINIMIZATION, AND/OR MITIGATION MEASURES

5.1 Minimize Floodplain Impacts

The proposed Project will not change the overall land use within the Project watershed, will not significantly increase impervious areas, and will not result in significant fill in the floodplain. Based on the results of the hydraulic analysis, the proposed bridge will result in insignificant increases in WSEs relative to the existing condition for the 100-year storm. Therefore, the overall Project's possible impact to the floodplain will be minimal.

5.2 Restore and Preserve Natural and Beneficial Floodplain Values

Temporary environmental impacts could be minimized with measures such as BMPs, seasonal construction work restrictions, revegetation, establishing a boundary for work around sensitive habitat, implementing dust, erosion, and sedimentation control measures, and other activities that are part of the Project's permit conditions.

5.3 Alternatives to Significant Encroachments

According to the hydraulic analyses of the existing and proposed bridge conditions, the 100-year flow will not significantly change as a result of the proposed action. There are no significant encroachments at the Project location with the existing and proposed bridge condition alignment and profiles. Therefore, alternatives to significant encroachments were not analyzed.

5.4 Alternatives to Longitudinal Encroachments

The proposed Project would not be a longitudinal encroachment to the existing floodplain and therefore, alternatives to longitudinal encroachments were not analyzed.

5.5 Coordination with Local, State, and Federal Water Resources and Floodplain Management Agencies

The County will coordinate with local, state, and federal water resource and floodplain management agencies as necessary during all aspects of the proposed Project. Regulatory permits and approvals would be required as the Project enters the final design phase. A 1602 Lake and Streambed Alteration Agreement with the California Department of Fish and Wildlife, 404 Nationwide Permit with the USACE, CVFPB Encroachment Permit, and 401 Water Quality Certification with the RWQCB are expected to be required for the Project. The local floodplain administrator should review the Project impacts and determine if further action is needed.

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Appendix A CVFPB Regulated Streams

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Barclays Official

CALIFORNIA CODE OF REGULATIONS

Title 23. Waters

Division 1. Central Valley Flood Protection Board

Vol. 32

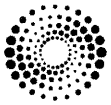

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Table 8.1—Regulated Streams and Nonpermissible Work Periods

[1] Flood season November 1 through July 15
[2] Flood season November 1 through April 15

Stream Title	*County–Limits*	*Flood Season*
Alta Main Canal	Fresno	1
American River	Sacramento — to Nimbus Dam	2
Antelope Creek	Placer — to settlement ponds	2
Antelope Creek	Tehama	2
Angel Slough	Butte	2
Arcade Creek	Sacramento — to Roseville Road	2
Ash Creek	Modoc	2
Ash Slough	Madera	2
Atherton Cove	San Joaquin — northeast bank only	2
Auburn Ravine	Sutter and Placer	2
Banta Carbona Intake Canal	San Joaquin	2
Beacon Creek	Sacramento — Morrison Creek to Franklin Boulevard	2
Battle Creek	Tehama	2
Bear Creek	Merced	2
Bear Creek	San Joaquin, up to Jack Tone Road	2
Bear Creek	Shasta, reach within designated floodway of the Sacramento River	2
Bear River	Sutter, Placer & Yuba	2
Berenda Slough	Madera — Avenue 21–1/2 to Ash Slough	2
Best Slough	Yuba	2
Big Chico Creek	Butte	2
Black Rascal Creek	Merced	2
Butte Basin	Butte, Glenn, and Colusa	2
Butte Creek	Butte and Glenn — to Skyway Bridge	2
Butte Creek Diversion Canal	Sutter	2
Butte Slough	Sutter	2
Byrd Slough	Fresno	1
Cache Creek	Yolo, Yolo Bypass to 1/2 mile west of I–5	2
Cache Slough	Solano	2
Calaveras River	San Joaquin — to New Hogan Dam	2
Cameron Slough	Fresno, within the Kings River designated floodway	1
Canal Creek	Merced	2
Cherokee Creek	Butte	2
Chowchilla Canal Bypass	Merced, Madera, and Mariposa	1
Chowchilla River	Merced, Madera and Mariposa, to Buchanan Dam	2
Churn Creek	Shasta — within Sacramento River floodway	2
Cirby Creek	Placer	2
Clarks Fork	Kings	1
Clear Creek	Shasta — Sacramento River to Whiskeytown Dam	2
Clover Creek	Shasta — to 1.1 miles upstream from Millville Plains Road	2
Clover Creek	Lake	2
Cole Slough	Fresno	1
Colusa Bypass	Colusa	2
Colusa Basin Drain and Canal	Glenn, Colusa, and Yolo	2
Colusa Trough	Colusa	2
Coon Creek	Placer and Sutter	2
Consumnes River	Sacramento	2
Cottonwood Creek	Shasta and Tehama — divides counties — to Dutch Gulch Dam	2
Cottonwood Creek South Fork	Tehama	2

[The next page is 4.9.]

Appendix B Lake County Hydrology Design Standards

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LAKE COUNTY

HYDROLOGY DESIGN STANDARDS

Lake County Department of Public Works
Water Resources Division
255 N. Forbes Street
Lakeport, CA 95453
(707)263-2341

Adopted June 22, 1999

These Standards provide design criteria and the methodology used to estimate peak flows for drainages within Lake County.

These Standards are based on information provided by the National Weather Service, the USDA Natural Resources Conservation Service, the California Department of Water Resources, and the California Department of Transportation.

It is the intent that these Standards be utilized for estimating flows in minor waterways (drainage areas less than one square mile) with time of concentrations of less than two hours. For larger drainage areas, we recommend the use of more detailed calculations and/or models, such as TR20, TR-55, HEC-1 and HEC-HMS.

WATERWAY DESIGN CRITERIA

A "waterway" is defined as being a natural or artificial channel or depression in the surface of the earth or an underground conduit system that conveys storm water runoff.

For the purposes of design criteria contained herein, waterways are divided into three classifications:

1. Major Waterways: having a tributary drainage area of four square miles or more; shall require a design frequency of re-occurrence of one in 100 years. This frequency would only apply to design in urban and suburban areas and not, for instance, agricultural channel design.
2. Secondary Waterways: having a tributary drainage area of between one and four square miles; shall require a design frequency of re-occurrence of once in 25 years.
3. Minor Waterways: having a tributary drainage area less than one square mile; shall require a design frequency of re-occurrence of once in 10 years.

Commercial sites, industrial sites, residential subdivisions, and manufactured home parks or subdivisions shall be designed to carry the 10-year storm in the storm drain system, and the 100-year storm within the confines of the streets. Secondary and major waterways passing through the site shall be designed to their respective design flows. All new building pads should be designed such that they are not inundated by a 100-year flood event from local drainage facilities. Flooding from regional sources will be considered on a case-by-case basis.

Best Management Practices (BMPs), such as filter strips and sedimentation basins, are usually designed for the 2-year event. BMP's designed for the 2-year event will properly treat over 90% of the flow during its life. Design criteria, such as included in the California Storm Water Best Management Practice Handbooks should be used.

Open channels should be designed with a minimum of six inches of freeboard at the design flow. Closed conduit systems should be designed with no surcharging at the design flow. Culvert inlets may be surcharged to efficiently use the culvert. To reduce routine maintenance, facilities should be designed with a self-cleansing velocity of 3 feet per second. Erosive velocities in unlined channels and culvert outlets should be minimized, or erosion resistant lining provided.

ROADWAY DESIGN CRITERIA

Roadway drainage design is a matter of properly balancing technical principles and data with the environment giving due consideration to other factors such as safety and economics. Drainage features to remove runoff from the roadway and to convey surface and stream waters originating upstream of the roadway to the downstream side should be designed to accomplish these functions without causing objectionable backwater, excessive velocities or unduly affecting traffic safety. Chapters 800 to 890 of the CALTRANS Highway Design Manual should be used for drainage design of public roadways within Lake County. The following minimum design standards apply to Lake County:

Bridges/Major Culverts: Design in conformance with Chapter 820 of the Highway Design Manual. For Major Waterways and streams that are included in the Flood Insurance Study (FIS), a 100-year flood should be used for design purposes. Bridges over streams included in the FIS may not increase the base flood elevation more than one foot. If a floodway is present, the bridge may not encroach on the floodway or must be designed with no increase the base flood elevation.

Arterial and Collector Roadways: Cross culverts should be designed for a 25-year flood event with headwater six inches below the edge of the traveled way. A 100-year event should be used if the drainage is defined as a Major Waterway.

Drainage along the roadway, i.e. gutter flow, should be designed for a 25-year event with flow contained within the shoulder or parking lane. Roadside ditches should be designed for a 25-year flood event with six inches of freeboard. The 100-year event should be contained within the roadway.

Local Roadways: Cross culverts must be designed for a 10-year flood event with headwater six inches below the edge of the traveled way. Secondary and Major Waterways should be designed for the corresponding recurrence interval.

Drainage along the roadway, i.e. gutter flow, should be designed for a 10-year event with flow contained within the shoulder or parking lane. Roadside ditches should be designed for a 10-year flood event with six inches of freeboard. The 100-year event should be contained within the roadway.

In the event of sheet flooding occurring in the area of a bridge or culvert, exceptions to the above standards will be considered on a case-by-case basis.

HYDROLOGIC DESIGN

Estimation of flood flows from minor waterways and for drainage areas that have significant areas of urban development should be through use of the Rational Formula. Secondary and major waterways should have the flood flows estimated from detailed calculations and/or models. Design shall be based on the assumption that all upstream areas are fully developed, consistent with zoning at the time of project approval.

Rational Formula

Design discharge for minor waterways and urban areas shall be determined by use of the rational formula:

$$Q = C\ I\ A\ K$$

Where:
Q = design discharge in cubic feet per second, cfs
C = runoff coefficient based on full development
I = rainfall intensity in inches per hour
A = drainage area in acres
K = coefficient of intensity

Runoff Coefficient:

The runoff coefficient for undeveloped areas is selected from Table 1. For developed areas, the runoff coefficient is calculated based on the runoff coefficient from Table 1 and the percentage of area that is covered by impermeable surfaces. Table 2 provides some typical ranges for the area covered by impermeable surfaces for different levels of development. Table 3 provides some

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Appendix C Lake County General Plan

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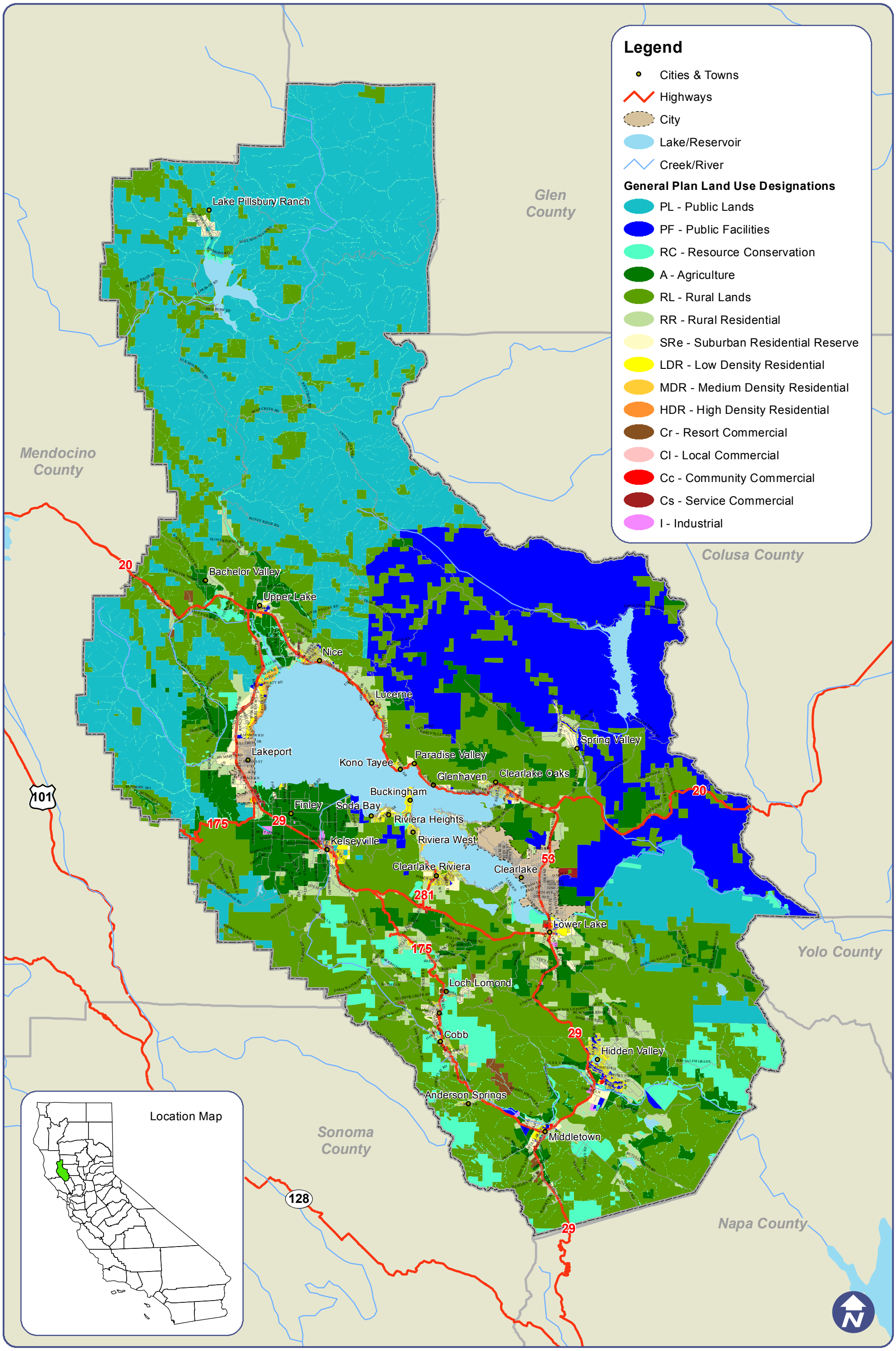

Figure 3-1 General Plan Land Use Map

Fig 3-1 Land Use Map.mxd

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Appendix D Rational Method

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1243 Alpine Road, Suite 108
Walnut Creek, CA 94596
Phone: 925.941.0017
FAX: 925.941.0018
www.wreco.com

System	1				2				3				4			
Basin	**Upper Clover Watershed**				**Middle Clover Watershed**				**Middle Creek Rd**				**Washington St**			
Physical Dimensions																
Flowline length, total:	3,043	ft			1,926	ft			864	ft			370	ft		
Sheet flow length:	90	ft			90	ft			0	ft			0	ft		
Shallow conc. flowline length:	2,953	ft			1,836	ft			864	ft			370	ft		
Pipe flow length:	0															
Ditch length:	0	ft				ft				ft				ft		
Catchment highest elevation:	1,377	ft			1,355	ft			1,351	ft			1,348	ft		
Sheet flow low elevation:	1,376	ft			1,355	ft			1,351	ft			1,348	ft		
Shallow con. flow lowest elevation:	1,356	ft			1,351	ft			1,350	ft			1,347	ft		
Pipe flow lowest elevation	0															
Catchment lowest elevation:	1,356	ft			1,351	ft			1,350	ft			1,347	ft		
Catchment area, A:	115.4	acres			104.0	acres			8.2	acres			9.0	acres		
Design Return Period	100	years			100	years			100	years			100	years		
Sheet flow Roughness Coefficient:	0.24	*Dense grass*			0.24	*Dense grass*			0.24	*Dense grass*			0.24	*Dense grass*		
Source: Caltrans Highway Design Manual. July 1, 2008. Table 816.6A																
2-year, 24-hour rainfall depth, P_2:	3.168	in			3.168	in			3.168	in			3.168	in		
NOAA Atlas 14																
Intercept Coefficient, k, for shallow conc. flow:	0.457	*Grassed waterway*			0.457	*Grassed waterway*			0.62		*pavement and small upland guilies*		0.62		*pavement and small upland guilies*	
Source: Caltrans Highway Design Manual. July 1, 2008. Table 816.6B																
Adjustment factor , C(f), for design storm	1.25	100	year flood		1.25	100			1.25	100			1.25	100		
Runoff Coefficients for Developed Areas																
Source: Caltrans Highway Design Manual. July 1, 2008. Table 819.2B		adjusted	Acreage	%		adjusted				adjusted				adjusted		
Parks, cemeteries:	0.20	0.25	0	0%	0.20	0.25	0	0%	0.20	0.25	0	0%	0.20	0.25	0	0%
Railroad yard areas:	0.30	0.375	0	0%	0.30	0.375	0	0%	0.30	0.375	0	0%	0.30	0.375	0	0%
Umimproved areas	0.20	0.25	81.02	70%	0.20	0.25	67.54	59%	0.20	0.25	0	0%	0.20	0.25	0	0%
Business: neighborhood areas	0.60	0.75	0	0%	0.60	0.75	0	0%	0.60	0.75	0	0%	0.60	0.75	0	0%
Streets, asphaltic	0.80	1	0	0%	0.80	1	0	0%	0.80	1	0	0%	0.80	1	0	0%
Residential, single-family areas	0.40	0.5	34.16	30%	0.40	0.5	36.47	32%	0.40	0.5	8.24	100%	0.40	0.5	9	100%
Total			115.18	100%			104.01	100%			8.24	100%			9	100%
Composite C of basin:	0.26	0.32			0.24	0.30			0.40	0.50			0.40	0.50		

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System	1	2	3	4	
Basin	**Upper Clover Watershed**	**Middle Clover Watershed**	**Middle Creek Rd**	**Washington St**	
Dimensions					
Shallow flow high elevation:	1376.0	1354.5	1351.0	1348.0	ft
Shallow flow low elevation:	1356.0	1351.0	1350.0	1347.0	ft
Shallow flow length:	2,953	1,836	864	370	ft
Shallow flow slope:	0.68%	0.19%	0.12%	0.27%	
Parameters					
Intercept Coefficient, k:	0.457	0.457	0.62	0.62	
Velocity, V:	1.23	0.65	0.69	1.06	ft/s
Shalllow Conc. Flow Travel time, Tt:	39.9	46.8	20.8	5.8	min

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System	1	2	3	4	
Basin	**Upper Clover Watershed**	**Middle Clover Watershed**	**Middle Creek Rd**	**Washington St**	
Dimensions					
Sheet flow path length, L:	90	90	0	0	ft
Sheet flow high elevation:	1,377	1,355	1,351	1,348	ft
Sheet flow low elevation:	1,376	1,355	1,351	1,348	ft
Slope of flow, S:	0.0111	0.0056	0.0000	0.0000	ft/ft
Manning's n:	0.24	0.24	0.24	0.24	
2-year, 24-hour rainfall depth, P_2:	3.168	3.168	3.168	3.168	in
Sheet Flow Travel time, Tt:	16.7	22.0	0.0	0.0	min

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System	1	2	3	4		
Basin	**Upper Clover Watershed**	**Middle Clover Watershed**	**Middle Creek Rd**	**Washington St**	**Total**	
Sheet Flow Travel time, Tt:	16.68	22.01	0.00	0.00		min
Shalllow Conc. Flow Travel time, Tt:	39.90	46.76	20.81	5.83		min
Total Travel Time, Tt:	56.57	22.01	20.81	5.83		min
Time of concentration of system	56.57	22.01	20.81	5.83		min
Runoff Coefficients for Developed Areas, C:	0.32	0.30	0.50	0.50		unitless
Catchment area, A:	115.4	104.0	8.2	9.0		ac
100-year storm						
Design storm rainfall intensity, i:	1.15	1.90	1.95	3.60		in/hr
Runoff, Q:	43.1	60.1	8.0	16.2	127.5	cfs

Appendix E FEMA Flood Insurance Study

Middle Creek Frequency Discharge, Drainage Area Curves

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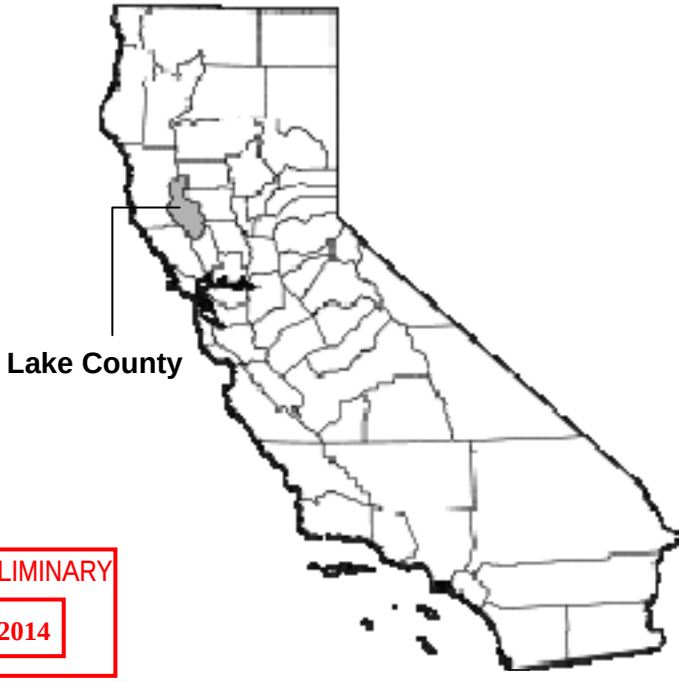
FLOOD INSURANCE STUDY

VOLUME 1 OF 2

LAKE COUNTY, CALIFORNIA

AND INCORPORATED AREAS

Community Name	Community Number
BIG VALLEY BAND OF POMO INIDANS	060397
CLEARLAKE, CITY OF	060714
LAKE COUNTY (UNINCORPORATED AREAS)	060090
LAKEPORT, CITY OF	065038



REVISED PRELIMINARY

JUNE 18 2014

REVISED

Month Day, Year

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER

06033CV001B

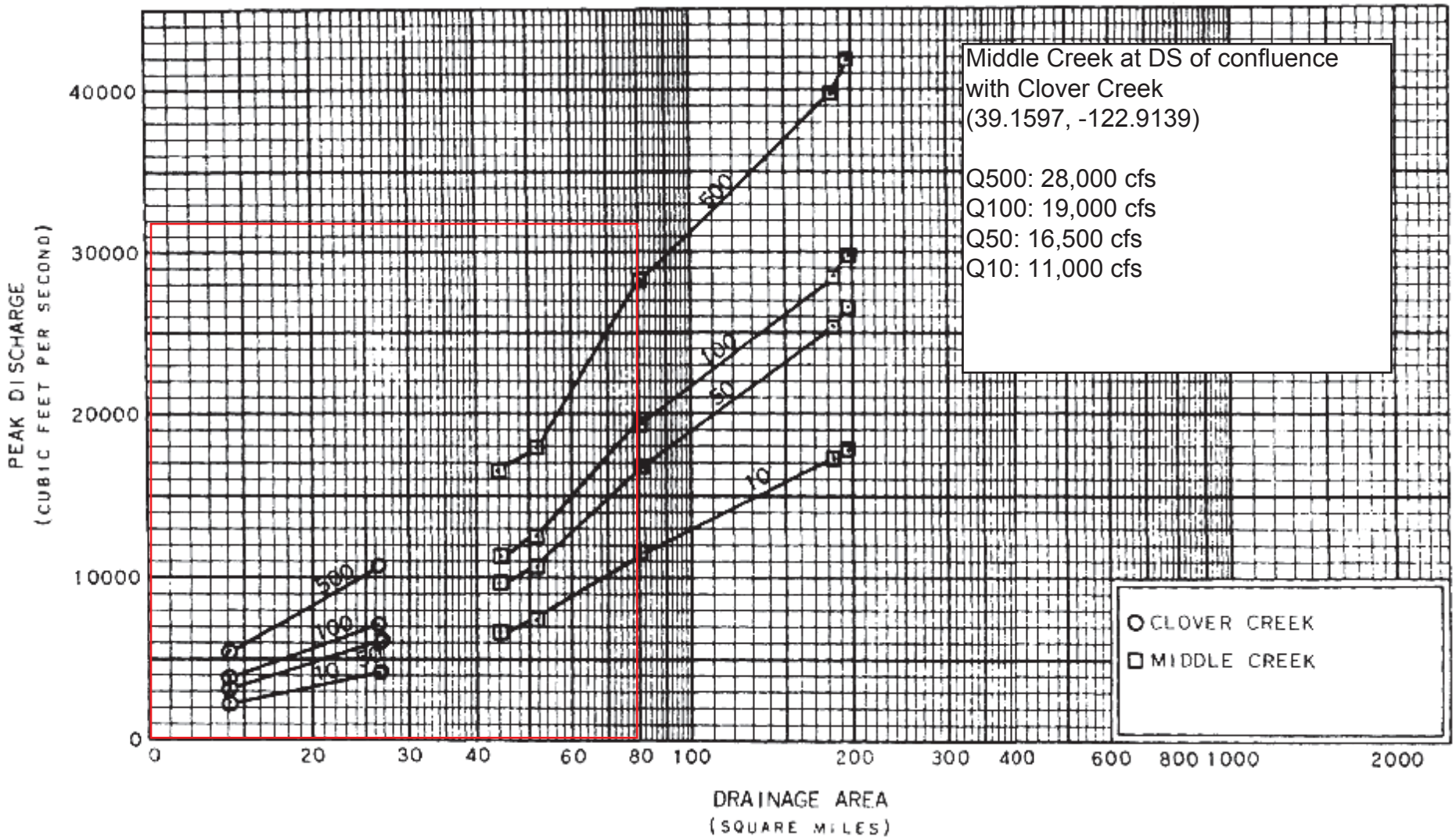


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

LAKE COUNTY, CA

AND INCORPORATED AREAS

FREQUENCY DISCHARGE, DRAINAGE AREA CURVES

CLOVER CREEK AND MIDDLE CREEK