FLOOD INSURANCE STUDY

SUTTER COUNTY, CALIFORNIA

(UNINCORPORATED AREAS)

REVISED: JUNE 16, 2015

Federal Emergency Management Agency
FLOOD INSURANCE STUDY NUMBER
060394V000B

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this Flood Insurance Study may be revised and republished at any time. In addition, part of this Flood Insurance Study may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the Flood Insurance Study. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current Flood Insurance Study components.

ATTENTION: On FIRM panels 0603940810F, 0603940815F, 0603940820F, 0603940840F, and 0603940880F, levees for multiple flooding sources throughout Sutter County have not been demonstrated by the community or levee owners to meet the requirements of Section 65.10 of the NFIP regulations in 44 CFR as it relates to the levees' ability to provide 1-percent annual chance flood protection. The subject areas are identified on FIRM panels (with notes and bounding lines) and in the FIS report as potential areas of flood hazard data changes based on further review.

FEMA has updated levee analysis and mapping protocols. Until such time as FEMA is able to initiate a new flood risk project to apply the new protocols, the flood hazard information on the aforementioned FIRM panels that are affected by the multiple levees is being added as a snapshot of the prior effective information presented on the FIRMs and FIS reports dated December 2, 2008. As indicated above, it is expected that affected flood hazard data within the subject area could be significantly revised. This may result in floodplain boundary changes, 1-percent annual chance flood elevation changes, and/or changes to flood hazard zone designations.

The effective FIRM panels and the FIS will again be revised to update the flood hazard information associated with the levees when FEMA is able to initiate and complete a new flood risk project to apply the new protocols.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

Page

FIGURES

TABLES

EXHIBITS

FLOOD INSURANCE STUDY
SUTTER COUNTY, CALIFORNIA (UNINCORPORATED AREAS)

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) revises and updates a previous FIS/Flood Insurance Rate Map (FIRM) for Sutter County, California (Unincorporated Areas). This information will be used by Sutter County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

Please also note that FEMA has identified levees in this jurisdiction that have not been demonstrated by the community or levee owner to meet the requirements of Part 65.10 of the NFIP regulations as it relates to the levee's ability to withstand a 1% annual chance flood event. As such, there are temporary actions being taken until such time as FEMA is able to initiate a new flood risk project to apply new protocols. Please refer to the Notice to Flood Insurance Study Users page at the front of this FIS report for more information.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for Auburn Ravine, Curry Creek, Curry Creek Bypass, East Side Canal, Howsley Creek, King Slough, North King Slough, Pleasant Grove Creek, Pleasant Grove Creek Bypass, and Pleasant Grove Creek Canal were performed by Born, Barrett & Associates, for the Federal Emergency Management Agency (FEMA), under Contract No. EMW-84-C-1638. This study was completed in August 1986.

On July 6, 1998, the original study was revised to incorporate revised hydrologic and hydraulic analyses of the Pleasant Grove Creek Canals and new hydrologic and hydraulic analyses of the Sacramento River, Cross Canal, and Pleasant Grove Creek affecting the unincorporated areas of Sutter County. The hydrologic and hydraulic analyses for the restudy were performed by the U.S. Army Corps of Engineers (USACE), Sacramento District (the Study Contractor (SC)), for FEMA, under Interagency Agreement No. EMW-87-E-2509, Project Order No. 16. This work was completed in January 1989.

The July 6, 1998, revision also incorporated the hydrologic and hydraulic analyses for interior flooding within the Natomas area, bounded by the Sacramento River to the west, the American River and Natomas East Main Drainage Canal to the south, Natomas East Main Drainage Canal to the east, and Cross Canal to the north. The hydrologic and hydraulic analyses for the restudy were performed by Ensign & Buckley for the Sacramento Area Flood Control Agency. This work was completed in March 1998.

In addition the July 6, 1998, revision incorporated the hydrologic and hydraulic analyses for the reach of Natomas East Main Drainage Canal from Dry Creek to Sankey Road performed by Borcalli & Associates for Sacramento County. This work was completed in April 1998.

December 2, 2008 Revision

On December 2, 2008, a second revision incorporated the Lower Feather River (LFR) study performed by the USACE, Sacramento District, for the State of California, Department of Water Resources (DWR). The LFR Study included an analysis of the Lower Feather River, Yankee Slough and the Bear River. This study also included analysis of levee failure and overland flow. This work was completed in February 2005.

The December 2, 2008 revision also incorporated the de-accreditation of the levees surrounding the Natomas Basin. As a result of the decertification the entire Natomas Basin was mapped within Zone AE, with an elevation of 33 feet (NGVD 1929). The Natomas Basin, which lies within Sutter County, as well as the City and County of Sacramento, is approximately 86 square miles bounded by the Sacramento River to the west, the American River and Natomas East Main Drainage Canal to the south, Natomas East Main Drainage Canal to the east, and Cross Canal to the North.

The levees surrounding the Natomas Basin were decertified by a letter dated July 20, 2006 from the USACE Sacramento District to the Sacramento Area Flood Control Agency. The letter stated that the USACE would no longer support their position regarding certification of the levee system surrounding the Natomas area based on their finding in the Corps "Final Geotechnical Report for Sacramento River East levee and Natomas Cross Canal South Levee" dated November 29, 2005 and "Natomas Levee Evaluation Report" dated March 13, 2006. These findings concluded the presence of physical conditions that were conducive to deep levee under seepage in the Natomas Area. As a result, the landward area of BFE in the Natomas area was determined to be 33.1 feet (NGVD 29 datum) according to the Flood Insurance Study, Sacramento City and County, California, FBFM and FIRM Work map, January 1989 by the USACE Sacramento District (Reference 27).

The December 2, 2008, revisions to the published FIS reports for Sacramento County (Unincorporated Areas), and the City of Sacramento, California were published concurrently with this restudy to reflect the de-accreditation of the levees surrounding the Natomas Basin.

June 16, 2015 Revision

The June 16, 2015, revision incorporated updated mapping for the Natomas Basin based on an application jointly submitted by the City of Sacramento, Sacramento County and Sutter County to replace the Zone AE (BFE of 33.1 feet NGVD 29 datum) with the A99 Zone designation. The "Sacramento Area Flood Control Agency Natomas Basin Flood Protection System A99 Eligibility Summary Report" (Reference 28), dated June 20, 2012, is the basis for the application to revise the SFHA. This report was revised on March 26, 2014. This request is based on the fact that adequate progress has been made on the flood protection system project to warrant a change in zone designation to Zone A99, as defined by Paragraph 61.12(b) of the NFIP regulations. As part of the requirements, the community is required to provide annual updates on the progress of the flood project, as defined by Paragraph 61.12 (e) of the NFIP regulations.

Due to the uncertainty of levee certifications throughout Sutter County, the Zone A and Zone AE designations on the non-landward side of the Natomas Basin will be secluded since the levees in other areas of the Sutter County have not been shown to comply with Section 65.10 of the NFIP Regulations. As such, the flood hazard data will be revised at a later date to update the flood hazard information associated with these structures. In the meantime, flood hazard data has been re-published from the December 2, 2008, FIS and FIRM for Sutter County and should continue to be used until this FIS is revised to update the flood hazard information in these areas.

Revisions to the published FIS reports for Sacramento County (Unincorporated Areas), and the City of Sacramento, California are being published concurrently with this restudy to reflect the SFHA revision to Zone A99 for the Natomas Basin in those communities.

1.3 Coordination

For the original study, a meeting was held in March 1984 to identify the streams requiring detailed study. The meeting was attended by representatives of the SC, FEMA, and the County. Results of the subsequent hydrologic analyses were coordinated with the Sutter County Planning Department, the U.S. Soil Conservation Service (SCS), the DWR, the U.S. Geological Survey (USGS), the USACE, and the U.S. Bureau of Reclamation.

For the second revision, dated July 6, 1998, a notice of study initiation was sent out in May 1987. This notice contained a request for pertinent data, and was sent to various Federal, State, and local agencies. Direct contacts for information were made with representatives of the City of Sacramento, Sacramento and Sutter Counties, and the State of California. An announcement of the intent to perform a flood elevation study for selected portions of the City of Sacramento and unincorporated areas of Sacramento and Sutter Counties was published in *The Sacramento Union* on June 3, 10, and 17, 1987. An intermediate coordination meeting was held on November 29, 1988. The meeting was attended by representatives of the City of Sacramento, Sacramento and Sutter Counties, the State of California, FEMA, other public agencies, and the SC. The initial results of this study, specifically the technical data on floodplain boundaries, water-surface profiles, and floodways, were reviewed.

For the third revision, dated December 2, 2008, the USACE staff contacted representatives of local Reclamation District (RD) 1001, RD 784, RD 2103, and the Marysville Levee Commission to obtain accounts of historical flooding. On May 28, 2003, the State of California, DWR held a meeting in Marysville of local agency representatives to alert local agencies that the Lower Feather River study was in progress and that many levees in the study might be determined to not meet FEMA certification requirements. Represented agencies included the USACE, DWR, State Reclamation Board, RD 1001, RD 784, RD 817, RD 718, LD 1, Yuba County Water Agency (YCWA), Yuba County, Sutter County, and the City of Wheatland. Subsequent meetings were held in response to requests from local agencies to meet with DWR and USACE staff to discuss issues pertaining to levee certification.

Two Consultation Coordination Officer (CCO) meetings were held for the second revision with representatives of Sutter County. The first meeting was held on September 14, 2006 and the final meeting was held on December 28, 2007. All problems raised at both meetings have been addressed in this study.

For this revision, dated June 16, 2015, a CCO meeting was held with representatives of Sutter County, FEMA, and the study contractor on August 13, 2014. All problems raised at this meeting have been addressed in this study.

2.0 AREA STUDIED

2.1 Scope of Study

This FIS covers the unincorporated areas of Sutter County, California. The incorporated Cities of Yuba City and Live Oak are not included in this study.

All or portions of the following streams were studied by detailed methods by either the original study, the 1998 restudy, or by the 2008 restudy (Table 1). Limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM.

As part of the 2008 restudy, the 2005 USACE LFR study addressed flooding from the Feather River, Yankee Slough, and the Bear River. However, it did not assess the potential for failure of the Natomas Cross Canal north levee as a result of ponded floodwaters on the north side of the levee nor did it assess the potential for failure of the Wadsworth Canal southeast levee or the Sutter Bypass east levees as a result of ponded floodwaters against those levees. In addition, the LFR study did not consider interior flooding.

Table 1. Streams Studied by Detailed Methods

Stream	Upstream and Downstream Study Limits	Reach Length (Miles)
Auburn Ravine	Sutter-Placer County Line to East Side Canal Confluence	3.4
Bear River	Highway 65 near Wheatland to Confluence with Feather River	11.54
Cross Canal	Mouth to Pleasant Grove Creek Canal	5
Curry Creek	Sutter-Placer County Line to Pleasant Grove Creek Canal Confluence	2.3
Curry Creek Bypass	Sutter-Placer County Line to Curry Creek Confluence	1.4
East Side Canal	Auburn Ravine Confluence to Cross Canal Confluence	1.9
Feather River	Yuba River Confluence to Sacramento River Confluence	27.25
Howsley Creek	Sutter-Placer County Line to Pleasant Grove Creek Canal Confluence	3.5
King Slough	Sutter-Placer County Line to East Side Canal Confluence	3.5
Natomas East Main Drainage Canal	Sankey Road to Sacramento River Confluence	15
North King Slough	Sutter-Placer County Line to King Slough Confluence	3.1
Pleasant Grove Creek	Sutter-Placer County Line to Pleasant Grove Creek Canal Confluence	2.8
Pleasant Grove Creek Bypass	Pleasant Grove Creek Confluence to Howsley Creek Confluence	2.1
Pleasant Grove Creek Canal	Curry Creek Confluence to Cross Canal Confluence	3.4
Sacramento River	Freeport bridge to Verona	33
Yankee Slough	5,500 feet upstream of Brewer Road to Bear River Confluence	6.6

2.2 Community Description

Sutter County is situated in northern California, approximately 30 miles north of Sacramento and adjacent to Colusa, Butte, Yuba, Placer, Sacramento, and Yolo Counties. The total land area contained within the county is 602 square miles. According to U.S. Census figures, the population of Sutter County was 78,930 in 2000, 64,415 in 1990, and 52,246 in 1980 (Reference 1). The economy of the county is based primarily on agriculture and related industries.

The climate is characterized by hot, dry summers and cool winters. The mean annual precipitation is approximately 18 inches. Temperatures range from an average of 96 degrees Fahrenheit (°F) in summer to 36°F in winter (Reference 2). Flood-producing rain storms occur between November and April.

The detailed shallow-flooding study area is characterized by a nearly level floodplain. The soils are moderately well drained and moderately to coarse textured developed in stratified medium to coarse textured alluvium (Reference 2).

2.3 Principal Flood Problems

Flooding due to levee failures in the area is well documented (References 3, 4, 5, 6, and 7). Since the completion of Oroville Dam in 1964, the two most significant floods in the study area occurred in 1986 and 1997. Nearly 50,000 people from Yuba City, Marysville, and surrounding areas were evacuated because of fears of additional levee breaks (Reference 4).

The 2005 USACE LFR study was calibrated to flooding that occurred during the January 1997 event.

General rain floods can occur in the study area anytime during the period from November through April. This type of flood results from prolonged heavy rainfall and is characterized by high peak flows of moderate duration and by a large volume of runoff. Flooding is more severe when antecedent rainfall has resulted in saturated ground conditions.

The severity of flooding on all the streams studied is intensified by backwater conditions between stream systems. Floodwater elevations are increased in the lower portions of tributary streams due to the backwater effect from main streams reducing hydraulic gradients and flow-storage areas. During this time there will be a high degree of coincidental l-percent-annual-chance floodflows on all the study area waterways.

There are six areas within the limits of the first revision where the high flow of floodwaters on some channels has a great impact (causing backwater conditions) on the hydraulic regimen of other channels. High flows on the Sacramento River generate backwater conditions on the lower reaches of the Cross Canal. The American River peak 1-percent-annual-chance flows induce backwater conditions in the lower reach of the Natomas East Main Drainage Canal. Coincidentally, high flows on the Natomas East Main Drainage Canal cause backwater conditions on the lower reaches of Arcade and Dry Creeks. High flows on Cross Canal create backwater conditions on Pleasant Grove Creek Canal.

2.4 Flood Protection Measures

The Sacramento River, Sutter Bypass, the Feather River, Yankee Slough, Wadsworth Canal, Cross Canal, the Bear River, and Tisdale Bypass are bounded by levees that were constructed as part of the Sacramento River Flood Control Project, which was authorized by the Flood Control Act of 1917 as modified by the Acts of 1928, 1937, and 1941.

Existing flood protection measures include sections of modified channel along parts of several of the streams studied.

The East Side Canal and Pleasant Grove Creek Canal (owned and maintained by RD 1001 and 1000, respectively) have been modified through channel enlargement, straightening and levee construction.

Three upstream reservoirs on the Bear River only provide incidental storage that helps to attenuate the peak of major flood events or store flood water early in the flood season before the reservoirs have filled.

East Side Canal intercepts flows from Auburn Ravine, King Slough, and several other tributaries. Pleasant Grove Creek Canal intercepts flow from Howsley Creek, Pleasant Grove Creek, and Curry Creek. The two canals join to form Cross Canal, which discharges water to the Sacramento River.

Upstream of the modified channel sections, the stream channels remain natural, and, in certain areas, have a limited flow capacity. Some of the factors that contribute to lower flow capacity are bridges, overgrowth, debris, reduced cross sectional area, and limited or no banks to contain the water. Floodwater escapes the natural channels and is trapped behind levees of then modified sections and cannot enter into the East Side or Pleasant Grove Creek Canal systems. Trapped floodwater is then siphoned under the two canals through corrugated metal pipe culverts varying in diameter from 20 to 42 inches. These discharge into RD 1001 drainage canals. RD 1001 then pumps this water into Cross Canal near Verona (Reference 2).

A system of pumping plants, five discharging into the Natomas East Main Drainage Canal and two into the Cross Canal, transfers collected drainage waters from land areas adjacent to the two canals and adds to floodflows in the canals. During the occurrence of coincidental l-percent-annual-chance flood, approximately 1,640 cubic feet per second (cfs) is pumped into Natomas East Main Drainage Canal and 970 cfs into Cross Canal.

Within this jurisdiction lie levees that have not been demonstrated by the community or levee owner to meet the requirements of NFIP regulation 65.10 regarding its ability to provide protection from the 1% annual chance flood event. Please refer to the Notice to Flood Insurance Study Users page at the front of this FIS report for more information.

3.0 ENGINEERING METHODS

For the flooding sources studied by detailed methods in the community, standard hydrologic and hydraulic study methods were used to determine the flood-hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10); for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

Note: Within this jurisdiction lie levees that have not been demonstrated by the community or levee owner to meet the requirements of NFIP regulation 65.10 as it relates to its ability to provide protection from the 1% annual chance flood event. Please refer to the Notice to Flood Insurance Study Users page at the front of this FIS report for more information.

3.1 Hydrologic Analyses

Original Study

The hydrologic data for the original study were derived from a study conducted by the SCS. (Reference 2).

First Revision

The hydrologic data for the July 6, 1998, revision (with the exception of the revised reach of Natomas East Main Drainage Canal from Dry Creek to Sankey Road and the Natomas area interior flooding) were derived from information contained in a hydrology study that was conducted as part of an in-progress investigation by the USACE (Reference 5).

Backwater conditions are prevalent on all the waterways included in the first restudy. The Dynamic Wave Operational Model (DWOPER) computer program was used to develop hydrologic data for the restudy area. The DWOPER model was calibrated based on flow and stage hydrographs and high-water marks recorded during the February 1986 flood. Minimal data for all but two the Sacramento and American Rivers was available for the 1986 flood event. The DWOPER model of the Sacramento and American Rivers was calibrated based on flow hydrographs from the February 1986 storms. The DWOPER model of the remaining study streams was based on estimated flows, high-water marks, and available staff gage readings.

The l-percent-annual-chance flood hydrograph volume for the Sacramento River was estimated based on historical data recorded at the Verona, I Street, and Freeport gages. The February 1986 flood hydrographs at the Verona and I Street gages were used to estimate the shape of the l-percent-annual-chance flood hydrograph for the Sacramento River. For the upper study reach of the Sacramento River, the l-percent-annual-chance flood hydrograph was estimated to be basically the same as the hydrograph for the February 1986 flood. Between the I Street and Freeport gages the l-percent-annual-chance floodflow is approximately 3 percent greater than the flow during the February 1986 flood. The l-percent-annual-chance flood hydrograph for the American River was based on streamflow records. The l-percent-annual-chance flood hydrographs for the other study streams are based on rainfall-runoff computations and statistical analyses of precipitation and synthetic general rainstorms.

HEC-l, a Generalized Computer Program Flood Hydrograph Package (Reference 8), was used for all these analyses. Streamflow routings were based on storage-discharge relationships developed for reaches along each stream.

An analysis of the recorded rainfall data for precipitation stations located both in and just outside the study area indicated that 24-hour storm waves were preeminent during the February 1986 storm. Therefore, a 24-hour general rainstorm was chosen and developed for the streams originating in the greater Sacramento area. Precipitation amounts for computation of l-percent-annual-chance, 24 hour general rainstorms were developed based on an annual rainfall depth-duration frequency analysis for a Sacramento County rainfall recording station (Reference 9) that was selected as being representative for all the study basins because of its central location in the study area. Rainfall amounts for this station and other nearby stations were compared with similar data in the National Oceanic and Atmospheric Administration (NOAA) Atlas 2 for California (Reference 9*)* for authentication. Point rainfall amounts were then adjusted (reduced) based on criteria (areal distribution methodology) in References 10 and 11. Rainfall amounts for the 24-hour storms were determined for subareas of individual basins. The adjusted point rainfall amounts for the selected frequencies were multiplied by the ratio for the subarea Normal Annual Precipitation (NAP) to the total basin NAP. The subarea amounts were then averaged for each basin

Distribution of the 24-hour general rainstorm amounts for the 1-percent-annual-chance flood was based on the 96-hour standard project storm criteria presented in a 1971 USACE publication (Reference 10).

Loss rate data for the Arcade Creek and Dry Creek basins were based on information presented in two other Hydrology Office Reports (References 11 and 12). Loss rate data for the Natomas East Main Drainage Canal, Cross Canal, and Pleasant Grove Creek Canal were based on data developed for Reference 11 and knowledge of the areas. The loss rates were also based on the initial and constant infiltration loss concept and the analyses of soil cover and land uses. Land uses were based on available aerial photography and personal observation of the basins.

Unit hydrographs for Arcade Creek above Watt Avenue and Dry Creek were computed based on the Los Angeles Valley S-graph used during two previous Hydrology Office Reports (References 11 and 12). Unit hydrographs for Arcade Creek below Watt Avenue were computed using Clarks parameters. Unit hydrographs for the Natomas East Main Drainage Canal, Cross Canal, and Pleasant Grove Creek Canal were computed using the Valley S-curve and current characteristics for the basins.

Flood hydrographs for the study area were combined and routed downstream using appropriate flow-distribution analyses and the Modified Puls routing procedure. The effects of pumped discharges into the Natomas East Main Drainage Canal from the east and west were accounted for during the analyses and routing procedures.

Where pertinent, the stages for the flow hydrographs on the main stems were combined with the corresponding peak flow hydrographs for the tributary drainages to determine the maximum stage for the tributary systems. Depending on timing and location along the tributaries, the maximum stage on the main stems may or may not coincide with the peak flow for the tributary streams.

lnterbasin transfer of floodwaters occurs with overflow from the Pleasant Grove Creek Canal across Sankey Road to the Natomas East Main Drainage Canal.

The USACE UNET one-dimensional (1-D) unsteady flow computer program (Reference 13) was used to determine peak discharges for the revised reach of Natomas East Main Drainage Canal from Dry Creek to Sankey Road and to route the hydrographs generated by HEC-1 models through the storage areas located adjacent to the Western Pacific Railroad and along Natomas East Main Drainage Canal to the new Natomas East Main Drainage Canal pump station located just upstream of the confluence of Dry Creek.

Peak discharges for flows overtopping Sankey Road and causing interior flooding within the Natomas area were determined using the USACE UNET program. The Environmental Protection Agency Storm Water Management Model (Reference 14) rainfall-runoff model, calibrated to the 1986 flood, was used as input into the UNET model.

Second Revision

Feather River Hydrology - The hydrologic analysis for the Lower Feather River extended from the confluence with the Yuba River down to the confluence of the Sacramento River. While the Lower Feather River hydrology made extensive use of data developed for the Sacramento and San Joaquin River Basins Comprehensive Study (Comp Study) prepared by the USACE in 2003, none of the synthetic storms developed for the Comp Study were centered at locations along the Feather River within the study area. Thus, two hypothetical storm centerings were developed for the most upstream and downstream locations within the study reach: the Shanghai Bend centering and the Latitude of Verona storm centering.

The hypothetical storm patterns were generated using methods and procedures documented in Rain Flood Flow Frequency Analysis, Feather and Yuba Rivers, California, by the USACE in 1999, which was approved by FEMA. The hydrographs were constructed following the methods described in the Comp Study.

There are twenty-six reservoirs within the Yuba-Feather-Sacramento River system. The reservoir routing for the Feather River system was accomplished using both HEC-5 and ResSim modeling packages. A HEC-5 model was constructed for the entire Sacramento River Basin as part of the Comp Study. The HEC-5 Feather-Yuba subwatershed models developed for the Comp Study were converted to a ResSim model for the Lower Feather River Study. The ResSim model was used to model the Feather River system from Oroville down to Nicolaus. ResSim models incorporating both the Shanghai Bend and the Latitude of Verona storm centerings were developed. The Shanghai Bend centering produced the maximum channel stages on the Feather River and the Lower Bear River and thus, only the Shanghai Bend storm centering was used in the final hydrologic models.

While a number of ResSim model runs were developed to incorporate a forecast uncertainty component to the local flow contributions downstream of a reservoir, the 10-, 2- and 1-percent-annual-chance event final models assumed complete certainty in local flow contributions. The 0.2-percent-annual-chance event model incorporated a 20 percent contingency in the local flow contribution.

The model was calibrated using the 1997 flood event and the peak flows results were reasonably close to the stream gage data. The reservoir operational strategies were built in ResSim for the Feather River and the model results are reasonable.

The Comprehensive Study HEC-5 model was used to model the Sacramento River System down to the confluence with the Feather River (Verona). The HEC-5 model for the Sacramento River System was not included in the FEMA submittal.

Bear River Hydrology - The Bear River storm centering produced maximum stages in the upper Bear River and lower reaches of Dry Creek and Yankee Slough (tributaries to the Bear River) located in Yuba County. As part of the Bear River hydrology, data was also developed for the case of a storm centered over the Bear River tributaries. This case produced maximum stages in the upper reaches of Dry Creek and Yankee Slough. Hydrographs were developed for the 10-, 2-, 1-, and 0.2-percent-annual-chance exceedance events, and were used for the one dimensional channel hydraulic models. Four separate HMS models were created for this LFR study:

- Bear River above Wheatland gage
- Dry Creek above Jasper Lane
- UP Intercept Canal above Plumas Lake
- Yankee Slough above Swetzer Road

Bear River and the Dry Creek HMS models were calibrated to the January 1997 flood event. The following scenarios were modeled in HMS, a) the 10-, 2-, 1-, and 0.2-percent-annual-chance exceedence events for the event centered on the Bear River along with coincident flow from the tributaries that would produce a 10-, 2-, 1-, and 0.2-percent-annual-chance exceedence flow at the confluence of the Bear and the Feather River; and b) the 10-, 2-, 1-, and 0.2-percent-annual-chance exceedence events for a storm centered on each major tributary (Dry Creek, UP Intercept and Yankee Slough).

Peak discharge-drainage area relationships for the streams studied by detailed methods are shown in Table 2, "Summary of Discharges".

Table 2. Summary of Discharges

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharge (Cubic Feet Per Second)			
		10% Annual-Chance	2% Annual-Chance	1% Annual-Chance	0.2% Annual-Chance
Auburn Ravine At Pleasant Grove Road	64.43	N/A	N/A	4,650[1]	N/A
Bear River At Wheatland	292	25,550	39,400	44,330	54,700
Cross Canal At Confluence with Sacramento River	289.14	N/A	N/A	16,100	N/A
Curry Creek At Pleasant Grove Road	14.53	N/A	N/A	1,480	N/A
East Side Canal At Pacific Canal	222.73	N/A	N/A	15,730	N/A
Howsley Creek At Pleasant Grove Road	1.98	N/A	N/A	370	N/A
King Slough At Pleasant Grove Road	8.85	N/A	N/A	4,350[1]	N/A
Pleasant Grove Creek Bypass At Pleasant Grove Road	0.36	N/A	N/A	1,320	N/A
Pleasant Grove Creek Above Confluence With Pleasant Creek Canal	45.24	N/A	N/A	4,280	N/A
Above Creek Bypass At Pleasant Grove Road	45.70	N/A	N/A	3,000	N/A
Pleasant Grove Creek At Cross Canal	62.55	N/A	N/A	5,600	N/A

Flooding Source and Location	Drainage Area (sq. mi.)	Peak Discharge (Cubic Feet Per Second)			
		10% Annual-Chance	2% Annual-Chance	1% Annual-Chance	0.2% Annual-Chance
Sacramento River At Verona	21,300	N/A	N/A	93,000	N/A
Yankee Slough At Swetzer Road	28.4	926	1,950	2,480	4,050

[1] This peak discharge has been adjusted due to overflow conditions upstream.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied by detailed methods were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. Flood elevations shown on the FIRM are primarily intended for flood insurance rating purposes. For construction and/or floodplain management purposes, users are cautioned to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

Original Study

Cross sections for the backwater analyses were obtained from USGS 7.5-minute series topographic maps at a scale of 1:24,000, with a contour interval of 5 feet (Reference 16). The below-water sections were obtained by field measurement. All bridges and culverts were field surveyed to obtain elevation data and structural geometry.

Roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations of the streams and floodplain areas. Roughness values for the streams ranged from 0.035 to 0.06, while floodplain roughness values ranged from 0.03 to 0.05 for all floods.

Water-surface elevations (WSELs) for the 1-percent-annual-chance recurrence interval were computed through use of the USACE HEC-2 step-backwater computer program (Reference 17). A starting WSEL was determined by using the 1-percent-annual-chance level backwater of the Sacramento River at the Cross Canal and the 1-percent-annual-chance normal-depth elevation in Cross Canal at the Sacramento River.

Approximate flooding in the remaining portions of the study was taken directly from the Flood Hazard Boundary Map (FHBM) for Sutter County (Reference 19). Levees in these areas were evaluated to determine the level of flood protection. Flooding in the levee-protected areas was determined from WSELs assuming levee failure and estimated using historical stage information from USGS gages along the Sacramento River.

First Restudy

Cross-section data for Natomas East Main Drainage Canal from just upstream of

Northgate Boulevard to Main Avenue (4 miles) and for the lower 2 miles of Arcade Creek were surveyed by the City of Sacramento. Cross sections for Natomas East Main Drainage Canal from Main Avenue upstream to the Sacramento/Sutter County line (6 miles) and for the lower 2 miles of Dry Creek were derived from topography developed for the current feasibility study by the USACE (Reference 5). Cross-section data for Natomas East Main Drainage Canal from the county line upstream to approximately Sankey Road (3 miles) and for Pleasant Grove Creek Canal (4 miles) were surveyed and provided by the SC. Cross-section data for Cross Canal (5 miles) were provided by the State of California. Topographic maps (Reference 16) and field surveys were also used to assist in developing cross-section data for the study area.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the FIRM. The level of flooding for the Sacramento River was computed based on stage-frequency curves at the three existing gages, and adjusting the February 1986 flood profile (Reference 18) to generate the 1-percent-annual-chance flood profile.

Manning's "n" values used in the July 6, 1998, revised study hydraulic were determined by field observations of the streams and floodplain areas (historical flooding). The channel and overbank Manning's "n" values for the streams are listed in the following tabulation.

Flooding Source	Channel	Overbank
Natomas East Main Drainage Canal	0.030-0.070	0.030-0.090
Cross Canal	0.030-0.080	0.030-0.120
Pleasant Grove Creek Canal	0.035-0.080	0.035-0.070

The level of flooding for the Sacramento River was computed based on stage-frequency curves at the three existing gages, and adjusting the February 1986 flood profile (Reference 18) to generate the 1-percent-annual-chance flood profile.

WSELs for the 1-percent-annual-chance flood for the other stream sources studied were computed through the use of the USACE HEC-2 computer program (Reference 17). Starting WSELs for the study streams were based on concurrent 1-percent-annual-chance stage elevations on main stems. The HEC-2 models were calibrated based on February 1986 surveyed high-water marks.

Top-of-levee profiles for the Sacramento River from Freeport Bridge to Verona (approximately 33 miles) were surveyed by the State of California.

The overland flood flow routing scenarios associated with the July 6, 1998 study are as follows. Generally, the reach of Sacramento River east levee, between the Town of Freeport upstream to Miller Park in Sacramento, is considered unstable during a 1-percent-annual-chance flood. Two basic scenarios of flooding caused by levee failure due to instability were considered - one beginning north and the other south of Sutterville Road.

Floodwaters starting north of Sutterville Road would inundate parts of the downtown Sacramento and William Land Park areas. Floodwaters would pond along the north side of the levee north of Sacramento Executive Airport. The levee would fail due to overtopping and floodwaters would then spread south inundating the Executive Airport and Meadow View/Pocket areas. Eventually, the floodflows would overtop the Morrison Creek levee system near the Sacramento River and Interstate Highway 5.

Floodwaters starting south of Sutterville Road would spread east to the Union Pacific Railroad tracks and south to the Morrison Creek levee system. The floodwaters would pond against the northern side of the Morrison Creek levee reach between the Sacramento River and Interstate Highway 5 and then overtop the levee and continue southerly into the Beach-Stone Lakes Basin.

Second Restudy

The survey data on which the hydraulic models and floodplain mapping were based is listed in Table 3.

Table 3. Survey Data Summary

Model Name	Model Type	Data Source	Survey Year	Contour Interval
Channel	HEC-RAS	Comprehensive Study - Photogrammetric & Bathymetric Data[1]	1997	2 foot
Sutter Basin	FLO-2D	Comprehensive Study Photogrammetric	1997	2 foot

[1]Bathymetric data was not available for Bear River and tributaries (Dry Creek, Yankee Slough). Cross section inverts in these reaches reflect low flow water surface elevations at time of photogrammetric survey.

Table 4 lists bridges represented in the model within the LFR study area and data sources for dimensions. For bridges in which field measurements were used to obtain dimensions, elevations were obtained by estimating the vertical distance between top of levee and bridge deck. Top of levee elevations from the survey data were then used to estimate elevations of bridge features.

Table 4. Bridge Data

River/Stream	HEC-RAS River Mile	Crossing	Data Source
Feather River	9.270	HWY 99	As-Built Drawing
Feather River	27.955	UPRR	Field Measurements
Feather River	27.970	5th Street	As-Built Drawing
Feather River	28.321	HWY 20	As-Built Drawing
Bear River	3.565	HWY 70	As-Built Drawing
Bear River	4.066	UPRR	Field Measurements
Bear River	6.925	Pleasant Grove Rd.	As-Built Drawing
Bear River	11.540	HWY 65	As-Built Drawing
Bear River	11.568	UPRR	Field Measurements

The starting point for developing the channel hydraulic model was the UNET (Reference 13) model developed for the Comp Study (References 21 and 22). River alignments and cross section geometry from this model were imported into HEC-RAS (References 20). Manning's n values were initially taken from the UNET model, but were later adjusted during calibration.

Downstream boundary conditions consisted of stage-discharge rating curves at the Verona stream gage on the Sacramento River and at the "Near Woodland" gage in the Yolo Bypass near Interstate 5.

The channel model was calibrated to the 1997 storm event. The model was calibrated by adjusting Manning's "n" values to provide a reasonable fit to observed peak stages. Peak stage data was available in the form of recorded stage hydrographs at gauges, and observed high water marks collected in the weeks following the storm event. The calibrated model closely reproduced stage hydrographs at gage locations. Table 5 summarizes observed and computed peak stages at the stream gage locations bounding the LFR study area. Observed high water marks are included in the hydraulic model, and can be plotted using HEC-RAS.

Table 5. 1997 Peak Stages at Stream Gage Locations

River	River Mile	Gage Location	Operating Agency	1997 Recorded Stage (ft, NGVD29)	1997 Computed Stage (ft, NGVD29)
Feather River	27.5	Yuba City	DWR	75.2	75.2
Feather River	8.0	Nicolaus	DWR	47.3	47.2
Yuba River	6.1	Near Marysville	DWR	88.6	88.7
Bear River	6.9	Pleasant Grove Road	DWR	70.8	70.7

Model Simulations

Twelve simulations were performed with no levee failures. These correspond to the combination of three storm centerings (Shanghai-Yuba, Bear River, and Bear River Tributaries) and four event magnitudes (the 10-, 2-, 1-, and 0.2-percent-annual-chance exceedance events).

Additional simulations were performed for the 1-percent-annual-chance events to identify combinations of levee failures that produce increased stages at locations throughout the Lower Feather River levee system. Bear River tributaries can become flooded when Bear River levees fail, allowing additional water into the tributaries. The lower Bear River can become flooded if a levee fails on the Yuba River left bank. Table 6 lists the channel model simulations that were run along with the HEC-RAS short identifications (short IDs). The short IDs are useful for identifying output data in the HEC-RAS project. As an example, the short ID "100-BR-A" indicates the 100-year (1-percent-annual-chance) Bear River centering with levee failure scenario A. The other short IDs are SHY for the Shanghai Bend storm centering, and BRT for the Bear River Tributary storm centering. The different scenarios were developed for the purpose of identifying the maximum 1-percent-annual-chance composite water-surface profile in the channel.

Table 6. 1-Percent-Annual-Chance Model Simulations

HEC-RAS Short ID	Levee Failure Locations
100-SHY	No levee failures
100-BR	No levee failures
100-BRT	No levee failures
100-BR-A	Bear River (L) RM 11.50-7.00, 6.916-6.00, 3.85-3.58, 3.00-1.01; Yankee Slough (L) RM 6.37-5.71, 5.38-4.34, 4.26-3.56, 3.25-2.00, 1.75-1.00; Dry Creek (L) RM 4.44-4.00, 5.16-4.70
100-BR-B	Bear River (R)RM 11.50-7.98; Dry Cr. (R) RM 2.85-2.38, 2.23-2.05, 1.87-1.00
100-SHY -C	Bear River (L) RM 3.00-1.01
100-SHY-D3	Feather River (R) RM 22.50-20.00
100-BR-E	Bear River (L)RM 11.50-10.00
100-BR-F	Bear River (L) RM 8.75-8.25
100-SHY-G	WPIC (R) RM 1.25-0.25; Dry Creek (L) RM 2.23-2.05, 1.87-1.00
100-BR-H	WPIC (R) RM 1.25-0.25 Dry Creek (L) RM 2.23-2.05, 1.87-1.00
100-BR-I	Bear River (R)RM 11.50-7.00 Dry Creek (L) RM 4.60-3.75,3.50-2.24, 1.87-1.00
100-BR-J	Bear River (R) RM 5.49-4.37; WPIC (L) RM 1.25-0.25; Best S1. (L) RM 1.00-0.25
100-BR-K	Bear River (R) RM 5.49-4.37; WPIC (L) RM 4.75-2.75; Best S1. (L) RM 1.00-0.25; Best S1. (R) RM 1.00-0.25
100-SHY-P	Feather River (L) RM 27.00-13.50
100-BR-Q	Bear River (R)RM 11.25-7.25
100-BRT-R	Dry Creek (L) RM 5.09-3.25

The levee failure scenarios were represented in HEC-RAS models by specifying lateral weirs at the overbank ground elevation to simulate the absence of the levee.

Flood profiles generated are for Yankee Slough and for the Feather and Bear Rivers for the 10-, 2-, 1-, and 0.2-percent-annual-chance events. For each of these four events, the profile is the maximum of the three storm centerings evaluated and plotted. Note that the Base (1-percent-annual-chance) Flood Elevation for the Lower Feather River system is a composite using the highest 1-percent-annual-chance water surface elevation (WSEL) among all the modeled scenarios (with and without levees), except for those cross sections where the highest WSEL exceeds the top of levee elevation. In these instances, the top-of-levee elevation was used to determine the 1%-percent-annaul-chance WSEL. The model simulation which yielded the maximum water surface at each location for the 1-percent-annual-chance event is indicated by the HEC-RAS short ID.

The Lower Feather River Study showed that if the levee along the west side of the Feather River failed, floodwaters would leave the Feather River and pond in the area bounded by the levees located along the east side of the Sutter Bypass and the west side of the Feather River.

3.3 Vertical Datum

Flood elevations shown in this FIS report and on the FIRM are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding vertical datums, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

Fax: (301) 713-4172, or
Telephone: (301) 713-3242

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at the above listed information.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS report provides l-percent-annual-chance data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent-annual-chance flood elevations; delineations of the l-percent-annual-chance and 0.2-percent-annual-chance floodplains; and l-percent-annual-chance floodway. This information is presented on the FIRM and in many components of the FIS, including Flood Profiles, Floodway Data tables and Summary of Stillwater Elevation tables. Users should reference the data presented in the FIS as well as additional information that may be available at the local community map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied by detailed methods, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps.

The l-percent-annual-chance floodplain boundaries in the area affected by the levee-failed assumption were delineated, using topographic maps at a scale of 1:24,000, with a contour interval of 5 feet (Reference 16), and WSELs determined as previously described.

For the streams studied in detail, except for the reach of Natomas East Main Drainage Canal north of Dry Creek, flood boundaries were delineated using topographic maps at a scale of 1:24,000, enlarged to 1:12,000, with contour intervals of 5 and 10 feet (Reference 16).

Flood boundaries for Natomas East Main Drainage Canal north of Dry Creek were delineated using topographic maps at a scale of 1:6,000, with a contour interval of 2 feet (Reference 12).

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM. On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, AH), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM.

Approximate 1-percent-annual-chance floodplain boundaries in some portions of the study area were taken directly from the FHBM for Sutter County, California (Unincorporated Areas) (Reference 19).

Within this jurisdiction lie levees that have not been demonstrated by the community or levee owner to meet the requirements of NFIP regulation 65.10 regarding its ability to provide protection from the 1% annual chance flood event. As such, the floodplain boundaries in this area are subject to change. Please refer to the Notice to Flood Insurance Study Users page at the front of this FIS report for more information on how this may affect the floodplain boundaries shown on this FIRM.

4.2 Floodways

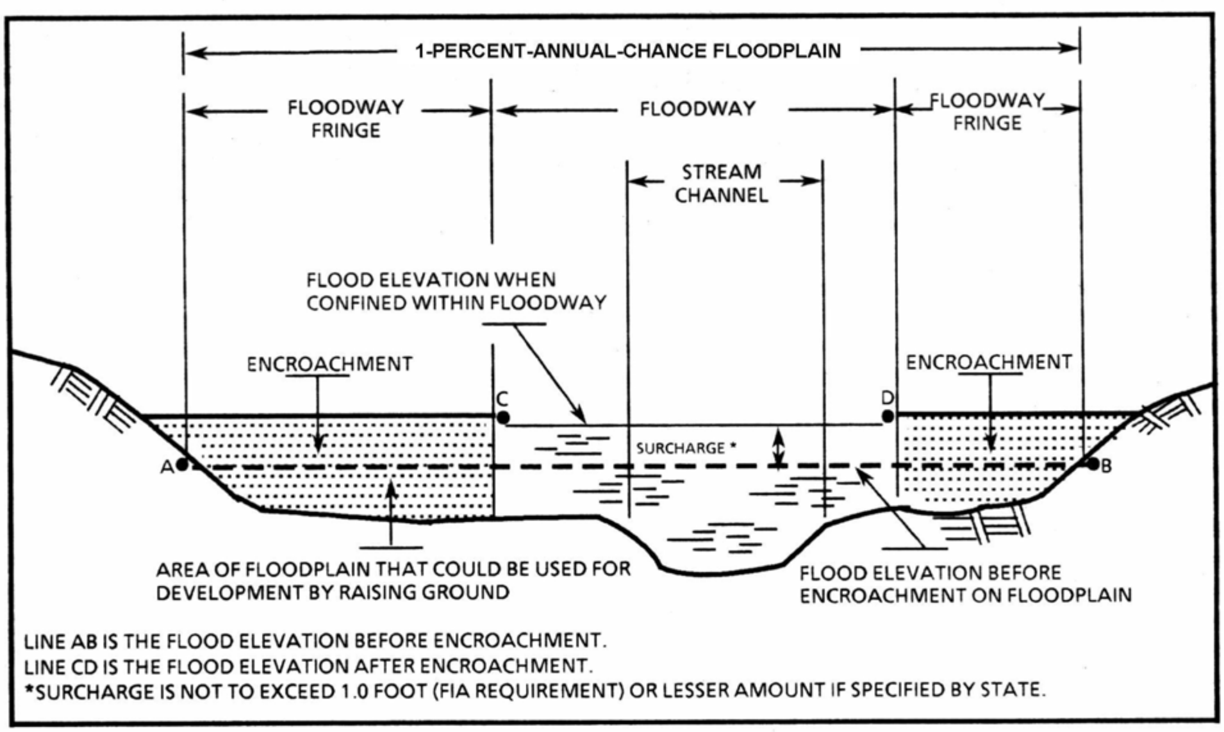
Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent-annual-chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

For the first revision, floodways were determined wherever step-backwater calculations were computed. However, a floodway was not established for the 0.5-mile reach south of Sankey Road at the upstream terminus of Natomas East Main Drainage Canal. This area of shallow sheet flow has no defined channel but, for this study, was considered an extension of Natomas East Main Drainage Canal.

The floodways presented in this revision were computed for certain stream segments on the basis of equal-conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (see Table 7, "Floodway Data"□). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the WSEL of the 1-percent-annual-chance flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1.

Figure 1. Floodway Schematic



FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Cross Canal								
A	0.107	485	5,830	2.7	39.2	39.2	39.2	0.0
B	0.489	515	12,550	1.2	39.4	39.4	39.4	0.0
C	1. 252	518	10,406	1.4	39.5	39.5	39.5	0.0
D	1.949	535	13,235	1.1	39.5	39.5	39.5	0.0
E	2.596	539	11 ,830	1.2	39.6	39.6	39.6	0.0
F	2.914	513	10,612	1.4	39.6	39.6	39.6	0.0
G	3.789	548	10,368	1.4	39.7	39.7	39.7	0.0
H	4.323	559	10,147	1.4	39.8	39.8	39.8	0.0
I	4.406	489	8,612	1.7	39.8	39.8	39.8	0.0
J	4.518	562	8,863	1.6	39.9	39.9	39.9	0.0
K	4.959	554	8,068	1.8	40.1	40.1	40.1	0.0
L	5.242	907	11,786	1.2	40.2	40.2	40.2	0.0

NOTE: These cross sections lie within an area that has not been updated on the FIRM at this time due to the presence of a levee that has not been demonstrated to meet the requirements of NFIP Regulation 65.10. Please refer to the Notice to Flood Insurance Study Users page at the front of this FIS for more information.

[1] Miles above confluence with the Sacramento River

TABLE 7

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

FLOODWAY DATA

CROSS CANAL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)[2]	MEAN VELOCITY (FEET PER SECOND)[2]	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY[2] (FEET NGVD)	INCREASE[2]
Natomas East Main Drainage Canal								
A	11.918	181	__	__	32.7	32.7	__	__
B	12.126	172	__	__	32.8	32.8	__	__
C	12.416	243	__	__	33.1	33.1	__	__
D	12.624	246	__	__	33.6	33.6	__	__
E	12.849	250	__	__	35.5	35.5	__	__
F	12.993	202	__	__	35.6	35.6	__	__
G	13.249	229	__	__	35.8	35.8	__	__
H	13.524	205	__	__	36.2	36.2	__	__
I	13.732	194	__	__	36.5	36.5	__	__
J	13.982	203	__	__	36.6	36.6	__	__
K	14.253	202	__	__	36.6	36.6	__	__
L	14.473	201	__	__	36.6	36.6	__	__

NOTE: These cross sections lie within an area that has not been updated on the FIRM at this time due to the presence of a levee that has not been demonstrated to meet the requirements of NFIP Regulation 65.10. Please refer to the Notice to Flood Insurance Study Users page at the front of this FIS for more information.

[1] Miles above confluence with the Sacramento River

[2] Data not available

TABLE 7

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

FLOODWAY DATA

NATOMAS EAST MAIN DRAINAGE CANAL

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Pleasant Grove Creek Channel								
A	0.568	403	4,213	0.6	40.3	40.3	40.3	0.0
B	0.858	381	3,972	0.7	40.3	40.3	40.3	0.0
C	1.119	356	3,622	0.7	40.3	40.3	40.3	0.0
D	1.403	361	3,989	0.7	40.4	40.4	40.4	0.0
E	1.664	351	3,724	0.7	40.4	40.4	40.4	0.0
F	1.978	337	3,753	1.3	40.5	40.5	40.5	0.0
G	2.266	318	3,430	1.4	40.6	40.6	40.6	0.0
H	2.556	307	3,176	1.5	40.7	40.7	40.7	0.0
I	2.792	295	2,885	0.3	40.7	40.7	40.7	0.0
J	3.031	257	2,653	0.3	40.7	40.7	40.7	0.0
K	3.298	189	1,864	0.0	40.7	40.7	40.7	0.0
L	3.550	165	1,215	0.0	40.7	40.7	40.7	0.0
M	3.785	135	1,323	0.0	40.7	40.7	40.7	0.0

NOTE: These cross sections lie within an area that has not been updated on the FIRM at this time due to the presence of a levee that has not been demonstrated to meet the requirements of NFIP Regulation 65.10. Please refer to the Notice to Flood Insurance Study Users page at the front of this FIS for more information.

[1] Miles above confluence with Cross Canal

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base (1-percent-annual-chance) flood elevations (BFEs) or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by detailed methods. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 foot and 3 feet. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 1-percent annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 1-percent annual chance floodplain that will be protected by a Federal flood protection system where construction has reached specific statutory milestones. No BFEs or flood depths are shown within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by levees. No BFEs or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use the zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

Within this jurisdiction lie multiple levees that have not been demonstrated by the community or levee owner to meet the requirements of NFIP regulation 65.10 regarding its ability to provide protection from the 1% annual chance flood event. Please refer to the Notice to Flood Insurance Study Users page at the front of this FIS report for more information on how this may affect the FIRM.

7.0 OTHER STUDIES

A watershed area study covering Sutter and Placer Counties was prepared by SCS and was published in April 1982 (Reference 2).

A revised FIS for the unincorporated areas of Sacramento County, dated September 1988, has been published (Reference 23). Portions of four waterways (the Sacramento and American Rivers, Natomas East Main Drainage Canal, and Dry Creek) that were investigated in the restudy were also included in the September 1988 revision for Sutter County. The stream mileages for three of the four waterways are greater in the restudy. Only the lower reach of Dry Creek was reanalyzed because of its interrelationship with major levee systems.

An FIS report for the unincorporated areas of Sutter County, dated April 1988, has been published (Reference 25). Three of the waterways (Sacramento River, Cross Canal and Pleasant Grove Creek Canal) that were investigated in the restudy were also included in the April 1988 study. The stream mileages for Cross Canal and Pleasant Grove Creek Canal are the same for both studies. The stream mileage for the Sacramento River is greater in the restudy.

The April 1988 Sutter County FIS (Reference 25) did not contain flood profiles. However, it does contain BFE data for Pleasant Grove Creek Canal and Cross Canal (except for the lower portion). The lower portion of Cross Canal was studied by approximate methods in the April 1988 study, whereas it was studied by detailed methods in the first restudy.

As part of the first revision, l-percent-annual-chance discharge for the Sacramento River was added to Summary of Discharges (Table 2), and the l-percent-annual-chance discharges for Pleasant Grove Creek Canal and Cross Canal were revised due to the restudy.

In December 2005, the USACE published the Sacramento and San Joaquin River Basins Comprehensive Study (Comprehensive Study). It is a compilation of numerous technical analyses that were conducted to inventory resource conditions in the Sacramento and San Joaquin River Basins and to analyze problems for flood management and ecosystem restoration.

This report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the NFIP.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Federal Insurance and Mitigation Division, FEMA Region IX, 1111 Broadway, Suite 1200, Oakland, California 94607-4052.

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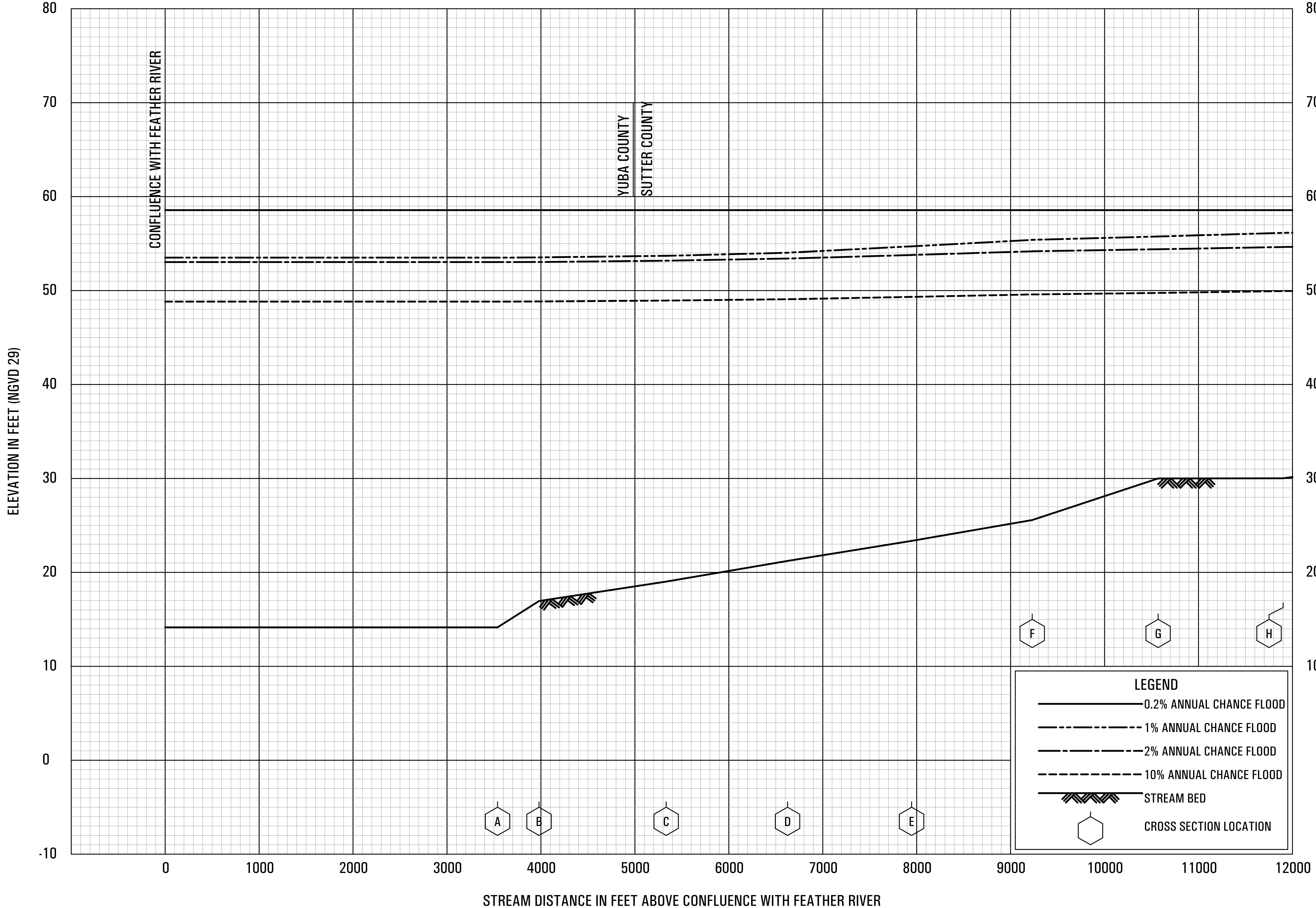


FLOOD PROFILES

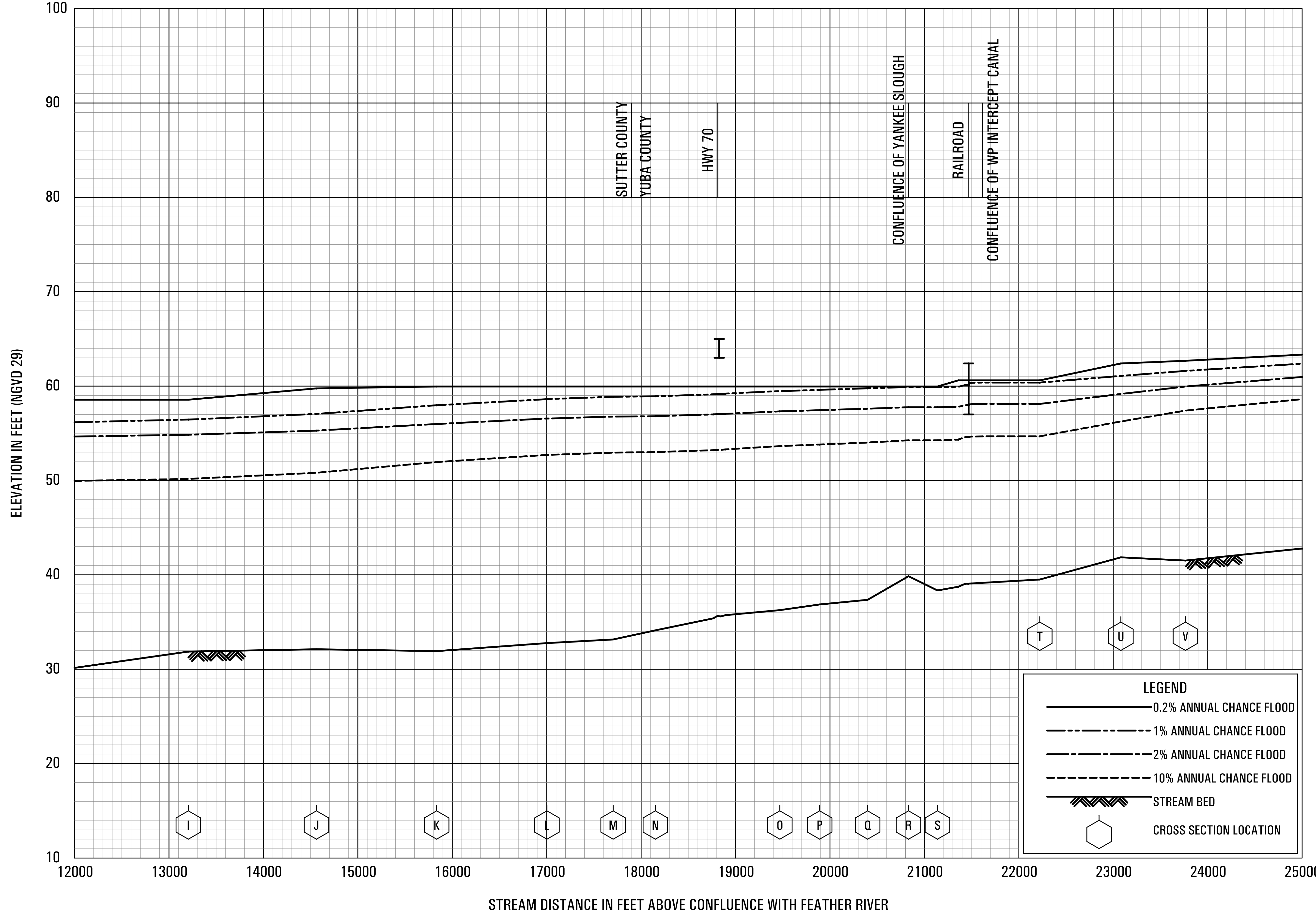
BEAR RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

01P



FLOOD PROFILES

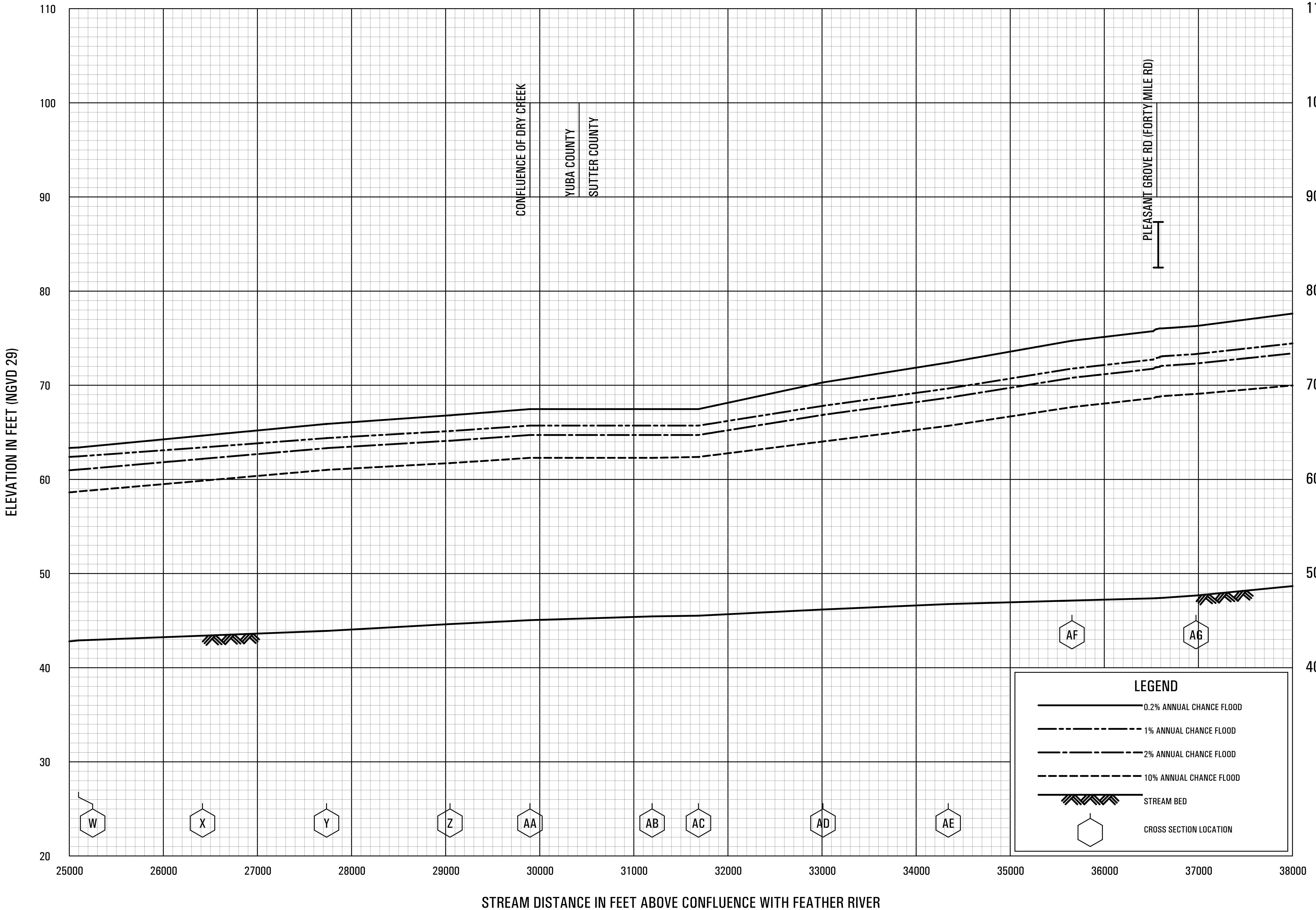
BEAR RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

02P



FLOOD PROFILES

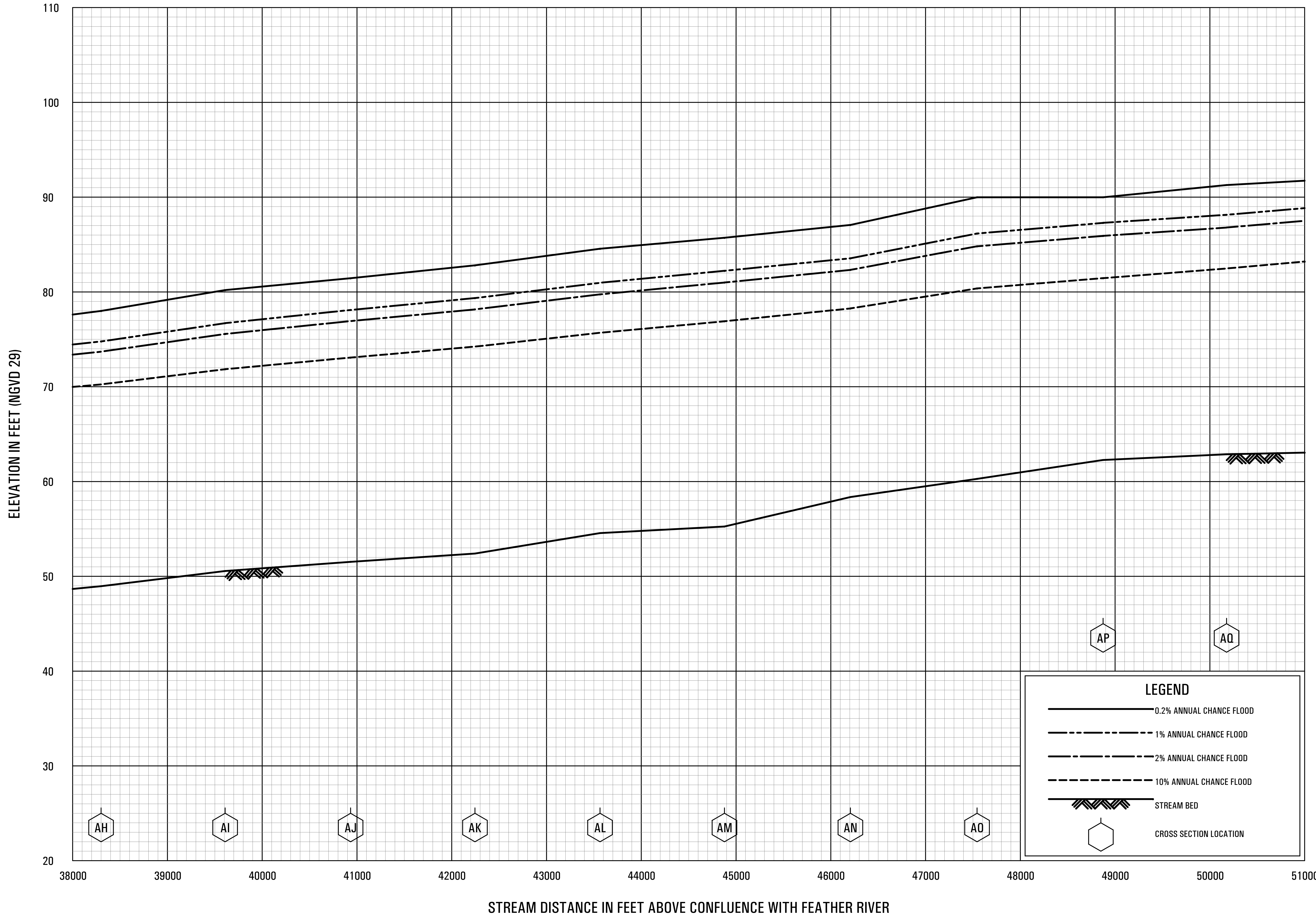
BEAR RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

03P



FLOOD PROFILES

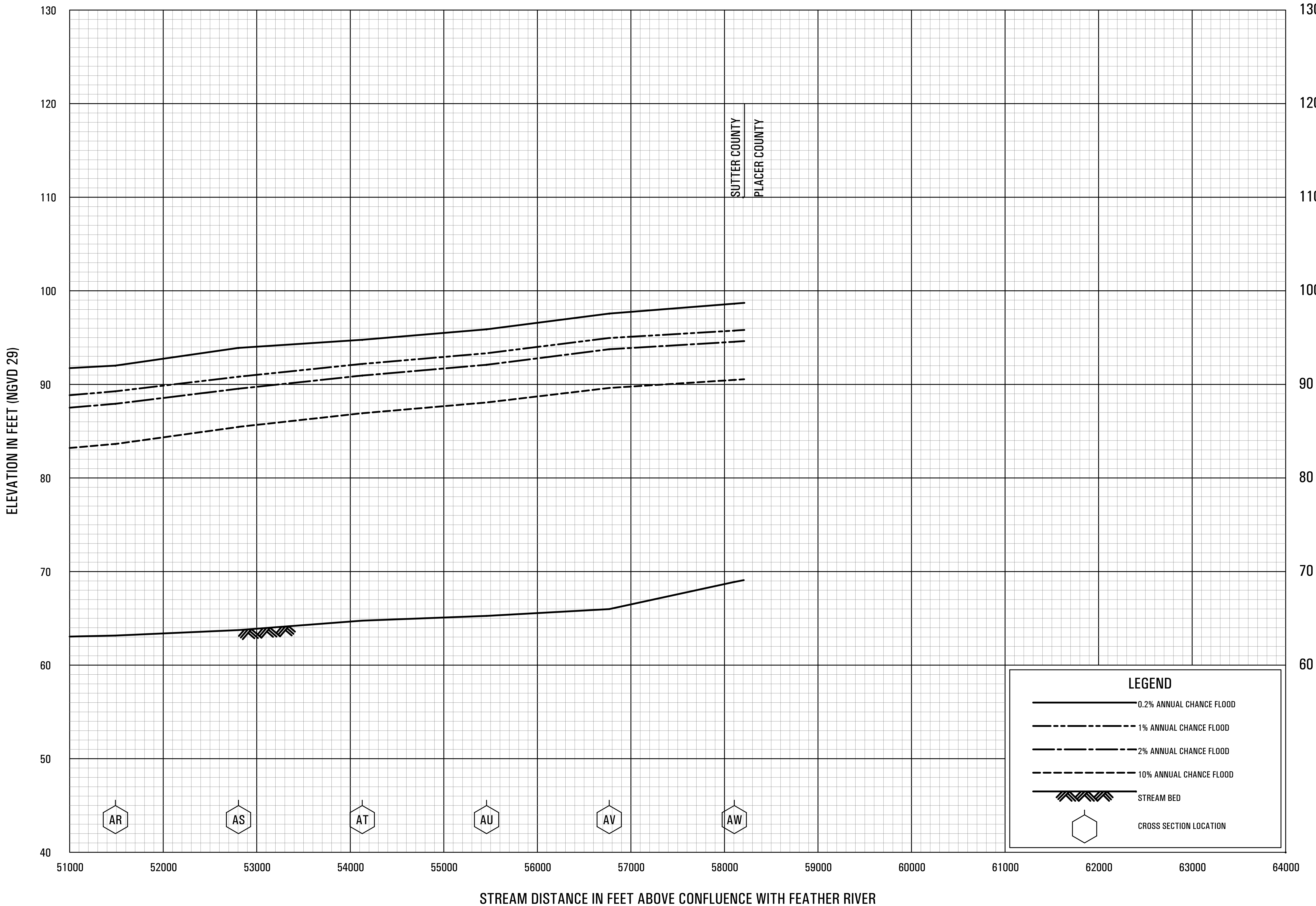
BEAR RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

04P



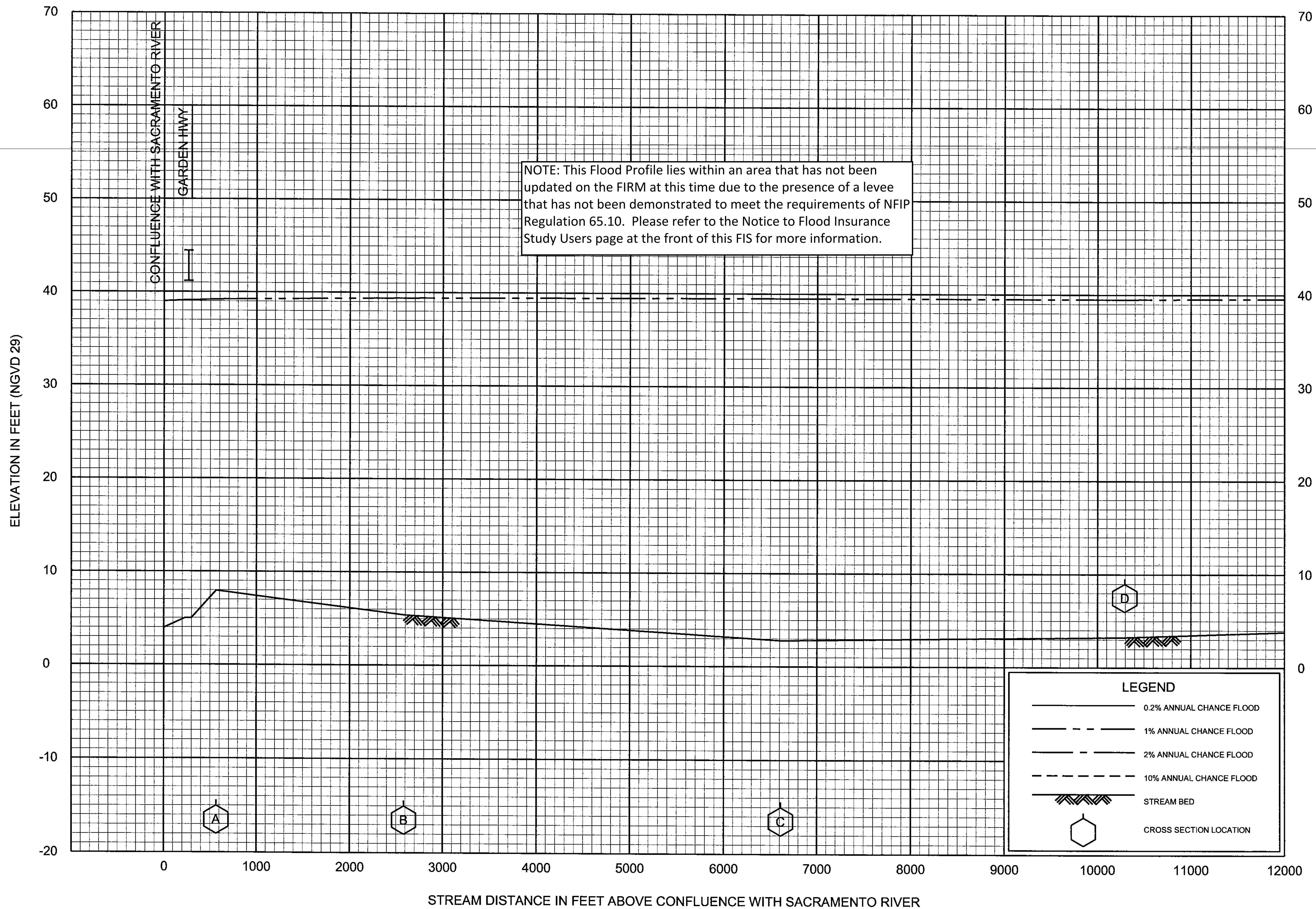
FLOOD PROFILES

BEAR RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA
(UNINCORPORATED AREAS)

05P



FLOOD PROFILES

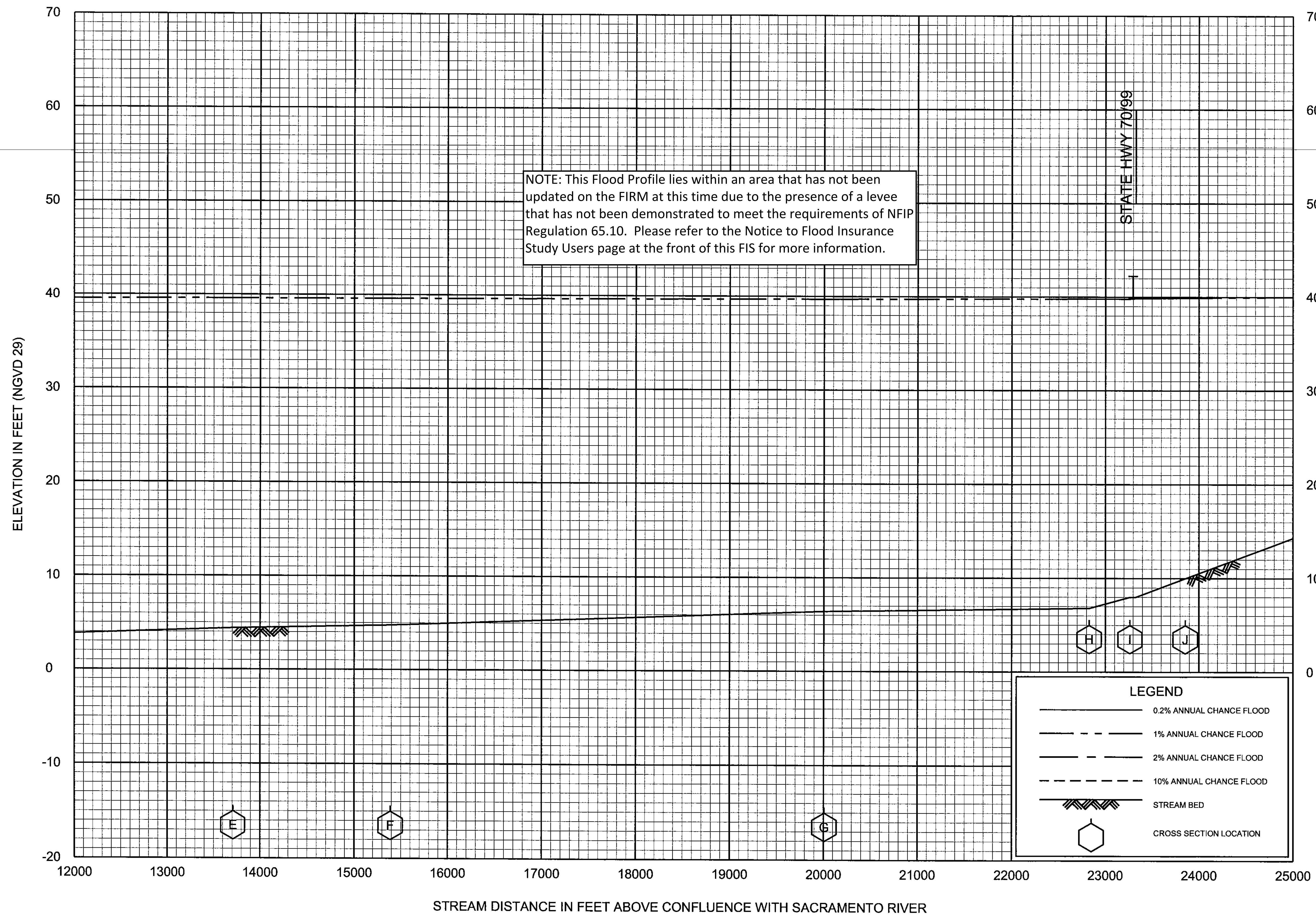
CROSS CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

06P



FLOOD PROFILES

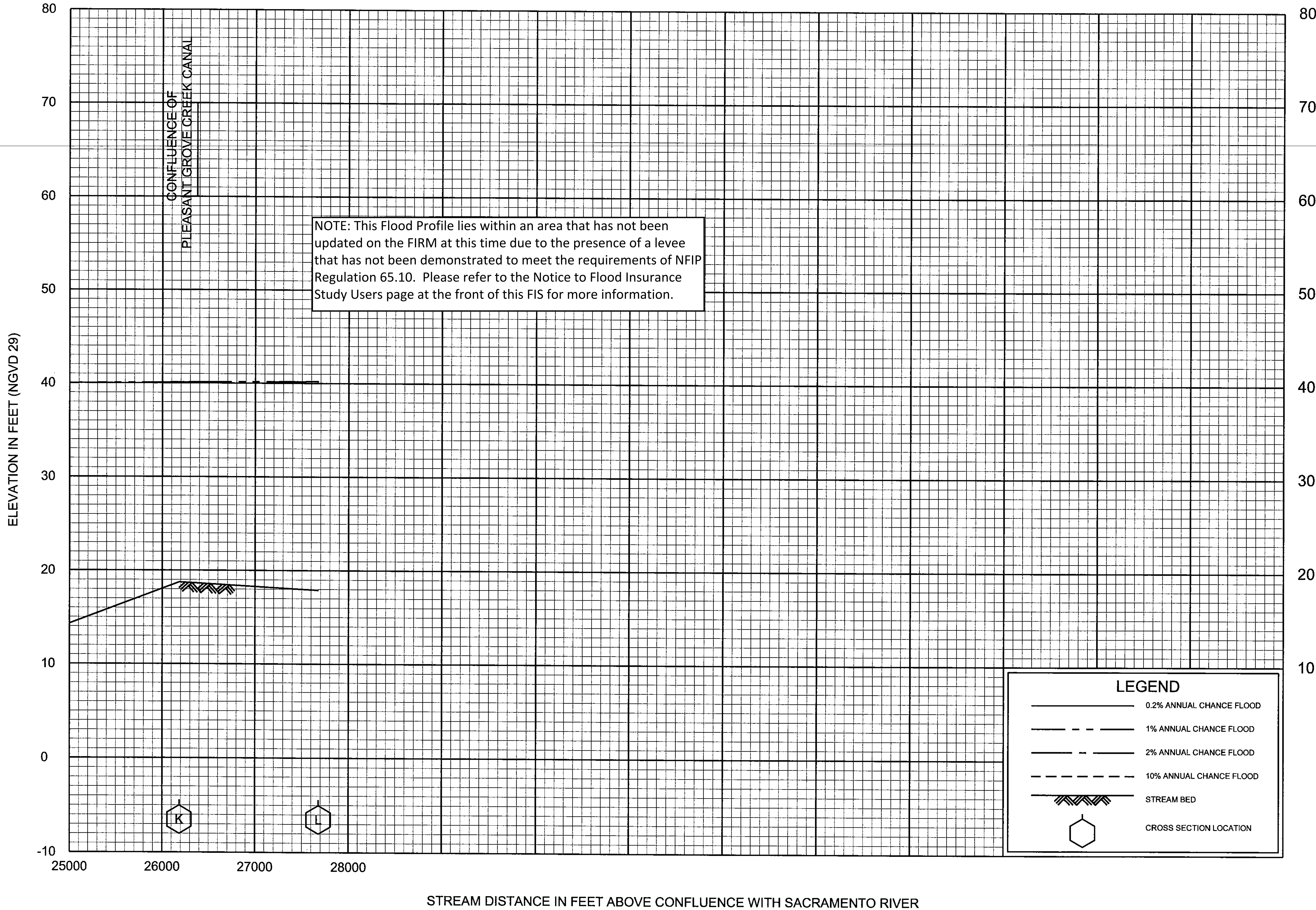
CROSS CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

07P



NOTE: This Flood Profile lies within an area that has not been updated on the FIRM at this time due to the presence of a levee that has not been demonstrated to meet the requirements of NFIP Regulation 65.10. Please refer to the Notice to Flood Insurance Study Users page at the front of this FIS for more information.

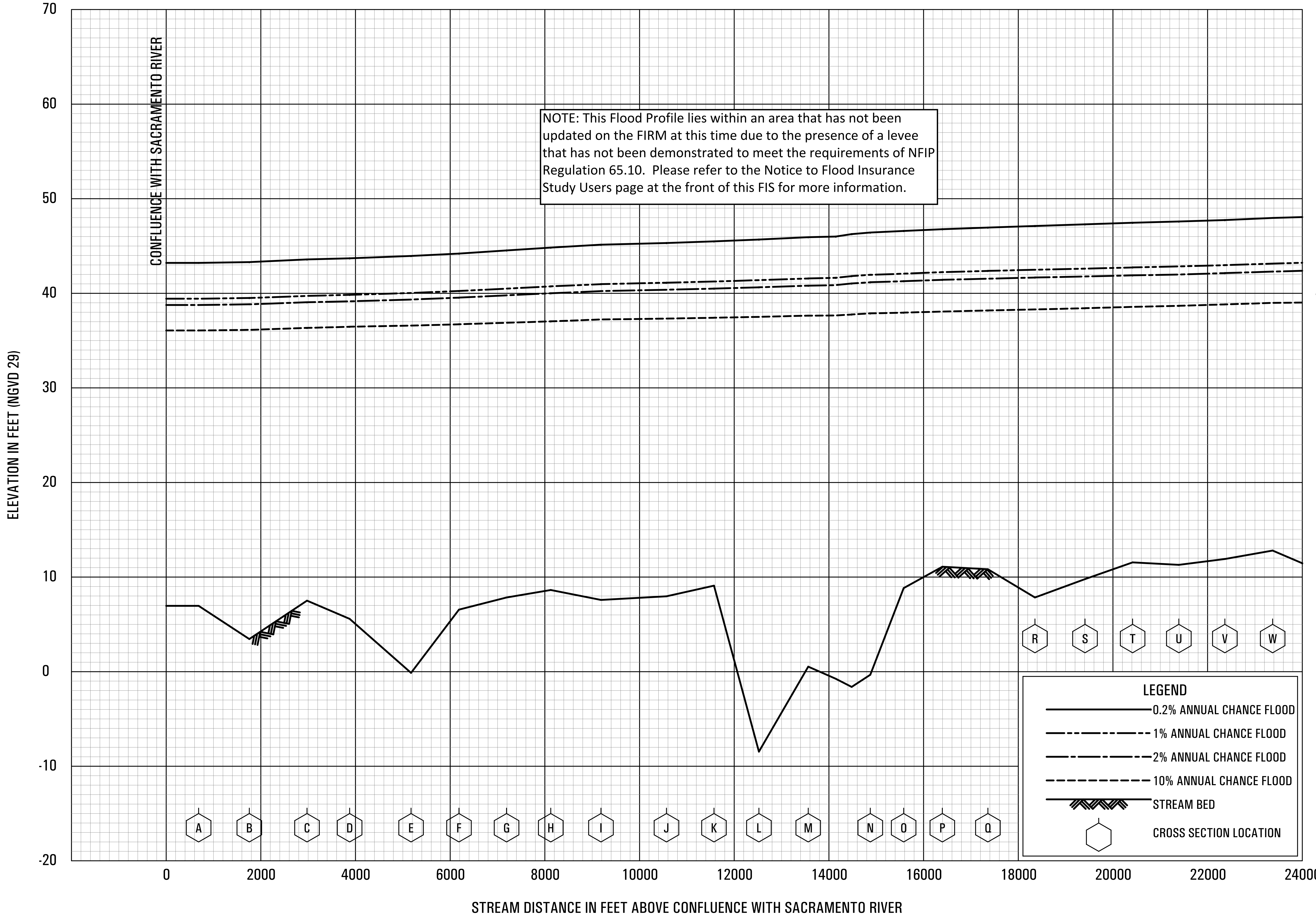
FLOOD PROFILES

CROSS CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)



FLOOD PROFILES

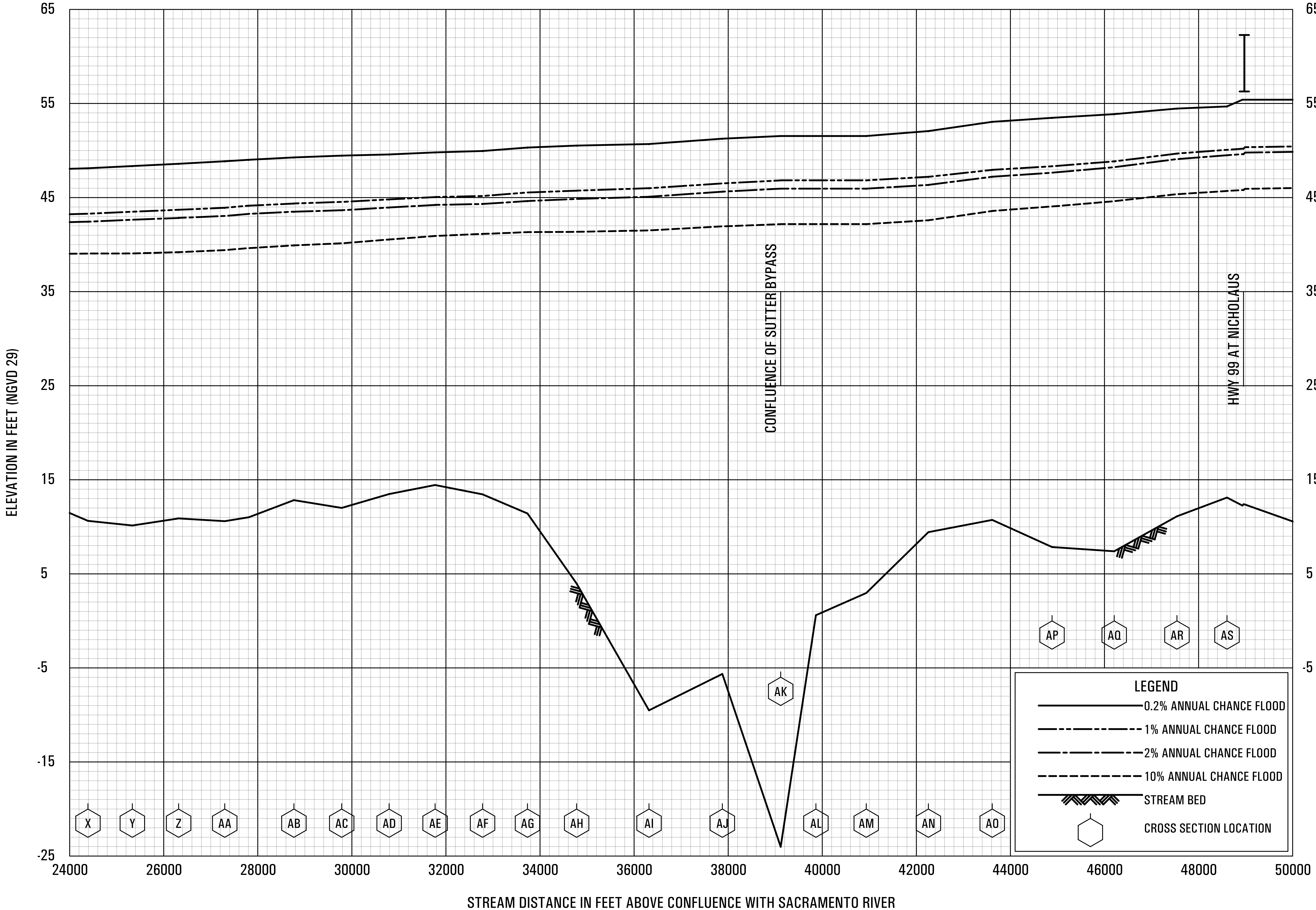
FEATHER RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

09P



FLOOD PROFILES

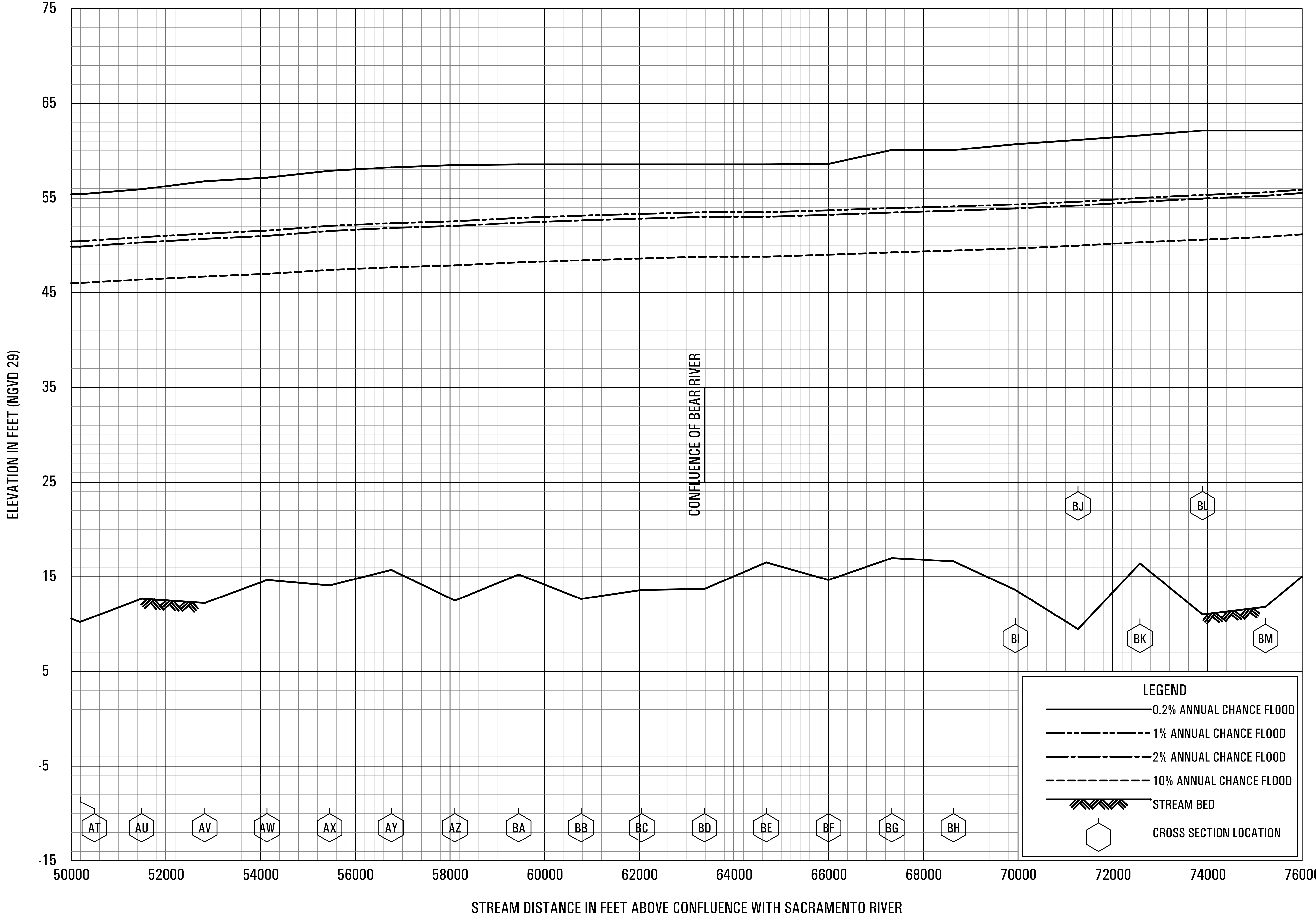
FEATHER RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

10P



FLOOD PROFILES

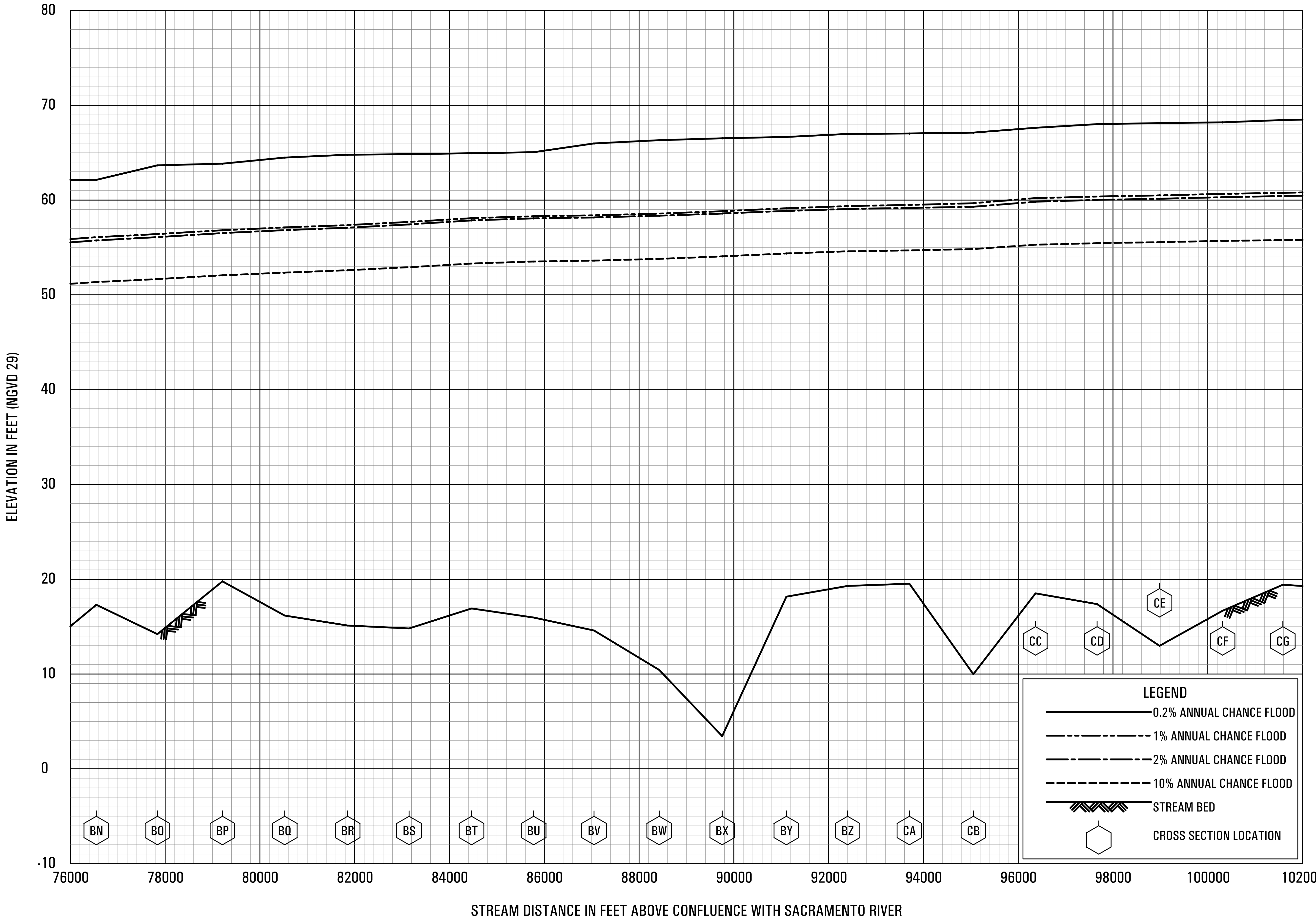
FEATHER RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

11P



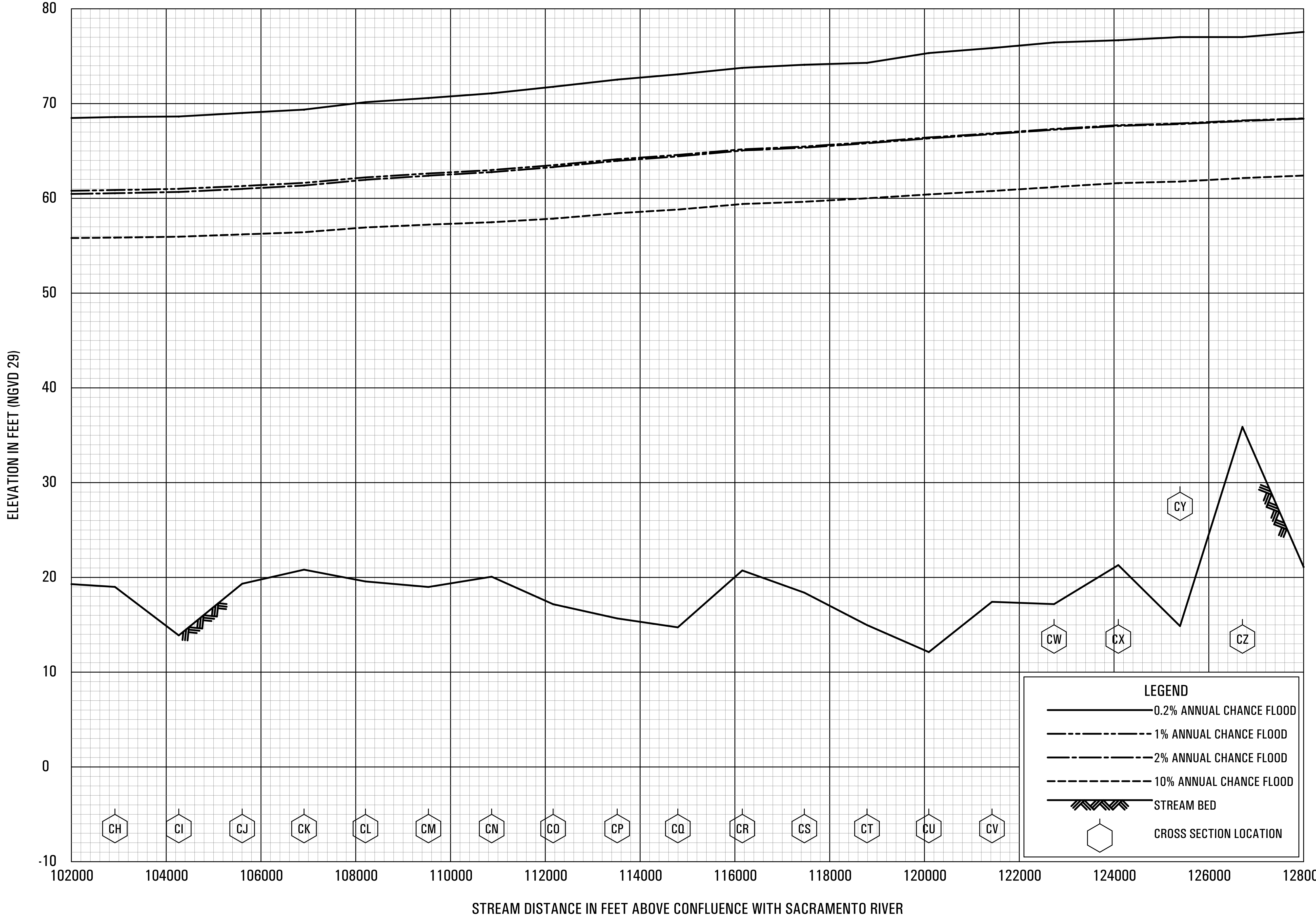
FLOOD PROFILES

FEATHER RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)



FLOOD PROFILES

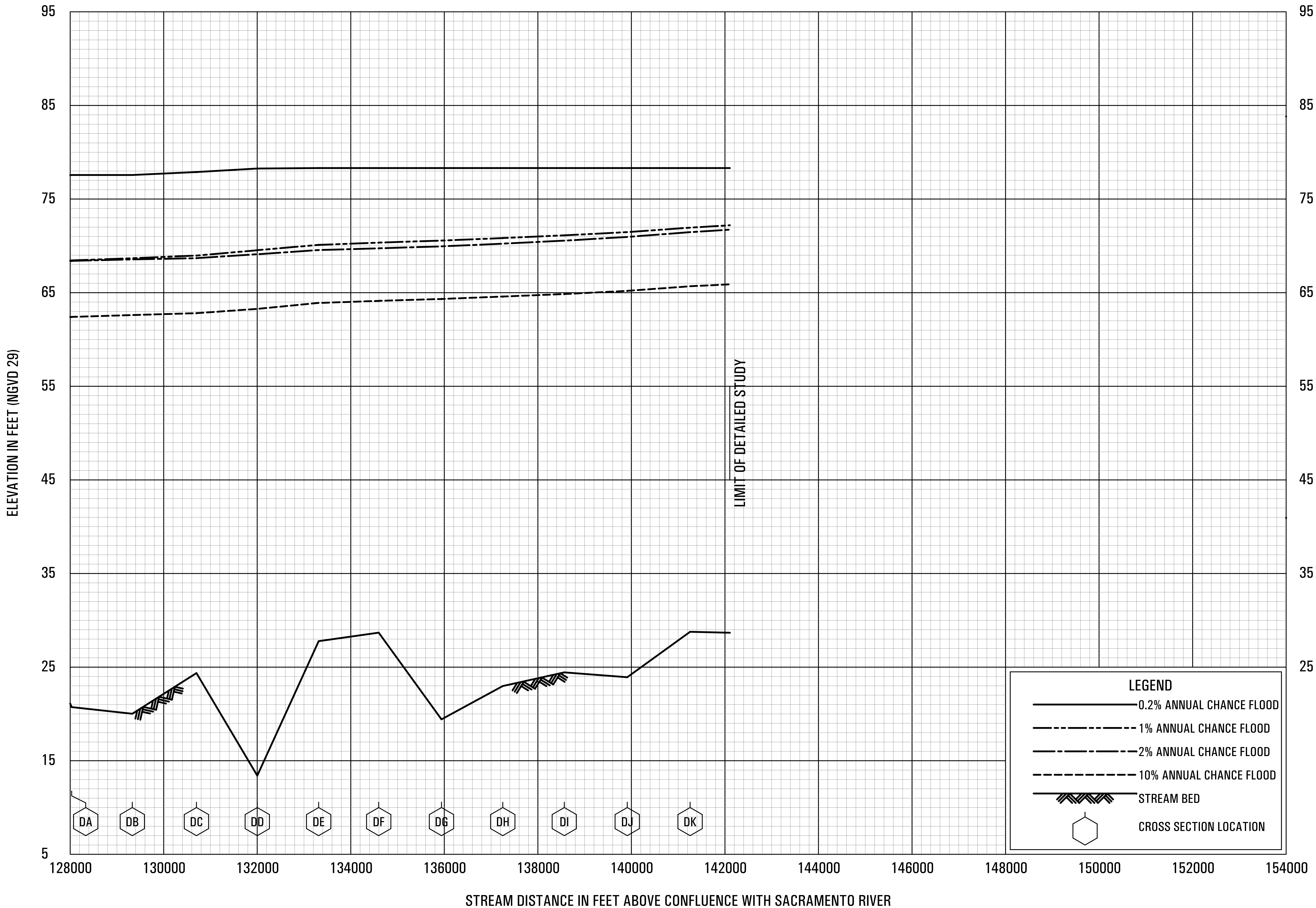
FEATHER RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

13P



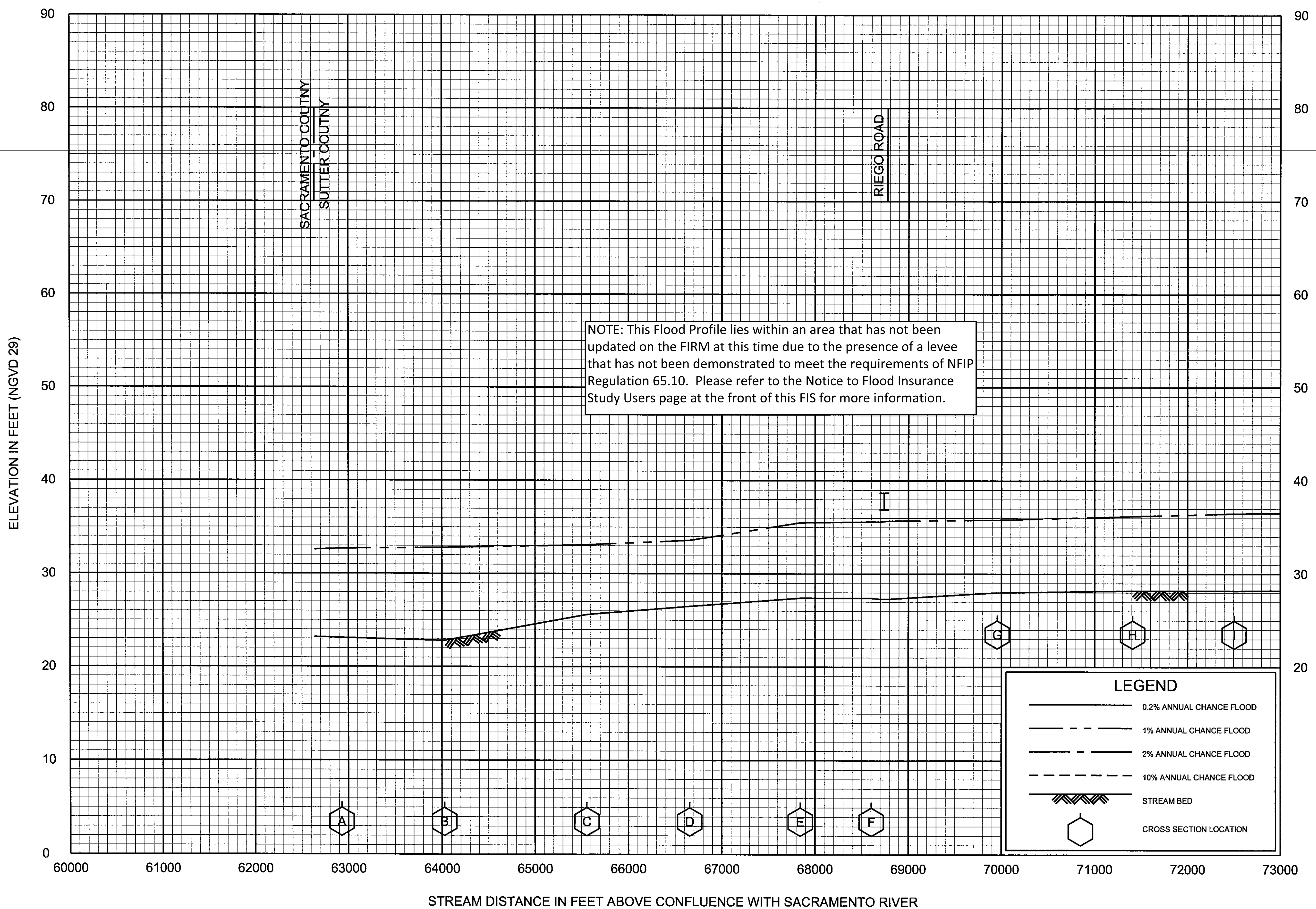
FLOOD PROFILES

FEATHER RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)



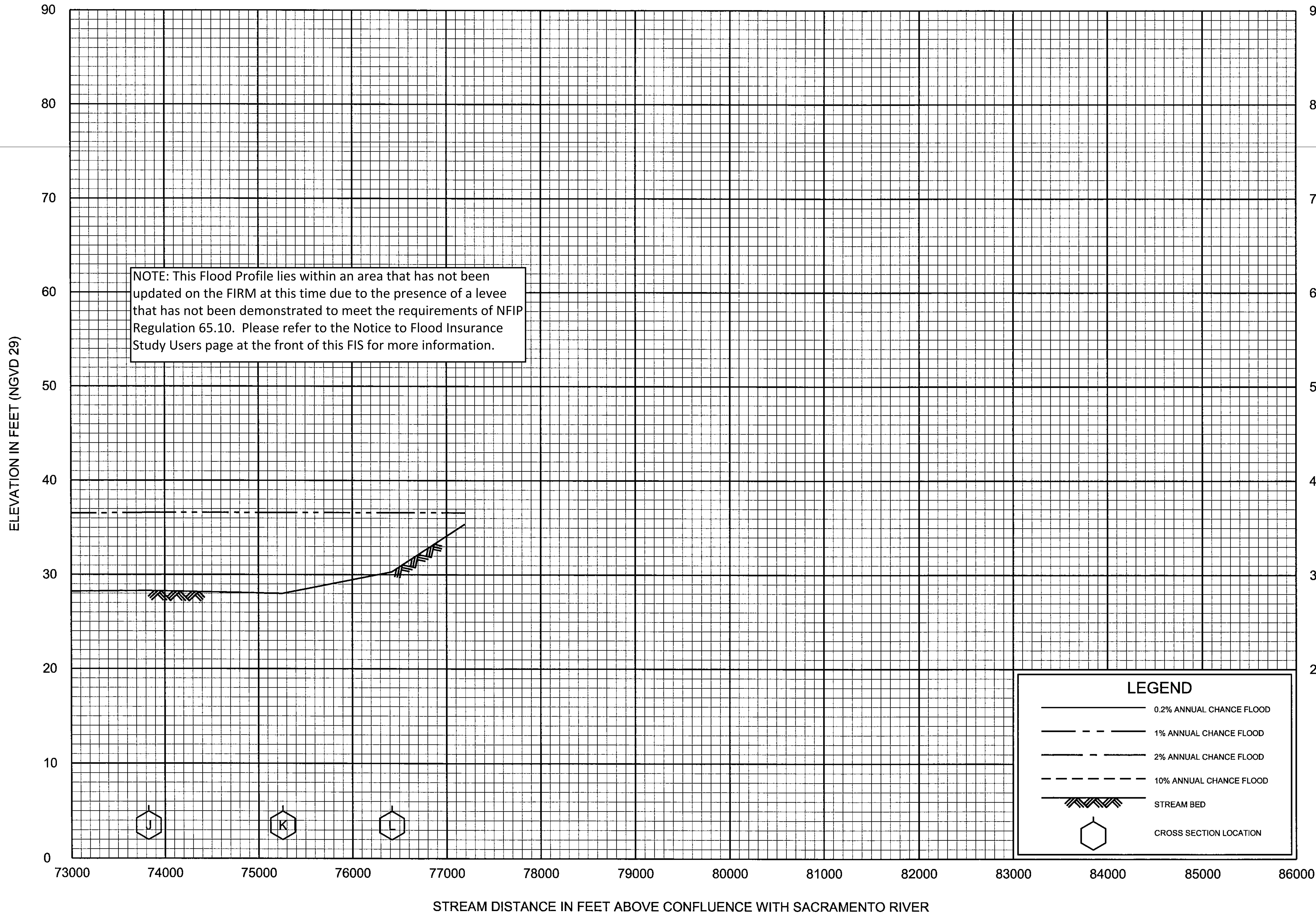
FLOOD PROFILES

NATOMAS EAST MAIN DRAINAGE CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)



FLOOD PROFILES

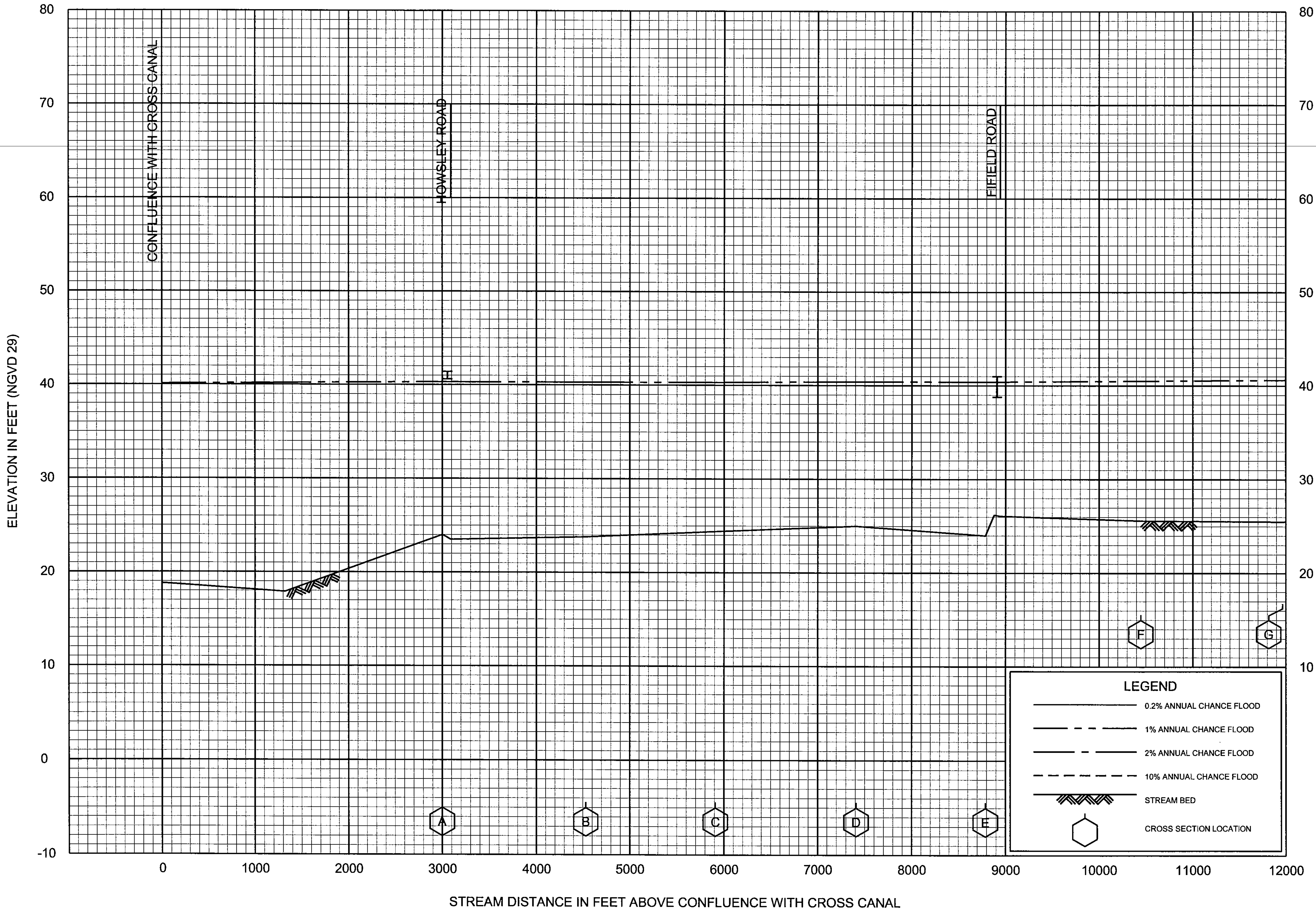
NATOMAS EAST MAIN DRAINAGE CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

16P



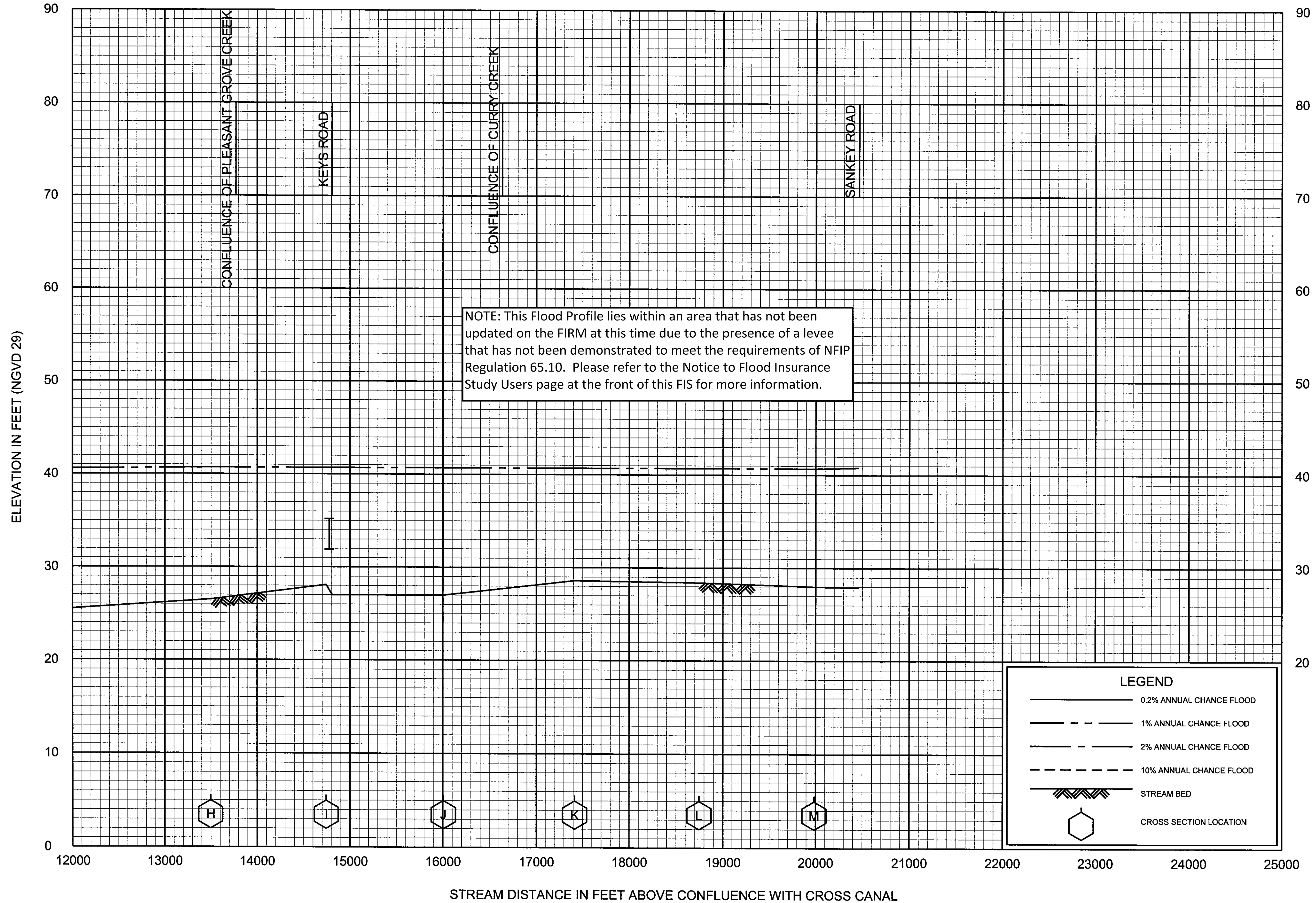
FLOOD PROFILES

PLEASANT GROVE CREEK CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)



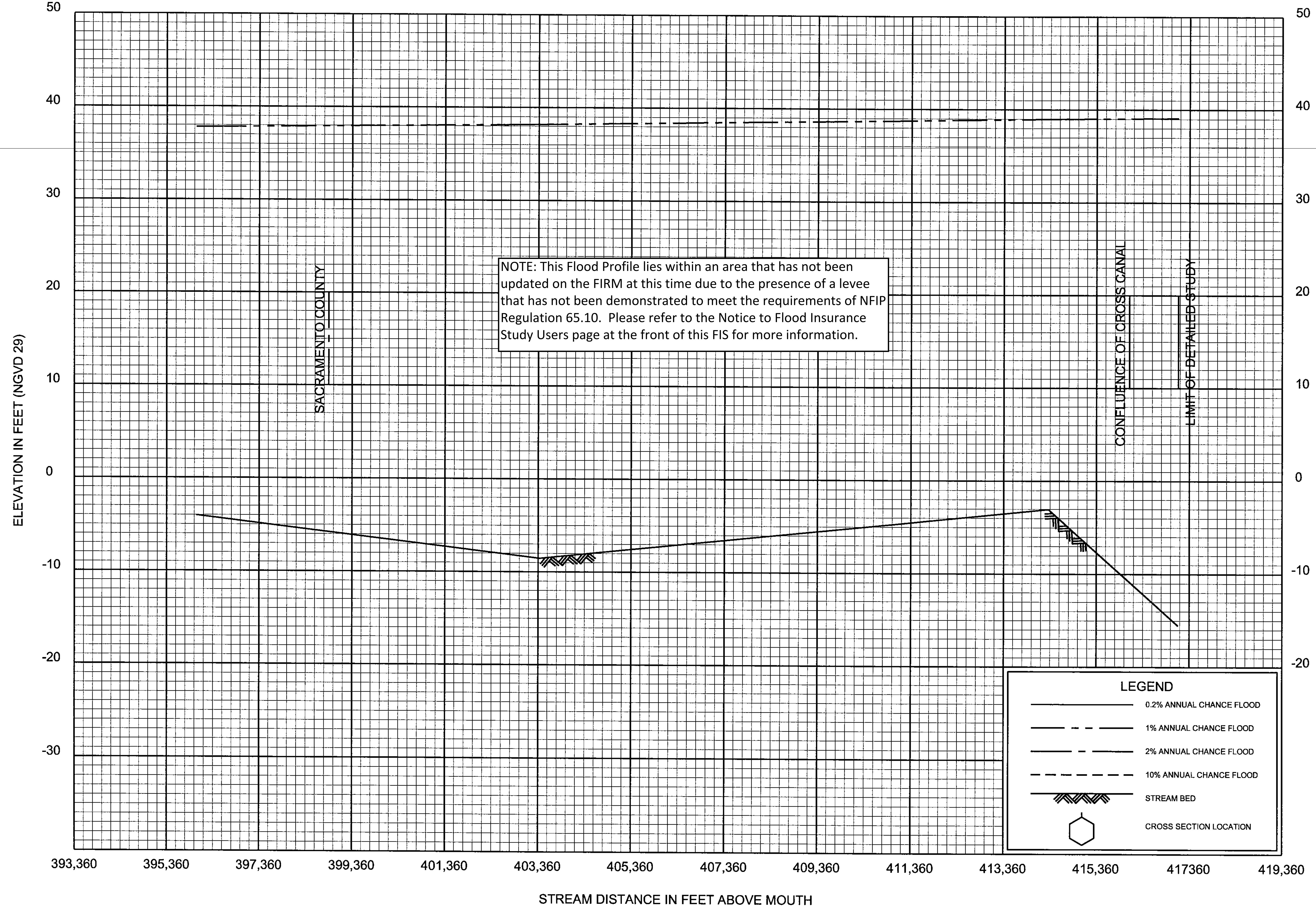
FLOOD PROFILES

PLEASANT GROVE CREEK CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)



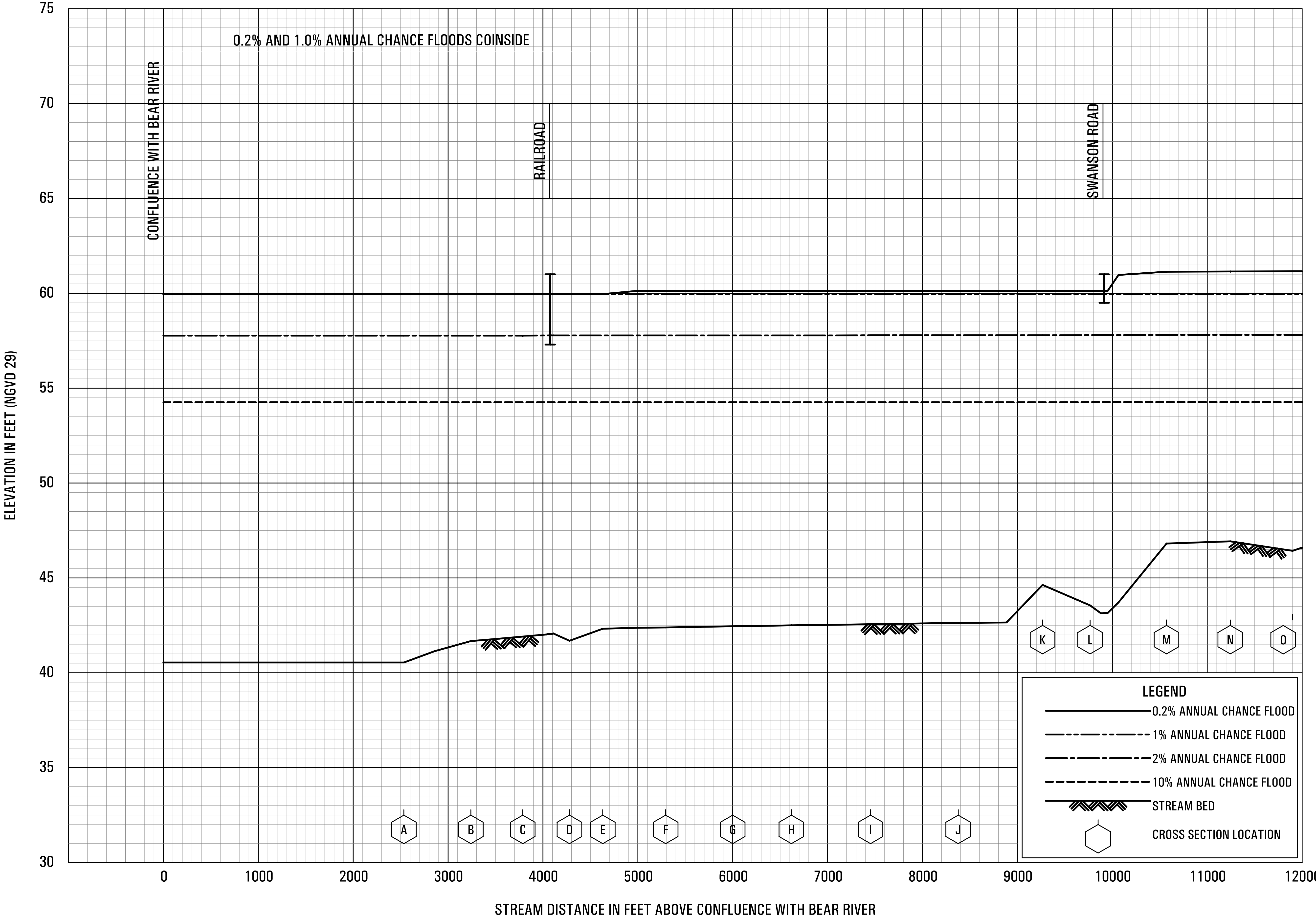
FLOOD PROFILES

SACRAMENTO RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)

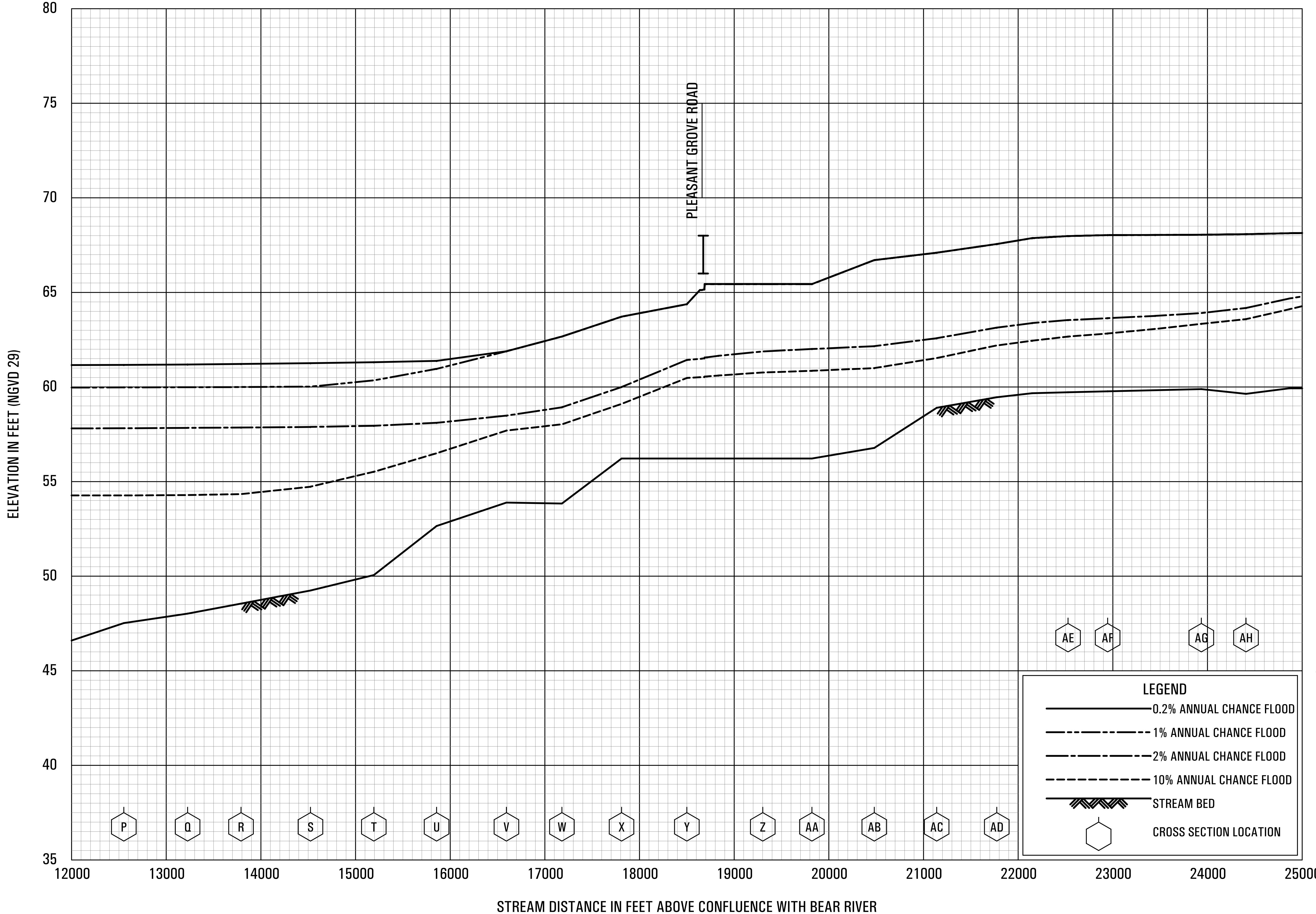


FLOOD PROFILES

YANKEE SLOUGH

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA
(UNINCORPORATED AREAS)



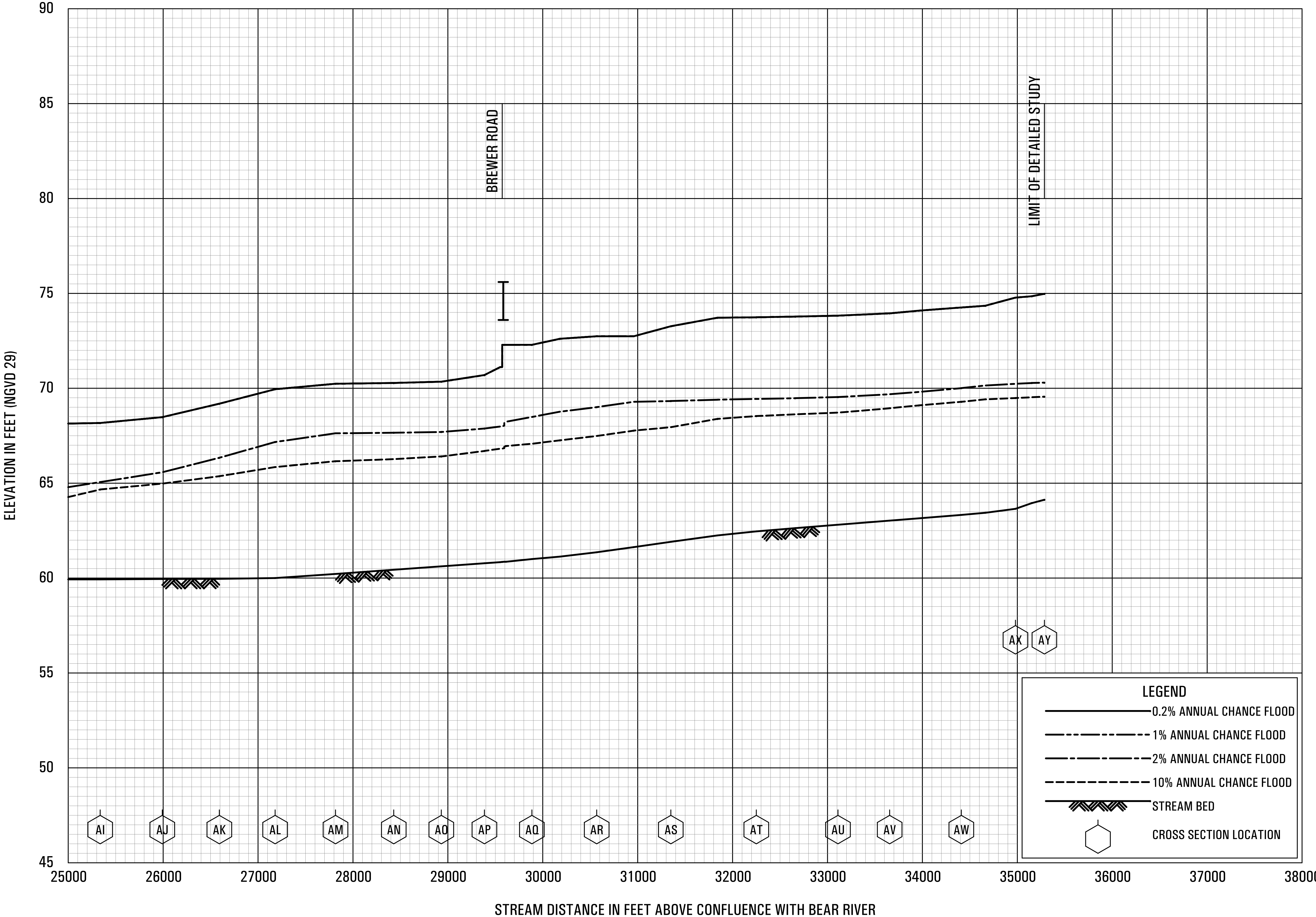
FLOOD PROFILES

YANKEE SLOUGH

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)



FLOOD PROFILES

YANKEE SLOUGH

FEDERAL EMERGENCY MANAGEMENT AGENCY

SUTTER COUNTY, CA

(UNINCORPORATED AREAS)