Technical Memorandum

Channel Capacity Report
2015 Restoration Year

SAN JOAQUIN RIVER
RESTORATION PROGRAM

January 2015 - Final Report

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List of Abbreviations and Acronyms

CBBS	Chowchilla Bypass Bifurcation Structure
CCAG	Channel Capacity Advisory Group
CDEC	California Data Exchange Center
CFS	Cubic feet per second
CPT	Cone Penetration Test (Cone Penetrometer Test)
CVFPP	Central Valley Flood Protection Plan
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPB	Central Valley Flood Protection Board
Delta	Sacramento-San Joaquin Delta
DMC	Delta-Mendota Canal
DTM	Digital Terrain Model
DWR	Department of Water Resources
FSRP	Flood System Repair Project
GAR	Geotechnical Assessment Report
GDR	Geotechnical Data Report
GOR	Geotechnical Overview Report
LMAs	Local Maintaining Agencies
LSJLD	Lower San Joaquin Levee District
LSJRFC Project	Lower San Joaquin River Flood Control Project
MNWR	Merced National Wildlife Refuge
NRDC	Natural Resources Defense Council
NULE	Non-Urban Levee Evaluation
O&M	Operations and Maintenance
PEIS/R	Program Environmental Impact Statement/Environmental Impact Report
RACER	Remedial Alternatives and Cost Estimates Report
Reclamation	Bureau of Reclamation
Restoration Area	San Joaquin River Restoration Program Restoration Area
RFMP	Regional Flood Management Plan
RM	River mile
ROD	Record of Decision
SJLE Project	San Joaquin Levee Evaluation Project
SJRRP	San Joaquin River Restoration Program
SPFC	State Plan of Flood Control
WSE	Water surface elevation
WSP	Water surface profile
ULE	Urban Levee Evaluation
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USJR	Upper San Joaquin River

Definitions

San Joaquin River Restoration Program (SJRRP): The SJRRP (also known as Program) was established in late 2006 to restore and maintain fish populations in good condition in the mainstem of the San Joaquin River (SJR) below Friant Dam to the confluence of the Merced River, while reducing or avoiding adverse water supply impacts.

Settlement: In 2006, the SJRRP was established to implement the Stipulation of Settlement in *NRDC, et al., v. Kirk Rodgers, et al.*

Program Environmental Impact Statement/Environmental Impact Report (PEIS/R): The Bureau of Reclamation (Reclamation), as the federal lead agency under the National Environmental Policy Act (NEPA) and the California Department of Water Resources (DWR), the state lead agency under the California Environmental Quality Act (CEQA), jointly prepared a Program Environmental Impact Statement/Report (PEIS/R) and signed a Record of Decision and Notice of Determination (ROD and NOD), respectively, in 2012 to implement the Settlement.

Channel Capacity Advisory Group: The Channel Capacity Advisory Group provides focused input to Reclamation's determination of "then-existing channel capacity" within the Restoration Area.

Then-existing channel capacity: The channel capacity within the Restoration Areas that correspond to flows that would not significantly increase flood risk from Restoration Flows in the Restoration Area. Then-existing channel capacities currently being followed were defined from an analysis included in the PEIS/R; this annual report will recommend updating then-existing channel capacity based on recently completed evaluations.

In-channel capacity: The flow at which the water surface elevation is maintained at or below the elevation of the outside ground (i.e., along the landside levee toe).

1.0 Executive Summary

Background

The San Joaquin River Restoration Program (SJRRP) was established in late 2006 to implement a Stipulation of Settlement (Settlement) in NRDC, et al., v. Kirk Rodgers, et al. The U.S. Department of the Interior, Bureau of Reclamation, the Federal lead agency under the National Environmental Policy Act, and the California Department of Water Resources (DWR), the State lead agency under the California Environmental Quality Act, prepared a joint Program Environmental Impact Statement/Report (PEIS/R) to support implementation of the Settlement.

The Settlement calls for releases of Restoration Flows, which were initiated in 2014 and are specific volumes of water to be released from Friant Dam during different water year types, according to Exhibit B of the Settlement. Federal authorization for implementing the Settlement is provided in the San Joaquin River Restoration Settlement Act (Act) (Public Law 111-11). Reclamation signed the Record of Decision (ROD) on September 28, 2012. Both the PEIS/R and the ROD committed to establishing a Channel Capacity Advisory Group (CCAG) to determine and update estimates of then-existing channel capacities as needed and to maintain Restoration Flows at or below estimates of then-existing channel capacities. Then-existing channel capacities in the Restoration Area (leveed reaches within the San Joaquin River between Friant Dam and the confluence of the Merced River and the flood control bypass) correspond to flows that would not significantly increase flood risk from Restoration Flows. This Channel Capacity Report is for the 2015 Restoration Year and is the second report in a series of reports prepared annually. The 2015 Report, prepared in coordination with the CCAG, fulfills the commitments in the ROD.

The primary objective of this report is to provide the CCAG and the public a summary of the prior Restoration Year's data, methods, and estimated channel capacities and recommendations for monitoring and management actions for the following year. Identifying then-existing channel capacity is critically important to ensure the release of Restoration Flows would not significantly increase flood risk in the Restoration Area. This report only considers flood risks associated with levee failure when estimating then-existing channel capacity; all other potential material impacts, including agricultural seepage, are addressed in other analyses.

CCAG Roles and Responsibilities

The CCAG is comprised of members from the Bureau of Reclamation (Convener), California Department of Water Resources (DWR, Co-convener), U.S. Army Corps of Engineers (USACE), Lower San Joaquin Levee District (LSJLD), and the Central Valley Flood Protection Board (CVFPB). The role of the CCAG is to: (1) provide independent review of Reclamation's estimates of then-existing channel capacity as needed; (2) provide independent review of Channel Capacity Reports; (3) participate in CCAG meetings; (4) provide independent and timely review of data; and (5) provide input and guidance on monitoring and management actions.

Study Area

This Channel Capacity Report focuses on the portion of the Restoration Area where levees exist along channels to control flows. The leveed reaches on the San Joaquin River start at Gravelly Ford (River Mile 226.9) and continue to the Merced River confluence (River Mile 118.2). The study area also includes the Eastside Bypass from Sand Slough Connector to the confluence with the San Joaquin River and the Mariposa Bypass.

Findings and Recommendations

Then-existing channel capacities are defined as flows that would correspond to the appropriate levee slope stability and underseepage Factors of Safety based on USACE criteria for levees. The application of the criteria requires the collection and evaluation of data at locations throughout the Restoration Area. Until adequate data are available to apply the USACE criteria, the release of Restoration Flows would be limited to those that would remain in-channel (the water surface elevation in the river remains below the levees). Based on the results of technical studies summarized in this report and detailed in Appendices, the 2015 recommended then-existing channel capacities will be the same as 2014 for the San Joaquin River and flood bypasses and are described in Table ES-1 below.

Table ES-1
Current and Recommended Then-existing Channel Capacity

Reach	Current and Recommended Then-existing Channel Capacity (cfs)
Reach 2A	1,630
Reach 2B	1,120
Reach 3	2,760
Reach 4A	970
Reach 4B1	Not Analyzed
Reach 4B2	930
Reach 5	1,940
Middle Eastside Bypass	370
Lower Eastside Bypass	2,890
Mariposa Bypass	350

Current Channel Capacity Studies and Related Work Completed

The following technical studies and related work that were included in the 2014 Channel Capacity Report (2014 Report) continue to support the recommended then-existing channel capacities in this report.

In-channel Capacity Study

The In-channel Capacity Study for the San Joaquin River and the Eastside and Mariposa bypasses between Friant Dam and the confluence with the Merced River was conducted in 2013. This study provides initial channel capacity estimates within leveed reaches that can inform then-existing channel capacity prior to sufficient data becoming available to determine levee slope stability and underseepage Factors of Safety.

Computed water-surface profiles were compared to the outside ground elevations adjacent to both the left and right levees along the extent of each reach. The in-channel flow capacity of each reach was determined to be the highest flow rate through the reach where the water-surface elevation is at or below the outside ground elevation for any part of the reach. Results for each reach are summarized in Table ES-2 below; these inform the 2014 and the 2015 recommended then-existing channel capacity outlined in Table ES-1.

Table ES-2.
Summary of In-channel Capacity for Each Side of Levee by River Reach

Reach	Levee Side	In-channel Capacity[1] (cfs)
Reach 2A	Left	2,430
Reach 2A	Right	1,630
Reach 2B (Entire Reach)	Left	0
Reach 2B (Entire Reach)	Right	0
Reach 2B (Excluding Mendota Pool)[2]	Left	1,120
Reach 2B (Excluding Mendota Pool)[2]	Right	1,550
Reach 3	Left	3,680
Reach 3	Right	2,760
Reach 4A	Left	970
Reach 4A	Right	1,340
Reach 4B2	Left	1,370
Reach 4B2	Right	930[3]
Reach 5 (All Levees)	Left	1,940
Reach 5 (All Levees)	Right	2,500
Reach 5 (Excluding Left Levee downstream of Mud Slough)	Left	2,350
Reach 5 (Excluding Left Levee downstream of Mud Slough)	Right	2,500
Middle Eastside Bypass (Eastside Bypass Reach 2)	Left	10
Middle Eastside Bypass (Eastside Bypass Reach 2)	Right	370
Lower Eastside Bypass (Eastside Bypass Reach 3)	Left	2,970
Lower Eastside Bypass (Eastside Bypass Reach 3)	Right	2,890
Mariposa Bypass	Left	650
Mariposa Bypass	Right	350

[1] Capacity based on outside ground elevations.
[2] Portion of reach above influence of Mendota Pool (about River Mile 209.5).
[3] Capacity excludes localized deep depressions, which would reduce capacity to 50 cfs.

Middle Eastside Bypass Geotechnical Assessment

As a preliminary component of the San Joaquin Levee Evaluation (SJLE) Project and to further investigate in-channel capacity results in the Middle Eastside Bypass relative to levee performance, preliminary levee seepage and stability analyses were completed at three sites with the lowest in-channel capacity along the left levee bank. The analysis was performed to better understand the potential levee seepage and stability impacts in a reach with low outside ground elevations compared to the channel, resulting in unreasonably low in-channel capacity.

Table ES-3 summarizes the acceptable maximum water surface elevation, and approximate height of water on the waterside levee toe compared to the relative outside ground. The analysis results and recommendations summarized in Table ES-3 and in Appendix D are based on preliminary data. The results and recommendations should be refined once more detailed information becomes available.

Table ES-3.
Summary of Preliminary Analysis Results for Channel Capacity Assessment[1]

Site	Maximum Water Surface Elevation (feet, NAVD88)	Approximate Height of Water on the Levee[2]
1	100.7	1.2
2	104.0	6.5
3	101.7	3.7

[1] Height of water on the levee at a particular location does not necessarily translate directly to another site, i.e. if water were at a height of 1 foot on the levee at Site 1 then the height of water on the levee at a different location could be different.
[2] Height of water relative to the typical outside ground elevation.

The geotechnical assessment indicates that a water surface elevation of 100.7 ft on the left levee would contain flows of at least 570 cfs without causing levee stability impacts. Because the right levee in-channel capacity is 370 cfs and was not part of the preliminary geotechnical assessment, the in-channel capacity of the Middle Eastside Bypass is 370 cfs.

Future Program Actions with the Potential to Impact Then-existing Channel Capacity

Throughout Settlement implementation, the maximum downstream extent and rate of Restoration Flows to be released would be limited to then-existing channel capacities. As channel or structure modifications are completed with additional environmental compliance, Restoration Flow releases would be correspondingly increased in accordance with then-existing channel capacities and with the release schedule. If release of water from Friant Dam is required for flood control purposes, concurrent Restoration Flows would be reduced by an amount equivalent to the required flood control release. If flood control releases from Friant exceed the concurrent scheduled Restoration Flows, no additional releases above those required for flood control would be made for SJRRP purposes. Until sufficient data are available to determine the levee seepage and stability Factors of Safety, Reclamation would limit initial Restoration Flow releases to those flows which would remain in-channel. When sufficient data are available to determine the Factors of Safety, Reclamation would limit the release of Restoration Flows to those flows which would maintain standard USACE levee performance criteria at all times.

This report, similar to the 2014 Report, describes both the future Program studies and monitoring and non-program actions with the potential to inform then-existing channel capacity. The future Program technical studies continue to include verification and monitoring of in-channel capacity, the implementation of the San Joaquin Levee Evaluation Project (includes geotechnical exploration and analysis), continued study and updates to the Reach 2A Morphology Study (as needed), continued subsidence monitoring and study, as well as a vegetation study. The Program monitoring activities may continue to include: gage monitoring, water surface profile surveys, aerial and topographic surveys, erosion monitoring, vegetation surveys, and suspended sediment monitoring.

There are other entities that are active in the Restoration Area and whose programs may help inform or impact then-existing channel capacity. The SJRRP will need to closely coordinate and collaborate with these entities by sharing data and coordinating specific actions along the river that can inform or impact channel capacity. These entities and activities include the LSJLD's operation and maintenance of the bypass system and river channel; the U.S. Fish & Wildlife Service operation of weirs within the boundaries of the Merced National Wildlife Refuge along the Middle Eastside Bypass (Eastside Bypass Reach 2), and DWR/FloodSAFE efforts such as the Non-Urban Levee Evaluations, the Regional Flood Management Planning effort and the Flood System Repair Project. The SJRRP will continue to coordinate with these non-Program efforts and actions, and the CCAG will consider the effect of these actions in future Channel Capacity Reports.

2.0 Introduction

The San Joaquin River Restoration Program (SJRRP) was established in late 2006 to implement a Stipulation of Settlement (Settlement) in *NRDC, et al., v. Kirk Rodgers, et al*. The U.S. Department of the Interior, Bureau of Reclamation (Reclamation), the Federal lead agency under the National Environmental Policy Act (NEPA), and the California Department of Water Resources (DWR), the State lead agency under the California Environmental Quality Act (CEQA), prepared a joint Program Environmental Impact Statement/Report (PEIS/R) to support implementation of the Settlement. The Settlement calls for releases of Restoration Flows. Restoration Flows were initiated in 2014 and are specific volumes of water to be released from Friant Dam during different water year types, according to Exhibit B of the Settlement. Federal authorization for implementing the Settlement is provided in the San Joaquin River Restoration Settlement Act (Act) (Public Law 111-11). Reclamation signed the Record of Decision (ROD) on September 28, 2012. Both the PEIS/R and the ROD committed to establishing a Channel Capacity Advisory Group (CCAG) to determine and update estimates of then-existing channel capacities as needed and to maintain Restoration Flows at or below estimates of then-existing channel capacities. Then-existing channel capacities in the Restoration Area (the San Joaquin River between Friant Dam and the confluence of the Merced River) correspond to flows that would not significantly increase flood risk from Restoration Flows. Sections of the PEIS/R applicable to the CCAG are included in Appendix A of this report.

This Channel Capacity Report for the 2015 Restoration Year (2015 Report) is the second in the series of annual reports required to fulfil the commitments in the ROD. The first annual Channel Capacity Report (2014 Report) was prepared for the 2014 Restoration Year and was finalized on January 29, 2014. The 2014 Report can be found at the SJRRP website under the following link:

http://restoresjr.net/program_library/02-Program_Docs/2014/Channel_Capacity_Report_Final_-_2014_Accessible.pdf.

The 2014 Report provided an update to the PEIS/R then-existing channel capacities and highlighted future studies and data gaps that will be key in informing future channel capacities. Since there are no significant channel capacity studies that have been completed since the 2014 Report, this report will not be revising the recommendation for then-existing channel capacities for the 2015 Restoration Year. In doing so, this report will only describe past studies used to directly support the recommendations for then-existing channel capacity, updates to studies described in the 2014 Report, and new studies that have been initiated since the 2014 Report. The 2015 Report will also continue to summarize and provide updates of the future actions, and the studies and monitoring that will impact future then-existing channel capacities.

The 2015 Report was available for a 60-day public review and comment period beginning on September 3, 2014 to November 3, 2014. Written comments were received by Paramount Farming. The comments and responses are summarized and included in Appendix F of this Report.

2.1 Objective

This Channel Capacity Report is required by the SJRRP PEIS/R and the corresponding ROD. The primary objective of the report is to provide the CCAG and the public a summary of the prior year's data, methods, and estimated channel capacities and the following year's monitoring and management actions. In doing so, it will present data, evaluations, estimates of then-existing channel capacity, and management actions to address levee stability, hydraulics, and sediment transport within the system in accordance with levee performance standards. Identifying then-existing channel capacity is critically important to ensure the release of Restoration Flows in 2015 will not significantly increase flood risk in the Restoration Area. This report only considers flood risks associated with levee failure when estimating then-existing channel capacity. All other potential material impacts, including agricultural seepage, are addressed in other analyses.

This report shall be prepared annually in coordination with the CCAG. The purpose of the CCAG is to provide independent review of estimated then-existing channel capacities, monitoring results, and management actions to address vegetation and sediment transport within the systems as developed by the Bureau of Reclamation (Reclamation).

2.2 CCAG Roles and Responsibilities

The CCAG is comprised of the following organizations and representatives:

- Bureau of Reclamation (Convener):
    - Pablo Arroyave, Deputy Regional Director (primary)
    - Alicia Forsythe, SJRRP Program Manager (alternate)
- CA Department of Water Resources (Co-convener):
    - Paula Landis, Chief, Division of Integrated Regional Water Management (primary)
    - Kevin Faulkenberry, Chief, South Central Region Office (alternate)
- U.S. Army Corps of Engineers:
    - To be determined, Project Manager (primary)
    - Christy Jones, Lead Water Manager (alternate)
- Lower San Joaquin Levee District:
    - Reggie Hill, General Manager (primary)
    - Robert Tull (alternate)
- Central Valley Flood Protection Board:
    - Len Marino, Chief Engineer (primary)
    - Ali Porbaha, Senior Engineer (alternate)

The roles and responsibilities of the CCAG members are as follows:

- **Provide independent review of Reclamation's estimates of then-existing channel capacity as needed**: Provide an independent review of Reclamation's estimated then-existing channel capacities, monitoring results, and management actions to address levee stability, hydraulics, and sediment transport within the system estimated by Reclamation in accordance with standard USACE levee performance criteria.
- **Provide independent review of Channel Capacity Reports**: Annually or in the event Reclamation proposes increasing the upper limit of releases for Restoration Flows, Reclamation will release a public report detailing the new upper limits of releases and data and methods used to develop the new upper limits of releases. The CCAG provides input during the development of these public reports.
- **Participate in Channel Capacity Advisory Group meetings:** Reclamation organizes working meetings for the CCAG to review progress made in developing the annual reports. These meetings are an opportunity for the CCAG to comment on content as it is developed. CCAG members attend and participate in working meetings.
- **Provide independent and timely review of data**: The CCAG provides a timely review of data, analytical methodology, and results used to estimate the then-existing channel capacities.
- **Provide input and guidance on monitoring and management actions**: Reclamation provides occasional updates on on-going erosion monitoring and management results – including monitoring of potential erosion sites – to the CCAG. The CCAG provides comments on information provided through these updates.

2.3 Channel Capacity Technical Factors

There are several factors that can impact and limit channel capacity. The following is a summary of the factors that could be considered when evaluating and recommending then-existing channel capacities, as well as determining potential future improvements and other management actions of the SJRRP.

- **Levee Integrity** - Channel capacity may be limited if the levee is not constructed to design criteria (e.g., insufficient slope stability Factor of Safety or underseepage Factor of Safety) or if there is insufficient data to assess levee performance. In addition, observations (e.g., boils, sloughing, seepage, etc.) made of the performance of a levee during historical flow releases can also provide information on levee integrity and stability. Considering the observations, as well as other factors may result in an increase or decrease channel capacity.
- **Erosion** - Stream bank erosion that encroaches on the levee prism or has a significant potential to encroach on the levee prism increases the potential for levee failure. Therefore, channel capacity may be limited if erosion is present that could result in levee failure during a flow release.
- **Duration and Timing and Flow Releases –**The duration and timing of flow releases may cause water to be against a levee for a period of time which could result in the levee becoming saturated. As the levee becomes saturated, seepage through and sloughing of the

soil can occur, which could result in the loss of foundation stability and ultimately potential levee failure.

- **Sediment Transport** - Sedimentation or scouring may change the geometry of the channel and increase or decrease channel capacity.
- **Subsidence** - Ground subsidence may change the geometry of the channel and increase or decrease channel capacity. Subsidence may also reduce freeboard, thus increasing the potential for overtopping during flow releases.
- **Vegetation** - In-channel vegetation may impact flow and stage and is measured by channel roughness in a hydraulic analysis. Changes in in-channel vegetation can increase or decrease channel capacity.
- **Operation and Maintenance** - Levee operation and maintenance (O&M) programs are necessary to assess changed conditions that could impact channel capacity and to provide flood fight capability in case of levee failure. Channel capacity may be limited if there are inadequate O&M resources to monitor conditions that could affect channel capacity.
- **Constructed Improvements** - Levee construction may improve levee integrity or channel geometry and increase channel capacity.
- **Additional Factors** - Other future conditions (i.e. climate change, structures, land encroachments, etc.) not listed above, or those recommended by the CCAG will also be a consideration in evaluating channel capacity.

The above factors, as well as others are being considered as part of the current or future SJRRP studies and monitoring to determine then-existing channel capacity.

2.4 PEIS/R Approach to Minimizing Flood Risk

As outlined in the PEIS/R, Reclamation will minimize flood risk from Restoration Flows throughout the Settlement implementation process by undertaking three integrated measures: (1) establish a CCAG and determine and update the estimates of then-existing channel capacities as needed; (2) maintain Restoration Flows below estimates of then-existing channel capacities; and (3) closely monitor erosion and perform maintenance and/or reduce Restoration Flows as necessary to avoid erosion-related impacts. The CCAG was established in coordination with Department of Water Resources (DWR) and prior to the release of Restoration Flows for the 2014 Restoration Year. Reclamation is to prepare an annual report, which would include data and methods used to develop estimates of then-existing channel capacities. A draft report is provided to the CCAG for its review and comment for a period of 60 days. In the event that comments or recommendations are received from the CCAG within 60 days, Reclamation would be required to consider and respond to such comments and prepare a final report for distribution to the CCAG within 60 days of the close of the draft report review period. Reclamation will not increase Restoration Flows above the previously determined then-existing channel capacities until 10 days after the final report is prepared and distributed to the CCAG. Draft reports include the data, methods, and estimated channel capacities; flow limits and any maintenance activities; and monitoring efforts and management actions. Draft and final reports will be made available to the public concurrent with their distribution to the CCAG. This report is the second in the series of annual Channel Capacity Reports.

Reclamation will convene the CCAG as required until 2030, but may stop earlier, provided that then-existing channel capacities are determined to equal or exceed the maximum proposed Restoration Flows throughout the Restoration Area. If after 2030 then-existing channel capacities decrease such that full Restoration Flows cannot be conveyed, the CCAG would be reconvened and function as described above until such time that the then-existing channel capacities are determined to equal or exceed the full Restoration Flows.

3.0 Study Area

The San Joaquin River originates from the Sierra Nevada Mountains and carries snowmelt from mountain meadows to the valley floor before turning north and becoming the backbone of tributaries draining into the San Joaquin Valley. It is California's second longest river and discharges to the Sacramento-San Joaquin Delta (Delta) and, ultimately, to the Pacific Ocean through San Francisco Bay.

In 1944, Reclamation completed construction of Friant Dam on the San Joaquin River. With the completion of Friant-Kern Canal in 1951 and Madera Canal in 1945, Friant Dam diverted San Joaquin River water supplies to over 1 million acres of highly productive farmland along the eastern portion of the San Joaquin Valley. In 1959, construction of the Lower San Joaquin River Flood Control Project (LSJRFC Project) began. The LSJRFC Project was completed in 1967 and provides flood protection along the San Joaquin River and tributaries in Merced, Madera, and Fresno Counties. The LSJRFC Project includes 108 river miles (RMs), 191 miles of levees, and protects over 300,000 acres. An additional 67 miles of non-Project levees also provide flood projection along the San Joaquin River.

The study area starts from the Friant Dam and ends at the confluence of the San Joaquin River with the Merced River. The Channel Capacity Report will focus on the portion of the study area where levees exist along channels to control flows. The leveed reaches on the San Joaquin River start at Gravelly Ford (RM 226.9) and continue to the Merced River confluence (RM 118.2). The study area also includes the Eastside Bypass from Sand Slough Connector to the confluence with the San Joaquin River and the Mariposa Bypass. The study area is shown in Figure 3-1.

The study area reaches are shown in Figure 3-2 and are describe below. Currently SJRRP flows pass through Reaches 1 through 4A, through the Sand Slough Connector Channel and into the Eastside Bypass, where they travel through Eastside Bypass before entering Reach 5 of the San Joaquin River. Since Reach 1 does not have levees, it is not the focus of the analyses included in this report and is not discussed further. The flood capacities of each of the reaches within the study area, as part of the overall flood control system are shown in Figure 3-3 (DWR, 1985).

3.1 Reach 2

Reach 2 marks the beginning of the LSJRFC Project levees and therefore the start of this report's study area. Reach 2 begins at Gravelly Ford and extends approximately 24 miles downstream to the Mendota Pool, continuing the boundary between Fresno and Madera counties. This reach is a meandering, low-gradient channel. Reach 2 is subdivided at the Chowchilla Bypass Bifurcation Structure (CBBS) into two subreaches. Both Reach 2A and Reach 2B were dry in most months prior to the SJRRP. Reach 2A is subject to extensive seepage losses. Reach 2B is a sandy channel with limited conveyance capacity. Reach 2A has a flood design capacity of 8,000 cubic feet per second (cfs) while Reach 2B has a flood design capacity of 2,500 cfs. In Reach 2B, seepage problems are reported to occur at discharges in excess of 1,300 cfs (McBain & Trush, 2002). The levees in Reach 2B are not part of the LSJRFC Project. As part of the SJRRP, setback levees are anticipated to be constructed in Reach 2B to increase its capacity to at least 4,500 cfs.

3.2 Reach 3

Reach 3 begins at Mendota Dam and extends approximately 23 miles downstream to Sack Dam. Reach 3 conveys flows of up to 800 cfs from the Mendota Pool for diversion to the Arroyo Canal at Sack Dam, maintaining year-round flow in a meandering channel with a sandy bed. This reach continues along the boundary between Fresno and Madera counties. The sandy channel meanders through a predominantly agricultural area, and diversion structures are common in this reach. Reach 3 has a flood design capacity of 4,500 cfs. The levees in Reach 3 are also not part of the LSJRFC Project. Flood flows from the Kings River are conveyed to Reach 3 via Fresno Slough and Mendota Dam.

3.3 Reach 4

Reach 4 is approximately 46 miles long, and is subdivided into three distinct subreaches. Reach 4A begins at Sack Dam and extends to the Sand Slough Control Structure. Other than short 1-2 mile levee segments at the downstream end, levees in Reach 4A are not part of the LSJRFC Project (Figure 3-3). This subreach is dry in most months except under flood conditions and SJRRP flows. Reach 4B1 begins at the Sand Slough Control Structure and continues to the confluence of the San Joaquin River and the Mariposa Bypass. Only the lower 2 miles of Reach 4B1 levees just upstream of the Mariposa Bypass are part of the LSJRFC Project. All flows reaching the Sand Slough Control Structure are diverted to the flood bypass system via the Sand Slough Connector Channel, leaving Reach 4B1 perennially dry for more than 40 years, with the exception of agricultural return flows. Reach 4B1 has a flood design capacity of 1,500 cfs, but the current channel capacity is unknown and could be zero in some locations (SJRRP, 2011). As part of the SJRRP, setback levees may be constructed in Reach 4B1 to increase its capacity to at least 475 cfs and possibly up to 4,500 cfs, depending on the alternative. Reach 4B2 begins at the confluence of the Mariposa Bypass, where flood flows in the bypass system rejoin the mainstem San Joaquin River. Reach 4B2 extends to the confluence of the Eastside Bypass. The levees in this reach are all part of the LSJRFC Project. Reach 4B2 has a capacity of 10,000 cfs.

3.4 Reach 5

Reach 5 of the San Joaquin River extends approximately 18 miles from the confluence of the Eastside Bypass downstream to the Merced River confluence. This reach receives flows from Mud and Salt sloughs, and channels that run through both agricultural and wildlife management areas. Much of Reach 5 includes levees that are within the LSJRFC Project. Reach 5 is the end of the study area and has a flood design capacity of 26,000 cfs.

3.5 Eastside Bypass and Mariposa Bypass

The Middle Eastside Bypass (Reach 2) extends from Sand Slough Connector Channel to the Eastside Bypass Control Structure. Flood flows from Reach 4A of the San Joaquin River and the Upper Eastside Bypass (Reach 1) and the Chowchilla Bypass can be diverted into the bypass at the head of this reach. The Merced Wildlife Refuge is in the middle of this reach of the bypass and diverts some flows to its Refuge by using two weirs. The Lower Eastside Bypass (Reach 3) extends from the head of the Mariposa Bypass to the head of Reach 5, and receives flows from Deadman, Owens, and Bear creeks. The Mariposa Bypass extends from the Mariposa Bypass Control Structure to the head of Reach 4B2. A drop structure is located near the downstream end of the Mariposa Bypass that dissipates energy from flows before they enter the mainstem San Joaquin River. The flood design flow for the Middle Eastside Bypass (Reach 2) is 16,500 cfs; the Lower Eastside Bypass (Reach 3) is between 8,000 cfs at its upstream end and 18,500 cfs just downstream of its confluence with Bear Creek; and 8,500 cfs for the Mariposa Bypass. As part of the SJRRP, the Middle and Lower Eastside bypasses may be used for Restoration Flows, but its overall design flood capacity will not be increased.

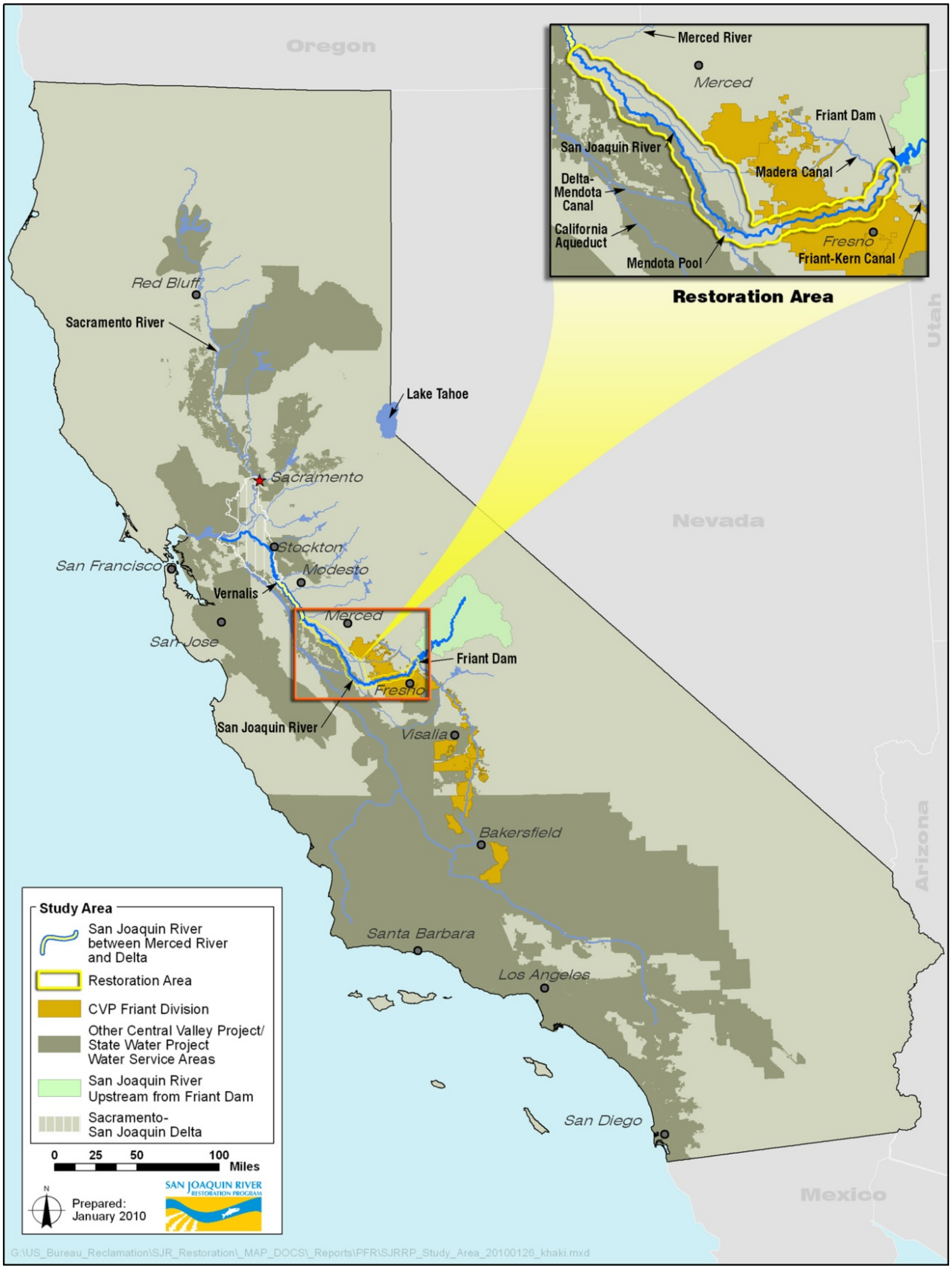

Figure 3-1.

San Joaquin River Restoration Program Location

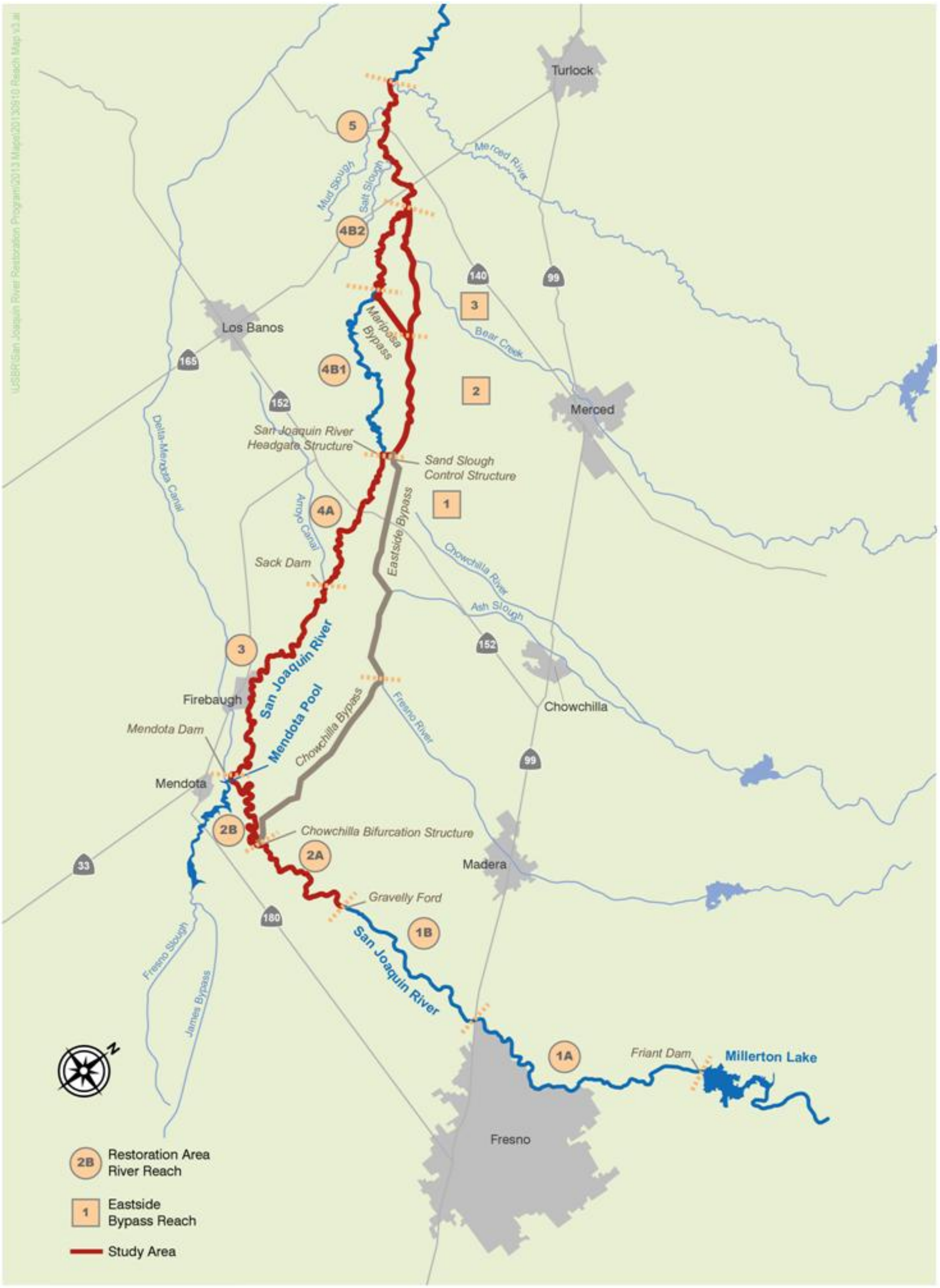

Figure 3-2.

San Joaquin River Reaches and Flood Bypass System

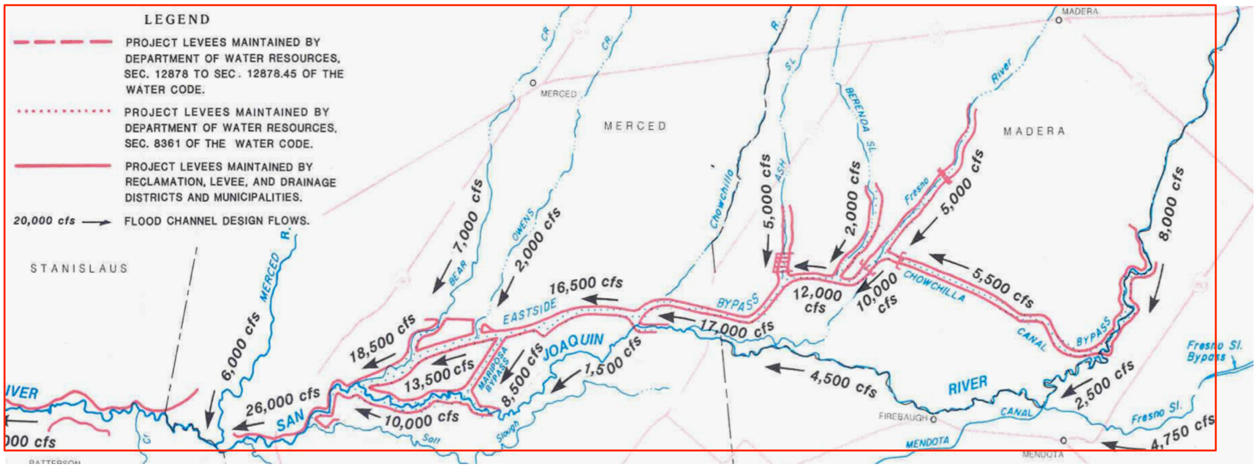

Figure 3-3.

Flood Channel Design Flows

4.0 Then-existing Channel Capacity Criteria

Then-existing channel capacities, as defined for this report, consider levee stability and seepage, but not other factors like agricultural seepage. This section presents the levee evaluation criteria described in the PEIS/R for determining then-existing channel capacity and briefly describes the process that will be used to collect data and perform analyses to determine levee conditions to further refine then-existing channel capacity estimates.

4.1 PEIS/R Levee Criteria

An objective of the SJRRP is to minimize increases in flood risk due to the release of Restoration Flows. To achieve this objective, the PEIS/R included the levee design criteria developed by USACE in Design and Construction of Levees Engineering and Design Manual (Manual No. 1110-2-1913) (USACE 2000), Engineering Manual: Slope Stability (Manual No. 1110-2-1902) (USACE 2003), and Design Guidance for Levee Underseepage (Engineering Technical Letter No. 1110-2-569) (USACE 2005). The levee design criteria and guidelines are to be applied throughout the Restoration Area.

The levee criteria are included in the PEIS/R to reduce the risk of levee failure to less-than-significant-levels by meeting levee slope stability and underseepage Factors of Safety. The PEIS/R states that Restoration Flows should not cause the levee slope stability Factor of Safety to be below 1.4, or the underseepage Factor of Safety to be reduced below the value corresponding to an exit gradient at the (landside) toe of the levee of 0.5. The levee slope stability Factor of Safety is defined as the ratio of available shear strength of the top stratum of the levee slope to the necessary shear strength to keep the slope stable (USACE 2003). The application of the levee slope stability Factor of Safety of 1.4 is required for federally authorized flood control projects. The underseepage Factor of Safety is defined as a ratio of the critical hydraulic gradient to the actual exit gradient of seepage on the levee. USACE design guidance recommends that the allowable underseepage Factor of Safety used in evaluations and/or design of seepage control measures should correspond to an exit gradient at the toe of the levee of 0.5 (in general this would provide a Factor of Safety of 1.6), but states that deviation from recommended design guidance is acceptable when based and documented on sound engineering judgment and experience (USACE 2005). The SJRRP will continue to coordinate with DWR, CVFPB, and USACE to ensure appropriate methods and criteria are used in all levee evaluations and design.

Until adequate data are available to determine these Factors of Safety, Reclamation would limit the release of Restoration Flows to those that would remain in-channel. In-channel flows are flows that maintain a water surface elevation at or below the elevation of the landside levee toe (i.e., the base of the levee). When sufficient data is available to determine the levee slope stability and underseepage Factors of Safety, Reclamation would limit Restoration Flows to levels that would correspond to the appropriate levee slope stability Factor of Safety of 1.4 or higher and an underseepage Factor of Safety corresponding to an exit gradient at the toe of the levee of 0.5 or lower at all times. Implementing this measure would reduce the risk of levee failure due to underseepage, through-seepage, and associated levee stability issues to less-than-significant levels.

In addition, systematic levee condition monitoring would be implemented as described in more detail in PEIS/R Appendix D, *Physical Monitoring and Management Plan*. Observation of levee erosion, seepage, boils, impaired emergency levee access, or other indications of increased flood risk identified through ongoing monitoring at potential erosion sites would indicate that the minimum Factors of Safety are not met and would trigger immediate reductions in Restoration Flows at the site. Such observations would supersede channel capacity estimates, and Restoration Flows would be reduced in areas where these conditions occur.

4.2 Future Evaluation Process

The SJRRP will continue to complete and update the studies necessary to determine then-existing channel capacity. This includes, in part, collecting and assessing the necessary geotechnical data to determine the appropriate levee slope stability and underseepage Factors of Safety. To complete this task, the San Joaquin Levee Evaluation Project (SJLE Project) was initiated by DWR. The SJLE Project includes collecting geotechnical data along the river and flood bypasses, evaluating the levee geotechnical performance at various water surface elevations, and identifying levees and appropriate actions to improve levee performance. The goal of this evaluation is to gain adequate information on the levees to determine the levee slope stability and underseepage Factors of Safety. This will provide Reclamation with the necessary information to make decisions on Restoration Flow releases that will reduce the risk of levee failure. Details of the SJLE Project and other studies and monitoring that may be used to inform channel capacities are summarized in the Section 10 - Future Program Studies and Monitoring with the Potential to Inform Then Existing Channel Capacity.

5.0 Data and Analytical Tools

The following sections describe the data and analytical tools used to determine then-existing channel capacity. The sections provide an overview of the restoration hydrograph and hydraulic, sediment transport modeling and levee assessment tools. This section also includes a summary of the overall strategy Reclamation and DWR developed for the coordination and application of the hydraulic and sediment modeling tools.

5.1 Restoration Hydrograph

The SJRRP flow hydrograph involves a spring and a fall pulse with base flow releases of 350 cfs from Friant Dam in the summer and winter months in most year types. These hydrographs are provided in Exhibit B of the Settlement and the Restoration Flow hydrograph at Friant Dam is summarized in Figure 5-1. Spring flow pulses range from 1,500 cfs maximum release in a critical-high year type, to a 4,000 cfs release in a wet year type. The Restoration Administrator, an independent individual called for in the Settlement, makes recommendations to the Secretary of the Interior on how best to shape the hydrograph to meet the Restoration Goal of the Settlement. The Restoration Administrator has the flexibility to adjust the hydrographs, consistent with the Settlement, including releasing buffer flows of up to 10 percent, mobilizing gravel with an up to 8,000 cfs pulse, and flexibly scheduling the spring pulse volume within a period defined as 28 days in advance of the Settlement Exhibit B hydrographs (i.e. beginning on February 1 with 500 cfs), and 28 days later than the Exhibit B hydrographs (ending on May 28 at 4,000 cfs). The fall pulse volume may be flexibly scheduled from October 1 to November 30. In wet year types, an additional volume is available for riparian recruitment that can extend 60 to 90 days past the end of the spring pulse flow.

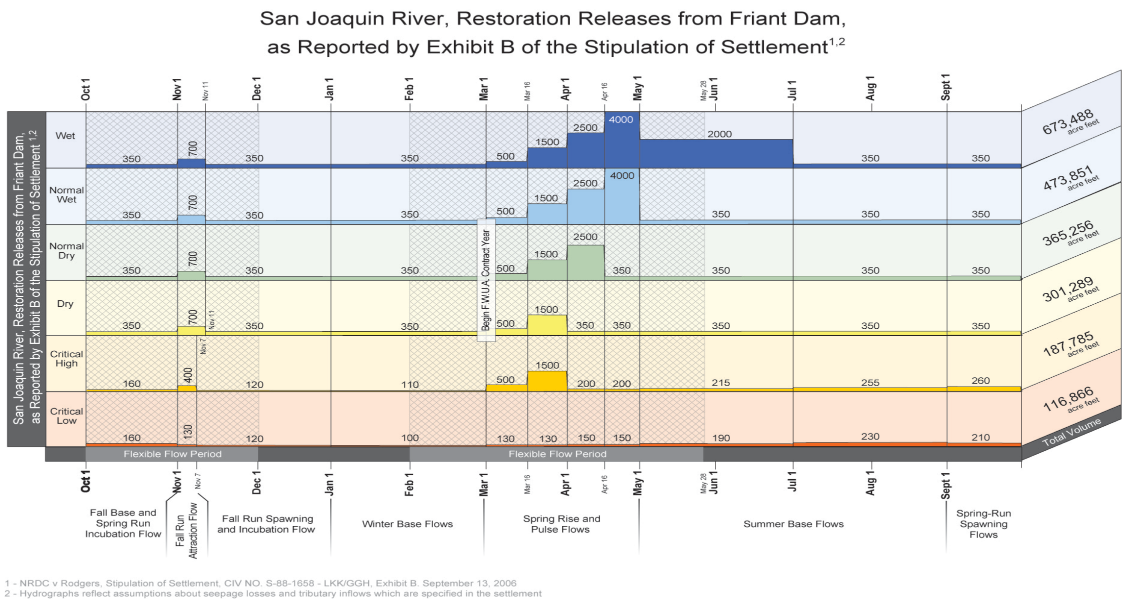

Figure 5-1.

Restoration Flow Hydrograph at Friant Dam

In order to determine the Restoration Hydrograph, Reclamation will first use DWR forecasts to predict the unimpaired inflow to Millerton Lake. Then this volume is allocated to the Friant Division long-term contractors and water users in Reach 1 per Reclamation standard practice, and to the SJRRP using a methodology called Method 3.1 gamma. Reclamation then submits an allocation and a default flow schedule to the Restoration Administrator, with flow volumes by type (i.e., base flow, spring pulse, fall pulse, riparian recruitment). The Restoration Administrator responds with a flow recommendation using the flexibility as described above to change the flow schedule. Reclamation confirms that the Restoration Administrator recommendation is consistent with all applicable regulation (Settlement, Water Board Orders, channel capacity), accepts the recommendation, and then implements the schedule. See the Restoration Flow Guidelines, available here: http://restoresjr.net/program_library/02-Program_Docs/SJRRP_RFG_December_2013.pdf for more information.

Based on the schedule identified in the Settlement, Restoration Flows began on January 1, 2014. At present, because of seepage and possible levee stability issues, the river system is not capable of passing the full Restoration Flows, and so flows are released up to the then-existing channel capacity. This report provides Reclamation's analysis of then-existing channel capacities, and the CCAG was formed to provide a peer review of that analysis in helping Reclamation determine the recommended Restoration Flows that can be released without significantly increasing flood risk. Preparation of this report and review by the CCAG will continue until such time that then-existing channel capacities are determined to equal or exceed the maximum proposed Restoration Flows throughout the Restoration Area.

The studies described in Section 7 of this report evaluate a maximum flow of 4,500 cfs in each of the study reaches. This maximum flow is based on the Settlement required capacity in Reach 2B and Reach 4B. Restoration Flows may be as high as 8,000 cfs in the upper reaches to perform functions such as flushing spawning gravels, but are expected to attenuate so not to exceed a maximum channel capacity of 4,500 cfs in Reach 2B.

5.2 Hydraulics

One-dimensional (1-D) steady-state Hydrologic Engineering Center's River Analysis System (HEC-RAS) hydraulic models of the 150-mile reach of the San Joaquin River and Bypass System between Friant Dam (RM 267.6) and the mouth of the Merced River (RM 118.2) were developed and validated by Tetra Tech, Inc. (Tetra Tech) and DWR to support the SJRRP. Two-dimensional (2-D) hydrodynamic models of all of the reaches except for Reach 5 were developed by Reclamation. DWR also developed a site specific model of a 2.5-mile segment of the downstream portion of Reach 2A. The following describes how these models were used to evaluate channel capacity in this report.

5.2.1 1-D Modeling

The HEC-RAS hydraulic models provide a means of evaluating current 1-D hydraulic conditions along the river and flood bypass system over a range of flows, including those specified in the Settlement and flood events (Tetra Tech, 2014). The 1-D models have been used to perform a number of analyses related to channel capacity, including:

- Assess channel capacities, including an evaluation of the degree to which sedimentation would affect channel capacities in Reach 2A.
- Provide input to sediment-transport analyses, including an evaluation of the sediment-transport behavior in Reaches 2A, 2B and 3.
- Assess potential effects of Restoration Flows on levee underseepage, levee erosion and stability, channel stability and flood carrying capacity.

5.2.2 2-D Modeling

Reclamation has developed 2-D hydrodynamic models for reaches 1B, 2A, 2B, 3, 4A, 4B1, 4B2 of the San Joaquin River and the Eastside Bypass. The 2-D models use the depth-averaged St. Venant equations and an unstructured mesh to model water surface elevation, depth, and velocities and report the above plus bed shear stress, critical sediment diameter, and sediment transport capacity at each quadrilateral or triangular mesh cell. Applications of 2-D models for channel capacity studies could include modeling of side channels, bank erosion, local flow velocity and eddy patterns, as well as flow over in-channel bars and levees.

5.3 Sediment Transport

1-D and 2-D sediment transport models are also being employed by the SJRRP. These models were developed to evaluate the effects of SJRRP actions on sediment transport along the river and flood bypasses. The existing sediment transport models were developed using Reclamation's SRH modeling system and incorporate the same foundational input data used in the hydraulic models described above. These models were also employed to evaluate channel capacity as described below.

5.3.1 1-D Modeling

Reclamation developed SRH-1D sediment transport models to assess the reach-averaged erosion and deposition impacts of the SJRRP to Reaches 1 through 5 in the PEIS/R. These models would be useful for evaluating future channel capacity studies by simulating the future reach-averaged sediment transport, erosion and deposition in the SJR and flood bypass system under various flow routing scenarios. However, SRH-1D and other 1-D models are limited in their ability to simulate local sediment transport conditions resulting from topographic variability within a cross section, in river bends, around structures (such as bifurcations), and the differences between channel and floodplain deposition.

5.3.2 2-D Modeling

Tetra Tech developed and calibrated a 2-D sediment-transport model for the approximately 2.5-mile reach immediately upstream from the CBBS. The model was developed to provide a refined tool that can be used to predict the behavior of the downstream portion of Reach 2A and to provide a more accurate estimate of sediment movement from Reach 2A through the San Joaquin River Control Structure at the CBBS and into Reach 2B under various conditions (Tetra Tech, 2013a). This model was used to complete a Reach 2A Sediment Study, which is summarized in the 2014 Report. This model will likely continue to be used in future evaluations of the sediment conditions within the vicinity of the CBBS.

5.4 Geotechnical

A preliminary seepage and stability analyses to evaluate levee impacts in the Middle Eastside Bypass was performed using the 2-D finite element software program SEEP/W, developed by GEO-SLOPE International, Ltd. The model uses topographic and geotechnical data to analyze underseepage and excess pore-water pressure. This is to determine exit gradients and the controlling water surface elevation that may result in failure due to underseepage. The levee slope stability analysis was performed using SLOPE/W, a 2-D limit equilibrium stability analysis software program developed by GEO-SLOPE International, Ltd. following the Spencer Method. The same topography used for the seepage analysis was also used for the slope stability analysis. Pore-water pressures calculated by the SEEP/W models are imported into SLOPE/W. The model uses effective shear strengths for the different soil layers to determine the minimum factor of safety for surfaces that affect the overall stability of the levee for different water surface elevations. The SEEP/W and SLOPE/W tools are used in the geotechnical evaluations of the San Joaquin Levee Evaluation (SJLE) Project described in Section 10.1.2.

5.5 Modeling Strategy

Numerical modeling has been a key tool used by the SJRRP to develop designs for the site-specific projects and perform quantitative evaluation of SJRRP actions. A set of modeling tools have been developed and applied for this work, including hydraulic, sediment transport, vegetation, temperature, flow routing, levee stability, and groundwater models. In response to comments received by the CCAG during the preparation of the 2014 Report, Reclamation and DWR have developed a strategy for two of these sets of modeling tools—hydraulic and sediment transport—to describe how these tools will be reviewed, used, and distributed.

The SJRRP has developed hydraulic and sediment transport modeling tools to evaluate then-existing channel capacity, as well as to complete other studies and actions implemented by the SJRRP. Having separate tools available for different modeling applications provides the flexibility to meet both efficiency and accuracy needs. No single model was deemed appropriate to effectively model all aspects that are necessary to understand the actions of the SJRRP. The additional complexity caused by employing different models that can generally meet similar objectives is necessary to ensure that the appropriate models are being utilized for the appropriate purpose. In response to the preparation of the 2014 Report, the SJRRP received comments that a transparent modeling methodology and coordination effort is needed to evaluate and determine then-existing channel capacity including quantifying in-channel capacity, assessing changes to flood operations, and identifying potential maintenance needs.

In response to these comments, Reclamation and DWR have developed a strategy memorandum specifically for the hydraulic and sediment transport modeling, which is included in Appendix B. The strategy summarizes the models available, general differences, and preferred usage to develop and evaluate SJRRP actions. Selection of the appropriate tool for any specific study, including channel capacity, will depend on the purpose of the study, level of detail needed, and the preference of the agency performing the analysis. The tools used to determine then-existing channel capacities for the 2015 Restoration Year were primarily the 1-D hydraulic model. However, the 2-D hydraulic and 1-D and 2-D sediment transport models were used and will continue to be used in other studies to evaluate channel capacity.

6.0 Current Then-existing Channel Capacity

For the 2014 Restoration Year, the SJRRP limited Restoration Flow releases to then-existing channel capacities recommended in the 2014 Report. These capacities were based on the In-channel Capacity Study and Middle Eastside Geotechnical Assessment described in Section 7.0 of the 2014 Report. Limiting Restoration Flows to these capacities reduced the risk of levee failure due to underseepage, and through-seepage. The current then-existing channel capacities are shown in Table 6-1.

Table 6-1
Current Then-existing Channel Capacity

Reach	Current Then-existing Channel Capacity (cfs)
Reach 2A	1,630
Reach 2B	1,120
Reach 3	2,760
Reach 4A	970
Reach 4B1	Not Analyzed
Reach 4B2	930
Reach 5	1,940
Middle Eastside Bypass	370
Lower Eastside Bypass	2,890
Mariposa Bypass	350

7.0 Completed Channel Capacity Studies and Related Work

The following section summarizes the technical studies and related work that has been completed at the time of publication of this report that relate to channel capacities. In the 2014 Report, five studies were evaluated to recommend then-existing channel capacities. Of the five studies, only two studies—In-channel Capacity Study and Middle Eastside Geotechnical Assessment—were directly used to make the capacity recommendation. So, for this report, the same In-channel Capacity Study and the Middle Eastside Bypass Geotechnical Assessment will remain in this section of the report as they were directly used to make capacity recommendations for this year's report. The other studies can be found in the 2014 Report. There have been no additional studies that have been completed to refine the recommendations in the 2014 Report. The following describes the studies that were specifically evaluated to determine the recommended then-existing channel capacities in this report.

7.1 In-channel Capacity Study

A channel capacity study of the San Joaquin River and the Eastside and Mariposa bypasses between Friant Dam and the confluence with the Merced River was conducted. That study, the *San Joaquin River In-channel Capacity Analysis* (Tetra Tech, 2013b), dated February 14, 2013, is included in Appendix C. This study provides initial channel capacity estimates within leveed reaches that can inform then-existing channel capacity prior to sufficient data becoming available to determine levee slope stability and underseepage Factors of Safety.

In general, the purpose of the study was to identify the flow in each reach at which the water-surface elevation would stay below the levees in each reach. Specific tasks included determining the channel capacity for each reach, as well as the approximate length of the left and right bank levee where the water surface elevation of 2,000 cfs and 4,500 cfs flows exceeded the outside ground elevation. The *Working Draft Framework For Implementation* (Reclamation, 2012), dated Jun 19, 2012, identifies a Restoration Flow release of up to 2,000 cfs as a necessary core action for successful implementation of the Settlement. Therefore, this study also determined the length of levee for the 2,000 cfs threshold. The following sections summarize the study.

7.1.1 Methodology and Assumptions

The in-channel capacity was evaluated for each subreach that is bounded by levees in Reaches 2A, 2B, 3, 4A, 4B2, 5, Middle Eastside Bypass, Lower Eastside Bypass, and the Mariposa Bypass. As part of the SJRRP, new setback levees are being evaluated for Reach 4B1 to safely convey Restoration Flows. Since the current capacity is assumed to be negligible, it is assumed that no Restoration Flows will be conveyed in this reach until channel capacity improvements are made. Therefore, Reach 4B1 was not included in this analysis. Setback levees are also anticipated in Reach 2B, but because Restoration Flow releases will be routed through this reach prior to their construction, channel capacity was evaluated along the levees upstream from the direct impacts of Mendota Pool.

The 1-D HEC-RAS hydraulic models, discussed in Section 5.2 - Data and Analytical Tools were used for the analysis. As an initial step, the landside levee toe elevations were identified for each reach. In this analysis, the outside ground elevation adjacent to the landside levee toe was selected to represent the elevation of the landside levee toe. The elevations were identified at each hydraulic model cross-section primarily through inspection of the cross-sectional topography and were verified through review of the aerial photography and contour mapping. The outside ground elevations were selected for both the left and right levees. In-channel capacities reported in this analysis are based on water-surface profiles developed by running the models over a series of local flows. Figure 7-1 is a conceptual figure of the outside ground elevation location and the in-channel flow capacity.

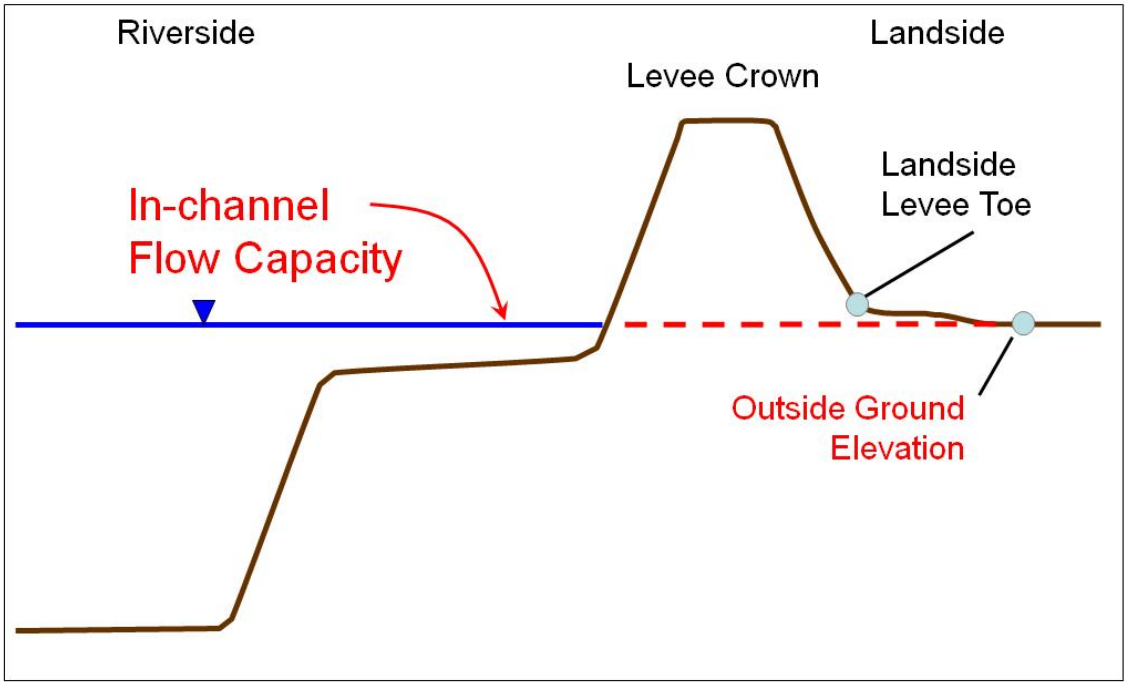

Figure 7-1.
Levee Schematic Defining Levee Features and In-channel Capacity

7.1.2 Analysis and Results

Computed water-surface profiles were compared to the outside ground elevations adjacent to both the left and right levees along the extent of each reach. The in-channel flow capacity of each reach was determined to be the highest flow rate through the reach where the water-surface elevation is at or below the outside ground elevation for any part of the reach. Results for each reach are described in the following sections and are summarized in Table 7-1.

Table 7-1.
Summary of In-channel Capacity for Each Side of Levee by River Reach

Reach	Levee Side	In-channel Capacity[1] (cfs)
Reach 2A	Left	2,430
Reach 2A	Right	1,630
Reach 2B (Entire Reach)	Left	0
Reach 2B (Entire Reach)	Right	0
Reach 2B (Excluding Mendota Pool)[2]	Left	1,120
Reach 2B (Excluding Mendota Pool)[2]	Right	1,550
Reach 3	Left	3,680
Reach 3	Right	2,760
Reach 4A	Left	970
Reach 4A	Right	1,340
Reach 4B2	Left	1,370
Reach 4B2	Right	930[3]
Reach 5 (All Levees)	Left	1,940
Reach 5 (All Levees)	Right	2,500
Reach 5 (Excluding Left Levee downstream of Mud Slough)	Left	2,350
Reach 5 (Excluding Left Levee downstream of Mud Slough)	Right	2,500
Middle Eastside Bypass (Eastside Bypass Reach 2)	Left	10
Middle Eastside Bypass (Eastside Bypass Reach 2)	Right	370
Lower Eastside Bypass (Eastside Bypass Reach 3)	Left	2,970
Lower Eastside Bypass (Eastside Bypass Reach 3)	Right	2,890
Mariposa Bypass	Left	650
Mariposa Bypass	Right	350

[1] Capacity based on outside ground elevations.
[2] Portion of reach above influence of Mendota Pool (about RM 209.5).
[3] Capacity excludes localized deep depressions, which would reduce capacity to 50 cfs.

In **Reach 2A**, along the right and left levees, the highest local flow for which the water-surface is at or below the outside ground elevation is 1,630 and 2,430 cfs, respectively (Figures 3 through 5 in Appendix C). For about 3.3 miles of this reach, the water surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee.

In **Reach 2B**, outside ground elevations along the lower portion of this reach are generally lower than the normal pool elevation at Mendota Dam (Figures 6, 7, 8, and 9 in Appendix C). When considering the entire reach, including Mendota Pool, the capacity along both sides of the channel is 0 cfs. As a result, the existing flow capacity was evaluated for the entire reach as well as only for the portion of the reach upstream from the influence of the pool. When only the portion of the reach upstream from the influence of the pool is considered, the highest local flow in which the water surface is at or below the outside ground elevation is about 1,120 cfs along the left levee and 1,550 cfs along the right levee. For about 17.7 miles of this reach, the water surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee (includes the levees influenced by Mendota Pool).

In **Reach 3**, outside ground elevations are reasonably high along much of the reach except for an area immediately upstream of Sack Dam (Figures 10 through 12 in Appendix C). Flow capacity in this area is limited by a depression on the right side that has a capacity of 2,760 cfs. On the left side of the channel, the capacity of the outside ground elevation is 3,680 cfs. For about 7.1 miles of this reach, the water surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee.

In **Reach 4A**, the maximum local flow for which the water-surface is at or below the outside ground elevation is 1,340 cfs for the right levee and 970 cfs for the left levee (Figures 13 through 16 in Appendix C). The water surface elevation is above the outside ground for almost all of the Reach at 4,500 cfs. For about 17.8 miles of this reach, the water surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee.

In **Reach 4B2**, the ground adjacent to the right levee in Reach 4B2 has many depressions, but due to one localized and deep depression along the right levee, the in-channel capacity is limited to about 50 cfs (Figures 17 through 20 in Appendix C). Aerial photographs and contour mapping indicate that these depressions are relatively small, and can contain water even at low flows, which would not make them a levee stability issue. If these local, right side depressions are excluded from the analysis, the capacity along the right levee increases to 930 cfs. The outside ground along the left levee is not as low, which results in an in-channel capacity of approximately 1,370 cfs. For about 14.0 miles of this reach, the water surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee.

In **Reach 5**, most of the areas with limited capacities occur along the mid- to upper- portion of this reach, but one exception is a levee feature that exists along the left side of the channel near the downstream end of the reach (Figures 21 through 24 in Appendix C). The highest local flow for which the water-surface is at or below the outside ground elevation is 1,940 and 2,500 cfs along the left and right levees, respectively. However, since much of the outside ground adjacent to the left levee contains many local depressions, these results likely represent a conservative estimate of the in-channel flow capacity in this reach. For about 3.7 miles of this reach, the water surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee.

In the **Middle Eastside Bypass** (Eastside Bypass Reach 2), at the upstream end of this reach, the channel bed is near the elevation of the ground outside of the levees on both the right and left sides. The computed water-surface profiles indicate that the highest local flow for which the water-surface is at or below the outside ground elevation along the left levee is about 10 cfs, and along the right levee is 370 cfs. These low in-channel capacities are the result of the low outside ground elevations compared to the channel bed. However, a low-flow channel keeps much of these flows confined several hundred feet away from the levees. So, to better characterize the potential levee impacts along the reach, sites with a capacity of less than 300 cfs were identified and a preliminary geotechnical analysis was completed (see Section 7.2).

In the **Lower Eastside Bypass** (Eastside Bypass Reach 3), the computed water-surface profiles indicate that the highest local flow for which the water-surface is at or below the outside ground elevation along the left levee is 2,970 cfs and along the right levee is 2,890 cfs (Figures 29 through 31 in Appendix C). For about 3.6 miles of this reach, the water surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee.

In the **Mariposa Bypass** along the left and right levees, the highest local flow for which the water-surface is at or below the outside ground elevation is 650 and 350 cfs, respectively (Figures 32 through 35 in Appendix C). As evident from the low in-channel capacity, the outside ground elevations in this reach are relatively low when compared to the main flow channel, but they are also relatively uniform throughout the entire reach. For about 6.6 miles of this reach, the water surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee.

7.2 Middle Eastside Bypass Geotechnical Assessment

The In-channel Capacity Study (Section 7.1) identified three locations along the Eastside Bypass with unusually low channel capacities ranging from 10 cfs to 240 cfs. As a preliminary component of the SJLE Project, and to further investigate in-channel capacity results in the Middle Eastside Bypass relative to levee performance, preliminary levee seepage and stability analyses were completed at each of these three sites. Analyses of the remainder levees of the Eastside Bypass will be performed under subsequent SJLE Project tasks. This preliminary analysis was performed to better understand the potential levee seepage and stability impacts in the reach with high ground elevations along the landside levee toe resulting in unreasonably low in-channel capacity. The result of this analysis is reported in the *Middle Eastside Bypass Geotechnical Assessment* dated August 30, 2013 (URS, 2013), is included in Appendix D. The analyses were conducted using geotechnical exploration data collected as part of the SJLE Project, which will be documented in subsequent SJLE Project data reports. Additional geotechnical analyses in this and other reaches will be completed as part of the SJE Project (see Section 10.1) and documented in subsequent SJLE Project analysis reports.

7.2.1 Background and Past Levee Performance

Until adequate data are available to determine levee performance, the SJRRP is limiting the release of Restoration Flows to those that would remain in-channel. The purpose of this analysis is to determine the amount of water that can be placed on the waterside levee slopes without exceeding geotechnical criteria for stability and seepage at the three critical sites along the left levee of the Middle Eastside Bypass (Figure 1, Appendix D). Site 1 occurs in the upper portion of the reach with an in-channel capacity of 10 cfs. Site 2 is located adjacent to the Merced Wildlife Refuge and has an in-channel capacity of 120 cfs. Site 3 occurs about 6,500 feet downstream of Site 1 and has an in-channel capacity of 230 cfs.

Documented past performance events in the area of the Middle Eastside Bypass include seepage, boils, sloughing, cracking, widespread erosion, and near overtopping. However, there have been no documented reports of breaches. Based on the observations made by the Lower San Joaquin Levee District (LSJLD) staff, the primary issues appear to be chronic seepage and inundation once water gets on to the waterside levee slopes (i.e., not necessarily highwater events).

Underseepage may cause piping and internal erosion of material due to excessive pore water pressure under the foundation blanket layers, and may negatively impact slope stability by reducing effective stresses in both embankment and foundation soils. Underseepage conditions are generally expressed by an average vertical exit gradient. Excessive gradients can result in the formation of sand boils, piping and levee failure if left unrepaired.

7.2.2 Geotechnical Approach and Criteria

The analyses completed at the three sites were limited to levee seepage and stability. Due to the a lack of exploration data along the levee toe, cross sections were developed at the sites using available levee crest drilling data that was laterally extrapolated to capture the landside and waterside toes. At each site, sensitivity cases were analyzed for four different water surface elevations (WSE), which were used to interpolate the WSE corresponding to acceptable criteria for seepage and stability.

For the seepage analysis, underseepage conditions are generally expressed by an average vertical exit gradient. The average vertical exit gradient criteria used for the assessment are shown in Table 4-1 of Appendix D. The allowable vertical gradients range from less than 0.5 for the landside levee toe, and between 0.5 and 0.8 for landward locations up to 150 feet from the levee toe.

For the slope stability analysis, the same stratigraphy and models used in the seepage analysis were used to assess slope stability. A factor of safety number is typically used to characterize the stability of a slope, which is the ratio of the available shear strength to the shear strength required for equilibrium. A minimum factor of safety of 1.4 is required for slip surfaces that could affect the overall stability of the levee (i.e. deeper seated failures that intersect with the levee crown and impact the full height of the levee).

The three sites were analyzed for seepage and slope stability using a series of sensitivity models to cover a range of possible field conditions. Soil strength and seepage parameters selected for the analysis were determined using a combination of exploration data, engineering judgment, the knowledge of the materials in the area and the recommendations of the DWR Levees and Evaluations Program.

7.2.3 Analysis and Results

At **Site 1,** a 3 feet to 4 feet deep landside ditch is located approximately 30 feet from the landside levee toe. Based on the exploration data available, the levee embankment is comprised of a mixture of silty and clayey sand, silt and clay. Subsurface materials consist of silts and clays with interbeds of silty sand and clayey sand. Due to variability of the landside blanket conditions and the presence of the ditch, a sensitivity analysis was completed assuming varying blanket thicknesses ranging from 1.5 feet to 10 feet thick. In general, the analysis shows that underseepage is the controlling geotechnical failure mode for the Site 1 if the landside ditch is empty and slope stability if the landside ditch is full. Approximately 1-foot (ditch empty) and about 5 feet (ditch full) of water on the levee would be acceptable for this site.

At **Site 2**, where there is no landside ditch, available exploration data shows the levee embankment is comprised of silts and clays. Subsurface materials are similar to those at Site 1, but overall the landside blanket is thicker. A landside 12.5 foot-deep-blanket was assumed and sensitivity analysis consisted of reducing the strength parameters for the top three soil layers and increasing the permeability contrast between the blanket and the underlying aquifer layer. The analysis shows that landside slope stability is the controlling geotechnical failure mode and approximately 6.5-foot of water on the levee would be acceptable for this site.

At **Site 3** there is also not a landside ditch, but there is a slight landside depression approximately 30 feet landward of the landside levee toe. Based on the exploration data available, the levee embankment is similar to Site 2. Subsurface materials are comprised of silts and clays with interbeds of sand, silty sand and clayey sand. The landside blanket is variable in this area, but was assumed to be between 5- to 6-foot-thick. Two sensitivity analyses were completed that consisted of modifying the boundary conditions, and increasing the permeability contrast between the blanket and aquifer. In general, the analysis shows that underseepage is the controlling geotechnical failure mode and approximately 3.5-foot of water on the levee would be acceptable at this site.

Table 7-2 summarizes the acceptable maximum water surface elevation, and approximate height of water on the waterside levee toe compared to the relative outside ground elevation. The analysis results and recommendations summarized in Table 7-2 and in Appendix D are based on preliminary data and the results and recommendations should be refined once more detailed information becomes available.

Table 7-2.

Summary of Preliminary Analysis Results for Channel Capacity Assessment[1]

Site	Maximum Water Surface Elevation (feet, NAVD88)	Approximate Height of Water on the Levee[2]
1	100.7	1.2
2	104.0	6.5
3	101.7	3.7

[1] Height of water on the levee at a particular location does not necessarily translate directly to another site, i.e. if water were at a height of 1 foot on the levee at Site 1 then the height of water on the levee at a different location could be different.

[2] Height of water relative to the typical outside ground elevation

After the acceptable WSEs were determined at the critical sites, the 1-D HEC-RAS hydraulic models were used to determine the corresponding flow at each site. For Site 1, the flow that corresponds to 100.7 feet (NAVD88) is about 520 cfs. For Site 2, the flow that corresponds to 104.0 feet (NAVD88) is greater than 4,500 cfs. For Site 3, the flow that corresponds to 101.7 feet (NAVD88) is about 2,270 cfs. These flows are higher than the report in-channel capacity flows identified in Section 7.1 above. However, because the right levee in-channel critical site is 370 cfs and was not part of the preliminary geotechnical assessment, the in-channel capacity of the Middle Eastside Bypass is 370 cfs.

8.0 Recommended Then-existing Channel Capacities

The purpose of this section is to present the recommended then-existing channel capacities based on results from the current channel capacity studies summarized in the previous sections of this report. Then-existing channel capacities are defined as flows that would not significantly increase flood risk from Restoration Flows in the Restoration Area. To reduce this risk, the PEIS/R included levee design criteria for levee slope stability and underseepage Factors of Safety based on USACE criteria for levees. The application of the criteria requires the collection and evaluation of data at locations throughout the Restoration Area. Until adequate data are available to apply the USACE criteria, the release of Restoration Flows would be limited to those that would remain in-channel (the water surface elevation in the river remains below the levees).

Since no additional studies have been completed to better inform channel capacity, the In-channel Capacity Study summarized in Section 7.1 and the Geotechnical Analysis of the Middle Eastside Bypass summarized in Section 7.2 continue to provide the best information for determining then-existing channel capacities. The results in these two studies were again, used to inform recommended then-existing channel capacities. This information uses in-channel capacity as the best estimate of then-existing channel capacities for all reaches. The only exception is the Middle Eastside Bypass, in which adequate data was available to perform a geotechnical analysis.

Based on the 2014 Report, and the results summarized in Sections 7.1 and 7.2 and detailed in Appendices C and D, the recommended then-existing channel capacities for the San Joaquin River and flood bypasses within the Study Area are described below.

- The recommended then-existing channel capacity for Reach 2A is 1,630 cfs based on a low point along the right levee approximately 1.6 miles upstream from the CBBS.
- The recommended then-existing channel capacity for Reach 2B is 1,120 cfs based on a low point along the left levee approximately 4.6 miles upstream of the Mendota Dam. The influence of the Mendota Pool was not considered because normal pool water surface elevations in the pool are already higher than some outside ground elevations adjacent to levees and Restoration Flows would not significantly change this water surface due to the requirements to operate Mendota Dam to maintain a relatively constant pool elevation.
- The recommended then-existing channel capacity for Reach 3 is 2,760 cfs based on a low depression along the right levee about 11.4 miles upstream of Sack Dam.
- The recommended then-existing channel capacity for Reach 4A is 970 cfs based on a low area along the left levee just upstream of Sand Slough.
- The recommended then-existing channel capacity for Reach 4B2 is 930 cfs based on the low ground elevation along the right levee approximately one mile downstream of the confluence of the Mariposa Bypass. The three major depressions were not considered in this or the previous analysis, which would limit the flow to 50 cfs, since these depressions would likely fill with water and reduce levee stability concerns.
- The recommended then-existing channel capacity for Reach 5 is 1,940 cfs, based on a low point along the right levee near the downstream end of the reach.

- The recommended then-existing channel capacity for the Middle Eastside Bypass (Eastside Bypass Reach 2) is 370 cfs. The left levee in the upper portion of the bypass has an in-channel capacity of 10 cfs, but further geotechnical analysis of the low areas below 300 cfs showed that the maximum acceptable water surface elevation on the levee would correspond to a flow of over 500 cfs. However, the next lowest capacity is 370 cfs, which is along the right levee.
- The recommended then-existing channel capacity for the Lower Eastside Bypass (Eastside Bypass Reach 3) is 2,890 cfs based on the low point along the right levee just downstream of the Eastside Bypass Control Structure.
- The recommended then-existing channel capacity for the Mariposa Bypass is 350 cfs based on a low point along the right levee about 1.3 miles upstream of the drop structure.

Table 8-1 summarizes the current and recommended then-existing channel capacities for each reach of the San Joaquin River and the flood bypasses. This report recommends no change in the then-existing channel capacities from the 2014 Report.

Table 8-1.
Current and Recommended Then-existing Channel Capacity

Reach	Current Then-existing Channel Capacity (cfs)	Recommended Then-existing Channel Capacity (cfs)
Reach 2A	1,630	1,630
Reach 2B	1,120	1,120
Reach 3	2,760	2,760
Reach 4A	970	970
Reach 4B1	Not Analyzed	Not Analyzed
Reach 4B2	930	930
Reach 5	1,940	1,940
Middle Eastside Bypass	370	370
Lower Eastside Bypass	2,890	2,890
Mariposa Bypass	350	350

9.0 Future Program Actions with the Potential to Improve Then-existing Channel Capacity

Throughout Settlement implementation, the maximum downstream extent and rate of Restoration Flows to be released would be limited to then-existing channel capacities. As channel or structure modifications are completed with additional environmental compliance, maximum Restoration Flow releases would be correspondingly increased in accordance with then-existing channel capacities and the release schedule. Consistent with the commitments made in the PEIS/R ROD, Restoration Flows would be reduced, as needed, to address material seepage and levee stability impacts, as identified in the Physical Monitoring and Management Plan in Appendix D of the PEIS/R. If releases of water from Friant Dam are required for flood control purposes, concurrent Restoration Flows would be reduced by an amount equivalent to the required flood control release. If flood control releases from Friant exceed the concurrent scheduled Restoration Flows, no additional releases above those required for flood control would be made for SJRRP purposes.

Until sufficient data are available to determine the levee seepage and stability Factors of Safety, Reclamation would limit Restoration flow releases to those flows which would remain in-channel. When sufficient data are available to determine the Factors of Safety, Reclamation would limit the release of Restoration Flows to those flows which would maintain standard USACE levee performance criteria at all times.

The following sections identify potential immediate, near-term and long-term actions by the SJRRP that could affect then-existing channel capacity due to changes in the physical conditions within the Restoration Area. The listed potential actions and projects is not a comprehensive list, but a list of actions that may be implemented. Future actions listed in future annual reports may change as monitoring is conducted and physical changes within the Restoration Area occur and are identified. . If any actions increase then-existing channel capacities, a new Channel Capacity Report will be prepared prior to Reclamation increasing Restoration Flows.

9.1 Immediate Actions

Immediate actions are described at a project-level in the PEIS/R including specific details in the *Physical Monitoring and Management Plan* in Appendix D. Potential immediate actions to a reduction in channel capacity continue to include removal of vegetation and debris and/or restrictions on Restoration Flows that would exceed channel capacity.

Since the start of Interim and Restoration Flows, the SJRRP has implemented flow limitations and immediate flow reductions to address issues related to then-existing channel capacity, mainly for groundwater seepage and will continue to do so on an as-needed basis during the release of Restoration Flows.

Vegetation removal would be conducted by mechanical or chemical means. Nonnative plant removal would receive priority over removal of native species. These responses could include unplanned emergency actions or actions taken within the water year.

9.2 Near-Term Actions

In addition to immediate actions, the SJRRP is evaluating sediment, vegetation and operational and maintenance projects that are being considered for implementation in the next couple of years (near-term) to address the potential to maintain or increase then-existing channel capacities. The following sections update the anticipated implementation schedules of the near-term actions described in the previous year's 2014 Report, as well as provide updates and future activities related to levee stability and channel capacity summarized in the *Physical Monitoring and Management Plan*.

9.2.1 Sediment Removal Projects

Sediment deposition in the Eastside Bypass contributes to reduced channel capacities. At present, there is one proposed project to remove sediment from the river system near the confluence of the Eastside Bypass (Eastside Bypass Reach 2) and Reach 4B1 of the San Joaquin River. An Appraisal level study was conducted for this project in 2013, and a technical memorandum was completed documenting the concepts and costs for this study. This project has the potential to increase the low flow channel capacity in the Middle Eastside Bypass, which parallels Reach 4B1. It is expected that this project will be completed in 2015 or 2016.

9.2.2 Vegetation Removal Projects

Vegetation within the channel can reduce channel capacity by increasing channel roughness. Vegetation management may be necessary to maintain then-existing channel capacities. Reclamation is continuing to work with a local non-profit, the San Joaquin River Parkway and Conservation Trust, to identify, manage, and monitor invasive aquatic and riparian species. The existing program is anticipated to continue into the future.

9.2.3 Operations and Maintenance Improvements

Overall operation and maintenance including vegetation and sediment management, structure and gate operations, levee stability and integrity of the San Joaquin River and flood bypasses can impact then-existing channel capacity. Reclamation is continuing to actively pursue a financial assistance agreement with the LSJLD to fund LSJLD's efforts to adapt to changes in maintenance type and frequency and to make modifications to existing operations to account for changes as a result of the release of SJRRP Restoration Flows, such as increases in vegetation growth or increased maintenance or operation of structures.

9.2.4 Seepage Management Plan

Reclamation has developed a Seepage Management Plan and Seepage Project Handbook to guide efforts related to groundwater seepage. It should be noted that the actions and findings of the Seepage Management Plan, although related to channel capacity, is being reported as it relates to agricultural seepage only. However, data collection and seepage projects will be closely coordinated to determine effect on channel capacities. Reclamation releases Restoration Flows in a manner that groundwater levels do not exceed thresholds that could cause seepage issues due to Restoration Flow releases.

There are 93 groups of assessor parcels that may need seepage projects and will be evaluated for impacts. Reclamation will be gradually implementing seepage projects by parcel group based on flow restriction. Reclamation has implemented the first two projects, and anticipates implementing a third in 2015 or 2016. Once these three are implemented, Reclamation estimates approximately 300 cfs can pass into the Eastside Bypass (subject to real time groundwater monitoring). The Seepage Management Plan and Seepage Project Handbook can be found at the SJRRP website under the following link: http://restoresjr.net/flows/Groundwater/index.html#SMP.

9.3 Long-Term Actions

Long-term actions by the SJRRP will be needed to achieve then-existing channel capacities in the San Joaquin River and flood bypasses that can convey maximum Restoration Flow releases. Potential long-term actions could include, but would not be limited to, the following: providing a larger floodplain between levees through the acquisition of land and construction of setback levees; re-grading of land between levees; construction of sediment traps; sediment removal; levee improvements; construction of grade control structures; and channel grading.

Long-term actions would require a determination of need, identification for funding, and site-specific environmental compliance documentation. These actions would be considered by the SJRRP to allow the continued increase of then-existing channel capacity to meet full Restoration Flows.

The SJRRP is continuing to work on several long-term projects related to increasing site-specific channel capacity as provided for in the Settlement paragraphs 11(a) and 11(b). These projects include the following activities to be completed in future years:

- Construct Mendota Pool Bypass. Building a bypass around the Mendota Pool to convey at least 4,500 cfs from Reach 2B to Reach 3. This could also include a fish screen or positive fish barrier to avoid fish straying into Mendota Pool.
- Modify Reach 2B to convey at least 4,500 cfs. The channel would be modified to expand its capacity to at least 4,500 cfs with integrated floodplain habitat. New levees would be constructed to accommodate Restoration Flows, increasing the flood capacity of the reach.
- Modify Reach 4B1 to convey at least 475 cfs. Reach 4B would be modified to convey at least 475 cfs with integrated floodplain habitat. In addition to modifications of the Reach 4B1 channel to convey at least 475 cfs, the Settlement and the San Joaquin River Restoration Settlement Act, Public Law 111-11, Section 10009(f)(2)(B) also requires that a determination be made on increasing the channel capacity to 4,500 cfs. Modification of the San Joaquin River Headgate Structure and other structures would also need to be completed to enable fish passage and flow routing. These modifications are to be made consistent with the decision as to whether 4,500 cfs is routed through Reach 4B1.

9.4 Framework for Implementation

All of the immediate, near-term, and long-term actions identified above are included in the SJRRP's *Framework for Implementation*. The *Framework for Implementation* is being revised to prioritize SJRRP actions and provide a realistic schedule and associated future funding need to form the basis of continued implementation of the Settlement and the Settlement Act. The revised *Framework* will accomplish the following:

1. Prioritize the SJRRP "core" actions to allow for a more focused and thoughtful implementation of the Settlement and Settlement Act;
2. Provide an accurate and achievable reflection of budget and schedule for planning and transparency purposes; and,
3. More clearly assign roles and responsibilities for each Implementing Agency to allow for better agency budget planning and more efficient planning and approval for construction actions.

The SJRRP and stakeholders are working together to identify timelines for gradually increasing channel capacity and increasing levels of unimpeded passage. With regard to actions to increase channel capacity, the San Joaquin Levee Evaluation (SJLE) Project is assisting the SJRRP in assessing flood risks associated with the SJRRP based on geotechnical data. Once this evaluation is complete, then-existing channel capacities will be refined according to the USACE levee seepage and slope stability criteria. At that time, the SJRRP will have a better understanding of what levee projects will be needed.

10.0 Future Program Studies and Monitoring with the Potential to Inform Then-existing Channel Capacity

There are several factors that can impact and limit channel capacity. Potential factors could include overall levee construction or integrity (e.g., insufficient slope stability factor of safety or underseepage factor of safety); flow duration and timing that could saturate the levee and cause instability; erosion of the stream banks that could cause potential levee failure; sedimentation or scouring; ground subsidence; and increased roughness from vegetation. Other future conditions, such as climate change and operation and maintenance while not directly impacting channel capacity, could have long-term impacts on overall performance of the conveyance system. These factors, as well as others were considered in developing future SJRRP studies and monitoring to determine then-existing channel capacity. The following section summarizes the specific studies and data collection activities planned by the SJRRP to allow a better understanding of then-existing channel capacity or changes in channel capacity.

10.1 Technical Studies

The 2014 Report described several future technical studies that either build on the studies described in Section 7.0 – Current Channel Capacity Studies and Related Work Completed or will provide additional information necessary to identify future then-existing channel capacities. All of those studies are currently being conducted and the following describes a status update of these activities.

10.1.1 Verification and Monitoring of In-channel Capacity

The In-channel Capacity Verification and Monitoring study is being conducted by DWR to validate the existing in-channel capacities determined in the In-channel Capacity Study (Section 7.1) in critical areas and implement a monitoring program to ensure that changes in in-channel capacity can be promptly identified.

Specifically, DWR will be collecting additional topographic surveys to verify the 2008 LiDAR and evaluating impacts to in-channel capacity from the operation of the Merced Wildlife Refuge Weirs in the Middle Eastside Bypass. DWR will also develop an in-channel water surface elevation monitoring plan to evaluate future changes in the in-channel capacity due to vegetation, sedimentation, or other channel changes. The objective is to develop a monitoring plan for the critical locations identified in each reach that limit the flow capacity of the reach. The plan will include a review of the existing monitoring stations to determine if they are close enough and adequate for monitoring the critical sites. If the existing monitoring sites are not adequate, new sites will be identified in consultation with other on-going programs so that new stage and flow measuring devices can be installed. The plan will verify that the correlations of gaged flows to the water-surface elevations/stages at the critical locations are good and reliable. The study is expected to be completed in the first part of 2015.

10.1.2 San Joaquin Levee Evaluation Project

The SJLE Project assists the SJRRP in assessing flood risks associated with the SJRRP with respect to levee seepage and stability. Completion of this study will help determine and update then-existing channel capacity based on meeting USACE levee seepage and stability criteria using geotechnical data. Under the SJLE Project, DWR is performing geotechnical explorations, to assess the integrity of the existing levees within the Restoration Area with respect to seepage and stability. The Project will also identify potential alternatives to remediate the existing levees. As portions of SJLE Project study area overlap with DWR's Non-Urban Levee Evaluation (NULE) Project, which is summarized in Section 11.3.1 of this report, the SJLE Project will be using some of the NULE Project data and processes.

DWR has completed in June 2013, geotechnical explorations of Priority 1 levees including Cone Penetrometer Tests (CPTs) and borings. DWR also implemented electrical resistivity imaging (ERI) to identify conditions that may indicate the presence of paleo-channels beneath the existing levees. The purpose of this work is to help plan a more cost-efficient supplemental subsurface exploration plan for Priority 1 levees. The field work for the ERI work was completed in March 2014 and the Geophysical Data report was completed in June 2014. The final Geotechnical Data Report that summarizes all of the data collection efforts is expected in January 2015, and the Geotechnical Overview Report that includes analysis of and recommendation for levee improvements will be following in April 2015. Details of the specific tasks that will be completed as part of this study are summarized in Section 10.1.2 of the 2014 Report.

10.1.3 Reach 2A Morphology Study

The Reach 2A Sediment Study was carried out in the lower portion of Reach 2A to investigate the sediment deposition upstream from the CBBS, which may have been a result of the 2009 through 2011 Interim Flow releases and the 2010 and 2011 flood flow releases. The study showed that in the short-term, Interim and Restoration flows did not have a significant impact on channel capacity in the lower portion of Reach 2A. Additional work has not been completed since the preparation of the 2014 Report; however, if changes in sediment movement through the lower portion of Reach 2A occur due to an increase in flow magnitude or frequency, additional work in the form of a Reach 2A Morphology Study may be completed. This study would help the SJRRP determine the short-term and long-term channel response in Reach 2A and the CBBS and its potential impact on then-existing channel capacity. This information can also be used to assess the potential need to change then-existing channel capacity in Reach 2A or take immediate or long term-actions. The goal will be to provide the SJRRP with a better understanding of expected long-term Reach 2A channel capacity changes and Reach 2B and Chowchilla Bypass sediment supply through the CBBS. The initial study was described in Section 7.3 of the 2014 Report; a summary of the potential work that could be completed is in Section 10.1.3 of the 2014 Report.

10.1.4 Subsidence Monitoring and Studies

This following section briefly describes the methods and results of the subsidence monitoring and levee surveys completed since 2011 by the Bureau of Reclamation, Mid–Pacific Region, Division of Design and Construction, Surveys and Mapping Branch (MP-220) and the California Department of Water Resources, South Central Region Office (DWR-SCRO) for the San Joaquin River Restoration Program (SJRRP). Additional details are also provided in *Technical*

Memorandum, Subsidence Monitoring and included in Attachment E. The results of the monitoring are being used to study subsidence within the Restoration Area and to support the various studies that will help the SJRRP determine changes in then-existing channel capacities as a result of subsidence.

Reclamation Geodetic Control Network

In 2011, Reclamation established the SJRRP Geodetic Control Network, using static GPS methods, to investigate subsidence within the SJRRP Restoration and surrounding study areas. To monitor the rate of subsidence over time, Reclamation conducts bi-annual surveys, in July and December, of the established network made up of 85 control points. The control point elevations are updated after each survey and are used by the SJRRP to study subsidence, as well as to provide more accurate horizontal and vertical control for other studies.

After each survey, Reclamation prepares exhibit maps that compare the most recent data with the data from the previous survey, as well as from previous years. The exhibit maps give a good overall picture of the subsidence trends within the SJRRP Restoration Area. Figure 10-1 shows the calculated annual subsidence rates ranging from about 0.15 ft/year to 0.75 ft/year based on survey data collected in December 2011 and December 2013, and averaged over a two year period. The calculated annual subsidence rates will vary with time, but in general, appear to either remain constant, or in some areas increase since the start of the surveys. Appendix E includes exhibit maps comparing the six month monitoring events (calculated as annual subsidence rates) starting in December 2011 through December 2013.

Beginning in May 2012 Reclamation began monitoring the Arroyo and Temple-Santa Rita (TSR) Canals to understand the localized subsidence near Sack Dam. This data is being collected to support the design efforts for the Arroyo Canal Fish Screen and Sack Dam Fish Passage Project. The project is currently on hold until the SJRRP can better understand the magnitude of future subsidence and the effect of subsidence on the final design and operations.

The SJRRP is using the semiannual monitoring data and the Arroyo and TSR survey, in part to support and update the technical memorandum *Subsidence Design Criteria for the San Joaquin River Restoration Program (DRAFT), Technical Memorandum No. SUB-1* (Reclamation, 2013), which documents subsidence within the SJRRP Restoration Area, and establishes recommended subsidence criteria that will be applied to the designs for future site-specific projects in Reach 2B, Reach 4B, and at the Arroyo Canal diversion in Reach 3. A final draft of the Technical Memorandum will be circulated for comment, and finalized in 2015.

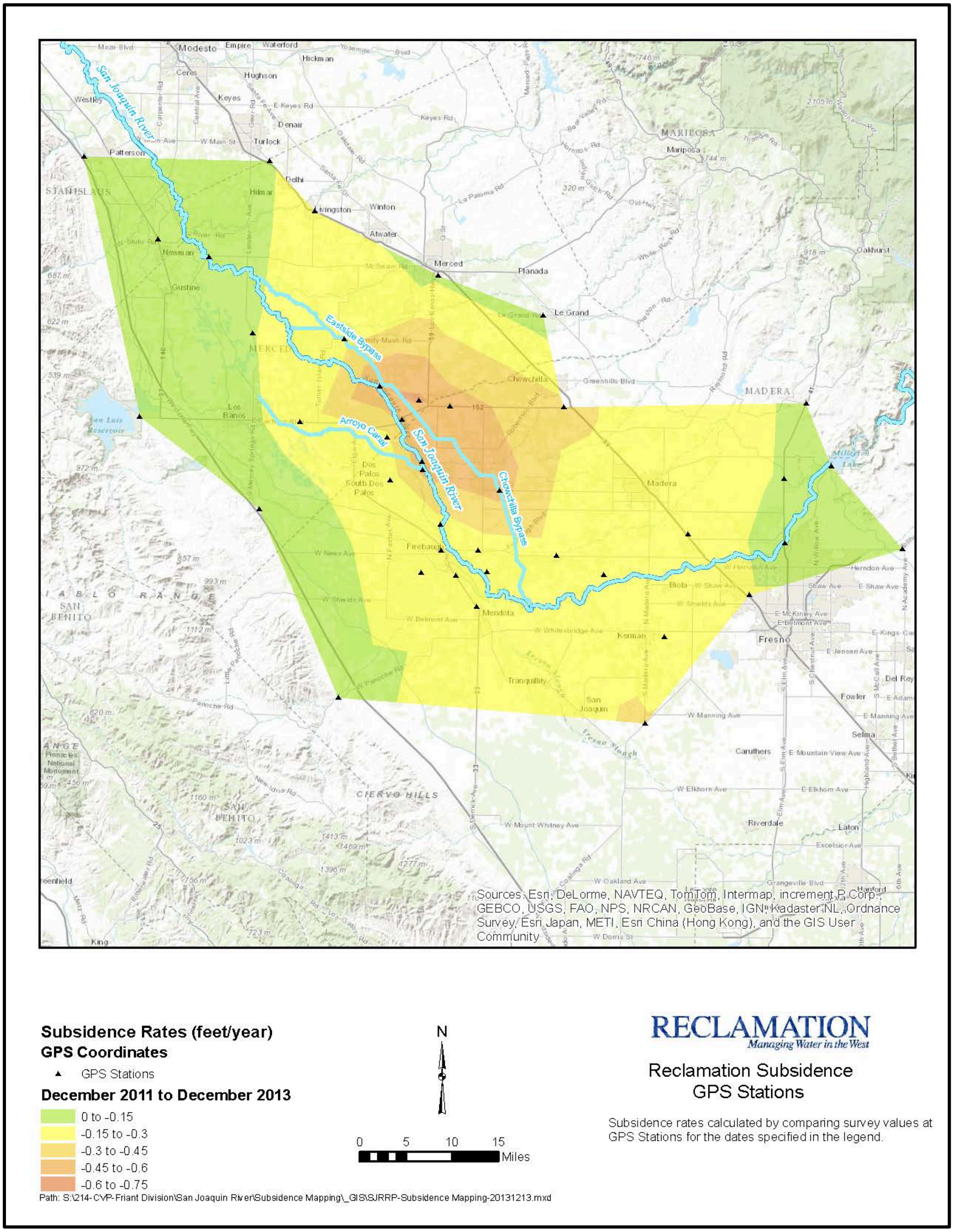

Figure 10-1.

Regional Subsidence Map

DWR Capacity Studies and Analysis

In late 2012 and again in 2013, DWR completed surveys of the tops of approximately 65 miles of levees within the downstream portion of Reach 2A; the Eastside Bypass from its confluence with the Fresno River to the Eastside Bypass Control Structure; and the Mariposa Bypass. Profiles that compare the 2008 LiDAR with the top of the levee surveys from 2012 and 2013 for the survey data are shown in Appendix E. In addition to the above surveys, DWR also completed surveys in 2013 and 2014 of the levee and channel in the lower portion of Reach 3, Reach 4A, and the Middle Eastside Bypass; however, this data is still being analyzed at the time of the preparation of this report.

The 2012 processed survey data was used to estimate annual subsidence rates by calculating the difference between the 2012 data and the 2008 LiDAR elevations. The estimated annual rates from 2012 were used to develop 1-D hydraulic models of the flood bypasses to determine potential future impacts to flood flow capacity as a result of subsidence. The findings of this study were summarized in Section 7.4 of the 2014 Report. A comparison of the levee survey data collected in 2012 and the follow-up survey in 2013 shows that the average annual rates of subsidence range from less than 0.2 ft/year to about 1.2 ft/year. The areas with the highest rates of subsidence, such as Road 4 within the bypass, correspond with those identified by Reclamation's Geodetic Control Network surveys. However, the average annual calculated rates for the Geodetic Control Network surveys and the levee surveys can vary because of the differences in the survey extent and location, data collection method (top of levee versus control points), and the overall density of points collected (100 – 300 ft intervals along the levees versus a single control point).

To better understand the effects of continued subsidence on channel capacity, DWR will use the levee and channel survey data to complete a flow capacity study in the lower portion of Reach 3, Reach 4A and the Middle Eastside Bypass. The study includes analysis of the data collected in 2012, 2013 and 2014, an update of the 1-D hydraulic modeling tools, and an update to in-channel capacities, if necessary. The results of the study will also inform the geotechnical evaluations being completed as part of the SJLE Project, and the Verification and Monitoring of In-channel Capacity study.

In addition to completing the channel capacity study, DWR has started to move forward with a study within the flood bypasses to understand how subsidence is changing the sediment transport. The study is designed to better understand and quantify how subsidence-induced sedimentation will affect channel capacity and to provide information on the amount of sediment removal that may be required to maintain necessary design flow capacities. Results from the sediment transport study could provide information to further evaluate bypass flow capacities, as well as refine certain aspects of the design for the Reach 4B, Eastside Bypass and Mariposa Bypass Channel and Structural Improvements Project.

10.1.5 Vegetation Modeling

Reclamation will use existing SRH-2D hydraulic models to quantify potential increases in river stage given increases in riparian growth in reaches that convey the SJRRP Restoration Flows. This study will help the SJRRP determine if action needs to be taken to maintain or reduce then-existing channel capacities. It is expected that the analysis will be performed in Reaches 2A and

4A as they have the highest potential for vegetation recruitment as a result of rewetting. The existing conditions Reclamation-built 2-D models, described briefly in Section 5.0 -- Data and Analytical Tools, will be used as a starting condition. The potential increase in vegetation will be estimated using analogs to surrounding reaches. Various methods will be used to predict the increase in river stage due to increasing vegetation density. A technical report documenting the effect of vegetation roughness in Reaches 2A and 4A is expected in 2015.

10.2 Monitoring Activities

The SJRRP is continuing various monitoring activities for different studies and purposes. The monitoring described below will guide implementation of the Settlement for observing and adjusting to changes in physical conditions within the Restoration Area including those changes that may impact channel capacity. These monitoring activities are described in the *Physical Monitoring and Management Plan*, which is in Appendix D of the PEIS/R, or the *Restoration Flow Guidelines,* or the *Seepage Management Plan.* The following sections describe the monitoring that may be undertaken on an as-needed basis.

10.2.1 Flow monitoring

The objective of continuing to monitor flow is to ensure compliance with the hydrograph releases in Exhibit B of the Settlement and any other applicable flow releases without exceeding then-existing channel capacity. Reclamation, DWR and the USGS currently maintain 23 flow and staff gages along the San Joaquin River and tributaries between Friant Dam and the Merced confluence. These gages are used to determine the flow in each reach of the river. All of the gages shown in Figure 10-2 below are telemetered and available online at the California Data Exchange Center (CDEC). Each of the operating agencies also conducts periodic flow measurements in order to develop and adjust rating curves as necessary. Final daily average data is determined monthly by Reclamation, as requested by DWR, and annually by the USGS. Flow monitoring stations provide calibration data for hydraulic models and a key dataset for comparison and evaluation. Monitoring of these stations would continue as needed to help ensure Restoration Flows do not exceed then-existing channel capacities.

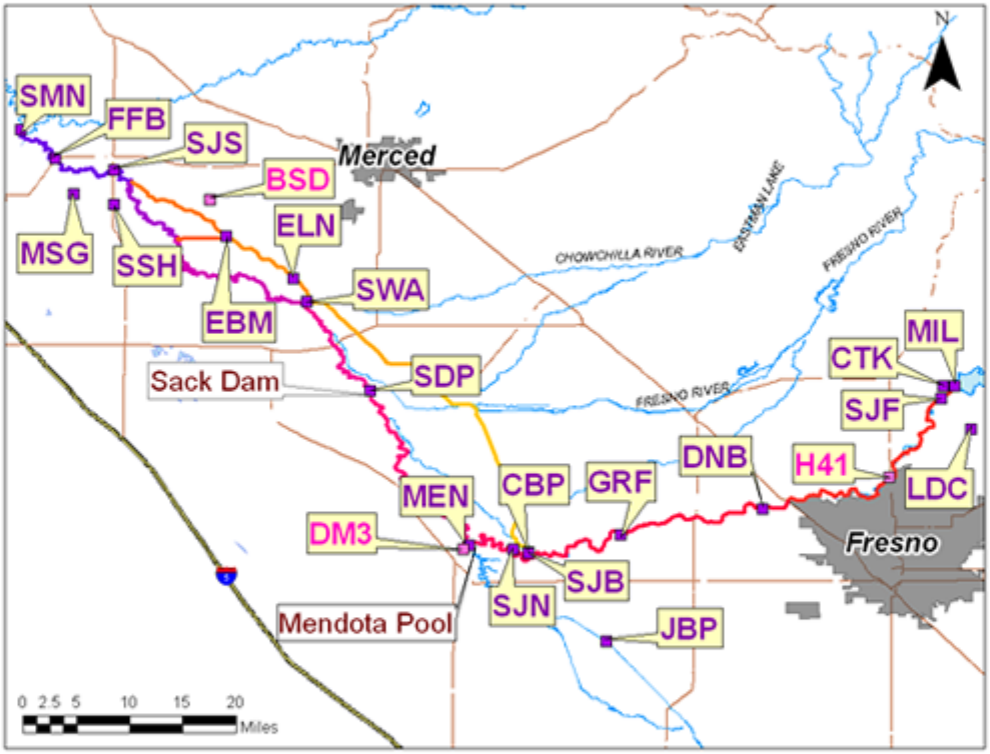

Figure 10-2.

Current flow gages (purple) and staff gages (pink) available on CDEC

10.2.2 Water surface profile surveys

Along with flow monitoring, water surface profile (WSP) surveys help inform the SJRRP of the potential changes in stage and channel capacity as a result of a change in specific or reach-wide conditions due to vegetation, channel work and sediment transport. In 2014, additional WSP surveys may be completed in some reaches, depending on flow releases from Friant and model calibration needs.

10.2.3 Aerial Photography and Topographic surveys

The purpose of the aerial photography and topographic surveys is to obtain information about the river stage, hydraulic roughness, river width, and bed elevation to assist with scientific studies that would inform the SJRRP about how physical changes in the system are impacting then-existing channel capacities. A number of survey data sets have been collected in this region before and after the Settlement to support the SJRRP. The most current topography was the aerial LiDAR completed in 2008 and bathymetric surveys that were completed in 2010/2011. Because of subsidence experienced in the Restoration Area and the uncertainties on the rates of subsidence, additional LiDAR surveys will be collected in early 2015. Bathymetry surveys in some reaches will be completed in 2014, as needed. New terrain surfaces will be created with this updated topographic data and will be used for site-specific designs and to update hydraulic models and studies which could be used to inform then-existing channel capacity.

Aerial photography with both natural color and infrared will be completed at the same time as LiDAR in early 2015.

DWR also has conducted multiple topographic surveys in Reaches 2A and 2B between 2008 and 2013. The goal is to monitor long-term changes in these reaches to identify depositional and erosional trends that could change the hydraulics of the system and potentially effect channel capacity in these reaches. The current phase of this study involves using the survey data to estimate the changes in sediment volume that has occurred. DWR will continue to periodically complete additional surveys, as needed, and surveys are likely for 2015.

10.2.4 Erosion Monitoring

Erosion monitoring of the channel and channel banks would be conducted by the SJRRP to identify areas that may potentially compromise levee integrity for consideration of future management actions and projects (flow reduction, revetment, armoring, etc.). Monitoring would be completed using several standard methodologies and protocols commonly employed by DWR, reclamation districts, and/or USACE to monitor levee erosion. These surveys would assess the condition of potential erosion sites, and could include a variety of techniques such as aerial photography and topographic surveys.

10.2.5 Vegetation surveys

The purpose of the previous and future vegetation surveys is to obtain information on the establishment and recruitment of vegetation. This information can be used by the SJRRP to determine if actions need to be taken to address capacity issues as a result of increased channel roughness from vegetation. Annual surveys have occurred since 2011 and future surveys will be conducted annually as part of baseline SJRRP monitoring. The extent and scope of the monitoring is discussed in Section 10.2.5 of the 2014 Report.

10.2.6 Suspended Sediment

Reclamation continues to collect suspended sediment data to inform channel capacity through the development of an annual sediment hydrograph for the Restoration Area. Each year, the USGS collects suspended-sediment, bedload, bed gradation data, and stream discharge eight times at several locations. These sampling sites, listed in the order of the downstream direction, are: Highway 41, Skaggs Bridge, Gravelly Ford, 1.3 miles west of Napa Ave (above CBBS), below CBBS, and below Mendota Dam. This information will be useful to DWR and Reclamation as they develop studies on the sedimentation impacts on channel capacity in the San Joaquin River and flood bypasses.

11.0 Non-Program Actions and Studies that May Influence Future Channel Capacity

There are several other entities that are active in the Restoration Area and whose programs may help inform or impact then-existing channel capacity. The SJRRP will need to closely coordinate and collaborate with these entities by sharing information and data, as well as coordinating specific actions along the river that can inform or impact channel capacity. This section provides recent updates of the programs, actions, and studies of other agencies that could impact or allow a better understanding of future channel capacity within the SJRRP Restoration Area. The 2014 Report provides a more complete description of these activities of these agencies. A new DWR program, the Flood System Repair Project, was also added to this report.

11.1 Lower San Joaquin Levee District

The LSJLD is a local agency that is responsible for operation, maintenance, and emergency management of the LSJRFC Project, which is part of the State Plan of Flood Control (SPFC) facilities within the SJRRP Restoration Area. The LSJLD operates and maintains levees, bypasses and other facilities built in connection with the SPFC and these actions directly impact the capacities of the reaches in the study area. The LSJLD identified six erosion sites along Reach 2A of the San Joaquin River experiencing increased levels of bank erosion that threaten the flood control levee system. To reduce this potential and maintain channel capacity, bank stabilization efforts currently underway consist of lining the banks with erosion-resistant materials such as rock, concrete rubble and local hard-pan. Four of the six sites have been completed and the LSJLD has started work on one of the remaining two sites and the other to follow as resources allow.

11.2 Merced National Wildlife Refuge

The U.S. Fish & Wildlife Service (USFWS) currently operates a pair of weirs within the boundaries of the MNWR along the Middle Eastside Bypass (Eastside Bypass Reach 2) that could have an impact on channel capacity. These weirs are referred to as the upper and lower wildlife refuge weirs, since they are located at the upstream and downstream intersections of the MNWR and the bypass. These structures have the ability to check water both upstream of the MNWR and within its boundaries for diversion to the various wetlands operated by USFWS. When the boards are placed into the weirs, they have can have an impact on water surface elevation and capacity of the bypass. As stated in Section 10.1.1, DWR is completing a study that evaluates the impacts of weir operations on channel capacity.

11.3 DWR

In implementation of its FloodSAFE initiative, DWR is leading three specific efforts within the SJRRP Restoration Area that may affect or inform channel capacity.

11.3.1 Non-Urban Levee Evaluations

As a component of its FloodSAFE initiative, DWR has been performing geotechnical evaluations of over 1,800 miles of levees throughout the Central Valley. The evaluations are divided into the Urban Levee Evaluations (ULE) Project for levees protecting populations greater than 10,000 and the NULE Project for remaining levees including a portion of the levee features within the Restoration Area. The evaluations are limited to Project levees and appurtenant Non-Project levees, which protect part of a basin partially, protected by Project levees or may impact the performance of Project levees.

As discussed in the 2014 Report, the subsurface exploration portion of the program was completed in 2012 and consisted of approximately 5 CPTs and 1 exploratory boring on the levee crest per mile with occasional explorations on the levee toe. A total of 164 CPTs and 40 borings were drilled on or along levees in Reaches 2A, 3, and 4A. A total of 125 CPTs and 46 borings were drilled along the Eastside Bypass and Chowchilla Bypass Canal. The Geotechnical Data Report (GDR) for this effort was completed in February 2014. NULE Geotechnical Overview Report (GOR) analysis is being performed currently and seepage and stability results will be presented in the GOR for existing levees. The GOR will also include proposed alternatives for remediating the existing levees. The GOR is expected to be completed by mid to late 2014. The NULE assessments and SJLE Project will continue to coordinate data collection efforts and findings, which could be used to inform next year’s then-existing channel capacity.

11.3.2 Regional Flood Management Planning

As part of its FloodSAFE initiative, DWR is also coordinating a Regional Flood Management Planning effort for the Central Valley. The regional planning effort supports locally-developed Region Flood Management Plans (RFMP) and is an important step in refining and implementing the Central Valley Flood Protection Plan (CVFPP). The main goal of the RFMP is to identify high priority regional flood risk reduction solutions that are both economically viable and implementable. As part of the regional planning effort, the Upper San Joaquin River (USJR) Region, that encompasses a significant part of the Restoration Area, was created.

The USJR Region is currently preparing a RFMP that describes the region's flood hazards, flood control systems, and ultimately the vision for a "floodsafe" region. Currently, there are 86 projects and management actions that are being proposed for the RFMP and it is expected that several of the proposed projects will reduce flood risk in the Restoration Area. Ten SJRRP projects are currently included on the USJR Region’s project list and the USJR Region has been coordinating with the SJRRP on potential projects that could increase then-existing channel capacities in the Restoration Area. This planning effort will help illuminate the regional flood risk reduction benefits of the SJRRP.

The USJR Region is diligently working to complete the RFMP and several sections of the RFMP have been drafted. The USJR is also finalizing a method for ranking projects and actions. In its work on the RFMP, monthly coordination with regional stakeholders has been essential in soliciting input and comments on the projects and regional priorities. One of the regional project implementation strategies is to “bundle” projects together its packages that will greatly increase the multi-benefit funding possibilities for the regional projects and actions. This could help to integrate the regional projects and make them implementable. Ultimately, the RFMP will help inform the federal, state, and local agencies of the regional flood management needs and lead to implementation of the projects and actions needed for a "floodsafe" region. The last part of the regional planning effort in the USJR Region is to work with the regional stakeholders to develop a financial plan to identify a strategy to fund the priority actions with a collection of federal, state, and local funding sources. The plan is scheduled to be complete in January 2015.

11.3.3 Flood System Repair Project

As part of its FloodSAFE initiative, DWR is also implementing one of the CVFPP's near-term priority actions, the Flood System Repair Project (FSRP) to help Local Maintaining Agencies (LMAs) reduce flood risks in non-urban areas. Through FSRP, DWR is assisting LMAs by providing them with technical and financial support to repair documented critical problems with flood control facilities of the State Plan of Flood Control (SPFC) in non-urban areas.

The objectives of the FSRP are to repair documented critical problems like erosion sites (50-feet in length or less), hydraulic control structures, and deteriorated levee patrol roads. Under the FSRP, DWR is working with the LSJLD to re-rock 25.5 miles of levee roadways to provide all-weather access to the levees. This will help reduce flood risks by improving the reliability of the levees for levee monitoring during flood events. In addition, the FSRP is working with the LSJLD to modernize the Chowchilla Bypass, San Joaquin River, Eastside Bypass, and Mariposa Bypass control structures' electronic gate controls. These modifications will improve the system operations by providing a more reliable system and allowing the ability to adjust gate settings quicker for more efficient operation. The LSJLD prepared the plans and specifications and is working with DWR on the schedule and funding. The LSJLD is in the process of acquiring the needed permits. The current plan is for the work to start in the spring of 2015.

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13.0 Appendices

A. PEIS/R Text Related to Channel Capacity, 2012
B. Hydraulic and Sediment Transport Modeling Strategy, 2014
C. San Joaquin River In-channel Capacity Analysis, 2013
D. Middle Eastside Bypass Geotechnical Assessment, 2013
E. Technical Memorandum, Subsidence Monitoring, 2014
F. Responses to Comments, 2015