Technical Memorandum

Public Draft

Channel Capacity Report
2020 Restoration Year

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List of Abbreviations and Acronyms

CCAG	Channel Capacity Advisory Group
CCR	Channel Capacity Report
CFS	Cubic feet per second
CPT	Cone Penetration Test (Cone Penetrometer Test)
CVFPB	Central Valley Flood Protection Board
DWR	Department of Water Resources
GCR	Geotechnical Conditions 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
NOD	Notice of Determination
O&M	Operations and Maintenance
PEIS/R	Program Environmental Impact Statement/Environmental Impact Report
Reclamation	Bureau of Reclamation
Restoration Area	San Joaquin River Restoration Program Restoration Area
RM	River mile
ROD	Record of Decision
SJLE Project	San Joaquin Levee Evaluation Project
SJRRP	San Joaquin River Restoration Program
WSE	Water Surface Elevation

Definitions

San Joaquin River Restoration Program (SJRRP): The SJRRP (also abbreviated 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 (CCAG): 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 Area that correspond to flows that would not significantly increase flood risk from Restoration Flows in the Restoration Area. This annual report will recommend updating then-existing channel capacity based on recently completed evaluations.

In-channel capacity: The channel capacity 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

The San Joaquin River Restoration Program (SJRRP) was established in late 2006 and is a comprehensive, long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of the Merced River and restore a self-sustaining Chinook salmon fishery in the river while reducing or avoiding adverse water supply impacts. The first water releases from Friant Dam in support of the SJRRP, called Interim Flows, began October 1, 2009, which later became Restoration Flows beginning on January 1, 2014. The SJRRP has committed to reporting annually the upper limit of Restoration Flows that will not significantly increase flood risk within the Restoration Area. This Channel Capacity Report (CCR) is for the 2020 Restoration Year (2020 CCR) and is the seventh report in a series of annual reports required to fulfill a commitment in the SJRRP's environmental document.

To determine the upper limit of Restoration Flows that can be conveyed in each channel, the SJRRP has completed comprehensive evaluations of over 60 miles of levees which include a drilling program and seepage and stability modeling to evaluate the risk of levee failure. For those levees that have not been evaluated, the SJRRP keeps Restoration Flows within the channel to prevent water on the levee itself which also reduces the risk of a levee failure. This CCR details the recommended upper limit of Restoration Flows, which is referred to as "then-existing" channel capacity that can be conveyed in each reach based on levee capacity. The previous and recommended then-existing channel capacities in the San Joaquin River and flood bypasses are shown in Table ES-1. Recommended capacity changes were made in the Middle Eastside Bypass, Mariposa Bypass and Reach 4B2.

It should be stated that in addition to consideration of then-existing channel capacities, the release of Restoration Flows would also be limited by agricultural seepage. These limiting flows are shown as footnotes in Table ES-1. It should also be acknowledged that then-existing channel capacities identified in this report are applicable to Restoration Flows only, and are often much less than the flows the channels will convey during flood events. Flood releases are routed based on a different set of criteria, and even though the flows can exceed current levee seepage and slope stability criteria (which define then-existing capacity limits) they have not historically resulted in significant levee failures.

A complete discussion of the data and analysis conducted to determine previous then-existing channel capacities can be found on the SJRRP website:

http://www.restoresjr.net/restoration-flows/levee-stability-channel-capacity/

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

Reach	Current Then-existing Channel Capacity (cfs)[1]	Recommended Then-existing Channel Capacity (cfs)[1]
Reach 2A	6,000[2]	6,000[2]
Reach 2B	1,210	1,210
Reach 3	2,860[3]	2,860[3]
Reach 4A	2,840[4]	2,840[4]
Reach 4B1	Not Analyzed	Not Analyzed
Reach 4B2	930	2,570
Reach 5	2,350	2,350
Middle Eastside Bypass	580	1,070[5]
Lower Eastside Bypass	2,890	2,890
Mariposa Bypass	350	810

[1] Then-existing channel capacity shown in this table is based on levee stability only and does not consider Restoration Flow limitations related to agricultural seepage.
[2] Capacity not assessed for flows greater than 6,000 cfs. Restoration Flows are limited to approximately 2,140 cfs due to agricultural seepage.
[3] Restoration Flows are limited to approximately 720 cfs due to agricultural seepage.
[4] Restoration Flows are limited to approximately 250 cfs due to agricultural seepage.
[5] In 2019 one of the weirs that allowed for flow diversions within the Merced National Wildlife Refuge was removed, so the capacity would be 1,070 cfs based on geotechnical data.

The 2020 CCR also includes a summary of two studies completed in 2019, one that is related to subsidence and the other that is a geotechnical evaluation of the levees in two of the reaches which resulted in recommended changes in then-existing channel capacity. The first study, *Evaluation of the Effects of Future Subsidence on Capacity up to 2,500 cfs in Reach 4A and Middle Eastside Bypass,* evaluates the potential effects of future subsidence on the flow capacity of the Middle Eastside Bypass and Reach 4A over the next several years. This was to help the SJRRP determine which levees in these reaches need to be improved to reduce the risk of a levee failure from future increases in Restoration Flows. The study shows that most of the levees will continue to convey Restoration Flows. However, approximately 2.5 miles of levees may need improvement after the next 15 years or so because of ongoing subsidence. These levees should be periodically assessed by the SJRRP to determine if improvements are needed.

The second study, *Levee Capacity Evaluation of Mariposa Bypass and Reach 4B2*, helps determine then-existing channel capacities of the Mariposa Bypass and Reach 4B2 using geotechnical evaluations of the levees in these reaches. The results of the study show that approximately 9 miles of levees would need improvement to convey up to maximum Restoration Flows. Because of the levee evaluations, this CCR recommends a change of then-existing channel capacities in Reach 4B2 and the Mariposa Bypass from 930 cfs to 2,570 cfs, and 350 cfs to 810 cfs, respectively.

The other recommended change to then-existing channel capacity is for the Middle Eastside Bypass. The current then-existing channel capacity for this reach was based on the operation of weirs that were used to divert water in the Merced National Wildlife Refuge. The weirs are no longer operational, as one of the weirs was removed in 2019. This now results in a change in

then-existing channel capacity from 580 cfs to 1,070 cfs and is based on a previous geotechnical evaluation of the levees in that reach.

The SJRRP continues to implement studies and projects to refine then-existing channel capacity estimates and increase capacities to meet the 4,500 cfs maximum Restoration Flows. Specifically, the Reach O levee improvement project and Reach 2B Improvements project will increase flow capacities in the Middle Eastside Bypass and Reach 2B, respectively. These projects will begin in 2020 and will be detailed in future CCRs.

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, 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)/Notice of Determination (NOD) on September 28, 2012. Both the PEIS/R and the ROD/NOD 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 (CCR) for the 2020 Restoration Year (2020 CCR) is the seventh in the series of annual reports required to fulfill the commitments in the ROD/NOD. The 2014 CCR was the first report that was followed by six subsequent reports that based recommended then-existing channel capacities on new information regarding levee stability, subsidence or other SJRRP considerations. The reports also included information on the CCAG roles and responsibilities, technical factors when considering channel capacity, the criteria and evaluation process for determining capacity, as well as the data and analytical tools used to determine channel capacity. Previous Channel Capacity Reports can be found at the SJRRP website at the following link:

http://www.restoresjr.net/restoration-flows/levee-stability-channel-capacity/

The 2020 CCR updates then-existing channel capacities for the Middle Eastside Bypass, Mariposa Bypass and Reach 4B2 of the San Joaquin River. Then-existing channel capacities for other reaches in the Restoration Area will remain the same as those recommended in the 2018 and 2019 CCRs. The 2018 CCR recommended then-existing channel capacity is based on geotechnical data in portions of Reach 2A, Reach 4A, and the Middle Eastside Bypass. This year's CCR includes two new studies related to subsidence and channel capacity based on geotechnical assessments of the levees in the Mariposa Bypass and Reach 4B2. The CCR also includes a summary of studies and monitoring that will be completed the following year. All other background information on channel capacity, including how then-existing channel capacity was developed, can be found in the 2018 CCR.

The 2020 CCR will be available for a 60-day public review and comment period beginning on November 4, 2019. Comments are due on January 3, 2020 to Reclamation and DWR and may be mailed (hard copy or electronic) to the following:

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3.0 Study Area

The study area starts from the Friant Dam and ends at the confluence of the San Joaquin River with the Merced River. The CCR 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 the Sand Slough Connector Channel to the confluence with the San Joaquin River and the Mariposa Bypass. The study area reaches are shown in Figure 3-1. Currently, Restoration Flows pass through Reaches 1 through 4A, the Sand Slough Connector Channel and the Eastside Bypass before entering Reach 5 of the San Joaquin River. Portions of the Study area are also within the Lower San Joaquin River Flood Control (LSJRFC) Project, which includes 191 miles of levees and protects over 300,000 acres. An additional 67 miles of non-Project levees also provide flood protection along the San Joaquin River.

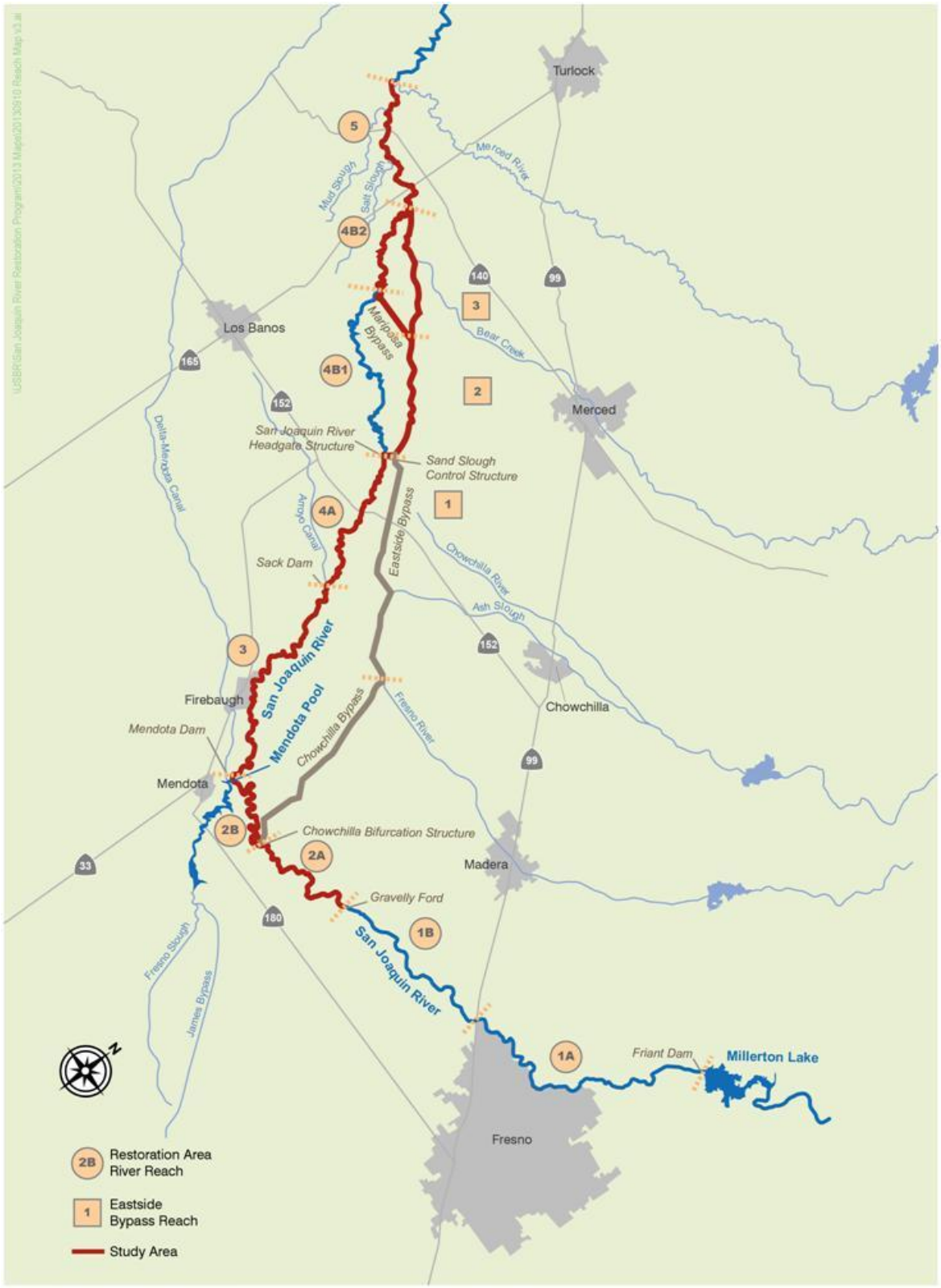

Figure 3-1.

San Joaquin River Reaches and Flood Bypass System

4.0 Completed Channel Capacity Studies and Related Work

The following sections summarize the new technical studies that have been completed at the time of publication of this report that relate to channel capacity. This year's report includes two studies, one that describes the projected effect of subsidence on the ability of the system to convey Restoration Flow and one that determines then-existing channel capacities in the Mariposa Bypass and Reach 4B2 based on the findings from the levee evaluations performed in 2019.

The first study, *Evaluation of the Effects of Future Subsidence on Capacity up to 2,500 cfs in Reach 4A and Middle Eastside Bypass*, evaluates the potential effects of subsidence through 2031 on the flow capacity of the Middle Eastside Bypass and Reach 4A. The goal of this study is to identify the levees that will need to be improved to convey 2,500 cfs considering the effects of subsidence and the maximum allowable water surface elevation (WSE). The maximum allowable WSE is based on geotechnical evaluations of the levees in these reaches that identified the point on the levees where underseepage would create significant risk of levee failure based on USACE criteria for levee seepage and slope stability. The second study, *Levee Capacity Evaluation of Mariposa Bypass and Reach 4B2*, determines then-existing channel capacities of the Mariposa Bypass and Reach 4B2 based on maximum allowable WSEs using geotechnical evaluations for these reaches. Both studies are described below.

4.1 Subsidence Study for Flows up to 2,500 cfs

Subsidence is affecting channel capacities throughout the Restoration Area; the reaches that subsidence has the highest potential to change then-existing channel capacity are the Middle Eastside Bypass and 2.5 miles of the downstream end of Reach 4A. DWR performed a hydraulic study that estimates the effects of subsidence on channel capacities in 2016 and then estimates the effects of future subsidence to 2031 on channel capacities in these reaches. This study identifies the levees within the Middle Eastside Bypass and Reach 4A that may need to be improved to convey 2,500 cfs considering subsidence and the maximum allowable WSE. The maximum allowable WSEs were documented in a Geotechnical Condition Report (GCR) prepared by DWR in 2015. The study, *Evaluation of the Effects of Future Subsidence on Capacity up to 2,500 cfs in Reach 4A and Middle Eastside Bypass*, dated September 2019, is included in Appendix B and is summarized below.

4.1.1 Study Topography and Tools

The study was conducted using validated 1-D steady state Hydrologic Engineering Center's River Analysis System (HEC-RAS) baseline models of the river and flood bypass with 2008 topography and where available 2010-2011 bathymetry. The model geometry was updated based on top of levee surveys completed by DWR in 2016. In updating the model geometry, the 2008 cross-sections elevations were adjusted by the total subsidence that was measured between the

2008 LiDAR and the 2016 surveys. The model geometry was further modified to reflect future subsidence conditions in 2031. For the 2031 condition, the elevations in the model were adjusted by the total amount of subsidence that was projected to occur between 2016 and 2031. The total amount of subsidence was calculated using average annual rates from 2011 to 2018 determined by Reclamation in its bi-annual surveys. Figure 4-1 shows the average annual subsidence rates range from about 0.15 ft/year to 0.75 ft/year in the Restoration Area and about 0.15 ft/year to 0.5 ft/year in the Middle Eastside Bypass and Reach 4A. The total amount of subsidence that was estimated to occur between 2016 to 2031 is shown in Table 4-1.

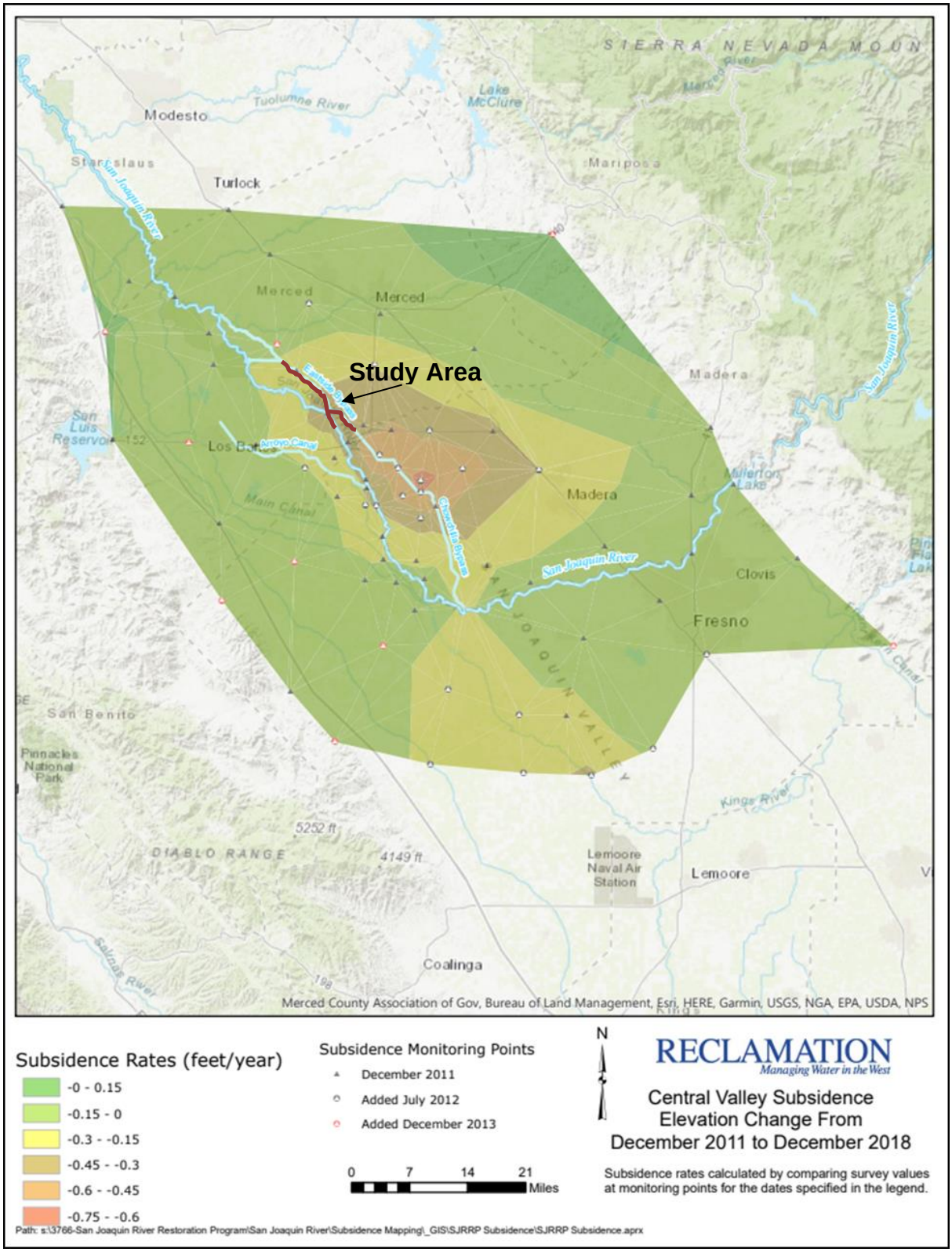

Figure 4-1.
Regional Subsidence Map

4.1.2 Analysis and Results

The hydraulic models were used to compute the WSEs at 2,500 cfs in 2016 and 2031(subsided condition). The computed water-surface profiles at 2,500 cfs in the Middle Eastside Bypass and Reach 4A were compared to the maximum allowable WSEs for each reach identified in the 2015 GCR (Figures 4-2 and 4-3). Table 4-1 summarizes the maximum allowable WSEs, the WSEs at 2,500 cfs, and the WSE difference for 2016 and 2031 for each reach identified in the GCR. The water surface profiles and the maximum allowable WSE are shown in Figures 4 through 6 of Appendix B. Figures 4-2 and 4-3 identify those reaches that exceed the maximum allowable WSE and therefore exceed the USACE criteria for seepage and stability at flows greater than 2,500 cfs.

Table 4-1.

Results for 2016 and 2031 Allowable Maximum WSE and WSE at 2,500 cfs

GCR Reach	Subsidence	2016			2031		
	2016-2031 Total (ft)	Maximum Allowable WSE (ft)	2,500 cfs WSE (ft)	WSE Elevation Difference (ft)	Maximum Allowable WSE (ft)	2,500 cfs WSE (ft)	WSE Elevation Difference (ft)
A	-2.8	98.1	93.3	4.8	95.4	90.9	4.5
B	-3.1	104.1	93.7	10.4	101.0	91.3	9.7
C	-3.3	97.2	96.2	1.0	93.9	93.1	0.8
D	-3.5	99.3	98.5	0.8	95.8	95.1	0.7
E	-4.8	102.3	99.6	2.7	97.5	95.9	1.6
F	-5.4	101.2	99.9	1.3	95.9	96.0	-0.1
G	-5.7	109.7	100.9	8.8	104.1	96.3	7.8
H	-5.6	106.6	100.4	6.2	100.9	96.1	4.8
I	-5.6	106.1	100.4	5.7	100.4	96.1	4.3
J	-2.9	94.9	93.4	1.5	92.0	91.0	1.0
K	-3.2	99.5	95.3	4.2	96.3	92.4	3.9
L	-3.4	98.3	98.3	0.0	94.9	95.0	-0.1
L	-4.0	100.0	99.1	0.9	96.0	95.6	0.4
M	-4.1	104.1	99.2	4.9	100.0	95.7	4.3
N	-4.6	101.3	99.6	1.7	96.7	95.9	0.8
O	-5.0	98.1	99.8	-1.7	93.0	95.9	-2.9

Reach O, located along the right levee, was the only reach that exceeds the maximum allowable WSE at 2,500 cfs in 2016. The capacity of this reach is limited to 1,070 cfs (Tetra Tech, 2015) and is scheduled to be improved in 2020. By 2031, the hydraulic models predicted that the WSE in three of the reaches will encroach upon or exceed the maximum allowable WSEs if subsidence continues at the annual average rate calculated between 2011 to 2018. The WSE in Reaches O, F and L are each predicted to encroach on the maximum allowable WSE by 2031 (see Figure 4-2). The WSE at 2,500 cfs in Reach F and L reaches would be approximately 0.1 feet above the maximum allowable WSE.

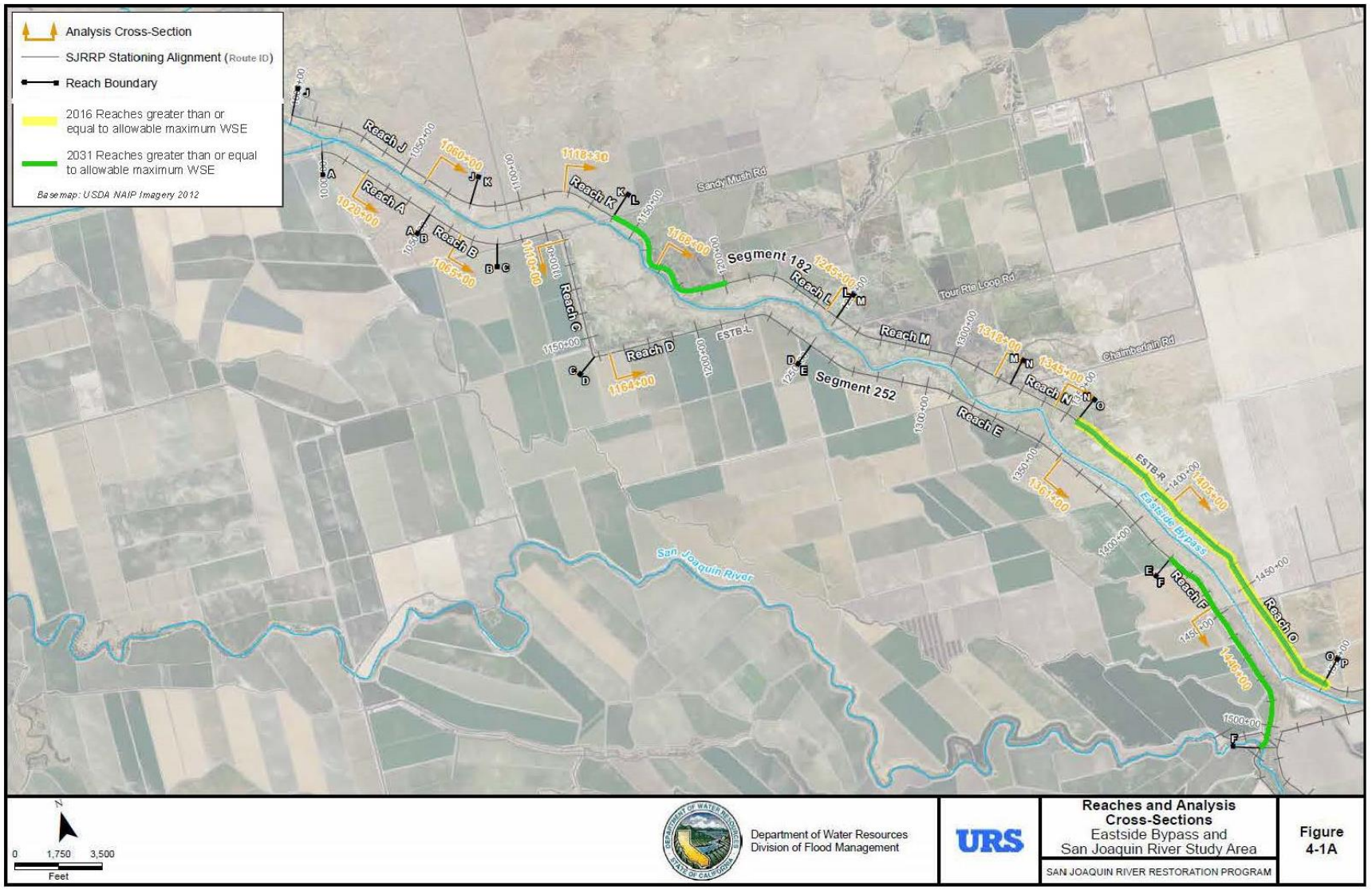

Figure 4-2.
Middle Eastside Bypass Reaches with Then-existing Channel Capacities Less than 2,500 cfs

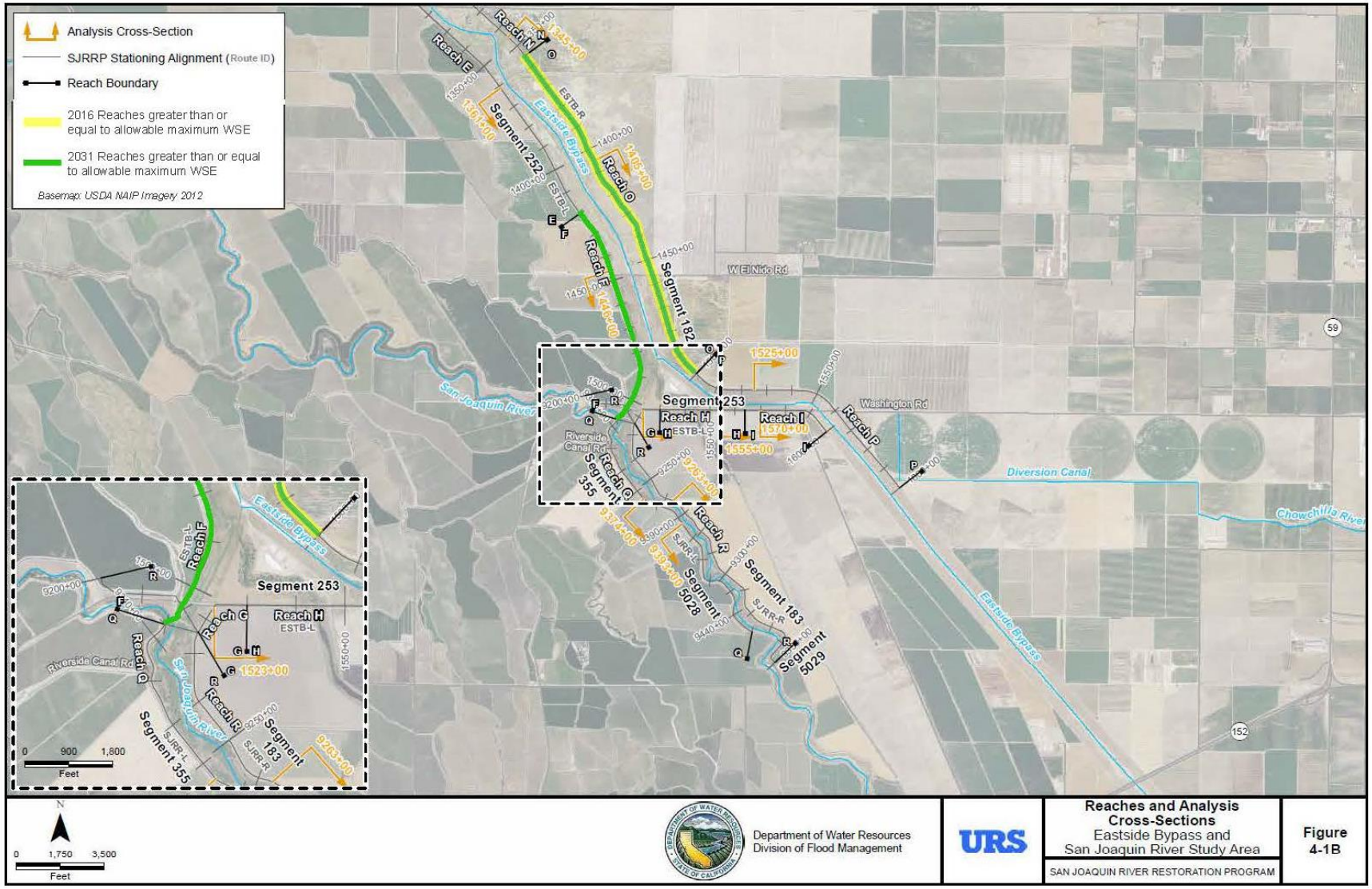

Figure 4-3.
Upper Eastside Bypass and Reach 4A with Then-existing Channel Capacities Less than 2,500 cfs

4.1.3 Conclusion

The results of this hydraulic analysis show that the WSE at 2,500 cfs is still below the maximum allowable WSE in 2016 even when subsidence is considered. Although Reach O is currently exceeding the maximum allowable WSE, DWR plans on improving Reach O in 2020 which will increase the capacity of the reach to least 2,500 cfs. However, because subsidence is reducing the capacity in this reach, the SJRRP needs to determine if additional reaches need improvement over the next several years. The results show that subsidence could reduce the capacity of approximately 2.5 miles of levees in Reaches F and L to less than 2,500 cfs by 2031. Although the SJRRP will meet its goal of providing channel capacity up to 2,500 cfs by 2024, the reaches that are close to the maximum allowable WSE at 2,500 cfs will be evaluated periodically to determine if improvements will be needed over the next five to ten years.

4.2 Priority 2 Geotechnical Assessment

Levee evaluations along the San Joaquin River and flood bypasses are being conducted by DWR to assist the SJRRP in assessing flood risks due to levee seepage and stability associated with the release of Restoration Flows for the SJRRP. The evaluations were performed under DWR's San Joaquin Levee Evaluation (SJLE) Project (Section 7.2.4) and included the exploration and evaluation of existing levees within the Restoration Area that will be used to convey future Restoration Flows.

In identifying the priorities of the SJLE Project, DWR classified levee segments in the Restoration Area in one of three categories representing an increasing priority for the need to complete the geotechnical evaluation and analyses. Details of the specific tasks, including the methodology for prioritization of the levees are summarized in Section 10.1.2 of the 2014 CCR. Priority 1 levees, which were completed in 2014 are in Reach 2A, the Middle Eastside Bypass, and the lowest portion of Reach 4A. The Priority 2 levee evaluations were completed in 2019 and include about 30 miles of levees in Reach 4B2 and the Mariposa Bypass. The evaluations included reconnaissance-level geotechnical explorations, soils testing, and seepage and stability analyses at multiple water surface elevations along multiple levee segments. The results for the Priority 2 levees are included in a 2019 GCR.

The following section summarizes the flow analysis completed to identify the maximum flow that can be conveyed on the levees in each reach without exceeding USACE criteria for levee underseepage and slope stability. The study, *Levee Capacity Evaluation of Mariposa Bypass and Reach 4B2*, dated September 2019, is included in Appendix C. Figure 4-4 shows the study area and reaches.

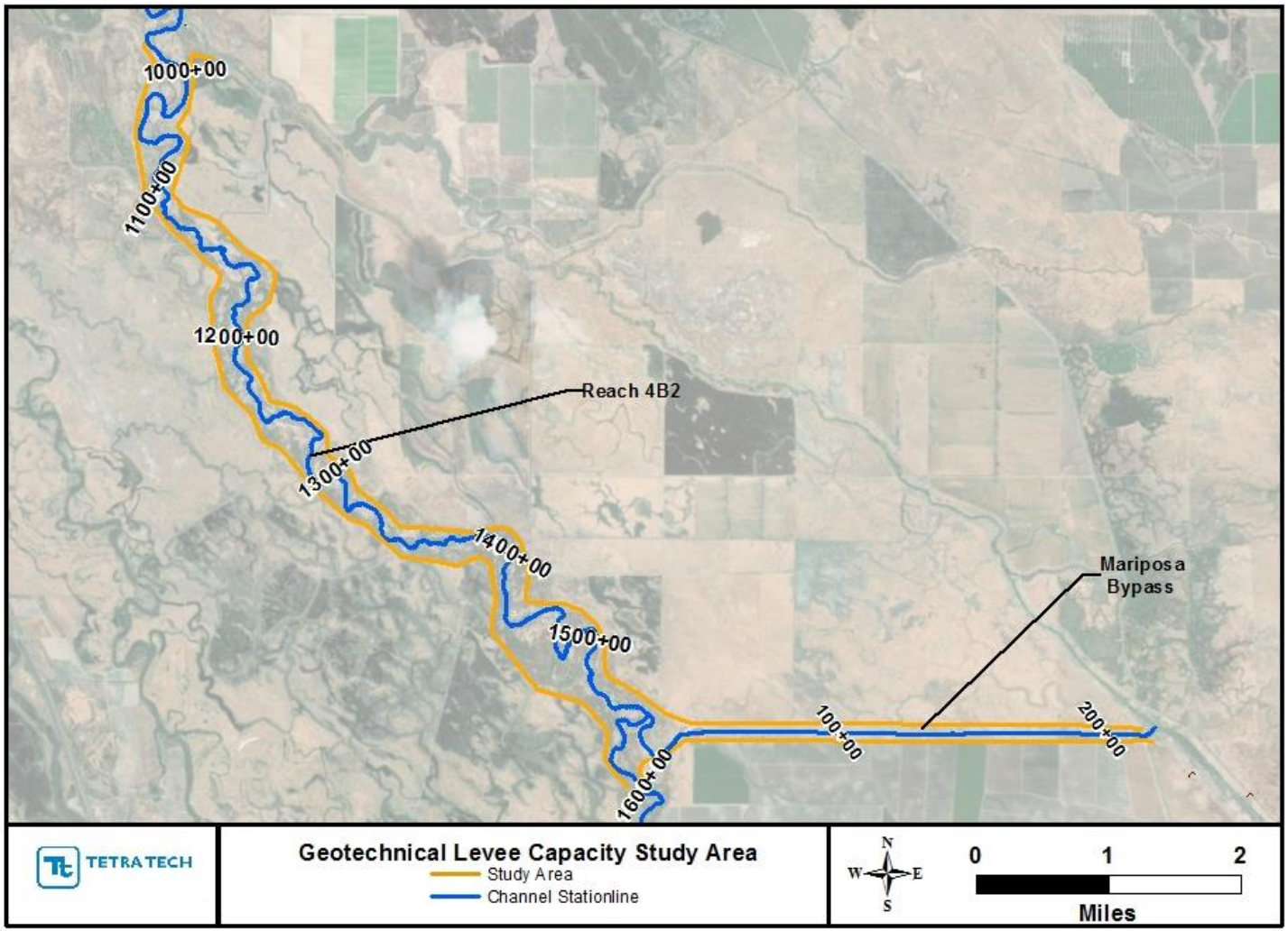

Figure 4-4.

Site Map of Study Area

4.2.1 Study Topography and Tools

The result of the Priority 2 evaluations were the maximum allowable WSEs in 21 sub-reaches (Figures 2 through 5 of Appendix C) within Reach 4B2 and the Mariposa Bypass. A hydraulic analysis was completed to establish flow capacity in these levee sub-reaches using the maximum allowable WSEs from the Priority 2 levee evaluations. In performing the analyses, 1-D hydraulic models developed for the SJRRP was employed. The geometry in the existing-conditions hydraulic models are based on 2008 LiDAR overbank elevations and 2011/2012 in-channel bathymetry. These models were not adjusted for subsidence due to the lack of subsidence in these area that would result in a change to the capacities.

4.2.2 Analysis and Results

A range of flows up to the full Restoration Flow of 4,500 cfs were modeled in Reach 4B2 and the Mariposa Bypass. The maximum allowable WSEs at the assigned model cross sections were used to interpolate a discharge based on flow profiles for the range of flows. If the associated discharge was greater than 4,500 cfs then a capacity of ">4,500 cfs" was reported and no further analyses was made. Because a canal is landside and adjacent to a majority of the left levee, the maximum allowable WSEs were developed for two canal scenarios: maximum WSEs based on no water in the canal and maximum WSEs assuming a flow depth of two feet in the canal. Table 4-2 summarizes the maximum allowable WSEs, and discharge capacity for each sub-reach.

Table 4-2 shows that in Reach 4B2, when considering the maximum allowable WSE assuming a dry canal, 17 of 22 analyzed sub-reaches had a capacity that exceeded the maximum Restoration Flows of 4,500 cfs. For this scenario where the canal is dry, the limiting capacity would be 2,450 cfs. Assuming a depth of 2 ft in the canal resulted in only two sub-reaches that had a capacity of less than 4,500 cfs, which slightly increased the limiting capacity to 2,570 cfs in Reach 4B2. Table 4-3 shows that in the Mariposa Bypass when considering the maximum allowable WSE and a dry canal, five of the of the eleven sub-reaches had a capacity of less than 4,500 cfs. For this scenario, the limiting capacity is 335 cfs. Although the number of sub-reaches that exceed 4,500 cfs did not change when assuming 2 ft of water in the adjacent canal, the overall limiting capacity increased to 810 cfs.

4.2.3 Conclusions

The SJRRP does not plan to convey Restoration Flows in Reach 4B2 or the Mariposa until future channel work is performed throughout the Restoration Area (Section 6.3). However, the results of this study will be used to update then-existing channel capacity for these reaches. Then-existing channel capacities in the 2020 CCR will now be based on geotechnical data and not on in-channel capacity. The results do show that at least flows up to 2,500 cfs can be conveyed in Reach 4B2. To convey full Restoration Flows of up to 4,500 cfs, about 3.5 miles of levees in Reach 4B2 and about 6 miles of levees in the Mariposa Bypass would need to be

improved. In reaches adjacent to canals, the maximum WSE is based on 2-feet depth of water in the adjacent canals. This assumption is based on observations that the canals are usually wet during flood events. This assumption would need to be evaluated and discussed with the canal owners prior to applying these results.

Table 4-2.
Flow Capacities of Sub-reaches in Reach 4B2

Sub-Reach Location	Model Cross Section	Maximum Allowable WSE Assuming Dry Canal (feet)	Discharge Capacity (cfs)	Maximum Allowable WSE Assuming 2 ft depth in Canal (feet)	Final Discharge Capacity (cfs)
A	994+43	83.2	> 4,500	N/A[1]	> 4,500
B1	1099+75	82.4	> 4,500	N/A	> 4,500
B2	1139+89	80.5	2,450	83.0	> 4,500
C1	1222+01	84.7	> 4,500	N/A	> 4,500
C2	1269+30	86.2	> 4,500	N/A	> 4,500
D	1357+61	83.7	1,950	85.7	3,650
E1	1404+59	89.8	> 4,500	N/A	> 4,500
E2	1422+67	89.0	> 4,500	N/A	> 4,500
F1	1462+79	87.8	4,440	89.8	> 4,500
F2	1497+07	87.7	3,370	89.6	> 4,500
I	1010+90	82.1	> 4,500	N/A	> 4,500
J	1135+26	83.5	> 4,500	N/A	> 4,500
K	1156+70	84.0	> 4,500	N/A	> 4,500
L1	1345+20	88.0	> 4,500	N/A	> 4,500
L2	1198+24	84.2	> 4,500	N/A	> 4,500
L3	1345+20	88.0	> 4,500	N/A	> 4,500
L4	1198+24	84.2	> 4,500	N/A	> 4,500
L5	1345+20	88.0	> 4,500	N/A	> 4,500
M	1381+94	85.0	2,570	N/A	2,570
N	1396+07	88.0	> 4,500	N/A	> 4,500
O	1453+75	89.4	> 4,500	N/A	> 4,500
P	1512+68	91.1	> 4,500	N/A	> 4,500

[1] N/A (not applicable) means there is not a canal adjacent to that sub-reach, so a capacity assuming 2-ft of water in the canal was not completed.

Table 4-3.
Flow Capacities at the GCR Cross Section in the Mariposa Bypass

Sub-Reach Location	Model Cross Section	Maximum Allowable WSE Assuming Dry Canal (feet)	Discharge Capacity (cfs)	Maximum Allowable WSE Assuming 2 ft depth in Canal (feet)	Final Discharge Capacity (cfs)
G	14+43	88.0	2,940	89.1	4,450
H1	99+61	86.5	335	88.2	810
H2	185+13	90.5	980	92.5	2,000
Q	3+80	87.0	2,166	N/A[1]	2,170
R	66+64	91.8	> 4,500	N/A	> 4,500
S	87+43	93.0	> 4,500	N/A	> 4,500
T1	156+06	91.5	1,800	N/A	1,800
T2	191+46	97.8	> 4,500	N/A	> 4,500
T3	156+06	91.5	1,800	N/A	1,800
T4	191+46	97.8	> 4,500	N/A	> 4,500
U	35+85	90.2	> 4,500	N/A	> 4,500

[1] N/A (not applicable) means there is not a canal adjacent to that sub-reach, so a capacity assuming 2-ft of water in the canal was not completed.

5.0 Recommended Then-existing Channel Capacities

The purpose of this section is to present the recommended then-existing channel capacities based on results from the channel capacity studies summarized in this and previous reports. 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). How then-existing channel capacity is determined for each reach is described below.

In-channel capacities were the best estimate of then-existing channel capacities for Reach 2B, Reach 3, portions of Reach 4A, Reach 5, and Lower Eastside Bypass. The studies used to determine the capacities in these reaches are summarized in the 2017 and 2018 CCRs. These include: the *San Joaquin River In-channel Capacity Analysis* (Tetra Tech, 2015b) (included in the 2017 CCR) with update included in Appendix B of the 2018 CCR. For Reach 2A, the lower 2.5 miles of Reach 4A, and the Middle Eastside Bypass adequate data was available to perform a geotechnical analysis and these results were used to determine then-existing channel capacity. The study details used to determine the then-existing channel capacity for Reach 2A, and the lower 2.5 miles of Reach 4A are included in the 2017 CCR with an update included in Appendix C of the 2018 CCR.

The 2020 CCR recommends changes to then-existing channel for three reaches: Reach 4B2, the Mariposa Bypass, and the Middle Eastside Bypass. The previous studies used to determine then-existing channel capacity in the Middle Eastside Bypass considered geotechnical analysis and the operations, as well as, removal of the weirs within the Merced National Wildlife Refuge. One of the weirs was removed in 2019 as described in Section 6.3 and results in a recommended change to then-existing channel capacity from 580 cfs to 1,070 cfs. The change in recommended then-existing channel capacity is based on the previous geotechnical assessment and data described in Appendix C of the 2018 CCR.

The *Levee Capacity Evaluation of Mariposa Bypass and Reach 4B2* summarized in Section 4.0 — Completed Channel Capacity Studies and Related Work, did update the results of the in-channel capacity analysis used to develop the then-existing channel capacity in Reach 4B2 and the Mariposa Bypass. In Reach 4B2, then-existing channel capacity increased from 930 cfs to 2,570 cfs and is now based on geotechnical data. In the Mariposa Bypass, the capacity increased from 350 cfs to 810 cfs and is also now based on geotechnical data. Table 5-1 summarizes the current and recommended then-existing channel capacities for each reach of the San Joaquin River and the flood bypasses, as well as the method used to determine then-existing channel capacity.

Then-existing channel capacities recommended below do not consider limitations to Restoration Flows as it relates to agricultural seepage. For the 2020 Restoration Year, releases of Restoration

Flows in Reach 2A, Reach 3, and Reach 4A are limited by agricultural seepage, and not levee stability. Table 5-1 also notes current limitations of Restoration Flows based on agricultural seepage. Details of how these seepage limits are determined and limit Restoration Flows are in the *Seepage Management Plan* described in Section 6.2.2 of this report**.**

Table 5-1.

Current and Recommended Then-existing Channel Capacity

Reach	Current Then-existing Channel Capacity (cfs)[1]	Recommended Then-existing Channel Capacity (cfs)[1]	Method used to determine Then-existing Channel capacity
Reach 2A	6,000[2]	6,000[2]	Geotechnical Assessment
Reach 2B	1,210	1,210	In-channel
Reach 3	2,860[3]	2,860[3]	In-channel
Reach 4A	2,840[4]	2,840[4]	Geotechnical Assessment and In-channel
Reach 4B1	Not Analyzed	Not Analyzed	--
Reach 4B2	930	2,570	Geotechnical Assessment
Reach 5	2,350	2,350	In-channel
Middle Eastside Bypass	580	1,070[5]	Geotechnical Assessment
Lower Eastside Bypass	2,890	2,890	In-channel
Mariposa Bypass	350	810	Geotechnical Assessment

[1] Then-existing channel capacity shown in this table is based on levee stability only and does not consider limitations to Restoration Flows related to agricultural seepage.

[2] Capacity not assessed for flows greater than 6,000 cfs. Restoration Flows are limited to approximately 2,140 cfs due to agricultural seepage.

[3] Restoration Flows are limited to approximately 720 cfs due to agricultural seepage.

[4] Restoration Flows are limited to approximately 250 cfs due to agricultural seepage.

[5] In 2019 one of the weirs that allowed for flow diversions within the Merced National Wildlife Refuge (MNWF) was removed, increasing the capacity to 1,070 cfs.

6.0 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 capacity. As channel or structure modifications are completed, corresponding maximum Restoration Flow releases would be increased in accordance with then-existing channel capacity 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 the San Joaquin River within the Restoration Area contains flow other than Restoration Flows, concurrent Restoration Flows may be reduced such that the total flow does not exceed then-existing channel capacity. If flood control releases from Friant Dam or other flood control facilities in the San Joaquin River system 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. If any actions increase then-existing channel capacity, a new Channel Capacity Report will be prepared prior to Reclamation increasing Restoration Flows.

6.1 Immediate Actions

Immediate actions are described at a project-level in the PEIS/R including specific details in the *Physical Monitoring and Management Plan*. 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 Restoration Flows, the SJRRP has implemented flow limitations and immediate flow reductions to address issues related to capacity, mainly for agricultural seepage and will continue to do so on an as-needed basis during the release of Restoration Flows from Friant Dam. The PEIS/R states that during flood releases from Friant Dam no Restoration Flows will be released, except in the case when flood releases do not meet minimum scheduled Restoration Flows. This CCR addresses Friant releases to meet full Restoration Flows in the system and the channel capacities in the CCR are to ensure flood risk is minimized by Friant Dam releases staying below levees in areas where no levee information is available or below the USACE criteria for levee seepage and stability.

Recent conditions have highlighted a situation where Restoration Flows can mix with flood flows when Friant Dam is not in flood operations, but tributaries of the San Joaquin River are in flood operations. These tributaries — Little Dry Creek and Cottonwood Creek in Reach 1A; Kings River in Reach 3; Fresno River, Ash Slough and Berenda Slough in the Upper Eastside Bypass; and Owens Creek, Duck Slough, and Bear Creek in the Lower Eastside Bypass — could in themselves exceed the levee stability criteria or when mixed with Restoration Flows exceed the criteria. The latter could increase flood risk in the system from the additional Restoration Flows from Friant Dam. The reaches that could be affected in this situation include Reach 2A, Reach 2B, Reach 3, Reach 5, Middle Eastside Bypass, and the Lower Eastside Bypass.

During any such occurrence, DWR and Reclamation will coordinate on the best way to minimize flood risk. This is a rare case and is not expected to have much significance on levee stability within the Restoration Area. This is especially true in those reaches were agricultural seepage limitations currently exist.

6.2 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 near-term actions are described in more detail in the 2018 CCR and are summarized in the *Physical Monitoring and Management Plan* (in Appendix D of the PEIS/R). Updates on some of these actions are described below.

6.2.1 Maintenance

The maintenance of the channels within the Restoration Area can impact then-existing channel capacity. Specifically, vegetation and how it is managed can reduce channel capacity by increasing channel roughness. Because of the channel being wetted year-round since 2016, the LSJLD is unable to perform some of its channel maintenance activities using its existing resources and procedures. DWR has met with the LSJLD to better understand it's maintenance operations to identify what changes are needed to continue maintenance in those reaches that convey Restoration Flows. DWR is currently drafting a report that identifies maintenance methods and potential costs in a wet system. DWR plans to meet with the LSJLD and CVFPB in the latter half of 2019 to discuss the contents of the report and to determine a path forward for implementation.

6.2.2 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. Anticipated Restoration Flow limitations for each reach due to agricultural seepage for the 2020 Restoration Year is shown in Table 6-1.

The *Seepage Management Plan* and *Seepage Project Handbook* can be found at the SJRRP website under the following link:

http://www.restoresjr.net/restoration-flows/seepage-projects/

Table 6-1.

Restoration Flow Limitations as it Relates to Agricultural Seepage

Reach[1]	Seepage Management Plan Approximate Restoration Flow Limitations[2] (cfs)
Reach 2A	2,140
Reach 2B	1,300
Reach 3	720[3]
Reach 4A	250[3]

[1] Only critical reaches have been evaluated for potential seepage impacts.
[2] Subject to real time groundwater monitoring.
[3] Restoration Flow limitation due to agricultural seepage has been updated based on real-time monitoring.

6.3 Long-Term Actions

Long-term actions by the SJRRP will be needed to achieve then-existing channel capacity 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 changing site-specific channel capacity as provided for in the Settlement paragraphs 11(a) and 11(b). A status update on advancement of the long-term progress includes:

- Construct Mendota Pool Bypass and Reach 2B Improvements. The Compact Bypass would route flows and fish around the Mendota Pool and would improve channel capacity to at least 4,500 cfs from Reach 2B to Reach 3. Additionally, the Mendota Pool Control Structure would allow for deliveries into Mendota Pool, as appropriate. Pool operations would continue at the same water surface elevation as it does now, and the project includes a fish screen to avoid fish straying into Mendota Pool. Construction of this project is planned to begin in 2020. In the meantime, Reclamation continues to maintain the existing flood conveyance infrastructure. During 2019, Reclamation stabilized existing levees near the Mendota Pool by addressing seven seepage locations and a levee breach that was estimated to be 30 feet wide. A summary of the work completed can be referenced at the following website:

  http://www.restoresjr.net/?wpfb_dl=2354

  As construction proceeds and the river slope equilibrates through the new bypass channel, this reach will be an active site of erosion and deposition and may influence downstream sediment transport. Though sediment transport modeling indicates that much of the mobile sediment will move out the Restoration Area, monitoring stations are being established to track the effects of Mendota Pool Bypass on key infrastructure and channel capacity (Section 7.2.6).

- Construct levee and fish passage improvements in the Middle Eastside Bypass (the Eastside Bypass between the Sand Slough Control Structure and Mariposa Bypass). The improvements that will impact channel capacity include reinforcing two miles of right levee along the Eastside Bypass to improve levee stability and reduce seepage. This improvement will increase Restoration Flows to at least 2,500 cfs in the reach. Another improvement includes removing two weirs located in the Eastside Bypass and operated by U.S. Fish and Wildlife Service within the MNWR to allow for fish passage. Removal of the weirs began in 2019 and will be completed in 2020, and construction of the levee improvements are anticipated to begin in 2020.

6.4 Framework for Implementation

The long-term actions identified above, with the exception of the Reach 4B Project, are included in the SJRRP's 2018 *Funding Constrained Framework for Implementation* (Constrained Framework). This is an update of the *2015 Revised Framework for Implementation* (Revised Framework), given a more limited future funding stream than previously anticipated. The first stage (termed Stage 1) has the primary goal of beginning the reestablishment of spring-run and fall-run Chinook salmon in the San Joaquin River between the Merced River and Friant Dam through the establishment of volitional fish passage, sufficient flows to manage temperatures, and provide for the basic habitat needs of the species. Both the current Constrained Framework and previous Revised Framework establish the following:

- Five-year visions to provide clear, realistic, and accomplishable steps towards meeting the Restoration Goal and Water Management Goal;

- Achievable schedules based upon realistic Federal and State of California appropriation levels, improving our ability to plan and be transparent on actions; and

- More clearly defined roles and responsibilities for each Implementing Agency, increasing each agency's ability to budget, plan, and approve construction actions.

This Constrained Framework provides a more realistic schedule and associated future funding needs for the SJRRP Implementing Agencies to focus on "core" actions identified in the 2012 Framework and Implementation of the Settlement and the Settlement Act. The Constrained Framework includes objectives to have 2,500 cubic feet per second of channel capacity throughout the San Joaquin River to Reach 4A, the Eastside Bypass and Reach 5 by the end of 2024. Channel capacity improvements include levee improvements identified by the remaining reaches constrained by then-existing channel capacity, and groundwater seepage projects needed to release flows without causing crop yield impacts. Approximately $20 million of levee improvement projects and $72 million of seepage projects are included in the Constrained Framework.

The Constrained Framework can be found at the SJRRP website under the following link:

http://www.restoresjr.net/?wpfb_dl=2163

7.0 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 SJRRP studies and monitoring to determine then-existing channel capacity. The following sections summarize studies and data collection activities by the SJRRP to provide a better understanding of then-existing channel capacity or changes in in-channel capacity.

7.1 Technical Studies

The following describes the activities that are ongoing or may be conducted during the following Restoration Year.

7.1.1 San Joaquin Levee Evaluation Project

The SJLE Project led by DWR assists the SJRRP in assessing flood risks associated with the SJRRP with respect to levee seepage and stability. As part of the work, DWR identified three priorities for levee evaluations representing an increasing priority for the need to complete geotechnical evaluations and analyses. DWR has completed its evaluation of Priority 1 levees and as a result will be reinforcing approximately 2 miles of levee along the Eastside Bypass to improve levee stability and reduce seepage (same levee improvement project described in Section 6.3 above). In 2019, DWR also completed a geotechnical assessment of the Priority 2 levees, which are being considered in this CCR. At the end of 2019, DWR will have identified for the SJRRP potential future remediation needs and associated costs for improvement of the Priority 2 levees. Additional geotechnical exploration of the Priority 3 levees has been put on hold until funding becomes available.

7.1.2 Modeling Tools and Updates

The SJRRP has developed hydraulic and sediment transport modeling tools to evaluate the flow, seepage, and structural actions as part of meeting the Restoration Goal of the Settlement. Due to continued subsidence, a new flight of aerial photography and LiDAR was flown in 2015 of all reaches of the San Joaquin River from Friant Dam to the Merced River confluence as well as the Chowchilla, Eastside, and Mariposa Bypasses. Bathymetric surveys were also completed in 2015 and 2016. The data has been processed and new terrain surfaces have been prepared for critical

reaches. Some of the modeling tools have been updated to reflect the most recent data depending on the location, priority and effort. Currently, the model used by the SJRRP for the various studies have provided the level of accuracy needed for the specific effort. However, DWR and Reclamation plan to conduct additional site-specific surveys to verify the 2015 LiDAR to determine if all or some of the modeling tools need additional updates.

7.1.3 Subsidence Studies

Previous channel capacity reports include a description of the methods and results of the subsidence monitoring and levee surveys completed by Reclamation and DWR-SCRO for the SJRRP. In 2019, DWR completed topographic surveys of the top of levees in Reach 4A, the Middle Eastside Bypass and the Mariposa Bypass. The results of this subsidence monitoring will be assessed in 2020 to determine if an update to the model topography in key reaches will be necessary. The DWR and bi-annual surveys by Reclamation will continue to determine if subsidence is impacting then-existing channel capacity.

7.2 Monitoring Activities

The SJRRP is continuing various monitoring activities for different studies and purposes. These activities are described in the *Physical Monitoring and Management Plan*, which is in Appendix D of the PEIS/R, the *Restoration Flow Guidelines,* and the *Seepage Management Plan.* Typical activities, including flow, sediment mobilization and erosion monitoring, and water surface profile surveys are also described in previous channel capacity reports and are conducted when needed. Updates on the ongoing monitoring activities are described below.

7.2.1 Flow Monitoring

The objective of continuing to monitor flow is to ensure compliance with Restoration Administrator flow recommendations and/or 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 several 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. In 2019, DWR installed a gage to measure tributary inflows from Owens Creek and plans to install a gage in Reach 4A at Highway 152 later this year. All the gages are available online at the California Data Exchange Center (CDEC).

7.2.2 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 subsidence, vegetation, channel work and sediment transport. To help with

model calibration, in June 2019, additional WSP surveys were completed in Reach 3, Reach 4A, the Middle Eastside Bypass and the Mariposa Bypass during Flood Flow releases of about 2,500 cfs from Friant Dam. Additional WSP surveys may again be completed in 2019/2020 for some reaches, depending on flow releases from Friant Dam and model calibration needs.

7.2.3 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. In addition to the topographic surveys to monitor for subsidence, additional aerial photography and topographic surveys are being considered over the next three years to aid in the design of the Mendota Pool Compact Bypass and Reach 2B setback levees. Subsidence and future channel changes may also prompt the need for additional surveys in other areas within the next five years.

7.2.4 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 roughness from vegetation within the channel and helps inform availability of fish habitat. Annual surveys have occurred since 2011 and future surveys will be conducted annually after flood events as part of baseline SJRRP monitoring. River stage and shallow groundwater levels were monitored in July 2019 in potential recruitment areas during flood flows ramp-down. The extent and scope of vegetation monitoring is discussed in Section 10.2.5 of the 2014 CCR.

7.2.5 Levee Monitoring Program

The SJRRP has committed to minimizing flood risk from Restoration Flows as outlined in the PEIS/R. This effort includes collecting levee performance data within the Restoration Area with a focus on levees most critical to limiting the release of restoration flows. Because levee evaluations are limited to a seepage and stability analysis, and do not include assessment of other levee failure mechanisms, a field monitoring program was established to evaluate the levees during high-water events and during Restoration Flows, which allow early identification of potential problems.

Prolonged flood releases from Friant Dam into the summer months during the Water Year 2019 resulted in five rounds of visual levee inspection between February and July. The visual inspections were completed in the Middle Eastside Bypass and Reach 4B2. These inspections did not reveal any major performance issues. Future levee monitoring is expected to continue on an as-needed basis depending on flood and Restoration Flow releases as well as changes in channel capacity identified in future channel capacity reports.

7.2.6 Sediment Monitoring

The purpose of sedimentation mobilization and erosion monitoring is to obtain information on sediment mobilization, bar formation, bank erosion, and bed erosion. This information will be useful for developing studies to determine the impacts of sedimentation and erosion on channel capacity as well as a key step in consideration of any sediment management actions. As described in Section 2.2.4 and Response to Comment O-EC-64 on page ii-197 of the Mendota Pool Bypass and Reach 2B EIS/R, as well as, in the PEIS/R, if unacceptable levels of erosion or deposition occur in priority locations that limit channel capacity or impact infrastructure, monitoring could trigger a suite of erosion and deposition management measures. Details regarding the ongoing sediment monitoring efforts are summarized in 10.2.7 of the 2018 CCR.

8.0 References

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