Appendix A

PEIS/R Text Related to Channel Capacity

December 2012

Chapter 2.0
Description of Alternatives

Minimize Increases in Flood Risk in the Restoration Area due to the Release of Interim and Restoration Flows. Throughout Settlement implementation, the maximum downstream extent and rate of Interim and Restoration flows to be released would be maintained at or below then-existing channel capacities. As channel or structure modifications are completed with additional environmental compliance, maximum Interim Flow releases would be correspondingly increased in accordance with then-existing channel capacities and with the release schedule. Consistent with the Act, Interim and Restoration flows would be reduced, as needed, to address material seepage impacts, as identified through the monitoring program (see Appendix D, "Physical Monitoring and Management Plan"). If release of water from Friant Dam is required for flood control purposes, concurrent Interim and 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 Interim and Restoration flows, no additional releases above those required for flood control would be made for SJRRP purposes.

Then-existing channel capacities within the Restoration Area correspond to flows that would not significantly increase flood risk from Interim and Restoration flows in the Restoration Area. The action to release Interim and Restoration flows includes measures that would achieve the following objectives: (1) commit Reclamation to implementing actions that would meet performance standards that minimize increases in flood risk as a result of Interim or Restoration flows, (2) limit the release and conveyance of Interim and Restoration flows to those flows that would remain in-channel until adequate data are available to apply the performance standards and until the performance standards are satisfied, and (3) enable the Settlement to be implemented in coordination with other ongoing and future actions outside of the Settlement that could address channel capacity issues identified in the Settlement or through the SJRRP or other programs. Implementation of measures that achieve these objectives would allow for the safe release and conveyance of Interim and Restoration flows throughout the duration of Settlement implementation. Reclamation would implement the following three integrated measures that collectively minimize increases in flood risk as a result of Interim or Restoration flows during Settlement implementation:

- **Establish a Channel Capacity Advisory Group and Determine and Update Estimates of Then-Existing Channel Capacities as Needed –** The establishment and administration of a Channel Capacity Advisory Group to provide independent review of estimated then-existing channel capacities, monitoring results, and management actions to address vegetation and sediment transport within the system as identified by Reclamation.

- **Maintain Interim and Restoration Flows at or Below Estimates of Then-Existing Channel Capacities –** The process for limiting Interim and Restoration flows to reduce the risk of levee failure due to underseepage, through-seepage, and associated levee stability issues to less-than-significant levels.

- **Closely Monitor Erosion and Perform Maintenance and/or Reduce Interim and Restoration Flows as Necessary to Avoid Erosion-Related Impacts –** The commitment by Reclamation to implement erosion monitoring and management, including monitoring potential erosion sites, reducing Interim and Restoration flows as necessary, and reporting ongoing results of monitoring and management actions to the Channel Capacity Advisory Group.

Only limited data are currently available on San Joaquin River channel capacities and levee conditions. The levee design criteria developed by U.S. Army Corps of Engineers (USACE) and presented 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) would be applied throughout the Restoration Area to identify the Interim or Restoration flows that would not cause the levee slope stability Factor of Safety to be reduced below 1.4, or the underseepage Factor of Safety to be reduced below the value corresponding to an exit gradient at the 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), and minimum levee slope stability factors of safety are given by USACE levee criteria shown in Table 2-6. The application of the levee slope stability Factor of Safety of 1.4 is required for federally authorized flood control projects. Through-seepage is calculated as part of the slope stability analysis and does not have a separate Factor of Safety. 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 for use 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).

Table 2-6.
Minimum Factors of Safety - Levee Slope Stability

Type of Slope	Applicable Stability Conditions and Required Factors of Safety			
	End-of-Construction	Long-Term (Steady Seepage)	Rapid Drawdown[a]	Earthquake[b]
New Levees	1.3	1.4	1.0 to 1.2	(see below)
Existing Levees	--	1.4[c]	1.0 to 1.2	(see below)
Other Embankments and Dikes[d]	1.3[e,f]	1.4[c,f]	1.0 to 1.2[f]	(see below)

Source: U.S. Army Corps of Engineers. 2000. Design and Construction of Levees Engineering and Design Manual. Manual No. 1110-2-1913. April. Table 6-1b, page 6-5.

Notes:

[a] Sudden drawdown analyses. F. S. = 1.0 applies to pool levels prior to drawdown for conditions where these water levels are unlikely to persist for long periods preceding drawdown. F. S. = 1.2 applies to pool level, likely to persist for long periods prior to drawdown.

[b] See ER 1110-2-1806 for guidance. An EM for seismic stability analysis is under preparation.

[c] For existing slopes where either sliding or large deformation have occurred previously and back analyses have been performed to establish design shear strengths lower factors of safety may be used. In such cases probabilistic analyses may be useful in supporting the use of lower factors of safety for design.

[d] Includes slopes which are part of cofferdams, retention dikes, stockpiles, navigation channels, breakwater, river banks, and excavation slopes.

[e] Temporary excavated slopes are sometimes designed for only short-term stability with the knowledge that long-term stability is not adequate. In such cases higher factors of safety may be required for end-of-construction to ensure stability during the time the excavation is to remain open. Special care is required in design of temporary slopes, which do not have adequate stability for the long-term (steady seepage) condition.

[f] Lower factors of safety may be appropriate when the consequences of failure in terms of safety, environmental damage and economic losses are small.

Until adequate data are available to determine the Factors of Safety, Reclamation would limit the release of Interim and Restoration flows to those which 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 are available to determine the Factors of Safety, Reclamation would limit Interim and Restoration flows to levels that would correspond to a 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. 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 Interim and Restoration flows at the site. Such observations would supersede channel capacity estimates, and Interim and Restoration flows would be reduced in areas where these conditions occur. Potential immediate responses to reduce, redirect, or redivert Interim or Restoration flows to reduce flow in downstream reaches is described in Section 2.4.3. All project- and program-level actions would be performed in compliance with USACE requirements, including requirements set forth by USACE as conditions of permits issued for implementation of such actions (see Chapter 28.0, “Consultation, Coordination, and Compliance,” for a description of the needed permits, petitions, compliance documents, etc. for the project- and program-level actions).

Detailed discussion of these three measures to reduce flood risk from the release and conveyance of Interim and Restoration flows is presented below.

Establish a Channel Capacity Advisory Group, and Determine and Update Estimates of Channel Capacities as Needed. In coordination with DWR and prior to releasing Interim Flows in Water Year 2013, Reclamation would establish a Channel Capacity Advisory Group to provide independent review of then-existing channel capacities estimated by Reclamation in accordance with standard USACE levee performance criteria. The Channel Capacity Advisory Group would provide timely independent review of data, analytical methodology, and results used to estimate then-existing channel capacities. The Channel Capacity Advisory Group would be comprised of the following:

- One member from the U.S. Bureau of Reclamation
- One member from the California Department of Water Resources
- One member from the U.S. Army Corps of Engineers
- One member from the Lower San Joaquin Levee District
- One member from the Central Valley Flood Protection Board

Reclamation would prepare a report annually or whenever Reclamation contemplates increasing the upper limit of releases for Interim or Restoration flows, which would include data and methods used to develop estimates of then-existing channel capacities. A draft report would be provided to the Channel Capacity Advisory Group for its review and comment for a period of 60 days. In the event that comments or recommendations are received from the Advisory Group within 60 days, Reclamation would be required to consider and respond to such comments and prepare a final report for distribution to the Channel Capacity Advisory Group within 60 days of the close of the draft report review period. Reclamation would not increase Interim or Restoration flows above the previously determined then-existing channel capacities until 10 days after the final report is prepared and distributed to the Channel Capacity Advisory Group. The first draft report shall be completed within 1 year of signing the PEIS/R Record of Decision. Draft reports would include the data, methods, and estimated channel capacities; flow limits and any maintenance activities; and monitoring efforts and management actions as described in this project description. Draft and final reports would be made available to the public concurrent with their distribution to the Channel Capacity Advisory Group.

Reclamation would convene the Channel Capacity Advisory Group 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 Channel Capacity Advisory Group 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.

Maintain Interim and Restoration Flows at or Below Estimated Then-Existing Channel Capacities. Until sufficient data are available to determine the Factor of Safety, Reclamation would limit initial Interim and Restoration flow releases to those flows that would remain in-channel, as described below. When sufficient data are available to determine the Factors of Safety, Reclamation would limit the release of Interim and Restoration flows to those flows that would maintain standard USACE levee performance criteria (i.e., a levee slope stability Factor of Safety of at least 1.4) and an underseepage Factor of Safety corresponding to an exit gradient at the toe of the levee of 0.5 or less) at all times.

In coordination with DWR, Reclamation would apply standard USACE levee performance criteria for levees under a steady state of saturation and consider past performance and hydrologic and hydraulic modeling to determine and update estimates of channel capacities. The resulting estimated channel capacities would be used to establish limits for Interim and Restoration flows throughout the Restoration Area.

Reclamation would be required to provide this estimate to the Channel Capacity Advisory Group for review, as previously described.

In the event that insufficient information is available to develop an estimate of channel capacities that maintain a minimum Factors of Safety for levees under saturated conditions by Water Year 2013, Reclamation would limit initial Interim and Restoration flows to those flows which would remain in-channel, as determined by DWR using one-dimensional HEC-RAS hydraulic modeling and described in Appendix I of this Draft PEIS/R. In-channel flows would have less-than-significant effects on flood risk as explained in the PEIS/R impact assessment of in-channel flows.

Factors of Safety describe the potential for unsafe conditions to occur. Underseepage Factors of Safety are inversely related to the exit gradient of seepage on the levee. The exit gradient is the hydraulic gradient at which water leaves the soil surface under saturated conditions, and is a function of both structural design and hydrogeologic conditions. At a critical exit gradient, soil particles may move with water, resulting in unsafe conditions such as piping and boils (Craig 1997, USACE 2000). USACE design guidance recommends that the allowable underseepage Factor of Safety for use in evaluations and/or design of seepage control measures should correspond to an exit gradient at the landside toe of the levee of 0.5. In general, this would provide an underseepage Factor of Safety of about 1.6 (USACE 2005).

Levee slope stability Factors of Safety are determined as the ratio of available shear resistance to that required for equilibrium. Available shear resistance is the capacity of the levee slope materials to maintain static equilibrium. A Factor of Safety greater than 1.0 indicates that capacity exceeds demand and that the slope will be stable with respect to sliding along the assumed particular slip surface analyzed. A Factor of Safety less than 1.0 indicates that the slope will be unstable (USACE 2003). USACE recommends a Factor of Safety of 1.4 or greater for levees under a steady state of saturation for a prolonged time, such as occurs during flood conditions or with prolonged flows. .

Maintaining the USACE levee Factors of Safety as described above would be the key performance criteria for reducing the risk of levee failure due to underseepage, through-seepage, and associated levee stability issues to less-than-significant levels. Systematic levee condition monitoring would be implemented as described in more detail in Appendix D, “Physical Monitoring and Management Plan.” Observation of seepage or boils at the landside levee toe or evidence of levee erosion would indicate that the minimum Factors of Safety are not met. Such observations would supersede channel capacity estimates, and Interim and Restoration flows would be immediately reduced, redirected, or diverted in areas where these conditions occur until such time that seepage or boils are not observed during levee monitoring (see Section 2.3.4).

Closely Monitor Erosion and Perform Maintenance and/or Reduce Interim or Restoration Flows as Necessary to Avoid Erosion-Related Impacts. As part of the draft reports prepared by Reclamation and submitted to the Channel Capacity Advisory Group (as described previously), Reclamation would describe the monitoring and management actions taken within the Restoration Area over the prior year and the monitoring and

management actions planned for the following year. The draft reports would identify those monitoring and management actions that are a result of implementing the Settlement and those that are a result of regular operations and maintenance and capital improvements to flood control facilities of the Lower San Joaquin River Flood Control Project. The draft reports would be submitted to the Channel Capacity Advisory Group for review as previously described.

Reclamation would implement the flood-related monitoring and management actions included in the project description and in the draft reports to the Channel Capacity Advisory Group, and would work with the appropriate agency(ies) to implement these actions to meet the performance standards as previously described. As previously described, systematic levee condition monitoring would be implemented as described in more detail in Appendix D, "Physical Monitoring and Management Plan," and could lead to the immediate reduction of Interim or Restoration flows in areas where these conditions occur.

Erosion monitoring would be conducted by Reclamation using several standard methodologies and protocols commonly employed by DWR, reclamation districts, and/or USACE to monitor levee erosion. Aerial photography and/or ground surveys would be compared to identify changes in bank line over time, indicating potential erosion. True color aerial photographs would be inspected and compared to previous aerial photographs to identify areas of sediment mobilization, bar formation, and bank erosion. After these areas have been initially identified using aerial photography, they would be visited and inspected. If inspections indicate that erosion-related impacts exist or are imminent, management actions would be taken to address the issue.

Field surveys of potential erosion sites on the San Joaquin River between Friant Dam and the Merced River confluence would be conducted by Reclamation annually or on a basis as determined by Reclamation in coordination with the Channel Capacity Advisory Group. These surveys would assess the condition of potential erosion sites, and could include a variety of techniques such as aerial photography and topographic surveys. Previous information documents the existing sediment and geomorphology conditions within the Restoration Area. Existing information developed by Reclamation includes preliminary analyses conducted to identify locations susceptible to potential erosion through comparison of present-day channel positions (2004) and historical channel positions (1937, 1938). Reclamation identified areas that may be susceptible to future erosion using the following criteria:

- Areas of channel change between 1937 and 2004 or between 1938 and 2004 where the channel has shown lateral erosion along an outer bend or where it has the potential to reoccupy an old channel position and laterally erode banks along an outer bend, and that also have low topography (for instance, several outer bends in Reach 1A are located adjacent to high bluffs, which would be considered an area of slower erosion and are thus not identified).

- Meander necks where channel sinuosity is high and could create a cutoff.

- Areas along outer bends where excavated gravel pits are located close to the active channel, regardless of whether any historical channel change has occurred.

- Areas along outer bends that are located adjacent to developed areas (such as at Firebaugh).

- Areas with the potential for future erosion identified through this process and prioritized for monitoring based on potential impacts to infrastructure. The highest priorities were those with residential developments, buildings, and bridges. Other high-priority areas included those containing levees, irrigation canals, and roads with an apparent high potential to experience some lateral migration or bank erosion.

Sediment mobilization monitoring during these surveys would focus on specific potential erosion sites identified through this process, and would evaluate current and potential future erosion at these sites. Channel bed deposition would be evaluated as necessary by analyzing changes identified in topographic survey data and LIDAR surveys.

The Lower San Joaquin Levee District (LSJLD) and the Central Valley Flood Protection Board (CVFPB) currently have responsibility for implementing routine operations and maintenance or capital improvements to the Lower San Joaquin River Flood Control Project. Changes to the Lower San Joaquin River Flood Control Project would require USACE approval.

Erosion management actions identified through monitoring as described above may fall under the routine maintenance of the Lower San Joaquin River Flood Control Project currently performed by LSJLD. If increased maintenance activities and costs are required as a result of implementing the Settlement, including additional erosion management actions identified through the monitoring activities described in this section, Reclamation would conduct or enter into an agreement with others to conduct such additional maintenance activities. Currently, Reclamation is working with LSJLD to develop and implement an agreement to provide financial assistance for additional costs incurred by LSJLD. The financial assistance agreement is intended to assist LSJLD in adapting to changes in operations and maintenance activities, as needed to maintain the existing level of flood management under release of Interim and Restoration flows.