2015 ANNUAL EROSION INVENTORY ENGINEERING REPORT

SACRAMENTO RIVER BANK PROTECTION PROJECT
SACRAMENTO RIVER AND TRIBUTARIES

U.S. Army Corps
of Engineers
Sacramento District

JULY 2015

2015 ANNUAL EROSION RECONNAISSANCE ENGINEERING REPORT

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July 2016

US Army Corps of Engineers®

SACRAMENTO DISTRICT

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1.0 Authorization

The Sacramento River Bank Protection Project (SRBPP) was authorized for the protection of the existing levees and flood control facilities. It was originally authorized by the 86th Congress under the Flood Control Act of 1960, Public Law 86-645, Title II. It is currently authorized by the Water Resource Development Act of 2007. Under the current authorization (Phase II) there is just less than 3,500[1] linear feet (LF) available for repairs out of the original 405,000 LF. An additional 80,000 linear feet should be available at the completion of the Post Authorization Change Report. The project area consists of the leveed portion of the Sacramento River and its tributaries and sloughs, as shown in **Figure 1**.

2.0 Purpose

This report summarizes and documents the annual erosion reconnaissance of the Sacramento River Flood Control System (SRFCS). The erosion inventory is conducted every year[2] and consists of a visual inspection of the levees and banks of the Sacramento River Flood Control System by the Engineering Division. Personnel from various sections of the US Army Corps of Engineers collected photos with a GPS camera and data using a Trimble XH with GPS and GIS capabilities. The purpose of the reconnaissance is to maintain and update an inventory of erosion sites, identify new erosion sites, monitor existing erosion sites, and collect data to prioritize the sites for repair. A site is deemed an erosion site if the erosion is into the projection of the levee slope (section 5.0).

3.0 Project Background

The annual erosion inventory started in 1997, following the large flood event in the winter of 1996 and 1997. This flood event caused a levee breach and numerous flood fighting efforts throughout the SRFCS. The original goal of the inventory was to identify the eroded areas in the levee system and repair them. Since this time, environmental impact concerns resulted in a jeopardy opinion being issued by the resource agencies and have limited the repair work by the SRBPP. Following the jeopardy opinion, repairs were primarily performed under emergency work (PL84-99) or through local maintenance efforts. Under the SRBPP, one site on the Sacramento River and a few sites on the American River were repaired between 1997 and 2006.

In February 2006, after high flows in the rivers of the Sacramento Valley, the Governor of California, Arnold Schwarzenegger, declared a state of emergency for the Central Valley levees. In the following years, all the sites that were defined as “critical” in the 2005 inventory were repaired. Over 100 sites

[1] This is remaining linear feet after the completion of the repair on the Sacramento River at RM 26.0 left bank, which is currently under construction.

[2] The 2013 Erosion Inventory was only produced in Draft format, but all information gathered during that inventory is contained in this report. Due to funding and personnel constraints, no inventory was conducted in 2014.

have been repaired since the declaration through the combined efforts of the U.S. Army Corps of Engineers (USACE) and the California Department of Water Resources (DWR).

In the last few years, the number of sites being repaired has dwindled, primarily due to lack of funding and the ability to obtain real estate and planting rights. Since 2010, 6 sites[3] have been repaired by USACE under this program, 3 sites[4] have been repaired by CA DWR, and 9 sites[5] have been repaired by the local maintaining agency. Only one site is currently being repaired (SAC 26.0L)[6]. However new sites are identified and entered into the erosion inventory every year. Even as California enters its fourth year of drought, new sites continue to be found. There is currently a backlog of 200 erosion sites. The number of sites in need of repair far exceeds the number of sites that can be repaired each year. Therefore, a ranking system was developed to help determine which sites are the highest priority for repair. The priority list is based on engineering criteria of the most likely to fail, but does not account for economics, real estate, or environmental factors.

Currently, the project continues to have difficulty repairing erosion sites due to funding, real estate issues, and environmental constraints. Recent direction from USACE headquarters is that only erosion sites within economically justified basins can be repaired at this time. This means that the highest priority sites based on engineering criteria, may not qualify for repairs under USACE guidelines. However, under the authority of this project, we will still inventory all channels within the project description and develop the priority list based on the engineering criteria.

[3] FHR 7.0L, LAR 10.0L, LAR 10.6L, SAC 77.2L, SAC 57.0R, and SAC 57.2R
[4] CHC 3.9L, CHC 4.2L, and SAC 46.7L
[5] BTC 9.6L, GEO 11.2R, SAC 60.1L, STM 23.2L YUB 2.3L, SAC 154.0R, STM 23.8L, GEO 2.0L, and SAC 15.0L
[6] This site was under construction at the time of the field work but the repair will be complete when this document is finalized.

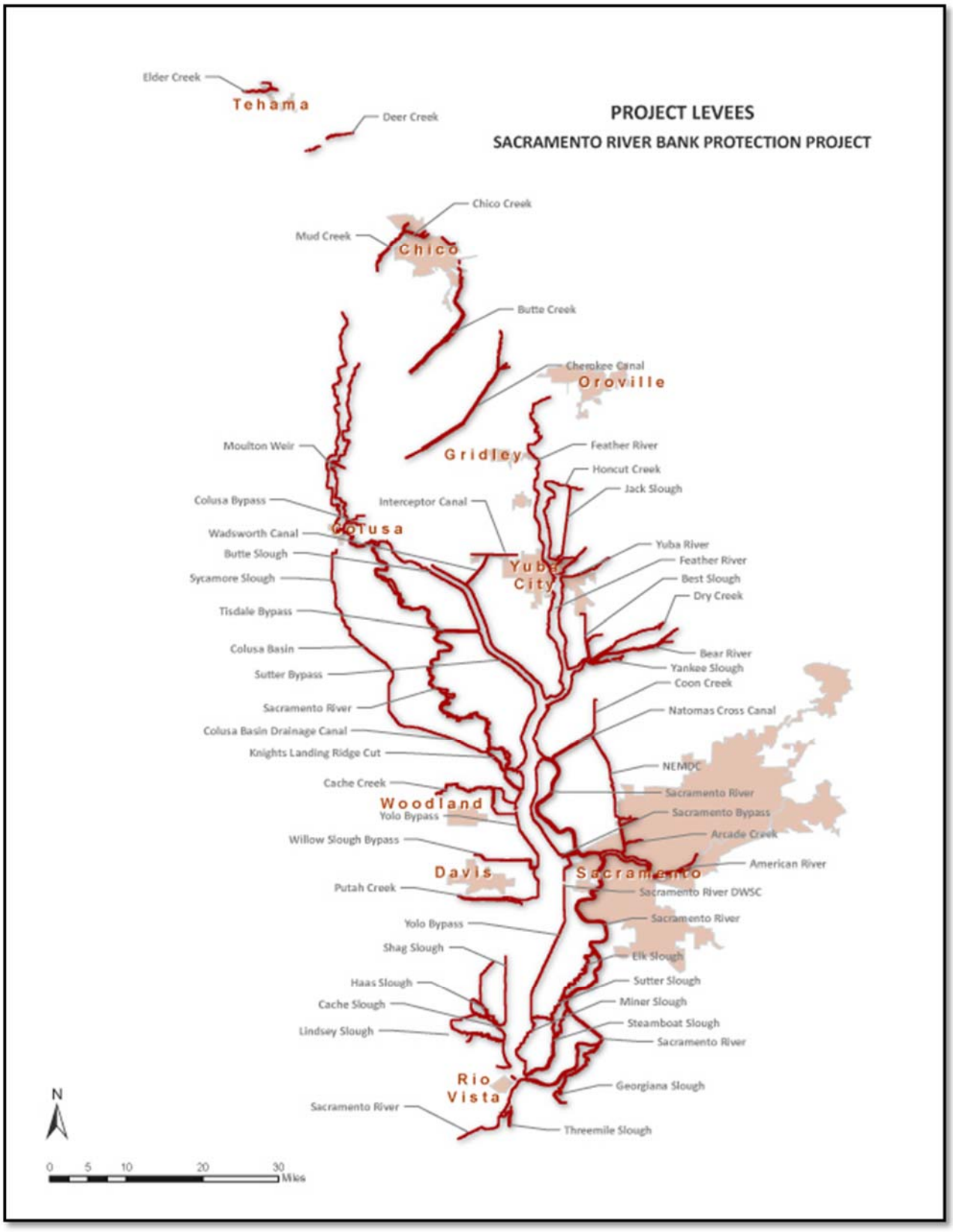

Figure 1. Project Levees of the Sacramento River Flood Control System

4.0 Reconnaissance Team and Inventoried Levees

There are two parts to the erosion inventory; these two parts are typically referred to as the "annual erosion inventory" and the "extended erosion inventory". The annual erosion inventory includes the levees of the SRFCS that are inspected every year. This includes the reaches that convey flow through the SRFCS on an annual basis. The extended inventory is only conducted after high flow events or a minimum of once every five years. The extended erosion inventory includes reaches of the SRFCS that either convey seasonal flow or do not typically convey flow on an annual basis, such as the bypasses.

The 2015 reconnaissance included a limited version of the annual inventory, which was conducted throughout the month of August, due to time constraints. The extended inventory was last conducted in 2011 and data reported for those sites is based on the 2011 Erosion Reconnaissance Report (USACE, 2012). The inspection was conducted by the USACE Engineering Division, and included team members from Hydraulic Analysis, GIS, Soil Design, Civil Design, and Levee Safety.

The majority of the annual reconnaissance was conducted by boat for optimal viewing of the channel banks and levees. However, some of the channels did not contain enough flow to navigate by boat, so they were inventoried by vehicle. **Table 1** lists the reaches of the SRFCS, frequency of inspection (annually or extended), year of last inspection, and the method of inspection. **Figure 2** shows the levees that are inspected annually and those inspected during the extended inventory.

Table 1. Inspected Reaches of the Sacramento River Flood Control System

SRFCS Reach	River Miles or Length	Inspection Frequency	Year of Last Inspection	Inspection Method
American River	RM 0 - 13	Annual	2015	Car[7]
Arcade Creek	2 miles	Extended	2011	Car
Bear River	RM 0 - 14	Annual	2013	Car
Best Slough	2 miles	Extended	2011	Car
Butte Creek	15 miles	Annual	2013	Car
Butte Slough	7 miles	Extended	2011	Car
Cache Creek and Cache Creek Settling Basin	11 miles	Annual	2015	Car
Cache Slough	14 miles	Annual	2015	Boat
Cherokee Canal	20 miles	Extended	2011	Car
Chico/Sycamore Creek	2 miles	Extended	2011	Car
Colusa Basin Drainage Canal and Sycamore Slough	35 miles	Extended	2011	Car
Colusa Weir Bypass	1 mile	Extended	2011	Car
Coon Creek Interceptor	5 miles	Extended	2011	Car
Cottonwood Creek	1 mile	Extended	2011	Car
Deer Creek	5 miles	Extended	2011	Car
Dry Creek (Bear River)	9 miles	Extended	2011	Car

[7] Due to low water levels, this reach was not accessible by boat.

Table 1. cont. Inspected Reaches of the Sacramento River Flood Control System

SRFCS Reach	River Miles or Length	Inspection Frequency	Year of Last Inspection	Inspection Method
East Interceptor Canal	3 miles	Extended	2011	Car
Elder Creek	4 miles	Extended	2011	Car
Elk Slough	9 miles	Annual	2015	Boat
Feather River	RM 0 - 7	Annual	2015	Car[8]
Feather River	RM 7 – 34	Annual	2013	Boat
Feather River	RM 34 - 60	Extended	2011	Car
Georgiana Slough	12 miles	Annual	2013	Boat
Haas Slough	8 miles	Extended	2011	Car
Honcut Creek	4 miles	Extended	2011	Car
Jack Slough	6 miles	Extended	2011	Car
Knights Landing Ridge Cut	6 miles	Extended	2011	Car
Linda Creek (Dry)	2 miles	Extended	2011	Car
Lindsey Slough	7 miles	Extended	2011	Car
Marysville Ring Levee	7 miles	Extended	2011	Car
Miner Slough	7 miles	Annual	2015	Boat
Moulton Weir Bypass	2 miles	Extended	2011	Car
Mud Creek	7 miles	Extended	2011	Car
Natomas Cross Canal	5 miles	Extended	2011	Car
Natomas East Main Drainage Canal	4 miles	Extended	2011	Car
Pleasant Grove Canal	4 miles	Extended	2011	Car
Putah Creek	9 miles	Extended	2011	Car
Sacramento Bypass	2 miles	Extended	2011	Car
Sacramento Deep Water Ship Channel	18 miles	Extended	2011	Car
Sacramento River	RM 3 - 90	Annual	2015	Boat
Sacramento River	RM 90 - 140	Annual	2015	Car[7]
Sacramento River	RM 140 - 184	Annual	2013	Boat
Steamboat Slough	11 miles	Annual	2015	Boat
Sutter Bypass	34 miles	Extended	2011	Car
Sutter Slough	6 miles	Annual	2015	Boat
Three Mile Slough	3 miles	Annual	2013	Boat
Tisdale Weir Bypass	4 miles	Extended	2011	Car
Ulatis Creek	4 miles	Extended	2011	Car
Wadsworth Canal	5 miles	Extended	2011	Car
West Interceptor Canal	2 miles	Extended	2011	Car
Western Pacific Interceptor Canal	6 miles	Extended	2011	Car
Willow Slough Bypass	8 miles	Extended	2011	Car
Yankee Slough	4 miles	Extended	2011	Car
Yolo Bypass	37 miles	Extended	2011	Car
Yuba River	RM 0 - 5	Extended	2011	Car

[8] Due to low water levels, this reach was not accessible by boat.

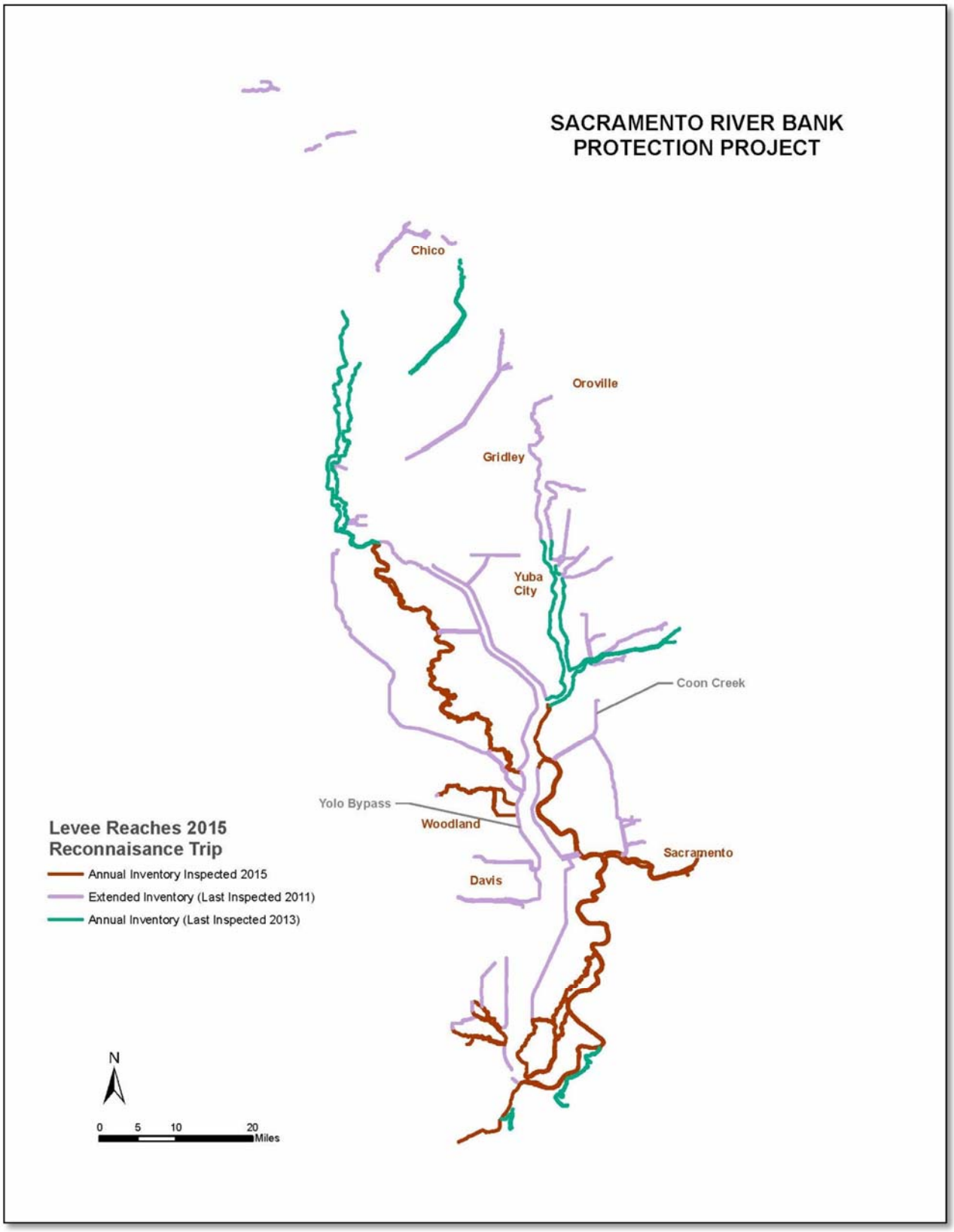

Figure 2. Levees Inspected in 2015

5.0 Inventory Criteria and Data Collection

The criteria for when an erosion site is added to the inventory is if the erosion encroaches into the projection of the 3H:1V levee slope, as shown in **Figure 3**. If a berm is present on an eroding bank, the site is added if the berm is typically less than 35 ft (this distance may vary given the levee height). There are areas in the SRFCS where the bank is visibly eroding, but if the erosion does not encroach into the projection of the levee slope, then it does not meet the criteria for an erosion site.

There are six (6) terms used to record the status of the sites as described below:

- Eroding: A site that is susceptible to an erosional breach during flood and/or normal flow conditions.
- New Erosion: A site identified in the current year as susceptible to an erosional breach during flood and/or normal flow conditions.
- Critical: A site that is an imminent threat to the integrity of the SRFCS and of highest priority for repair.
- Repaired: A site that was previously an erosion site that has since been repaired.
- Removed: A site that was previously an erosion site but was taken out of the inventory because it no longer meets the criteria.
- Under Construction: A site in which at the time of inspection was either being repaired or a contract has been awarded and the construction should begin shortly. This site will likely move to the repaired list in the next year's inventory.

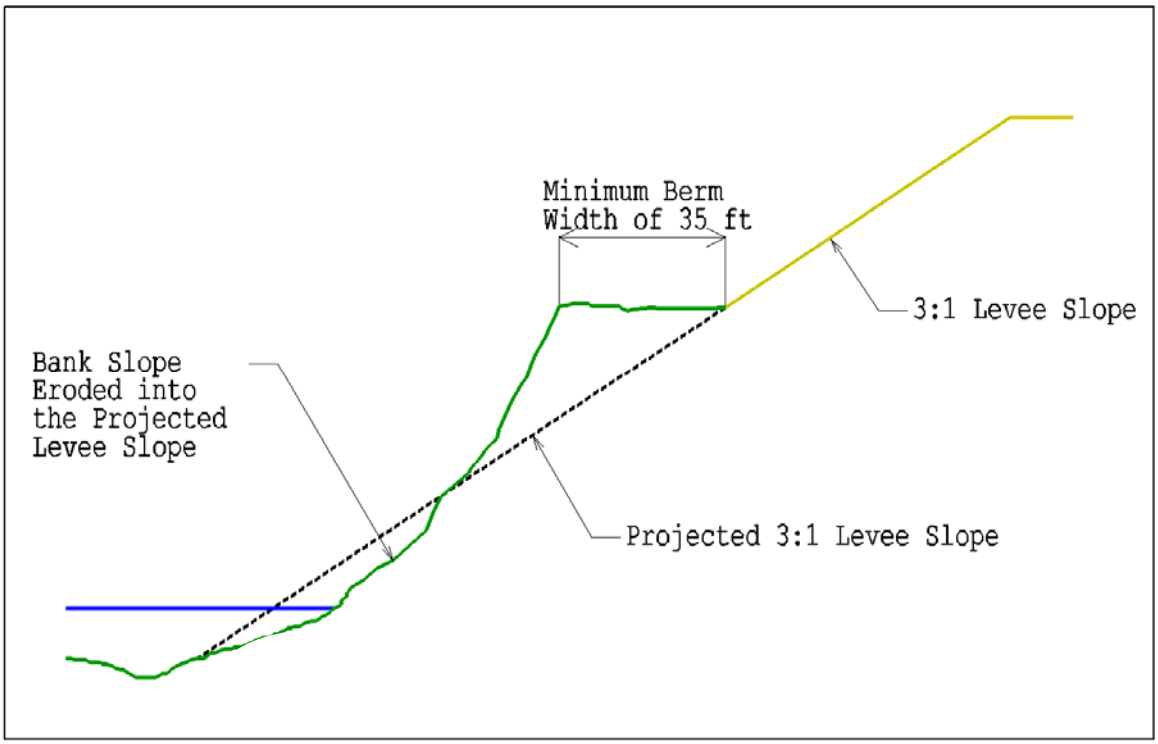

Figure 3. Schematic of Erosion Site Criteria

Each erosion site is identified with a unique name based on the naming scheme described below:

AAA_BB-B_C

Where:

AAA: Three letter river code

BB-B: River or Levee Mile (dash represents the decimal)

C: Bank designation (left or right bank, when looking downstream)

For example, Sacramento River RM 92.8 left bank would be expressed as SAC_92-8_L (All letters are capitalized, no spaces, and no periods)

Three letter river codes:

ACD - Arcade Creek
BER - Bear River
BES - Best Slough
BTC - Butte Creek
BTS - Butte Slough
CHC - Cache Creek
CHI - Chico Creek
CHS - Cache Slough
CHK - Cherokee Canal
CBD - Colusa Basin Drainage Canal
COB - Colusa Bypass
COO - Coon Creek
CWC - Cottonwood Creek
DEC - Deer Creek
DCN - Dry Creek (North, flows to Bear River)
DCS - Dry Creek (South, flows to NEMDC)
DWS - Deep Water Ship Channel
EMD - East Main Drain (Natomas)
EIC - East Interceptor Canal
ELC - Elder Creek
ELK - Elk Slough
FHR - Feather River
GEO - Georgiana Slough
HAS - Haas Slough
HNC - Honcut Creek
JSK - Jack Slough
KLR - Knights Landing Ridge Cut
LAR - Lower American River
LDS - Lindsey Slough
MR1 - Marysville Unit 1
MR2 - Marysville Unit 2
MR3 - Marysville Unit 3
MIR - Miner Slough
MLW - Moulton Weir Bypass
MUD - Mud Creek
MRS - Murphy Slough
NCC - Natomas Cross Canal
PGC - Pleasant Grove Canal
PUC - Putah Creek
SAC - Sacramento River
SAP - Sacramento Bypass
SAS - Sacramento Slough
SBP - Sutter Bypass
SHG - Shag Slough
STM - Steamboat Slough
STR - Sutter Slough
SYC - Sycamore Creek
SYS - Sycamore Slough
TIB - Tisdale Bypass
TMS - Three Mile Slough
ULB - Ulatis Creek Bypass
WAC - Wadsworth Canal
WIC - West Interceptor Canal
WPC - Western Pacific Interceptor Canal
WSB - Willow Slough Bypass
YAS - Yankee Slough
YOL - Yolo Bypass
YUB - Yuba River

At the erosion sites, specific data was collected for use in the inventory and the site ranking. This data included: Site Name, Waterway, River or Levee Mile, Bank Designation, Site Status, Length of Erosion, Width of Berm, Erosion Mechanism, Bank Slope, simplified Soil Classification, Issues effecting Stability, Observed Eddies, Wave Action, Bank Protection, Visible Encroachments, and Field Notes.

6.0 Reaches within the Sacramento River Flood Control System

The Sacramento River Flood Control System covers a large area and is made up of many different rivers, creeks, sloughs, and bypasses. Each reach within the system is unique and subject to different erosion processes. Below is a brief description of the different reaches.

Upper Reach of the Sacramento River – Ord Bend to Colusa (RM 185 to 144) – The upper reach of the Sacramento River is unique because the levees are setback and the channel naturally meanders and erodes. A typical picture of the Upper Sacramento River is shown in **Figure 4**. In general, the river has become somewhat sediment starved due to upstream reservoirs reducing the bedload from upstream. The river is highly erosive and erosion of the outer banks of the meandering bends and the development of sandbars are evident throughout the reach. The natural erosion of the banks is considered good for a healthy river system and environmental factors. However, when the erosion creeps into the projection of the levee slope, it can threaten the integrity of the SRFCS. There are currently 8 erosion sites in this reach.

Figure 4. Typical View of the Upper Reach of the Sacramento River.

Middle Reach of the Sacramento River – Colusa to Sacramento (RM 144 to RM 61) – The middle reach of the Sacramento River has the levees close to the river and multiple diversion structures to move flow into the bypass system. This reach was intentionally designed with the levees close to the banks to help move some of the bedload and debris that remained from the days of hydraulic mining. In addition, the USACE was responsible for keeping the river navigable up to the city of Colusa. As a result of this design, much of the reach is protected with rock, especially the outsides of bends. The majority of the rock in this reach is cobbles placed prior to the 1960's and some areas with more recent quarry stone. The cobble sites are reaching the end of their design life and starting to fail. Roughly one-third of the sites in this reach are from failed cobble sites. **Figure 5** shows a typical view of the Middle Sacramento River. There are currently 37 erosion sites in this reach.

Figure 5. Typical View of the Middle Reach of the Sacramento River.

Sacramento River – Delta Section (RM 61 to RM 15) – The delta reach of the Sacramento River has levees close to the banks and is tidally influenced. The location of the channel has been relatively stable for the past 150 years. A large percentage of this reach is already rocked. This area has heavy action from recreational boating, wind wave run-up, and the banks are heavily used by the public. Many of the levees are constructed of deposited dredge tailings from the bottom of the river. **Figure 6** shows a typical view of the Delta section of the Sacramento River. The causes of erosion in this reach are boat wake, wind wave, mass slope failure, fluvial processes, and human usage. There are currently 35 erosion sites in this reach, of which one (1) was new in 2013 and one (1) is new in 2015, two (2) are critical, and one (1) is under construction.

Figure 6. Typical View of the Sacramento River – Delta Section.

Lower Reach of the Sacramento River (RM 15 to RM 3) – The lower reach of the Sacramento River is very wide and the water surface is controlled by the tides. Only the left bank is leveed in this reach; the right bank is considered high ground. There is a narrow highway with no shoulder on top of the levee for half of the reach. Ocean-going cargo ships travel through this reach creating large wakes. The area is also subject to high winds and wind waves. Wind waves and boat wakes are the main cause of erosion in this reach. Bank stability is also an issue; the slopes of the levees are steep and constructed of poor (non-cohesive) soils; however the toe often contains some clay. **Figure 7** shows a typical view of the lower section of the Sacramento River. There are currently eight (8) erosion sites in this reach, of which five (5) are critical.

Figure 7. Typical View of the Lower Reach of the Sacramento River.

Steamboat Slough, Miner Slough, Sutter Slough, and Cache Slough – These distributary channels in the Sacramento Delta are predominately backwater channels with low velocities that are controlled by the tides. The erosion mechanism in these sloughs comes from wind wave, boat wake, tidal influences, slumping, human use, and tree pop-outs. **Figure 8** shows the confluence of Sutter and Miner Sloughs. Steamboat Slough has had over ten (10) repairs in the past decade and the levees continue to degrade. Steamboat currently has thirteen (13) erosion sites, of which one is critical. Miner Slough currently does not have any erosion sites and has had no identified erosion sites since the beginning of the inventory. Sutter Slough currently has nine (9) erosion sites, of which one is critical, one was new in 2013 and two (2) are new in 2015. A portion of Cache Slough is used by cargo ships to enter the Deep Water Ship Channel and therefore is subject to larger boat wakes. Cache Slough currently has eight (8) erosion sites, of which two were new in 2013.

Figure 8. View of the confluence of Miner and Sutter Sloughs.

Lindsey Slough, Haas Slough, Shag Slough, and Ulatis Creek Bypass – These channels are in the western Delta side of the SRFCS and they all conclude at Cache Slough. Lindsey Slough is a wide shallow channel with the levees set close to the banks. Haas Slough, Shag Slough, and Ulatis Creek Bypass are small channels that primarily carry agricultural runoff. The velocities in these channels are low and tidally influenced. The erosion mechanism in these channels comes from wind wave, tidal influences, and tree pop-outs. Haas Slough also has issues with the banks being trampled by cattle. **Figures 9** and **10** show a typical view of Haas Slough and Lindsey Slough, respectfully. Lindsey Slough has five (5) erosion sites and Haas Slough has two (2) erosion sites. There are no erosion sites on Shag Slough and Ulatis Creek Bypass.

Figure 9. Typical View of Haas Slough.

Figure 10. Typical View of Lindsey Slough.

Georgiana Slough – Georgiana Slough is unique in that it flows from the Sacramento River System into the San Joaquin River System. The upstream most two miles are regulated as a no wake zone. Georgiana Slough is completely influenced by the tides and subject to severe winds. The majority of the levee and bank slopes are steep with no berm. The banks are composed of poor soils, which do not meet current design standards. The left bank is in worse shape and contains 90% of the sites. Biotechnical repairs in the form of brush boxes have been used to try and protect the banks from wind waves and boat wakes; however, the majority of them have had limited to no success. The primary erosion factors are from wind wave, boat wake, tidal influence, and poor soils. Many of the sites along the left bank have started to merge together and soon the entire bank may be considered an erosion site. **Figure 11** shows a typical view of a Georgiana Slough levee. It is important to note that the local LMA (RD 563) has been working hard to repair many of the identified erosion sites, in the past few years, they have repaired one critical site, filled the worst erosion pickets at one erosion site so it is no longer considered critical (although still considered an erosion site), and shortened 3 sites with the

addition of rock revetment. This reach may benefit from a reach-wide repair. There are currently fifteen (15) erosion sites, of which two (2) are critical and one was new in 2013.

Figure 11. Typical View of Georgiana Slough.

Elk Slough – Elk Slough was cut off from the Sacramento River on the upstream end by the Sacramento River levee and therefore has no inflow, it is purely a backwater channel with some tidal influence. The channel is shallow, and the banks are full of vegetation and heavily used by humans. The levee slopes are over-steepened and built out of non-cohesive dredge material. The entire levee reach is in poor condition, with slumping, holes, and slope stability problems. **Figure 12** shows a typical view of Elk Slough. With the levees being in such poor shape the entire leveed reach (right bank and left bank) is classified as an erosion site. This reach would benefit from a reach wide repair.

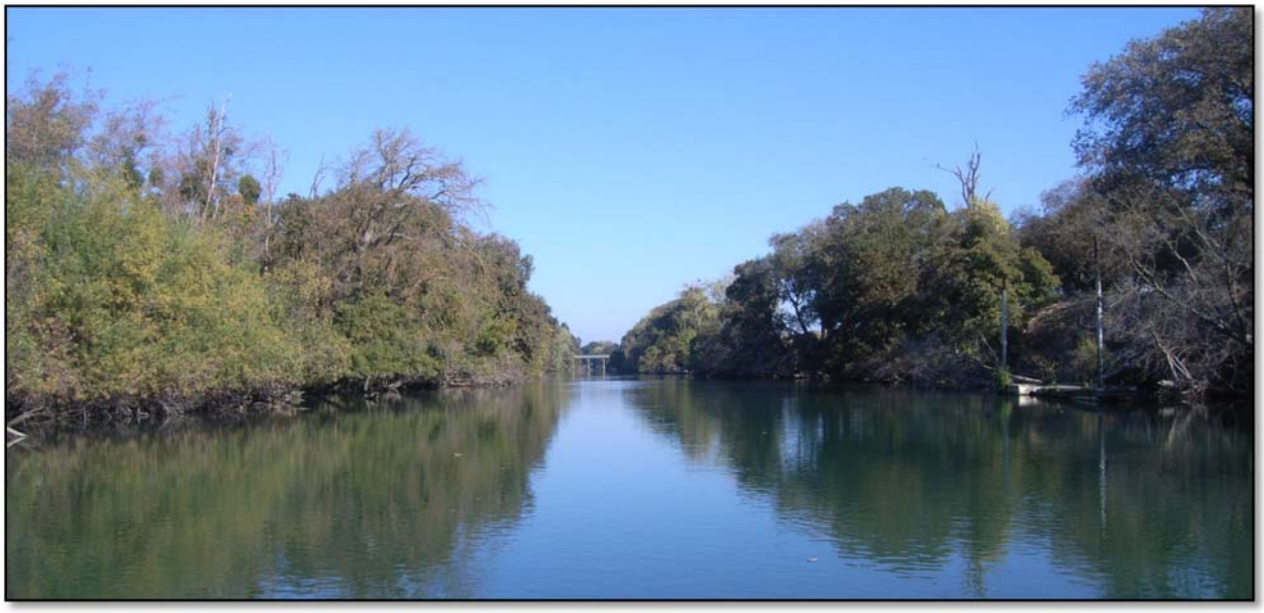

Figure 12. Typical View of Elk Slough.

American River – The American River is fed by Folsom Dam and is therefore generally sediment starved and has been eroding and transporting the fine materials from the channel bed. Once the fines have been removed and the bed armors, the channel is expected to move laterally and erode the banks. The right bank is setback from the channel for the lower 5 miles. Boat wake is not a concern as there is a no wake zone for the entire river. The main causes of erosion are fluvial, tree pop-outs, and public use. This river is generally well maintained and has had many bank repairs in the recent years. **Figure 13** shows a typical view of the American River. There is currently one erosion site on the American River.

Figure 13. Typical View of the American River.

Feather River, Northern Reach (RM 62 - 46) – The northern portion of the Feather River has a levee only on the right bank. The channel is meandering and the upstream overbanks still show the impacts of past hydraulic mining, with large gravel and dirt mounds visible throughout. The levees are heavily vegetated and there are places where structures (e.g. houses, canals) have been built into the landside of the levee. **Figure 14** shows a typical view of the northern reach of the Feather River. There are two (2) erosion sites in this reach of the Feather River.

Upper Reach of Feather River, North of Yuba River (RM 46 to RM 28) - The Feather River upstream of the Yuba River is a meandering river with setback levees on both sides. The channel gets close to the levees at a few of the meandering bends, which have been armored from past repairs. The river appears to have pushed the majority of the sediment leftover from hydraulic mining through this reach and with the construction of Oroville Dam, it has started to become sediment starved. Some active erosion was observed, but it was not close to the levees. There are currently no erosion sites in this reach.

Figure 14. Typical View of the Northern Reach of the Feather River.

Middle Reach of the Feather River, South of Yuba River (RM 28 to RM 7) – The middle reach of the Feather River is wide and shallow and has a large amount of sand bedload coming from the Yuba River. At RM 24.8, Shanghai falls, there is a large clay plug that has slowly been moving through the system. This feature acted as a grade control feature in the river and as of early February 2012, this clay plug has been breached. The full impacts of this breach are not yet known, but there will most likely be further erosion to the system. **Figures 15** shows the clay plug in its current state. The levees are setback in this reach and a new setback levee was recently constructed on the left bank from RM 25 to RM 18. The primary causes of erosion in this reach are fluvial and mass failure of eroded banks. There are currently three (3) erosion site in this reach of the Feather River, and two (2) were new in 2013.

Figure 15. View of Clay Plug on the Feather River at RM 24.8 in late 2012.

Lower Feather River (RM7 to RM 0) – The lower reach of the Feather River has a tight levee on the left bank and the Sutter Bypass on the right bank. The river is shallow and wide, with large sandbars throughout the channel. The primary causes of failure in this reach are fluvial and mass failure of eroded banks. **Figure 16** shows a typical view of the lower Feather River. There are currently seven (7) erosion sites in this reach of the river.

Figure 16. Typical View of lower Feather River.

Yuba River – The Yuba River is a meandering channel and the levees are setback by over a mile from the channel. The south levee was recently constructed and is generally in good condition for most of the reach. Recently, the local RD has constructed improvements to the south levee in order to meet the current USACE levee standards, including adding a slurry wall. There are currently no erosion sites in this river.

Bear River – The Bear River is an incised channel due to the loss of sediments from the Camp Far West Dam and historic sand and gravel mining. The levees are setback a short distance from the slightly meandering channel. **Figure 17** shows a typical view of the Bear River. A setback levee was recently constructed for the first two miles on the right bank. There are currently five (5) erosion sites on this river.

Figure 17. Typical View of Bear River.

Yankee Slough, Dry Creek, Western Pacific Interceptor Canal, and Best Slough – These channels are all tributaries to the Bear River. The leveed portion of Yankee Slough is four miles long and joins the Bear River at RM 3. The levees are set close to the channel and most of the channel is heavily vegetated. Dry Creek (often called North Dry Creek) joins the Bear River at RM 5. The north levee is just over a mile long and the south levee runs for 7 miles. Best Slough and the northern portion of the Western Pacific Interceptor collect the flows from the east and direct it down the southern portion of the Western Pacific Interceptor Canal (WPIC). The floodplain of the WPIC is a mixed use of wetland habitat and agriculture. There is one erosion site on Yankee Slough.

Natomas East Main Drainage Canal, Arcade Creek, and Dry Creek – Arcade Creek and Dry Creek (formerly known as Linda Creek, and now more commonly referred to as South Dry Creek) drain water from the Rio Linda, Roseville, Antelope, Citrus Heights, and Carmichael areas. Arcade Creek has the levees relatively close to the channel, however the small floodplain maintains a healthy riparian habitat. Dry Creek has a large floodplain but relatively little riparian habitat, as the floodplains appear to be used for cattle grazing. **Figure 18** shows a typical view of Dry Creek. The Natomas East Main Drainage Canal (NEMDC) directs the flow from Arcade and Dry creeks and sends it south to the American River. NEMDC is a man-made channel that runs north-south and protects the east side of Natomas. There are currently no erosion sites in this section of the system.

Figure 18. Typical View of Dry (Linda) Creek.

Natomas Cross Canal, Pleasant Grove Canal, and Coon Creek Interceptor – Pleasant Grove Canal and Coon Creek Interceptor collect water from the east foothills and communities of Lincoln and Pleasant Grove. These flows are then directed into the Natomas Cross Canal which moves the water down to the Sacramento River. Pleasant Grove Canal and Coon Creek only have levees on the east side. The levees are steep with some grass and shrub vegetation. The Natomas Cross Canal is man-made and the levee on the south side was recently rebuilt. The south levee is mowed and grazed by sheep in the summer while the north levee is tall grasses with shrubs/trees on the lower bank. **Figure 19** shows a typical view of the Natomas Cross Canal. There is one erosion site on the Natomas Cross Canal.

Figure 19. Typical View of the Natomas Cross Canal.

Cache Creek – The Cache Creek levees start near the town of Yolo and terminate at the Yolo Bypass. Cache Creek is a deeply incised channel with near vertical banks (over 20 ft in height) for the entire leveed reach. The channel is sediment starved from excessive in-stream gravel mining. Some sand and gravel are present in the channel bed, indicating that the channel may be starting to recover and become more stable. **Figure 20** shows a typical view of Cache Creek. The erosional mechanisms in this reach are toe erosion, fluvial and mass failure. The natural banks are too steep and the channel is too narrow for a traditional bank protection repair; setback levees have been the selected option for repair. This creek may benefit from a reach-wide repair. There are currently five (5) erosion sites on Cache Creek, one (1) is considered critical. DWR currently has plans to repair two (2) of these erosion sites with setback levees.

Figure 20. Typical View of Cache Creek.

Willow Slough Bypass – The Willow Slough levees start just north of the City of Davis and terminate at the Yolo Bypass. The Willow Slough Bypass directs flow from Willow Slough and agricultural runoff to the Yolo Bypass. Erosion is present along a good portion of the natural bank, but the erosion is not into the projection of the levee slope. There are currently no erosion sites on Willow Slough Bypass.

Putah Creek – Putah Creek runs from the Coastal Range to the Yolo Bypass. Most of the flow is stopped by the Monticello Dam, however the levees were designed prior to the construction of the Dam. The levees are set a good distance from the creek. There is a riparian corridor on the natural banks of the creek and the floodplains are used for crops and orchards. There are currently two (2) erosion sites on Putah Creek.

Elder Creek – Elder Creek is located in the upper Sacramento Valley, it flows from the east side of the Coastal Mountain range and ends at the Sacramento River near RM 230. Only portions of the creek, near the lower end, are leveed to protect the towns of Gerber and Tehama. Elder Creek is an incised channel with short levees. The channel meanders through a gravel bed and has multiple point bars. The primary mechanisms of erosion are fluvial and whole bank failure. **Figure 21** shows a typical view of Elder Creek channel and eroding bank. There are currently two (2) erosion sites on this creek.

Figure 21. Typical View of the Channel and Eroding Bank of Elder Creek.

Deer Creek – Deer Creek is located in the upper Sacramento Valley, it drains water from Lassen Mountain/Cascade Range and ends at the Sacramento River near RM 220. Only portions of the lower end are leveed and in most of the places where the creek is close to the levee, it is already rocked. Deer Creek is a natural stream with a boulder/cobble bottom and a riparian habitat. **Figure 22** shows a typical view of Deer Creek. The primary mechanisms of erosion are fluvial, whole bank failure, and tree pop-outs. There are currently two (2) erosion sites on this creek. The Deer Creek Watershed Conservancy is planning a reach wide repair and restoration to the lower portion of Deer Creek.

Butte Creek – Butte Creek is located in the Upper Sacramento Valley, near the City of Chico, it drains water from the Mount Lassen area into the Butte Sink. Butte Creek has levees close in distance to the natural bank on the upper leveed section and slightly setback levees on the lower portion of the creek. There are multiple grade control structures with fish ladders in the creek. The natural banks are generally made of sandy (non-cohesive) materials. The primary erosion mechanism in this reach is whole bank failure. There are currently no erosion sites on this creek.

Figure 22. Typical View of Deer Creek.

Big Chico Creek, Sycamore Creek, and Mud Creek – These three creeks drain from the Mount Lassen/Cascade Range and terminates at the Sacramento River at RM 196. Only a small portion of Big Chico Creek is leveed to protect the City of Chico. The levee is heavily used for running, biking, and horseback riding. The channel is braided and incised with a sand/gravel/cobble bed and an occasional tree. Sycamore Creek is a straightened channel that becomes more natural as it approaches Mud Creek. Mud Creek is a narrow channel, with incised portions and levees set close to the channel. **Figure 23** shows a typical view of Mud Creek. There is only one erosion site in this system and it is on Mud Creek.

Cherokee Canal and Cottonwood Creek – Cherokee Canal is a man-made canal, roughly 100 to 200ft wide that diverts water from the Lake Oroville area and Cottonwood Creek to the Butte Sink area. Cherokee Canal's floodplain serves multiple uses, it is grazed by cows in the summer, rice is grown, and it has some riparian habitat with many species of birds. There is only one erosion site on Cherokee Canal.

Figure 23. Typical View of Mud Creek.

Moulton Weir Bypass, Colusa Weir Bypass, Tisdale Weir Bypass, and Sacramento Weir Bypass – These four weirs and bypasses are important features to the flood control project by diverting the high flows from the Sacramento River into either the Sutter Bypass or Yolo Bypass. The Moulton Weir is located on the left bank of the Sacramento River at RM 158 and feeds water into the Butte Sink. It is a non-gated gravity weir, with a design capacity of 25,000 cfs, and it is typically the last of the gravity weirs to start spilling. The Moulton Bypass only has a levee on the south side and there are no erosion sites. The Colusa Weir is located on the left bank of the Sacramento River at RM 145 and feeds water into the Butte Sink, just north of the top of the Sutter Bypass. It is a non-gated gravity weir, with a design capacity of 70,000 cfs, and it is typically the second of the gravity weirs to start spilling. The Colusa Bypass only has two miles of levees on both sides and does not have any erosion sites. The Tisdale Weir is located on the left bank of the Sacramento River at RM 118 and feeds water into the Sutter Bypass. It is a non-gated gravity weir, with a design capacity of 38,000 cfs, and it is typically the first of the gravity weirs to start spilling. The Tisdale Bypass has four miles of levees on both sides and there are no erosion sites. The Sacramento Weir is located on the right bank of the Sacramento River at RM 63 and feeds water into the Yolo Bypass. It is a gated weir, with 48 wood plank gates that are opened manually when the river reaches a specified elevation at the I St Bridge. It has a design capacity of 112,000 cfs. The Sacramento Bypass has two miles of levees on both sides, the face of the south levee was recently relined with concrete. There are no erosion sites on the Sacramento Bypass.

Sacramento Deep Water Ship Channel – The Sacramento Deep Water Ship Channel runs from the Port of Sacramento (located in West Sacramento) to Cache Slough at RM 18. This man-made dredged channel was completed in 1963 and the navigable section is 30 ft deep and roughly 200 to 400 ft wide. The channel provides access for large ocean-going cargo ships to the Sacramento region. There is no inflow to the channel and it is tidally influenced for the entire length. While there are levees on both sides of the channel, only the east levee is considered a federal levee. The west side of the channel is the Yolo

Bypass. The channel has wide berms on both sides, ranging from 300 to 700 ft. There is only one erosion site in this channel.

Yolo Bypass – The Yolo Bypass runs from the Fremont Weir to the Sacramento River at RM 15 and carries the high flows from the Sacramento River, Feather River, and Sutter Bypass to the Delta. The bypass is several miles wide in sections. The land is used for agriculture, primarily rice, in the summers. Portions of the east levee (near West Sacramento) are heavily rocked (typically with quarry stone). Upstream of Cache Creek and downstream of Willow Slough Bypass, the lower half of the west levee is rocked to protect against wave wash. The primary erosion mechanism in this reach is wind wave. There are currently seven (7) erosion sites on the Yolo Bypass levees.

Sutter Bypass – The Sutter Bypass starts at the bottom of the Sutter Buttes, joins the Feather River at RM 7, and runs parallel to the Feather River until it joins the Sacramento River between RM 84 and 80. During high flows when the Sutter Bypass is running, the flow bisects the Sacramento River and continues over the Fremont Weir into the Yolo Bypass. It gets progressively larger and carries progressively more flow, with the capacity around 400,000 cfs at the confluence with the Sacramento River. The upper part of the floodplain is National Wildlife Refuge and the lower part is primarily agricultural use. The primary erosion mechanism is from wind waves. There is currently one erosion site on the bypass.

Colusa Basin Drainage Canal and Sycamore Slough – The Colusa Basin Drainage Canal runs along the west side of RD 108 and is often referred to as the Back Levee. The upper portion of this Back Levee is Sycamore Slough. It protects the area from the runoff of the east side of the Coastal Mountain Range. It ends at the Knights Landing Ridge Cut and there is also a connection to the Sacramento River, however the flow is controlled by a gated structure. There is one erosion site on Sycamore Slough and three (3) erosion sites on the Colusa Basin Drainage Canal.

Knights Landing Ridge Cut – The Knights Landing Ridge Cut runs from the Colusa Basin Drainage Canal to the Yolo Bypass. The levees are in poor condition with steep slopes and slumping of the toe throughout most of the system. There are cracks along the middle of the left levee crest that may indicate potential mass movement and further slumping. **Figure 24** shows a typical view of the Knights Landing Ridge Cut. There are seven (7) erosion sites in this reach.

Wadsworth Canal, East and West Interceptor Canals – The East and West Interceptor Canals collect runoff from the Sutter Buttes and directs it into the Wadsworth Canal. The canals are man-made and the levees are short, steep and vegetated with thick grasses. Wadsworth Canal is man-made with the purpose of directing flow into the Sutter Bypass. The levees have poor soils, over-steepened slopes, and active erosion throughout most of the channel. The primary mechanism of failure is whole bank failure. There are currently five (5) erosion sites on Wadsworth.

Figure 24. Typical View of the Knights Landing Ridge Cut.

7.0 Summary of the 2015 Erosion Reconnaissance

The 2015 inventoried erosion sites are tabulated in **Appendix A** and are shown graphically in **Appendix B - 2015 Sacramento River Erosion Reconnaissance Atlas**. Within Appendix A, Table A-1 lists all the erosion sites, Table A-2 lists the critical erosion sites, Table A-3 lists the new erosion sites, Table A-4 lists the erosion sites under construction, Table A-5 lists the removed and repaired sites, and Table A-6 lists the geographic coordinates for the erosion sites.

7.1 Erosion Sites

Based on the field investigation, the total number of erosion sites within the Sacramento River Flood Control System is 200 sites, of which 12 are critical, 10 are new (7 new in 2013 and 3 new in 2015), 1 is under construction, 7 were repaired (4 in 2013 and 3 in 2015), and 3 were removed (1 in 2013 and 2 in 2015). A detailed list of the sites per river/channel is provided in **Table 2**. This table includes the number of sites/channel for the 2012 erosion sites (last published report, the 2013 erosion sites (per the draft report), the 2015 erosion sites, the new sites in 2013 and 2015, and the repaired/removed sites in 2013 and 2015.

Table 3 breaks the sites down into linear feet to demonstrate the overall linear footage that still needs repair. The actual repair length may vary, depending on the design. Table 3 shows the amount of linear feet from the last published document (2012), the linear feet from both 2013 and the current year and the amount of linear feet added in 2013 and this year. In 2012, there were 265,625 linear feet of erosion within the SRFCS. In 2015, there is a total of 263,300 linear feet of concerning erosion in the SRFCS.

7.2 Critical Erosion Sites

Based on the field investigation, the total number of critical sites is twelve (12). One of these sites is on Cache Creek and accounts for 218 linear feet. Two of these sites are on Georgiana Slough and account

for 2,647 linear feet. Seven of these sites are on the Sacramento River and account for 5,844 linear feet. One of these sites is on Steamboat Slough and accounts for 949 linear feet. One critical site is on Sutter Slough and accounts for 2,180 linear feet.

Within the priority ranking discussed later, a site marked as critical may not come out on top with the ranking methodology. The ranking methodology takes into account many factors which may result in a breach. The more issues a site has, the more likely it is to breach and therefore it is higher on the priority list. However, if one or more factor(s) is severe enough, based on engineering judgment, that it may result in a breach from the next high flow event it is classified as critical and should be considered for repair before the top ranking sites within the methodology.

7.3 New Erosion Sites

Based on the field investigation, ten (10) erosion sites were added to the inventory (7 in 2013 and 3 in 2015). This is a relatively low number of new sites and can be attributed to the 4 years of drought where the system did not see any significant flows. The total linear feet added in 2013 and 2015 is 2,746 ft, which includes 3,147 ft from new sites and 2,056 ft from extending existing erosion sites.

7.4 Erosion Sites Under Construction

Of all the sites in the erosion inventory, one was under construction for repair at the time of the inspection. This erosion site accounts for 1,547 linear feet within the system. The site is located on Sacramento River at RM 26.0 left bank and was completed in 2016. This site should removed from the inventory after next year's inspection.

7.5 Repaired and Removed Sites

Based on the field investigation and knowledge of construction activities, seven (7) sites were repaired and three (3) sites were removed. The total linear feet repaired since 2012 was 3,005 ft, with two repairs being completed by the local maintaining agency, three repairs being completed by DWR, and 2 repairs completed by the US Army Corps of Engineers. The total linear feet removed was 3,317 ft and these sites were removed since they no longer qualify as erosion sites.

Table 2. Summary of 2015 Erosion Sites by Channel

Waterway	2012 Erosion Sites	2013 New Erosion Sites	2015 New Erosion Sites	2013 Repaired/ Removed Erosion Sites	2015 Repaired/ Removed Erosion Sites	2015 Erosion Sites	2015 Critical Erosion Sites
American River	1	0	0	0	0	1	0
Arcade Creek	0	0	0	0	0	0	0
Bear River	5	0	0	0	0	5	0
Best Slough	0	0	0	0	0	0	0
Butte Creek	0	0	0	0	0	0	0
Butte Slough	0	0	0	0	0	0	0
Cache Creek	7	0	0	2	0	5	1
Cache Slough	6	2	0	0	0	8	0
Cherokee Canal	1	0	0	0	0	1	0
Chico/Sycamore Creek	0	0	0	0	0	0	0
Colusa Basin Drainage Canal	3	0	0	0	0	3	0
Colusa Weir Bypass	0	0	0	0	0	0	0
Coon Creek Interceptor	0	0	0	0	0	0	0
Cottonwood Creek	0	0	0	0	0	0	0
Deer Creek	2	0	0	0	0	2	0
Dry Creek (North)	0	0	0	0	0	0	0
Dry Creek (South)	0	0	0	0	0	0	0
East Interceptor Canal	0	0	0	0	0	0	0
Elder Creek	2	0	0	0	0	2	0
Elk Slough	2	0	0	0	0	2	0
Feather River	10	2	0	0	0	12	0
Georgiana Slough	15	1	0	1	0	15	2
Hass Slough	2	0	0	0	0	2	0
Honcut Creek	0	0	0	0	0	0	0
Jack Slough	0	0	0	0	0	0	0
Knights Landing Ridge Cut	7	0	0	0	0	7	0
Lindsey Slough	5	0	0	0	0	5	0
Marysville Ring Levee	0	0	0	0	0	0	0
Miner Slough	0	0	0	0	0	0	0
Moulton Weir Bypass	0	0	0	0	0	0	0
Mud Creek	1	0	0	0	0	1	0
Natomas Cross Canal	1	0	0	0	0	1	0
Natomas East Main Drainage Canal	0	0	0	0	0	0	0
Pleasant Grove Canal	0	0	0	0	0	0	0
Putah Creek	2	0	0	0	0	2	0
Sacramento Bypass	0	0	0	0	0	0	0
Sacramento Deep Water Ship Channel	1	0	0	0	0	1	0

Table 2 cont. Summary of 2015 Erosion Sites by Channel

Waterway	2012 Erosion Sites	2013 New Erosion Sites	2015 New Erosion Sites	2013 Repaired/ Removed Erosion Sites	2015 Repaired/ Removed Erosion Sites	2015 Erosion Sites	2015 Critical Erosion Sites
Sacramento River	94	1	1	2	5	88	7
Steamboat Slough	13	0	0	0	0	13	1
Sutter Bypass	1	0	0	0	0	1	0
Sutter Slough	6	1	2	0	0	9	1
Sycamore Slough	1	0	0	0	0	1	0
Three Mile Slough	0	0	0	0	0	0	0
Tisdale Weir Bypass	0	0	0	0	0	0	0
Ulatis Creek	0	0	0	0	0	0	0
Wadsworth Canal	5	0	0	0	0	5	0
West Interceptor Canal	0	0	0	0	0	0	0
Western Pacific Interceptor Canal	0	0	0	0	0	0	0
Willow Slough Bypass	0	0	0	0	0	0	0
Yankee Slough	1	0	0	0	0	1	0
Yolo Bypass	7	0	0	0	0	7	0
Yuba River	0	0	0	0	0	0	0
Total	**201**	**7**	**3**	**5**	**5**	**200***	**12**

* Note - Two sites on the Sacramento River were combined, so the numbers do not look like they add up.

Table 3. Summary of 2015 Linear Footage of Erosion by Channel

Waterway	2012 Linear Feet	2013 New Linear Feet	2015 New Linear Feet	2013 Repaired/ Removed Linear Feet	2015 Repaired/ Removed Linear Feet	2015 Linear Feet
American River	190	0	0	0	0	190
Arcade Creek	0	0	0	0	0	0
Bear River	1,643	0	0	0	0	1,643
Best Slough	0	0	0	0	0	0
Butte Creek	0	0	0	0	0	0
Butte Slough	0	0	0	0	0	0
Cache Creek	2,718	0	0	1,157	0	1,561
Cache Slough	3,874	1,267	0	0	0	5,141
Cherokee Canal	34	0	0	0	0	34
Chico/Sycamore Creek	0	0	0	0	0	0
Colusa Basin Drainage Canal	1,976	0	0	0	0	1,976
Colusa Weir Bypass	0	0	0	0	0	0
Coon Creek Interceptor	0	0	0	0	0	0
Cottonwood Creek	0	0	0	0	0	0
Deer Creek	363	0	0	0	0	363

Table 3 cont. Summary of 2015 Linear Footage of Erosion by Channel

Waterway	2012 Linear Feet	2013 New Linear Feet	2015 New Linear Feet	2013 Repaired/ Removed Linear Feet	2015 Repaired/ Removed Linear Feet	2015 Linear Feet
Dry Creek (North)	0	0	0	0	0	0
Dry Creek (South - Linda)	0	0	0	0	0	0
East Interceptor Canal	0	0	0	0	0	0
Elder Creek	460	0	0	0	0	460
Elk Slough	99,615	0	0	0	0	99,615
Feather River	11,012	470	0	0	0	11,482
Georgiana Slough	22,145	458	0	1,463	0	21,140
Hass Slough	3,745	0	0	0	0	3,745
Honcut Creek	0	0	0	0	0	0
Jack Slough	0	0	0	0	0	0
Knights Landing Ridge Cut	7,484	0	0	0	0	7,484
Lindsey Slough	2,484	0	0	0	0	2,484
Marysville Ring Levee	0	0	0	0	0	0
Miner Slough	0	0	0	0	0	0
Moulton Weir Bypass	0	0	0	0	0	0
Mud Creek	300	0	0	0	0	300
Natomas Cross Canal	191	0	0	0	0	191
Natomas East Main Drainage Canal	0	0	0	0	0	0
Pleasant Grove Canal	0	0	0	0	0	0
Putah Creek	728	0	0	0	0	728
Sacramento Bypass	0	0	0	0	0	0
Sacramento Deep Water Ship Channel	81	0	0	0	0	81
Sacramento River	71,073	237	1,568	1,589	3,319	67,970
Steamboat Slough	5,783	0	0	0	0	5,783
Sutter Bypass	162	0	0	0	0	162
Sutter Slough	5,483	314	889	0	0	6,686
Sycamore Slough	98	0	0	0	0	98
Three Mile Slough	0	0	0	0	0	0
Tisdale Weir Bypass	0	0	0	0	0	0
Ulatis Creek	0	0	0	0	0	0
Wadsworth Canal	16,124	0	0	0	0	16,124
West Interceptor Canal	0	0	0	0	0	0
Western Pacific Interceptor Canal	0	0	0	0	0	0
Willow Slough Bypass	0	0	0	0	0	0
Yankee Slough	147	0	0	0	0	147
Yolo Bypass	7,712	0	0	0	0	7,712
Yuba River	0	0	0	0	0	0
Total	**265,625**	**2,746**	**2,457**	**4,209**	**3,319**	**263,300**

8.0 Site Priority Ranking

8.1 Site Priority Ranking Factors

The erosion sites catalogued in this 2013 Erosion Reconnaissance Report were ranked to help decide which sites should be the highest priority for repair. The sites were ranked using a methodology based on engineering factors. The ranking factors are described in detail below and the score sheet is shown in **Table 4**. For this ranking, sites with higher scores are considered to have higher potential for levee breaching.

Ranking Factors:

1. Site Length – Linear feet of the erosion site. This measurement is made based on measured GPS points taken in the field, either along the water's edge or top of levee, depending on inspection method.
2. Berm Width – Width of the berm or bench, if present. This measurement is an estimate based on visual inspection.
3. Bank Slope – The horizontal to vertical ratio of the eroding bank slope. This slope is an estimate of the overall bank slope throughout the eroding section.
4. Soil Characteristic – Soil characteristic of the eroding section. This is a generalized assessment of soils and broken down into simplistic options based on the cohesive properties of the bank/levee.
5. Velocity – The average channel velocity for a 100-yr event, based on a UNET model of the entire Sacramento River System. This factor also takes into account the presences of visible eddies or perceived potential for eddies based on engineering judgment.
6. Erosion Rate – The rate at which each site is retreating, in feet per year. This rate is an average rating based on the BSTEM (Bank Stability and Toe Erosion Model) study results performed by the USDA (USDA, 2010) where available, the Sediment Study performed by Northwest Hydraulics, and historic aerial imagery.
7. Additional Stability Factors – Additional factors that could contribute to stability issues, including trees with exposed roots, slumping, seepage[9], holes from either animals or tree pop-outs, vertical sections of bank, cracks, and wind/boat waves.

Again, the methodology used here can result in some non-critical sites being ranked higher than critical sites. The ranking methodology takes into account many factors which may result in a breach. The more issues a site has, the more likely it is to breach and therefore it is higher on the priority list. However, if one or more factor(s) is severe enough, based on engineering judgment, that it may result in a breach from the next high flow event it is classified as critical and should be considered for repair before the top ranking sites within the methodology.

[9] A site was identified as having a seepage problem if the Periodic Levee Inspection Report (PI) identified seepage for the levee segment as unacceptable.

Table 4. Site Ranking Score Sheet

Factor	Score	Definition
Site Length	0	less than 100 ft
	1	100 to 500 ft
	2	500 to 1000 ft
	3	1000 to 2000 ft
	4	2000 to 5000 ft
	5	greater than 5000 ft
Berm Width	0	Greater than 35 ft of berm
	1	35 to 30 ft of berm
	2	26 to 30 ft of berm
	3	21 to 25 ft of berm
	4	16 to 20 ft of berm
	5	11 to 15 ft of berm
	6	5 to 10 ft of berm
	8	less than 5 ft of berm
	10	No berm
Bank Slope	0	3H:1V Slope (33%)
	2	2.5H:1V Slope (40%)
	4	2H:1V Slope (50%)
	6	1.5H:1V Slope (66.6%)
	8	1H:1V Slope (100%)
	9	0.5H:1V Slope
	10	Vertical Slope
Velocity	0	Backwater
	1	Less than 1 ft/s
	2	1 to 2 ft/s
	3	2 to 3 ft/s
	4	3 to 4 ft/s
	5	4 to 5 ft/s
	7	5 to 6 ft/s
	8	6 to 7 ft/s
	9	7 to 8 ft/s
	10	greater than 8 ft/s
	+1	Eddy Observed

Factor	Score	Definition
Soil Character-istic	2	Cohesive
	5	Stratified
	7	Non-Cohesive
Erosion Rate	0	0 ft/yr
	1	Less than 0.2 ft/yr
	2	0.2 to 0.4 ft/yr
	3	0.4 to 0.6 ft/yr
	4	0.6 to 0.8 ft/yr
	5	0.8 to 1 ft/yr
	6	1 to 2 ft/yr
	7	2 to 3 ft/yr
	8	3 to 4 ft/yr
	9	4 to 5 ft/yr
	10	Greater than 5 ft/yr
	+1	5 ft of erosion within last year
	+2	10 ft of erosion within last year
Additional Stability Factors	+2	Trees with exposed roots
	+4	Slumping
	+2	Seepage
	+1	Holes from animals
	+2	Holes from tree pop-outs
	+1	Short vertical sections
	+2	Tall vertical sections
	+1	Shallow cracks
	+2	Deep Cracks
	+1	Wind Waves
	+1	Recreational Boat waves
	+2	Waves from Cargo Ships

8.2 Site Priority Ranking Results

Table 5 provides the engineering site ranking and erosion score based on the erosion factors discussed earlier. The table also provides the length of the site. In this table, erosion sites in red indicate critical erosion sites, sites in green indicate new sites (in 2015), and sites in blue indicate sites that are currently being repaired. One site was upgraded to critical in 2013, Sutter Slough RM 24.7R, which has a severe slump of the levee bank at the downstream end that could lead to a whole bank failure if left unrepaired. One site was upgraded to critical in 2015, Sacramento River RM 12.1L, which has extremely large trees with exposed roots on a nearly vertical levee slope, which will likely pop-out in the upcoming years and likely take a large chunk of the levee with them. Further erosion at the critical sites increases the probability of potential levee breach, threatening the integrity of the SRFCD.

The Sacramento River at RM 11.2L is ranked highest due to the lack of any berm, steep banks, with some vertical sections, poor soil materials, slumping, wave wash from wind and cargo ships, the large trees with exposed roots, and the erosion into the top of the levee crown which is undermining the State Highway that sits on top of this levee. This site is identified as critical, the rate at which it is eroding, including the erosion under the highway foundation is alarming. The other top spots this include: Sacramento River at RM 13.6L , Sacramento River at RM 12.1L Sacramento River at RM 17.2L, Sacramento River at RM 16.8L, Sutter Slough at RM 27.3R, and Feather River at RM 5.0L.

Table 5. Engineering Site Priority Ranking

Priority Placement	Erosion Site	Erosion Ranking Score	Erosion Length (ft)
1	Sacramento River RM 11.2 L	57	1229
2	Sacramento River RM 13.6 L	56	303
3	Sacramento River RM 12.1 L	52	1165
3	Sacramento River RM 17.2 L	52	1001
5	Sacramento River RM 16.8 L	50	591
6	Sutter Slough RM 27.3 R	49	1023
7	Feather River RM 5 L	48	1666
8	Feather River RM 3.8 L	47	2094
8	Sacramento River RM 7.9 L	47	481
8	Sacramento River RM 8.2 L	47	203
11	Feather River RM 5.8 L	46	1030
11	Georgiana Slough RM 0.3 L	46	1096
11	Georgiana Slough RM 3.8 L	46	2589
11	Sacramento River RM 7.3 L	46	619
11	Sacramento River RM 10.8 L	46	820
11	Sacramento River RM 41.9 R	46	1360
11	Sacramento River RM 55.7 R	46	1150

Note: Erosion sites in red indicate critical erosion sites, sites in green indicate new sites, and sites in blue indicate sites that are currently being repaired.

Table 5 cont. Engineering Site Priority Ranking

Priority Placement	Erosion Site	Erosion Ranking Score	Erosion Length (ft)
11	Sacramento River RM 172 L	46	1546
19	Feather River RM 6.6 L	45	710
19	Sacramento River RM 8 L	45	758
21	Cache Creek RM 2.4 L	44	218
21	Feather River RM 6 L	44	487
21	Steamboat Slough RM 24.7 R	44	949
21	Sutter Slough RM 24.7 R	44	2180
25	Bear River RM 5.7 L	43	474
25	Feather River RM 17.8 L	43	1858
25	Georgiana Slough RM 4.5 L	43	1396
25	Sacramento River RM 26 L	43	1547
25	Sacramento River RM 131.8 L	43	665
30	Cache Slough RM 15.9 L	42	377
30	Sacramento River RM 18 L	42	444
30	Sacramento River RM 123.3 L	42	679
30	Sutter Slough RM 25.2 R	42	694
30	Sutter Slough RM 27.1 R	42	255
35	Elk Slough RM 0.2 L	41	49631
35	Elk Slough RM 0.2 R	41	49983
35	Georgiana Slough RM 6.3 L	41	4152
35	Georgiana Slough RM 6.8 L	41	1251
35	Sacramento River RM 43.2 R	41	992
35	Steamboat Slough RM 25 L	41	264
35	Sutter Slough RM 26.5 L	41	621
42	Cache Creek RM 3.5 R	40	450
42	Feather River RM 1 L	40	1054
42	Sacramento River RM 27 L	40	504
42	Sacramento River RM 56.7 R	40	662
42	Steamboat Slough RM 25.8 R	40	243
47	Georgiana Slough RM 4.3 L	39	1052
48	Cache Creek RM 2.8 L	38	209
48	Cache Creek RM 5.4 L	38	198
48	Lower American River RM 1.8 L	38	190
48	Putah Creek RM 7.2 L	38	305
48	Sacramento River RM 18.1 L	38	267
48	Sacramento River RM 122.3 R	38	236

Table 5 cont. Engineering Site Priority Ranking

Priority Placement	Erosion Site	Erosion Ranking Score	Erosion Length (ft)
54	Georgiana Slough RM 2.5 L	37	992
54	Georgiana Slough RM 5.3 L	37	3389
54	Sacramento River RM 120.6 L	37	190
54	Steamboat Slough RM 23.6 R	37	768
54	Steamboat Slough RM 24.8 L	37	773
54	Sutter Slough RM 25.7 R	37	709
54	Wadsworth Canal RM 2.1 L	37	3422
54	Wadsworth Canal RM 2.1 R	37	3376
62	Bear River RM 4.9 R	36	64
62	Cache Creek RM 3.4 L	36	487
62	Colusa Basin Drainage Canal RM 0.9 L	36	968
62	Georgiana Slough RM 1.7 L	36	1528
62	Georgiana Slough RM 5.8 L	36	458
62	Georgiana Slough RM 8.3 L	36	565
62	Haas Slough RM 7.9 L	36	2150
62	Sacramento River RM 62.9 R	36	537
62	Sacramento River RM 118 R	36	837
62	Steamboat Slough RM 22.8 R	36	643
62	Steamboat Slough RM 26 L	36	312
62	Sutter Slough RM 28.4 R	36	314
74	Colusa Basin Drainage Canal RM 19.2 L	35	397
74	Feather River RM 0.6 L	35	901
74	Sacramento River RM 22.7 L	35	311
74	Sacramento River RM 23.2 L	35	589
74	Sacramento River RM 74.4 R	35	1343
74	Sacramento River RM 122 R	35	311
74	Sacramento River RM 143.5 R	35	602
74	Steamboat Slough RM 15.7 R	35	338
74	Steamboat Slough RM 24.1 R	35	55
83	Cache Slough RM 21.1 R	34	1625
83	Deer Creek RM 0.9 R	34	265
83	Knights Landing Ridge Cut RM 3.7 L	34	678
83	Sacramento River RM 43.1 R	34	646
83	Sacramento River RM 48.6 R	34	581
83	Sacramento River RM 77.7 R	34	156
83	Sacramento River RM 99 L	34	1745
83	Sacramento River RM 127.9 R	34	562

Table 5 cont. Engineering Site Priority Ranking

Priority Placement	Erosion Site	Erosion Ranking Score	Erosion Length (ft)
83	Sacramento River RM 152.6 L	34	1555
83	Steamboat Slough RM 23.9 R	34	168
93	Georgiana Slough RM 9.3 L	33	1117
93	Knights Landing Ridge Cut RM 4.7 L	33	1266
93	Sacramento River RM 56.5 R	33	465
93	Sacramento River RM 58.5 L	33	386
93	Sacramento River RM 75.3 R	33	2753
93	Sacramento River RM 87.1 L	33	1239
93	Sacramento River RM 116 L	33	831
93	Sacramento River RM 152.8 L	33	299
93	Sacramento River RM 164.3 R	33	1200
93	Sacramento River RM 164.7 R	33	1117
93	Steamboat Slough RM 18.8 R	33	359
104	Colusa Basin Drainage Canal RM 0.5 L	32	611
104	Georgiana Slough RM 7.2 L	32	332
104	Knights Landing Ridge Cut RM 5.8 L	32	2986
104	Sacramento River RM 54.8 L	32	325
104	Sacramento River RM 55.2 L	32	866
104	Sacramento River RM 71.3 R	32	522
104	Sacramento River RM 116.5 L	32	3393
111	Bear River RM 1.9 L	31	432
111	Elder Creek RM 1.4 L	31	331
111	Haas Slough RM 9.7 L	31	1595
111	Knights Landing Ridge Cut RM 3 L	31	1113
111	Lindsey Slough RM 0.7 R	31	280
111	Sacramento River RM 38.5 R	31	364
111	Sacramento River RM 56.6 L	31	262
111	Wadsworth Canal RM 2.4 L	31	4603
111	Wadsworth Canal RM 2.4 R	31	4617
120	Bear River RM 0.8 L	30	452
120	Cache Slough RM 23.6 R	30	1149
120	Sacramento River RM 22.5 L	30	900
120	Sacramento River RM 35.4 L	30	484
120	Sacramento River RM 136.6 R	30	725
120	Yankee Slough RM 1.7 L	30	147
120	Yolo Bypass RM 2.3 R	30	1822

Table 5 cont. Engineering Site Priority Ranking

Priority Placement	Erosion Site	Erosion Ranking Score	Erosion Length (ft)
127	Deer Creek RM 2.4 L	29	97
127	Lindsey Slough RM 1.9 L	29	358
127	Sacramento River RM 24.8 L	29	783
127	Sacramento River RM 31.6 R	29	442
127	Sacramento River RM 52.7 L	29	158
127	Sacramento River RM 83.9 R	29	987
127	Sacramento River RM 92.8 L	29	833
127	Sacramento River RM 95.8 L	29	912
127	Sacramento River RM 104.5 L	29	1424
127	Sacramento River RM 111 R	29	110
127	Sacramento River RM 125.6 R	29	415
127	Sacramento River RM 130 L	29	712
127	Steamboat Slough RM 18.9 R	29	330
127	Steamboat Slough RM 25.5 R	29	580
127	Yolo Bypass RM 2.8 R	29	2502
142	Bear River RM 2.5 L	28	222
142	Georgiana Slough RM 7 R	28	774
142	Knights Landing Ridge Cut RM 3.5 R	28	418
142	Lindsey Slough RM 2.4 L	28	139
142	Sacramento River RM 23.3 L	28	584
142	Sacramento River RM 26.3 R	28	472
142	Sacramento River RM 52.4 L	28	117
142	Sacramento River RM 86.9 R	28	517
142	Sacramento River RM 138.1 L	28	1308
142	Wadsworth Canal RM 4.3 R	28	106
142	Yolo Bypass RM 0.1 R	28	427
142	Yolo Bypass RM 4.2 R	28	1652
154	Cache Slough RM 22.5 R	27	191
154	Sacramento River RM 21.9 L	27	237
154	Sacramento River RM 53.8 L	27	155
154	Sutter Slough RM 26.9 L	27	637
158	Cherokee Canal RM 11.7 R	26	34
158	Lindsey Slough RM 0.6 R	26	1620
158	Sacramento River RM 21.5 L	26	547
158	Sacramento River RM 25.2 L	26	326
158	Sacramento River RM 50.3 L	26	89
158	Sacramento River RM 86.3 L	26	3035

Table 5 cont. Engineering Site Priority Ranking

Priority Placement	Erosion Site	Erosion Ranking Score	Erosion Length (ft)
158	Sacramento River RM 141.5 R	26	696
158	Sutter Slough RM 26.1 R	26	252
158	Sycamore Creek RM 9.3 L	26	98
158	Yolo Bypass RM 1.2 R	26	215
158	Yolo Bypass RM 2 R	26	267
169	Cache Slough RM 22.6 R	25	933
169	Cache Slough RM 22.9 R	25	260
169	Feather River RM 50.9 R	25	371
169	Georgiana Slough RM 11 L	25	449
169	Knights Landing Ridge Cut RM 3.1 L	25	658
169	Knights Landing Ridge Cut RM 3.9 R	25	366
169	Sacramento River RM 85.4 R	25	1025
169	Sacramento River RM 104 L	25	3443
169	Sacramento River RM 151 R	25	1748
178	Cache Slough RM 22.8 R	24	258
178	Cache Slough RM 23 R	24	348
178	Lindsey Slough RM 0.8 R	24	86
178	Sacramento River RM 123.7 R	24	122
178	Sacramento River RM 136.6 L	24	616
183	Mud Creek RM 4.4 R	23	300
183	Putah Creek RM 0.1 L	23	423
183	Sacramento River RM 115.9 R	23	540
183	Yolo Bypass RM 2.6 R	23	827
187	Feather River RM 47.5 R	22	842
187	Sacramento River RM 33.9 R	22	328
187	Sacramento River RM 101.3 R	22	188
187	Sacramento River RM 157.7 R	22	484
191	Elder Creek RM 3 R	21	129
192	Feather River RM 12.3 R	20	177
192	Sacramento River RM 55.5 L	20	384
192	Sacramento River RM 78.3 L	20	654
195	Feather River RM 12.8 R	19	293
195	Sacramento River RM 125.8 L	19	115
197	Sutter Bypass RM 11.1 L	18	162
198	Natomas Cross Canal RM 3 R	17	191
198	Sacramento Deep Water Ship Channel RM 5 L	17	81
198	Sacramento River RM 168.3 L	17	149

9.0 Conclusions

Following the 2015 annual erosion inventory we offer the following conclusions:

- There are currently 200 erosion sites in the inventory, or approximately 263,300 linear feet of eroding sites within the system.
- There are 10 new erosion sites (7 from 2013 and 3 from 2015) and 5,203 linear feet of eroding bank were added in 2013 and 2015.
- There are 12 critical erosion sites: one on Cache Creek, two on Georgiana Slough, seven on the Sacramento River, one on Steamboat Slough, and one on Sutter Slough. One of these erosion sites were upgraded to critical in 2013 and another upgraded to critical in 2015.
- All identified erosion sites need to be repaired. Critical and top ranking erosion sites should be considered the highest priority for repair.
- Given the large backlog of erosion sites that need to be repaired, the repair rate, and the constantly changing policy implementation guidance adding constraints as to which sites can be repaired, the risk that one of these sites will have an imminent failure or breach in the coming years has increased.
- Repairs of the eroding banks and levees needs to be completed to restore the intended flood damage risk reduction that is provided by the Sacramento River Flood Control System.

10.0 References

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