## Draft Technical Memorandum

# Flood System Long-Term Operations, Maintenance, Repair, Rehabilitation, and Replacement Cost Evaluation

## May 2016

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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# Foreword

On behalf of the Department of Water Resources I am pleased to present the May 2016 Flood System Long-Term Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) Cost Evaluation. This technical memorandum (TM) is intended to help flood management planners, engineers, and budget analysts at the local, State, and federal levels estimate resource needs and understand the challenges related to the OMRR&R of the State Plan of Flood Control. It is my hope that this TM raises awareness of the complex issues, challenges, and real costs related to maintaining the levees, channels, and structures in the Central Valley.

The 2012 Central Valley Flood Protection Plan (CVFPP) laid the foundation necessary for compliance with the Central Valley Flood Protection Act of 2008 and a new approach to flood management in the Central Valley. The level of flood risk in the Sacramento and San Joaquin River basins is one of the highest in the nation largely due to the extreme hydrological cycle of droughts and floods and continued urban development near our waterways. Many parts of the flood system are old and degraded, our riverine ecosystems are in decline, seepage and engineering design deficiencies plague the levees, and the backlog of deferred maintenance projects continues to increase. In response, the 2012 CVFPP included the improvement of operations and maintenance as the first of its supporting goals. While much progress has been made to address these issues through bond-funded large capital projects, necessary ongoing maintenance is still critically underfunded. Within their budgets and assurances, maintainers must make difficult decisions and prioritize their work to sustain a functioning flood control system. Societal expectations, changing standards, regulatory requirements, and multiple uses of the flood management system have all influenced the current cost of OMRR&R. This TM attempts to comprehensively quantify the cost.

This document represents a collaborative effort by many knowledgeable and dedicated individuals who provided input, data, guidance, and review of the subject matter and issues. Without their contribution, this body of work would not have been possible. This work signifies a crucial step toward a deeper understanding of OMRR&R issues and associated costs and will be used to inform each 5-year update to the CVFPP. Further updates to the TM may be undertaken, but are not anticipated at this time. The TM will remain as a draft document pending approval of the Supplemental Program Environmental Impact Report accompanying the 2017 CVFPP.

Christopher Williams
OMRR&R Workgroup Leader
Division of Flood Management

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## *This Document Prepared by:*

### Management Review

Mary Jimenez
*DWR*
*Supervising Engineer, Planning Branch*

Mike Mierzwa
*DWR*
*Chief, Central Valley Flood Planning Office*

Edward Winkler
*CH2M HILL Engineers, Inc.*
*CVFPP Project Manager*

### Preparation Team

Christopher Williams
*DWR*
*Senior Engineer, Planning Branch*

Natasha Nelson
*DWR*
*Program Manager I, Floodway Ecosystem Sustainability Branch*

Eric McGrath
*DWR*
*Senior Engineer, Maintenance Support Branch*

Michael Wright
*CVFPB*
*Senior Engineer, Enforcement Section*

### Technical Support

Mark Oliver
*CH2M HILL Engineers, Inc.*
*TM Consultant Project Manager*

Minta Konieczki
*CH2M HILL Engineers, Inc.*
*TM Consultant Assistant Project Manager*

Thomas Engler
*MBK Engineers*
*TM Senior Consultant*

Jordan Vazquez
*CH2M HILL Engineers, Inc.*
*TM Staff Consultant*

Laura Byrd
*CH2M HILL Engineers, Inc.*
*TM Staff Consultant*

Jacqueline Todak
*CH2M HILL Engineers, Inc.*
*TM Staff Consultant*

David Christophel
*CH2M HILL Engineers, Inc.*
*TM Senior Consultant*

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Issue Summary #2, Environmental Compliance and Other Transactional Costs

Issue Summary #3, Comparison of Setback and Rebuild-in-Place Levee Maintenance Costs

Issue Summary #4, Prioritizing and Addressing the Cost of Inspection Compliance

Issue Summary #5, Cost of Addressing Levee Pipe Penetrations in State Plan of Flood Control

Issue Summary #6, Vegetation Management: Cost of Maintaining Channel Capacity

Issue Summary #7, Cost of Sediment Removal in the State Plan of Flood Control

Issue Summary #8, Three Amigos Nonstructural Alternative Project at the San Joaquin River National Wildlife Refuge

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# 1.0 Introduction and Background

This *Flood System Long-Term Operations, Maintenance, Repair, Rehabilitation, and Replacement Cost Evaluation Technical Memorandum* (OMRR&R Cost Evaluation TM or TM) was prepared as part of the Central Valley Flood Protection Plan (CVFPP) to support estimating the "true" full cost of long-term operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) of current and proposed urban and rural facilities within those areas in the Central Valley of California protected by the State Plan of Flood Control (SPFC).[1,2] The SPFC and systemwide planning areas are shown on Figure 1-1. This OMRR&R Cost Evaluation TM was developed in coordination with DWR, Central Valley Flood Protection Board (CVFPB), Regional Flood Management Planning regions, other regional experts and work groups, and Local Maintaining Agency (LMA) staff. An OMRR&R Work Group (Work Group) convened in December 2013 and met regularly through March 2016. Over this time, approximately 35 individuals participated in the Work Group, including those representing DWR's Central Valley Flood Planning Office, Flood Maintenance Office (FMO), Executive Office, Hydrology and Flood Operations Office, Statewide Infrastructure Investigations Branch, and the prior FloodSAFE Environmental Stewardship and Statewide Resources Office (FESSRO); representatives of the CVFPB; and a team of consultants. Each of the Work Group members made a valuable contribution, and the data and other information provided by the Regional Flood Management Planning regions, LMAs, and other local entities were essential for estimating the true full cost of long-term OMRR&R.

The *2012 Central Valley Flood Protection Plan* (2012 CVFPP) (DWR, 2012a) included a supporting goal to improve operations and maintenance (O&M) of the SFPC, as follows:

> Improve Operations and Maintenance – Reduce systemwide maintenance and repair requirements by modifying the flood management systems in ways that are compatible with natural processes, and adjust, coordinate, and streamline regulatory and institutional standards, funding, and practices for operations and maintenance, including significant repairs.

Flood management system O&M and repair, rehabilitation, and replacement (RR&R) obligations for SPFC facilities are shared among the State and LMAs. LMAs represent any city, county, district, or other political subdivision of the State that is authorized to maintain levees. As described in Section 1.2, Inclusion of RR&R into Standard LMA Responsibilities, the federal government, State, and LMAs have not consistently understood or implemented OMRR&R of SPFC facilities (DWR, 2012b). OMRR&R challenges were discussed extensively during the

[1] The SPFC refers to the flood protection system in the Sacramento River and San Joaquin River watersheds comprising federally and State-authorized projects for which the CVFPB or California Department of Water Resources (DWR) has provided assurances of cooperation to the United States federal government.

[2] The term "true" refers to the estimated cost of maintaining flood facilities at the level necessary to maintain their designed function over the long term. The current expenditures of LMAs may or may not reflect the investment needed to appropriately maintain those facilities.

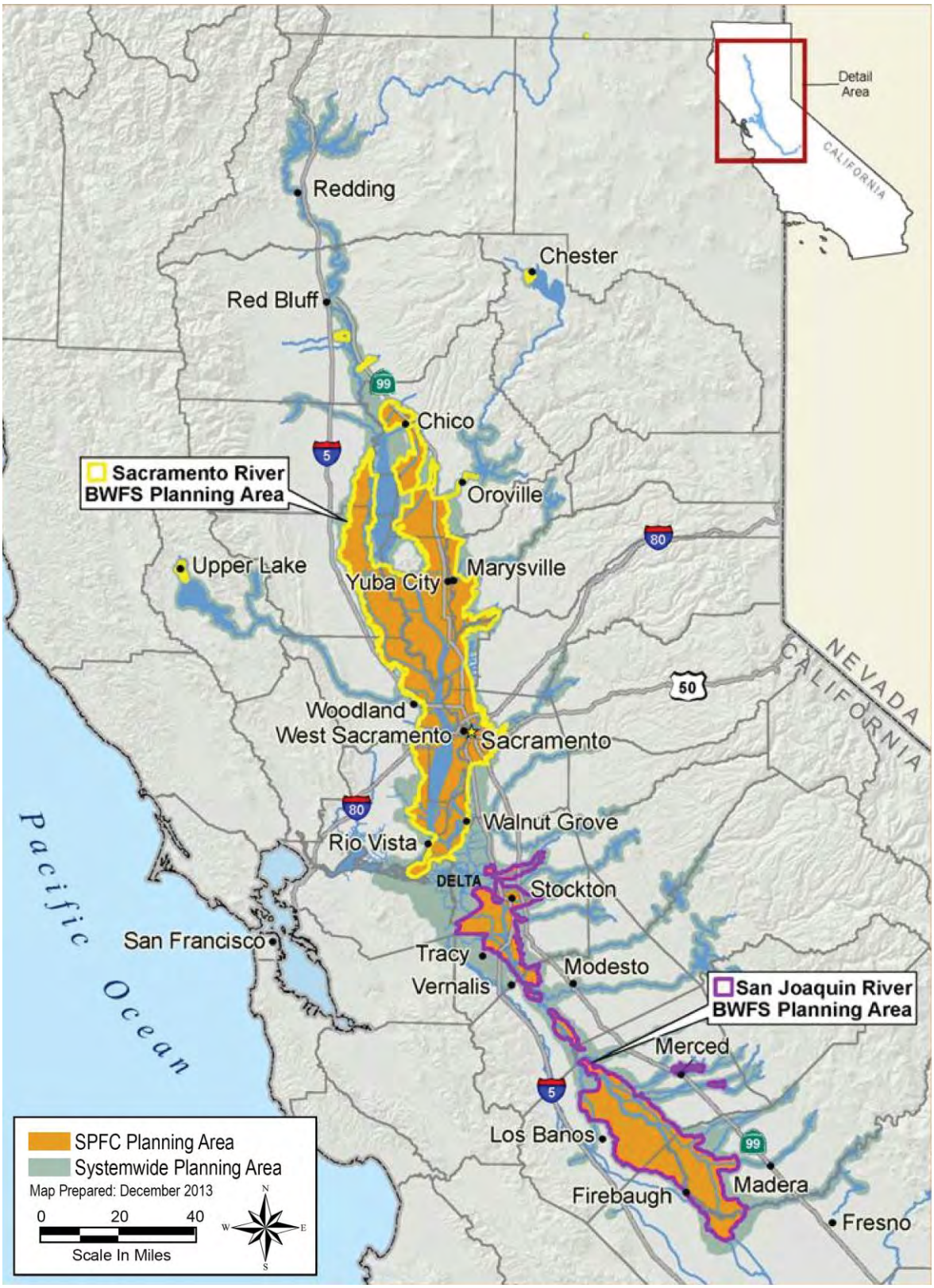


**Figure 1-1. State Plan of Flood Control and Systemwide Planning Areas**

Key:
BWFS = Basin-Wide Feasibility Studies

2012 CVFPP development process, and significant efforts were made to incorporate OMRR&R needs in the planning process and to characterize OMRR&R costs.

All flood management facilities and features require adequate and sustainable long-term OMRR&R to properly maintain their function and avoid potential economic, environmental, and social costs associated with system failures. Long-term OMRR&R is essential to support system integrity of existing facilities and future improvements being evaluated for the 2017 CVFPP. Current annual OMRR&R funding and associated spending is estimated to be approximately $30 million[3], which is far short of the estimated amount needed to conduct proper OMRR&R (see Section 5.4, Overall Summary of OMRR&R Cost Estimates). Reliable funding using all potential sources at the State and local level will be critical to sustainable OMRR&R.

This TM identifies the cost of proper OMRR&R of facilities that are assumed to be in good working order. It is recognized and important to note that substantial facility repair and rehabilitation is required given the age and condition of the current system, changing design standards, and inadequate funding to conduct proper O&M over the last several decades. Additionally, some facilities were not designed or constructed to accommodate current conditions, including increasingly urbanizing areas. Costs associated with addressing necessary deferred maintenance and system/facility design deficiencies are being developed by DWR, LMAs, and the Regional Flood Management Planning regions across the system. Figure 1-2 identifies the six Regional Flood Management Planning regions that are within the Sacramento and San Joaquin River basins. These additional costs are substantial and will be required to bring the system back into working order. After facilities are rehabilitated to proper condition, consistent OMRR&R commensurate with the costs identified in this OMRR&R Cost Evaluation TM will support avoidance of future major repairs. The costs presented in this TM indicate that OMRR&R of SPFC facilities is drastically underfunded, and funding will need to be substantially increased to realize long-term system performance.

This TM includes the following chapters:

- Chapter 1.0 – Introduction and Background
- Chapter 2.0 – Factors and Challenges Influencing OMRR&R Costs
- Chapter 3.0 – Current OMRR&R Activities, Practices, and Standards
- Chapter 4.0 – Approach for Estimating Long-Term OMRR&R Costs
- Chapter 5.0 – Sacramento and San Joaquin OMRR&R Costs
- Chapter 6.0 – Potential Funding Sources
- Chapter 7.0 – Recommendations and Next Steps
- Chapter 8.0 – References
- Chapter 9.0 – Acronyms and Abbreviations

[3] Current spending estimate based on 2013 AB 156 data rounded to $30 million.

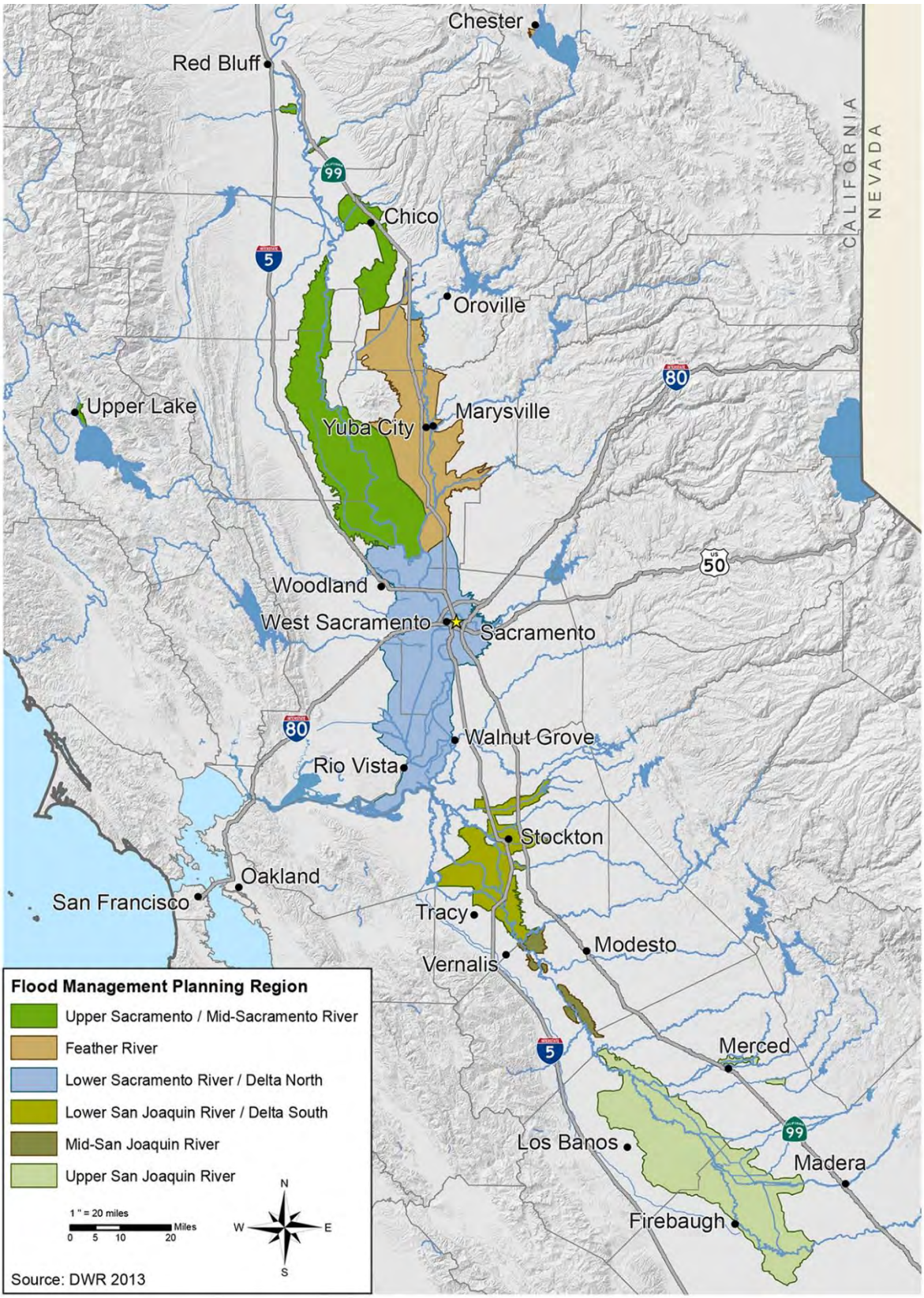


**Figure 1-2. Regional Flood Management Planning Regions**

Issue summaries on the following topics are included in Appendix A, OMRR&R Key Issue Summaries:

- Issue Summary #1, Existing Conditions and the 1955/1957 Design Profiles
- Issue Summary #2, Environmental Compliance and Other Transactional Costs
- Issue Summary #3, Comparison of Setback and Rebuild-in-Place Levee Maintenance Costs
- Issue Summary #4, Prioritizing and Addressing the Cost of Inspection Compliance
- Issue Summary #5, Cost of Addressing Levee Pipe Penetrations in State Plan of Flood Control
- Issue Summary #6, Vegetation Management: Cost of Maintaining Channel Capacity
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- Issue Summary #9, District Governance: Consolidation Opportunities and Challenges
- Issue Summary #10, Lessons Learned from Hurricane Katrina – Redesigning Cities
- Issue Summary #11, Lessons Learned from Hurricane Katrina – Spreading the Cost

## 1.1 Definition of O&M and OMRR&R

"Operation and maintenance (O&M)" is the traditional term used to describe the routine activities necessary for a healthy flood control system. "Operation, maintenance, repair, rehabilitation, and replacement (OMRR&R)" is a more recently developed term used to describe and include the comprehensive set of non-routine activities needed to ensure an effective flood management system. Activities are guided, in part, by O&M manuals developed by U.S. Army Corps of Engineers (USACE) in the mid-1950s and hydraulic design criteria developed at approximately the same time (these guidance documents and the challenges in their use are further described below and in Appendix A, OMRR&R Key Issue Summaries). Broad definitions and descriptions of each component of OMRR&R follow.

### 1.1.1 Operation

***Daily activities needed to keep the system functioning properly and for a responsible agency to perform its duties.***

Routine operation includes all activities performed by levee maintaining agencies to function as a viable organization. Such functions include staffing expenses, overhead, inspecting facilities, purchasing equipment, obtaining permits, conducting general management duties to ensure proper facility function, and operating facilities during high water events. Other functions critical

to the operation of the flood control system include high-water patrolling; operating weir gates, pipe closures, and pumping plants; and flood fighting. Facilities inspections identify potential weaknesses in the system caused by encroachments and penetrations through levees, and the condition of dams and other facilities. Local agencies routinely inspect levee condition; in addition, DWR and USACE inspect State- or federally sponsored projects.

### 1.1.2 Maintenance

***Routine activities (including minor repairs) that need to be performed to keep the system operational.***

Routine or periodic maintenance includes activities that must be performed annually or semiannually, including vegetation management (such as invasive species and channel snags), sediment removal, mowing, rodent and burrowing vector control to maintain levee integrity, minor erosion repair, levee crown repairs, crown road surfacing, and bank stabilization. Other typical activities include maintaining pumping plants, gates and closure structures, weirs and overflow structures, and other flood control facilities as necessary.

### 1.1.3 Repair

***Non-routine activities needed to fix damage caused by a specific event.***

Repair includes activities that address damage to portions of levees, channels, and other infrastructure as a result of a storm or other event. Such activities can include minor, moderate, or major levee bank or channel repair and stabilization, and repairs to structures. In general, such activities are non-routine and bring a damaged element or portion of the flood control system back to original (or improved) condition. Given the age and condition of the current system and inadequate funding to conduct proper O&M over the last several decades, substantial facility repair is required throughout the system.

### 1.1.4 Rehabilitation

***Non-routine activities needed to fix damage caused by prolonged wear and tear degradation.***

Rehabilitation is generally considered activities that address significant facility issues associated with aging portions of levees, channels, and other infrastructure. Such activities can include major levee bank or channel rehabilitation and stabilization, and significant structure repairs. In general, such activities are non-routine and bring a deteriorated element or portion of the flood control system back to original (or improved) condition. Given the age and condition of the current system and inadequate funding to conduct proper O&M over the last several decades, substantial facility rehabilitation is required throughout the system.

### 1.1.5 Replacement

***Installation of new equipment and facilities needed when components have either failed or exceeded their useful life.***

Some flood control structures and systems are aging and approaching the end of their designed and useful life. Replacement of such facilities (by either a functionally equivalent or upgraded structure) is necessary where repair and rehabilitation is not an option, such as replacing metal

culverts that are beyond their design life. In general, replacement activities are limited to minor flood management structures. Larger facilities and structures such as the major weirs operated by the State on the Sacramento River are consistently maintained and are anticipated to remain operational well into the future. Replacement of these and other facilities (or portions of facilities such as partial levee replacement) is generally considered a capital improvement project and is beyond the scope of typical OMRR&R.

## 1.2 Inclusion of RR&R into Standard LMA Responsibilities

Although California's flood management infrastructure has prevented billions of dollars of damage and saved many lives, resources for OMRR&R and much-needed improvements have not kept up with demands, putting people, property, and the environment at increased risk. LMAs are not only faced with insufficient funding to conduct the activities needed to maintain and operate SPFC facilities, but they are also working under conditions, design standards, and environmental regulations that have changed since the flood infrastructure was constructed. These changes have complicated OMRR&R and affected the ability to perform necessary activities needed to ensure a fully functioning flood system.

The Central Valley Flood Management Planning Program produced an internal draft technical memorandum in April 2012 titled *Operation and Maintenance Roles and Responsibilities* (DWR, 2012b). This document discusses DWR's current understanding and definition of O&M versus OMRR&R, including roles and responsibilities associated with SPFC facilities that are based on existing regulations, legislation, and agreements. The original project assurances provided to the federal government in the 1950s make no mention of repair, rehabilitation, and replacement (RR&R). The term was first introduced in the Water Resources Development Act of 1986 (WRDA 1986), Section 103(j):

> Any project to which this section applies (other than a project for hydroelectric power) shall be initiated only after non-Federal interests have entered into binding agreements with the Secretary to pay 100 percent of the operation, maintenance, *replacement, and rehabilitation* [emphasis added] costs of the project, to pay the non-Federal share of the costs of construction required by this section, and to hold and save the United States free from damages due to the construction or operation and maintenance of the project, except for damages due to the fault or negligence of the United States or its contractors.

Although responsibility for the RR&R of SPFC facilities is not widely agreed upon across agencies, USACE included the responsibility for RR&R in the engineering regulation published in 1994 titled *Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual for Projects and Separable Elements Managed by Project Sponsors* (USACE, 1994). Section 1 of this regulation states:

> This regulation provides instructions for the preparation of operation and maintenance manuals outlining the responsibilities of those local sponsors that have entered into binding agreements with the Secretary of the Army to be solely

responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R), and to pay 100 percent of the associated costs.

As the responsibility for portions of OMRR&R has shifted, funding issues have become more pronounced, requiring additional interpretation of SPFC assurance agreements, O&M manuals, and governing codes and regulations. Accordingly, interpretations of responsibility and necessary funding can differ. For example, LMAs may claim that a particular OMRR&R activity is beyond their capability to perform or is required because of system design deficiencies, and then rely on codified provisions to pass RR&R responsibility to supervising agencies. However, the reasoning used by an LMA to determine an OMRR&R activity is beyond their capability is often influenced simply by economic factors, i.e., lack of available funding. Historically, this was not a major issue because federal programs such as the Sacramento River Bank Protection Program (SRBPP) and Public Law 84-99 (PL 84-99; administered by USACE) were relied on to fund necessary repairs associated with damages from significant flood events. However, federal funding is becoming more difficult to obtain, the program supporting SRBPP will reach its limits of federal authority soon, and eligibility requirements for post-event assistance through PL 84-99[4] are becoming increasingly more difficult to meet.

Because necessary OMRR&R activities have not been completed and because numerous features and facilities do not meet current design standards as constructed, the flood management system needs significant repair and improvement. This is exemplified by aging levees, overgrown and sediment-filled floodwater conveyance channels, and numerous pipe penetrations through flood system levees that have exceeded their useful life and need detailed inspection, repair, or replacement.

## 1.3 Purpose and Scope of this OMRR&R Cost Evaluation TM and its Relation to Other Efforts

This OMRR&R Cost Evaluation TM supports the overall cost estimation effort underway as part of the 2017 CVFPP to ensure the sustainable long-term operation of facilities within the SPFC area. As described above, the costs identified in this TM are estimated to be the true annual long-term amount necessary to conduct adequate and timely OMRR&R. This estimated level of necessary spending—which accounts for more stringent USACE O&M standards, additional USACE RR&R responsibilities, increasing mitigation costs, and correcting original system design deficiencies—typically exceeds the ability of LMAs and the State to raise the necessary revenue. Proposition 218 requirements exacerbate difficulties in raising revenue.

### 1.3.1 OMRR&R Cost Evaluation TM Scope

The estimated true long-term OMRR&R costs in this TM assume fully functioning facilities that meet applicable standards. Costs were generally categorized and identified in the following manner by Regional Flood Management Plan (RFMP) region and basin:

- Urban and rural levees
- Sediment removal in channels

[4] PL 84-99 defines federal rehabilitation assistance for flood control works.

- Vegetation removal in channels
- Small and major structures

As further described in Chapter 4.0, Approach for Estimating Long-Term OMRR&R Costs, cost development was largely based on input provided by RFMP representatives, as well as DWR, CVFPB, and district LMAs and related experts.

### 1.3.2 Objectives of this OMRR&R Cost Evaluation TM

Objectives of this OMRR&R Cost Evaluation TM are as follows:

- Develop and document a defensible approach and range of unit and annual costs to assist the State and LMAs (within those areas in the Central Valley of California protected by the SPFC) with long-term maintenance cost identification, budgeting, and funding needs.

- Support the development and eventual implementation of CVFPP-planned physical features with respect to required OMRR&R activities and associated anticipated costs.

- Identify potential funding sources to support identified necessary funding requirements.

- Document current trends, challenges, and obstacles faced by those responsible for maintaining the system.

- Proof-check findings through case studies and regional coordination and outreach.

- Clearly present all findings to support raised awareness of the importance of proper OMRR&R and risks associated with inadequate funding and resources.

### 1.3.3 Costs Not Included in this OMRR&R Cost Evaluation TM

Estimated OMRR&R costs identified in this TM do not account for capital improvements or design repairs required to address known design deficiencies. Key efforts, such as RFMPs, BWFS, Central Valley Flood System Conservation Strategy (Conservation Strategy), and DWR grant programs, are currently identifying capital investments needed to repair, rehabilitate, and replace substantial pieces of the flood control system. These large investments needed to update the system have been brought about by historical patterns of limited funding availability and deferred maintenance, identification of system design deficiencies, land use changes, better understanding of Central Valley hydrology and potential climate change impacts, changing regulatory standards, and increasing environmental requirements. The RFMPs identified $13.9 billion in regional improvements across the six regions. The majority of the projects identified in the RFMPs could be attributed to deferred maintenance and correcting deficiencies. This TM assumes that these improvements will be completed and only addresses continued OMRR&R of the system.

### 1.3.4 Use of this OMRR&R Cost Evaluation TM

The costs identified in the TM are intended to assist flood management stakeholders in raising awareness of the need for substantial funding to address sustainable OMRR&R of flood control facilities within the SPFC. The annual OMRR&R unit costs identified in this TM are also being

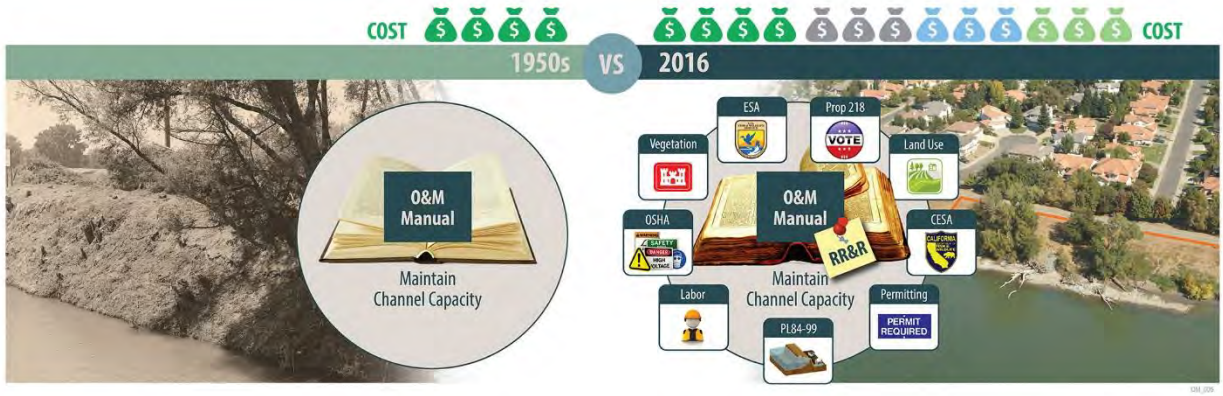
used to evaluate proposed system modifications that are part of the 2017 CVFPP. Increased permitting and environmental compliance costs are becoming a larger proportion of OMRR&R costs, and efforts are being made to make the environmental compliance process more efficient and cost effective.

## 1.4 State's Interest in Integrated Flood Management

The State has a fundamental interest in promoting the health and safety of its people, robust and sustainable economic growth, and a healthy ecosystem. Specific to flood management, the State has a responsibility for, and primary interest in, building and maintaining flood management facilities. In the course of implementing the CVFPP, the State will apply integrated flood management approaches wherever feasible.[5] This approach for addressing flood risk recognizes the interconnection of flood management actions within broader water resources management and land use planning, the value of coordinating across geographic and agency boundaries, the need to evaluate opportunities and potential impacts from a system perspective, and the importance of environmental stewardship and sustainability. A project is considered "sustainable" when it is socially, environmentally, and financially feasible for an enduring period. For the CVFPP, a sustainable project will also have flexibility to adapt to potential future changes such as climate change. DWR has made it a policy to include sustainability as a criterion in all decision-making processes.

[5] Section 9616(a) of the Central Valley Flood Protection Act of 2008 indicates that "The plan [CVFPP] shall include a description of both structural and nonstructural means for improving the performance and elimination of deficiencies of levees, weirs, bypasses, and facilities, including facilities of the State Plan of Flood Control, and, wherever feasible, meet multiple objectives…"

# 2.0 Factors and Challenges Influencing OMRR&R Costs




Numerous factors influence OMRR&R costs, including changing standards, shifting responsibility for O&M and RR&R activities, confusion regarding the baseline conditions that channel maintenance requirements are tied to, recognizing and adopting ecosystem functions into the flood control system, permitting and mitigation needs, and issues related to floodplain management and land use. These, combined with uncertain funding sources, challenge LMAs to perform the required OMRR&R to sustain a functioning flood control system. The following sections describe these factors and their influences on OMRR&R costs.

## 2.1 Changing Standards

LMA obligations for O&M of flood control facilities are described in various State and federal codes and O&M manuals published by USACE for facilities within the SPFC area. Despite the availability of these codes and manuals, the federal government, State, and LMAs have not consistently understood or implemented O&M practices. In addition, although most LMAs have historically only been responsible for O&M, changes in standards now require that SPFC facilities be repaired, rehabilitated, and replaced (referred to as "RR&R") as needed. This relatively new requirement, in combination with current engineering design criteria, movement toward increased environmental stewardship, and evolving environmental policies and regulations, is forcing LMAs to modify their approaches toward OMRR&R activities and has influenced costs (DWR, 2014b). Issues of concern include the following:

- Management of woody vegetation around flood control works to meet new USACE standards (Engineering Technical Letter 1110-2-583, April 30, 2014). In California's Central Valley, woody vegetation has great ecological and aesthetic value, and can be costly to remove.

- New and reconstructed levee engineering design criteria addressing underseepage concerns and requiring engineered levee fill material.

- Limited availability of funding at all levels of government.
- Consideration of increased levels of protection for urban and urbanizing areas and small communities in accordance with Senate Bill 5 (SB5) requirements.
- Environmental compliance for routine O&M activities.
- Stewardship of established fish and wildlife habitats, and protection of listed species.
- Basic flood response plans in response to Urban Levee Design Criteria (ULDC) requirements.

Faced with limited funding, increasing regulatory constraints, and changing expectations for the many uses of the flood management system, it is increasingly difficult for DWR and LMAs to operate and maintain levees and channels. This difficulty has contributed to ineligibility for federal levee rehabilitation funds under PL 84-99 and could negatively affect levee accreditation under the Federal Emergency Management Agency (FEMA) National Flood Insurance Program.

## 2.2 Shifting Responsibility

33 *Code of Federal Regulations* (CFR) governs USACE's flood control actions—USACE is charged with constructing facilities to provide flood protection and establishing rules, codes, and standards for maintaining these facilities. USACE then turns over responsibilities for O&M (and more recently, OMRR&R) to a nonfederal sponsor, which is the CVFPB for the SPFC. USACE transfers these responsibilities by executing assurances of cooperation with the nonfederal sponsor. At a minimum, these assurances obligate the nonfederal sponsor to (1) provide, without cost to the United States, all lands, easements, and rights-of-way necessary for construction of the project; (2) hold and save the United States free from claims for damages caused by the construction works; and (3) operate, maintain, repair, rehabilitate, and replace all the works after completion, in accordance with regulations prescribed by USACE, California Water Code (CWC) Section 8617, and WRDA 1986, Section 103(j), except for facilities listed in CWC Section 8361 that are maintained by DWR or those that the State (DWR) has taken responsibility for pursuant to CWC Section 12878. O&M, and more recently RR&R, is delegated to LMAs by CWC Section 8370 and included in local assurance agreements with the LMAs.

Assurances provided prior to the passage of WRDA 1986 only included O&M. As described in Section 1.2, most LMAs contend that the RR&R components should not apply because LMAs were not originally charged with nor agreed to such components. Regardless, USACE now includes the RR&R components in inspections, and LMA noncompliance may lead to ineligibility for PL 84-99. Furthermore, as asserted in this TM, RR&R are critical components to system sustainability. Whether the responsibility of LMAs or not, the costs associated with RR&R activities must be planned for, and reliable funding sources for these activities must be identified.

### 2.2.1 Federal Responsibility

USACE Sacramento District is the federal government's liaison with the CVFPB and DWR for all SPFC facilities. Primary actions of the Sacramento District are to partner with the CVFPB in developing new flood management projects in the Sacramento and San Joaquin River watersheds and prepare O&M manuals that specify O&M requirements. USACE assists in statewide planning efforts and project development, funds the federal share of project costs, administers PL 84-99 assistance programs, performs project inspections, and reviews proposed manual addendums/revisions. These manuals are usually in their original form and may not address new engineering standards and evolved O&M or RR&R requirements regarding environmental policies and stewardship. LMAs have been challenged by USACE requirements conflicting with other environmental permitting restrictions (e.g., vegetation removal), which influence OMRR&R costs. It is, however, USACE-developed O&M manuals and PL 84-99 that govern the OMRR&R of flood control facilities (USACE, 2006).

### 2.2.2 State Responsibility

According to CWC Section 8617, the CVFPB is the State agency responsible for the OMRR&R of existing SPFC facilities. The CVFPB's activities are governed by 23 *California Code of Regulations* (CCR), and the CVFPB is the official State signatory that provides assurances of cooperation to the federal government for SPFC facilities. The CVFPB and DWR share management responsibilities for flood protection in the Central Valley. However, the performance of O&M is assigned, as appropriate, on a unit-by-unit basis to an LMA. The CVFPB is required to enforce, within its jurisdiction, on behalf of the State, appropriate standards for the construction, maintenance, and protection of adopted flood control plans that will best protect the public from floods. DWR works with the CVFPB and provides staff and technical services to carry out many CVFPB responsibilities, including project development, inspections, O&M of some facilities, and flood project funding and administration. The SPFC facilities that are listed under CWC Section 8361 are to be maintained and operated by DWR on behalf of the State, with costs to be defrayed by the State. SPFC facilities not being adequately operated and maintained by an LMA and not listed under CWC Section 8361 can be taken over by the State, pursuant to CWC Section 12878 (maintenance areas), with costs to be paid by the beneficiaries of the maintained area. It is these facilities that influence the O&M costs at the State level, along with the obligation of SPFC facility inspection and assisting LMAs with their O&M efforts (23 CCR).

### 2.2.3 Local Responsibility

CWC Section 8618 allows LMAs to make agreements with the CVFPB, obligating them to perform State-required flood control facilities activities. For example, CWC Section 8370 states that "it is the responsibility, liability and duty of reclamation districts, levee districts, protection districts, drainage districts, municipalities, and other public agencies within the Sacramento River Flood Control Project limits, to maintain and operate the works of the project within the boundaries or jurisdiction of such agencies." Under the direction of the LMA board of directors, the LMA superintendent is responsible for OMRR&R of all portions of the project within their local area boundaries.

LMAs must accept OMRR&R responsibility from the CVFPB to receive cost-share funds from the State. LMAs also must adhere to their established assurance agreements and USACE

maintenance requirements in order to maintain eligibility for financial assistance from the federal government as stated in PL 84-99. The provision of federal financial assistance eligibility is one of the major factors influencing OMRR&R costs at the local level, because lack of funding assistance can result in deferred and increased maintenance and associated costs (USACE, 2006).

## 2.3 Roles and Responsibilities Challenges

Although many OMRR&R roles and responsibilities are identified through a combination of USACE O&M manuals and provisions of the CFR, a lack of common understanding still exists among the CWC and State, federal, and local agencies regarding their roles and responsibilities of several key O&M categories. The following roles and responsibilities challenges are summarized from the 2012 Central Valley Flood Management Planning Program *Operations and Maintenance Roles and Responsibilities* (DWR, 2012b):

- Delineation of levee/channel interface
- Erosion maintenance and bank protection
- Seepage maintenance
- Encroachments
- Penetrations
- RR&R

### 2.3.1 Delineation of Levee/Channel Interface

CWC Section 8361 indicates that DWR must maintain specific enumerated project features, including the "channels and overflow channels" of the Sacramento River and tributaries; and the LMAs are responsible for other features, including levees, in the San Joaquin River system. A common elevation used in delineating the levee/channel interface is the elevation of the levee toe at the time of construction. But this levee/channel interface becomes difficult to enforce, especially when it is under water or covered in riprap or a waterside berm. In addition, sedimentation, erosion, subsidence, and other forces often alter the elevation of the levee over time and obfuscate the levee/channel interface (23 CCR).

### 2.3.2 Erosion Maintenance and Bank Protection

33 CFR 208.10 requires superintendents to repair damages caused by erosion. Unit-specific O&M manuals typically state that DWR will provide assistance or advice to LMAs for damage to the project works that are beyond the capability of local interests to repair. However, whether a given repair is beyond the capability of the LMA is subject to interpretation. Historically, USACE has also assisted in correcting erosion deficiencies through SRBPP. However, USACE has recently begun applying benefit-cost standards to erosion projects where historically benefit-cost ratios were assumed adequate, thereby limiting the amount of federal investment in erosion repairs. This is complicated by the reality that small-scale erosion, when left unaddressed, can eventually result in large-scale erosion that threatens levee integrity and requires more significant repairs (USACE, 1955). DWR has addressed this issue recently with the development of the Flood System Repair Project (FSRP) and is currently working through a pilot program to

streamline environmental permitting for small erosion sites through the Small Erosion Repair Program (SERP).

### 2.3.3 Seepage Maintenance

Although some instances of seepage can be attributed to inadequate maintenance, the vast majority of seepage issues are legacies of the original levee design and old construction practices. Nevertheless, 33 CFR 208.10 and the SPFC standard O&M manuals specifically require that levees should be maintained by the superintendent such that "no seepage, saturated areas, or sand boils are occurring." If inspections find evidence or history of active seepage, extensive saturated areas, or boils, USACE can change the levee's status to "inactive" under the PL 84-99 rehabilitation assistance program (USACE, 2006). Large-scale projects to prevent seepage by installing slurry walls have been completed recently in some urban areas with local and State cost-share; however, such projects have generally not occurred in rural areas due to insufficient funding sources and lack of economic benefits.

### 2.3.4 Encroachments

More than 18,000 encroachment permits have been issued by the CVFPB since its inception. Encroachments are any obstruction or physical intrusion by construction of works or devices, planting or removal of vegetation, or caused by any other means, for any purpose, into the flood control project, waterway area of the flood control project, or area covered by an adopted plan of flood control (23 CCR, Chapter 1, Article 2, Section 4 (m)). Responsibilities for encroachment control are currently shared among the CVFPB, LMA, and encroachment owner, depending on the following:

- Whether an encroachment is permitted
- Whether an encroachment is being properly maintained
- Whether an encroachment has a major detrimental impact on the SPFC
- Whether the encroachment was in existence before the adoption or authorization of a project by the United States or before the adoption or authorization of a plan of flood control by the State

In addition to typical encroachments owned by an individual or company, some encroachments exist as a result of the levee system itself. Uncertainty as to ownership and the responsibility for these encroachments, given their age (primarily interior drainage ditches adjacent to the landside levee toe, retaining walls, riprap, and pipes), can make removal or demolition problematic. Some of these encroachments can be found in as-built drawings, but others are either not seen in as-built drawings, or as-built drawings cannot be located. These encroachments are typically maintained by the LMA, but many have either exceeded their lifespan or need improvements to meet current standards (DWR, 2012c).

If any person or organization deems construction or modification necessary within the levee regulatory easement, that person or organization must apply for an encroachment permit from the CVFPB. Standard procedure is now for the CVFPB to obtain permission from USACE through

33 United States Code Section 408 before issuing an encroachment permit. Although many encroachment permits allow for the CVFPB to bring noncompliant encroachments into compliance or remove them altogether at the encroachment owner's expense, specific regulations and processes to complete these enforcement actions have previously been nonexistent. The CVFPB is currently working on changes to regulations to strengthen their enforcement capabilities. In the meantime, the burden remains on LMAs to work with encroachment owners to keep their respective facilities in such condition to support inspection compliance or risk losing PL 84-99 assistance.

### 2.3.5 Penetrations

In order to address existing penetrations, a penetration's effect on SPFC facilities and its date of installation relative to the adoption or authorization of a project by the federal or State government must be known, yet can be difficult to obtain. The CVFPB is responsible for permitting and enforcement actions related to penetrations that were not constructed as part of the original levee system. According to Utility Crossing Inventory Program (UCIP) inventories, more than 5,400 penetrations exist through SPFC levees; some of these remain unpermitted, and other are likely still unidentified. In addition, some levee penetrations have been abandoned by the owner. 23 CCR regulations state that if the penetration is abandoned, it will be removed at the expense of the owner and not replaced. However, documentation of abandoned penetrations is often limited or nonexistent.

### 2.3.6 RR&R

Responsibility for RR&R of SPFC facilities is not widely agreed upon across agencies. With an increasing number of SPFC facilities becoming obsolete or nearing the end of their expected service lives, establishing clear responsibilities for SPFC facility RR&R is important. Whether a given repair is beyond the capability of the LMA can be subject to interpretation. Additionally, the use of "replacement" is generally restricted to the context of replacing missing or broken parts or replacing equipment of a structure. "Rehabilitation" is not mentioned in 33 CFR 208.10 (USACE, 1955).

In more recent assurance agreements, additional provisions for RR&R were included, and the term "O&M manuals" was replaced with "Operation, Maintenance, Repair, Replacement and Rehabilitation manuals." The State has subsequently included requirements for OMRR&R in assurance agreements with LMAs.

LMAs have historically planned for only routine O&M costs and typically do not have the resources to complete costly RR&R work. Clear responsibilities and funding sources for SPFC facility RR&R must be established. The costs for OMRR&R of flood control facilities is influenced by this disconnect between interpretation of legacy O&M assurance agreements and current OMRR&R activities (DWR, 2012c).

## 2.4 The 1955/1957 Design Profiles and the "Baseline" Standard for OMRR&R

The original hydraulic design of the SPFC is documented within various USACE documents that are referred to as the "1955/1957 design profiles," the years the water surface and levee height design profiles were developed for the San Joaquin and Sacramento River systems, respectively. These profiles were developed to provide the basis of design and to establish appropriate levee profiles for the flood control system, in part, to support O&M activities. However, in some areas, original designs are not sufficient to support adequate flood protection and are not the ultimate O&M guidance source. The development of the profiles and challenges in using the profiles as a source of guidance in some areas to support OMRR&R is further discussed in Issue Summary #1, Existing Conditions and the 1955/1957 Design Profiles, in Appendix A.

## 2.5 Permitting and Mitigation Needs and Emerging Issues

Transactional costs include those that are associated with planning, facilitating, or supervising an action on the ground, from beginning to end. Transactional costs are highly variable and often project- and site-specific. These costs may include design, construction management, various real estate-related activities, biological and engineering surveys, and permitting and mitigation compliance.

Environmental compliance and mitigation needs are among the greatest challenges for conducting OMRR&R of SPFC levees and facilities. DWR and LMAs typically comply with environmental laws and requirements on a project-by-project basis. As a result, each project has a separate regulatory process that includes agency consultation, an environmental effects assessment, and identification of individual mitigation measures. This approach, collectively across multiple projects, results in delays in approvals and causes compounding project inefficiencies. At the same time, SPFC-related environmental stressors and disturbances are resulting in a sharp decline of aquatic and terrestrial habitat conditions and availability within the SPFC footprint, causing additional species and habitat to become protected with even stricter regulations, snowballing into a repetitive cycle of greater difficulty and expense in conducting OMRR&R activities.

Compliance with environmental regulations and permitting requirements can represent a significant cost in the OMRR&R of SFPC facilities. Although many O&M activities and some RR&R activities can be conducted under State exemptions, when activities would potentially affect habitat and special-status species, the environmental compliance process can be costly. In some cases, maintenance and repair activities have been delayed—resulting in deferred maintenance—because of actual or perceived permitting and mitigation timeframes and costs. It is not common practice for LMAs or DWR to track the cost of permitting and mitigation; therefore, only limited data on that portion of OMRR&R costs are readily available. Many believe environmental compliance costs are continuing to rise and become a larger proportion of OMRR&R costs, and the data that are available indicate that such costs can be substantial. DWR and LMAs are continuing to seek opportunities to minimize such costs while meeting their O&M and RR&R obligations. Issue Summary #2, Environmental Compliance and Other Transactional

Costs, in Appendix A provides additional information on transactional costs and a detailed discussion on issues related to environmental permitting and mitigation.

## 2.6 Uncertainty of Financing and Revenue Sources

Given the current expectations, inadequate funding is a problem for most LMAs, particularly for rural agricultural LMAs who have fewer assessees, yet are required to meet the same evolving OMRR&R standards. A stable revenue stream of the appropriate size is critical to proper OMRR&R of flood management facilities; however, several factors affect the ability for LMAs to raise adequate funds. These include Proposition 218, limited State assistance, and poor public understanding and awareness of the benefits provided by the SPFC and the actions needed to support proper maintenance. Specifically, many LMAs are highly reliant on the types of assessments and fees that are subject to Proposition 218, have limited flexibility to increase assessments as OMRR&R needs increase, and cannot assess beneficiaries outside of their jurisdictional boundaries. Therefore, activities are being prioritized within the financial capability of the LMAs, and lower-priority activities are being deferred or not occurring at all.

Additionally, for areas maintained by DWR, funding appropriations are generally not guaranteed and are often less than the full amount requested, which also results in deferral of noncritical activities. Other factors affecting the reliability of funding for OMRR&R activities include the application of benefit-to-cost ratios to receive federal funding, high FEMA flood insurance rates resulting from lack of levee accreditation that offset local availability of funds, and potential effects on the system from climate change. Additional discussion related to funding limitations and potential funding sources is provided in Chapter 6.0, Potential Funding Sources.

## 2.7 Setback Levees

Setback levees have been incorporated into several recent multi-benefit projects across the SPFC and are considered a potential multi-benefit method to improve flood risk, reintroduce floodplain habitat, and reduce the cost of OMRR&R, depending on conditions, location, and the state of current facilities. Where appropriate, setback levees can reduce flood risk by lowering flood stages and more efficiently moving floods through the system, and provide ecological, recreational, groundwater recharge, and economic benefits. Setback levees can be used for various applications, but, in general, are defined as “a new levee constructed behind an existing levee which allows for removal of a portion of the existing levee and creation of additional floodplain connected to the stream,” and may or may not require removal of part or all of an existing levee (DWR, 2009). The State Systemwide Investment Approach in the 2012 CVFPP also focused in part on leveraging flood system improvements to create habitat through levee setbacks, waterside planting berms, and extension and expansion of the bypass systems as appropriate (DWR, 2012a).

Like a traditional levee, setback levees require OMRR&R, which can be more or less costly than strengthened-in-place levees or levees along the river bank, depending on the location and application. Depending on the particular setback levee, typical O&M activities include mowing, rodent control, sediment removal, access maintenance, and even vegetation control (unless some

degree of riparian vegetation is incorporated into the project/setback levee), which are also typically required for existing or strengthen-in-place levees. Levees that conform to new, modern designs—whether setback or rebuild-in-place— may include features that are required to improve public safety and may cost more to maintain than older, existing levees. Current designs require features to improve public safety, such as relief wells (which require associated routine maintenance and drainage facilities) and new closure structures on pipes (which require annual inspections). Thus, whether levees are being degraded, rebuilt in-place, or set back, levee repairs to meet modern standards can result in additional OMRR&R costs.

In general, a key difference between setback and replacement/degradation/rebuild-in-place levees is how waterside levee slopes and banks are maintained, with associated costs depending on project specifics. Cost savings can be realized in some setback levee applications because of reduced erosion on the levee slope and toe, reduced need for bank protection or seepage/stability berms, and comparatively fewer encroachments. Furthermore, because setback levees are generally shorter in length than rebuild-in-place levees, additional cost savings may be realized as a result of reducing the total area requiring maintenance.

Depending on how the new floodplain area created by setting levees back is used, the costs associated with channel maintenance for a setback levee can be greater due to the increase in channel acreage and lower velocities that may provide rearing habitat for salmonids and reduce erosion, but may also induce channel aggradation. Identifying a preferred alternative to account for OMRR&R costs requires numerous considerations. Issue Summary #3, Comparison of Setback and Rebuild-in-Place Levee Maintenance Costs, in Appendix A provides examples of existing or planned setback levees and discusses how activities can differ for setback and rebuild-in-place levees when compared to existing historical levees.

## 2.8 Issues Related to Floodplain Management

Flood protection and management can be adversely affected by local land use activities that may not fully consider how the activity is integrated into a region's flood protection requirements and systems. DWR and LMAs do not have any direct authority over land use activities, yet many of these activities can affect OMRR&R activities. Effects can be minor, requiring unbudgeted but manageable maintenance effort; significant, creating a need for major levee repair projects; or even catastrophic, causing failure of the levee during a high water event, leading to a major flood. Examples include detention basins or swimming pools near levees that may induce underseepage, potable water or agricultural wells that may also induce underseepage and levee subsidence, or urban encroachments such as landscaping that may impede flood fighting or create seepage paths through or under the levee. Urbanization behind levees can also require changes to maintenance activities affecting O&M efficiencies, including mowing levees rather than burning them and working around additional gates and fences. In addition, nonintegrated land use activities can be cited by flood protection authorities as reason for decertification of a flood protection structure and removal of flood protection systems from aid programs such as PL 84-99.

"Land use activity" can mean any ministerial, discretionary, or other regulatory permit approvals that are likely to lead to a change to improved or unimproved land, including buildings or other

structures, mining, dredging, filling, grading, paving, excavation, or drilling operations, or storage of equipment or materials. These approvals include, but are not necessarily limited to, the following:

- General Plan amendments
- Zoning map changes
- Conditional use permits
- Design review permits
- Parcel mergers and lot line adjustments
- Sign permits
- Encroachment permits
- Public and private utilities
- Specific plans and amendments
- Zoning text amendments
- Planned development permits
- Subdivision maps and parcel maps
- Building permits
- Grading permits
- Onsite development permits
- Underground pipelines

Increasingly, land use activities are causing difficulties for LMAs and often result in additional costs to monitor and enforce potentially harmful land use decisions (California Central Valley Flood Control Association, 2013). Additionally, increased urbanization is being experienced in some areas where levees and other facilities were intended to protect agricultural areas. These activities and changes not only affect OMRR&R activities, but also increase the consequences of flooding, thereby increasing risk.

# 3.0 Current OMRR&R Activities, Practices, and Standards

OMRR&R activities and practices for SPFC facilities include adherence to existing O&M manuals and regulations, inspections, and required actions. DWR typically depends on LMAs to maintain levees and other SPFC facilities in good condition; whereas, DWR maintains channels of the Sacramento River system, many bypass levees, and all facilities identified in CWC Section 8361. DWR is also responsible for maintaining levees and facilities in areas where no LMA exists.

The following USACE O&M manuals for the Sacramento and San Joaquin River basins (one for each basin) identify the requirements for all SPFC facilities:

- *Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project* (USACE, 1955)
- *Standard Operation and Maintenance Manual for the Lower San Joaquin River Levees, Lower San Joaquin River and Tributaries Project* (USACE, 1959)

The content of these manuals was agreed on during the transfer of the facility to the State at the end of construction and has not been updated since their adoption. Unit-specific supplemental manuals have been developed for many portions of the system and have captured alterations and improvements to the SPFC. A unit may be a reach of levee, hydraulic area, pumping plant, weir, or other facility. As of 2010, when the Descriptive Document for the SPFC was updated (DWR, 2010), there were 118 unit-specific manuals. Some unit-specific supplemental manuals are fairly unique, such as supplements to cover environmental mitigation areas (Unit No. 118 Pt. 1-2 and Unit No. 521) and one supplement covering the cleared channels for the Sacramento Flood Plan (Unit No. 165).

The supplemental O&M manuals generally include the following:

- Level of protection provided by the unit's features
- Unit-specific O&M guidance
- Local conditions
- As-built drawings
- Copies of assurance letters provided by the State
- Any specialized facilities

Historically, O&M activities and more significant repairs have been conducted as necessary, but were often not documented. More recently, SPFC features altered to support an engineering solution (such as a stability berm on the landside of an SPFC levee or an emergency bank protection repair) are documented or "amended" to the unit-specific manuals using a short report termed an "addition or addendum to the supplement." Such actions also typically require an encroachment permit from the CVFPB. The short report includes the name of the construction

contract (for future reference), revised as-built drawings, and a letter from the State citing acceptance of responsibility. In some cases, new O&M tasks may be added to the unit-specific manual as part of the report, if they are deemed necessary to properly maintain the features (e.g., requirements for when monitoring wells should be sounded, and maintenance of added pumps, valves, gates, or relief wells). All new O&M manuals must be approved by the CVFPB and USACE and include acceptance of the altered project.

The supplemental unit-specific O&M manuals describe actions that LMAs are to follow for routine maintenance and special operations during high-water flood events. Some of the general rules for O&M of local flood control works specified in the supplemental unit-specific O&M manuals follow (DWR, 2010):

- O&M must be performed to achieve maximum benefits of SPFC facilities.
- O&M must be in accordance with USACE regulations.
- LMAs must maintain a reserve supply of materials for flood emergencies.
- No encroachments that adversely affect O&M will be allowed.
- No SPFC improvements will be performed without USACE approval.
- USACE must have access to SPFC facilities at all times.
- Maintenance and repairs will be performed as deemed necessary by USACE.
- Flood emergency coordination protocol must be established between LMAs and supervising agencies.

The standard and supplemental unit-specific manuals also contain detailed guidance regarding levees, channels, irrigation/drainage structures, and miscellaneous facilities. These chapters offer guidance pertaining to all SPFC facilities for maintenance, operation, erosion, vegetation, burrowing animals, patrol roads, and degradation of the levee crown. Discussion regarding the need for patrols during floods, local inspections, safety requirements, and flood-fighting procedures is also provided in these manuals.

To comply with assurances made to the federal government, DWR performs at least two of the four minimum annual inspections as specified in the two standard USACE O&M manuals and the supplemental unit-specific O&M manuals for each SPFC unit. LMAs typically provide at least two additional inspections. Some of the general inspections common to SPFC facilities include debris, channel vegetation, levee vegetation, encroachments, sedimentation, settlement, erosion, rodent damage, seepage conditions, structural conditions, and other conditions as specified by supplemental unit-specific O&M manuals (DWR, 2010). These inspections are an important O&M activity, and each unit's supplemental unit-specific O&M manual contains inspection criteria for that unit's facilities. In addition to the annual inspections performed by DWR and the LMAs, levee systems are also inspected through the USACE Rehabilitation and Inspection Program (RIP) associated with PL 84-99. Systems that receive unacceptable ratings

through either routine or periodic continuing-eligibility inspections are placed on inactive status in the RIP, which affects the amount and type of federal funding assistance a non-federal sponsor may receive following a flood event.

The federal and State inspections rely on the construction drawings in the O&M manual and approved encroachment permits to determine if all features observed in the field by inspectors have been properly documented, including repairs. The routine nature of the inspections also allows for State and local inspectors to note changes in facilities that may require further investigation, and the less frequent federal inspections result in very strict adherence to guidelines with little regard to the ever-changing condition of levees (i.e., rodent activity, vegetation growth, and minor rilling). Issue Summary #4, Prioritizing and Addressing the Cost of Inspection Compliance, in Appendix A provides more information on inspections and inspection compliance.

Since 1971, when new fixes or repairs were added to unit-specific supplemental O&M manuals, vegetation was often added to the as-built drawings to adequately mitigate project impacts. In parallel, protecting any vegetation plantings was also added as a new task to the unit-specific manual using the next letter or number in the sequence of tasks. Forty-five unit-specific manuals include this type of minor change (40 in the Sacramento River Basin and 5 in San Joaquin River Basin).

## 3.1 Levee Maintenance

### 3.1.1 Vegetation Management

The SPFC was originally designed with many levees purposefully constructed close together to induce scour of the accumulated hydraulic mining debris within the channels. As a result, many portions of the system allowed larger vegetation on the waterside slope of the levees “where desirable for the prevention of erosion and wave wash” (USACE, 1955). Vegetation management on levees in the SPFC has typically consisted of mowing, burning, and grazing to control grasses and small vegetation for visibility during inspections. The allowance of larger vegetation provides environmental benefit to many parts of the SPFC, but has also led to conflicts with current USACE policies for vegetation management on levees.

After Hurricane Katrina, USACE developed and has enforced strict vegetation management policies that have widely affected LMAs and other levee management entities (vegetation on levees was not a cause for the flood damage associated with Hurricane Katrina). USACE has established specific zoning criteria for vegetation on or within levees; these zones are made of the “vegetation free zone” and “vegetation management zone,” and are detailed in USACE Engineering Technical Letter 1110-2-583. DWR has formally responded to Engineering Technical Letter 1110-2-583 suggesting that strict enforcement of the USACE vegetation management policy will affect public safety in California, result in extensive and unnecessary environmental damage, and remove USACE’s responsibility to assist the State and LMA’s ability to ensure the integrity of California’s levee system. Vegetation removal on levees could potentially cost taxpayers billions of dollars and would likely result in negligible benefits to public safety.

The standard Sacramento River Flood Control Project O&M manual requires that "weeds and other vegetal growth in the channel shall be cut in advance of the flood season and, together with all debris, removed from the channel" (Section 6-02, Paragraph b.(1)). Depending on the presence of potential habitat, compliance with this requirement can require extensive coordination under the State and federal Endangered Species Acts.

Seven new stand-alone unit-specific manuals have been added for environmental mitigation areas (six in the Sacramento River Basin and one in the San Joaquin River Basin) that cover the proper maintenance of the mitigation sites to support compliance with the biological opinions issued by U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Services (as applicable). However, maintenance of mitigation sites can conflict with maintenance of flood control conveyance or be in direct conflict with standard O&M manual requirements. As discussed above, USACE began requiring that levee vegetation be removed following Hurricane Katrina, despite some unit-specific manuals showing allowable vegetation. DWR and LMAs continue to struggle to maintain all SPFC facilities in a way that meets the needs of flood control while protecting the vital ecosystem values that most channels and levees provide.

### 3.1.2 Rodent Control

Burrowing rodents can cause significant damage to the structural integrity of levees. Burrows created by beavers, ground squirrels, gophers, muskrats, opossums, badgers, and other animals can lead to rapid levee failures during floods. Burrowing rodents must be managed appropriately, including establishing an active animal abatement program with cooperation from federal, State, and local programs, as applicable. Successful rodent control techniques include fumigation, bait stations, bait broadcasting, or trapping (USACE, 2006). In addition to aggressive abatement programs, LMAs must also continuously complete repairs to correct for the slope instability created by rodent burrows. Common methods are grouting the rodent holes or excavating, backfilling, and compacting the burrows. Rodent burrows can be occupied by sensitive species including giant garter snake, burrowing owls, and other species. As a result, LMAs are increasingly being required to consult with USFWS and California Department of Fish and Wildlife (DFW) for appropriate environmental clearance and potential mitigation for these activities, resulting in additional costs and effort.

### 3.1.3 Encroachments and Pipe Maintenance

Encroachments are defined as any "excavations, structures, or other obstructions present within the project easement area" (USACE, 2006). Currently, the project easement area is a 10-foot minimum distance from the levee toe to the nearest obstruction. For SPFC facilities, this project easement area is regulated by the CVFPB as an acceptable levee clearance for an encroachment. Any encroachment within the 10-foot clearance zone of an SPFC facility without a valid encroachment permit from the CVFPB is strictly prohibited. Where access control is needed, the public sponsor should install gates that will allow continued access along the crown of the levee for surveillance and flood-fighting activities (USACE, 2006). If the CVFPB deems an encroachment as noncompliant and unable to be permitted, the encroachment shall be modified to meet compliance standards or shall be removed. Permits are only issued for encroachments that are determined not to create a detrimental impact on any SPFC facilities. DWR must inspect newly permitted encroachments to ensure compliance with encroachment conditions. DWR records and reports any unpermitted encroachments to the CVFPB and coordinates with LMAs

to abate unauthorized encroachments. The CVFPB is authorized by Assembly Bill (AB) 156 (2009) to take actions to address unauthorized encroachments, including issuance of cease and desist orders and imposing civil liability on a person or agency. Detrimental encroachments must be removed, abandoned, or suitably modified (DWR, 2014b).

More than 5,400 irrigation, drainage, and utility pipes that penetrate SPFC levees have been identified through the UCIP, which is administered by FMO. The UCIP was developed to standardize and document procedures for the inspection of all utilities penetrating levees (DWR, 2014b). LMAs are encouraged to use UCIP data to obtain details about the utility crossings in their jurisdictional area. Over 1,500 identified pipe penetrations are the responsibility of LMAs, and the remainder are the responsibility of private owners or public utility providers. Each of these penetrations introduces a possible threat to the integrity of the levee system and should be inspected, maintained, and, if needed, repaired regularly. Costs associated with the systematic repair, removal, or replacement of pipes are discussed below and in Chapters 4.0 and 5.0. Issue Summary #5, Cost of Addressing Levee Pipe Penetrations in State Plan of Flood Control, in Appendix A provides specific examples of pipe removal or replacement efforts and associated costs for the Sacramento River Basin and the Sacramento-San Joaquin Delta (Delta).

### 3.1.4 Minor Repairs (FSRP)

The FSRP was developed as a near-term priority action of the State Systemwide Investment Approach. The FSRP provides technical and financial assistance to LMAs for repairing documented critical problems with SPFC flood control facilities in non-urban areas. According to DWR, the objectives of the FSRP are as follows:

- Repair documented critical problems.
- Repair deteriorated levee patrol roads that provide all-weather access to the levees. These roads enable effective emergency response that manages residual flood risks.
- Repair minor levee problems proactively, such as erosion sites shorter than 50 feet.

Only projects meeting the following criteria are eligible for FSRP funding: erosion repair, levee repair, levee access road repair, hydraulic control structure and weir repair, pumping plant repairs to maintain design capacity, and channel capacity restoration. A maximum of $150 million from Proposition 1E funds will be allocated by the FSRP through fiscal year 2017. Cost-share will be established with eligible LMA sponsors for FSRP-eligible projects (DWR, 2013a).

## 3.2 Channel Maintenance

SPFC channels have undergone geomorphic change due to sedimentation, levee erosion, channel accretion and levee degradation, urbanization, reservoir storage, and dam operations such that considering the 1955/1957 profiles as the standard for O&M activities may no longer be viable. Furthermore, in recognizing the value of ecosystem functions, vegetation within SPFC channels has been allowed to establish, resulting in changes to channel roughness. As a result, DWR is evaluating SPFC channels on a reach-by-reach basis using updated hydraulic models and

assumptions. Issue Summary #1, Existing Conditions and the 1955/1957 Design Profiles, in Appendix A provides additional information.

### 3.2.1 Vegetation Management

As described above, vegetation management on SPFC levees and within channels is a continuing challenge. Table 3-1 lists SPFC channel vegetation management requirements contained in standard and supplemental unit-specific O&M manuals provided by USACE, 33 CFR, 23 CCR, and other sources.

**Table 3-1. Applicable Vegetation Management Requirements**

| Source | Requirement |
|---|---|
| 33 CFR 208 | Some flexibility is provided for allowing vegetation in a channel as long as project works function properly and are not impaired by debris, weeds, or wild growth. |
| 23 CCR | Vegetation that impedes or misdirects flood flows is not permitted to remain within a floodway or bypass. |
| Standard and Unit-Specific O&M Manuals | Generally, these manuals require that "the channel or floodway is clear of debris, weeds and wild growth." Vegetation is limited in a project flood control channel to non-dense brush or trees not more than 2 inches in diameter. Vegetation in a channel is allowed if the design water surface profile is maintained. |
| USACE Sacramento District | Allowable vegetation in a floodway shall not affect the capability of the project works to convey design flows within specified levels of freeboard, and shall not compromise the integrity or inspectability of the flood control project. Channels shall pass design flows at stage levels at or below the 1957 design profile. |
| Federal Endangered Species Act | Vegetation management activities could potentially adversely affect fish and wildlife species and their habitat. Section 7 of the federal Endangered Species Act outlines procedures for federal interagency cooperation for implementing the act.<br>Section 7 (a)(2) requires that federal agencies consult with USFWS and/or National Marine Fisheries Service so that "any action authorized, funded, or carried out by such agency" does not jeopardize the existence of a listed species or adversely modify critical habitat. |
| California Endangered Species Act | Vegetation management activities could potentially adversely affect fish and wildlife species and their habitat. Pursuant to the California Endangered Species Act, a permit from DFW is required for projects that could result in the "take" of a plant or animal species that is State-listed as threatened or endangered, or is a candidate species. Sections 2080 and 2081 of the California Fish and Game Code discuss permitting. |
| California Fish and Game Code Section 1600 Streambed Alteration Agreement | Because vegetation management activities conducted in channels could potentially change the bed, channel, or bank of a channel, and potentially adversely affect fish and wildlife species and their habitat, a California Fish and Game Code Section 1600 Streambed Alteration Agreement may be needed (California Department of Fish and Game, 2010). |

*Source: DWR, 2010.*

The *Superintendent's Guide to Operation and Maintenance* emphasizes the channel maintenance activities listed above and provides additional information for channel clearing. DWR employs the following three methods for channel clearing (DWR, 2014b):

1. **Uprooting and piling.** A medium or large bulldozer with a brush rake attachment or a dragline may be used to uproot and pile vegetation. Piled vegetation must be removed from the floodway before flood season. Where permitted by DFW and the CVFPB, burning can be performed as a disposal method.

2. **Selective cutting.** Hand tools such as chainsaws may be used. Woody growth of selected species less than 8 inches in diameter can be disposed of with a chipper. If permitted by DFW, chips can be disposed of by spreading. Personnel of the California Conservation Corps are often available to conduct selective clearing work at low cost.
3. **Translocating herbicides.** Herbicides can be used to kill aboveground and belowground plant parts, eliminating or greatly reducing regrowth. Special care must be taken to prevent drift or contamination of water. The following are methods for administering translocating herbicides:
    a. A tractor and a trailer-mounted storage tank with a high-pressure pump are used for spraying brush in channels without suitable access.
    b. Traditional spray equipment fitted with a long hose is used for narrow channels.
    c. Aerial application of herbicides is required for areas with limited access.

#### *Vegetation Resulting from Regrowth and Natural Regeneration*

Natural regeneration or regrowth of planted vegetation on or near project levee slopes or within channels can introduce various complications. Uncontrolled growth can interfere with routine maintenance and inspections, inhibit flood-fighting activities, and provide food sources and protective cover that attract burrowing animals. When large trees on levees or within the channel are toppled by wind, disease, or old age, they often dislodge broad areas of earth, create flow obstructions, and divert flow into levee sections, which increases erosion. It is critical that maintenance activities include trimming and pruning vegetation that may interfere with channel capacities. When properly managed, vegetation deters surface erosion resulting from rain, runoff, and flood flows. Issue Summary #6, Vegetation Management: Cost of Maintaining Channel Capacity, in Appendix A provides specific examples of vegetation management activities and associated costs for the Sacramento and San Joaquin River basins and Delta.

DWR must demonstrate compliance with USACE requirements—vegetation in a channel should not affect channel conveyance capacity and should not encroach on the freeboard. The specified levels of freeboard used to determine the extent of allowable vegetation throughout a channel often must be clarified; the freeboard cited in O&M manuals often conflicts with the freeboard specified in as-constructed plans. Knowing the required levels of freeboard is critical in assessing conveyance capacity and determining whether vegetation or other factors are impeding proper function of SPFC facilities. Preserving vegetation in relation to channel capacities is an essential piece of flood control project management and the CVFPP (DWR, 2011).

#### *Vegetation Maintained as Habitat*

Vegetation in channel ways can provide important habitat for a variety of fish and wildlife species, but it also can present challenges for maintenance activities where it is incompatible with flood system performance. Moving forward, future flood risk reduction projects under the CVFPP are anticipated to integrate ecosystem improvements (informed by the Conservation Strategy [(DWR, 2014c]) as part of a multi-benefit focus where practicable. These improvements are expected to be accomplished primarily by expanding or increasing river access to floodplains, increasing the frequency of inundation, and restoring strategically placed riverine and floodplain habitats such as riparian forest, wetlands, and shaded riverine aquatic cover. In addition, actions will be taken to restore fluvial processes and reduce ecosystem stressors.

Although these actions and resulting habitat features have the potential to increase vegetation management requirements at some locations, development of integrated flood/habitat projects through sound flood planning informed by the Conservation Strategy is intended to minimize these management requirements and help ensure that habitats function properly within the floodway without compromising system flood performance.

### 3.2.2 Bank Erosion Prevention and Repair

Levee erosion problems are the consequence of a system designed to scour debris accumulated by historical hydraulic mining activity combined with construction that predated modern engineering criteria and levee construction standards. These factors resulted in unsuitable levee materials and relatively narrow levee alignments in many locations.

Erosion repair and bank protection need to be conducted in a timely manner to prevent further erosion and possible levee failure. Deferring removal of accumulated debris or unhealthy large vegetation can result in redirecting flows that cause bank erosion. Some erosion can also be attributed to rainfall on the levee, causing rounding off of the shoulders and movement of the toe, and should be addressed through maintenance activities. Levee rutting or toe scarps can also occur as the result of adjacent farming activities, routine maintenance of levee slopes, or illegal trespass. These small ruts or minor erosion areas can lead to more major scouring if not corrected before flooding occurs.

Some erosion can be addressed through maintenance activities; whereas, others are best addressed through bank protection or levee setback projects. Superintendents are required to repair damages caused by erosion, and DWR will provide assistance and advice for damage that is beyond the capabilities of LMAs to repair. When small-scale erosion is left unaddressed, it can result in large-scale erosion, which requires more significant and costly repairs. Areas that are more susceptible to erosion due to soil type, levee geometry, or high water velocity should be noted and monitored after each high water event (DWR, 2014b).

Common erosion repairs to maintain minimum levee geometry standards generally consist of placing materials (such as rock) that can withstand erosive forces or levee widening. Recently, efforts have been made to incorporate natural vegetation and ecosystem components to prevent erosion. Some common methods are wind-wave buffers comprising mixed-story trees water-ward of the levee slope, native vegetation plantings along the channel banks to prevent erosion into the levee section, and incorporation of plantings and habitat components into rock protection projects to maintain existing habitat.

### 3.2.3 Sediment Removal

Since the SPFC facilities were constructed, maintenance standards have consistently required actions to address shoaling or sedimentation that reduces channel conveyance capacity or deflects flows within a channel. Channel sedimentation can occur in areas of significant flow expansion (i.e., bypass inlets), in backwater near confluences, or in some tidally influenced reaches. In addition to reducing channel conveyance capacity, sedimentation of natural channels can cause lateral redirection of flows, leading to bank erosion. (In cases where design channel capacity is not impaired, such flow redirection problems caused by sedimentation can be addressed by sediment redistribution within the channel, instead of more expensive sediment

removal and disposal.) Sedimentation can also induce vegetation encroachment when low-flow conditions prevent the natural removal of vegetation on bars that are formed along a channel. Several areas with known sedimentation problems, such as the Cherokee Canal and Yuba River, are still influenced by hydraulic mining debris from the nineteenth century. Sedimentation also often results from eroding river banks and agricultural runoff. Table 3-2 lists current applicable requirements for sediment management (DWR, 2010).

**Table 3-2. Applicable Sediment Management Requirements**

| Source | Requirements |
|---|---|
| 33 CFR 208 | Sediment management is to be performed in channels so that flood conveyance capacity is maintained. |
| Federal Clean Water Act Section 404 | Channel sedimentation management activities could require a Clean Water Act Section 404 permit to be obtained from USACE for discharge of dredged or fill material into "waters of the United States, including wetlands." Waters of the United States include traditionally navigable rivers and their tributaries, and adjacent wetlands that have a significant nexus with waters of the United States. If a Section 404 permit is required, a Clean Water Act Section 401 Water Quality Certification would also be required by the Regional Water Quality Control Board. |
| Unit-Specific O&M Manuals | Generally, these manuals limit sedimentation in a project flood protection system so that "the capacity of the channel or floodway is not being reduced by the formation of shoals." |
| Engineer Technical Letter 1110-2-583 | Some flexibility is provided for sediment management if the water surface profile is maintained. The operative rule is that "capacity of the channel or floodway is not being restricted by the formation of shoals" (USACE, 2014). |
| Standard O&M Manual for the Sacramento River Flood Control Project | The manual state that "the capacity of the channel or floodway is not being reduced by the formation of shoals" and "sediment, rubbish, industrial waste or any debris plugs or other obstructions should be removed from the channel to prevent any tendency for the flows to be deflected within the channel" (USACE, 1955). |

*Source: DWR, 2010.*

Historical sedimentation management has consisted of dredging within the channels combined with mechanically removing accumulated sediment in the bypass channels and at weirs. The general system design to promote channel scour has also resulted in removing most of the historic in-channel debris from hydraulic mining. However, sediment aggradation in the overbanks and weirs continues and requires continued maintenance to preserve channel capacities. Issue Summary #7, Cost of Sediment Removal in the State Plan of Flood Control, in Appendix A provides more detail on sediment removal activities and associated costs for the Sacramento and San Joaquin River basins and the Delta.

## 3.3 Major and Minor Structure Maintenance

Numerous minor and major flood control structures are essential parts of the Sacramento and San Joaquin River flood control projects. Minor structures include stop log or gated closure structures, pumping plants, monitoring wells and piezometers, retaining walls and floodwalls, pipe penetrations, and encroachments; whereas, major structures involve those facilities described in CWC Section 8361 and administered by DWR, including weirs, bypass outflow control structures, outfall gate facilities, and large regional pumping plants. OMRR&R of these structures is managed in accordance with unit-specific O&M manuals.

### 3.3.1 Nonstructural Measures

Increasingly, USACE, FEMA, and private industry are evaluating and beginning to implement nonstructural flood risk reduction measures. Examples include acquiring flood easements while degrading and abandoning existing levees (see Issue Summary #8, Three Amigos Nonstructural Alternative Project at the San Joaquin River National Wildlife Refuge, in Appendix A). Non-structural options (including associated habitat benefits) are being considered more often as an alternative to typical structures where applicable. Options can include purchase of agriculture or flood easements on lands protected by levees, raising infrastructure in the floodplain to reduce or avoid flood damages, and notching or removing existing levees to create transitory floodplain storage. Because the assets behind the levee can be protected and compensation to landowners agreed upon, these nonstructural measures can, in some cases, technically provide the same cost-to-benefit ratios as structural measures and reduce ongoing costs for O&M.

Regardless of the measure implemented (including the potential decommissioning of facilities), the level of protection assured to the federal government must be maintained unless revised by Congress. In addition, the LMAs are responsible to perform the O&M work as required in the O&M manuals (see CWC Sections 8370 and 8371). The unit-specific level of protection is found in the preamble language of the current unit-specific O&M manuals and in the Chief's Report for the applicable project.

# 4.0 Approach for Estimating Long-Term OMRR&R Costs

True long-term SPFC area OMRR&R costs over a 50-year time horizon were identified by reviewing various sources and receiving input from DWR staff, LMA representatives, and regional stakeholders and experts. The identification of these costs was driven by the 2012 CVFPP goal to improve O&M of SPFC facilities and the recognition that building out the State Systemwide Investment Approach will affect the current OMRR&R practices in the system. Although the CVFPP has a 30-year time horizon, a 50-year time horizon was chosen for this effort because it better corresponds to the typical design life of flood infrastructure.

Recent and historical practices and activities were investigated by gathering information and data from all available sources, including representatives from each of the six Regional Flood Management Planning regions. It is intended that the cost estimates and evaluation conducted while preparing this TM will support the improvement of long-term SPFC area OMRR&R while incorporating environmental stewardship as part of OMRR&R activities.

## 4.1 Background

This section summarizes past and current approaches used by DWR, LMAs, and USACE to estimate overall O&M costs.

### 4.1.1 Existing DWR Approach to Estimating and Tracking OMRR&R Costs

As part of AB 156, CWC Sections 1940 and 1941 added a requirement for LMAs to annually submit their O&M reports of project levees to DWR (also referenced herein as AB 156 data sets). DWR is tasked with summarizing this information and producing an annual report. The LMA information includes length of levees maintained, current and planned O&M activities, and annual O&M cost estimates for the upcoming fiscal year (July 1 through June 30).
This information is one of the primary ways DWR estimates and tracks annual SPFC O&M costs. According to CWC Section 1940, the information submitted to DWR includes the following five items:

1. Information known to the LMA that is relevant to the condition or performance of the project levee.

2. Information identifying known conditions that might impair or compromise the level of flood protection provided by the project levee.

3. A summary of the maintenance performed by the LMA during the previous fiscal year.

4. A statement of work and estimated cost for O&M of the project levee for the current fiscal year, as approved by the LMA.

5. Other readily available information contained in the LMA records relevant to the condition or performance of the project levee, as determined by the CVFPB or DWR.

As further discussed below, information provided through this process can vary substantially and often is a reflection of funding limitations rather than what is actually required to conduct adequate OMRR&R. Thus, an LMA questionnaire was developed (in addition to calls and meetings with representative LMAs in each basin) to obtain more consistent information for this TM. Other methods for obtaining information, including meetings with regional representatives, were also used as described below.

### 4.1.2 LMA Approaches to Identifying OMRR&R Costs

Many of the LMAs who have responsibility for SPFC facilities do not have the resources to properly execute the required OMRR&R tasks because of insufficient funding and staff.

LMAs obtain annual O&M dollars through assessment fees and ad valorem property taxes, and they prioritize annual O&M activities in accordance with the amounts received. LMAs created an annual budget knowing the fixed amount of money they will receive and which projects or activities they are able to fund. Long-term planning for larger and more expensive OMRR&R activities is typically done only as resources are available. LMAs generally save a portion of their annual budget for more significant repairs, such as non-routine repairs or rehabilitation projects, and use these limited reserves to leverage State and federal funding as it becomes available. These larger activities are prioritized according to the most critical needs of the system, and what staff and equipment are available.

Each LMA has its own system for tracking costs, future budgets, and resources. Additionally, each LMA has its own methods for prioritizing needs within their system and tracking the progress of addressing those needs. LMAs are knowledgeable about their own system and what works for their stakeholders, but they are often limited by funding availability.

### 4.1.3 USACE Approach to Identifying OMRR&R Costs

Although many USACE regulations and guidelines require inclusion of OMRR&R costs in project cost estimates, no specific federal guidance or regulations exist for developing such costs. Recent local projects, including Sutter Basin, Yuba Basin/Marysville Ring Levee, and American River Common Features, used existing LMA budget estimates as part of identifying overall OMRR&R project cost projections. Comparisons of alternatives evaluated for these projects did not address OMRR&R costs other than to indicate such costs would vary.

## 4.2 Identification of True OMRR&R Costs

As described above, the costs identified in this TM are estimated to be the true long-term amounts necessary to conduct adequate and timely OMRR&R, which is often not occurring because of funding limitations associated with original system design deficiencies and years of deferred maintenance.

### 4.2.1 OMRR&R Cost Evaluation TM Scope and Key Assumptions

The estimated true long-term OMRR&R costs in this TM assume fully functioning facilities that meet applicable standards. Costs were generally categorized and identified in the following manner by Regional Flood Management Planning region and basin:

- Urban and rural levees
- Sediment removal
- Vegetation removal
- Small and major structures

As described in Chapter 4.0, Approach for Estimating Long-Term OMRR&R Costs, cost development was largely based on input provided by DWR, LMAs, and RFMP representatives.

***Costs Not Included in this OMRR&R Cost Evaluation TM***

Estimated OMRR&R costs identified in this TM do not account for necessary deferred maintenance and repairs (which are known to be substantial and are being evaluated under other efforts) required to address known design deficiencies. Key efforts, such as the RFMPs, the Conservation Strategy, and DWR grant programs, are currently focused on addressing deferred maintenance and repairs generally arising as a result of limited funding availability, changing regulatory standards, and increasing environmental requirements. RFMP-estimated costs to address both original system design deficiencies and deferred maintenance are included in their regional projects lists. These efforts will identify both local and regional solutions to "catch up" in support of a well-functioning flood management system. This TM focuses on the true cost of OMRR&R for the systems once the catch-up work is complete.

### 4.2.2 Data Sources of OMRR&R Costs

Recognizing the funding limitations and corresponding constraints on OMRR&R activities, the development of a true cost for OMRR&R on the SPFC must account for the fact that current OMRR&R activities and funding are in most cases less than is needed to assure all facilities are in and remain in good working order. In support of developing a true cost, the following information sources were reviewed and developed and incorporated:

- Annual LMA O&M information from the local agency annual reports prepared by DWR in accordance with AB 156
- DWR cost and sediment removal records and estimates for O&M of State facilities (Sacramento and Sutter maintenance yards)
- Long-term OMRR&R LMA questionnaire
- Direct input from DWR, regional, and LMA experts and staff
- State-owned mitigation site O&M costs
- Delta Levees Maintenance Subventions Program (Delta Subventions Program) cost data
- SRBPP cost data
- USACE and Ayers erosion inventory reports

- UCIP data
- Published data on habitat conservation plans and advance mitigation costs and savings
- Regional Flood Management Planning information and direct input from the six regional flood management groups
- Sacramento-San Joaquin Delta Conservancy project cost data

### 4.2.3 Regional Flood Management Planning Regions

Following adoption of the 2012 CVFPP, DWR launched a regional effort to help local agencies develop comprehensive RFMPs. The RFMPs describe local flood management priorities, challenges, and potential funding mechanisms, and define site-specific improvement needs. The RFMPs identified numerous projects and efforts, and they recommended implementation to account for original system design deficiencies and deferred maintenance. Additionally, RFMP representatives within the six regions (see Figure 1-2) were solicited for feedback, and they suggested revisions to preliminary unit cost estimates based on the initial LMA questionnaire, existing data, and representative input. Input received from regional representatives was the primary source of information for levee cost estimates. Information obtained from regional representatives and other experts was included where relevant and noted as source data, as appropriate, in Chapter 5.0 of this TM.

### 4.2.4 Cost Escalation of OMRR&R Data Sources

The data sources used to develop OMRR&R cost estimates varied with respect to timeframe and detail. Cost data obtained through the Delta Subventions Program, for example, dates back to 1987, and cost data received through the LMA questionnaire is from 2013 and 2014 in most cases. To reflect current market conditions (e.g., labor rates, material costs, and transportation costs), OMRR&R cost data were escalated to 2014 dollars as needed. The Engineering News Record Construction Cost Index 20 Cities average was implemented in the cost escalation process. Footnotes throughout Chapter 5.0 acknowledge where cost data have been escalated to 2014 dollars.

### 4.2.5 Breakdown of OMRR&R Costs

SPFC area facility OMRR&R costs were categorized as follows:

- Levees
  - Urban
  - Non-urban
- Channels
  - Sediment removal
  - Vegetation and debris removal
- Structures
  - Minor
  - Major

SPFC RR&R costs were categorized as follows:

- SPFC levees
  - Urban
  - Non-urban
- SPFC structures
  - Minor
  - Major
- SPFC channels
  - giant reed (*arundo donax*) removal

### 4.2.6 Classifying LMAs – Urban or Non-Urban

To classify LMAs as either urban or non-urban, relevant Urban and Non-Urban Levee Evaluation (ULE/NULE) Program project maps were used to identify the physical location of the

LMA. LMAs were classified as urban if any unit of the LMA levees underwent a ULE level of study. Otherwise, the LMA was classified as non-urban.

### 4.2.7 OMRR&R Job Categories

Costs resulting from OMRR&R activities conducted by LMAs and DWR are categorized as either routine or non-routine. Activities such as sediment removal are considered routine and non-routine depending on the amount of sediment needing removal and the availability of substantial funding and regulatory constraints. In general, non-routine costs result from activities that require RR&R of SPFC facilities. Table 4-1 identifies 18 categories that account for OMRR&R costs on the SPFC, and indicates whether each activity is considered routine, non-routine, or both.

**Table 4-1. LMA Job Categories and Rate of Occurrence**

| Job Category | | Rate of Occurrence |
|---|---|---|
| J1 | **Payroll**<br>salaries, benefits, worker's comp, and unemployment insurance | Routine |
| J2 | **District/Agency Overhead**<br>insurance, elections, and taxes | Routine |
| J3 | **Levee Vegetation Control**<br>burning, mowing, grazing, and dragging | Routine |
| J4 | **Rodent Control**<br>baiting, trapping, grouting, and backfilling | Routine |
| J5 | **Patrolling**<br>high-water patrols and security monitoring | Routine and non-routine |
| J6 | **Inspections**<br>every 90 days minimum | Routine |
| J7 | **Crown Roadways**<br>gravel replenishment and grading | Routine |
| J8 | **Encroachment Management**<br>fences, stairs, pipes, and remediation plans | Routine |
| J9 | **Minor Structure Maintenance**<br>gates, signs, concrete, flap gates, and stop logs/closure structures | Routine |
| J10 | **Major Restoration/Repair**<br>erosion repairs, pipe replacement, and seepage/stability | Non-routine |
| J11 | **Equipment Costs**<br>purchase, rentals, maintenance, and fuel | Routine |
| J12 | **Pumping Plants**<br>operations, maintenance, and repairs | Routine |
| J13 | **Environmental Compliance**<br>permits, memoranda of understanding, and regulatory fees not captured in other job categories | Routine[1] |
| J14 | **Instrumentation Maintenance**<br>piezometers and relief wells | Routine |
| J15 | **Channel Maintenance**<br>sediment, vegetation, and debris removal and maintenance | Routine and non-routine |
| J16 | **Urban Levee Design Criteria Requirements**<br>flood safety and security plans, vegetation evaluation and inspections, right-of-way and land use plans, and flood relief structure plans | Routine[2] |
| J17 | **Capital Replacement Fund**<br>Reserve fund to cover replacement of pipes, pumps, structures, equipment, and tools | Non-routine |
| J18 | **Emergency Reserve Fund**<br>contingency fund for unforeseen events | Routine |

*Source: Developed by Work Group.*

Notes:

1 Environmental compliance costs for non-routine repairs or replacements are included in those project costs.

2 For urban areas only.

### 4.2.8 Approach to Identifying SPFC O&M Costs

O&M costs were identified using direct input from each of the six regional planning entities, the LMA questionnaire, input from DWR staff (including results from ongoing OMRR&R programs), and data from the Delta Subventions Program. Urban and rural LMA levee O&M costs were separated to capture the additional costs associated with urban area LMAs. Costs were developed in coordination with the following entities:

- Urban
  - American River Flood Control District
  - KSN, Inc., and MBK Engineers representing various LMAs
  - Levee District 1 (Sutter)
  - Maintenance Area 3
  - Maintenance Area 4
  - Maintenance Area 5
  - Maintenance Area 7
  - Maintenance Area 9
  - Maintenance Area 16
  - Marysville Levee Commission
  - Merced Irrigation District
  - Reclamation District 404
  - Reclamation District 784
  - San Joaquin County Flood Control and Water Conservation District
  - Three Rivers Levee Improvement Authority

- Rural
  - Brannan-Andrus Levee Maintenance District
  - KSN, Inc., and MBK Engineers representing various LMAs
  - Levee District 9
  - Lower San Joaquin Levee District
  - Maintenance Area 1
  - Maintenance Area 12
  - Maintenance Area 13
  - Maintenance Area 17
  - Reclamation District 70
  - Reclamation District 108
  - Reclamation District 341
  - Reclamation District 730
  - Reclamation District 817
  - Reclamation District 1001
  - Reclamation District 1500
  - Reclamation District 1660
  - Reclamation District 2092
  - Reclamation District 2103
  - Sacramento River West Side Levee District

- Regional
  - Feather River Regional Flood Management Planning region
  - Mid and Upper Sacramento River Regional Flood Management Planning region
  - Lower Sacramento River/Delta North Regional Flood Management Planning region
  - Lower San Joaquin River/Delta South Regional Flood Management Planning region
  - Mid San Joaquin River Regional Flood Management Planning region
  - Upper San Joaquin River Regional Flood Management Planning region

The following summarizes the evaluation process used to identify appropriate data sources to develop true OMRR&R unit cost estimates.

***AB 156 Data Source***

As described in Section 4.1.1, AB 156 requires LMAs to report their O&M activities and costs to DWR annually. Data have been collected since 2008 and are the basis for a technical document (unpublished) assessing the cost of O&M on the SPFC. According to the *Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Protection System* (DWR, 2013b), over 90 percent of maintenance areas complied with AB 156 in 2011–2013, indicating a relatively robust cost data set. However, the AB 156 cost data are typically reported as one lump-sum total cost; are not verified; and, according to the *Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Protection System*, "the quality of reporting for some LMAs is also unsatisfactory" (DWR, 2013b).

Although AB 156 data were considered potentially unreliable, data for the 2008 through 2013 period were obtained and categorized into Sacramento or San Joaquin River Basin LMAs, and then further categorized according to urban and non-urban areas. LMAs were classified as urban if *any* unit of the LMA levees underwent a ULE level of study. Otherwise, the LMA was classified as non-urban.

Table 4-2 shows the number of LMAs that reported O&M budget information through AB 156.

**Table 4-2. LMAs Reporting AB 156 Data (2008 through 2013)**

| Year | No. of LMAs in AB 156 Data Set | Percent of LMA Areas Reported | Non-Urban | Urban |
|---|---|---|---|---|
| 2008 | 54 | 85 | 34 | 20 |
| 2009 | 71 | 79 | 53 | 18 |
| 2010 | 76 | 83 | 55 | 21 |
| 2011 | 81 | 92 | 58 | 23 |
| 2012 | 77 | 93 | 56 | 21 |
| 2013 | 90 | 95 | 67 | 23 |

*Source: AB 156 data as collected by DWR.*

AB 156 data varied greatly both annually and between LMAs. In general, the data were based on what funding was available as opposed to what was necessary to conduct all necessary activities. Reported costs from 2008 through 2013 varied substantially each year across the basins and categories. Accordingly, the Work Group determined the AB 156 data set was not an appropriate data source for developing cost estimates; and thus, other sources and methods of obtaining information should be used.

### *LMA Questionnaire and Job Categories*

The Work Group developed the LMA questionnaire (see Appendix B) to obtain specific information not available through the AB 156 data set. The LMA questionnaire is a data-gathering tool developed to gain a better understanding and categorize the line-item budgets of LMAs by requesting specific OMRR&R background information regarding the following:

- Height and length of levees maintained
- Use of in-house labor or contracted services
- Internal drainage facilities maintained
- OMRR&R activities performed and their rate of occurrence
- Special facilities, such as relief wells, piezometers, closure structures, or monitoring wells, maintained
- Special environmental permits or routine maintenance agreements
- Line-item budgets and actual costs for OMRR&R in the last 2 years

The LMA questionnaire was sent in May 2014 via email to all LMAs on the AB 156 contact list (107 in total). Responses to the questionnaire were accepted throughout the cost estimation process. Information was received from 10 urban and 15 non-urban LMAs in the Sacramento River Basin, and 2 urban LMAs in the San Joaquin River Basin. No non-urban LMAs from the San Joaquin River Basin responded to the questionnaire; as a result, the Work Group relied on direct interviews with non-urban districts and regional representatives to develop costs for the San Joaquin River Basin. Strict confidentiality was maintained during the collection and use of LMA budget information.

To develop a more detailed estimation of the true cost of OMRR&R on the SPFC, a detailed list of cost items was developed for processing LMA questionnaire-respondent information. The list includes specific OMRR&R job activities rolled into various job categories, as described in Table 4-1. All OMRR&R activities performed by LMAs on the SPFC fall into these categories. As LMAs responded to the questionnaire, individual LMA budgets were evaluated and each expense categorized according to the menu of cost items shown in Table 4-1. Many LMAs do not perform all OMRR&R activities shown in the table; some LMAs perform most activities, and others perform only a few. LMAs vary in size, geographic location, and infrastructure responsibility. Each LMA has flood control infrastructure in different states of serviceability and, therefore, organizes, accounts for, and plans OMRR&R activities in different ways.

However, after discussion and review with regional representatives, the data obtained through the questionnaire process were determined, in most cases, to reflect current spending given funding limitations versus true OMRR&R costs; therefore, the data were not used to identify estimated unit costs.

### *Delta Subventions Program*

The Delta Subventions Program is a cost-share program that provides technical and financial assistance to local LMAs in the Delta for the maintenance and rehabilitation of non-project and eligible project levees. The Delta Subventions Program is authorized by CWC Sections 12980 through 12995 and is managed by DWR. The Delta Subventions Program's purpose is to help LMAs with the costs associated with levee maintenance and rehabilitation. The Work Group analyzed claims data available for the Delta Subventions Program and noted that Delta levee districts, as a result of this State cost-shared program, annually and routinely analyze and rehabilitate deteriorating levees.

The Delta Subventions Program data set spans 1993/1994 to 2009/2010, and costs were escalated to 2014 dollars. Results showed the Delta levee LMAs spend slightly more, on average, than the LMAs reported through the questionnaire. Given the availability of multi-year data, and because the program provides LMAs with the ability to make repairs annually (allowing LMAs to proactively address maintenance issues rather than defer until an event occurs or funding becomes available), the Delta Subventions Program data were considered the most appropriate source for estimating urban and non-urban levee RR&R costs (in addition to regional input as discussed below). Results of the analysis are provided in Chapter 5.0.

### *Coordination with Regional Groups/Stakeholders and Review of RFMPs*

After the preliminary results were circulated and confirmed through the above reviews, the costs were then presented to DWR management, the CVFPB, and other stakeholders in 2015 and early 2016. Feedback obtained through these meetings revealed that many preliminary estimated costs, although much higher than existing costs, still appeared to be low and not capturing all true costs.

As a result, unit costs, deferred maintenance, and specific regional issues were reviewed and discussed with each of the six planning regions. Meetings were held with each of the regions to obtain input, and revisions were made and suggestions documented for each region to ensure costs were appropriately identified, as well as issues, concerns, and challenges. The results of these meetings and associated suggested revisions are incorporated throughout this TM, and specific suggested unit cost revisions are documented in Chapter 5.0.

The RFMP information included in the actual regional plans generally provided planning-level cost estimates related primarily to design deficiency and deferred maintenance projects within the SPFC area. Cost estimates for design deficiency and deferred maintenance issues are not the focus of this TM and, therefore, were not developed nor included as part of the overall OMRR&R estimate for this TM.

### *Channel Maintenance*

Channel maintenance activities including sediment, vegetation, and debris removal are conducted by DWR for the Sacramento River Flood Control Project and generally by LMAs in the San Joaquin Valley. Estimated costs for the Sacramento River Basin were developed by using historical projects overseen by DWR—which have occurred as funding has been available—and input from regional experts. Estimated costs for the San Joaquin River Basin were based on direct interviews with LMAs and staff, as well as consultant staff.

**Sediment Removal.** The Work Group relied on input from the regional group and data from historical sediment removal events obtained from FMO to develop costs for sediment removal from SPFC channels in the Sacramento River Basin. The data set spans 1983 to 2010, and costs were escalated to 2014 dollars. Costs for sediment removal vary greatly depending on site locations, amount of sediment to be removed, availability of spoil areas, and environmental clearances required. Sediment removal in the San Joaquin River Basin differs from sediment removal in the Sacramento River Basin; Sacramento River Basin channels cover a greater area, and volume of sediment needing removal is greater. Some dredging is required in the lower San Joaquin River and Delta areas, which can be more costly than typical channel sediment removal. Sediment removal cost estimates for the San Joaquin River Basin relied on LMA staff and regional input. Average costs per cubic yard are provided in Chapter 5.0.

**Vegetation and Debris Removal.** To estimate channel vegetation and debris removal costs, 2010 DWR vegetation and debris removal cost data were reviewed and escalated to account for 10 percent annual labor increases each year since 2010, and LMA staff and regional input was obtained. Some locations within SPFC channels require vegetation clearing to be performed by hand because of sensitive habitats and necessary regulatory approvals. Costs for channel vegetation and debris removal were categorized to account for work performed by hand versus machine. In general, channel maintenance activities performed by hand are more costly than those performed by mechanical means. Costs associated with removing highly invasive species such as giant reed and tree of heaven were found to be much higher than for most other vegetation—given the difficulty in removing fast-growing species—and are accounted for by estimating presence throughout the valley. It is also expected that with additional environmental restrictions and the increasing number of ecosystem restoration and mitigation projects in the system as the State Systemwide Investment Approach is built out and elements of the Conservation Strategy are implemented, there will likely be more hand clearing of vegetation in the future. Costs per acre for both hand- and machine-channel maintenance, including removal of giant reed in the Sacramento River Basin are provided in Chapter 5.0. Giant reed removal was categorized as an RR&R activity, as described further in Section 4.2.9.

Cost information for San Joaquin River Basin channel maintenance was obtained directly from LMA and consultant staff. Channel vegetation and debris removal costs in the San Joaquin River Basin are currently lower than in the Sacramento River Basin, given LMA-contracted costs in the San Joaquin River Basin are generally lower compared to DWR labor costs in the Sacramento River Basin. Removal of giant reed is also an issue in the San Joaquin Valley. Channel vegetation and debris removal costs per acre in the San Joaquin River Basin are provided in Chapter 5.0.

#### *Minor Structures*

Minor structures include stop log or gated closure structures, pumping plants, monitoring wells and piezometers, retaining walls and floodwalls, pipe penetrations, and encroachments. Routine O&M of these types of structures is critical, but often overlooked for budgeting purposes. As became evident in the LMA data received, LMAs typically only account for routine power costs for pumping plants and do not separately account for other activities associated with minor structures such as video inspections of pipes, lubrication and minor repairs of pipe closure valves, routine inspection and maintenance of closure structure gates or stop logs, and inspection and minor repairs of floodwalls. Costs for minor structure O&M are likely included in the

general overhead expenses for the LMAs who have structures, and no further estimates were developed. However, it is anticipated that video inspections of pipes will be required in the future (once every 5 years) for pipes crossing SPFC levees; and thus, these projected costs were included in the overall estimates.

**Pipeline Penetrations.** UCIP data were used to estimate the number of pipes crossing SPFC levees. The UCIP is an effort underway by DWR to conduct a systemwide inventory of levee penetrations (pipeline and utility crossings) to gather information regarding their location, geometry, age, material, and purpose. Field surveys are under way throughout the system to visually inspect each crossing and assess integrity of site conditions (DWR, 2014a). Pipe penetrations within the Sacramento and San Joaquin River systems include three different types of pipe crossings: (1) permitted utility crossings, (2) public drainage crossings necessary for the proper function of the SPFC operated and maintained by LMAs, and (3) unpermitted crossings. To adequately quantify long-term RR&R costs (discussed below) on these minor structures, the following determinations were made:

- Permitted crossings would not be included because they are privately operated and maintained according to CVFPB permits.
- All crossings for which LMAs could potentially be responsible for as part of the system would be included.
- Most of the unpermitted crossings are or would be abandoned and, because of the lack of permits or agreements associated with these older facilities, responsibility could potentially fall on LMAs to remove unpermitted crossings from their levees.

The UCIP identified 5,455 utility crossings, 1,514 of which are the responsibility of LMAs. Costs for these anticipated future requirements were developed by reviewing industry standards or estimates for pipe inspections. Average cost per year for pipe inspections is provided in Chapter 5.0 and further discussed under RR&R, Section 4.2.9.

***Major Structures***

Major structures involve those facilities described in CWC Section 8361 and administered by DWR, and include weirs, bypass outflow control structures, outfall gate facilities, and large regional pumping plants. FMO provided O&M cost data spanning 2000 to 2014 for structures maintained by the Sacramento Yard and 2010 to 2013 for structures maintained by the Sutter Yard. A data set was also obtained for the O&M of the major structures in the San Joaquin River system. After review of these data and discussions with maintenance agencies, it was determined that major structures in the SPFC are generally well maintained, and the costs developed for major structure O&M are reasonable estimates moving forward. Chapter 5.0 provides the average cost per year for the O&M of major structures in the SPFC.

### 4.2.9 Approach to Identifying SPFC RR&R Costs

RR&R activities are generally considered efforts that are non-routine and are beyond the scope of typical O&M such as major repairs and required facility or partial replacements, as well as ongoing channel maintenance, but are not in response to deferred maintenance. Examples of deferred maintenance costs (including those driven by original system design deficiencies) not

included in this OMRR&R Cost Evaluation TM include addressing SPFC "legacy" maintenance issues such as seepage and underseepage, which are due to poor levee embankment material and poor levee foundation material.

RR&R activities are often in response to significant flood events or the need for replacing equipment and facilities when they have exceeded their useful life. Typically, these costs are not budgeted by LMAs. In general, RR&R activities are costly and, depending on the specific feature, can require an LMA to seek outside funding. Information on RR&R activities and costs is limited, and the Work Group relied on data sets from the Sacramento Bank Protection Project, FSRP estimates, Delta Subventions Program, RFMPs, LMA questionnaire, and discussions with the regional flood management groups. In general, the regions agreed that using the Delta Subventions Program data as the primary source (as further described below) was appropriate.

The following summarizes the overall approach used to identify current RR&R costs for SPFC levees and structures. RR&R costs are anticipated to be relatively equivalent for both the Sacramento and San Joaquin River basins and, thus, were not categorized separately by basin.

#### *Levee RR&R*

As described above, levee-related RR&R costs have generally been driven by necessary flood-event repairs and known erosion or levee stability issues. The Work Group determined the Delta Subventions Program data set is the most robust data set for estimating RR&R cost on SPFC levees because the funding program has encouraged more regular analysis and repair of levees. The data set spans 1993/1994 to 2009/2010, and costs are escalated to 2014 dollars. The Work Group decided that the RR&R costs obtained from the Delta Subventions Program data should apply to all non-urban SPFC levees for unit cost estimating purposes. The LMA questionnaire provided the estimated cost for urban LMAs to comply with ULDC requirements. Although urban levees are being improved to a higher standard to meet urban level of protection standards, the Work Group concluded that repair and rehabilitation costs for urban and non-urban levees would not differ substantially, and the cost for ULDC compliance would be the only significant differentiating factor for RR&R of urban SPFC levees. Chapter 5.0 provides the overall estimated average cost for RR&R on urban and non-urban SPFC levees.

#### *Minor Structures RR&R*

As discussed above, minor structures such as stop logs or gated closure structures, monitoring wells and piezometers, retaining walls and floodwalls, pipes, and encroachments are typically accounted for in levee RR&R costs, except for pipes. Many of these pipes were installed before or during original project construction prior to the 1950s, but no plans were implemented to assure these facilities could be replaced when they exceed their useful life. As a result, many pipes have reached the end of their useful life, and many of these structures need repair, replacement, or proper pipe abandonment.

**Pipe Removal/Replacement.** Although pipe removal, repair, and replacement could be considered a deferred maintenance issue because numerous pipes require replacement due to their age, costs were identified in this TM to account for the fact that some pipes, even if replaced, will again exceed their useful life during the CVFPP planning horizon (30 years). Furthermore, all pipes will need to be replaced at some point in the future. Costs were included as part of the overall RR&R estimate given such costs are often not accounted for in current

OMRR&R budgets and were not specifically identified in the RFMPs. These RR&R costs were annualized to an anticipated 50-year facility life to account for the continual need to replace pipes when they have reached the end of their useful life or have deteriorated beyond the point of repair. Planning for future replacement costs on an annualized basis should help the system avoid encountering a significant backlog of deferred replacement costs in the future.

As described above, UCIP identified 5,455 utility crossings, 1,514 of which are potentially the responsibility of LMAs. It was assumed that an estimated 90 percent of the potential LMA-responsibility pipes (1,362) need to be repaired or replaced in the next 20 years; and, furthermore, 912 privately owned crossings would be abandoned and potentially left for LMAs to remove. FMO provided cost information for recent levee-pipe-crossing projects that was used to determine costs for pipe removal and pipe replacement or abandonment. These costs were verified as appropriate in LMA interviews. The results for estimated average cost on minor structures are provided in Chapter 5.0.

Because of the complexity of quantifying and estimating long-term RR&R costs for other minor structures, including stop logs, gates, monitoring wells, and piezometers, and the apparently low cost for RR&R on these minor structures relative to pipe crossings on a systemwide basis, detailed estimates were not developed. It is, however, recommended that LMAs account for their facilities and include repair and replacement funds to ensure adequate reserves are available in the future to make needed repairs or replace aged facilities.

#### *Major Structures RR&R*

Discussions with DWR and LMA staff indicated major structures have historically been repaired and well maintained, and there is no immediate need to repair, replace, or rehabilitate these facilities. RR&R costs were not identified for this TM because it was assumed major structures would not require significant repairs over the next 50 years. However, it is recommended that funding reserves be established to ensure adequate funding is available in the future to continue making needed repairs or to replace aged facilities.

#### *Channel RR&R – Removal of Aggressive Invasive Vegetation*

Giant reed removal was considered an RR&R activity because it is much more costly than other vegetation management activities, and giant reed becomes established in large areas quickly. Giant reed needs to be cut near the root and treated with a herbicide, and treatments may need to be repeated. The cost varies greatly, depending on the density of the vegetation and the intensity of the treatment required for removal. Costs per acre for removing giant reed in the Sacramento and San Joaquin River basins are provided in Chapter 5.0.

#### *Emergency Repairs*

In addition to planning and accounting for RR&R of known facilities, there is also a growing need to plan for funding emergency repair projects historically funded through PL 84-99. This is because less funding is being made available through PL 84-99 for less severe flood events, and criteria used by USACE to determine PL 84-99 eligibility continues to be rigorous. Additionally, RR&R costs through federal programs are now being evaluated to determine if the benefits outweigh the costs of these projects. With increasing levee repair costs and lack of quantifiable multi-benefits, especially in the rural areas, projects are less likely to qualify for federal funding assistance after flood events, leaving the State and local agencies to fund these projects. Grant

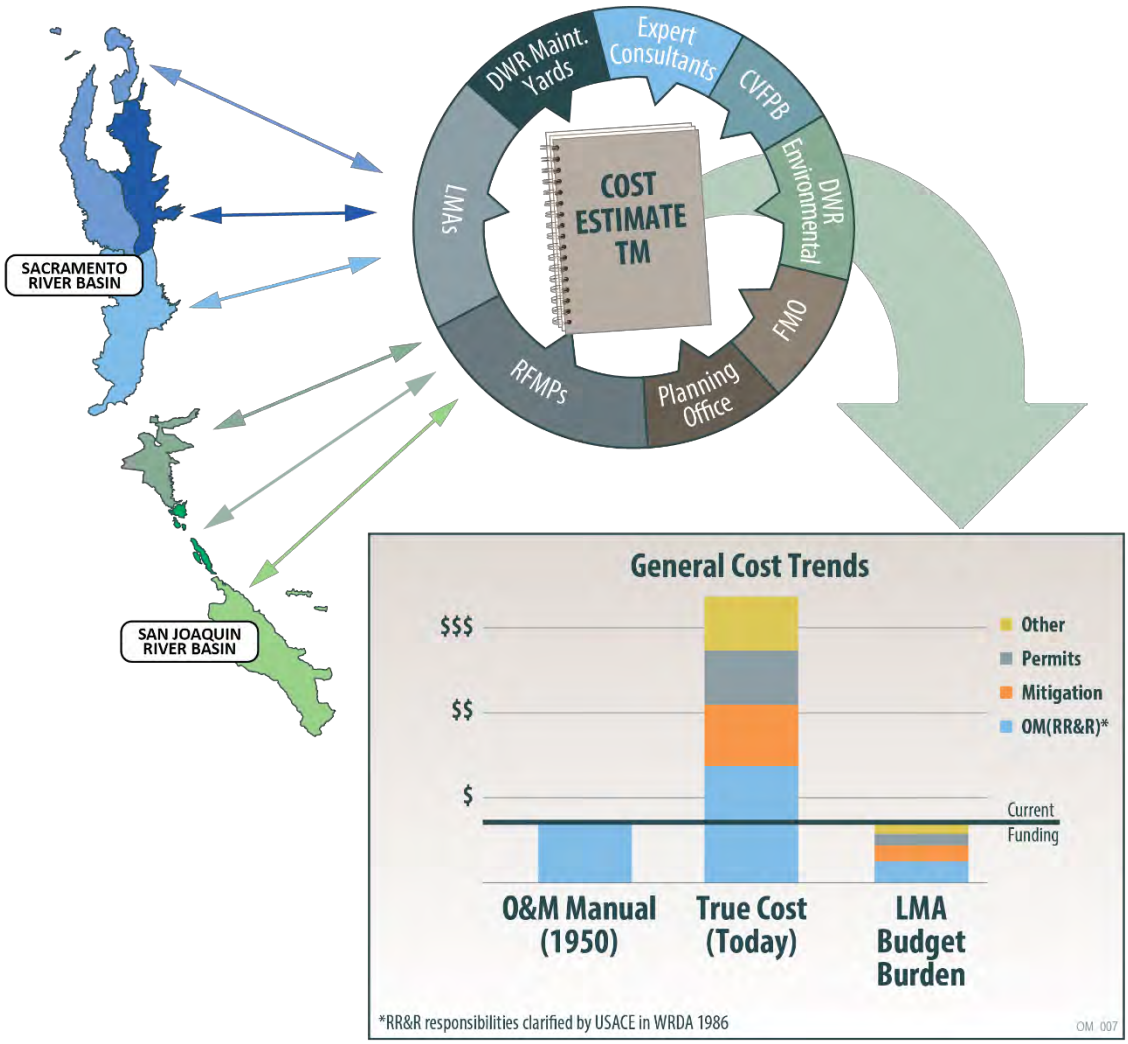
programs that provide financial incentives will be an important tool in advancing multi-benefit projects. The additional requirements of habitat creation and subsequent maintenance and monitoring of that habitat are benefits of statewide and national importance; therefore, those costs should not be the responsibility of the local agencies.

Fortunately, review of several recent emergency repair projects indicates that the actual costs of the repairs are not substantially different than if the work were performed prior to the emergency arising. Flood fighting and additional site monitoring results in additional costs, but often, emergency repairs result in more rapid permitting and transactional activities, which may reduce costs. Regardless of the minor increases or decreases in costs, it is strongly recommended that reserve funds be established to cover unforeseen RR&R costs such as flood damages.

### 4.2.10 Transactional Costs

Historically, DWR and LMAs have not separated transactional costs in their records, and few examples of the contribution that transactional costs make to overall O&M costs were available. The environmental compliance component of O&M transactional costs is similarly difficult to quantify because it is often embedded and tracked within design, supervision, and administration tasks. Issue Summary #2, Environmental Compliance and Other Transactional Costs, in Appendix A describes the limited cost information that was available, and discusses environmental permitting and mitigation, including programmatic or “long-term” permitting and advance mitigation approaches.

# 5.0 Sacramento and San Joaquin OMRR&R Costs




## 5.1 Background

This chapter provides the results of data compilation and analysis used to identify OMRR&R costs for the SPFC in the Sacramento and San Joaquin River basins. Costs are identified in terms of O&M and RR&R in the following categories:

- Operation and Maintenance (O&M)
  - Levee maintenance (urban and non-urban)
  - Sediment removal

  - Vegetation removal
  - Minor structures
  - Major structures

- Repair, Rehabilitation, and Replacement (RR&R)
  - Levees (urban and non-urban)
  - Vegetation removal
  - Minor structures
  - Major structures

The analysis, assumptions, and results are presented in terms of unit costs (e.g., dollars per mile to maintain existing levees) and anticipated total annual costs across the SPFC. Table 5-1 summarizes the development and identification of long-term OMRR&R unit costs by the categories listed above. As mentioned in Section 5.2, OMRR&R cost data were escalated to 2014 dollars as appropriate.

Available data and discussions with LMAs (including DWR maintenance yards, sometimes referenced simply as "yards") revealed the following key findings and factors that influence SPFC OMRR&R costs:

- True OMRR&R costs estimated to be necessary to keep SPFC facilities in proper working order are significantly higher than current spending, primarily due to funding limitations and evolving standards. O&M and RR&R costs are generally greater in years of higher flows to account for cleanup, minor repairs, and increased monitoring, patrol, and engineering costs associated with minor rehabilitation or repairs.

- Replacement of legacy pipes that pass through or under a levee that have exceeded their useful life will result in significant costs in the near term and continued annual long-term costs.

- LMA budgets are significantly affected by the rising costs of labor and benefits that can account for nearly half the overall budget for some districts reporting labor.

- Transactional costs including engineering design, construction management, real estate, surveys, and environmental compliance continue to rise.

- RR&R is a relatively new cost to the State and LMAs given the passage of the WRDA 1986.

**Table 5-1. Long-Term SPFC OMRR&R Unit Costs**

| Description | Range of Cost[1] | Approach | Estimated Unit Cost | Unit (Levee Mile)[2] | Estimated Total Annual Cost |
|---|---|---|---|---|---|
| **Sacramento River Basin Levee Operations and Maintenance (O&M)** | | | | | |
| **Urban Levees** | | | | | |
| Mid-Upper Sacramento River | $7,984 – $74,649/mile | Unit cost of $58,000/mile identified by adjacent Feather River region is based on cost projections required to support all necessary O&M activities and agreed appropriate by Mid-Upper Sacramento River region. | $58,000 | 10.5 | $609,000 |
| Feather River | $7,893 – $74,649/mile | Unit cost of $58,000/mile identified by Feather River region is based on cost projections required to support all necessary O&M activities. | $58,000 | 101.7 | $5,898,600 |
| Lower Sacramento River / Delta North | $17,877 – $82,000/mile | Unit cost of $58,000/mile identified is based on averaging range-of-costs input received from the region in addition to an evaluation-based estimate provided by adjacent Feather River region. | $58,000 | 148.0 | $8,584,000 |
| **Non-Urban Levees** | | | | | |
| Mid-Upper Sacramento River | $5,324 – $61,252/mile | Unit cost of $46,000/mile identified by adjacent Feather River region is based on cost projections required to support all necessary O&M activities and agreed appropriate by Mid-Upper Sacramento River region. | $46,000 | 335.6 | $15,437,600 |
| Feather River | $2,796 – $61,252/mile | Unit cost of $46,000/mile identified by Feather River region is based on cost projections required to support all necessary O&M activities. | $46,000 | 163.4 | $7,516,400 |
| Lower Sacramento River / Delta North | $6,642 – $82,000/mile | Unit cost of $46,000/mile identified is based on range-of-costs input received from the region in addition to an evaluation-based estimate provided by adjacent Feather River region. | $46,000 | 330.9 | $15,221,400 |
| **Channel Sediment Removal** | | | | **Unit (CY)[2]** | |
| Mid-Upper Sacramento River | $2.30 – $25.84/CY | Cost information for Sacramento River Basin ranged from $2.30 to $25.84/CY from the historical data analysis (1983–2010) of sediment removal events across the three RFMP regions; average of most recent (since 2006) years is $10/CY according to FMO records. | $10.00 | 375,000 | $3,750,000 |
| Feather River | (Same as above) | (Same as above.) | $10.00 | 25,000 | $250,000 |
| Lower Sacramento River / Delta North | (Same as above) | (Same as above.) | $10.00 | 150,000 | $1,500,000 |
| **Channel Vegetation and Debris Removal** | | | | **Unit (Acre)[2]** | |
| Mid-Upper Sacramento River | $530 – $1,490/acre | FMO cost records for channel vegetation management in the Sacramento Valley indicate an average cost of $530/acre and a maximum of $1,167/acre for machine clearing; hand-clearing average is $1,490/acre with a maximum of $2,333/acre. Unit cost is the average of the range between machine and hand-clearing costs. | $1,000 | 1,500 | $1,500,000 |
| Feather River | (Same as above) | (Same as above.) | $1,000 | 1,500 | $1,500,000 |
| Lower Sacramento River / Delta North | (Same as above) | (Same as above.) | $1,000 | 1,500 | $1,500,000 |
| **Minor Structures O&M** | | | | **Unit (Pipe)[2]** | **Total Annual Cost (Averaged over 5 Years)** |
| Mid-Upper Sacramento River | $300 – $3,500/once every 5 years | Majority of minor structures O&M costs are captured within routine levee O&M costs identified above other than pipe inspections. Cost estimates for video inspection of pipes ranged from $300 to $3,500/pipe (conducted once every 5 years) with an average of $2,000/pipe inspection. | $2,000 (per pipe every 5 years) | 306 | $122,400 |
| Feather River | (Same as above) | (Same as above.) | $2,000 (per pipe every 5 years) | 172 | $68,800 |
| Lower Sacramento River / Delta North | (Same as above) | (Same as above.) | $2,000 (per pipe every 5 years) | 218 | $87,200 |
| **Major Structures O&M** | | | | **Unit (Year)** | |
| Mid-Upper Sacramento River | $405,211 – 553,493 (Sutter Yard); $2,587 – $157,667 (Sacramento Yard) | O&M data for Sutter maintenance yard (available 2010–2013) indicate an average annual cost of $470,968; Sacramento maintenance yard O&M data (available 2000–2014) indicate an average annual cost of $58,854. Total average annual cost of the two yards is $529,822 (rounded to $530,000). | $530,000 | 1 | $530,000 |
| Feather River | - | NA (no major structures exist within this region). | - | - | - |
| Lower Sacramento River / Delta North | - | NA (no major structures exist within this region). | - | - | - |

**Table 5-1. Long-Term SPFC OMRR&R Unit Costs**

| Description | Range of Cost[1] | Approach | Estimated Unit Cost | Unit (Levee Mile)[2] | Estimated Total Annual Cost |
|---|---|---|---|---|---|
| **San Joaquin River Basin Levee Operations and Maintenance (O&M)** | | | | | |
| **Urban Levee O&M** | | | | | |
| Lower San Joaquin River / Delta South | $50,000/mile | Unit cost of $50,000/mile identified by regional representatives is based on cost projections required to support all necessary O&M activities. | $50,000 | 73.1 | $3,655,000 |
| Mid San Joaquin River | - | NA (no urban levees exist within the region). | NA | 0.0 | - |
| Upper San Joaquin River | $50,000/mile | Unit cost of $50,000/mile identified by Lower San Joaquin River/Delta South regional representatives is based on cost projections required to support all necessary O&M activities and agreed appropriate by Upper San Joaquin River region. | $50,000 | 1.7 | $85,000 |
| **Non-Urban Levee O&M** | | | | | |
| Lower San Joaquin River / Delta South | $33,000/mile | Input from regional representatives indicated that although costs may be closer to $50,000/mile (same as urban), relatively lower risk and spreading of costs annually would result in a unit cost of approximately $33,000/mile. | $33,000 | 108.9 | $3,593,700 |
| Mid San Joaquin River | $33,000/mile | Unit cost of $33,000/mile identified by Lower San Joaquin River/Delta South regional representatives is based on cost projections required to support all necessary O&M activities and agreed appropriate by Mid San Joaquin River region. | $33,000 | 52.1 | $1,719,300 |
| Upper San Joaquin River | $33,000/mile | Unit cost of $33,000/mile identified by Lower San Joaquin River/Delta South regional representatives is based on cost projections required to support all necessary O&M activities and agreed appropriate by Upper San Joaquin River region. | $33,000 | 367.7 | $12,134,100 |
| **Channel Sediment Removal** | | | | | |
| Lower San Joaquin River / Delta South | $2.50 – $36.55/CY | Cost information from the region indicated wet channel dredging cost of $36.55/CY (2014 dollars). Additional communications indicated costs as low as $2.50/CY. Unit cost determined to be average of the range. | $20.00 | 60,000 | $1,200,000 |
| Mid San Joaquin River | $2.50 – $10.00/CY | Range of costs varied from a low of $2.50/CY based on communication with LMAs (agreed by Work Group to not account for all costs) to $10.00 CY provided in Sacramento Basin. Selected unit cost determined to be the average of the range. | $6.25 | 25,000 | $156,250 |
| Upper San Joaquin River | (Same as above) | (Same as above.) | $6.25 | 25,000 | $156,250 |
| **Channel Vegetation and Debris Removal** | | | | **Unit (Acre)[2]** | |
| Lower San Joaquin River / Delta South | $330 – $1,490/acre | (Unit cost agreed to be the same as Sacramento River Basin.) | $1,000 | 300 | $300,000 |
| Mid San Joaquin River | (Same as above) | (Same as above.) | $1,000 | 300 | $300,000 |
| Upper San Joaquin River | (Same as above) | (Same as above.) | $1,000 | 300 | $300,000 |
| **Minor Structures O&M** | | | | **Unit (Pipe)[2]** | **Total Annual Cost (Averaged over 5 Years)** |
| Lower San Joaquin River / Delta South | $300 – $3,500/every 5 years | Majority of minor structures O&M costs are captured within routine levee O&M costs identified above other than pipe inspections. Cost estimates for video inspection of pipes ranged from $300/pipe to $3,500/pipe (conducted once every 5 years) with an average of $2,000/pipe inspection. | $2,000 (per pipe every 5 years) | 412 | $164,800 |
| Mid San Joaquin River | (Same as above) | (Same as above.) | $2,000 (per pipe every 5 years) | 80 | $32,000 |
| Upper San Joaquin River | (Same as above) | (Same as above.) | $2,000 (per pipe every 5 years) | 326 | $130,400 |
| **Major Structures O&M** | | | | **Unit (Year)** | |
| Lower San Joaquin River / Delta South | $38,742 – $70,000/year | Information provided by regional representative indicated a range of $38,742 to $70,000/year for structures in the region; the regional information provided suggested using the higher end of the range ($70,000/year). | $70,000 | 1 | $70,000 |
| Mid San Joaquin River | - | (No major structures exist within the region.) | - | 1 | - |
| Upper San Joaquin River | $21,760 – $83,721/year | Information provided by regional representatives. The majority of major structures in the region are located in the Lower San Joaquin Levee District. Selected unit cost determined to be the average of the range. | $51,100 | 1 | $51,100 |

**Table 5-1. Long-Term SPFC OMRR&R Unit Costs**

| Description | Range of Cost[1] | Approach | Estimated Unit Cost | Unit (Levee Mile)[2] | Estimated Total Annual Cost |
|---|---|---|---|---|---|
| **Sacramento and San Joaquin River Basins Repair, Replace, and Rehabilitate (RR&R)** | | | | | |
| **Urban Levee RR&R** | | | | | |
| Mid-Upper Sacramento River | $1,944 – $21,811 | The urban LMA RR&R unit cost estimate includes the non-urban LMA average cost per mile obtained through the Delta Subventions Program of $13,000/mile and the ULDC average cost per mile of $4,375/mile rounded up to $5,000/mile, for a total of $18,000/mile. | $18,000 | 10.5 | $189,000 |
| Feather River | (Same as above) | (Same as above.) | $18,000 | 101.7 | $1,830,600 |
| Lower Sacramento River / Delta North | (Same as above) | (Same as above.) | $18,000 | 148.0 | $2,664,000 |
| Lower San Joaquin River / Delta South | (Same as above) | (Same as above.) | $18,000 | 73.1 | $1,315,800 |
| Mid-San Joaquin River | NA | (No urban levees exist within the region.) | $18,000 | 0.0 | - |
| Upper San Joaquin River | (Same as Sacramento River Basin) | (Same as Sacramento River Basin.) | $18,000 | 1.7 | $30,600 |
| **Non-Urban Levee RR&R** | | | | **Unit (Levee Mile)[2]** | |
| Mid-Upper Sacramento River | $6,239 – $21,811 | The non-urban LMA RR&R unit cost estimate includes the non-urban LMA average cost per mile obtained through the Delta Subventions Program of $13,000/mile. | $13,000 | 335.6 | $4,362,800 |
| Feather River | (Same as above) | (Same as above.) | $13,000 | 163.4 | $2,124,200 |
| Lower Sacramento River / Delta North | (Same as above) | (Same as above.) | $13,000 | 330.9 | $4,301,700 |
| Lower San Joaquin River / Delta South | (Same as above) | (Same as above.) | $13,000 | 108.9 | $1,415,700 |
| Mid San Joaquin River | (Same as above) | (Same as above.) | $13,000 | 52.1 | $677,300 |
| Upper San Joaquin River | (Same as above) | (Same as above.) | $13,000 | 367.7 | $4,780,100 |
| **Channel Giant Reed Removal** | | | | **Unit (Acre)[2]** | |
| Mid-Upper Sacramento River | $7,000 – $10,000 | Sources included meetings with regional representatives and information from FMO. No LMAs reported costs. Giant reed removal estimated cost range is from $7,000 to $10,000/acre based on FMO input. Upper end of was range chosen for unit cost given other regions identified costs as high as $25,000/acre. | $10,000 | 28 | $280,000 |
| Feather River | (Same as above) | (Same as above.) | $10,000 | 17 | $170,000 |
| Lower Sacramento River / Delta North | $7,000 – $20,000 | Sources included meetings with regional representatives and information from FMO. No LMAs reported costs. Giant reed removal cost is estimated at $7,000 to $20,000/acre based on regional input. Upper end of range was chosen for unit cost given other regions identified costs as high as $25,000/acre. | $20,000 | 6 | $120,000 |
| Lower San Joaquin River / Delta South | $330 – $25,000/acre | Regional input indicated giant reed removal cost at $25,000/acre. | $25,000 | 4 | $100,000 |
| Mid San Joaquin River | (Same as above) | (Same as above.) | $25,000 | 0 (no giant reed reported in this region) | $0 |
| Upper San Joaquin River | (Same as above) | (Same as above.) | $25,000 | 18 | $450,000 |
| **Minor Structures RR&R** | | | | **Total Units (Pipe) Replaced Annually[2]** | **Total Annual Cost (Averaged over 30 Years)[3]** |
| Mid-Upper Sacramento River | NA | UCIP data were used to estimate that 2,274 SPFC levee pipe penetrations required replacement. The cost for pipe removal and replacement is based on FMO's estimate of $240,000/pipe. The total cost of replacing the identified pipes is estimated to be $545,760,000. Replacement is assumed to occur over a 30-year period, which would result in an annual replacement cost of $18,192,000 across the SPFC. | $240,000 | 12–13 | $3,008,000 |
| Feather River | (Same as above) | (Same as above.) | $240,000 | 8–9 | $2,024,000 |
| Lower Sacramento River / Delta North | (Same as above) | (Same as above.) | $240,000 | 19–20 | $4,648,000 |
| Lower San Joaquin River / Delta South | (Same as above) | (Same as above.) | $240,000 | 20–21 | $4,920,000 |
| Mid San Joaquin River | (Same as above) | (Same as above.) | $240,000 | 3–4 | $752,000 |
| Upper San Joaquin River | (Same as above) | (Same as above.) | $240,000 | 11–12 | $2,840,000 |

**Table 5-1. Long-Term SPFC OMRR&R Unit Costs**

| Description | Range of Cost[1] | Approach | Estimated Unit Cost | Unit (Levee Mile)[2] | Estimated Total Annual Cost |
|---|---|---|---|---|---|
| **Major Structures RR&R** | | | | **Unit (year)** | |
| Mid-Upper Sacramento River | NA | Consistent scheduled O&M of major structures within the SPFC indicates no RR&R is required other than the potential for significant capital cost associated with total replacement. The Work Group determined such replacement costs would need to made in the future on a case-by-case basis. | - | - | - |
| Feather River | (Same as above) | (Same as above.) | - | - | - |
| Lower Sacramento River / Delta North | (Same as above) | (Same as above.) | - | - | - |
| Lower San Joaquin River / Delta South | (Same as above) | (Same as above.) | - | - | - |
| Mid San Joaquin River | (Same as above) | (Same as above.) | - | - | - |
| Upper San Joaquin River | (Same as above) | (Same as above.) | - | - | - |

*Source: Developed by Work Group.*
Key:
CY = cubic yard
NA = none available
Notes:
1 Sources for cost estimates included the LMA questionnaires received within the region (which generally were determined in coordination with regions to be more indicative of existing costs rather than true needed cost to ensure facilities remained in good working order), DWR maintenance staff, Delta Subventions Program data, and regional LMA staff and consultants. Reported costs ranged significantly for some categories; the approach to identification of selected unit costs is provided for each category.
2 Unit totals developed for each region are based on available data and estimates where available.
3 Annual costs account for minor rounding errors associated with estimating the number of annual pipe penetration replacements.

## 5.2 O&M Costs

As identified in Chapter 4.0, Approach for Estimating Long-Term OMRR&R Costs, numerous sources were used to estimate SPFC O&M costs. These sources included direct input from RFMP (regional) representatives; communication with DWR and LMA staff and associated review of program costs, records, and estimates; and Delta Subventions Program claims data.

### 5.2.1 Levee Maintenance – Data Sources

***LMA Questionnaire and Interviews with LMAs***

As discussed in Chapter 4.0, 27 LMAs responded to the LMA questionnaire, with the majority of the responses being received from LMAs in the Sacramento River Basin including all State maintenance areas. The Work Group subsequently contacted numerous LMAs within both the Sacramento and San Joaquin River basins to obtain information (particularly for the San Joaquin River Basin) and verify questionnaire responses. Results from the LMA questionnaire are presented in Sections 5.2.1 and 5.3.1. These costs in general were determined to be what districts are currently spending with limited funding, but do not represent necessary spending levels to fully maintain their facilities.

***Delta Subventions Program Data***

The Delta Subventions Program is designed to help LMAs with the cost of levee maintenance and rehabilitation. Summary data for annual claims were obtained from the ongoing Delta Subventions Program and analyzed to assist in developing an appropriate estimate for current levee O&M costs and RR&R costs, which are discussed in Section 5.3. These data, using costs dating back to 1993/1994 and escalated to 2014 dollars, result in an average cost-per-levee mile of $12,750, rounded up to $13,000 per levee mile, for routine levee O&M. These results were fairly consistent with the LMA questionnaire average for the Sacramento River Basin non-urban LMAs ($11,373 per levee mile) and further support these findings. Subsequent discussions with regional representatives indicated these data underestimated costs required to conduct full proper maintenance.

***Input from Regional Representatives***

Input from each of the six RFMP representatives was critical to developing unit costs and annual cost estimates, as they are most familiar with the day-to-day activities of managing their facilities and local system. Regional representatives were engaged through direct meetings, email correspondence, and phone interviews. Where information was available, regions provided input (e.g., levee O&M cost per mile) or concluded that costs developed in adjacent areas represented an accurate and appropriate estimate of costs for their region.

### 5.2.2 Levee O&M – Urban

***Sacramento River Basin Urban LMAs***

LMA questionnaire results indicated that urban LMAs in the Sacramento River Basin currently spend an average of approximately $21,300 per levee mile per year on O&M, ranging from $8,102 to $53,296. In addition to routine O&M costs, several districts also reported channel

maintenance and RR&R costs, which are discussed in subsequent sections. As was the case for non-urban levees, reported urban levee O&M costs in general were determined to be what districts are currently spending rather than what is necessary to fully maintain their facilities.

Regional input revealed estimated costs of true O&M were higher than identified through the initial questionnaire review and coordination process. Estimates of true O&M costs provided by regional representatives ranged from $53,104 to $82,000 per levee mile for urban levee O&M. These costs were based on input from the Lower Sacramento – Delta North regional LMAs and detailed estimates being developed in the Feather River region. As shown in Table 5-1, an average cost of $58,000 per mile was determined appropriate, based primarily on estimates provided by the Feather River region and agreed appropriate by the other two regions in the basin.

### *San Joaquin River Basin Urban LMAs*

Prior to meeting with RFMP representatives across the San Joaquin River Basin, the Work Group obtained cost information from two urban districts as no questionnaires were received from urban LMAs. Through the interview process, it was determined that average annual San Joaquin River Basin urban levee O&M costs were approximately $32,600 per levee mile with a range of $20,403 to $44,765 per levee mile.

Similar to the Sacramento River Basin, San Joaquin River Basin regional input regarding costs for urban levee O&M was higher than the average of the questionnaire data. Estimates of true O&M cost provided by regional representatives within the San Joaquin River region were approximately $50,000 per levee mile (other than Mid San Joaquin River, which contains no urban SPFC facilities). These costs were based on current estimates being developed for San Joaquin Area Flood Control Agency and River Islands.

### *Urban Levee O&M by Region*

Table 5-2 categorizes urban levee O&M cost estimates by region.

**Table 5-2. Urban Levee O&M Cost Estimates by Region**

| Region | Estimated $/Levee Mile[1] | Levee Miles[2] | Estimated Annual Cost |
|---|---|---|---|
| Mid-Upper Sacramento River | $58,000 | 10.5 | $609,000 |
| Feather River | $58,000 | 101.7 | $5,898,600 |
| Lower Sacramento River / Delta North | $58,000 | 148.0 | $8,584,000 |
| Lower San Joaquin River / Delta South | $50,000 | 73.1 | $3,655,000 |
| Mid San Joaquin River | NA | 0.0 | - |
| Upper San Joaquin River | $50,000 | 1.7 | $85,000 |
| | **Total** | **335.0** | **$18,831,600** |

Notes:
1 Unit cost estimates were provided and/or confirmed by RFMP regional representatives.
2 Levee lengths are based on the December 31, 2011, version of the California Levee Database (DFM_CALeveeDatabase_v3.0_R1_20111231_10.mdb) and RFMP boundaries.

### 5.2.3 Levee O&M – Non-Urban

***Sacramento River Basin Non-Urban LMAs***

Questionnaire results indicated that non-urban LMAs in the Sacramento River Basin currently spend an average of approximately $11,400 per levee mile per year on O&M, with costs ranging from $2,796 to $28,468 per levee mile across districts. Other reported costs included channel maintenance, RR&R, and ULDC, which are discussed in subsequent sections. Input regarding true costs received from non-urban levee O&M was found to be significantly higher than indicated by questionnaire data. Regional representatives estimated costs at $46,000 per levee mile for each region. These costs were based on a detailed evaluation conducted in the Feather River region.

***San Joaquin River Basin Non-Urban LMAs***

The Work Group received limited responses to the LMA questionnaire in the San Joaquin River Basin. Limited input initially indicated districts were spending approximately $5,000 per levee mile. Input provided by RFMP representatives in the Lower San Joaquin study area indicated true costs for non-urban levee O&M were significantly higher than the limited questionnaire and additional data obtained. True costs were suggested to be approximately $33,000 per levee mile for the regions within the San Joaquin River Basin, with subsequent RFMP planning regions agreeing this number was an appropriate estimate.

***Non-Urban Levee O&M by Region***

Non-urban levee O&M cost estimates are categorized by region in Table 5-3.

**Table 5-3. Non-Urban Levee O&M Cost Estimates by Region**

| Region | Estimated $/Levee Mile[1] | Levee Miles[2] | Estimated Annual Cost |
|---|---|---|---|
| Mid-Upper Sacramento River | $46,000 | 335.6 | $15,437,600 |
| Feather River | $46,000 | 163.4 | $7,516,400 |
| Lower Sacramento River / Delta North | $46,000 | 330.9 | $15,221,400 |
| Lower San Joaquin River / Delta South | $33,000 | 108.9 | $3,593,700 |
| Mid San Joaquin River | $33,000 | 52.1 | $1,719,300 |
| Upper San Joaquin River | $33,000 | 367.7 | $12,134,100 |
| | **Total** | **1,358.6** | **$55,622,500** |

Notes:
1 Unit cost estimates were provided and/or confirmed by RFMP regional representatives.
2 Levee lengths are based on the December 31, 2011, version of the California Levee Database (DFM_CALeveeDatabase_v3.0_R1_20111231_10.mdb) and RFMP boundaries.

### 5.2.4 Channel Maintenance

Channel maintenance costs, including sediment, vegetation, and debris removal were developed separately with data sets specific to these O&M activities. Channel maintenance is conducted by DWR in the Sacramento River Basin and generally by LMAs in the San Joaquin River Basin. Estimated costs were developed based on FMO project information escalated to 2014 dollars and input from regional representatives. In general, channel maintenance activities have occurred as

funding has been available or in response to significant flood events. Cost summaries received through the LMA questionnaire were not used given the limited data received.

### *Sediment Removal*

Sediment removal costs were based on information provided by DWR maintenance staff including project costs documented through the Sacramento and Sutter maintenance yards. Sediment removal has been largely event driven, and has been greatly influenced by site characteristics and funding availability. On average, approximately 500,000 CY of sediment are removed each year. Data prior to 2005 in general include only construction costs and do not include transactional costs. Since 2006, DWR has tracked all associated costs. As shown in Table 5-4, sediment removal costs have averaged approximately $10.00/CY, including transactional costs. The hauling and disposal of sediment can represent a significant portion of total project cost and can be a major driver of overall costs. In general, DWR has been able to reduce such costs given sediment has generally been either hauled to relatively adjacent State-owned lands, or accepted by local LMAs or other entities. Issue Summary #7, Cost of Sediment Removal in the State Plan of Flood Control, in Appendix A discusses sediment removal challenges further.

**Table 5-4. Sediment Removal Average Costs Per Cubic Yard[1]**

| Description | Amount |
|---|---|
| Average Cost Per Cubic Yard (Recent Years) after 2006 | $10.00[2] |
| Minimum Cost Per Cubic Yard (1987 and 1991) | $2.30 |
| Maximum Cost Per Cubic Yard (2009) | $20.88 |

*Source: Historical sediment removal data as collected by DWR.*

Notes:

1 Cost data were escalated to 2014.

2 Costs since 2006 account for all costs including transactional costs.

Sediment removal costs in the San Joaquin River Basin vary by region and, similar to the Sacramento River Basin, are driven by unique site conditions and funding availability. Given sediment removal is conducted by numerous LMAs and not tracked at the basin level, an estimate was developed to support the development of projected costs. Approximately 108,000 CY of sediment were assumed to be removed annually from the San Joaquin River Basin based on extrapolating estimates provided by the Lower San Joaquin Levee District (LSJLD). LSJLD includes approximately 14 percent of the channel acreage in the San Joaquin River Basin and has removed an average of 15,100 CY from their area of responsibility from 2006 to 2014. Assuming similar removal amount conducted throughout the remainder of the basin, 107,857 CY of sediment are estimated to be removed annually across the San Joaquin River Basin.

Although sale of sediment (sand) can be a source of revenue for some districts, it is more common for San Joaquin River Basin LMAs to incur cost for sediment removal. San Joaquin River Basin LMAs identified a wide range of unit cost from $2.50 to $36.55/CY, with the higher end of the range attributed to in-water sediment removal (dredging) and disposal costs in the Delta area. Sediment disposal costs were suggested to be a potential significant factor in overall removal costs that can vary greatly depending on haul distance, approach, and disposal site location and fees.

Based on the data and analysis summarized above, a unit cost per cubic yard and overall sediment removal cost were developed for the Sacramento and San Joaquin River basins by region as shown in Table 5-5. Anticipated sediment removal costs across the SPFC were determined by assuming that historical sediment removal rates would be similar in the future. Accordingly, it is estimated that approximately 660,000 CY of sediment will be removed throughout the entire SPFC each year.

**Table 5-5. Sediment Removal Cost Estimates by Region**

| Region | Estimated $/CY[1] | CY[2] | Estimated Annual Cost |
|---|---|---|---|
| Mid-Upper Sacramento River | $10.00 | 375,000 | $3,750,000 |
| Feather River | $10.00 | 25,000 | $250,000 |
| Lower Sacramento River / Delta North | $10.00 | 150,000 | $1,500,000 |
| Lower San Joaquin River / Delta South | $20.00 | 60,000 | $1,200,000 |
| Mid San Joaquin River | $6.25 | 25,000 | $156,250 |
| Upper San Joaquin River | $6.25 | 25,000 | $156,250 |
| | **Total** | **660,000** | **$7,012,500** |

Notes:
1 Unit cost estimates were provided and/or confirmed by RFMP regional representatives.
2 Cubic yard estimates are based on FMO input in the Sacramento River Basin and extrapolated through use of data provided by LSJLD in the San Joaquin River Basin.

### *Vegetation and Debris Removal*

Vegetation and debris removal were based on FMO data. Activities conducted in 2010 were deemed most appropriate for cost estimating purposes given the year was considered a "moderate flood year" and typical vegetation management projects were implemented. The Sacramento and Sutter maintenance yards cleared an estimated 1,087 and 3,265 acres of vegetation that year, respectively. Costs were escalated to 2014 assuming an annual 10 percent increase in labor cost each year since 2010 to account for increased labor wages for maintenance area employees. Costs ranged from $273 per acre for the Sutter Maintenance Area to $824 per acre for the Sacramento Maintenance Area.

Relatively greater channel clearing costs associated with the Sacramento maintenance yard (versus the Sutter maintenance yard) are assumed to result from the relatively greater restrictions in the urban areas serviced by the Sacramento maintenance yard. In addition, channel maintenance costs are also influenced by the channel dimensions, and environmental concerns and associated permitting costs. Narrow channels with little or no berm width, or areas in and around mitigation sites make machine clearing difficult or impracticable. Given these factors, the Work Group determined a unit cost of $1,000 per acre for channel vegetation management was appropriate.

Vegetation and debris removal costs in the San Joaquin River Basin were taken from data provided by the two LMAs interviewed. Cost data provided by these districts averaged $330 per acre for the San Joaquin River Basin. Subsequent input from regional representatives indicated that vegetation management costs should include wet-channel conditions estimates, which were closer to $1,000 per acre for typical channel O&M.

The approximate number of acres in the San Joaquin River Basin requiring channel vegetation and debris removal was developed by assuming proportionality between sediment removal and channel vegetation and debris removal. Given sediment removal in San Joaquin River Basin is approximately one-fifth of the Sacramento River Basin sediment removal, it was assumed that channel vegetation and debris removal would occur at the same ratio, resulting in an assumed annual removal of approximately 900 acres.

***Channel Vegetation and Debris Removal by Region***

Table 5-6 shows channel vegetation and debris removal costs categorized by region; it is assumed that the estimated acreages per basin will be spread evenly over the regions.

**Table 5-6. Channel Vegetation Removal Cost Estimates by Region**

| Region | Estimated $/Acre[1] | Acres[2] | Estimated Annual Cost |
|---|---|---|---|
| Mid-Upper Sacramento River | $1,000 | 1,500 | $1,500,000 |
| Feather River | $1,000 | 1,500 | $1,500,000 |
| Lower Sacramento River / Delta North | $1,000 | 1,500 | $1,500,000 |
| Lower San Joaquin River / Delta South | $1,000 | 300 | $300,000 |
| Mid San Joaquin River | $1,000 | 300 | $300,000 |
| Upper San Joaquin River | $1,000 | 300 | $300,000 |
| | **Total** | **5,400** | **$5,400,000** |

Notes:
1 Unit cost estimates were based on FMO data and confirmed by RFMP regional representatives.
2 Acreage estimates are based on FMO input in the Sacramento River Basin and are based on a similar ratio used for sediment removal estimates for the San Joaquin River Basin.

### 5.2.5 Minor Structures

As discussed in Chapter 4.0, minor structures include stop log or gated closure structures, pumping plants, monitoring wells and piezometers, retaining walls and floodwalls, pipe penetrations, and encroachments. Routine O&M activities for these types of structures are generally included in the overhead budget for LMAs. Therefore, routine minor structure O&M cost estimates were focused on new pipe penetration evaluation requirements. Recent changes to regulations require pipe penetrations be evaluated at least every 5 years. Inspections consist of using a camera to evaluate the inside of pipes through review by a qualified engineer to determine if any structural deficiencies have developed. Several National Association of Sewer Service Companies Pipeline Assessment and Certification Program-qualified pipe inspectors were contacted to determine inspection costs. Depending on factors including location, access to pipe, size of pipe, length of run, and other field conditions, costs were found to range from $300 to $3,500 for video inspection of a typical 300-foot run of pipe and the associated reporting. As discussed in Chapter 4.0, the DWR UCIP has identified 5,455 pipe crossings, of which 1,514 are the responsibility of LMAs. Assuming an average pipe inspection cost of $2,000, pipe inspections were projected to cost $3,028,000 every 5 years or $605,600/year across the SPFC.

***Minor Structures O&M by Region***

Table 5-7 categorizes minor structures O&M by region.

**Table 5-7. Minor Structures O&M Cost Estimates by Region**

| Region | Estimated Cost/Inspection[1] | Total Pipes/Region | Inspections/Year (Over a 5-Year Period)[2] | Estimated Annual Inspection Cost[2] |
|---|---|---|---|---|
| Mid-Upper Sacramento River | $2,000 | 306 | 61 | $122,400 |
| Feather River | $2,000 | 172 | 35 | $68,800 |
| Lower Sacramento River / Delta North | $2,000 | 218 | 44 | $87,200 |
| Lower San Joaquin River / Delta South | $2,000 | 412 | 82 | $164,800 |
| Mid San Joaquin River | $2,000 | 80 | 16 | $32,000 |
| Upper San Joaquin River | $2,000 | 326 | 65 | $130,400 |
| | **Total** | **1,514** | **303** | **$605,600** |

Notes:
1 Unit cost estimates were based on average costs obtained through input from National Association of Sewer Service Companies Pipeline Assessment and Certification Program-qualified pipe inspectors and confirmed by RFMP regional representatives.
2 Inspections are assumed to occur every 5 years; and thus, one-fifth of pipes in a given region would be inspected each year.

As the USACE requirements for pipe inspections are fully implemented over time, LMAs will likely evaluate other options for inspecting and testing pipes for integrity. Future options include vacuum testing levee pipe penetrations—available for siphon systems—which could reduce future inspection costs on a case-by-case basis.

### 5.2.6 Major Structures

As discussed in Chapter 4.0, costs for major structures were taken from the most recent DWR O&M records of facilities identified in Section 8361 of the CWC. Annual O&M costs for major structures were available from 2010 to 2013 for the Sutter maintenance yard and averaged approximately $471,000/year. Representative major structures serviced by the Sutter Yard include weirs, pumping plants, seepage ditches, and outfall gates. Annual O&M costs for major structures were available from 2000 to 2014 for the Sacramento maintenance yard and averaged approximately $59,000/year. Structures addressed by the Sacramento Yard include the Cache Creek settling basin weir structure, Knight's Landing outfall gates, Sacramento weir, and Fremont weir. Table 5-8 shows total Sacramento River Basin major structure O&M costs for the two yards.

**Table 5-8. Sacramento River Basin Major Structure Annual Costs**

| Location | Average Cost Per Year |
|---|---|
| Sacramento Maintenance Yard | $58,854 |
| Sutter Maintenance Yard | $470,968 |
| **Total** | **$529,822** |

*Source: SPFC major structures O&M costs provided by FMO.*

The estimated cost for O&M on major structures in the San Joaquin River Basin was based on representative districts that maintain the majority of major structures in the San Joaquin River Basin. These structures include flow control structures and drop structures. O&M on major structures in the San Joaquin River Basin was estimated to be approximately $121,100/year.

***Major Structures O&M by Region***

According to FMO, estimated annual O&M costs for major structures in the Sacramento Valley are $530,000. Major structures costs were provided by the Lower San Joaquin River/Delta South and Upper San Joaquin River regions at $70,000 and $51,100, respectively. The Mid San Joaquin River region contains no major structures.

## 5.3 RR&R Costs

Numerous sources were used to estimate costs for RR&R on the SPFC including annual LMA reports, LMA questionnaire results, direct conversations with LMA staff, Delta Subventions Program information, SRBPP data, FMO cost and material records and estimates, and input from the regions. RR&R unit costs were determined to be relatively equivalent for each basin. In addition to levee and structure RR&R, addressing invasive plant species such as giant reed continues to be a multi-year removal process beyond typical channel O&M. Further discussion of each category, and associated cost estimates and sources are provided in the following sections.

### 5.3.1 Levee RR&R – Data Sources

***LMA Questionnaire***

The LMA questionnaire results provided cost information related to the RR&R of SPFC facilities in both urban and non-urban areas for the Sacramento River Basin. Results showed that, on average, the cost-per-levee mile for RR&R in urban areas is $6,575, with costs ranging from $918 to $29,742. The average cost-per-levee mile for RR&R in non-urban areas is $5,570, with costs ranging from $42 to $39,823.

Nine Sacramento River Basin LMAs reported RR&R costs averaging $6,575 per levee mile per year, and two questionnaire respondents provided costs for compliance with additional requirements of the newly implemented ULDC averaging $4,375 per levee mile per year.

Reported costs for non-urban LMA RR&R averaged $5,570 per levee mile per year, with one district also reporting a ULDC cost of $2,778 per levee mile per year for flood safety planning. The Work Group determined the LMA questionnaire likely captures only a portion of the RR&R cost associated with the SPFC for both urban and non-urban districts in the Sacramento River Basin. RR&R cost responses were not received from the San Joaquin River Basin LMAs. These numbers were once again confirmed during coordination with the RFMP regions.

***Levee Erosion –SRBPP***

The SRBPP is a continuing construction project authorized by the Federal Flood Control Act of 1960 authorizing USACE to control erosion on the banks of the Sacramento River. The main aim of the program is to address levee and bank erosion caused by the Sacramento system's design to naturally scour the historical mining debris deposits and restore the natural bed elevations.

SRBPP cost data were obtained for the period 1975 to 2011. Approximately 396,209 linear feet of levees were repaired during these years at a total cost of $405,000,000. Average total costs were $1,022 per linear foot with an average annual cost of $10,945,946. SRBPP costs could not

be escalated to 2014 dollars because data were insufficient to determine actual expenditures per year; only a lump sum could be averaged per year. Therefore, comparisons to current unit costs are not appropriate.

USACE SPFC erosion site inventory information was obtained for the period 1997 to 2011. This inventory indicated that approximately 12 new erosion sites are discovered each year. Using both USACE and SRBPP data, the annual average length of levee erosion ranges from 10,708 to 18,468 linear feet on the SPFC. Assuming the average cost of $1,022 per linear foot for erosion repairs discussed above, costs would range from $10,945,946 to $18,874,296/year.

Because escalating costs was difficult and erosion repair costs are also included in the Delta Subventions Program and LMA questionnaire data, the SRBPP erosion data are only included here as information and were not used to estimate SPFC levee RR&R costs.

***Delta Subventions Program Data***

As previously discussed, the Delta Subventions Program data set spans 1993/1994 to 2009/2010, and provides costs (escalated to 2014 dollars) incurred by LMAs for routine levee maintenance and levee RR&R.

Using this data source, Figure 5-1 shows the annual average cost-per-levee mile for levee "rehabilitation." Review of the Delta Subventions Program data indicated that "rehabilitation" generally corresponded to overall levee RR&R.

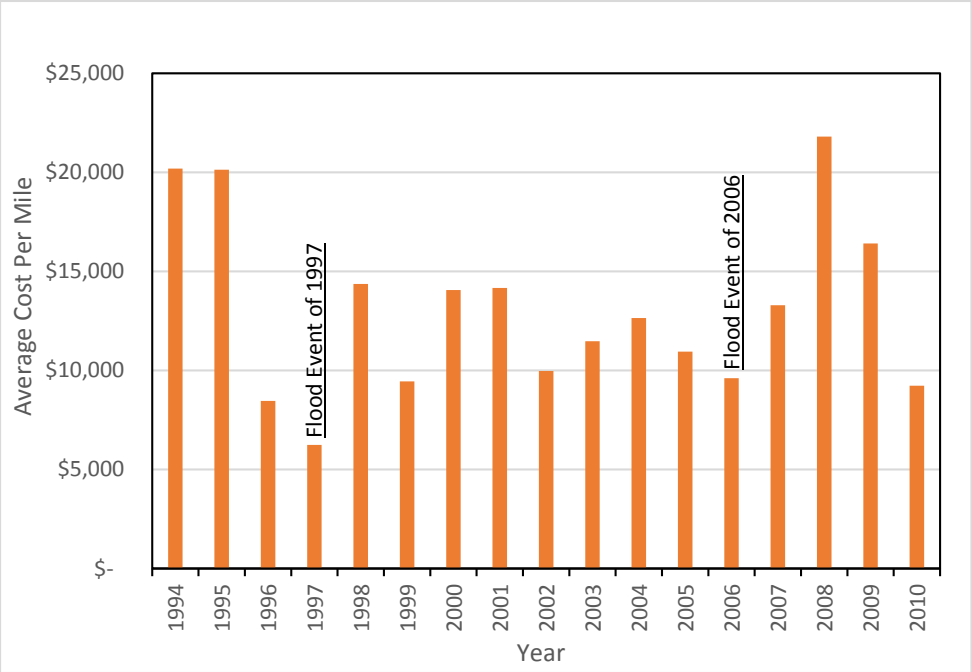



**Figure 5-1. Delta Levee Subventions Average Cost for Levee RR&R**

The Work Group determined that the Delta Subventions Program data most accurately reflect true levee RR&R unit costs. The Delta Subventions Program has been tracking levee RR&R costs for several decades, and Delta levee districts (as a result of this State cost-shared program)

annually and routinely analyze and rehabilitate deteriorating non-urban levees. These data in turn were determined to be the best available data set for both the Sacramento and San Joaquin River basins non-urban levees. The overall RR&R annual average cost over the 1994 to 2010 period identified in the Delta Subventions Data was $13,087, which was rounded to $13,000/year for the purposes of estimating annual RR&R costs for non-urban levees.

### 5.3.2 Levee RR&R – Urban

As previously discussed in Chapter 4, the ULDC requirements specific to urban levees are the primary factor differentiating urban and non-urban levee RR&R costs. The ULDC compliance average cost-per-levee mile (obtained through the LMA questionnaire) ranges from $1,944 to $6,805, and averages $4,375 per levee mile. The $4,375 average was rounded up to $5,000 then added to the $13,000 per levee mile identified for non-urban levee RR&R, to arrive at a total rounded estimate of $18,000 per levee mile to address RR&R for urban SPFC levees. This estimate was used in both the Sacramento and San Joaquin River basins, presented in this section and Section 5.3.3.

Anticipated annual levee RR&R costs across the SPFC were determined using the estimated 260.2 miles of urban levee in the Sacramento River Basin and an estimated 74.8 miles of urban levee in the San Joaquin River Basin, as follows:

- Sacramento River Basin urban levees RR&R: $4,683,600/year
- San Joaquin River Basin urban levees RR&R: $1,346,400/year
- Total SPFC urban levees RR&R: $6,030,000/year

***Urban Levee RR&R by Region***

Table 5-9 categorizes urban levee RR&R by region.

**Table 5-9. Urban Levee RR&R by Region**

| Region | Estimated $/Levee Mile[1] | Levee Miles[2] | Estimated Annual Cost |
|---|---|---|---|
| Mid-Upper Sacramento River | $18,000 | 10.5 | $189,000 |
| Feather River | $18,000 | 101.7 | $1,830,600 |
| Lower Sacramento River / Delta North | $18,000 | 148.0 | $2,664,000 |
| Lower San Joaquin River / Delta South | $18,000 | 73.1 | $1,315,800 |
| Mid San Joaquin River | $18,000 | 0.0 | $0 |
| Upper San Joaquin River | $18,000 | 1.7 | $30,600 |
| | **Total** | **335.0** | **$6,030,000** |

Notes:
1 Unit cost estimates were based on Delta Subventions Program and ULDC compliance data, and confirmed by RFMP regional representatives.
2 Levee lengths are based on the December 31, 2011, version of the California Levee Database (DFM_CALeveeDatabase_v3.0_R1_20111231_10.mdb) and RFMP boundaries.

### 5.3.3 Levee RR&R – Non-Urban

As described in Section 5.3.1, a unit RR&R cost per levee mile was developed using Delta Subventions Program historical data. Unit costs were determined to be approximately $13,000/mile.

Anticipated annual levee RR&R costs across the SPFC were determined using the estimated 829.9 miles of non-urban levee in the Sacramento River Basin and an estimated 528.5 miles of non-urban levee in the San Joaquin River Basin, as follows:

- Sacramento River Basin non-urban levees RR&R: $10,788,700/year
- San Joaquin River Basin non-urban levees RR&R: $6,873,100/year
- Total SPFC non-urban levees RR&R: $17,661,800/year

***Non-Urban Levee RR&R by Region***

Table 5-10 categorizes non-urban levee RR&R by region.

**Table 5-10. Non-Urban RR&R by Region**

| Region | Estimated $/Levee Mile[1] | Levee Miles[2] | Estimated Annual Cost |
|---|---|---|---|
| Mid-Upper Sacramento River | $13,000 | 335.6 | $4,362,800 |
| Feather River | $13,000 | 163.4 | $2,124,200 |
| Lower Sacramento River / Delta North | $13,000 | 330.9 | $4,301,700 |
| Lower San Joaquin River / Delta South | $13,000 | 108.9 | $1,415,700 |
| Mid San Joaquin River | $13,000 | 52.1 | $677,300 |
| Upper San Joaquin River | $13,000 | 367.7 | $4,780,100 |
| | **Total** | **1358.6** | **$17,661,800** |

Notes:
1 Unit cost estimates were based on Delta Subventions Program data and confirmed by RFMP regional representatives.
2 Levee lengths are based on the December 31, 2011, version of the California Levee Database (DFM_CALeveeDatabase_v3.0_R1_20111231_10.mdb) and RFMP boundaries.

### 5.3.4 Channel RR&R – Giant Reed

Clearing vegetation within flood control channels has generally been considered an O&M issue; however, removing invasive plant species such as giant reed is generally considered a much more labor-intensive and expensive activity than typically classified as an O&M action. Removing giant reed and other highly aggressive and invasive species will continue to be a significant issue and require extensive in-channel effort to maintain SPFC flood capacity. FMO and regional input indicates costs for giant reed removal have varied from approximately $10,000 to $25,000/acre depending on conditions. Total acreage was based on DFW data and proportioned by RFMP boundary. Table 5-11 shows estimated acreages of giant reed infestation throughout the SPFC and planning regions. Additional areas of giant reed are reported in Calflora and the California Invasive Plant Council (cal.ipc.org), but are not included in Table 5-11 because specific locations were not available. Figure 5-2 shows the available data regarding giant reed-infested areas.

**Table 5-11. Identified Giant Reed Locations/Sites by Region[1]**

| Region | Number of Sites | Estimated Acres |
|---|---|---|
| Mid-Upper Sacramento River | 178 | 138 |
| Feather River | 50 | 83 |
| Lower Sacramento River / Delta North | 145 | 31 |
| Lower San Joaquin River / Delta South | 83 | 18 |
| Mid San Joaquin River | 0 | 0 |
| Upper San Joaquin River | 247 | 90 |
| **Totals** | **703** | **360** |

Notes:

1 Giant reed locations/sites/acres were identified using State of California Geoportal data set names: ds292, ds333, ds633, ds624, and ds1000 available at <ftp://ftp.dfg.ca.gov/BDB/GIS/BIOS/Public_Datasets>. Of the 703 sites indicated, 273 included the size of the infestation area. Data used include various dates of observation beginning in 2003. The average site size in acres was extrapolated to the sites without reported acreages.

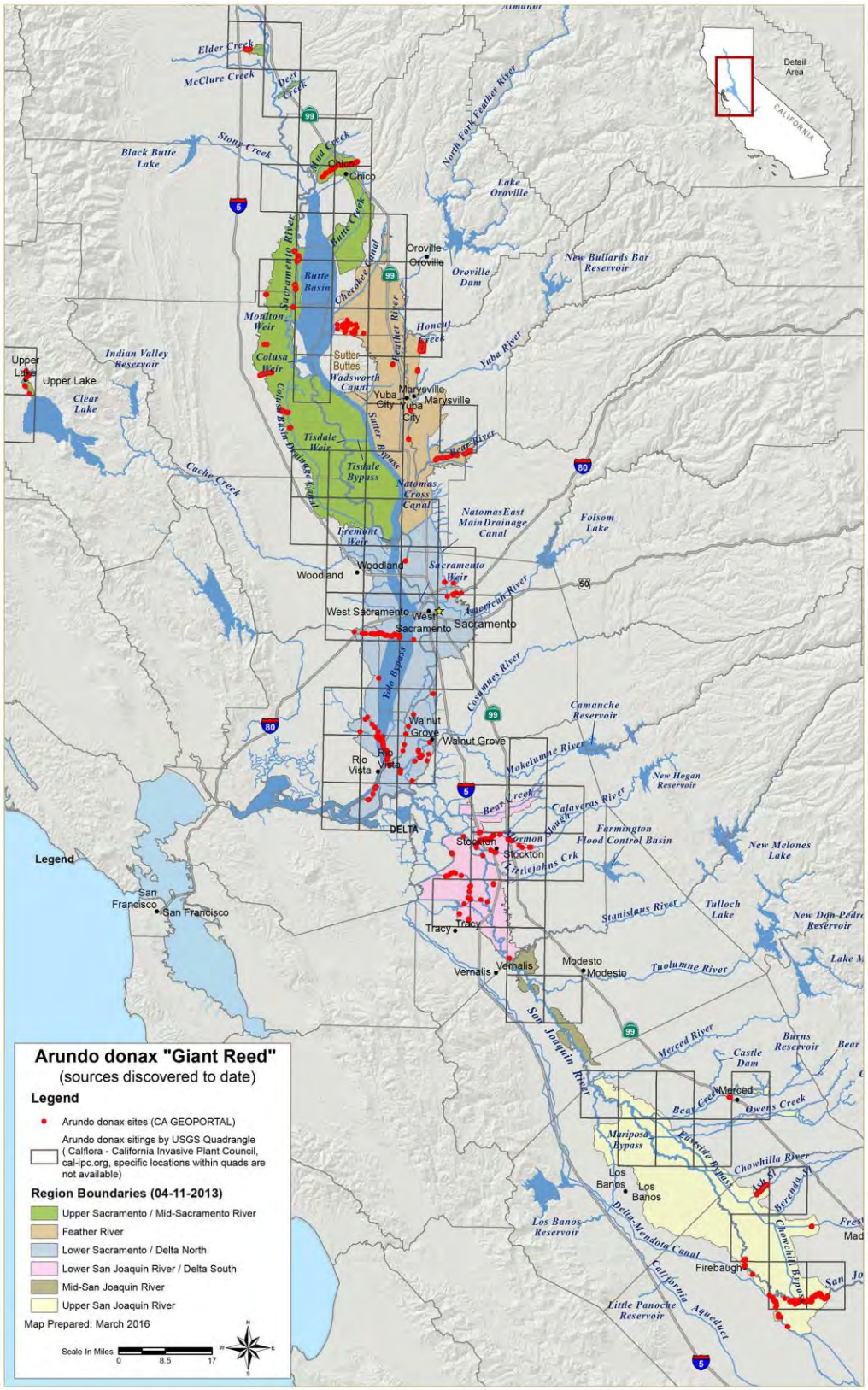



**Figure 5-2. Giant Reed Site/Locations throughout the SPFC Regions**

Table 5-12 shows the estimated annual cost for giant reed removal from SPFC channels by region over a 5-year period.

**Table 5-12. Giant Reed Removal Estimated Cost by Region**

| Region | Estimated $/Acre[1] | Annual Acreage Removal (over a 5-Year Period)[2] | Estimated Annual Cost |
|---|---|---|---|
| Mid-Upper Sacramento River | $10,000 | 28 | $280,000 |
| Feather River | $10,000 | 17 | $170,000 |
| Lower Sacramento River / Delta North | $20,000 | 6 | $120,000 |
| Lower San Joaquin River / Delta South | $25,000 | 4 | $100,000 |
| Mid San Joaquin River | $25,000 | NA | - |
| Upper San Joaquin River | $25,000 | 18 | $450,000 |
| | **Total** | **73** | **$1,120,000** |

Notes:
1 Unit cost estimates were based on FMO and regional representatives' input.
2 Estimated acres to be removed annually over a 5-year period. Total in this column is greater than one-fifth of the 360 total estimated acres reported in Table 5-11 because of rounding.

### 5.3.5 Minor Structures RR&R – Pipe Penetrations and Crossings

Similar to the O&M of minor structures as described in Section 5.2.5, RR&R of most minor structures is assumed to be accounted for in the estimated costs for levee RR&R. However, costs for abandoning and slip-lining, removing, and replacing aged pipe penetrations of levees (commonly called "legacy pipes") have long been recognized as a major, and that must be addressed throughout the SPFC. Penetrations through SPFC levees are documented through the UCIP. The primary goal of documentation is to develop an inventory of utility crossings penetrating State and federal flood project levees listed in Table 5-13. Including pipes and other utilities, 5,455 crossings or penetrations of SPFC levees have been identified. DWR estimates that 4,442 are permitted by either CVFPB encroachment permits, O&M manuals, or "as-built" records, and that 1,013 unpermitted crossings still remain in the SPFC. Table 5-13 shows the number of pipes penetrating SPFC levees, their permit status, and the number of pipe penetrations that are assumed to be the responsibility of LMAs.

**Table 5-13. Pipe Penetrations and Status**

| Category of Pipe | Number of Pipes |
|---|---|
| Total Levee Penetrations[1] | 5,455 |
| Permitted | 2,716 |
| Unpermitted[2] | 1,013 |
| Included in O&M/As-Built[3] | 1,726 |
| Generally Maintained by LMAs | 1,514 |

*Source: DWR UCIP data.*
Notes:
1 Includes all crossing types.
2 Unpermitted crossings are assumed to be the responsibility of LMAs for cost estimating purposes.
3 Includes only drainage pipes listed as the LMA's responsibility in the O&M manual or shown in the as-built drawings that are critical to the system's flood protection function.

DWR estimates that 1,514 pipe penetrations are potentially the responsibility of LMAs. Estimates provided by DWR and the regions indicated typical pipe abandonment and slip-line costs are approximately $35,000 per pipe, and typical pipe replacement costs are approximately $240,000 per pipe. Pipe removal costs were estimated to be approximately $180,000 per pipe.

As discussed in Chapter 4.0, it is estimated that 90 percent (1,362) of pipes for which LMAs may have responsibility need to be properly abandoned, repaired, or replaced in the next 20 years, and 90 percent (912) of the unpermitted crossings would also may need to be addressed by LMAs. Therefore, it is assumed that 2,274 pipes may need to be addressed by LMAs. Input received from FMO suggests that up to 70 percent (1,592) of these pipes could potentially be slip-lined rather than replaced; however, the actual approach taken for each pipe would need to be determined on a case-by-case basis. Assuming this best-case scenario as the lower bookend, the total cost to address the 2,274 pipes regardless of responsibility would be $219,400,000. Full replacement cost of the 2,274 pipes would be $545,760,000. The Work Group determined that the higher end of the range should be used to provide the most conservative estimate, noting that significant savings may be realized by using other methods. It is assumed that this total cost would be spread over a 30-year period, resulting in an annual cost of approximately $18,200,000 across the entire SPFC system.

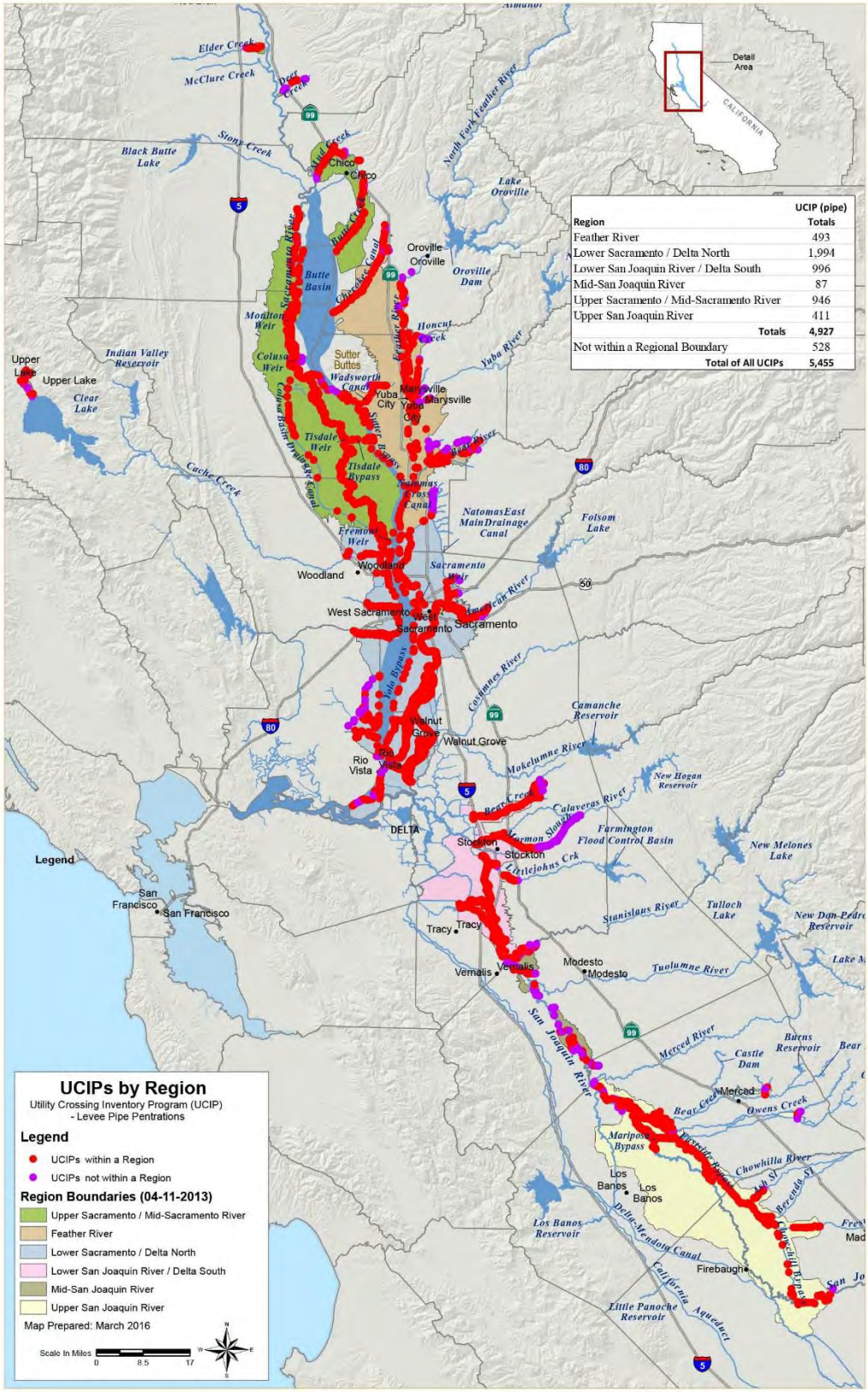
### *Minor Structures RR&R, Pipe Penetrations, by Region*

Table 5-14 categorizes estimated pipe penetration RR&R by region. A total cost per region is also shown using the estimated unit replacement cost of $240,000/pipe annually over a 30-year period. Figure 5-3 maps the available UCIP data and shows a regional breakdown of levee penetrations.

**Table 5-14. Pipe Penetrations RR&R Estimated Annual Cost by Region**

| Region | Number of Pipes[1] | Annual Cost over 30 Years[2] |
|---|---|---|
| Mid-Upper Sacramento River | 376 | $3,008,000 |
| Feather River | 253 | $2,024,000 |
| Lower Sacramento River / Delta North | 581 | $4,648,000 |
| Lower San Joaquin River / Delta South | 615 | $4,920,000 |
| Mid San Joaquin River | 94 | $752,000 |
| Upper San Joaquin River | 355 | $2,840,000 |
| **Totals** | **2,274** | **$18,192,000** |

Notes:
1 Number of pipes is based on DWR UCIP data.
2 Annual cost estimates are based on pipe replacement costs over a 30-year period provided by DWR and through regional input.




| Region | UCIP (pipe) Totals |
|---|---|
| Feather River | 493 |
| Lower Sacramento / Delta North | 1,994 |
| Lower San Joaquin River / Delta South | 996 |
| Mid-San Joaquin River | 87 |
| Upper Sacramento / Mid-Sacramento River | 946 |
| Upper San Joaquin River | 411 |
| **Totals** | **4,927** |
| Not within a Regional Boundary | 528 |
| **Total of All UCIPs** | **5,455** |

**Figure 5-3. UCIPs (Pipe Penetrations) throughout SPFC**

### 5.3.6 Major Structures RR&R

Major structures include hydraulic structures, pumping plants, and bridges along the Sacramento and San Joaquin River basins. DWR conducts scheduled facilities maintenance within the Sacramento River Flood Control Project; the cost is identified in Section 5.2.6. DWR has recently completed several significant repair projects totaling $50 million using Bond 1E funding. Thus, no additional substantial RR&R of major structures is anticipated in the next 50 years unless a major event or change in design alters the function; such costs would be substantial. Estimates have been developed for the proposed future expansion of the Fremont weir (approximately $150 million for 1 mile of extension) and the proposed future expansion of the Sacramento weir by 32 gates (approximately $169 million) (DWR, 2013c). These capital costs could be indicative of the magnitude of major structures replacement costs; however, such costs are not anticipated within the next 50 years and would be addressed as separate capital projects if implemented in this timeframe.

## 5.4 Overall Summary of OMRR&R Cost Estimates

Total estimated annual OMRR&R costs are approximately $131,130,000/year. Table 5-15 and Figure 5-4 summarize the estimated annual cost by activity type. The RR&R category includes urban levee, non-urban levee, channel, and structures. Appendix C breaks down costs by RFMP region and river basin. Table 5-16 includes a summary of cost estimates by region and basin.

**Table 5-15. Estimated Annual Cost of OMRR&R across the SPFC**

| Description | Annual Cost |
|---|---|
| Urban Levee O&M | $18,831,600 |
| Non-Urban Levee O&M | $55,622,500 |
| Channel Sediment Removal | $7,012,500 |
| Channel Vegetation/Debris Removal | $5,400,000 |
| Minor Structures O&M | $605,600 |
| Major Structures O&M | $651,100 |
| RR&R | $43,003,800 |
| **Total Cost** | **$131,127,100** |

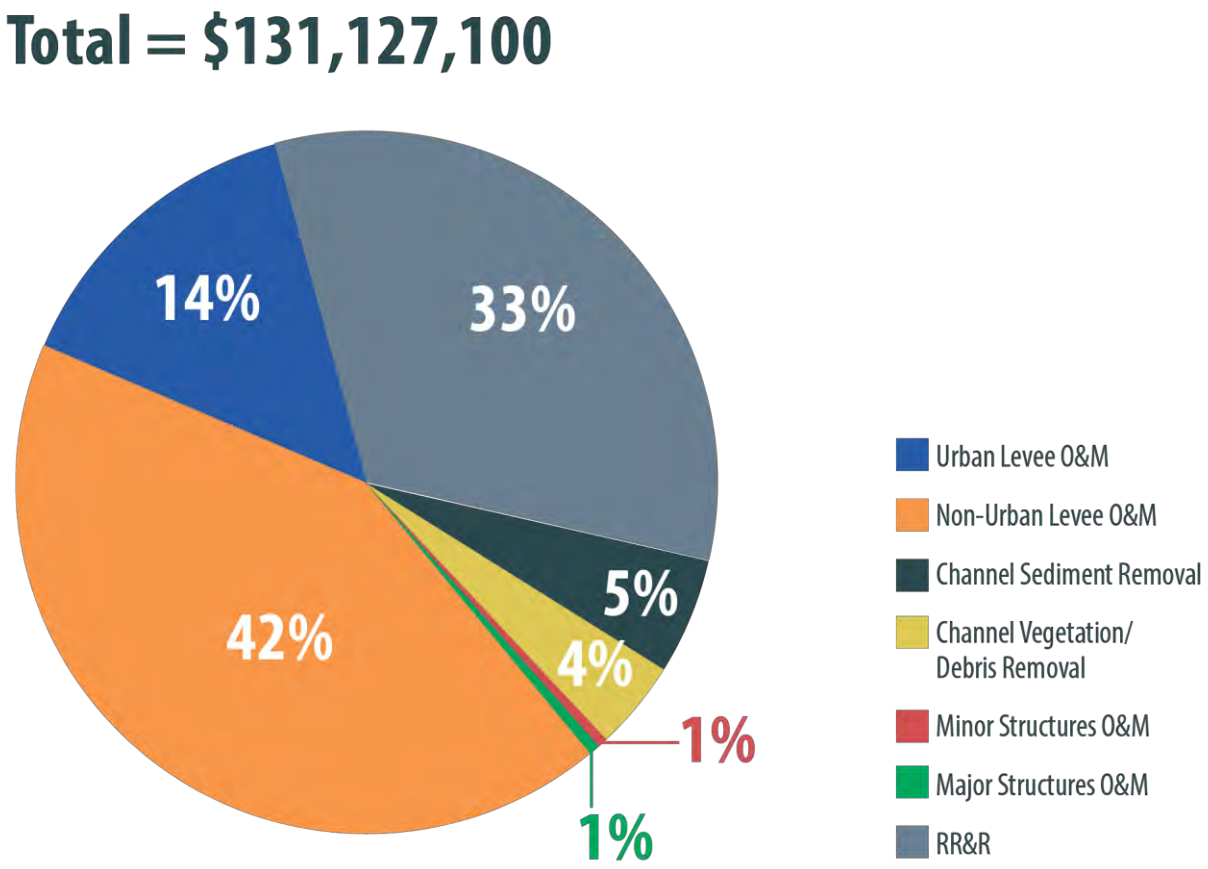



**Figure 5-4. SPFC OMRR&R Annual Cost Estimate by Facility**

Although difficult to accurately quantify, current OMRR&R spending within the Central Valley is estimated to be approximately $30 million/year based on AB 156-reported costs. Of this amount, FMO (which essentially operates as a collection of LMAs) annually budgets approximately $8.7 million. The DWR annual FMO budget can basically be broken down into what is spent on the 10 maintenance areas for which it is responsible under CWC 12878; what is spent on other levee, channel, and structure maintenance activities for which it is responsible under CWC 8361; plus a mixture of general funds and bond funds for other non-routine activities and programs. The general fund budget for fiscal year 2016/2017 as reported to the CVFPB in April 2016 was $3.3 million for maintenance areas and $5.4 million. DWR maintains less than 10 percent of levee miles within the SPFC (152 of the roughly 1,600), but their budget represents 29 percent of the LMA-reported spending.

Regardless of the accuracy of this estimated level of spending, it is substantially less than the over $131 million true cost estimated in this TM. It is reasonable to conclude that OMRR&R is substantially under staffed and underfunded throughout the Central Valley.

**Table 5-16. Summary of Cost Estimates by Region and Basin**

| Description | Mid-Upper Sacramento River | Feather River | Lower Sacramento River and Delta North | Total Sacramento River Basin | Lower San Joaquin River / Delta South | Mid San Joaquin River | Upper San Joaquin River | Total San Joaquin River Basin | Total SPFC |
|---|---|---|---|---|---|---|---|---|---|
| Urban Levee O&M | $609,000 | $5,898,600 | $8,584,000 | **$15,091,600** | $3,655,000 | 0 | $85,000 | **$3,740,000** | **$18,831,600** |
| Non-Urban Levee O&M | $15,437,600 | $7,516,400 | $15,221,400 | **$38,175,400** | $3,593,700 | $1,719,300 | $12,134,100 | **$17,447,100** | **$55,622,500** |
| Channel Sediment Removal | $3,750,000 | $250,000 | $1,500,000 | **$5,500,000** | $1,200,000 | $156,250 | $156,250 | **$1,512,500** | **$7,012,500** |
| Channel Vegetation and Debris Removal | $1,500,000 | $1,500,000 | $1,500,000 | **$4,500,000** | $300,000 | $300,000 | $300,000 | **$900,000** | **$5,400,000** |
| Minor Structures O&M | $122,400 | $68,800 | $87,200 | **$278,400** | $164,800 | $32,000 | $130,400 | **$327,200** | **$605,600** |
| Major Structures O&M | $530,000 | 0 | 0 | **$530,000** | $70,000 | 0 | $51,100 | **$121,100** | **$651,100** |
| **Subtotal O&M** | $21,949,000 | $15,233,800 | $26,892,600 | **$64,075,400** | $8,983,500 | $2,207,550 | $12,856,850 | $24,047,900 | **$88,123,300** |
| Urban Levee RR&R | $189,000 | $1,830,600 | $2,664,000 | **$4,683,600** | $1,315,800 | $0 | $30,600 | $1,346,400 | **$6,030,000** |
| Non-Urban Levee RR&R | $4,362,800 | $2,124,200 | $4,301,700 | **$10,788,700** | $1,415,700 | $677,300 | $4,780,100 | $6,873,100 | **$17,661,800** |
| Channel Giant Reed Removal[1] | $280,000 | $170,000 | $120,000 | **$570,000** | $100,000 | $0 | $450,000 | $550,000 | **$1,120,000** |
| Minor Structure RR&R[2] | $3,008,000 | $2,024,000 | $4,648,000 | **$9,680,000** | $4,920,000 | $752,000 | $2,840,000 | $8,512,000 | **$18,192,000** |
| Major Structure RR&R | $0 | $0 | $0 | **$0** | $0 | $0 | $0 | $0 | **$0** |
| Subtotal RR&R | $7,839,800 | $6,148,800 | $11,733,700 | **$25,722,300** | $7,751,500 | $1,429,300 | $8,100,700 | $17,281,500 | **$43,003,800** |
| **TOTAL OMRR&R** | **$29,788,800** | **$21,382,600** | **$38,626,300** | **$89,797,700** | **$16,735,000** | **$3,636,850** | **$20,957,550** | **$41,329,400** | **$131,127,100** |

Notes:
1 Cost associated with estimated acres to be removed annually over a 5-year period.
2 Annual cost estimates are based on assumed pipe replacement costs over a 30-year period provided by DWR and through regional input.

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# 6.0 Potential Funding Sources

Funding the OMRR&R of the existing SPFC is a substantial and ongoing challenge for local and State agencies because of the lack of reliable revenue sources, Proposition 218 limitations, competition for limited grant funds across LMAs, difficulty qualifying for loans without adequate or reliable revenue sources, and escalating transactional costs associated with performing necessary activities (e.g., regulatory compliance). This challenge is compounded by the additional OMRR&R that will be required with the improvements and additions to the Central Valley flood management infrastructure identified in the CVFPP (including additional work required to achieve and maintain urban level of flood protection) as well as the estimated costs identified in this TM. Although the estimates of the true cost of OMRR&R summarized in Chapter 5.0 will be challenging to finance, opportunities exist to use existing programs, implement creative solutions, and create future OMRR&R-specific programs.

Adequate annual OMRR&R activities within the flood management system are needed to ensure a fully functioning system that sufficiently reduces flood risk, benefitting both those within and outside the floodplain. Consideration of opportunities to financially assist LMAs through new or existing State programs is one of the issues being evaluated as part of the CVFPP. Modeling such a program after the Delta Subventions Program, which provides funding on a cost-share basis to local levee maintaining agencies for rehabilitation and maintenance of levees in the Delta, would be one possibility.

## 6.1 Identifying Beneficiaries

According to *California's Flood Future Report*, $106 billion of structures and $3.6 billion of agricultural lands are at risk from flooding in the Sacramento and San Joaquin California Water Plan hydrologic regions, in addition to lives and property (DWR and USACE, 2013). As demonstrated in previous years, flooding can substantially affect the Central Valley's infrastructure and economy. The needed increase in annual OMRR&R spending identified in this TM is necessary to ensure a well-performing system that, in turn, minimizes loss of life; damage to property, crops, and structures; frequency of flood inundation; and ecological damage.

Traditionally, flood management system components, such as levees, were built to protect certain geographic areas, with O&M funded by property taxes, fees, and assessments collected from the commercial or residential landowners who were directly being protected. However, the collective benefits of flood risk reduction can be realized by multiple entities in a variety of ways. Describing how residents throughout California benefit from well-maintained Central Valley flood risk management facilities is a crucial component of increased funding advocacy. For example, Sacramento Area Flood Control Agency's Natomas Basin levees, which were built to help reduce flood risk for Natomas Basin residents, also protect vital infrastructure with broad regional benefit. These facilities include the Sacramento International Airport, Interstate 5, Interstate 80, and California Highway 99, all of which serve thousands of citizens that reside outside the protected basin every day. Thus, the improved flood protection provided in the Natomas Basin extends the benefits of the levee system by providing uninterrupted

transportation services of commercial goods and people, as well as economic and public safety benefits.

Additionally, the State also benefits from a well-maintained system that reduces flood exposure. These benefits could include reduced liability of failure or significant damage to the SPFC facilities and reduction of economic losses. In recent times, the lessons learned from the 1986 Linda Levee collapse in Yuba County and subsequent Paterno lawsuit and decision provide a compelling wake-up call that all Californians can be financially liable for Central Valley levee failures and the effects of overall deferred maintenance. This lawsuit, when the settlement is fully paid, will end up costing Californians $500 million. This money could have been put to better use maintaining and rehabilitating the system, and widening bypasses to reduce hydraulic pressure on the system. Furthermore, proper annual OMRR&R of the SPFC facilities collectively contributes to achievement of the State's goal of improving public safety, environmental stewardship, and long-term economic stability, all of which provide statewide benefit.

Currently, few mechanisms exist to fund OMRR&R of the SPFC facilities, except for property taxes or assessments on property owners in the adjacent flood basin. The cost of systemwide flood management is currently not spread on a broad regional basis, except for general fund appropriations for channel maintenance and statewide general obligation bond funds for specific activities. General fund appropriations are often inconsistent and less than what is required, and bond funds are sporadic and for specific purposes. At the local level, many of the LMAs assess fees on local landowners in proportion to the benefits the parcel owner receives (benefit assessments). A benefit assessment requires analysis of LMA expected spending for OMRR&R activities. Bond sales or long-term financing mechanisms can become necessary when higher-cost RR&R project(s) become necessary (e.g., Sutter-Butte Flood Control Agency issued a bond for $41 million in 2013 for Feather River West Levee Rehabilitation [California Debt and Investment Advisory Commission, 2014]). Some LMAs are also a county government agency, which can borrow against the other taxes and fees collected for the population (tax revenue bonds).

## 6.2 Identifying Partners for Sharing Costs

As stated in Section 103 of the WRDA 1986, nonfederal interests are required to pay 100 percent of the OMRR&R costs of structural flood damage-reduction projects. Because of limited federal interest to perform OMRR&R on federally cost-shared projects, the financial responsibility to maintain the SPFC falls within local and State programs and cost-share. However, where a federal interest can be demonstrated in capital improvements (not within the USACE definition of OMRR&R) to the system through the USACE feasibility study process, then federal dollars can potentially be invested. Most maintenance activities are funded through the State's general fund or local assessments. At the local level, LMAs save a portion of their annual budgets to cover cashflow deficits for unexpected OMRR&R expenses. The LMA annualized budget is expected to cover routine work by using several financial tools. The *California Debt Issuance Primer Handbook* (California Debt and Investment Advisory Commission, 2005) describes all debt tools available to the State.

The federal interest, generally represented by USACE, has been constrained by in-depth feasibility studies, complicated authorization processes, and lack of federal funding. Although partnering with USACE will always be relevant to flood management projects, achieving cost-sharing agreements will be a time-consuming process. Furthermore, federal law requires that the nonfederal sponsors (State and locals) "pay 100 percent of the operation, maintenance, and replacement and rehabilitation costs of the project" (WRDA 1986, Section 103 (j)). USFWS has expressed interest in operating and maintaining ecosystem areas that complement their refuge system, and can do so under their own federal budget allocations.

Recently, State funding for investments in the flood management system has been largely supported by general obligation bond[6] funds, such as Proposition 1E (which will expire in July 2016). However, the reliability of future bond funding is uncertain because of legislature unpredictability, political climate, the burden such debt service places on the State's general funds, and public support. LMAs often depend on the availability of State general obligation bonds (discussed below) to cost-share in their OMRR&R work.

To date, multiple State programs have been initiated with these bond funds to partially support LMAs with OMRR&R annual costs, including the following:

- **Early Implementation Program and Small Community Flood Risk Reduction** – Funds may be awarded to successful applicants (city or county with land use authority), first for feasibility studies, then ultimately for design and implementation of management actions that will reduce flood risks for small communities that are protected by the SPFC. The program is intended to provide competitive grants.

- **Urban Flood Risk Reduction** – Funds can be awarded to successful local applicants to support levee repair or improvement projects within the Central Valley that are located within the urban area and are SPFC facilities.

- **FSRPs** – Funds support State-identified priorities for non-urban levees, which include projects that repair documented critical problems, deteriorated levee patrol roads, and minor levee problems (such as erosion sites shorter than 50 feet) proactively.

- **Delta Subventions Program** – Funds administered by DWR for the CVFPB are given annually on a reimbursement basis to assist local LMAs in the Delta with the maintenance and rehabilitation of non-project and eligible project levees. Although normally a general fund program, general obligation bond funds have been used to supplement the work since 2009. The Delta Subventions Program has proven to be a successful program for sustainable OMRR&R of the Delta levee system.

- **Delta Levees Special Projects Program** – Funds can be awarded to successful local applicants to provide rehabilitation of non-project levees. Funds are limited to the local

[6] General obligation bonds are bonds secured either by a pledge of the full faith and credit of the issuer and/or by a promise to levy taxes in an unlimited amount as necessary to pay debt service. The State of California's general obligation bonds are full faith and credit bonds, to which the State's general fund, rather than any particular tax revenue, is pledged.

districts that protect water conveyance and water quality in the western Delta and designated areas of the Suisun Marsh. The program also funds habitat improvement projects to help meet mitigation and enhancement requirements associated with the enabling legislation.

Although the programs provide LMA applicants with the opportunity to secure funding for OMRR&R-related activities, some may have explicit restrictions on providing funding for actual OMRR&R costs.

## 6.3 Identifying Future Funding Sources

The CVFPP Investment Strategy and Financial Plan being developed as part of the 2017 CVFPP is expected to identify other loan programs, cost-sharing partnerships, and strategies for generating revenue for the basin-specific and systemwide improvements associated with the CVFPP. The Implementation chapter of the Conservation Strategy (DWR, 2015) identifies how new partners and access to new funding sources are necessary for long-term support of ecosystem enhancement elements. Furthermore, the six RFMPs have each developed a financial plan and strategy to identify funding sources, cost-sharing opportunities, and long-term financial sustainability within their specific regions for their prioritized projects. Although some of the current programs and strategies presented above have been successful in funding RR&R, frequently a significant gap occurs between the time the funds are needed and when funding is made available due to application and selection requirements. This timing issue, coupled with the large unmet OMRR&R need currently existing in the Central Valley's flood management system, can put significant strain on LMAs in need.

Although all of the above-identified existing programs have assisted in RR&R activities, only the Delta Subventions Program provides State assistance to LMAs for O&M, and several funding sources dedicated to capital improvements actually forbid funds being used for O&M activities. New approaches will be required to secure consistent and stable funding to ensure that proper OMRR&R occurs annually, and to reduce transactional costs. Some examples of existing and potential funding sources and strategies follow:

- Increased and consistent base-level State general fund for SPFC O&M.
- Establishment and eventual dispersal of local assistance funds through State grant programs.
- Local fees, assessments, and use taxes.
- Voter-approved new assessments through Proposition 218 elections.
- River basin assessment; this would be a State program that would return 85 to 90 percent of the funds raised back to the watershed, and could be allowed to be used for either capital or O&M costs.

- Changes to the State Constitution that would provide alternative procedures for funding flood control services independent of any other procedures and requirements in the State Constitution for funding flood control.

- Imposing a broad special tax, such as a new sales tax increment, to be dedicated for specific water-related activities.

- A water use tax or surcharge on the amount of water used. These funds could potentially fund some of the ecosystem restoration activities.

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# 7.0 Recommendations and Next Steps

This chapter recommends next steps in refining and tracking long-term SPFC OMRR&R costs, building on the estimated unit and annual costs provided in Chapter 5.0. Limitations of these estimates are identified, and suggestions are made for applying the data developed in this OMRR&R Cost Evaluation TM. Recommendations provided below are grouped within two categories: Section 7.1 outlines overall recommendations on the basis of Work Group findings, and Section 7.2 presents recommendations consistent with the major implementation issues identified in the Flood Management chapter of the *California Water Plan* (DWR, 2013d).

## 7.1 Overall Recommendations

The State should work with our regional partners to:

- Develop a subventions-type annual assistance program for LMAs outside of the Delta linked to dedicated and reliable general funds.
- Provide funding to assist LMAs with abandoning or replacing pipe crossings and resolving encroachment issues.
- Develop a sustainable program through State legislation to ensure adequate annual funding for DWR channel maintenance activities.
- Expand FSRP funding to assist LMAs in repairing small erosion sites.
- Continue the many cost-share or grant programs for repairs and improvements to the system to meet CVFPP goals.
- Implement regional or programmatic permitting strategies that reduce the cost and improve the efficiency of regulatory compliance for OMRR&R activities.
- Seek grants for assistance in creating landscape-scale permitting strategies (e.g., Section 6 grants from USFWS).
- Seek legislative improvements to existing regulatory requirements to help streamline the implementation of ongoing OMRR&R activities, such as refining State-mandated reporting requirements and reconsidering the application of Proposition 218 assessment proceedings to SPFC OMRR&R activities.
- Create a tracking system of OMRR&R activities and spending to provide transparency on the value that society will attain for their investment.

## 7.2 Recommendations Consistent with California Water Plan

### *Issue 1: Inadequate and Unstable Funding and Incentives*

- **Existing and potentially new funding sources should be evaluated and used to allow for necessary OMRR&R activities.** As discussed in Chapter 6.0, Potential Funding Sources, paying for the true full cost of OMRR&R across the SPFC will require the evaluation of potential funding sources, new financing options, and new programs necessary to minimize potential impacts on all beneficiaries, including people living behind levees, structures, property, agricultural interests, water supply, infrastructure, transportation, recreation, and the ecosystem. This is consistent with the California Water Plan, which recommends "By 2020, the State should develop broad-based public funding to support recreational facility planning, construction, and O&M in flood protection projects as required by California Water Code Sections 12840-12842."

- **"Local, State, and federal agencies should work together to develop a roundtable to assess the applicability of all potential funding sources, propose new funding options, and identify needed changes to legislation by 2020.** The roundtable initially would review existing funding sources identified in the online resource catalog of flood management funding created by State and federal agencies, review other funding mechanisms, and make recommendations. The roundtable should consider proposing changes or alterations to local funding restrictions by pursuing exemptions to existing statutes for public safety. For example, changes to current laws (e.g., Proposition 218) could include reclassification of flood management agencies as exempted public safety utilities. The roundtable also could pursue establishment of regional assessment districts" (DWR, 2013d).

### *Issue 2: Inadequate Data/Information and Inconsistent Tools*

- **RR&R categories need to be clearly defined and provided to LMAs to allow them to accurately develop and report short- and long-term RR&R costs.** The term "RR&R" is generally not well defined or consistently used across the SPFC. The OMRR&R Work Group (originally formed as the "O&M Workgroup") realized early in the development of this OMRR&R Cost Evaluation TM that the identifying RR&R costs was critical to developing the full true cost of all activities required to ensure the continued successful long-term operation of the SPFC.

- **AB 156 reporting requirements need to be modified to include standardized reporting, line-item cost reporting, and guidance to support obtaining consistent data. It is also recommended that an outreach effort be undertaken to clarify reporting needs and to reinforce that potential funding availability is tied to the receipt of accurate and consistent cost reporting.** Obtaining current and accurate OMRR&R data by LMA and river basin is critical to tracking current and future expenditures, and allowing more transparency for public reporting on return on public investments. DWR recognizes and this OMRR&R Cost Evaluation TM documents that the current method of obtaining information through the AB 156 process is not resulting in the receipt of consistent data. This inconsistency is due, in part, to the reporting of data in a lump-sum manner, which does not allow for distinguishing specific OMRR&R

activities and associated costs. The categories identified in Chapter 4.0, Table 4-1, should be defined and used (and consolidated as determined necessary) as part of the data acquisition process. Also, the value of reporting such costs accurately should be reinforced with the LMAs.

- **Transactional costs (including environmental compliance, right-of-way acquisition, and other such costs) need to be reported consistently and in a manner to support identification of successful implementation strategies and regional advance mitigation programs called for in the *California Water Action Plan* (including potential future cost savings).** Projects can vary with respect to necessary level of effort and costs to negotiate and obtain all required approvals clearances. Additional information is necessary to identify drivers and costs to differentiate how best to obtain approvals (including programmatic permitting and through development of regional advance mitigation to reduce project time delays and costs).

#### *Issue 3: Inadequate Public and Policy-Maker Awareness and Understanding of Flood Risk*

- **Improve public and policy-maker awareness of OMRR&R importance.** Oregon Department of Transportation (2014) recently produced a report on how payment of maintenance now can prevent more cost later, when they may no longer have a choice to delay action. A well-produced and well-received analysis can become a way for the State to communicate needs for stable funding sources and diverse financing options. It can help to identify new beneficiaries and demonstrate that proper maintenance is essential to maximizing the environmental, social, and economic benefits of the levees.

#### *Issue 4: Reduce Complex and Fragmented Governance Structure Impeding Agency Alignment and Systems Approach*

- **Overlapping jurisdictions and conflicting missions and priorities across various local, State, and federal agencies and tribal entities involved in flood management have led to inconsistent policies, regulations, enforcement, and practices.** The O&M standards for channel maintenance identified in the current federal O&M manuals (dating from the 1940s) with respect to accessibility and channel capacity can conflict with newly recognized ecosystem values and functions. Only a few SPFC areas have been granted an amendment to their O&M manuals, and approval for new practices is linked to when the federal project was originally authorized or reauthorized by Congress through a Chief's report. Given many of the SPFC channels provide high ecological value, and given the State's multi-benefit goals for environmental stewardship and ecosystem improvement, a revised approach to SPFC channel maintenance should be developed and documented.

- **OMRR&R of multi-benefit (multi-objective) components should be standardized and tracked to maximize benefits and avoid potential capacity limitations to the flood control system.** Review of current USACE guidance on the preparation of OMRR&R manuals and USACE inspections of completed projects identified significant gaps in guidance applicable to ecosystem restoration projects. The same holds true for recreational features (CWC Sections 12840 through 12842). Although USACE has

general guidance on the preparation of OMRR&R manuals, there is no specific guidance on OMRR&R for these multi-benefit features. The Work Group recommends the State establish guidance, criteria, and standards for the OMRR&R of ecosystem restoration sites and recreational features.

## 7.3 Limitations and Applicability

The following points summarize the limitations and suggested application of the data developed in this OMRR&R Cost Evaluation TM:

- This TM presents the estimated costs of thoroughly maintaining the SPFC, including full consideration of regulatory compliance—these have been termed the true costs. The total annual cost presented in Chapter 5.0 should be considered an "upper bookend" estimate if all OMRR&R activities were performed yearly with all necessary permits and no activities deferred. The difference between current expenditures and this true cost is significant and compelling.

- The Work Group recognizes the variability of OMRR&R activities from area to area within the SPFC and that costs incurred for OMRR&R vary greatly from LMA to LMA. Costs developed were based on regional input, information provided by LMAs, and existing information for current activities. In general, average annual costs of OMRR&R activities across the entire SPFC and the development of average unit costs for OMRR&R on the major features comprising the SPFC (e.g., levees, channels, and structures) were developed to assist in developing a defensible estimate. The Work Group recommends that the annual and unit costs documented in Chapter 5.0 be applied with the understanding that actual OMRR&R costs may differ from the estimates produced.

- The costs established in Chapter 5.0 should be considered as maintenance needs are evaluated for any new features or modifications of the flood control system.

- Because of the variability in the condition of SPFC levees, channels, and structures, applying the unit costs from Chapter 5.0 should be done with special consideration for the range of costs shown in Table 5-1, which are intended for planning purposes only.

# 8.0 References

California Debt and Investment Advisory Commission. 2014. 2013 Calendar of California Public Debt Issuance. Publication #14.08. Available at <http://www.treasurer.ca.gov/cdiac/reports/annual/2013/calendar.pdf>.

———. 2005. California Debt Issuance Primer Handbook. Publication #05-06. October. Available at <http://www.treasurer.ca.gov/cdiac/debtpubs/handbook.pdf>.

California Central Valley Flood Control Association. 2013. Flood Structure Protection Area. Rural LMA Topic Papers. December.

California Department of Fish and Game. 2010. Fish and Game Code Section 1600. Available at <http://www.leginfo.ca.gov/cgi-bin/displaycode?section=fgc&group=01001-02000&file=1600-1616>.

California Department of Water Resources (DWR). 2009. Interim Guidelines for Providing Funding to Local Public Agencies. Available at <http://www.water.ca.gov/floodsafe/fessro/deltalevees/special_projects/docs/special_interim_guidelines.pdf>. Accessed October 19, 2015.

———. 2010. State Plan of Flood Control Descriptive Document. November.

———. 2011. Flood Control System Status Report. December.

———. 2012a. 2012 Central Valley Flood Protection Plan. Sacramento, CA. Available at <http://www.cvfpb.ca.gov/CVFPP/>.

———. 2012b. Operations and Maintenance Roles and Responsibilities. Technical Memorandum. Sacramento, CA. April.

———. 2012c. Urban Levee Design Criteria. Sacramento, CA. May.

———. 2013a. Flood System Repair Project Guidelines. July.

———. 2013b. Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Protection System.

———. 2013c. Draft Fremont/Sacramento Weir Reconnaissance Level Designs and Cost Estimates.

———. 2013d. California Water Plan, Volume 3: Resource Management Strategies. Sacramento, CA. October. Available at <http://www.waterplan.water.ca.gov/cwpu2013/prd/>.

———. 2014a. Working Draft Regional Flood Management Plan for the Mid and Upper Sacramento River. April.

———. 2014b. Superintendent's Guide to Operation and Maintenance. May.

———. 2014c. Central Valley Flood System Conservation Strategy. Administrative Draft. Sacramento, CA. April.

———. 2015. Draft Central Valley Flood System Conservation Strategy. January.

California Department of Water Resources and U.S. Army Corps of Engineers (DWR and USACE). 2013. California's Flood Future: Recommendations for Managing the State's Flood Risk. Public Draft. Sacramento, CA. Available at <http://www.water.ca.gov/sfmp/resources/PRD_FFR_4-3-13MainRPT.pdf>.

DWR. *See* California Department of Water Resources.

DWR and USACE. *See* California Department of Water Resources and U.S. Army Corps of Engineers.

MHM. 2016. Feather River Regional Flood Management Plan; Feather River Levee LMA Budget; Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMMRR&R) Technical Memorandum. May 13.

Oregon Department of Transportation. 2014. Rough Roads Ahead; The Cost of Poor Highway Conditions to Oregon's Economy. Available at <http://www.oregon.gov/ODOT/COMM/Documents/RoughRoads2014.pdf>.

U.S. Army Corps of Engineers (USACE). 1955. Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project. Sacramento District. May.

———. 1959. Standard Operation and Maintenance Manual for the Lower San Joaquin River and Tributaries Project, California. Sacramento District. Available at <http://cdec.water.ca.gov/cgi-progs/products/san-joaquin-river-unit-000.pdf>. Accessed May 1, 2014.

———. 1994. Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual for Projects and Separable Elements Managed by Project Sponsors. Engineering Regulation No. 1110-2-401. September 30.

———. 2006. Levee Owner's Manual for Non-federal Flood Control Works. The Rehabilitation and Inspection Program, Public Law 84-99. March.

———. 2014. Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures. Engineering Technical Letter No. 1110-2-583. April 30.

USACE. *See* U.S. Army Corps of Engineers.

# 9.0 Acronyms and Abbreviations

| | |
|---|---|
| 2012 CVFPP | *2012 Central Valley Flood Protection Plan* |
| AB | Assembly Bill |
| BWFS | Basin-Wide Feasibility Studies |
| CCR | *California Code of Regulations* |
| CFR | *Code of Federal Regulations* |
| Conservation Strategy | Central Valley Flood System Conservation Strategy |
| CVFPB | Central Valley Flood Protection Board |
| CVFPP | Central Valley Flood Protection Plan |
| CWC | California Water Code |
| CY | cubic yard |
| Delta | Sacramento-San Joaquin Delta |
| Delta Subventions Program | Delta Levees Maintenance Subventions Program |
| DFW | California Department of Fish and Wildlife |
| DWR | California Department of Water Resources |
| FEMA | Federal Emergency Management Agency |
| FESSRO | FloodSAFE Environmental Stewardship and Statewide Resources Office |
| FMO | Flood Maintenance Office |
| FSRP | Flood System Repair Project |
| LMA | Local Maintaining Agency |
| LSJLD | Lower San Joaquin Levee District |
| NA | none available |
| O&M | operations and maintenance |
| OMRR&R | operations, maintenance, repair, rehabilitation, and replacement |

OMRR&R Cost Evaluation TM..... *Technical Memorandum – Flood System Long-Term Operations, Maintenance, Repair, Rehabilitation, and Replacement Cost Evaluation*

PL 84-99 ..... Public Law 84-99

RFMP ..... regional flood management plan

RIP ..... USACE Rehabilitation and Inspection Program

RR&R ..... repair, rehabilitation, and replacement

SB5 ..... Senate Bill 5

SERP ..... Small Erosion Repair Program

SPFC ..... State Plan of Flood Control

SRBPP ..... Sacramento River Bank Protection Program

TM ..... *Technical Memorandum – Flood System Long-Term Operations, Maintenance, Repair, Rehabilitation, and Replacement Cost Evaluation*

UCIP ..... Utility Crossing Inventory Program

ULDC ..... Urban Levee Design Criteria

ULE/NULE ..... Urban and Non-Urban Levee Evaluation

USACE..... U.S. Army Corps of Engineers

USFWS ..... U.S. Fish and Wildlife Service

Work Group..... OMRR&R Work Group

WRDA 1986 ..... Water Resources Development Act of 1986

# Appendix A
# OMRR&R Key Issues Summaries

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# Issue Summary #1 Existing Conditions and the 1955/1957 Design Profiles

*Rebuilding infrastructure and reinventing it using new technologies are essential to a new American Dream for the twenty-first century. Baby boomers who enjoyed the fruits of post-World War II investments must ensure that their children and grandchildren are not left stranded by winter storms or a failure to reinvest.*

***Rosabeth Moss Kanter, Professor of Business at Harvard Business School. 2015. Why Can't We Move? Solving America's Infrastructure Problem. Harvard Magazine. July-August.***

Flood control works in the Sacramento and San Joaquin River basins were built in increments over many decades; many levees were constructed by landowners and local entities prior to passage of the federal Flood Control Act in 1917. Many of the levees constructed prior to the initiation of the Sacramento River Flood Control Project in 1918 were included in the federal project with or without modification to meet U.S. Army Corps of Engineers (USACE) project standards. Most State Plan of Flood Control (SPFC) levees in operation today within the Sacramento River Basin were built between 50 and 100 years ago. Similarly, most SPFC levees in the San Joaquin River watershed downstream from the Merced River confluence were improved as directed by USACE in accordance with the Flood Control Act of 1944 between the mid-1950s and early 1970s. Upstream from the Merced River confluence, most SPFC levees were improved or constructed by the California Department of Water Resources (DWR) between the 1960s and early 1970s (DWR, 2011).

Many SPFC facilities now face pressures that were not known or did not exist when the facilities were originally constructed. Design criteria and construction methods have become more stringent over time as understanding of geotechnical, hydraulic, and other technical aspects of flood management has improved. As a result, most SPFC flood control facilities constructed in the early to mid-twentieth century do not meet current criteria (DWR, 2011). In some cases, facilities are now obsolete or have nearly exceeded their expected service life and are in need of major modification or repair. Facilities originally constructed primarily for navigation, sediment transport, and flood management are now also used for water supply conveyance, ecosystem functions, recreation, and other beneficial uses.

## The 1955 and 1957 Design Profiles

The hydraulic design of the SPFC is documented within various USACE documents that are referred to as the 1955/1957 design profiles. The profiles were developed to provide the basis of design and to establish appropriate levee profiles for the system.

## 1957 Design Profiles – Sacramento River Basin

The Sacramento River Basin profiles were completed and published in 1957 with design capacities developed on the basis of USACE analysis of the 1907, 1909, 1937, 1951, and 1955 floods on the Sacramento River. The Sacramento District USACE published the *Levee and Channel Profiles for the Sacramento River and Tributaries* as part of the Sacramento River Flood Control Project in 1957 (USACE, 1957). This document lists design flows for each reach of each feature of the Sacramento River Flood Control system and includes schematics of design water surface elevations (see Figure 1). The levee and channel profiles contained in this document are referred to as the 1957 design profiles.

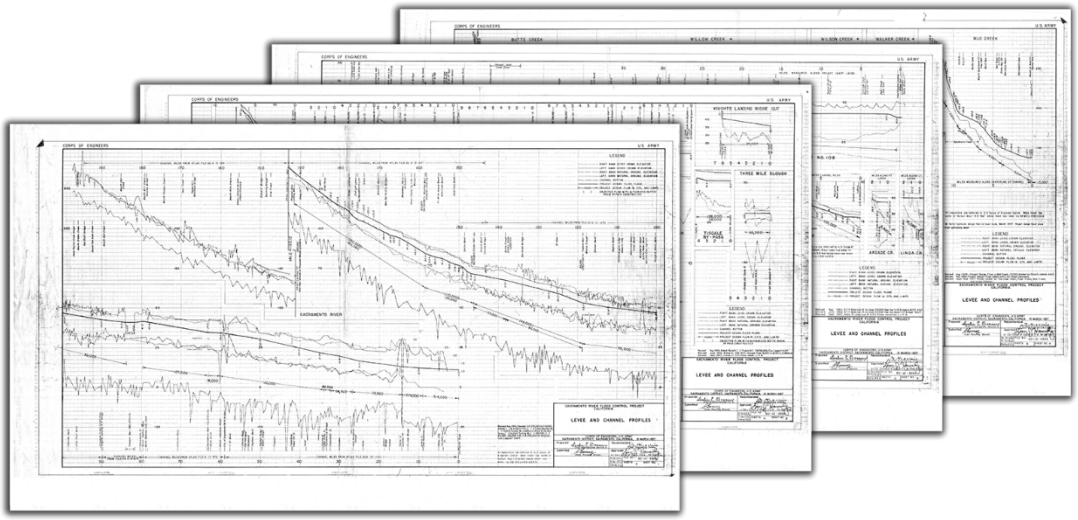

**Figure 1. Levee and Channel Profiles for the Sacramento River Flood Control Project**

## 1955 Design Profiles – San Joaquin River Basin

The San Joaquin River Basin design profiles (levee and channel profiles) were completed in 1955. In the San Joaquin River watershed (excluding the Mormon Slough Project), original design flows were derived from the *Report on Control of Floods, San Joaquin River and Tributaries Between Friant Dam and Merced River* (DWR, 1954) and later changed to reflect the 1955 design profile for the San Joaquin River, as shown in *Design Memorandum No. 1, San Joaquin River Levees, Lower San Joaquin River and Tributaries Project, California General Design* (1955 design profile) (USACE, 1955). This document lists design flows for each reach of each feature of the San Joaquin River flood control system and includes schematics of design water surface elevations (see Figure 2). For SPFC channels in the Mormon Slough Project, design capacities were based on the 1965 design profile (USACE, 1965).

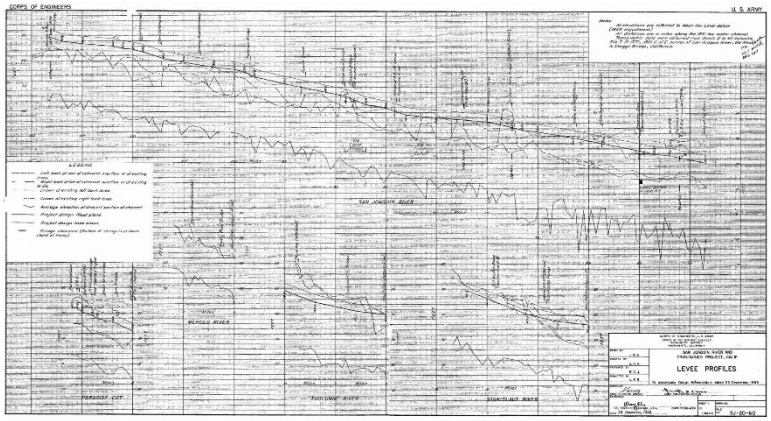


**Figure 2. Levee and Channel Profiles for the San Joaquin River and Tributaries Project**

For channels not delineated in the 1955, 1957, or 1965 design profiles, design capacities were determined based on as-constructed conditions and specified in appendixes to operations and maintenance (O&M) manuals provided by USACE.

### O&M and the 1955/1957 Profiles

Historically, DWR has viewed the 1955/1957 profiles as the standard to which O&M activities should be performed in order to ensure the hydraulic performance of the SPFC, including identification of levee crest and channel bottom elevations to assist in identifying channel capacities. The O&M manuals covering the SPFC consistently make reference to the 1955/1957 profiles as the guiding instrument for O&M activity. However, it is now recognized that the Sacramento and San Joaquin rivers, streams and tributaries, and the associated flood control works have undergone geomorphic change due to sedimentation, levee erosion, channel accretion and levee degradation, urbanization, reservoir storage, and dam operations such that considering the 1955/1957 profiles as the standard for O&M activities may no longer be viable.

## Existing Conditions of the SPFC

In 2011, DWR produced the Flood Control System Status Report (FCSSR) to document the existing conditions of the SPFC and inform the 2012 Central Valley Flood Protection Plan (CVFPP). The FCSSR describes the current physical condition of SPFC facilities at a systemwide level. The overall condition of urban levees, non-urban levees, channels, and flood control structures of the SPFC is summarized in the FCSSR as follows:

- **Urban levees** – Approximately one-half of about 300 miles of SPFC urban levees evaluated do not meet current levee freeboard, stability, or seepage design criteria at the design water surface elevation.

- **Non-urban levees** – Approximately three-fifths of about 1,230 miles of SPFC non-urban levees evaluated have a high potential for failure from under-seepage, through-seepage, structural instability, and erosion at the assessment water surface elevation. Non-urban levees

were evaluated on the basis of systematic, consistent, and repeatable analyses that correlated geotechnical data with levee performance history, not relative to any current design criteria.

- **SPFC channels** – Approximately one-half of the 1,016 miles of channels evaluated in the SPFC have a potentially inadequate capacity to convey design flows and require additional evaluation to confirm conditions.

- **SPFC flood control structures** – None of the 32 hydraulic structures or 11 pumping plants inspected by DWR for the SPFC were rated "unacceptable" during the 2009 inspections. Of the ten SPFC bridges inspected by DWR in 2009, two needed repairs.

### FCSSR Channel Capacity for the 2012 CVFPP

In the FCSSR, existing channel capacities were estimated through systemwide modeling performed via the Central Valley Floodplain Evaluation and Delineation program using the best data available at the time. Results indicated that approximately one-half of the 1,016 miles of SPFC channels are potentially unable to convey design flows, and approximately one-quarter of channel design capacities reported in O&M manuals do not agree with flows specified in the original 1955/1957 design profiles. The FCSSR acknowledges that additional evaluations are required.

Current modeling efforts performed by DWR (see discussion below) on a reach-by-reach basis show that many of the channels comprising the SPFC actually cannot convey their design flow while maintaining adequate freeboard (McGrath, 2015, pers. comm.).

### Issues with Calculating and Developing the 1955/1957 Design Channel Capacities

The channel capacities shown on the 1955/1957 design profiles that are used to determine operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) obligations were calculated from the design water surface elevations, which were based on steady-state, uniform-flow hydraulic computations of historical floods using data available at the time. Therefore, design channel capacities were based on a limited hydrological record; were highly dependent on the boundary conditions assumed, meaning the profiles typically only considered short reaches of the system; and did not consider variations in flow and depth with respect to time and distance. The design profiles, which are a series of flood elevations calculated at a series of points or cross sections through the system and connected by a straight line (see Figure 3), were defined by a limited number of cross sections, often times less than one per mile. These straight line interpolations do not account for changes in cross sections, vegetation, encroachments, bridges, or other features in the channels between the cross sections.

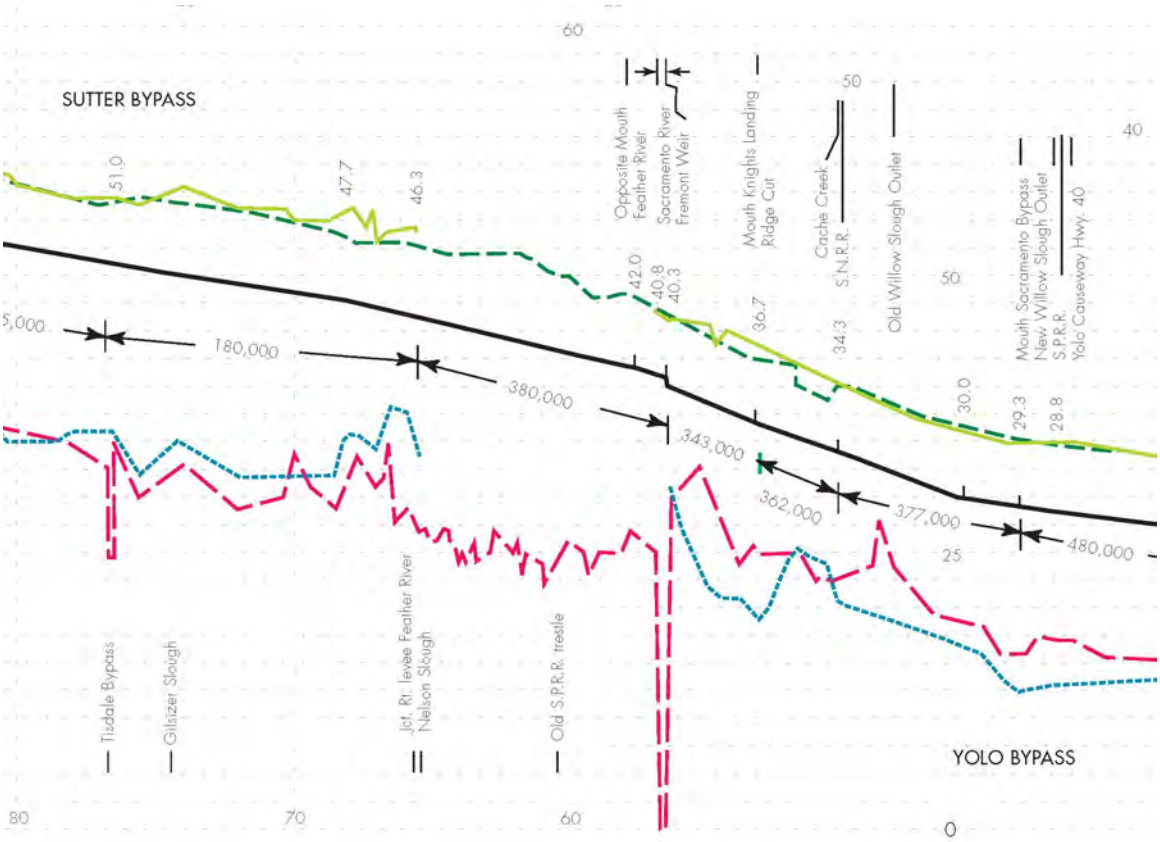


**Figure 3. Zoomed-In View of the 1957 Design Profile from Sutter Bypass at the Mouth of Tisdale Bypass to the Mouth of Sacramento Bypass in Yolo Bypass**

## Current SPFC Water Surface Elevation Modeling Efforts and Channel Capacity Understanding

Recent hydraulic modeling efforts, including the Central Valley Floodplain Evaluation and Delineation, have had difficulty re-creating the 1955/1957 design flows and profiles on a systemwide basis, even when assuming cleared trapezoidal channels with very low n-values. This could be due to several reasons including more advanced modeling capabilities, uncertainties in flood flow estimations used in the Sacramento and San Joaquin Project designs, changes in reach extents and cross sections, flow timing, and levee profiles and channel inverts that do not match the as-built condition. Some evaluations appear to indicate the original as-built condition could not pass the design flow at the design stage. For example, a recent study (ESA PWA, 2011) of the most critical section of the Cherokee Canal in Butte County between Cottonwood Creek and the Union Pacific Railroad Bridge south of Richland evaluated both the original design and current capacity. The 1957 design capacity in this reach is 11,500 cubic feet per second (cfs), assuming a Manning's n-value of 0.03. However, analysis results show the channel could only convey a maximum of 9,570 cfs, assuming as-built conditions and while maintaining at least 3 feet of freeboard.

More recently, DWR's Flood Maintenance Office has undertaken an effort to model the Sacramento River flood control system on a reach-by-reach basis to determine the ability to pass the design flows (see Figure 4). Reaches are prioritized through channel inspections and reporting of potential problems by local maintaining agencies, and then systematically modeled using one-dimensional HEC-RAS hydraulic models (two-dimensional models where available). Models are run using steady-state flows and boundary condition stages from the 1957 design, and freeboard is calculated by comparing the calculated stages to the existing top-of-levee elevations based on recent LiDAR data obtained. Where freeboard deficiencies are identified, remedial maintenance actions including vegetation and sediment removal are evaluated for implementation.

PRELIMINARY DATA - SUBJECT TO REVSION

FMO Model Summary Table (Only Channels with Available Model Data Included)

| | | Length in FMO Model (Miles) | | | | | | Deficient Length (Miles) Allowed/Sensitivity (in feet) shown below | | | | | Cross Sections with Required Freeboard and 57 Profile Data | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cross Sections with Levees and Freeboard Requirement | | | Cross Sections with 57 Profile Data Available | | 0 | 0 | 0 | 0 | 0 | | | |
| | | | | | | | | Cross Sections with Levees and Freeboard Requirement | | | Cross Sections with 57 Profile Data | | Average Deficiency (feet) | | |
| | | | | | | | | Freeboard Deficiency | | | WSE | WSE & FB | Freeboard | | |
| Channel | Status | Channel Center Line | Left | Right | At Least One Side | WSE | WSE & FB | Left | Right | At Least One Side | Only | | Left | Right | WSE |
| Bear River | In Process | 16.311 | 12.953 | 13.52 | 14.371 | 12.033 | 12.033 | 0 | 0 | 0 | 0 | 0 | N/A | N/A | N/A |
| Best Slough | In Process | 2.003 | 2.003 | 0 | 2.003 | 1.728 | 1.728 | 0 | N/A | 0 | 0 | 0 | N/A | N/A | N/A |
| Butte Creek (Lower) | Complete | 13.03 | 0 | 0 | 0 | 0 | 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Butte Creek (Upper) | Complete | 15.19 | 15.014 | 15.19 | 15.19 | 15.19 | 15.19 | 4.137 | 3.867 | 4.566 | 5.873 | 4.021 | 0.54 | 0.74 | 0.75 |
| Cache Creek | Complete | 10.106 | 10.106 | 10.106 | 10.106 | 9.992 | 9.992 | 2.605 | 3.265 | 4.336 | 0 | 0 | 0.54 | 0.7 | N/A |
| Cherokee Canal | Complete | 20.18 | 19.014 | 18.809 | 19.86 | 19.763 | 19.763 | 15.877 | 16.402 | 16.623 | 17.897 | 16.614 | 1.71 | 1.68 | 2.85 |
| Deer Creek | Complete | 9.568 | 3.947 | 2.029 | 4.494 | 6.324 | 4.26 | 2.062 | 1.903 | 2.752 | 5.795 | 2.494 | 1.92 | 1.79 | 4.81 |
| Dry Creek (Bear Tributary) | In Process | 2.782 | 2.655 | 1.826 | 2.782 | 1.49 | 1.49 | 0.695 | 0 | 0.695 | 0 | 0 | 0.84 | N/A | N/A |
| East Side Canal | Complete | 4.732 | 0 | 4.714 | 4.714 | 4.732 | 4.714 | N/A | 3.558 | 3.558 | 4.732 | 3.558 | N/A | 0.62 | 1.21 |
| Elder Creek | Complete | 4.232 | 3.854 | 3.972 | 4.052 | 4.232 | 4.052 | 2.369 | 2.718 | 2.955 | 2.653 | 2.534 | 1.6 | 1.59 | 1.49 |
| Knights Landing | In Process | 6.169 | 5.919 | 5.919 | 5.919 | 6.169 | 5.919 | 0.424 | 0.326 | 0.524 | 0 | 0 | 0.4 | 0.4 | N/A |
| Little Chico Diversion Channel | Complete | 2.793 | 0 | 1.306 | 1.306 | 2.793 | 1.306 | N/A | 0 | 0 | 0.018 | 0 | N/A | N/A | 0.2 |
| Mud Creek | In Process | 5.334 | 5.334 | 5.334 | 5.334 | 5.302 | 5.302 | 3.272 | 3.237 | 3.388 | 4.007 | 3.388 | 1.24 | 1.24 | 2.03 |
| Natomas Cross Canal | Complete | 5.06 | 5.06 | 5.06 | 5.06 | 5.06 | 5.06 | 0 | 0 | 0 | 5.051 | 0 | N/A | N/A | 0.34 |
| NEMDC | Complete | 4.416 | 3.844 | 4.416 | 4.416 | 4.416 | 4.416 | 0 | 0 | 0 | 3.827 | 0 | N/A | N/A | 0.83 |
| Putah Creek | In Process | 19.034 | 6.932 | 6.894 | 6.932 | 6.152 | 6.152 | 0.552 | 0.397 | 0.751 | 0 | 0 | 0.8 | 0.28 | N/A |
| Sutter Bypass (HEC-RAS) | Complete | 36.923 | 22.327 | 28.979 | 29.387 | 36.502 | 29.387 | 4.215 | 3.252 | 5.897 | 7.111 | 1.372 | 0.32 | 0.41 | 0.23 |
| Sutter Bypass (RMA2) | Complete | 31.093 | 30.18 | 30.758 | 31.035 | 30.595 | 30.595 | 3.312 | 4.245 | 5.439 | 23.961 | 5.048 | 0.79 | 0.72 | 0.58 |
| Sycamore Creek | In Process | 5.525 | 3.406 | 2.515 | 3.785 | 5.477 | 3.735 | 0.808 | 0.982 | 1.108 | 1.569 | 0.987 | 0.45 | 0.72 | 0.54 |
| Tisdale Bypass | Complete | 4.682 | 4.682 | 4.682 | 4.682 | 4.179 | 4.179 | 3.209 | 3.943 | 4.146 | 4.179 | 3.912 | 0.72 | 0.8 | 0.53 |
| Wadsworth Canal | Complete | 4.629 | 4.617 | 4.617 | 4.617 | 4.226 | 4.214 | 0.991 | 0.02 | 0.991 | 0 | 0 | 0.47 | 0.2 | N/A |
| Willow Slough Bypass | In Process | 8.296 | 7.655 | 7.655 | 7.655 | 7 | 7 | 0.959 | 2.515 | 2.773 | 0.062 | 0 | 0.18 | 0.28 | 0.1 |
| WPIC | In Process | 5.794 | 2.184 | 5.708 | 5.706 | 5.794 | 5.706 | 0 | 0 | 0 | 5.147 | 0 | N/A | N/A | 0.29 |
| Yankee Slough | In Process | 6.011 | 3.867 | 4.154 | 4.154 | 4.154 | 4.154 | 0.273 | 0.042 | 0.311 | 0.204 | 0 | 0.12 | 0.35 | 0.15 |
| | Total (Miles) | 242.893 | 174.453 | 187.761 | 197.558 | | | 17.391 | 18.633 | 24.804 | | | | | |
| | Deficient (%) | | | | | | | 10% | 10% | 13% | | | | | |

**Figure 4. DWR's Flood Maintenance Office Model Summary Table**

*Source: DWR FMO*

## Sutter Bypass and the 1957 Design Profiles

In 2011, a two-dimensional hydraulic model was developed for the Sutter Bypass with the intent of evaluating the 1957 design profile water surface elevation and comparing it to current 100- and 200-year storm events using existing conditions. The resulting analysis shown on Figure 5 indicates that using the existing conditions within Sutter Bypass makes it difficult to replicate the 1957 water surface profile. The flow conditions in Table 1 were applied in development of the Sutter Bypass hydraulic analysis. Additionally, current 100- and 200-year storm events significantly encroach on the available freeboard of the west levee of Sutter Bypass, as shown in Table 1.

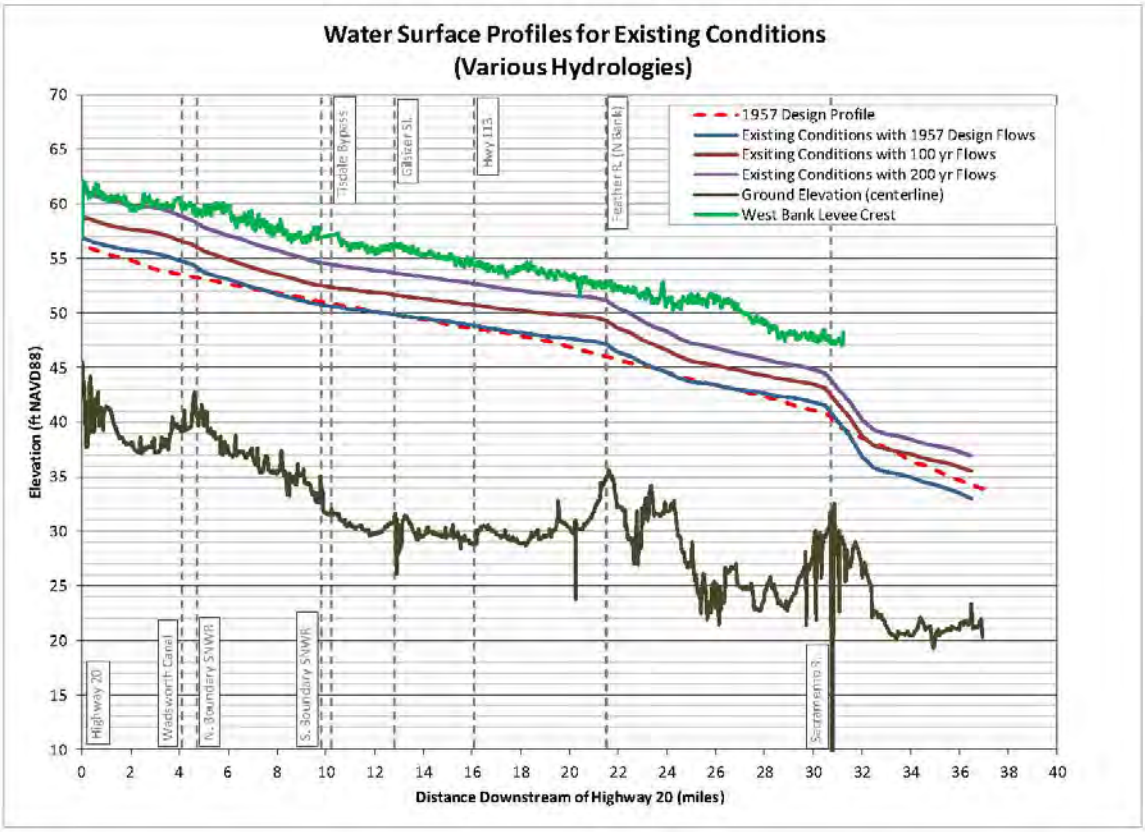


**Figure 5. Sutter Bypass Water Surface Profiles for Existing Conditions, the 1957 Profiles, 100- and 200-Year Storm Events**

*Source: Sutter Bypass Two Dimensional Hydraulic Modeling (CH2M HILL, 2013)*

**Table 1. Flow Conditions Applied in Development of the Sutter Bypass Hydraulic Analysis**

| Location | 1957 Design Flow (cfs) | 100-Year Flow (cfs) | 200-Year Flow (cfs) |
|---|---|---|---|
| Sutter Bypass at Long Bridge | 150,000 | 184,002 | 227,157 |
| Wadsworth Canal | 1,500 | 1,572 | 1,501 |
| Tisdale Bypass | 28,500 | 16,551 | 16,705 |
| Feather River | 200,000 | 323,826 | 377,289 |
| Sacramento River at Knights Landing | 30,000 | 39,564 | 40,337 |
| Knights Landing Ridge Cut | 19,000 | 304 | 340 |
| Cache Creek | 15,000 | 39,154 | 40,568 |
| Natomas Cross Canal | 22,000 | 24,871 | 27,877 |

*Source: Revised table from Sutter Bypass Two Dimensional Hydraulic Modeling (CH2M HILL, 2013)*

## References

California Department of Water Resources (DWR). 1954. Report on Control of Floods, San Joaquin River and Tributaries Between Friant Dam and Merced River.

———. 2011. Flood Control System Status Report. December.

CH2M HILL. 2013. Sutter Bypass Two Dimensional Hydraulic Modeling. October.

DWR. *See* California Department of Water Resources.

ESA PWA. 2011. Cherokee Canal: Conveyance Assessment of As-Designed and Existing Conditions to Support Preliminary Design Concepts for Channel Maintenance and Long-Term Corridor Management. May 27.

McGrath, Eric. 2015. Senior Water Resources Engineer. California Department of Water Resources, Flood Maintenance Office. Email communication with Jordan Vazquez of CH2M HILL regarding current flood channel capacity as it relates to the 1955/57 design profiles. September.

U.S. Army Corps of Engineers (USACE). 1955. Design Memorandum No. 1, San Joaquin River Levees, Lower San Joaquin River and Tributaries Project, California General Design.

———. 1957. Levee and Channel Profiles for the Sacramento River and Tributaries. March 15.

———. 1965. Mormon Slough Project, San Joaquin County, Plan of Improvement, Profile and Flood Plane. November 19.

USACE. *See* U.S. Army Corps of Engineers.

# Issue Summary #2
# Transactional Costs, Including Environmental Compliance

*The way in which we manage our water resources can improve the quality of our citizens' lives. It has affected where and how people live and influenced the development of this country. The country today seeks economic development as well as the protection of environmental values.*

***Lieutenant General Carl Strock, Chief of Engineers, U.S. Army Corps of Engineers. 2007. The Subcommittee on Water Resources and Environment, Committee on Transportation and Infrastructure, U.S. House of Representatives. February 14, 2007.***

Transactional costs include those associated with planning, facilitating, or supervising an action on the ground, from beginning to end. Transactional costs include design, in-office construction management, real estate activities, biological and engineering surveys, and environmental permitting and mitigation compliance. Transactional costs are highly variable and often project- and site-specific. In this issue summary, we attempt to identify, categorize, and quantify transactional costs associated with operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) activities. Because compliance with environmental regulations and permitting requirements can represent a significant cost in the OMRR&R of State Plan of Flood Control (SPFC) facilities and has resulted in deferred maintenance in some cases, this issue summary focuses on environmental compliance.

## Transactional Costs

Transactional costs for operations and maintenance (O&M) activities are challenging to quantify. O&M activities are usually carried out as routine, and transactional costs for O&M are not usually separated from other costs in State and local maintaining agency (LMA) records.

State records show that repair, rehabilitation, and replacement (RR&R) projects generally include estimates of transactional costs because RR&R projects generally require more detailed planning and budgeting.

To demonstrate the magnitude of transactional costs associated with Sacramento River flood projects in general, Table 1 presents transactional costs incurred on eight recent capital improvement projects compared to their construction costs. Construction costs include materials needed for construction, charges for equipment use (per mile or per hour), and staff time on the worksite (craft workers). These projects include the West Sacramento Levee Improvement Program (the Rivers and California Highway Patrol Academy projects), Three Rivers Levee Improvement Program Phases 2 through 4, and the Reclamation District (RD) 1001 Emergency Slip Repair Project. Additionally, the West Sacramento Levee Improvement Southport Project, which is currently being designed and permitted, is included with costs based on actuals to date plus estimated costs to complete. Because these are construction projects, they likely best represent the transactional costs for RR&R activities. No data were available for San Joaquin River projects.

**Table 1. Proportion of Transactional Costs to Construction Costs for Selected Capital Improvement Flood Projects[1]**

| Activity Element | Average | Range |
|---|---|---|
| **Transactional Costs (Itemized)** | | |
| • Site-by-site permitting to ensure regulatory compliance and payroll for design, supervision, and administration prior to construction (These costs are often lumped together.) | 19% | 12–33% |
| • Real estate (including payroll for supervision and administration) | 10% | 0–31% |
| • Cultural resources | <1% | 0–1% |
| • Environmental restoration onsite after completion of construction | <1% | 0–2% |
| • Offsite compensatory mitigation of impacts (includes itemized costs for mitigation of cultural, air quality, water quality, wetlands, or species impacts) | 3% | 0–11% |
| • Recreation (which is not a typical cost of RR&R, but is typical of capital projects) | 5% | 0–36% |
| • Payroll for construction supervision and administration[2] | 9% | 4–17% |
| **Transactional Costs (total of above Itemized Items)** | **46%** | **16–89%** |
| **Construction Costs (materials, craft worker time, equipment use)** | **54%** | **11–84%** |
| **Total Project Costs** | **100%** | **100%** |

*Source: MBK Engineers, 2015.*

Notes:
1 Projects include West Sacramento Levee Improvement Program (the Rivers and California Highway Patrol Academy projects), Three Rivers Levee Improvement Program Phases 2 through 4, RD 1001 Emergency Slip Repair Project, and West Sacramento Levee Improvement Southport Project.
2 Costs for the West Sacramento project are only estimated because the project is not yet constructed. These costs are included in the averages because there is a published estimate.

As shown in Table 1, transactional costs can represent a substantial proportion of total project costs and can nearly equal construction costs. The ranges of proportional costs indicate the variability of transactional costs. Transactional costs have significantly increased in the past decades.

Regulatory compliance costs in Table 1 are generally captured among the listed transactional cost categories and were not clearly defined individually in the data reviewed, except for specific onsite restoration or offsite compensatory mitigation components of a project. Additionally, the costs associated with environmental consultants are commonly included in the design, permitting, supervision, and administration costs. Without itemized costs, especially for O&M, the true costs of regulatory compliance and trends cannot be quantified.

### State Labor Costs and Design, Permitting, and Administration Costs

Costs per State employee, including the employee's salary, retirement from the California Public Employees' Retirement System (CalPERS) (including Social Security and Medicare), and health benefits costs, have increased by 24 percent since 1993-94 (Legislative Affairs Office [LAO], 2014). Between 1993-94 and 2012-13, costs per State employee increased from about $77,000 to nearly $96,000 per year. With pay increases and other CalPERS changes in 2014-15, costs per State employee would be more than 30 percent higher than in 1993-94, at more than $100,000 per year (LAO, 2014). As rates increase, the transactional costs of design, permitting, and

administration, as well as construction management, will also become more substantial in proportion to the costs directly related to construction.

### Real Estate Costs

When planning for major RR&R projects (e.g., seepage berms) that include the purchase of adjacent land, associated costs must be included in the project budget. Most of the SPFC lies next to high-value farmlands where the market determines permanent plantings (e.g., almonds, walnuts, wine grapes), particularly where water for irrigation is secure. Farm real estate in California has increased in value over time, especially as high-value permanent plantings become more common. In 2015, California farm real estate was valued at an average of $7,700 per acre, which is a record high for California, $400 per acre above the previous record set in 2014 and $1,030 per acre higher than just 5 years ago in 2011 (U.S. Department of Agriculture [USDA], 2015). Figure 1 shows farm real estate values from 1996 through 2009. Based on the capital projects evaluated in Table 1, land costs can be as high as 31 percent of the total cost of a project, and as land prices increase, this percentage of the total cost may increase.

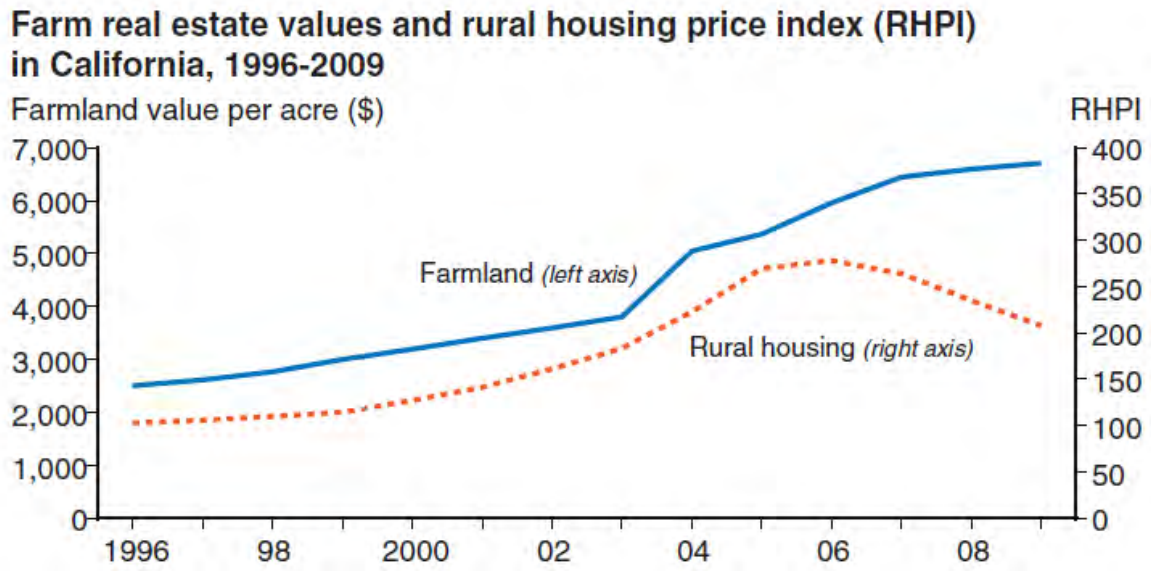


**Figure 1. Trends in Farm Real Estate in California**

*Source: USDA, 2012.*

Key:
RHPI = rural housing price index

## Environmental Compliance

### Applicable Regulations

California Department of Water Resources' (DWR's) Water Resources Engineering Memorandum 58b states that DWR must comply with applicable federal, State, and local environmental laws and other regulatory requirements. In addition, there is strong public support for environmental laws in California, with numerous entities (nongovernmental organizations) involved in ensuring compliance by DWR and the LMAs. As a result, environmental

requirements and permits are now integral to flood management activities. Environmental compliance is critical to ensuring that OMRR&R activities proceed in a timely fashion and are conducted in a manner that maintains the ongoing function of the flood facilities.

Each project that DWR and LMAs implement typically requires compliance and authorization of State and federal laws and regulations. For example, a levee repair project likely requires compliance with the California Environmental Quality Act (CEQA), National Environmental Policy Act (NEPA), federal Endangered Species Act (ESA), California Endangered Species Act (CESA), Sections 401 and 404 of the Clean Water Act (CWA), Sections 10 and 14 of the Rivers and Harbors Act (RHA) (33 United States Code [U.S.C.] 408), Section 106 of the National Historic Preservation Act (NHPA), and Section 1600 of the California Fish and Game Code. Each of these regulations has coordination needs, regulatory requirements, fees, and timelines. DWR's Flood Maintenance Office or Maintenance Area staff prepare the permit applications for regulatory agency review. Their costs, therefore, fluctuate with both State labor costs and the need for permits.

Table 2 specifies the OMRR&R activities and regulatory permits and approvals generally required. The applicability of these permits is influenced by the location of the OMRR&R activity and the proximity of the activity to the floodway and active channel. The information presented in Table 2 is organized to demonstrate those distinctions. Although in-water and near-water activities are generally subject to more regulation, there is considerable overlap in permitting responsibility within adjacent zones.

### Regional Permitting Challenges

Coordination with the Regional Flood Management Planning regions through the Regional Flood Management Plan (RFMP) process has given DWR a better understanding of permitting challenges in the regions, provided additional context to understand habitat and species needs, and provided a platform for collaboration between the regions and DWR. RFMPs present the regions' perspectives on environmental compliance and regulatory issues within their jurisdictions. Table 3 summarizes these perspectives (DWR, 2015a).

## Table 2. Typical Regulatory Compliance Requirements by OMRR&R Activity and Zone

| | National Environmental Policy Act | California Environmental Quality Act | Clean Water Act – Section 404 (USACE) | Clean Water Act – Section 401 (RWQCB) | Rivers and Harbors Act – Section 10 (USACE) | 33 U.S.C. 408 (USACE) | Coastal Zone Management Act/ California Coastal Act (BCDC) | Federal Endangered Species Act – Section 7 (USFWS/NMFS) | Federal Endangered Species Act – Section 10 (USFWS/NMFS) | California Endangered Species Act – Section 2081/2080.1 (DFW) | Magnuson-Stevens Fishery Conservation and Management Act (NMFS) | Migratory Bird Treaty Act (USFWS) | California Lake and Streambed Alteration Agreement (DFW) | California Fish and Game Code 3503/Nesting Birds (DFW) | Local Permits (grading, burn, chemical application) | Compensation or Mitigation within Permits (install, monitor, O&M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **In-Water[1]** | | | | | | | | | | | | | | | | |
| Channel/Encroachment Inspections | | | | | | | | | | | | | | | | |
| Channel Debris/Trash Removal | Y | Y | | | | | | | Y | Y | Y | | Y | | | Y |
| Channel Vegetation Management | Y | Y | | | | | Y | | Y | Y | Y | | Y | | | Y |
| Channel Scour Repair/Sediment Removal | Y | Y | Y | Y | Y | | Y | Y | | Y | Y | | Y | | | Y |
| Channel Weirs/Basins/Traps | Y | Y | Y | Y | Y | | Y | Y | | Y | Y | | Y | | | Y |
| Encroachment Repair/Replace/Remediate | Y | Y | Y | Y | Y | | Y | Y | | Y | Y | | Y | | | Y |
| Minor Erosion Repair | Y | Y | Y | Y | | | Y | Y | | Y | Y | | Y | | | Y |
| Pumping Facilities | Y | Y | | | | | | | Y | Y | Y | | | | | Y |
| Slide Repair | Y | Y | Y | Y | Y | Y | Y | Y | | Y | Y | | Y | | Y | Y |
| **Near-Water (Riparian/Active Floodplain)[2]** | | | | | | | | | | | | | | | | |
| Channel/Encroachment/Levee Inspections | | | | | | | | | | | | | | | | |
| Channel Scour Repair | Y | Y | Y | Y | Y | Y | Y | Y | | Y | Y | Y | Y | Y | Y | Y |
| Channel Sediment Removal | Y | Y | Y | Y | | | Y | Y | | Y | Y | Y | Y | Y | Y | Y |
| Channel Vegetation Management | Y | Y | | | | | Y | | Y | Y | Y | Y | Y | Y | Y | Y |
| Channel Weirs/Basins/Traps | Y | Y | Y | Y | Y | | Y | Y | | Y | Y | Y | Y | Y | Y | Y |
| Encroachment Repair/Replace/Remediate | Y | Y | | | | Y | Y | | Y | Y | | Y | Y | Y | Y | Y |
| Levee Burning | Y | Y | | | | | | | Y | Y | | Y | Y | Y | | Y |
| Levee Flap Gates and Valves Maintenance | Y | Y | | | | | | | Y | Y | | | Y | Y | | Y |
| Levee Mowing/Grazing | Y | Y | | | | | Y | | Y | Y | | Y | Y | Y | | Y |

## Table 2. Typical Regulatory Compliance Requirements by OMRR&R Activity and Zone

| | National Environmental Policy Act | California Environmental Quality Act | Clean Water Act – Section 404 (USACE) | Clean Water Act – Section 401 (RWQCB) | Rivers and Harbors Act – Section 10 (USACE) | 33 U.S.C. 408 (USACE) | Coastal Zone Management Act/ California Coastal Act (BCDC) | Federal Endangered Species Act – Section 7 (USFWS/NMFS) | Federal Endangered Species Act – Section 10 (USFWS/NMFS) | California Endangered Species Act – Section 2081/2080.1 (DFW) | Magnuson-Stevens Fishery Conservation and Management Act (NMFS) | Migratory Bird Treaty Act (USFWS) | California Lake and Streambed Alteration Agreement (DFW) | California Fish and Game Code 3503/Nesting Birds (DFW) | Local Permits (grading, burn, chemical application) | Compensation or Mitigation within Permits (install, monitor, O&M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Levee Rodent Control with Chemicals or Physical Means | Y | Y | | | | | | | Y | Y | | | | | | U |
| Levee Rodent Damage Repairs/Grouting | Y | Y | Y | | | Y | Y | | Y | Y | | | | | | Y |
| Levee Vegetation Maintenance and Slope Contouring | Y | Y | | | | | Y | | | Y | | Y | Y | Y | | Y |
| Minor Erosion Repair | Y | Y | Y | Y | Y | Y | Y | Y | | Y | | Y | Y | Y | | Y |
| Monitoring and Relief Wells | Y | Y | | | | Y | Y | | Y | Y | | Y | Y | Y | | Y |
| Pumping Facilities | Y | Y | | | | | | | Y | Y | Y | Y | Y | Y | | Y |
| Slide Repair | Y | Y | Y | Y | Y | Y | Y | Y | | Y | Y | Y | Y | Y | | Y |
| **Upland (Inactive Floodplain/Upland)[3]** | | | | | | | | | | | | | | | | |
| Levee Inspections | | | | | | | | | | | | | | | | |
| Encroachment Repair/Replace/Remediate | Y | Y | | | | | | | Y | Y | | Y | | Y | Y | Y |
| Flood Walls | Y | Y | | | | | Y | | Y | Y | | Y | | Y | | Y |
| Retaining Walls | Y | Y | | | | | Y | | Y | Y | | Y | | Y | Y | Y |
| Levee Burning | Y | Y | | | | | | | Y | Y | | Y | | Y | | Y |
| Levee Maintenance: (flap gates, valves, fencing, gates) | Y | Y | | | | | | | Y | Y | | | | Y | | Y |
| Levee Access Road Grading and Surfacing | Y | Y | | | | Y | Y | | Y | Y | | Y | | Y | | U |
| Levee Access Road Spraying | Y | Y | | | | | | | Y | Y | | Y | | Y | | U |
| Levee Vegetation Maintenance and Slope Contouring | Y | Y | | | | | Y | | Y | Y | | Y | | Y | | Y |

## Table 2. Typical Regulatory Compliance Requirements by OMRR&R Activity and Zone

| | National Environmental Policy Act | California Environmental Quality Act | Clean Water Act – Section 404 (USACE) | Clean Water Act – Section 401 (RWQCB) | Rivers and Harbors Act – Section 10 (USACE) | 33 U.S.C. 408 (USACE) | Coastal Zone Management Act/ California Coastal Act (BCDC) | Federal Endangered Species Act – Section 7 (USFWS/NMFS) | Federal Endangered Species Act – Section 10 (USFWS/NMFS) | California Endangered Species Act – Section 2081/2080.1 (DFW) | Magnuson-Stevens Fishery Conservation and Management Act (NMFS) | Migratory Bird Treaty Act (USFWS) | California Lake and Streambed Alteration Agreement (DFW) | California Fish and Game Code 3503/Nesting Birds (DFW) | Local Permits (grading, burn, chemical application) | Compensation or Mitigation within Permits (install, monitor, O&M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Levee Rodent Control with Chemicals or Physical Means | Y | Y | | | | | | | Y | Y | | | | | | |
| Levee Rodent Damage Repairs/Grouting | Y | Y | | | | Y | Y | | Y | Y | | | | | | Y |
| Monitoring and Relief Wells | Y | Y | | | | Y | Y | | Y | Y | | Y | | Y | | Y |
| Slide Repair | Y | Y | | | | Y | Y | | Y | Y | | Y | | Y | | Y |

*Source: Developed by OMRR&R Work Group.*

Key:
BCDC = Bay Conservation and Development Commission
DFW = California Department of Fish and Wildlife
NMFS = National Marine Fisheries Service
RWQCB = Regional Water Quality Control Board
U = Unusual circumstances may create an impact on a State or federal resource that requires mitigation
USACE = U.S. Army Corps of Engineers
USFWS = U.S. Fish and Wildlife Service
Y = Yes

Notes:
1 "In-water" refers to the wetted portion of a drainage that is typically (i.e., 1- to 2-year recurrence interval) wetted.
2 "Near-water" refers generally to the area between the in-water outboard margins landward to the hinge of a levee.
3 "Upland" refers to zone, is not water dependent, and is rarely if ever wetted.

**Table 3. Environmental Compliance and Regulatory Concerns and Challenges Listed by RFMPs**

| RFMP | Challenge or Concern | | | | Habitat and Species |
|---|---|---|---|---|---|
| | Land Use | Budgeting and Scheduling | Permitting | Access to Floodway | |
| Feather River | Need to increase use of Special Flood Hazard Areas to sustain agriculture. | Refining work windows that meet the needs of species protection and flood activities, both of which can be constrained by seasonal events and conditions, will support integrated management.<br>Excavation of rodent holes versus grouting to protect giant garter snakes is a more extensive and expensive repair process. | Compliance with laws is burdensome, lengthy, and expensive. As such, some LMAs typically avoid the permitting process altogether. Existing laws set relatively short time limits (thus LMAs need to renew a permit often).<br>Prefer a programmatic approach over the current piecemeal approach to mitigating adverse environmental effects. | LMAs have lost their historical freedom and license to maintain their system appropriately (clear vegetation, repair erosion, restore levee sections, and resurface roads) from late spring through fall. | |
| Mid Upper Sacramento River | Sutter Bypass should be considered for its unique features, including its agriculture, which provides value as habitat for species.<br>Incentivize and encourage wildlife-friendly farming practices. | The addition of environmental requirements on a historical system has resulted in competing needs for limited LMA funding.<br>LMAs are having difficulty conducting routine O&M of the levee system because, increasingly, resource agencies are requiring compensatory mitigation (an expense).<br>Reductions in the number of staff at regulatory agencies is increasing the time for a complete permitting package. | Prefer a programmatic approach over the current piecemeal approach to mitigating adverse environmental effects.<br>Regulatory requirements are affecting O&M and resulting in deferred maintenance. There is a “fear of the unknown.”<br>Even small projects with low construction costs require substantial review and permitting. | | Fish passage is needed at Moulton, Colusa, and Tisdale weirs.<br>Knights Landing Gates Fish Passage Improvements are needed to stop salmonids from straying from the Sacramento River to the Colusa Basin Drain. |
| Lower Sacramento River/Delta North | Implementation of restoration and setback levees to meet biological opinions will adversely affect agriculture. | LMAs are have difficulty conducting routine O&M of the levee system because, increasingly, resource agencies are requiring compensatory mitigation (an expense). | | | Need for refugia for giant garter snakes and other animals on Yolo Bypass west levee.<br>Impeded fish passage at the Fremont weir, Yolo Bypass toe drain, Lisbon weir, and irrigation dams in the northern end of Tule Canal. |

**Table 3. Environmental Compliance and Regulatory Concerns and Challenges Listed by RFMPs**

| RFMP | Challenge or Concern | | | | Habitat and Species |
|---|---|---|---|---|---|
| | Land Use | Budgeting and Scheduling | Permitting | Access to Floodway | |
| Lower San Joaquin River/Delta South | | | Erosion control permitting is complicated.<br>Need streamlined permitting for levees in RD 773 and RD 2058. | Many levees do not meet USACE Engineer Technical Letter 1110-2-583 vegetation standards in Stockton and surrounding areas. | |
| Mid San Joaquin River | | Funding is limited because land base in this area is agricultural (low tax yield). | Difficult to permit removal of vegetation, animal control, and controlled burns.<br>Prefer a programmatic approach over the current piecemeal approach to mitigating adverse environmental effects. | Not allowed to remove vegetation after a levee safety inspection when it is habitat for endangered species. | |
| Upper San Joaquin River | | Financing of the San Joaquin River Restoration Program is uncertain, and no long-term O&M agreements are in place yet.<br>Permitting Flood Emergency Management Agency repairs after flood events is challenging because requirements are costly and cumbersome. | Consistent regional mutual agreements with the permitting agencies are needed for O&M.<br>Permits are onerous and have resulted in reduced maintenance. | Have difficulty getting permits granted to remove excess vegetation (Lower San Joaquin Levee District). | |

## Environmental Permitting Costs

Environmental regulation compliance and permitting requirements can represent a significant cost in the OMRR&R of SPFC facilities. Although many O&M activities and some RR&R activities can be conducted under State exemptions, permitting and associated mitigation can cost up to 71 percent of the construction cost, depending on the presence of habitat and special-status species. These costs can affect LMAs, which in some cases have delayed necessary OMRR&R activities because of actual or perceived permitting and mitigation timeframes and costs. LMAs and DWR do not typically track the cost of permitting and mitigation, and, therefore, only limited data on that portion of OMRR&R costs are available. Many believe environmental compliance costs are rising and becoming a larger proportion of OMRR&R costs, and the data available indicate that such costs can be substantial. DWR and LMAs continue to seek opportunities to minimize such costs while meeting O&M and RR&R obligations; specific examples are described below. Chapter 7.0 of the OMRR&R Cost Evaluation Technical Memorandum includes two recommendations to improve the understanding of the costs associated with environmental compliance and permitting requirements.

The cost of environmental permitting depends on many factors, including the types of permits required, project size, location, and species that may be affected. Costs associated with obtaining permits generally include staff time to prepare applications, application fees, coordination with permitting agencies, and compliance with short- and long-term monitoring requirements. Some LMAs postpone maintenance activities because of the inability to fund such costs or obtain permits for the full range of needed maintenance activities. Other LMAs have completed O&M activities without obtaining sufficient environmental compliance permits, which can place them at legal risk.

In recent years, the Sacramento maintenance yard has accounted for its environmental coordination costs separately from other transactional costs. Environmental coordination costs for five projects are summarized in Table 4. These estimates do not include the coordination costs borne by other agencies. These costs are a lumped estimate of the time and funds spent to obtain permits, and the data were not refined enough to split the estimate into a line-by-line cost by permit type.

**Table 4. DWR's Environmental Coordination Costs on SPFC Facilities between 2004 and 2012**

| Project | Year | Project Size | Environmental Coordination Cost[1,2] | Total Project Cost[2] | Environmental Percentage |
|---|---|---|---|---|---|
| Wadsworth Canal Erosion Repair | 2008–2012 | 0.04 acre | $113,560 | $159,670 | 71% |
| Willows Slough Erosion Repair | 2007–2009 | 0.17 acre | $96,130 | $135,680 | 71% |
| Fremont Weir Sediment Removal | 2004–2007 | 919,372 cubic yards | $181,740 | $8,727,570 | 2% |
| Sacramento Weir Sediment Removal | 2007–2010 | 38,600 cubic yards | $129,700 | $805,990 | 16% |
| Tisdale Sediment Removal[3] | 2007–2009 | 1,712,800 cubic yards | $4,064,080 | $12,393,680 | 33% |
| **Rounded Total** | | | **$4.5 million** | **$22 million** | **Average: 21%** |

*Source: DWR Flood Maintenance Office.*

Notes:

1 The environmental coordination cost includes any activities related to environmental compliance (i.e., permitting, mitigation, and habitat restoration).

2. All costs are in 2014 dollar values according to the Engineering News-Record Construction Cost Index.

3 Environmental coordination costs include the Colusa State Recreation Area mitigation project costs and, therefore, those costs are included in the total project cost.

Environmental compliance costs presented in Table 4 include activities related to administration, permitting, mitigation, and habitat restoration. For example, the Tisdale Sediment Removal project triggered restoration of 85.5 acres of riparian forest at the Colusa State Recreation Area (CSRA) as project mitigation. Costs to DWR to implement this mitigation are included in the environmental coordination cost shown above. Finding suitable lands for mitigation is often difficult and time-intensive, so finding the CSRA was a huge success for DWR.

### *Possible Savings during CEQA Compliance*

DWR's Non-Urban Levee Evaluation Project has developed a comprehensive database of past performance issues on the Central Valley's non-urban levees. These issues are generally categorized as seepage-related (i.e., under-seepage and through seepage), levee stability-related, and erosion-related. These past performance issues define the locations for investigating alternative State-funded repairs under the Flood System Repair Project (FSRP). Within the DWR FSRP grant program, the project costs, including permitting and compensatory mitigation, for many locations have been estimated as part of a pre-feasibility study. Currently, no projects that have required mitigation have been implemented, so the cost of permitting and mitigation relative to construction is unknown. As part of FSRP, the costs and associated savings of permitting sites as a group were estimated, and associated savings were estimated. The results are included in Table 5; estimated savings are 3 to 8 percent of total costs.

### Table 5. Examples of Estimated Transactional Costs in Flood System Repair Project Grant Program

| Project Size (Watershed) | CEQA and Environmental Permitting Estimated Cost (without mitigation) | TES and Clean Water Act Mitigation Costs | Estimated Construction Costs and Real Estate (includes a contingency) | Environmental Cost Percentage) |
|---|---|---|---|---|
| 1,263 feet of rock revetment along waterside of levee (Sacramento River in the Delta) | Permitted site-by-site: $395,000<br>Permitted as a group: $240,000 | Low of $135,000 and high of $1,270,000 depending on availability of private mitigation bank credits<br>(offsite) | $4,812,000 | 35% (with high end mitigation estimate) as individual sites<br>31% (with high end mitigation estimate) as a group<br>(8% as group with low end of mitigation estimate) |
| 5,400 feet of combination drained seepage-stability berm (Sacramento River in the Delta) | Permitted site-by-site: $650,000<br>Permitted as a group: $190,000 | $150,000<br>(onsite) | $6,950,000 | 12% as individual sites<br>5% as a group |
| 2,250 feet of cutoff wall at two locations, and 800 feet of seepage berm with drainage (one site) and 1,400 feet of a widened levee (for erosion, one site)<br>(Sacramento River in the Delta) | Permitted site-by-site: $520,000<br>Permitted as a group: $180,000 | $312,500<br>(both onsite and off-site) | $10,900,000 | 8% as individual sites<br>5% as a group |
| Rock revetment (one site) and a site with combination drained seepage stability berm (four locations)<br>(San Joaquin River) | Permitted site-by-site: $747,500<br>Permitted as a group: $320,000 | For rock revetment: $80,000<br>For stability berms: $159,000 | For rock revetment: $2,600,000<br>For stability berms: $2,745,000 | 18% as individual sites<br>10% as a group |

*Source: DWR staff summary of Pre-Feasibility Studies prepared for DWR by URS Corporation (2012). Estimates are based on a 10% design and could have a variability of -20% and +60–100%.*

Key:
TES = threatened and endangered species

### *Possible Savings under an HCP for ESA Coverage*

The Feather River Regional Permitting Program (FRRPP) is intended to demonstrate the effectiveness of regional permitting and serve as a model for flood-related regional planning efforts in the remainder to the Central Valley. DWR is working with regulatory agencies that will participate in development and review of the associated Habitat Conservation Plan (HCP) and related permits, review stakeholder assessments, integrate with other plans, and determine a structure for additional stakeholder coordination.

In combination, implementing the FRRPP actions could result in lower costs for long-term OMRR&R than the estimates in Table 5, but this has not been quantified. Although the magnitude of potential cost savings would depend on many factors, evidence suggests that an HCP[1] could provide applicants substantial financial benefits. In an analysis of the development and operation of HCPs in California, Economic & Planning Systems, Inc. (EPS) outlined the benefits to private and public sectors from developing and implementing regional HCPs (EPS, 2014). The findings of that analysis include:

- Regional HCPs provide substantial benefits to those who participate, providing millions of dollars in savings through reduced uncertainty, time delays, and compliance costs.
- The increased certainty provided by regional HCPs and HCP/Natural Community Conservation Plans (NCCPs) relative to the alternative case-by-case permitting process is arguably the most significant benefit to the business community.
- Time reductions associated with HCP permit processing for land development, typically between 3 months and 3 years, result in annual savings to California developers of about $70 million.
- Reductions in direct regulatory compliance costs for private and public development projects are often achieved under regional HCPs, sometimes resulting in savings of more than $1 million for larger development projects.
- Regional HCPs facilitate the development of regional infrastructure, accelerating the benefits of their completion and operation and reducing costs.
- Regional HCPs significantly reduce the amount of time for State and federal regulatory agency staff to review and negotiate individual take permits and outcomes.

[1] Section 10 of the federal ESA authorizes USFWS and NMFS to issue an incidental take permit to a nonfederal entity whose activities could result in the take of a federally listed species. An HCP, which is required in support of an application for an incidental take permit, outlines the specific actions, geographic area, and timeframe over which the nonfederal entity's activities would occur, and specifies the measures the permittee (nonfederal entity) would implement to minimize and mitigate the effect of the take. HCPs and incidental take permits provide permitting efficiency and certainty because they establish a consistent process for long-term ESA compliance – generally on the order of decades, depending on the permit terms. HCPs have been developed for several Central Valley counties; however, all of them exclude SPFC features and river channels.

- Local jurisdictions and public agencies (e.g., water districts) benefit from adopted HCPs through efficiencies and cost savings with incidental take permitting.

- The economic benefits of regional HCPs could be further enhanced by additional integration with other environmental and regulatory permitting processes (such as integration with CWA Section 404 permitting for wetland impacts).

Although the assessment of HCP benefits described above suggests that they have the potential to reduce costs, the actual potential to influence costs remains uncertain and likely depends on several program-specific factors. The initial costs can be substantially offset if ESA Section 6 planning grants for HCP development from USFWS can be obtained, such as the $735,379 managed by DFW in 2014 for an HCP along the Feather River (USFWS, 2014). There are also programs at USFWS to obtain land acquisition grants. Nonetheless, the successful establishment of these regional plans as part of the strategy for long-term OMRR&R is anticipated to reduce deferred maintenance caused by repetitive permitting processes and reduce the amount spent on permit acquisition and staff engagement. Even if overall permitting costs are not reduced, a larger proportion of the investment would be devoted to OMRR&R activities and mitigation instead of the permitting process and staff time.

### *Possible Savings when Taking Action for Unavoidable Wetland Impacts*

Wetlands are protected under the CWA (33 U.S.C. 1344) because they absorb storm water, filter out pollution, recharge the underground water supply, and provide habitat for wildlife. Some OMRR&R projects require permits and compensatory mitigation for unavoidable impacts on wetlands, which are regulated by USACE and the U.S. Environmental Protection Agency (EPA). Along with proposals under FRRPP, the Environmental Permitting for Operations and Maintenance (EPOM) and the Collecting Canals programs are attempting to obtain programwide and multi-year coverage for impacts on wetlands. These programs are not at a stage where their costs and savings can be evaluated. There were no examples of possible savings found in the literature.

### *Savings through Avoidance of Impacts*

Avoidance of impacts can be a cost-effective way to complete a project. Agency officials, project developers, and other stakeholders that use landscape-scale strategies and plans can more effectively design projects that avoid potential conflicts with natural, cultural, and other valued resources and minimize impacts on those resources (USFWS, 2014). As such, mapping critical resources and using that information in the project design can help avoid impacts on species.

DWR routinely performs OMRR&R activities following best management practices to avoid impacts on sensitive species and habitat where habitat for the species has been mapped or occurrences documented. For example, State field crews have constructed fencing to exclude the giant garter snake from work areas and chosen laydown sites (locations where land disturbance will be high) in areas that are unlikely to attract snakes (such as upland and existing paved areas). However, even with avoidance measures, species may still be found in the work area. If this happens, DWR consults with the appropriate agency on the action needed, which is usually either to obtain the appropriate permit or to stop work in the area and submit a report of the incident. Some negotiations are time-constrained because of external factors (e.g., a road has been closed and needs to be re-opened), while others can proceed in negotiations for a longer

period. Short timeframes can force the project proponent to accept high ratios of impacts on compensation to end negotiations quickly. Finding a species in a work area without the appropriate permits causes work delays or stoppages and potential legal issues for an agency.

### Programmatic Permitting

Regional or programmatic permitting programs can be designed to include activities such as operations, maintenance, levee structural repairs, levee rehabilitation actions, improvements to levees or new levee construction, and multi-benefit flood management projects such as setback levees and ecosystem restoration and enhancement. The boundaries of each regional permitting program are determined based on numerous factors, including the distribution of habitats, watershed boundaries, the management areas of local flood risk management entities, and the local jurisdictions of other interested stakeholders (DWR, 2015b). Specifically, a regional permitting approach is designed to:

- Meet the multiple permit needs of multiple projects in regional groupings, rather than individually (project by project)
- Meet DWR permitting needs while providing opportunities for local flood management entities to participate and receive permit coverage
- Provide permits of durations greater than 10 years, and up to 30 years where possible, although some permits will have shorter durations
- Leverage and coordinate with other regional permitting efforts (e.g., HCP/NCCPs being developed by local jurisdictions) as much as possible

Although regional or programmatic permitting programs are desirable, they are also difficult and expensive to implement. Generally, regional permitting programs require (1) considerable upfront funding; (2) extensive data collection, compilation, and analysis; (3) significant public, stakeholder, and agency coordination; and (4) region-specific decisions regarding appropriate permit conditions. Programmatic permits are time- and cost-intensive to prepare for both the applicant and the permitting agency, and preparation effort can be similar to the aggregate effort and cost associated with a series of more-focused permits. Permit requirements, including monitoring, are often similar under a programmatic permit to those for a collection of individual, more-focused permits. Therefore, compliance with a programmatic permit can have a cost similar to one for complying with the requirements of a collection of individual permits.

Despite the investment, the benefits from programmatic planning and permitting can be substantial. Programmatic permits that include incidental take coverage from USFWS or NMFS can prevent project delays. Deferred maintenance and emergency repair costs can be reduced when regular O&M occurs on schedule, which supports a well-maintained flood system. Furthermore, when permitting requirements are developed in response to a series of proposed activities over time, they can be better tailored to protect habitat and species. Caltrans estimated large savings from its advance mitigation program because the need to find mitigation under duress was eliminated, especially in basins where the number of available credits from private banks is low or where land prices can spike quickly (Sciara et al., 2015). In one case, Caltrans saved $12.33 million in escalating land prices by acquiring land in advance (Sciara et al., 2015).

Studies on HCP programs around California have shown substantial savings. Several agencies that regularly perform work that has unavoidable impacts have pursued programmatic regulatory approvals and permits. DWR has several programs under development. Strategies on where to apply for these programs and estimates of the level of investment to gain these benefits are still being developed by DWR. Therefore, some programs have limited information available at this time. As such, the benefits from DWR's programs have not been quantified. However, DWR has identified the savings described in Table 6.

**Table 6. Programmatic Regulatory Process Savings**

| Type of Cost Reductions or Benefits Anticipated from Programmatic Work (with Bulleted Examples) | Programs Used/Proposed at DWR to Capture this Cost Reduction | Investment to Capture Cost Reduction |
|---|---|---|
| **Avoided Cost**<br>• Avoided land acquisition cost escalation<br>• Avoided short-term price increases at private mitigation banks<br>• Avoided costs of purchases made under duress | Because advance mitigation occurs earlier in the timeline of a project, it allows agencies to avoid escalation of land costs, and the agency has more flexibility to buy with favorable market conditions and avoid making purchases under duress. When mitigation is available in advance, the ratio of required mitigation can be reduced because there has been no temporal loss of habitat or species. | DWR issued a grant-solicitation for advance mitigation credits in 2012 and estimated it saved about 20% off the costs of purchasing credits at time of impact. The duties of one staff person were dedicated to administering the program which created an annual cost of $150,000 (1/2 time). Three years of staffing was necessary to net the partial release of credits at private banks. Future staffing to track releases of credits will remain low (1/8 – 1/10 time) until all credits are used and will become zero with no further capital costs. |
| **Economies of Scale**<br>• Costs savings from purchase of larger parcels of land<br>• Cost savings from consolidating parcel transactions (fewer staff resources and fees)<br>• Cost savings from a single monitoring program (less mobilization and fewer reports)<br>• Cost savings from a single permit program that is used for multiple projects (LFRCMP) | FRRPP would centralize the identification and creation of mitigation credits and create a single monitoring program. It would also allow for one permitting process to be used by multiple projects in a geographic area. | An early attempt to coordinate permits in the LFRCMP was staffed part time by several DWR offices (no estimate of time) and contracted at nearly $100,000 over 2 years (2010-11). Since 2013, the duties of one staff person in one DWR office were dedicated to administering a new permitting program along the Feather River and related HCP program, which has an annual cost of $150,000 (1/2 time). A contractor creates descriptive documents and related permit applications, and the contract has a cap of $1.3 million. Matching federal funds for this work make it a multi-million dollar investment. No estimate on the costs of the monitoring program because the HCP is still under development. |
| **Avoided Procedural Costs and Delays**<br>• Reduced procedural delays and faster approval timelines<br>• Cost savings from creation of one CEQA document | EPOM should allow CEQA and other permits to be issued with standardized procedures and more certainty.<br>To prepare for a large number of SWIFs, USACE's Sacramento District is proactively perusing the development of a programmatic | The EIR for EPOM is estimated to be $1.5 million in staffing and consultant time.<br>Creation of an umbrella Biological Assessment suitable to initiate USFWS consultation is estimated to cost DWR $100,000 in staff time. In addition, individual consultations on |

**Table 6. Programmatic Regulatory Process Savings**

| Type of Cost Reductions or Benefits Anticipated from Programmatic Work (with Bulleted Examples) | Programs Used/Proposed at DWR to Capture this Cost Reduction | Investment to Capture Cost Reduction |
|---|---|---|
| • Reduced legal costs related to individual CEQA lawsuits filed after the statute of limitation | BO. The submittal of SWIFs following the guidance in the BO should standardize the review of possible impacts on species and habitat and bring certainty on how they can be mitigated. | 11 SWIF documents are estimated at about $1 million. |
| **Higher Public Safety**<br>• Early intervention work can reduce flood risk with fewer environmental impacts | SERP focuses on getting CEQA and Section 1600 permits for typical small erosion repair projects on the premise it could eliminate delays for those that fit the typical description used in the permit. More permitting for projects that could affect TES species is still required for some SERP projects. | Creation of SERP costs between $1 million and $1.5 million in staffing and consultant time. |

*Source: DWR Flood Maintenance Office*
Key:
BO = biological opinion
EIR = environmental impact report
LFRCMP = Lower Feather River Corridor Management Plan
SERP = Small Erosion Repair Program
SWIF = System-Wide Improvement Framework

### *DWR Regional Permitting Programs*

To resolve the limitations of project-by-project permitting, DWR has developed, or is developing, several programmatic or regional permitting programs to increase effectiveness and efficiency of DWR's environmental compliance needs. Regional permits are becoming more desirable because they can be designed to satisfy a broad suite of regulatory requirements over a larger project area and can be available for regional and local partners such as LMAs. DWR is working in collaboration with the Regional Flood Management Planning regions to develop more streamlined approaches.

Table 7 summarizes current DWR regional or programmatic permitting programs and efforts underway to achieve environmental regulatory coverage for OMRR&R activities in the Sacramento Valley portion of the SPFC. Each program or effort is discussed after Table 7.

### Table 7. DWR's Current Efforts to Achieve Environmental Regulatory Coverage for O&M and Improvements in the Sacramento Valley Portion of the SPFC Facilities

| DWR Program | Major State Laws to Comply with; Regional or Programmatic[1] | Major Federal Laws to Comply with; Regional or Programmatic[1] | DWR Office Responsible for Delivery | Timeline | Coverage Area |
|---|---|---|---|---|---|
| **Programmatic Biological Opinion for SWIF (O&M)** | *USACE program that offers non-federal sponsors (e.g., CVFPB) a process through SWIF to remain temporarily eligible for PL 84-99 assistance while they correct unacceptable O&M deficiencies as part of a broader, systemwide improvement to their levee systems. SWIF can provide a nexus under Section 7 of ESA. Currently, a programmatic BO is being developed for 3 federally listed species (yellow-billed cuckoo, valley long-horned elderberry beetle, and giant garter snake) for SWIF, which will also include approximately 27 RHA, (33 U.S.C 408) activities.* | | | | |
| | USACE led, would not obtain coverage, but will work in conjunction with EPOM, FRRPP, and EPOM Plus | NEPA<br>Programmatic ESA (Section 7)<br>RHA (33 U.S.C 408 | Flood Maintenance Office (funding USFWS staff time)/FESSRO | February 2016 (Programmatic BO) | SPFC facilities under responsibility of the CVFPB; programmatic BO will cover Sacramento Valley portions; each levee system will have to go through the SWIF process. |
| **EPOM (O&M)** | *State permitting of DWR's O&M of the SRFCP for 5 to 10 years. DWR is required by CWC 8361 and 12878 to provide O&M on portions of SRFCP. A future phase, EPOM Plus, is proposed as long-term (10 plus years) permitting to obtain State and federal programmatic permits where DWR is required by CWC 8361 and 12878 to provide O&M on portions of SRFCP.* | | | | |
| | CEQA<br>CESA<br>LSAA | Initially would not obtain coverage, but will work with FRRPP, to provide future coverage as EPOM Plus including:<br>• NEPA<br>• ESA (Section 10)<br>• CWA (Sections 401, 404)<br>• RHA (Section 10)<br>• NHPA (Section 106) | Flood Maintenance Office | March 2016<br>(EPOM Plus in late 2019) | SPFC facilities within the SRFCP that DWR is required to provide O&M per CWC 8361 and 12878. |
| **Collecting Canals (O&M)** | *Permitting for DWR's O&M activities for collecting canals and appurtenant structures east of the Sutter Bypass for 5 to 10 years. DWR is required to provide O&M on these facilities per CWC 8361.* | | | | |
| | CEQA<br>CESA<br>LSAA | NEPA<br>ESA (Section 7)<br>CWA (Sections 401, 404 [Nationwide Permit])<br>NHPA (Section 106) | Flood Maintenance Office | Summer 2016 | Approximately 60 miles of collection canals and appurtenant structures east of Sutter Bypass. Conduct federal permitting for two bridges and 12 miles of sediment removal for the first year. |

**Table 7. DWR's Current Efforts to Achieve Environmental Regulatory Coverage for O&M and Improvements in the Sacramento Valley Portion of the SPFC Facilities**

| DWR Program | Major State Laws to Comply with; Regional or Programmatic[1] | Major Federal Laws to Comply with; Regional or Programmatic[1] | DWR Office Responsible for Delivery | Timeline | Coverage Area |
|---|---|---|---|---|---|
| **SERP (O&M)** | *Implement the repair of small erosion sites on levees that DWR is required to provide O&M per CWC 8361 and 12878. SERP sites are included within the FSRP grant program that DWR sponsors.* | | | | |
| | CEQA<br>CESA<br>LSAA | Regional General Permit<br>ESA (Section 7)<br>CWA (Sections 401, 404)<br>NHPA (Section 106) | Flood Maintenance Office | 2014-2019 | Repair small erosion along DWR levees with the SRFCP. |
| **FRRPP (O&M and Improvements)** | *The program provides regional and programmatic environmental compliance for flood risk management (O&M and improvements) actions within the Feather River Region. Proposed 30-year permit term.* | | | | |
| | CEQA<br>CESA<br>LSAA | NEPA<br>ESA (Section 10-HCP)<br>CWA (Sections 401, 404)<br>RHA (Section 10)<br>NHPA (Section 106) | FESSRO | by December 2017 (HCP, CEQA, NEPA) | SPFC facilities within the Feather River Region; coverers O&M responsibility of DWR and LMAs and improvement activities. |

Key:
BO = Biological Opinion
CVFPB = Central Valley Flood Protection Board
CWC = California Water Code
FESSRO = FloodSAFE Environmental Stewardship and Statewide Resources Office
LSAA = Lake and Streambed Alteration Agreement
PL = Public Law
SRFCP = Sacramento River Flood Control Project

Note:
1 Compliance with these regulations can be achieved via a regional or programmatic permit or agreement. Compliance with additional State and federal regulations will be required under each program.

**Environmental Permitting for Operations and Maintenance.** EPOM provides State regulatory coverage for DWR's O&M responsibilities. The project area that EPOM covers includes levees along the Sacramento River and its tributaries between Chico and the area south of Rio Vista. EPOM provides CESA incidental take permit and an EIR for CEQA compliance. Additionally, USFWS communicated to DWR in 2013 that it has concerns that the grouting of rodent holes in levees near giant garter snake habitat may result in incidental take under ESA, requiring ESA permits. DWR's Flood Maintenance Office is working with USACE and the CVFPB on developing SWIFs to obtain federal environmental coverage for O&M and 33 U.S.C. 408. DWR may try to obtain federal ESA coverage for rodent abatement, including hole/crack repair activities on levees; DWR hopes to have permitting for these activities in 2016 under EPOM.

**System-Wide Improvement Framework.** The SWIF is a USACE program for non-federal sponsors that provides the opportunity to transition degraded levees over time to USACE standards. By using a SWIF, sponsors can prioritize deficiencies to address the highest risk first to achieve systemwide risk reduction. SWIF offers participants a process to remain temporarily eligible for PL 84-99 assistance while they correct O&M deficiencies as part of a broader, systemwide improvement to their levee systems. Environmental compliance and consideration of other requirements, such as compliance with Section 7 of ESA and treaties with Native American tribes, must continue to be integrated into and accomplished as part of SWIF implementation. Any ESA compliance determined to be required for implementation of a SWIF will be accomplished by USACE under Section 7 of ESA.

DWR has requested that USACE prepare a programmatic BO to create certainty for the ESA consultations. USACE has worked with USFWS to establish the scope of a programmatic BO. If there can be agreement, this may create a programmatic path for ESA compliance within the PL 84-99 program. Once in place, and as part of the SWIF plan, the levee sponsor will provide analysis of effects on endangered species and if necessary NEPA compliance documentation for proposed action(s) to receive incidental take coverage under the programmatic BO. DWR is considering the preparation of SWIFs for its 11 Maintenance Areas as a strategy to permit incidental take under ESA (CVFPB, 2015).

**Collecting Canals.** DWR is required to maintain the collecting canals that are part of Project No. 6 in Sutter County. Maintenance of these canals could result in incidental take, as defined in CESA, of the giant garter snake. DWR proposes to adopt avoidance and minimization measures (AMMs), including novel AMMs, to reduce the potential for take of giant garter snakes. Without the proposed project, private landowners would haphazardly remove sediment from canals without implementing the AMMs or the practices proposed by DWR. Work on this program is ongoing and not fully developed.

**Small Erosion Repair Program.** SERP is a proactive, collaborative, multi-agency effort to develop a streamlined permitting process for the repair of up to 15 small erosion sites annually on DWR-maintained levees. Although the program focuses on using repair designs that include vegetation to provide environmental enhancements, a primary goal is continued integrity of the flood control levees and environmental benefits through timely repairs to avoid further loss of soil and existing vegetation. SERP provides incidental take coverage for the giant garter snake. One project has been completed under SERP as of the date of this report.

**Feather River Regional Permitting Program.** DWR is working with USFWS and NMFS to develop a regional HCP for the Central Valley Flood Protection Plan (CVFPP) activities in the Feather River Conservation Planning Area. The HCP will lead to issuance of an incidental take permit for activities that affect species listed under ESA and will provide for conservation planning and implementation over a large spatial and temporal scale. FRRPP is designed to meet the multiple permit needs of multiple projects in the Feather River Region while providing opportunities for local flood management entities to participate and receive permit coverage. It is designed to provide permits of durations greater than 10 years, and up to 30 years where possible, although some permits will have shorter durations. It is also designed to leverage and coordinate with other regional permitting efforts (e.g., HCP/NCCPs developed by local jurisdictions) as much as possible.

**Other Programs at DWR**

*Routine Maintenance Agreements.* LSAAs for routine maintenance (i.e., Routine Maintenance Agreements [RMA]) have been, and will continue to be, developed to provide permitting efficiency and reduced cost for permittees over obtaining individual agreements for maintenance activities. In 2001, DFW issued DWR's Sacramento and Sutter maintenance yards the first of a series of RMAs that provides an efficient process in which DWR submits detailed information after routine maintenance activities are proposed, and DFW quickly reviews the information to ensure that the proposed maintenance is covered under the RMA. Some of these activities require a permit from USACE before work is initiated.

*Lower Feather River Corridor Management Plan.* The LFRCMP establishes a long-term vision and strategy for managing a 20-mile-long, 12,000-acre river corridor of the Feather River. The LFRCMP identifies management actions to facilitate floodway management and maintenance of flood control facilities, enhance habitat and ecosystem functions, and support agricultural and recreational activities. The LFRCMP also describes a programmatic permitting approach that would efficiently link regulatory permitting and habitat enhancement actions to mitigate habitat impacts in advance and thereby simplify obtaining permits for maintaining flood management facilities. The LFRCMP would allow for issuance of incidental take permits under ESA Section 10 and CESA Section 2081 while minimizing or avoiding the need for additional mitigation. The permitting approach would also facilitate compliance with California Fish and Game Code Section 1600; CWA Sections 404, 402, and 401; RHA Section 10; and NHPA Section 106.

### Compensatory Mitigation

After real estate, compensatory mitigation costs are often the most significant portion of overall transactional costs. OMRR&R activities that require removal of vegetation that provides habitat or has the potential to directly affect special-status species and CWA Section 404 wetland/loss of federal waters often require compensatory mitigation. Compensatory mitigation is necessary when avoidance cannot be accomplished. Compensatory mitigation often requires that credits be purchased at designated conservation or mitigation banks or that turnkey mitigation sites be developed. Several laws require compensatory mitigation, and the requirements associated with each law vary. Compensatory mitigation costs vary based on habitat types and needs, including those that require more involved construction and long-term management. Table 8 lists current (as of 2015) costs of credits for wetlands and specific habitat types or species in Central Valley mitigation banks. The number of credits required is determined by the mitigation ratio, which is determined through the permit application process. Mitigation ratios vary by project and are calculated based on the type of habitat affected and the type and quality of mitigation proposed.

**Table 8. Costs for Credits by Habitat Type**

| Habitat Type or Species | Cost |
|---|---|
| **Riparian** | |
| Rancho Breisgau, River Partners | $55,000 base fee + $15,000/acre |
| Fremont Landing Conservation Bank, Wildlands | $80,000/acre |
| Cosumnes Floodplain Mitigation Bank, Westervelt Ecological Services | $75,000/acre |
| **Shaded Riverine Aquatic** | |
| Fremont Landing Conservation Bank, Wildlands | $80,000/acre |
| Cosumnes Floodplain Mitigation Bank | $75 – $95 per linear foot |
| Jelly's Ferry, River Partners | $103,450 base + $15,000/acre |
| French Camp Conservation Bank, Delta Habitat | $3,000 per credit |
| River Ranch Valley Elderberry Longhorn Beetle Conservation Bank, Wildlands | $4,000 per credit |
| **Jurisdictional Wetlands** | |
| National Fish and Wildlife Foundation Wetland In-Lieu Fee Program | $150,000 for up to the first 5 credits; $125,000 when between 5 and 10 credits are required; and $100,000 when more than 10 credits are required |
| **Other Species of Concern** | |
| Salmon at Bullock Bend | Estimated as high as $100,000 per credit |
| **Delta Smelt** | |
| Giant garter snake | $35,000 per acre (2011 costs) in Sacramento River Basin, $58,000 per acre (2013 costs) in San Joaquin River Basin |

*Sources: DWR Floodway Ecosystem Sustainability Branch*

In recent years, regulating agencies have placed a higher emphasis on the long-term sustainability of compensatory mitigation sites, which has resulted in stricter requirements and a greater focus on long-term management. The cost of compensatory mitigation credits is generally determined by the following:

- Raw land
- Construction cost (if required)
- Financial endowment to support long-term management
- Conservation easements
- Permitting/coordination and entitlement

Mitigation bank credit costs have been increasing by approximately 5 to 10 percent annually due to increasing "carrying" costs (Hemmen, 2015, pers. comm.). A carrying cost occurs when the funds spent or loaned cannot be used for other investments that may also capture higher return on investment. Mitigation bank credit costs also increase because money for property tax and insurance has been paid for another year, and mitigation banks want to recover all expenses invested in the mitigation project.

Because the financial investment for mitigation bank restoration projects is done in advance of impacts (or revenue), the mitigation banks must carry the cost while they wait for a return on their investment. These costs will vary depending on the entities funding the mitigation bank. A majority of the cost of compensatory mitigation is determined by cost of raw land; as property values increase and suitable lands becomes less available, mitigation costs increase. Land costs can represent nearly 70 percent of the total cost of a mitigation project. Increased monitoring (resulting in larger endowments being required) and agency requirements, such as DFW implementing a mitigation banking fee in 2012, are also increasing mitigation bank credit costs (Hemmen, 2015, pers. comm.).

Costs of onsite restoration have increased as prices on the plants, mulching, and seeds have increased with inflation. The cost of labor for installation has increased as well. The final costs of onsite restoration can increase substantially based on the amount of annual precipitation expected, soil type, slope of the site, amount of weed control needed, and quality of the existing native seed bed. Site-by-site analysis will allow for a better estimate of costs, and the general numbers presented in Table 8 should be used with caution.

In 2008, USACE and EPA clarified compensatory mitigation standards through the Compensatory Mitigation for Losses of Aquatic Resources Final Rule (2008 USACE Mitigation Rule) relating to the CWA wetlands/waters of the U.S. This rule was in response to studies that found that the mandate of no net loss of habitat was not being met, particularly one published in 2001 by the National Research Council. In 2012, USACE released its Standard Operating Procedure for Determination of Mitigation Ratios (USACE, 2012). The methodology involves a calculation that compares the impact with the proposed mitigation site and allows for clear documentation of how mitigation ratios are determined.

### Advance Mitigation

The Water Action Plan by California Natural Resources Agency (CNRA) sets as an objective that flood control projects should incorporate regional advance mitigation as a means to expedite planning and reduce costs. Assembly Bills 5 and 156 (Chapters 366 and 368, respectively, filed with the Secretary of State on October 10, 2007, codified at Water Code Section 8590 et seq.) specify powers, duties, and jurisdiction of DWR and the CVFPB in carrying out Senate Bill 5. In particular, Water Code Section 8613 states that DWR "may establish a system of mitigation banking by which mitigation credits may be acquired in advance for flood control work to be performed by the Board, the Department, or a local agency authorized to operate and maintain SPFC facilities."

DWR is planning and funding the development of projects to be used as advance mitigation for habitats and species most commonly affected by flood risk management. Advance mitigation establishes habitat before flood projects or actions that need mitigation are permitted. Thus, the created mitigation credits (in the form of habitat) are ready to use at the time of project permitting (where impacts are treated as debits), potentially increasing the efficiency of the permit process and reducing project approval delays and the temporary loss of habitat.

Advance mitigation planning involves collaboration with local, regional, State, and federal partners to address economic, social, and environmental effects on human and biological communities. Advance mitigation also contributes to DWR's environmental commitment by planning for conservation, restoration, and maintenance of the biological diversity and natural physical processes of ecosystems and plans and implements projects that contribute to the recovery of State-protected and federally protected species and other at-risk species. At this time, credits from one of the three projects have started to be released, but the expected savings from private banking could be on the order of 25 percent or more. Table 9 lists advance mitigation projects funded or under contract since 2013.

### Factors Influencing Future Cost of Regulatory Compliance

As noted previously, the cost of regulatory compliance for a specific project or activity can vary substantially depending on numerous factors. However, regulatory compliance costs may also be influenced by the approach and strategy used by an applicant to meet the regulatory requirements. This section describes how the cost of regulatory compliance for OMRR&R might be influenced by the following:

- The ability to avoid impacts completely
- The permitting strategy employed (HCPs and regional management plans)
- Project design (and new technology)
- New species listings and changes in regulations
- Need for fish passage improvements in the system

### Table 9. Advance Mitigation Projects Funded/under Contract since 2013

| Project Title/ Applicant | Proposal Process | Funding Amount (Total Project Cost) | Advance Mitigation Benefits/ Credits Expected | Status as of December 1, 2015 |
|---|---|---|---|---|
| **Grasslands Giant Garter Snake Mitigation Preserve** *Westervelt Ecological Services* | Direct expenditure | $4,164,000 ($3,164,000 from Proposition 1E for impacts on giant garter snake at SPFC facilities, and $1,000,000 from the Delta Levees Program for impacts on giant garter snake at Delta levees)*($9,050,372)* | This 281-acre mitigation bank will provide 130 giant garter snake credits (from USFWS and DFW), which will be used to offset impacts on giant garter snakes from SPFC and Delta Levees Program activities throughout the San Joaquin Valley and South Delta. | Bank approved; BEI signed July 8. Construction completed in October 2015. First credits (27.9 of DWR's 130 credits) released August 7, 2015; second release (25%, or additional 46.5 credits) occurred November 24. |
| **Hidden Valley Ranch Acquisition** *Reclamation District 2092* | Direct expenditure | $3,900,000 *($9,300,000)* | Acquisition of this 497-acre property in the Lower San Joaquin River Conservation Planning Area adds to the flood benefits realized at the adjacent Dos Rios Ranch and the San Joaquin River National Wildlife Refuge. Cumulatively, these properties will provide river-floodplain connectivity to more than 1,000 acres, absorb approximately 10,000 acre-feet of floodwaters, and increase flood protection for downstream communities. Phase 2 will focus on achieving mitigation. | **Acquisition complete.** Funded October 9, 2013; escrow closed November 5, 2013. CEQA notice of exemption filed. |
| **Salmonid Conservation Bank** *Westervelt Ecological Services* | State contracting process: secondary request for proposals to the original Proposal Solicitation Package | $4,656,867.50 *(Unknown)* | A mitigation bank that creates floodplain on a 115-acre property along the Sacramento River (between Colusa and Verona) is expected to generate 57.5 advance mitigation credits from NMFS (for salmonids), which will be used to offset impacts on salmonids from SPFC activities. Riparian (DFW) credits and possibly Swainson's hawk credits (DFW and USFWS) will also be created at the site. | Prospectus drafted; permit applications and draft CEQA document completed September 2015 (Notice of Determination recorded November 2, 2015). First credits expected for release in 2016. |
| **TRLIA Feather River Floodway Corridor Restoration Project** *TRLIA* | Proposal Solicitation Package (grant) | $4,440,000 *($9,130,289)* | Funding would be used to enhance 500 acres of a 1,600-acre levee setback area, creating a mosaic of riparian forest, riparian scrub, valley oak woodland, and perennial grassland. This project is expected to generate advance mitigation credits from DFW (for riparian habitat and possibly for yellow-billed cuckoo), and possibly USFWS (for valley elderberry longhorn beetle and yellow-billed cuckoo). | Draft prospectus approved by DFW and USFWS in September 2015; other BEI documents under development. TRLIA Board to consider adoption of Draft Initial Study/Mitigation Negative Declaration in 2016. |

*Source: DWR Floodway Ecosystem Sustainability Branch*
Key:
BEI = Bank Enabling Instrument
TRLIA = Three Rivers Levee Improvement Authority

### *Ability to Avoid Impacts*

Knowing where sensitive species and their habitat might be found and taking proactive measures to avoid them can be a cost-effective way to implement OMRR&R projects. DFW (2015a) is updating information on species locations and habitat affiliations to improve a project applicant's ability to avoid impacts by either moving the project to less sensitive locations or taking specific measures inside the habitat area(s). An unexpected species found in a work area can increase compensatory mitigation to a high level. As future studies refine maps, more avoidance could be undertaken in OMRR&R.

### *Permitting Strategy*

The strategy applied to acquiring permits and complying with environmental regulations could have a substantial influence on the overall cost of long-term OMRR&R. To date, most permitting has been conducted on a project-by-project basis with a short-term view, which can result in delays in project approvals and inefficiencies associated with preparing individual regulatory compliance documents for each project. It also can result in poor conservation outcomes. Conducting permitting and mitigation on a programmatic and regional basis may improve efficiency and reduce the cost of regulatory compliance overall.

A regional or programmatic approach represents a more predictable, cost-effective, and efficient process than project-by-project permitting and supports planning for regional advance mitigation focused on improving ecosystem functions, resulting in better conservation outcomes and reduced costs for the operation, maintenance, and improvement of the SPFC. The California Water Action Plan (CNRA, California Department of Food and Agriculture [CDFA], and California Environmental Protection Agency [Cal/EPA], 2016) identifies regional advance mitigation as a means to expedite planning for flood protection.

Part of the permitting challenge relates to the overlapping regulatory jurisdictions and conflicting regulations. Given the number and complexity of regulatory permits and approvals, along with the flood and environmental opportunities presented by the CVFPP, DWR intends to work with public safety and environmental regulatory agencies to formulate recommended changes to State and federal legislation, policies, and procedures to improve the efficiency and effectiveness of the permitting process in the long term.

Shifting from conventional, project-by-project mitigation requires new ways of planning and funding DWR's mitigation activities. Advance mitigation, which serves multiple projects, has the potential to create economies of scale for monitoring and maintenance tasks that are essential to reducing OMRR&R costs, as well as providing better habitat for sensitive species. Fewer mobilization costs will be related to maintenance teams to manage mitigation lands under advance mitigation, and this should reduce the per-acre cost to maintain these sites. Consolidated monitoring and reporting on mitigation site conditions (such as vegetative cover and extent of trespass) should decrease the amount of regulatory documentation and streamline the workload for OMRR&R staff. Information on the costs of ongoing mitigation maintenance and monitoring is limited, making it difficult to estimate cost savings from such activities implemented through advance mitigation.

### *Project Design*

Installing new levees or improving existing levees has the potential to reduce OMRR&R costs for several years after installation. Cost savings could be highest when a levee is placed higher in elevation or away from erosive forces. Planting of vegetation on a designed waterside berm can also reduce erosive forces. These cost savings would have to be evaluated against the increased acreage in the floodway and potential for induced sediment dropout in these less erosive conditions, which may increase O&M costs. This type of construction requires models and soil tests to determine actual cost savings.

In some instances, because of the condition of the existing levee and constraints on constructing a new levee setback, SPFC facilities could be improved by widening or raising existing levees. This was done in the Natomas Basin north of Sacramento. The O&M costs related to erosion may decline under this design because the existing levee is left in place to protect the toe of the levee. As a side benefit, the levee that is under erosive force now provides several types of waterside habitat along the river that had been lost because of past construction projects.

In many locations, remediating or improving the existing levee would be the most feasible way to address long-term flood risk management needs. In these locations, where technically feasible, and in conformance with USACE requirements, designs for levee repair and rehabilitation can incorporate environmental engineering measures that would reduce O&M costs while still providing important habitat features. For example, in lieu of only using rock revetment, new designs should consider biotechnical bank protection and waterside vegetation. If these new designs prove durable, this may decrease O&M costs. Pilot studies to test durability of these methods would be necessary prior to full-scale adoption for projects that are consistent with DWR's comprehensive approach to water management.

### *New or Changed Species Listings and Regulations*

Changes in environmental laws and regulations can influence the long-term cost of OMRR&R. With increased demands on land and water, declining populations of some species, and the effects of future sea-level rise and climate change, additional and potentially more restrictive regulation is likely. A recent example is the USFWS listing and designation of critical habitat for yellow-billed cuckoo in California. Although the effects of this federal listing on OMRR&R are uncertain, the location of critical habitat within the flood management system likely will present additional challenges for system maintenance activities. An HCP could reduce the risk because the applicant can request coverage for species not yet listed and have coverage for incidental take during the permit period.

Changes in regulations also have the potential to reduce costs. Typical OMRR&R activities are conducted under environmental laws and regulations, each with its specific objectives and permitting process. As a consequence, the permitting processes are not well coordinated and can present different requirements for achieving similar objectives. Targeted changes in regulations and policies that resolve these inefficiencies while maintaining the original purpose of the regulation could reduce permitting processing times and the overall cost of conducting OMRR&R. The California Water Action Plan (CNRA, CDFA, and Cal/EPA, 2016) has recommended a task force to expedite permitting to improve flood protection.

### *Fish Passage Improvements*

Because of the unforeseen consequences flood control facilities have on fish, new engineering solutions have been found to improve fish passage or to prevent fish stranding as flood waters recede. Installation of new structures at weirs, pumps, and dams will change the OMRR&R needs for some LMAs and DWR. Such components as screens on pumps, concrete ramps, or inflatable dams will need repair or replacement during their life cycle. Some of the large fish passage proposals associated with the Yolo Bypass are still under design; the design team only has large ranges for the possible OMRR&R costs of the proposed structures. To provide an order of magnitude, OMRR&R estimates of non-SPFC fish passage and barrier changes are summarized in Table 10. A study of the costs CALFED incurred for fish passage (Hayes, 2000) recognized that OMRR&R of these structures must be considered early in the design. For example, most fish screens require cleaning systems that must be maintained, and as a result of damage or corrosion, parts of the screen and it associated mechanisms will need to be replaced.

## Uncertainty Related to the Future of Regulatory Compliance

Although the approaches described above will provide more certainty in permitting and should lead to reduced costs over time, other environmental factors affect long-term OMRR&R, as described in the following sections.

### *Implementation of the Conservation Strategy and OMRR&R Costs*

The Conservation Strategy (DWR, 2015b) has identified several ecosystem restoration opportunities along reaches of the SPFC. The document also promotes the integration of ecosystem restoration opportunities into future flood risk reduction projects consistent with the goals and objectives of the 2017 CVFPP Update. The Conservation Strategy will focus on restoring river system function and processes (e.g., geomorphic function), creating and restoring important habitats (e.g., riparian, including shaded riverine aquatic cover; wetlands; and wildlife-friendly agriculture), and addressing the needs of target species that inhabit the flood system. The Conservation Strategy is also intended to provide the technical framework for a regional permitting strategy that will improve the efficiency of permitting and reduce the need for project-by-project permits.

Implementation of the restoration guided by the Conservation Strategy will restore habitat at selected locations within and adjacent to the floodway to benefit native species, including the Conservation Strategy's 18 targeted species. Funding and new partnerships will need to be identified to support long-term maintenance and management of these properties so that habitat values are sustained and so restored habitats do not cause hydraulic impacts. Where the addition of vegetation to a floodway may have a measureable effect on channel capacity or could conflict with maintenance of SPFC facilities or other infrastructure, feasible restoration opportunities will be linked to other flood risk management actions to ensure adequate channel capacity (DWR, 2015b).

**Table 10. Spectrum of Costs for OMRR&R of Fish Passage and Barrier Improvement Projects Off and On SPFC Levees and Facilities**

| Name of Project and Components Used (CVFPB Permit No.) | Installed by and Installation Date | Maintainer | Estimate of OMRR&R Needs and Costs | Expected Accuracy Range(s) |
|---|---|---|---|---|
| A new ladder to improve downstream passage at Daguerre Point Dam along Yuba River | Yuba County Water Agency (Conceptual) | Not identified | Year-round daily inspection by two workers. Minor monthly maintenance and more extensive annual maintenance. Periodic sediment and debris removal from the in-river structures. A rate of $48.00/hour was used. The assumed time spent at the site varied from 30 minutes to 2 hours daily, with monthly and annual work either 8 hours (by two people) or 16 hours (by four people), respectively. The replacement costs assigned at 10-year intervals included costs for such items as valves, pumps, level and flow instruments, electrical motor control centers, fish screen cleaner motors, and emergency generators. | -20 percent to -50 percent on the low side and +30 percent to +100 percent on the high side |
| A barrier to ensure target species adults enter the facility passage at Daguerre Point Dam along Yuba River | Yuba County Water Agency (Conceptual) | Not identified | Barrier is placed and removed periodically. 1998 cost estimate was $116,160/year to facilitate passage at Daguerre Point Dam. | -20 percent to -50 percent on the low side and +30 percent to +100 percent on the high side |
| Knights Landing Fish Weir (Permit 19037) | RD 108 Installed in 2015 | DWR West Sacramento maintenance personnel | None on file. | Not on file |
| Fish Passage Improvement Project at the Red Bluff Diversion Dam – New Screens and Pumps, New Forebay, Mitigation of Habitat | Bureau of Reclamation and Tehama Colusa Canal Authority. Installed in 2010-12 | Tehama Colusa Canal Authority | Must operate pumps, clean screens, and monitor forebay. | |
| E.A. Fairbairn Water Treatment Plant – Replace 12 fish screens and install 6 additional screens (Permit 17227) | City of Sacramento | City of Sacramento | 1998 cost estimate was $156,000 to construct fish screens $5,000/year to operate. | |

**Table 10. Spectrum of Costs for OMRR&R of Fish Passage and Barrier Improvement Projects Off and On SPFC Levees and Facilities**

| Name of Project and Components Used (CVFPB Permit No.) | Installed by and Installation Date | Maintainer | Estimate of OMRR&R Needs and Costs | Expected Accuracy Range(s) |
|---|---|---|---|---|
| Butte Creek Actions (1998 Estimates) – including new fish ladder and two fish screens at Durham Mutual Dam | Not identified | The structures are owned and operated under a Cooperative Management Plan of several owners | $624,000 to construct fish ladder and $479,000 to construct screens.<br>$19,000/year to operate fish ladder and $14,000/year to operate fish screens. | -20 percent to -50 percent on the low side and +30 percent to +100 percent on the high side |
| Butte Creek Actions (1998 Estimates) – including new fish ladder and fish screen at White Mallard Dam | Not identified | The structures are owned and operated under a Cooperative Management Plan of several owners | $409,000 to construct fish ladder and $871,000 to construct fish screen.<br>$12,000/year to operate fish ladder and $26,000/year to operate fish screen. | -20 percent to -50 percent on the low side and +30 percent to +100 percent on the high side |

*Sources: USFWS, 1998, 2015a, 2015b; Yuba Salmon Forum, 2013.*

### *OMRR&R and Habitat Mitigation in Floodways*

The use of land for conservation and ecosystem restoration is becoming a significant influence on OMRR&R practices, floodway management, and flood planning. With the growing recognition that the SPFC needs ecosystem restoration wherever feasible, LMAs and DWR are struggling to set up budgets to cover anticipated new maintenance requirements associated with these lands, including enough staff to process potential additional permits. The increasing number of mitigation planting and habitat enhancement projects within the channels, bypasses, and other floodways of the Sacramento and San Joaquin River flood systems, together with existing "legacy" mitigation projects, is compounding the already challenging regulatory environment. Failure to properly plan, maintain, and manage mitigation and habitat enhancement projects is resulting in adverse impacts on hydraulic capacity, conveyance, and the ability to inspect, monitor, and flood fight. Further, plantings are migrating beyond their original project limits, and the lack of safe harbor agreements is creating financial and operational constraints for the LMAs.

Long-term partnerships with those placing habitat in the floodway could resolve many of the current conflicts. Project-sponsored habitat mitigation projects by LMAs that have already given assurances to the federal government have had success in restoring useful habitat in the floodways, where OMRR&R responsibilities were clearly understood. (e.g., giant garter snake habitats involved in recent TRLIA projects). Conversely, when private land is obtained for habitat mitigation by private companies or Joint Power Authorities who seek mitigation for their own impacts, OMRR&R responsibilities are less defined and the State becomes responsible for areas that will directly affect SPFC facilities.

### *Mitigation Banks and CVFPB Encroachment Permits*

The permitting and construction of mitigation banks in a designated floodway can be complex and lengthy because of the time and funding required to negotiate conservation agreements in the Central Valley. Few mitigation banks in the Central Valley are within the jurisdiction of the CVFPB because most have been placed in upland areas. Establishment of mitigation banks within the SPFC can create potential conflicts between providing adequate flood control and protecting species and habitat. To reduce future land management conflicts, the CVFPB has begun to require more robust encroachment permit conditions; applications now include more specifics such as detailed design with hydraulic modeling, a long-term management plan, and a financing mechanism to pay for the property maintenance in perpetuity.

The CVFPB can revoke encroachment permits on restored properties where proper management is neglected or lacking (DWR, 2010). Table 11 lists mitigation banks that have or may have encroachment permits approved by the CVFPB.

**Table 11. Chronology of Mitigation Banks that Have (or May Have) Encroachment Permits from the CVFPB**

| Name | CVFPB Action | Bank Establishment Date | Signatory Agencies |
|---|---|---|---|
| **Before 2008 USACE Mitigation Rule** | | | |
| Pope Ranch | #17280 – June 2001 | April 2001 | USFWS, DFW |
| Ridge Cut | #18406 – Sept. 2009[1] | Feb. 2009 (approx.) | USFWS (although there was a DFW review in 2008 and DFW is named in the Conservation Easement) |
| **After 2008 USACE Mitigation Rule** | | | |
| Fremont Landing and Sacramento River Ranch Wetlands Mitigation Bank | #18603 – Oct. 2010 (for Fremont Landing section only) | May 2013 | NMFS, DFW, USACE |
| Liberty Island / North Delta Fish Conservation Bank | #18334 – July 2010<br>#18723 – May 2012 | Sept. 2010 | USFWS, NMFS, DFW |
| Colusa Basin | #18845 – Oct. 2013[1] | June 2014 | USACE, EPA, DFW, USFWS |
| Capital Conservation Bank | #18856 – April 2014, amended May 2014 | Under review | Not approved |
| Lower Yolo Conservation Bank | #18862 – Application withdrawn April 13, 2015 | Under review | Not approved |
| Bullock Bend | #19042 – under review | Under review | Not approved |
| TRLIA's Advance Mitigation in Feather River Setback | #19079 – under review | Under review | Not approved |

*Sources: Regulatory In-lieu Fee and Bank Tracking Information System, 2015; DFW, 2015b; and CVFPB, 2015.*
Note:
1 This bank is within a designated floodway and not within federal (project) levees.

## Conclusion

Transactional costs can be significant and, in particular, environmental compliance costs can represent a challenge for agencies responsible for OMRR&R of the SPFC. Programmatic permits are intended to allow for more comprehensive compliance with major environmental laws at a regional level over the long term (DWR, 2010). In addition to regional permitting, another key element of improving the regulatory compliance process will be to implement multi-benefit projects that include flood protection and habitat conservation or restoration components. The incorporation of restoration and enhancement actions into flood-infrastructure improvement projects and O&M activities is consistent with the objectives of the CVFPP and Conservation Strategy. This multi-benefit approach creates the opportunity to develop flood management projects that may be more sustainable and cost-effective and can provide ecological benefits while protecting public safety over the long term.

Without integrated approaches to improve the effectiveness and efficiency of the environmental regulatory process, the complexity of meeting environmental regulations may continue to result in project delays, increased costs, and inadequate environmental improvements. Continued

collaboration at local, State, and federal levels will be important in navigating regulatory complexities and for crafting approaches that will support the shift to long-term integrated management of the system that serves both public safety and environmental needs.

## References

California Department of Fish and Wildlife (DFW). 2015a. User's Manual for the California Wildlife Habitat Relationships System and BioView. Version 9.0. Available at <https://nrmsecure.dfg.ca.gov/FileHandler.ashx?DocumentID=88643>. June 15. Accessed December 21, 2015.

———. 2015b. Conservation and Mitigation Banks in California Approved by CDFW. Available at < https://www.wildlife.ca.gov/Conservation/Planning/Banking/Approved-Banks>. Accessed October 2015.

California Department of Water Resources (DWR). 2010. Policy Paper: Environmental Stewardship. September.

———. 2012. DWR staff summary of Pre-Feasibility Studies prepared for DWR by URS Corporation.

———. 2015a. Regional Flood Management Planning Phase 1 Summary. Sacramento, CA. August.

———. 2015b. Central Valley Flood System Conservation Strategy. Draft. Sacramento, CA. January.

California Natural Resources Agency, California Department of Food and Agriculture, California Environmental Protection Agency (CNRA, CDFA, and Cal/EPA). 2016. California Water Action Plan 2016 Update. Available at <http://resources.ca.gov/docs/california_water_action_plan/Final_California_Water_Action_Plan.pdf>. Accessed February 3, 2016.

Central Valley Flood Protection Board (CVFPB). 2015. Meeting of the Central Valley Flood Protection Board. Item 12(b): Update regarding Letters of Intent submitted by Local Maintaining Agencies to develop System Wide Improvement Framework plans the resulting effects on USACE Public Law 84-99 eligibility. December 18. Available at <http://www.cvfpb.ca.gov/meetings/2015/12-18-2015.cfm>. Accessed December 21, 2015.

———. 2016. Webcasting of Board Meetings. Available at <http://cvfpb.ca.gov/meetings/meetings.cfm>. Accessed January 2016.

CNRA, CDFA, and Cal/EPA. *See* California Natural Resources Agency, California Department of Food and Agriculture, California Environmental Protection Agency.

CVFPB. *See* Central Valley Flood Protection Board.

DFW. *See* California Department of Fish and Wildlife.

DWR. *See* California Department of Water Resources.

Economic & Planning Systems, Inc. (EPS). 2014. Economic Effects of Regional Habitat Conservation Plans. Available at <http://www.buttehcp.com/documents/Documents/Other%20Documents/Economic%20Benefits%20White%20Paper%20-%20CHCPC.pdf>. Accessed March 23, 2016.

EPS. *See* Economic & Planning Systems, Inc.

Hayes, Darryl. 2000. Fish Protection Facility Cost Drivers and Considerations: Why are Costs all Over the Board? Presented at the Salmon Habitat Restoration Workshop. November 14 to 16. Sponsored by National Marine Fisheries Service. Available at <http://www.st.nmfs.noaa.gov/st5/Salmon_Workshop/17_Hayes.pdf>. Accessed February 2, 2016.

Hemmen, Travis. 2015. Vice President. Westervelt Ecological Services. Telephone conversation and email correspondence with Mark Oliver of CH2M HILL regarding mitigation banking. November.

LAO. *See* Legislative Affairs Office.

Legislative Affairs Office (LAO). 2014. The 2014-15 Budget: State Worker Salary, Health Benefit, and Pension Costs. May. Available at <http://www.lao.ca.gov/reports/2014/budget/state-compensation/state-compensation-030414.pdf>. Accessed January 26, 2016.

MBK Engineers. 2016. Proportion of Transactional Costs to Construction Costs for Selected Capital Improvement Flood Projects Table.

Regulatory In-lieu fee and Bank Tracking Information System (RIBTIS). 2015. RIBITS Web site. Available at <http://geo.usace.army.mil/ribits/index.html>. Accessed October 2015.

Sciara, Gian-Claudia, Elizabeth Stryjewski, Jacquelyn Bjorkman, James H. Thorne, Melanie Schlotterbeck. 2015. Task 3 Report: The Business Case for Advance Mitigation in California. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-15-03. Available at <http://its.ucdavis.edu/research/publications/publication-detail/?pub_id=2421>. Accessed January 11, 2016.

U.S. Army Corps of Engineers (USACE). 2012. Standard Operating Procedure for Determination of Mitigation Ratios.

U.S. Department of Agriculture (USDA). 2012. Trends in U.S. Farmland Values and Ownership. <http://www.ers.usda.gov/media/377487/eib92_2_.pdf>. February. Accessed January 26, 2016.

———. 2015. Land Values, 2015 Summary. Prepared by National Agricultural Statistics Service. <http://usda.mannlib.cornell.edu/usda/current/AgriLandVa/AgriLandVa-08-05-2015.pdf>. Accessed January 29, 2016.

U.S. Fish and Wildlife Service (USFWS). 1998. Central Valley Project Improvement Act Tributary Production Enhancement Report. Prepared by CH2M HILL. May.

———. 2014. A Strategy for Improving the Mitigation Policies and Practices of the Department of the Interior. A Report to the Secretary of the Interior from The Energy and Climate Change Task Force. April.

———. 2015a. Fish Passage in Lower Antelope Creek. Prepared by Stillwater Sciences and Resource Conservation District of Tehama County. January.

———. 2015b. Butte Sink, Willow Creek-Lurline, and North Central Valley Wildlife Management Areas. Draft Comprehensive Conservation Plan and Environmental Assessment. Available at <http://www.fws.gov/uploadedFiles/Region_8/NWRS/Zone_1/Sacramento_Complex/Sacramento/Uploaded_Files/Other/WMAs%20CCP%20-%20Public%20Draft%20June%202015.pdf>. June. Accessed February 1, 2016.

USACE. *See* U.S. Army Corps of Engineers.

USDA. *See* U.S. Department of Agriculture.

USFWS. *See* U.S. Fish and Wildlife Service.

Yuba Salmon Forum. 2013. Assessment of Infrastructure and Related Items to Support Anadromous Fish Passage to the Yuba River Watershed. Prepared by MWH. March.

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# Issue Summary #3
# Setback and Rebuild-in-Place Levee Maintenance Cost Examples

*Flood risk management, as opposed to traditional flood defence or flood control paradigms, can therefore be seen as a continuous process that attempts to utilize limited resources of time, social effort, environmental capital and money to deliver multiple benefits.*

***P. Sayers, Y. L.i, G. Galloway, E. Penning-Rowsell, F. Shen, K. Wen, Y. Chen, and T. Le Quesne. 2013. Flood Risk Management: A Strategic Approach. Paris, UNESCO.***

As described in Section 2.7 of the *Technical Memorandum – Flood System Long-Term Operations, Maintenance, Repair, Rehabilitation, and Replacement Cost Evaluation*, setting levee reaches back from rivers is considered a method for improving flood risk, reintroducing floodplain habitat, and reducing the cost of operations, maintenance, repair, rehabilitation, and replacement (OMRR&R); the effectiveness of this method depends on conditions, location, and the state of current facilities. The following provides further detail regarding funding and implementation drivers; summarizes examples where setback levees have been constructed or are planned; and describes how OMRR&R activities can differ for setback and rebuild-in-place levees when compared to existing historic levees. These examples are recent projects, some of which are still being developed; thus, limited data were available for analysis. Setback levee examples should be routinely revisited to evaluate the potential cost increases, savings, and project benefits as compared to existing levees and those that have been strengthened in place to better inform future OMRR&R cost analyses.

## Setback Levee Funding and Implementation Drivers

Numerous laws, policies, and funding opportunities have been established in recent years to promote multi-benefit projects, including setback levees:

- **Propositions 1E and 84:** California voters passed the Disaster Preparedness and Flood Prevention Bond Act (Proposition 1E) and the Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act (Proposition 84) in November 2006, authorizing the sale of nearly $5 billion in State bonds for flood management improvements throughout the state with $4.275 billion of this amount specifically earmarked for the repair and improvements to State and federal flood projects within the Central Valley (California Department of Water Resources [DWR], 2007). Proposition 1E and 84 funding has been provided through various DWR programs for State Plan of Flood Control (SPFC) projects that include levee setbacks or flood management planning that includes consideration of levee setbacks (California Natural Resources Agency, 2015).

- **California Senate Bill 5 (2007):** The Central Valley Flood Protection Plan must include descriptions of structural and nonstructural alternatives for enhancing performance and eradicating deficiencies of levees, weirs, bypasses, and facilities, and such alternatives should provide multiple benefits, including promoting natural hydrologic and geomorphic processes, increasing and improving aquatic habitats, minimizing flood management operation and maintenance requirements, and promoting native species recovery and stability and overall community diversity (DWR, 2011).

- **Cost Sharing Formulas:** DWR established cost sharing formulas for repairs and improvements, one of which reduces agencies' required contribution from 30 percent for levee replacements to 20 percent for levee setbacks (DWR, 2014). Multi-benefit projects that attract multiple sources of funding to foster both lower waterside vegetation and levee improvements designed to address public safety are considered a high priority for the use of public funding (Section 1.1 of Appendix D, DWR, 2015).

- **Delta Plan:** The Delta Plan called for setting back levees, where feasible, to improve migratory corridors for anadromous fish and songbirds along the Sacramento River between Freeport and Walnut Grove; the San Joaquin River from the Delta boundary to Mossdale; and the north and south forks of the Mokelumne River, Paradise Cut, Steamboat Slough, and Sutter Slough (Delta Stewardship Council [DSC], 2015).

- **Delta Levee Investment Strategy:** This strategy focused on reducing the likelihood of a levee failure and associated consequences by analyzing risks, economics, engineering, and decision-making approaches to establish funding priorities and develop a comprehensive Delta levee investment plan (DSC, n.d.). Investment strategy development includes consideration of levee setbacks in the Delta (DSC, 2015).

## Recently Completed and Proposed Setback Levee Projects

The following setback levee projects within the SPFC have been completed or are currently proposed.

### Sherman Island's Setback and Waterside Benches

The funding and drivers described above have influenced the buildout of several recent projects in the legal Delta. For example, Reclamation District (RD or District) 341 has completed many levee upgrades and restoration projects on Sherman Island, in part to address ongoing seepage and settlement issues. Using DWR's Special Project funds in fiscal year (FY) 2004-05, RD 341 constructed approximately 6,000 linear feet of setback levee on a non-SPFC (private) levee section along Mayberry Slough on the southern edge to increase levee stability and provide 6.87 acres of intertidal channel margin habitat and 1.68 acres of riparian scrub shrub. More recently, the District used the same funding source to protect an SPFC (federal) levee on the northern edge from wind and wave erosion by installing a new riprap cover on the waterside slope and a splash cap on the crown for 15,700 feet of levee. In the design, they accounted for the planting of 10,950 feet of both willow riparian wetland (1.29 acres) and willow riparian habitat (3.14 acres) on the waterside of that repaired section. RD 341 was expected to pay for its OMRR&R of its new designs under the Subventions program (described in detail below).

The State reimburses the majority of the reclamation district's costs for OMRR&R work on Delta levees (both non-project and project) through a major State program known as Subventions. Budgets for the Subventions program are adopted at the Central Valley Flood Protection Board (CVFPB) meetings every October (see for example, CVFPB, 2015). The State portion of the operations and maintenance (O&M) budget for any district is partially based on availability of State funds for Subventions, which has varied from $12 million to as much as $26 million annually since passage of the flood control public bond measure in the 2006 election (CVFPB, 2015). The approved maximum reimbursement for RD 341 in that time period has been around $289,000 to $304,000 (about $14,800 to $15,500 per mile; see example at CVFPB, 2015, Table 2, column 6), and internal records show they spent between 40 and 70 percent of that every year. Thus, the District's 20-year average of State spending within the Subventions program for O&M is $7,000/levee mile (Nelson, 2015). It is unclear from the publicly available data if the new habitat areas have changed the O&M actions undertaken by RD 341 because they (as well as other RDs) do not categorize their spending by location when supplying copies of invoices and staff costs to the Subventions staff. However, in contrast to some of the upstream setback levees, these segments remain in bankfull conditions at all times under the influence of tides, and there is no State-required channel maintenance; therefore, there are no additional costs to DWR's Maintenance Yard staff from these installations.

### Proposed Southport Setback Levee

The approximate 6-mile Sacramento River levee in Southport near Sacramento is generally considered to be the most vulnerable portion of the West Sacramento levee system. Studies have identified several levee deficiencies including under-seepage, erosion, and stability issues. The City of West Sacramento and the West Sacramento Area Flood Control Agency (WSAFCA) are currently in the process of implementing flood risk reduction measures along the Sacramento River South Levee in the City of West Sacramento. Adjacent-to-the-river levee designs were initially proposed, but additional evaluations indicated that a 250-foot-wide landside seepage berm would be required along much of the levee to mitigate detrimental under-seepage. Instead, a setback levee was proposed approximately 150 feet from the existing levee that incorporates a smaller seepage berm (minimum of 80 feet wide) and shallow cutoff walls (to reach a clay layer below the surface). These features will address deficiencies of through-seepage, under-seepage, slope stability, geometry, erosion, encroachments, and noncompliant vegetation. WSAFCA's goal for this project is to achieve a minimum of 200-year levee performance for the City of West Sacramento. The project would bring the levee up to standard with federal and State levee design criteria, as well as provide opportunities for ecosystem restoration and public recreation.

Frequent bankfull events primarily define channel morphology in this section of river. During modeling completed as part of project design, it was determined that out-of-bank flows under hypothetical levee setback conditions would marginally affect the frequency of bankfull events, but would not likely significantly influence channel morphology over time. The engineer's recommendations in the 90 percent design (HDR, 2015) include both vegetation and sediment removal in the setback area on an as-needed and infrequent basis.

RD 900 will be responsible for maintaining flood control features that protect West Sacramento residents. The final set of OMRR&R activities needed for this section of river will only be determined after construction is completed (around 2020) and the State has signed an assurance agreement with RD 900. Although the final set of OMRR&R activities has not been developed,

generally, any addition of the area where channel maintenance would occur (as needed vegetation and sediment removal in the setback area) would add O&M costs, but a smaller berm width could result in cost savings compared to the initial repair-in-place option. Although channel maintenance costs could potentially increase, setting back this reach of levee from the channel will provide an erosion buffer, and, therefore, will likely save on frequent erosion protection projects. This erosion buffer would also likely reduce long-term OMRR&R costs for erosion repairs in this reach of levee.

As an ancillary benefit, the proposed Southport setback levee has opened up opportunities to create onsite biological mitigation between the degraded existing levee and the new setback levee, which supports the State Systemwide Investment Approach goal for the SPFC system to be more resilient and incorporate more ecosystem processes. The project will include creating inlet breaches and degrading the current levee to promote access to water to support adjacent riverside vegetation associated with the proposed setback levee (WSAFCA, 2013). Using lands bought as part of the flood control feature construction and adding vegetation to create onsite mitigation is proposed to minimize costs and avoid purchasing mitigation bank credits offsite from private banking companies.

### Setbacks at Bear River

Established as a joint powers agency by Yuba County and RD 784 in May 2004, the Three Rivers Levee Improvement Authority (TRLIA) improved levees and floodway corridors to provide 200-year protection in Yuba County, along the Yuba, Feather, and Bear rivers. As part of a variety of relatively recent flood management projects, TRLIA completed the Bear River setback levee in 2006. The levee spans 9,600 feet at the confluence of the Bear and Feather rivers, south of Plumas Lake (Sacramento River Watershed Program, n.d.a).

The primary goals of the project were to repurpose and replace the previously existing, weakened levee with a setback levee to improve the floodway hydraulics, and to vegetate the riverbank and floodplain to reduce erosion and increase habitat for wildlife. The nonprofit organization, River Partners, assisted with the latter goal by planting native trees and shrubs in the 600-acre-plus setback area. Total project cost was approximately $62 million, which was funded by a number of sources with approximately 50 percent provided through Proposition 13 (Sacramento River Watershed Program, n.d.a) and the remainder by local funds (Brunner, 2015).

The Bear River setback levee footprint and design components are maintained by RD 784. Based on actual costs in FYs 2012-2013 and 2013-2014 (not including District overhead) and estimated costs for FY 2014-2015, the annual estimated cost is $109,919. Some of these costs were driven by current design requirements and standard practice (e.g., inclusion of relief wells, v-ditches, and toe drains), which improve public safety, but also require additional maintenance, repair, and rehabilitation services. Evolving State and federal regulations require pump testing and rehabilitation of relief wells on all new levees regardless of their placement, resulting in a minimum of $100,000 per year over a 5-year cycle. Additional costs included addressing levee and infrastructure damages related to vandalism and garbage dumping associated with increased public recreational access. Security measures include the construction of security barriers (pipe fences and cement walls) to prevent unauthorized motor vehicle incursions (these additional costs are not unique to setback levees).

The setback area (339 acres) and the floodway (300 acres) were created as an ecological preserve and are currently maintained by TRLIA via contract with River Partners (TRLIA contracts, 2008, 2009a, and 2009b). The estimated annual O&M cost for the 639-acre ecological preserve is $52,000 per year. TRLIA is in the process of acquiring a third-party manager (Sacramento Valley Conservancy) to manage the site and has set aside funding for an endowment for the long-term care of the property (Brunner, 2015; Fordice, 2015).

### Feather River Levee Repair Project

In addition to the Bear River project, TRLIA also completed the Feather River Levee Repair Project in 2009. The Feather River Levee Repair Project includes a 6-mile-long setback levee on the eastern side of the Feather River between the Yuba River and Bear River junctions. The project provides a key component to the 200-year flood protection levee system that protects residents of South Yuba County, and opened up 1,600 acres for expanded floodway and habitat restoration. Unlike the previous levee, the setback levee meets all new DWR urban levee 200-year design criteria.

The project corrected many floodway and levee deficiencies for both Yuba and Sutter counties. Portions of the levee were set back approximately 0.5 mile from the old levee location, which widening the floodway, and lowered flood stage and flow velocity, resulting in reduced levee erosion. The widening of the floodway via the setback levee reduced the cost of levee improvements within Sutter County. The setback levee was constructed so as to eliminate the severe under-seepage problems that existed with the old levee.

RD 784 provides O&M for the setback levee, and TRLIA provides O&M for the expanded floodway. The levee within the setback area consists of the levee embankment, land- and waterside access corridors, a landside utility corridor, multiple relief wells, and a waterside vegetated wind wave buffer (which replaces the need for riprap). On the basis of actual out-of-pocket costs (not including District overhead), the annual estimated costs for FY 2012–2013, FY 2013–2014, and estimated costs for FY 2014–2015 is $125,918. Similar to the Bear River setback, new designs added a minimum of $100,000 per year over a 5-year cycle. Additional costs are similar to those described above for the Bear River project. The costs of security measures are difficult to annualize because building has been predicated on available funding, fluctuating material and labor costs, and the cost of fuel. Security measures include the construction of security barriers (pipe fences and cement walls) to prevent unauthorized motor vehicle incursions, and armed security is hired during extended holidays when an increase in levee and infrastructure damage has been experienced. The actual costs of maintaining the wave wash buffer and fence, which protects the levee and leased farmland, is currently unknown. Closed-circuit television is used, but those costs are currently being borne by TRLIA and have not yet been transferred to RD 784. For this particular project, the setback levee O&M cost is greater than the O&M cost for the deficient replaced levee. TRLIA supplements the RD 784 levee maintenance budget (60 to 70 percent) with revenues obtained through its Benefit Assessment District.

The expanded floodway contains approximately 470 acres of orchards, wetlands, an elderberry mitigation site, a cultural site, and open areas. A large portion of open area (500 acres) is being developed by TRLIA for DWR for a State advanced mitigation site (River Partners, 2015). TRLIA maintains the expanded floodway area. TRLIA and the State are working together to

place other restoration and recreational activities within the open areas of the setback area. The estimated yearly O&M cost for the wetlands, elderberry, and cultural areas is $100,000. TRLIA is in the process of acquiring a third-party manager (Sacramento Valley Conservancy) to manage these sites in the future State advanced mitigation site. TRLIA has set aside funding for an endowment for the long-term care of the mitigation properties. The orchards are leased, and the maintenance of the orchards is performed by the lessee. The revenues from the leased orchards may be used to provide a revenue stream for the expanded restoration and recreational activities.

### Proposed Hamilton City Setback Levee

Hamilton City is located less than a mile west of the Sacramento River, approximately 90 miles north of Sacramento in Glenn County. The city is currently protected by the aging J Levee, which was constructed in 1904 and currently provides a 10-year level of protection. Significant flood events have required the community to be evacuated six times since 1980 (The Nature Conservancy [TNC], 2014).

U.S. Army Corps of Engineers (USACE) initially drafted a levee plan for Hamilton in 1975; however, a cost-benefit analysis determined that the improvements could not be justified financially. USACE policy changes in 2003 associated with habitat restoration, in addition to flood protection, revised the cost-benefits analysis approach and subsequent determination of project feasibility. The Hamilton City project became the first in the country to gain USACE approval under the revised multi-benefits policy.

The proposed project is intended to increase flood protection of the area to the 75-year level by replacing the J Levee with 6.8 miles of setback levee that will consequently restore 1,400 acres of floodplain habitat. Additionally, as a result of the habitat restoration that will take place, the area will be reconnected with the Sacramento River National Wildlife Refuge and a California Department of Fish and Wildlife State Wildlife Area, creating a total of 4,000 acres of riparian habitat, benefitting 50 inhabitant species. Construction of the project is expected to begin fall 2015 (Hacking, 2015; Sacramento River Watershed Program, n.d.b).

TNC assisted in leading the acquisition of the floodplain and had spent $12 million on the project as of 2013 (TNC, 2014). Construction costs using local, State, and federal sources is estimated to be approximately $72.9 million, with the federal government bearing nearly two-thirds of the costs (Hacking, 2015). Annual maintenance and operations expenses are estimated to be approximately $55,000, which would be the responsibility of the CVFPB (USACE, 2004). Local community members organized an annual Levee Festival, from which over $100,000 has been raised since 1998, in addition to forming their own reclamation district (RD 2140) (Sacramento River Watershed Program, n.d.b.). RD 2140 also completed an annual O& fund and a tax assessment that generates $60,000 annually (Hacking, 2015).

To date, USACE has removed and transported approximately 30 elderberry bushes from the footprint of the first phase of the new levee. USACE has also conducted the required safety assurance review and completed soil testing of various borrow sites, including at the Glenn-Colusa Irrigation District, which offered to donate suitable soil at no cost. The results indicated that the soil received from Glenn-Colusa Irrigation District is suitable and will be used for levee construction. Construction has commenced, and the levee is expected to be completed in 2018, with restoration and revegetation lasting until 2021 (RD 2140, 2015).

## Proposed Strengthen-in-Place Levee Projects

### Feather River West Levee Project

The Feather River West Levee Project is a fix-in-place improvement project to strengthen 41.4 miles of existing levee along the western bank of the Feather River from just south of Yuba City to the Thermalito Afterbay at the northern end of the Sutter Basin. The proposed project includes installation of a soil-bentonite cutoff wall within the structural section of the levee. The levee will be reconstructed to existing pre-project geometry and meet USACE standards. The project design would reduce the risk of geotechnical failure modes related to through- and under-seepage. The project does not include increasing the height of the levees. Flood risk in the communities of Biggs, Gridley, Live Oak, and Yuba City would be reduced with project implementation. The estimated project cost is $748 million (USACE, 2013).

As part of the environmental review process, the annual OMRR&R costs were estimated to be $454,000, which represented an increase of $22,000 over existing costs at the time. The 2013 Supplemental Environmental Impact Statement conducted for the project listed typical OMRR&R activities, which were described as applicable both before and after project implementation (USACE, 2013). The activities listed include:

- Vegetation removal and control in compliance with Engineering Technical Letter No. 1110-2-583, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures
- Rodent control and repair of rodent damage
- Slope regrading and reseeding
- Repair of waterside erosion
- Maintenance of relief wells and collection ditches
- Maintenance and repair of flap gates to minimize internal drainage
- Patrol road and ramp maintenance
- Inspection and patrolling including participation in federal and State inspection programs, routine patrolling to identify maintenance needs and to assure flood worthiness, and continuous patrolling during high water conditions
- Flood fighting
- Sandbagging of the gap in the levee crown for passage of the railroad during high water conditions to prevent flooding of Yuba City and vicinity

During the environmental review process, a qualitative analysis of the anticipated change in OMRR&R costs was completed. The project includes installation of a soil-bentonite cutoff wall within the structural section of the levee. The levee will be reconstructed to existing pre-project

geometry and meet USACE standards. The slurry wall will reduce the short-term maintenance cost due to a reduction in seepage. The reconstruction of the upper half of the levee (side slopes, vegetation removal, grass re-establishment, and crown road replacement) will also reduce the short-term maintenance cost. With the installation of the slurry wall, many of the existing relief wells can be decommissioned or converted to other functions, and this will reduce short-term maintenance costs. The levee safety requirements for typical levee cross sections (side slopes, crown, and O&M road widths) will increase the current maintenance costs somewhat due to a larger vegetation management footprint. The replacement of utility and drainage pipe crossings will reduce maintenance costs in the short term (see Issue Summary #5, Cost of Addressing Levee Pipe Penetrations in State Plan of Flood Control). Overall, the short-term OMRR&R will decrease. However, in the long term, the OMRR&R cost is about the same because the commitments remain unchanged. This assumption remains to be tested since the project is only in construction at this time.

### Conclusion

At this time, long-term OMRR&R costs do not appear to vary greatly for setback versus repair-in place. OMRR&R costs are generally affected by the addition of project features such as berms or relief wells or the reduction in encroachments such as pipe crossings or utilities, all of which can be components of either a setback or repair-in-place levee. Evaluation of OMRR&R costs and the ancillary benefits as part of either kind of project requires a review of all factors and individual site characteristics and funding availability.

## References

Brunner, Paul. 2015. Executive Director. Three Rivers Levee Improvement Authority (TRLIA). Written comments on November 30, 2015, draft of New Costs from Setback and Rebuild-in-Place Levees. December 1.

California Department of Water Resources (DWR). 2007. California Flood Legislation Summary. Available at <http://www.water.ca.gov/legislation/2007-summary.pdf>. Accessed November 19, 2015.

———. 2011. Central Valley Flood System Conservation Strategy Funding Guidelines. September. Available at <http://www.water.ca.gov/floodsafe/fessro/docs/announce_guidelines.pdf>. Accessed October 20, 2015.

———. 2014. Cost Share Guidelines for State-Local Cost Shared Flood Programs and Projects, Adopted to Comply with AB5, Section 25, California Water Code Section 9625. Available at <http://www.water.ca.gov/floodmgmt/docs/Cost-Share-Guidelines-Final-12-11-14.pdf>. Accessed December 21, 2015.

———. 2015. Integrated Regional Water Management Implementation Grant Program Funded by Proposition 84. Available at <http://www.water.ca.gov/irwm/grants/docs/p84_implementation/P84_2015%20IRWM_GL_Final_050515.pdf>. Accessed October 19, 2015.

California Natural Resources Agency. 2015. Bond Accountability, State Plan of Flood Control Programs. Available at <http://bondaccountability.resources.ca.gov/ProgramList.aspx?Prop=5&ChapterPK=74&ChapterName=State plan of flood control>. Accessed December 11, 2015.

Central Valley Flood Protection Board (CVFPB). 2015. October 23 Meeting of the Central Valley Flood Protection Board, Item 8A – 2015-16 Delta Levee Maintenance Subventions Program. Available at <http://www.cvfpb.ca.gov/meetings/2015/10-23-2015.cfm>. Accessed December 21, 2015.

CVFPB. *See* Central Valley Flood Protection Board.

Delta Stewardship Council (DSC). n.d. Delta Levees Investment Strategy. Available at <http://deltacouncil.ca.gov/delta-levees-investment-strategy>. Accessed October 19, 2015.

———. 2015. State Investment in Delta Levees, Key Issues for Updating Priorities. January.

DSC. *See* Delta Stewardship Council.

DWR. *See* California Department of Water Resources.

Fordice, Steven. 2015. General Manager. Reclamation District 784. Written comments on November 30, 2015, draft of New Costs from Setback and Rebuild-in-Place Levees. December 3.

Hacking, Heather. 2015. J Levee gets another boost of funding, protection for Hamilton City on the way. ChicoER. May 27. Available at <http://www.chicoer.com/general-news/20150527/j-levee-gets-another-boost-of-flood-funding-protection-for-hamilton-city-on-the-way>. Accessed October 14, 2015.

HDR. 2015. Southport Sacramento River Early Implementation Project 90% Design Documentation Report. Prepared for West Sacramento Area Flood Control Agency, Sacramento, CA. July.

Nelson, Natasha. 2015. Program Manager. California Department of Water Resources, FloodSAFE Environmental Stewardship and Statewide Resources Office. Written comments on December 11, 2015, draft of New Costs from Setback and Rebuild-in-Place Levees. December 22.

Reclamation District 2140 (RD 2140). 2015. Hamilton City Flood Damage Reduction Ecosystem Restoration Project Fact Sheet. Available at <https://assets.documentcloud.org/documents/2217905/hamilton-city-j-levee.pdf>. Accessed November 30, 2015.

River Partners. 2015. Feather River Riparian Habitat Restoration Project Kick-off. Winter 2015. Available at <http://www.riverpartners.org/news-and-events/newsletters/2015_v12n1_FeatherRiver.html>. Accessed December 21, 2015.

Sacramento River Watershed Program. n.d.a. Bear River Setback Levee Project. Available at <http://www.sacriver.org/aboutwatershed/roadmap/projects/bear-river-setback-levee-project>. Accessed October 20, 2015.

———. n.d.b. Hamilton City Levee Setback. Available at <http://www.sacriver.org/aboutwatershed/roadmap/projects/hamilton-city-levee-setback>. Accessed October 14, 2015.

The Nature Conservancy (TNC). 2014. Reducing Climate Risks with Natural Infrastructure. Available at <http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/california/ca-green-vs-gray-report-2.pdf>. Accessed October 13, 2015.

TNC. *See* The Nature Conservancy.

TRLIA Contracts. 2008. Agreement for Professional Services, Signed August 19. Available at <http://www.trlia.org/docs/documents/Contracts/River%20Partners/Contract%20Elderberry%20Transplant%20Aug.19.08.pdf>. Accessed December 21, 2015.

———. 2009a. Third Amendment to Agreement between Three Rivers Levee Improvement Authority and River Partners, Signed October 13. Available at <http://www.trlia.org/docs/documents/Contracts/River%20Partners/Amendment%203%20Elderberry%20Transplant%20Oct.13.09.pdf>. Accessed December 21, 2015.

———. 2009b. Second Amendment to Agreement between Three Rivers Levee Improvement Authority and River Partners, Signed August 4. Available at <http://www.trlia.org/docs/documents/Contracts/River%20Partners/Amendment%202%20Elderberry%20Transplant%20Agmt%20Aug.4.09.pdf>. Accessed December 21, 2015.

U.S. Army Corps of Engineers (USACE). 2004. Hamilton City, Glenn County, California. Available at <http://planning.usace.army.mil/toolbox/library/ChiefReports/hamilton_ca.pdf>. Accessed on October 14, 2015.

———. 2013. Sutter Basin Pilot Feasibility Draft Report – Draft Environmental Impact Report/Supplemental Environmental Impact Statement. June.

USACE. *See* U.S. Army Corps of Engineers.

West Sacramento Area Flood Control Agency (WSAFCA). 2013. West Sacramento Levee Improvement Program Southport EIP 65% Design. Prepared by HDR, Drawing Dated April 25. Available at <https://www.cityofwestsacramento.org/documents/Flood/TO465PercentDESIGNSTRIPMAP20130425VPWEXTENSIONVillageParkwayExt.pdf>. Accessed December 21, 2015.

WSAFCA. *See* West Sacramento Area Flood Control Agency.

# Issue Summary #4
# Prioritizing and Addressing the Cost of Inspection Compliance

*The amount of funds remaining for [investment in] the rural areas and the small communities will be limited because there is simply not enough money to go around.*

***Bill Edgar comment on the Delta Stewardship Council's Delta Levee Investment Strategy – Draft Policy Paper.***

State Plan of Flood Control (SPFC) facilities are inspected annually by California Department of Water Resources (DWR). The resulting *Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Control System* is published each year, and notes levee condition and potential issues including structural integrity and erosion concerns. Local maintaining agencies (LMAs) conduct their own inspections focused on limiting the potential for levee failures via a variety of potential causes including erosion, rodent-caused weakening of facilities, and pipe penetrations.

U.S. Army Corps of Engineers (USACE) also conducts periodic routine inspections of project levees for quality assurance. USACE uses the overall ratings from their inspections to determine eligibility in their Rehabilitation Program (RP), which is also known as Public Law (PL) 84-99. Repairs are also made in response to State and federal inspection results on a priority basis depending on the potential for major failure and available funding. The Central Valley Flood Protection Board (CVFPB) is considering ways to prioritize repairs to bring those who have failed their inspections back into compliance.

## DWR Inspections

As discussed above, DWR, under the authority of California Water Code Sections 8360, 8370, and 8371, performs a verification inspection of the maintenance performed by LMAs, and reports to USACE periodically regarding the status of the SPFC. DWR's inspection of the SPFC uses the California Data Exchange Center as a database for inspection results. The inspection reports are available on the internet at cdec.water.ca.gov.

In recent years, inspection criteria are being more rigorously applied by DWR as well as USACE inspectors. USACE directed that the State use the inspection checklist found in USACE *Flood Damage Reduction System Inspection Report* when inspecting the SPFC. DWR uses checklists similar to USACE for most categories, but uses interim vegetation inspection criteria to evaluate vegetation-related issues. DWR completes spring inspections in May, documenting the location, size, type, and rating of maintenance deficiencies while working with the LMAs to assist in planning maintenance activities prior to the flood season. DWR completes annual fall inspections in November, verifying the status of previously noted and any additional deficiencies

that should be corrected to help ensure adequate performance during the flood season. LMAs conduct inspections in the winter and summer, completing the requirement to conduct four inspections each year. DWR uses a rating system similar to the USACE system described below.

## USACE Inspections

The USACE PL 84-99 program, pursuant to 33 United States Code 701n, is a voluntary program that includes the repair and restoration of participating flood risk reduction projects, such as levee systems. All levee systems that participate in PL 84-99 are inspected by USACE and rated against nationally consistent standards that USACE determined to be essential for the reliable performance of the levee system. Levee systems that have received an "Acceptable" or "Minimally Acceptable" overall system rating on the last periodic or routine/continuing eligibility inspection are "Active" in PL 84-99 and, consequently, are eligible to receive rehabilitation assistance from USACE to repair or restore levee systems to pre-disaster condition if they are damaged by a flood event. Levee systems that receive an "Unacceptable" overall system rating or that choose to no longer participate in the program are placed in "Inactive" status and are not eligible for rehabilitation assistance under PL 84-99 (USACE, 2011).

Although a system status of inactive results in a loss of PL 84-99 rehabilitation assistance following a flood event, it does not necessarily result in a loss of Federal Emergency Management Agency National Flood Insurance Program certification or accreditation, nor does it result in a loss of federal assistance for emergency flood fighting. Conversely, a system status of active does not guarantee rehabilitation assistance will be provided, only that the system is eligible. Rural LMAs may have difficulty meeting the benefit cost ratio requirements to receive the rehabilitation assistance.

The periodic inspection is similar to a routine inspection and is conducted by a multidisciplinary team, led by a professional engineer. It includes a more detailed, comprehensive, and consistent evaluation of the levee system condition than might be performed in routine State and local inspections. The program has seen a large increase in funding over the last few years as USACE is focused on having a full description of their portfolio of federal assets.

Inspection results for the Sacramento District, which includes all SPFC levee systems, are available on the internet at http://www.spk.usace.army.mil/Missions/CivilWorks/LeveeSafetyProgram/LeveeSystemsInspectionStatus.aspx.

## Current Status of SPFC Relating to PL 84-99

Inspection ratings vary from LMA to LMA and with geographic location; however, it is evident that an increasing number of LMAs and State Maintenance Areas are currently not active in PL 84-99 RP. Figure 1 shows the most current status of the SPFC in relation to PL 84-99. The majority of the systems/levee miles comprising the SPFC are not active in PL 84-99 RP. The red portion of the graphical bar would increase if a Letter of Intent were not filed by the CVFPB stating an LMA's intention to develop a System Wide Improvement Framework (SWIF) plan. The SWIF process is further explained below.

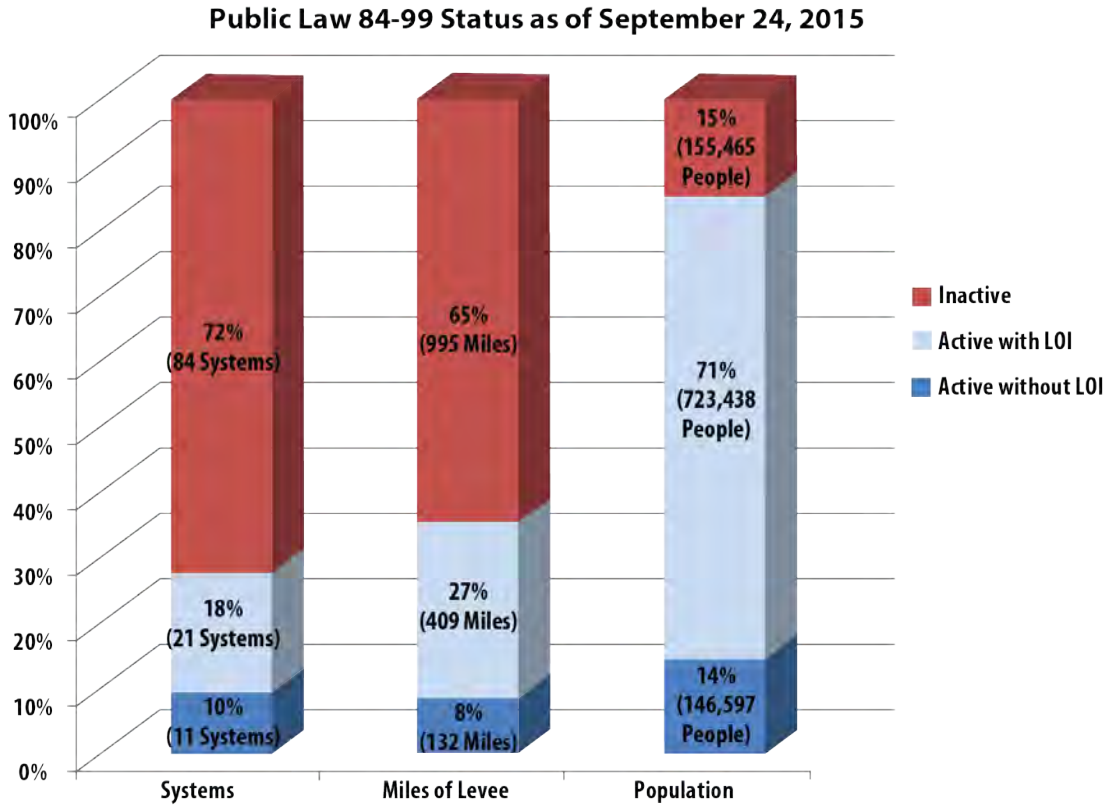


**Figure 1. PL 84-99 Status as of September 2015**

*Source: Chief Engineer's Report given to the CVFPB at the September 25 meeting (September 2015).*

An SWIF is a plan developed by the levee sponsor(s) and accepted by USACE to implement systemwide improvements to a levee system (or multiple levee systems within a watershed) to address systemwide issues, including correction of unacceptable inspection items in a prioritized way to optimize flood risk reduction. Developing and implementing solutions to address such deficiencies might require a multi-year effort and coordination among multiple entities. This may be especially true when resources protected under the Endangered Species Act or Tribal treaty rights could be affected by any changes to the levee system. USACE is making the SWIF process available to levee sponsors facing such challenges as a way to facilitate the development of solutions to satisfy the multiple requirements that apply to their levee systems while allowing levee sponsors participating in the SWIF process to remain eligible for PL 84-99 rehabilitation assistance funding while addressing deficiencies. The first SWIF deadlines under this new process are for Maintenance Area 09 – City of Sacramento – American River Left Bank, and Reclamation District (RD or District) 1000 – Natomas in May 2016 (CVFPB, 2015).

Levee sponsors that receive an overall levee system inspection rating of "Unacceptable" or have been "Inactive" in the rehabilitation program may regain eligibility for PL 84-99 rehabilitation assistance through the SWIF process. Upon approval by USACE of the Letter of Intent from the

CVFPB (who is the nonfederal sponsor), the area will initially receive an up to 2-year reinstatement of eligibility for PL 84-99 rehabilitation assistance. Continued eligibility will be determined annually based on milestones described in the subsequent SWIF (USACE, 2011).

## Current Status of SPFC Facilities by Deficiency Type

In general, the Maintenance Areas and many LMAs receive less-than-acceptable inspection ratings largely on the basis of encroachments, vegetation growth, rodent control, and levee crown maintenance, as shown on Figure 2 and Table 1. Districts tend to prioritize repairs they deem as absolutely necessary to avoid levee failure and potential flood damage, leaving many inspection issues unresolved due to lack of funding and resources. The unresolved issues are usually noted again during follow-up inspection, resulting in an unacceptable operation and maintenance rating for the LMA.

Because of the drought and lack of large flood events in the last 5 years, currently, only a handful of erosion and seepage problems are affecting the ratings of levee systems However, historically after major storms, USACE has participated in the repair of deficiencies for those levees that are active in the program. After the 2005-2006 storms, 20 seepage sites and 173 erosion sites were determined to be eligible for PL 84-99 assistance by USACE (DWR, 2011), and millions of federal dollars assisted in those repairs. Because so many of the levee systems are now inactive in the PL 84-99 program, future storm damages will become the full financial burden of the State and LMAs.

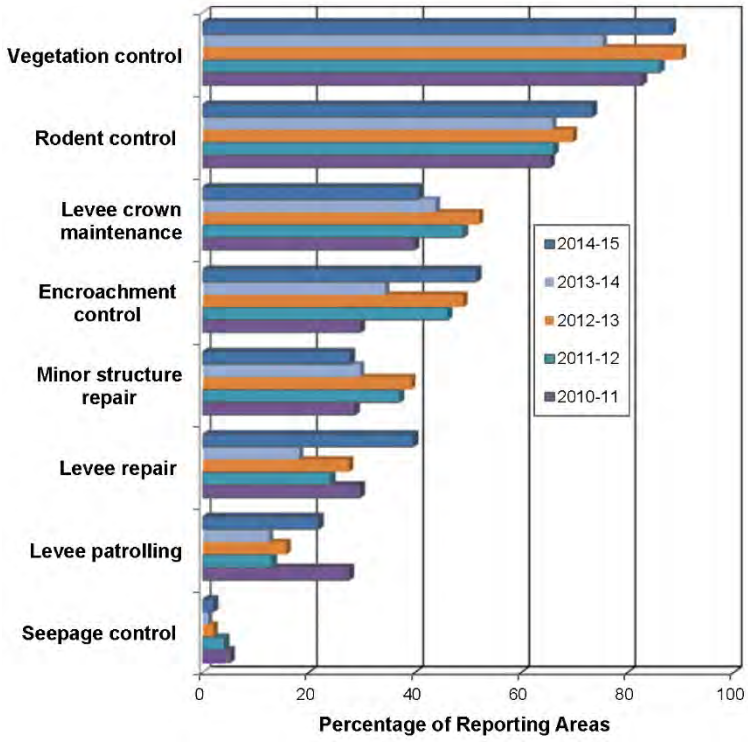


**Figure 2. Performed Activities Reported from 2011 to 2015**

*Source: Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Protection System (DWR, 2015).*

## Estimated Cost for Inspection Compliance

The following describes the most recent USACE inspection results and ratings for specific LMAs in the Sacramento River Basin, the Sacramento-San Joaquin Delta (Delta), and the San Joaquin River Basin; summarizes average annual expenditures in accordance with Assembly Bill 156; and summarizes the estimated cost to achieve active status in PL 84-99 RP.

### Sacramento River Basin

Table 1 shows the results of the most recent USACE inspection of RD 1001, which is a fairly typical rural LMA in the Sacramento Valley. As shown in the table, the vast majority of unacceptable items are related to encroachments and vegetation growth. The SWIF for RD 1001 is due to USACE in November 2016 (CVFPB, 2015).

**Table 1. Summary of RD 1001 Minimally Acceptable/Unacceptable Items – USACE Inspection 2012**

| | Minimally Acceptable | Unacceptable | Approximate Items Per Mile (rounded up) |
|---|---|---|---|
| **RD 1001 – Levee Miles Maintained = 44.03 Project and 15.53 Non-Project** | | | |
| Animal Control | 4 | 264 | 7 |
| Slope Stability/Cracking | 39 | 8 | 2 |
| Depression/Rutting | 18 | 88 | 3 |
| Seepage | 5 | 2 | 1 |
| Encroachments | 281 | 659 | 22 |
| Vegetation Growth/Sod Cover | 12 | 623 | 15 |
| Erosion/Bank Protection | 69 | 56 | 3 |
| Total | 428 | 1,700 | |
| System Rating, Status in PL 84-99[1] | Unacceptable – Active with Letter of Intent | | |

*Source: USACE, 2015.*
Note:
1 August 2015.

### Correlating Operations, Maintenance, Repair, Rehabilitation, and Replacement Expenses with Inspection Rating

Correlating RD 1001's average annual operations, maintenance, repair, rehabilitation, and replacement expenditures with their inspection rating reveals that funding does not always guarantee an acceptable inspection rating. The District is currently active in USACE's RP, despite the critical issues found during recent inspections, because they submitted a Letter of Intent and are working on an SWIF to address major issues such as erosion, seepage, and encroachments. RD 1001 is a fairly well-funded rural district with an average budget that equates to $20,000/per mile. However, with legacy encroachment issues, new standards regarding encroachment inspection, and evolving vegetation criteria, the District has difficulty meeting the minimally acceptable rating in these detailed inspections. In addition, RD 1001 has several larger seepage and stability issues that have developed over time, but are difficult and expensive to repair within the operation and maintenance budget. This highlights the need for LMAs to

develop and maintain long-term reserve funds to make these larger-scale repairs or implement non-routine activities.

Of the approximate 1,700 unacceptable and critical items identified, RD 1001 has focused on items such as vegetation, animal control, rutting, and cracking issues. This work generally required more rigorous routine maintenance activities such as rodent baiting, tree removal, and slope dragging and reseeding. In addition, the District has begun working with encroachment owners to correct deficiencies or provide inspection data to meet the changing standards. Remaining encroachment, slope stability, and erosion issues that will require lengthy planning and implementation will then be covered in the SWIF.

## State Planning for Reactivation under PL 84-99

Starting in 2008, the CVFPB has been receiving three to six periodic inspection reports at their monthly meetings held in Sacramento (see their Web site for agendas and copies of presentations). Each presentation includes several photos showing examples of levee deficiencies and a copy of the PL 84-99 report card. Report cards serve as a findings summary of USACE periodic inspections. An example is found in Figure 3. In total, all 108 federal levee systems in the SPFC have been inspected and the results reported.

System: RD 0150 - Merritt Island
System Rating: Unacceptable
Approved SWIF/LOI: No
PL 84-99 RP Eligibility: Inactive

| | | RD 0150 - Merritt Island - Unit 1, Sutter Slough (MRT1) | RD 0150 - Merritt Island - Unit 2, Sacramento River (MRT2) | RD 0150 - Merritt Island - Unit 3, Elk Slough (MRT3) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| General | Operations and Maintenance Manuals | M | M | M | | | | | |
| | Emergency Supplies and Equipment | A | A | A | | | | | |
| | Flood Preparedness and Training | M | M | M | | | | | |
| Levee - Items Affecting PL 84-99 RP Eligibility | Encroachments | M | U | U | | | | | |
| | Closure Structures | NA | NA | NA | | | | | |
| | Slope Stability | M | M | M | | | | | |
| | Erosion/Bank Caving | A | M | U | | | | | |
| | Animal Control | U | U | U | | | | | |
| | Culverts/Discharge Pipes | NA | NA | NA | | | | | |
| | Underseepage Relief Wells/Toe Drainage Systems | NA | NA | NA | | | | | |
| Levee Embankments - Other Items | Vegetation Growth | M | M | M | | | | | |
| | Sod Cover | A | M | M | | | | | |
| | Settlement | M | M | M | | | | | |
| | Depressions/Rutting | M | U | U | | | | | |
| | Cracking | A | A | A | | | | | |
| | Riprap Revetments & Bank Protection | M | M | M | | | | | |
| | Revetments other than Riprap | NA | NA | NA | | | | | |
| | Seepage | A | A | A | | | | | |

**Legend**

| | | | |
|---|---|---|---|
| A | Acceptable | M | Includes Unacceptable observations not likely to prevent performance in next flood event |
| M | Minimally Acceptable | U | Serious deficiency noted in past inspection report has not been corrected within the established timeframe |
| U | Unacceptable | U | Likely prevents performance in next flood event |
| N/A | Not Applicable | | |

**The worst rating is used to determine the overall segment system ratings and PL 84-99 Eligibility**

**Figure 3. Merritt Island's System Report Card from Periodic Inspection**

The CVFPB members have become increasingly aware that the State Maintenance Areas and LMAs have been unable to maintain active status in the RP. Tackling all of the State-maintained levee systems (5 systems under California Water Code 12878 and 10 systems with California Water Code 8361 responsibilities) simultaneously is cost prohibitive. Therefore, CVFPB staff and DWR have been working on prioritizing USACE SWIF Letter of Intent submittals (see Item 12, CVFPB, 2015) and how to best use their enforcement program (see Title 23 of the *California Code of Regulations*, Article 4). One option is to prioritize actions based on the Levee

Safety Action Classification (LSAC) ratings (created in 2006 by USACE) for areas outside the legal Delta. The LSAC ratings focus on both the levee's performance and the consequences of a levee failure (see Figure 4). Because these ratings are new and must be approved by a federal committee, there are few available for public release. Until these ratings are available and can be reviewed for their utility as a selection tool, data on size of the population protected, crops, and structure value protected, along with a metric showing the level of need for Endangered Species Act permitting (e.g., miles of giant garter snake habitat) is being used as an alternate.

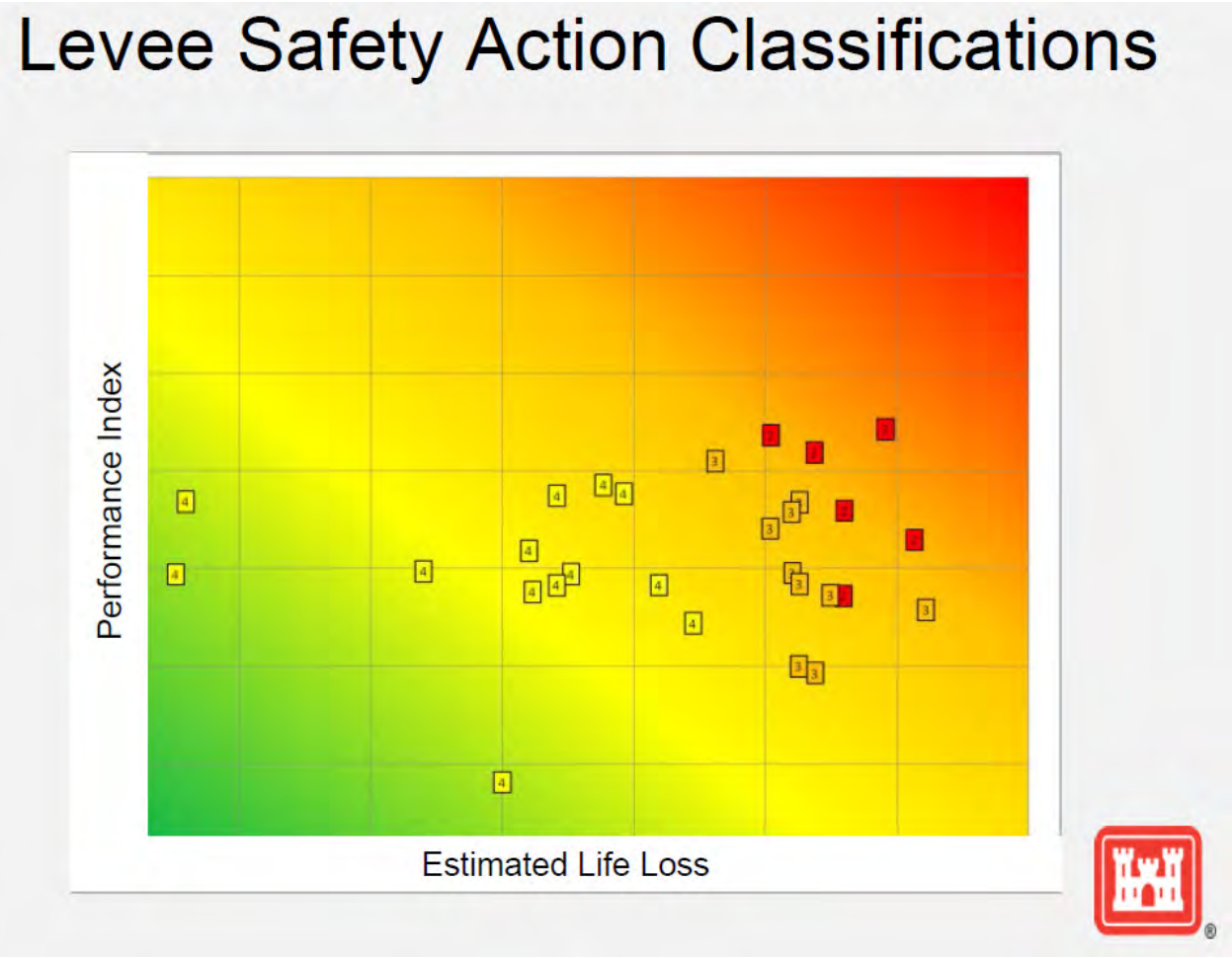


**Figure 4. Example of Hypothetical Levee Segments Plotted within LSAC**

*Source: USACE, 2013.*

Note: Those in red indicate a higher risk to the State because performance is poor and there is a high estimated life loss.

The Delta Stewardship Council (Council) is in the process of developing the Delta Levees Investment Strategy (DLIS), which is a part of implementing the 2013 Delta Plan. Specifically, the 2013 Delta Plan includes Recommendation RR R4, which directs the Council, in consultation with DWR, the CVFPB, the Delta Protection Commission, local agencies, and the California Water Commission to develop updated funding priorities for State investments in Delta levees. The DLIS includes the development of a decision tool to allow for the evaluation of flood risk (life and property loss), water supply, ecosystem, and Delta as Place metrics in making decisions

on how to prioritize State funding through the Delta Levees Maintenance Subventions Program and Delta Levees Special Projects Program. Funding prioritization must be tied to the interests of the State, which are being defined in the context of the DLIS as part of the process. The funding priorities, which will be in the form of an updated levee investment policy and decision support tool, should be available in 2016. The way that State funding is prioritized will influence the PL 84-99 status of levees in the Delta.

USACE, CVFPB, and local agencies continue to implement site-specific projects as they become ready for construction. These projects could improve levees such that they will no longer be classified as inactive under PL 84-99. In addition, many LMA and some State Maintenance Areas are using the Letter of Intent to bring themselves back into active status as a temporary measure. Using a prioritization matrix (see an example on Figure 5), CVFPB staff should be able to prioritize the near-term actions; and with proper funding, these inactive systems could become active again through the RP process.

## References

California Department of Water Resources (DWR). 2011. Flood Control Systems Status Report, Appendix A – Levee Status. A component of the CVFPP. Available at <http://www.water.ca.gov/cvfmp/2012cvfpp.cfm>. Accessed June 17, 2015.

———. 2015. Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Protection System.

Central Valley Flood Protection Board (CVFPB). 2015. Meeting of the Central Valley Flood Protection Board. Item 12(b): Update regarding Letters of Intent submitted by Local Maintaining Agencies to develop System Wide Improvement Framework plans and the resulting effects on USACE Public Law 84-99 eligibility. December 18. Available at <http://www.cvfpb.ca.gov/meetings/2015/12-18-2015.cfm>. Accessed December 21, 2015.

CVFPB. *See* Central Valley Flood Protection Board.

DWR. *See* California Department of Water Resources.

U.S. Army Corps of Engineers (USACE). 2011. Memorandum for Commanders, Major Subordinate Commands and Districts, Subject: Policy for Development and Implementation of System-Wide Improvement Frameworks (SWIFs). November 29.

———. 2013. Levee Safety Program Presentation by William Empson. Available at <http://samekc.org/useruploads/files/same_levees_empson_draft.pdf>. Accessed June 16, 2015.

———. 2015. National Levee Database. August.

USACE. *See* U.S. Army Corps of Engineers.

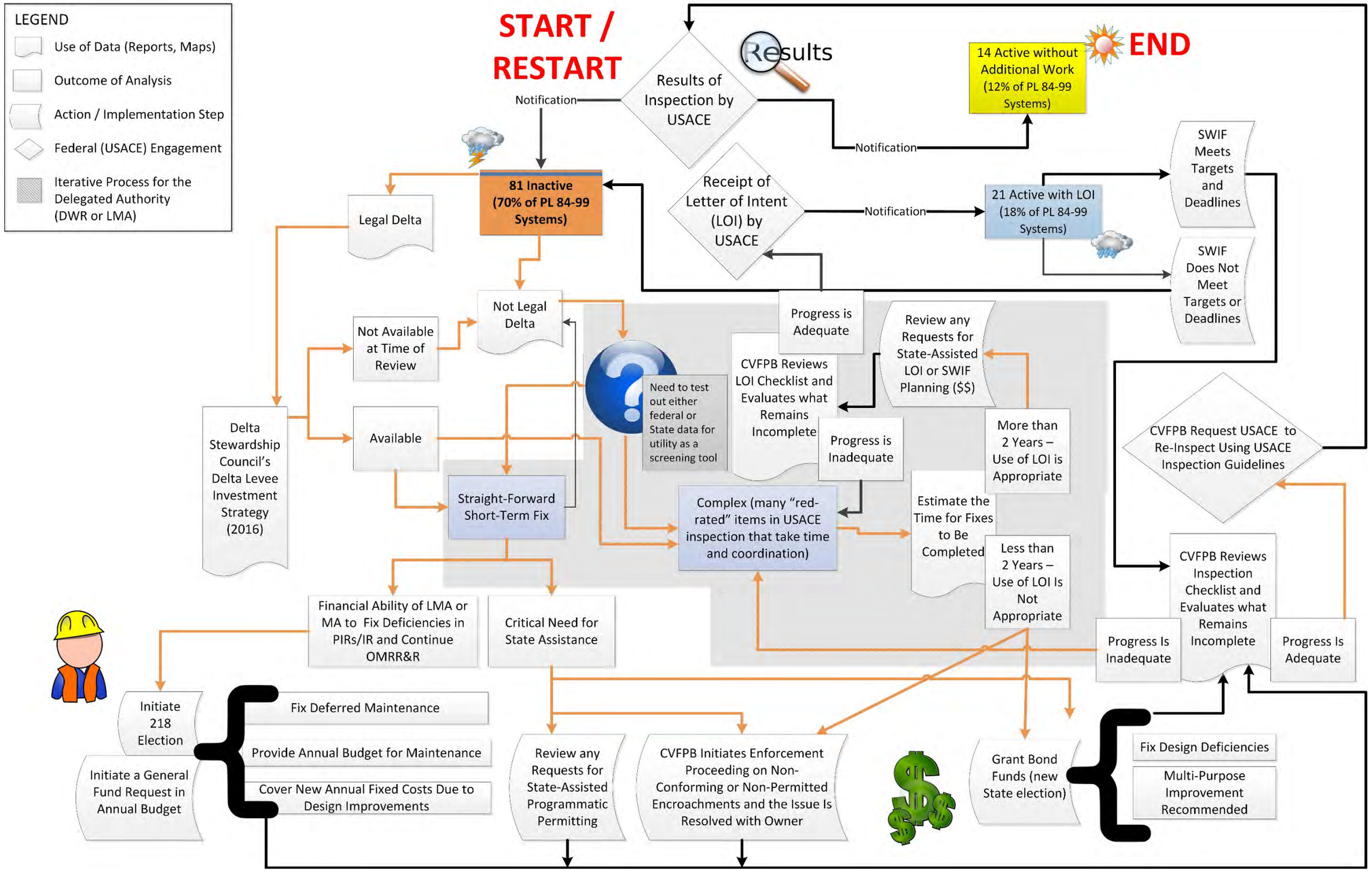


**Figure 5. Priority Investment Flow Chart: Evaluating the 116 Systems within PL 84-99 (as of December 2015)**

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# Issue Summary #5
# Cost of Addressing Levee Pipe Penetrations in State Plan of Flood Control

*Maintenance is never as exciting as new investment. Repairing roads and bridges might be necessary, but the very mention of infrastructure provokes yawns. Spending big money to end up with pretty much the same thing afterwards doesn't whip up taxpayer support. It's easier to let things crumble until there's an outcry.*

***Rosabeth Moss Kanter, Professor of Business at Harvard Business School. 2012. When the Going Gets Tough, the Tough Do Maintenance. Harvard Business Review. October 11.***

Levee penetrations are constructed objects, such as pipes, that cross under or through a levee or floodwall and can create a preferential seepage path or hydraulic connection with the waterside of a levee (see Figure 1). There are approximately 5,500 pipe penetrations throughout State Plan of Flood Control levees, of which approximately 90 percent are projected to need replacement in the next 20 years. It is estimated that up to 1,000 pipes (which serve no current purpose and, in some cases, the owner is unknown) may need to be removed in the near future (DWR, 2014). The removal, repair, rehabilitation, and replacement of pipe penetrations represents a large portion of projected operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs for the State Plan of Flood Control. Environmental permitting and mitigation costs for addressing pipe penetrations are generally not captured in the cost estimates discussed below.

**Figure 1. Levee Pipe Penetration and Associated Erosion and Scour**

## Sacramento River Basin

### Feather River West Levee

The west levee of the Feather River extends approximately 45 miles from Thermalito Afterbay to the confluence with Sutter Bypass (see Figure 2). Various local maintaining agencies (LMAs) including Maintenance Area (MA) 3, MA 7, MA 16, Levee District 1 (Sutter), and Levee District 9 (Sutter) share responsibilities along the levee that protect agricultural and urban areas from Gridley to Yuba City. Because the levee experiences seepage problems during high water, the Sutter Butte Flood Control Agency (SBFCA) – a coalition of LMAs, cities, and local interests groups – is currently in the process of constructing new levee seepage barriers.

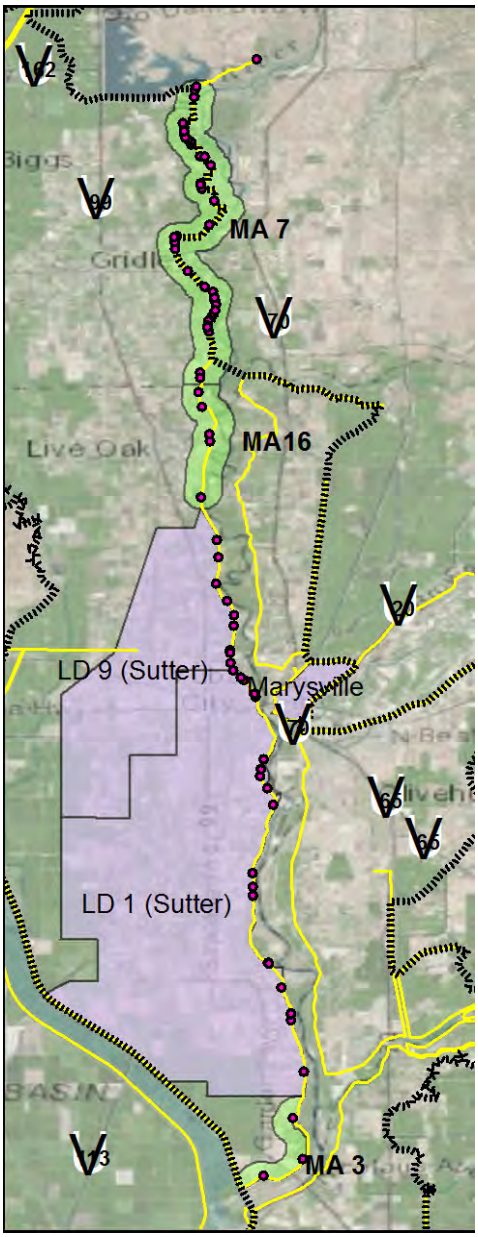


**Figure 2. Feather River West Levee and Associated Pipe Penetrations**

SBFCA is also addressing pipe penetrations by making modifications to and replacing specific pipes, as well as removing those that are no longer needed. According to the Utility Crossing Inventory Program (UCIP), 113 pipes cross the west levee, of which 63 are unpermitted. SBFCA is scheduled to remove 55 pipe crossings (49 percent of those documented in the UCIP); most are irrigation and drainage related as shown in Table 1.

**Table 1. West Levee Pipe Crossings**

| Type of Pipe Penetration | No. |
|---|---|
| Irrigation | 43 |
| Drainage | 39 |
| Sewer-Wastewater | 6 |
| Electric Power | 2 |
| Drinking Water (treated/untreated) | 5 |
| Gas, Oil, Steam, Petroleum, Chemical | 10 |
| Communication Cables and Conduits | 3 |
| Unknown | 5 |

SBFCA's construction cost estimates, produced in 2014, indicate costs can be reduced if groups of pipe crossings are removed/replaced at the same time rather than individually (SBFCA, 2014). Environmental compliance was conducted separately and is not included in these costs. Costs for two of the segments follow:

- **Segment B** (6.1 miles) – Pipe removal and disposal costs totaled $108,000 for 10 pipes ($10,800 each); 8 of the 10 pipes were replaced at a cost of $1.5 million ($187,000 each).

- **Segment D** (11.4 miles) – Pipe removal and disposal costs totaled $1.15 million for 45 pipes ($25,550 each); 28 of the 45 pipes were replaced at a cost of $4.6 million ($164,000 each).

Cost differences between the two segments are generally due to the diameter of pipe removed; Segment B involved removal of pipes generally less than 24 inches in diameter, and Segment D generally involved pipe with diameters of 24 inches and greater. Pipe replacement costs differences were also driven by the number of pipes replaced (28 for Segment D and 8 for Segment B with relatively greater costs associated with utility bypasses and extra costs). Figure 3 shows SBFCA's construction cost estimates, which reveal an increase in cost for pipe removal, disposal, and pipe replacement associated with increasing pipe diameter.

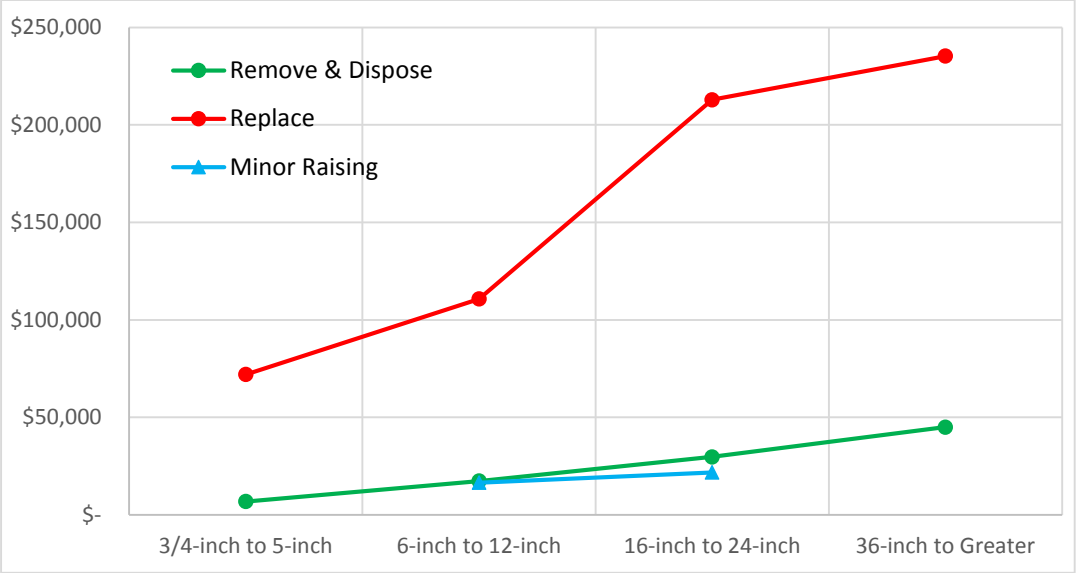


**Figure 3. Average Cost per Pipe for Addressing Penetrations Versus Pipe Diameter**

*Source: SBFCA Feather River West Levee Project Bid Contract Documents, developed by OMRR&R Work Group.*

Note: "Minor raising" refers to relatively minor raising of siphon pipe penetrations where costs are generally not driven by pipe diameter given relatively minor earthwork and reuse of existing pipe material.

### Butte Creek Pipe Replacement

In 2005, the Sutter Maintenance Yard performed an emergency repair of a deteriorated drainage pipe within MA 5 located in the left bank of Butte Creek. The 30-inch-diameter, 125-foot-long corrugated metal pipe required immediate replacement because of pipe wall deterioration. Video inspection revealed a sizable hole approximately 80 feet into the pipe, with significant water flow exiting through the hole and eroding the levee. Repairs included removal of the old pipe, realignment to allow for a perpendicular penetration through the levee, various support structures, and installation of new 30-inch-diameter pipe. Costs for the replacement were approximately $240,000 including $70,000 in construction labor, $100,000 in construction materials, and $70,000 for property research surveys and permits. This project falls on the replacement curve approximately where expected for a 30-inch-diameter pipe penetration (see Figure 3).

## Delta

According to the UCIP, 1,943 utilities crossing project levees are in the legal Delta, most of which are irrigation and drainage related. Delta levee crossings are listed in Table 2.

**Table 2. Delta Levee Crossings**

| Type of Pipe Penetration | No. |
|---|---|
| Irrigation | 839 |
| Drainage | 357 |
| Sewer-Wastewater | 70 |
| Electric Power | 152 |
| Drinking Water (treated/untreated) | 86 |
| Gas, Oil, Steam, Petroleum, Chemical | 110 |
| Communication Cables and Conduits | 75 |
| Unknown/Other | 254 |

Some of the Delta islands receive a portion of their protection from a project levee (such as Sherman Island and Twitchell Island), and the remaining portions of the islands depend on non-project levees. The number of penetrations in non-project levees is not available through the UCIP data.

Between 2011 and 2014, eight islands within the Delta received Special Projects funding from DWR to improve non-project levee profiles and, in some cases, to improve levee roads. During this work, contractors replaced and modified siphon pipes penetrating the base along the crown of the levees (see Figure 4), in part to avoid seepage issues within the levee prism. Design of older pipe penetrations included an inlet and levee crossing below the base flood elevation for the island versus new designs that place pipe penetrations above the base flood elevation as shown on Figure 4. To date, 47 pipes have been replaced or modified for a total cost of about $900,000 or $19,148 per pipe replacement. Costs ranged from $10,500 to $37,250 per pipe, without permitting or transactional cost, because the siphon pipes were just a short distance under a disturbed road base and on non-project levees. Obtaining Central Valley Flood Protection Board permits can add an additional approximate $25,000 including engineering drawings and required minor surveys. DWR estimates more than half of the pipe penetrations along these eight islands have not been modified or replaced. The pipe penetrations mentioned above are through non-project levees and are not included in the UCIP list provided in Table 2.

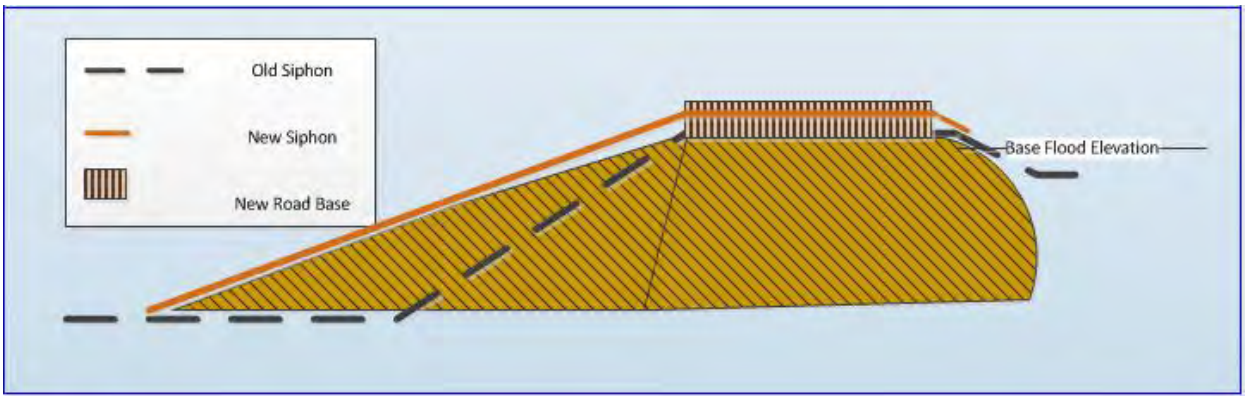


**Figure 4. Schematic of Pipe Replacement/Modification**

Between 2009 and 2014, 13 islands also had removal, replacement, or abandonment of pipes as part of their subvention claims to DWR. Those pipes in non-project levees (12 islands) were similar in costs to Special Projects with an average of $17,000 per pipe. Most of these pipes are just beneath the road base on the crown of the levee and do not require permitting or mitigation.

## San Joaquin River Basin

According to the UCIP, 1,275 utilities cross San Joaquin River Basin levees, excluding those within the Delta, most of which are irrigation and drainage related. San Joaquin River Basin levee crossings are listed in Table 3.

**Table 3. San Joaquin River Basin Levee Crossings**

| Type of Pipe Penetration | No. |
|---|---|
| Irrigation | 265 |
| Drainage | 830 |
| Sewer-Wastewater | 10 |
| Electric Power | 19 |
| Drinking Water (treated/untreated) | 22 |
| Gas, Oil, Steam, Petroleum, Chemical | 40 |
| Communication Cables and Conduits | 46 |
| Unknown/Other | 43 |

Penetration replacement and repair costs are anticipated to generally be on the same order of magnitude as those identified in the Sacramento River Basin.

## References

California Department of Water Resources (DWR). 2013. Memorandum Post Construction Report, Butte Creek Culvert Replacement near Nelson Road. August.

———. 2014. Utility Crossing Inventory Program data. June.

DWR. *See* California Department of Water Resources.

Sutter Butte Flood Control Agency (SBFCA). 2014. Feather River West Levee Project Bid Contract Documents. February.

# Issue Summary #6
# Vegetation Management: Cost of Maintaining Channel Capacity

*…the challenge of modern [Flood Risk Management] is to manage conveyance in a way that simultaneously promotes habitats while achieving the desired reduction in flood risk.*

***P. Sayers, Y. L.i, G. Galloway, E. Penning-Rowsell, F. Shen, K. Wen, Y. Chen, and T. Le Quesne. 2013. Flood Risk Management: A Strategic Approach. Paris, UNESCO.***

Managing vegetation in the State Plan of Flood Control (SPFC) is a constant challenge for local maintaining agencies (LMAs) as vegetation can be quick to establish and costly to remove. Channel capacity within the SPFC has decreased in the 50 to 100 years since levees were constructed due to geomorphic change (i.e., sedimentation, levee erosion, channel accretion, and levee degradation), urbanization, reservoir storage, and dam operations. Vegetation type, the presence of invasive or special-status species, surrounding land uses, encroachments, and permitting requirements are all factors that drive the cost of vegetation management. Vegetation removal within stream channels can be particularly challenging given necessary federal and State approvals, including those related to listed species and habitats. According to a Legislative Analyst's Office report, $88.8 million were spent in California by a number of agencies, including the California Department of Fish and Wildlife (DFW) and the U.S. Department of Food and Agriculture, on managing invasive species in the 2012-2013 fiscal year (Legislative Analyst's Office, 2013). The amounts spent by the California Department of Transportation, CalFire, and California Department of Water Resources (DWR) were not included in this estimate; so the real amount of funding dedicated to invasive species management is presumed to be significantly higher. As described in Chapter 5, Sacramento and San Joaquin OMRR&R Costs, removal of invasive species such as giant reed (*Arundo donax*) represents a significant cost for DWR and LMAs.

## Sacramento Region

Vegetation removal in the Sacramento Valley Region is generally addressed by DWR Maintenance Areas. Costs to remove vegetation vary and are influenced by the cost of labor and whether removal can be completed by mechanical means or must be done by hand. Landside vegetation is removed by LMAs only when necessary given funding constraints (see Issue Summary #4, Prioritizing and Addressing the Cost of Inspection Compliance).

### Long Bridge Vegetation Removal

Long Bridge is located at the northern end of Sutter Bypass, near the new Highway 20 bridge, which runs east to west, south of the Sutter Buttes. The area does not have any known hydraulic issues, but requires regular channel clearing. DWR generally performs this type of maintenance

under a routine operations and maintenance agreement with DFW in lieu of permits that could significantly increase the cost of the vegetation removal (McGrath, 2016a, pers. comm.).

DWR annually removes vegetation from the bridge, which crosses a large grassland, as part of maintaining bypass capacity. Routine maintenance requires only mowing, a relatively low-intensity treatment that falls under the scope of the agreement with DFW. In recent years, costs per acre have averaged approximately $60 per acre, with a total of approximately 50 acres in the project area (McGrath, 2016a and 2016c, pers. comm.).

### Elder Creek Channel Rehabilitation Project

The Elder Creek Flood Control Project levees were designed to allow up to 17,000 cubic feet per second (cfs) of flood conveyance to protect the town of Gerber, in Tehama County, and adjacent roads, railroads, buildings, and agricultural lands. Due to unmanaged vegetation growth and sediment accumulation, the channel capacity has been reduced to just 9,000 cfs (DWR, 2015). To bring Elder Creek back into U.S. Army Corps of Engineers 1957 design profile capacity, DWR has recently undertaken a vegetation removal project within a 4-mile section of the creek located south of Gerber. This is a non-routine project that will require a number of permits and other documents for ground disturbance, including California Environmental Quality Act, Clean Water Act 404, Clean Water Act 401, DFW 1600, U.S. Army Corps of Engineers 408, and a Central Valley Flood Protection Board Encroachment Permit, in addition to the cost of removing the vegetation (McGrath, 2016c, pers. comm.).

The primary species of concern at the Elder Creek project site is giant reed, which needs to be cut near the root and treated with a herbicide. The cost of this treatment varies greatly, depending on the density of the vegetation and the intensity of the treatment required. Vegetation removal at Elder Creek required rental equipment, including an excavator with mulching head; tractor; two inmate crews; three Sutter Maintenance Yard crew members; spraying; and re-spraying (McGrath, 2016d, pers. comm.). Project costs to date have been approximately $10,000 per acre, which is regarded as normal for an area with a high vegetation density; areas with lighter vegetation may be managed for as low as $7,000 per acre (McGrath, 2016d, pers. comm.).

In addition to giant reed, elderberry shrubs (a critical habitat for the federally endangered valley elderberry longhorn beetle) were also identified in the project area. It was initially determined that these shrubs would need to be trimmed or cut down prior to construction; however, DWR later concluded that 15 shrubs could remain unharmed, which saved the project an estimated $300,000 in mitigation costs (McGrath, 2016b, pers. comm.).

## Delta Region

Sediment buildup constrains channel capacity in the Sacramento-San Joaquin Delta (Delta), but vegetation in channels is less of a concern from a flood management perspective. Currently, vegetation within channels is not a concern for channel capacity in the Delta. However, various non-native invasive species occur in the Delta that require active and costly management. The California Department of Parks and Recreation Division of Boating and Waterways manages invasive aquatic vegetation in the Delta. California Department of Parks and Recreation received

$3.4 million from the Harbors and Watercraft Revolving Fund in the 2012-2013 fiscal year to manage invasive species (Legislative Office of Affairs, 2013).

Water hyacinth (*Eichhornia crassipes*) continues to remain an issue in the Delta, despite the State having spent $45 million over the last 15 years in an effort to control the invasive species. This persistence is largely because the plant is regarded as one of the fastest growing in the world, with the ability to grow to span over 6,500 square feet in a single growing season. The longevity of the seeds also plays a major role, as they can live 15 to 20 years. The major concern with the species is that it creates dense mats, at times up to 6 feet thick, which prevents the free flow of water within waterways and deprives native organisms of the sunlight and nutrients they require to survive. Furthermore, the plants increase water acidity levels when they decompose.

In addition to the water hyacinth, numerous other plants are currently causing financial and ecological damage in the Delta; most notably, these include Brazilian waterweed (*Egeria densa*), spongeplant (*Limnobium laevigatum*), giant reed, and yellowstar thistle (*Centaurea solstitiali*). These invasive aquatic species pose such threats as depriving native species of vital nutrients, restricting water movement, trapping organic matter, altering water pH, and damaging propellers. Although these concerns are primarily ecological and recreational, the restriction of free-flowing water has the potential to create flood management problems.

## San Joaquin Region

Vegetation management within the San Joaquin Valley portions of the SPFC is overseen by the State and completed by LMAs. Vegetation removal costs in the San Joaquin Valley vary depending on location, vegetation type, and presence of habitat. Other major challenges within the basin include invasive plants that restrict capacity, increase sedimentation, and can promote additional vegetation growth. In the Lower San Joaquin River/Delta South Regional Flood Management Planning Region, per-acre costs for the removal of giant reed, a particularly labor-intensive species to remove, can be as high $25,000 per acre (Kjeldsen Sinnock Neudeck, 2014). The nonprofit organization, River Partners, hired the California Conservation Corps, a relatively inexpensive labor force, to remove giant reed along the San Joaquin River for approximately $17,000 per acre (Andrews, 2016 pers. comm.). In the Upper San Joaquin River Regional Flood Management Planning Region, many areas have dense communities of invasive vegetation established in the floodway, including the mainstem San Joaquin River, the flood bypass system, and many of the tributaries. This vegetation has compromised channel capacity and inhibited the establishment of native riparian vegetation, which provides critical habitat.

## References

Andrews, Betty. 2016. Principal Engineer. Director. River Partners. Email to Mark Oliver of CH2M HILL regarding the cost of removing giant reed. February 19.

California Department of Water Resources (DWR). 2015. Elder Creek Channel Rehabilitation Project, Initial Study/Proposed Mitigated Negative Declaration. May.

DWR. *See* California Department of Water Resources.

Kjeldsen Sinnock Neudeck. 2014. Technical Memorandum, SJAFCA and SJCFCWCD Zone 9 – Assessment of O&M Future Funding Needs. November 21.

Legislative Analyst's Office. 2013. Overview of Invasive Species Management in California.

McGrath, Eric. 2016a. Senior Engineer. California Department of Water Resources, Flood Maintenance Office. Email to Minta Konieczki of CH2M HILL regarding Vegetation Management Issue Summary. February 8.

———. 2016b. Senior Engineer. California Department of Water Resources, Flood Maintenance Office. Telephone conversation with Jacqueline Todak of CH2M HILL regarding Elder Creek and Long Bridge vegetation management questions. February 16.

———. 2016c. Senior Engineer. California Department of Water Resources, Flood Maintenance Office. Email to Jacqueline Todak of CH2M HILL regarding Elder Creek and Long Bridge vegetation management questions. February 19.

———. 2016d. Senior Engineer. California Department of Water Resources, Flood Maintenance Office. Email to Jacqueline Todak of CH2M HILL regarding Elder Creek and Long Bridge vegetation management questions. February 22.

# Issue Summary #7
# Cost of Sediment Removal in the State Plan of Flood Control

*The management of sediment in river basins and waterways has been an important issue for water managers throughout history…water managers today face many complex technical and environmental challenges in relation to sediment management.*

***International Sediment Initiative. 2011. Technical Documents in Hydrology.***

Responsibility for the operation and maintenance (O&M) of most State Plan of Flood Control (SPFC) channels and floodways in the Sacramento Valley requires California Department of Water Resources (DWR) to regularly monitor channel performance and consider sediment removal at various locations. In the San Joaquin River system, sediment removal is generally the responsibility of and conducted by local maintaining agencies (LMAs) as discussed below.

## Sacramento River Basin

Sediment removal projects have been conducted at many locations across the valley over the last 30 years including the Sacramento Bypass, Tisdale Bypass, Yolo Bypass, Sycamore Creek, and Colusa weir among others. DWR data indicate that costs per cubic yard of sediment removed have ranged from $2.00 to $19.00 (escalated to 2014 dollars) depending on the total volume, required environmental clearances, and the economy at the time.

Inspections and hydraulic modeling of the Fremont weir demonstrated that sediment buildup had decreased the ability of the weir to pass flood waters into the Yolo Bypass, thereby causing higher flows to remain in the Sacramento River. To return the area upstream and downstream from the weir to design grade, DWR's Division of Engineering identified that approximately 920,000 cubic yards of sediment necessitated removal in 2006 within a 280-acre area (see Figure 1) to maintain the design flow over the weir and into the Yolo Bypass (DWR, 2007a). Sediment removal of this magnitude is not a routine occurrence at Fremont weir; flood control system projects of this type are usually reactive to flood events that deposit sediment over many years. Previous sediment removal in this area occurred in 1986, 1987, and 1991. DWR estimates that recent sediment removal projects have only partially addressed the sedimentation and shoaling issues across the SPFC. Many areas require additional sediment removal including Fremont weir, Sacramento Bypass, Tisdale Bypass, Elder Creek, and Cherokee Canal (Mid and Upper Sacramento River Regional Flood Management Plan, 2014).

Permits and approvals were required from a variety of agencies including U.S. Army Corps of Engineers (USACE), California Department of Fish and Wildlife, Central Valley Regional Water Quality Control Board, Central Valley Flood Protection Board, National Marine Fisheries Service, State Historic Preservation Office, and Native American Heritage Commission prior to

project implementation. A spoil area for the excavated material was made available by a local landowner at no cost, significantly reducing the real estate costs for the project. Total cost of the project was approximately $9 million (2014 dollars), which equated to approximately $10.00/cubic yard (see Table 1).

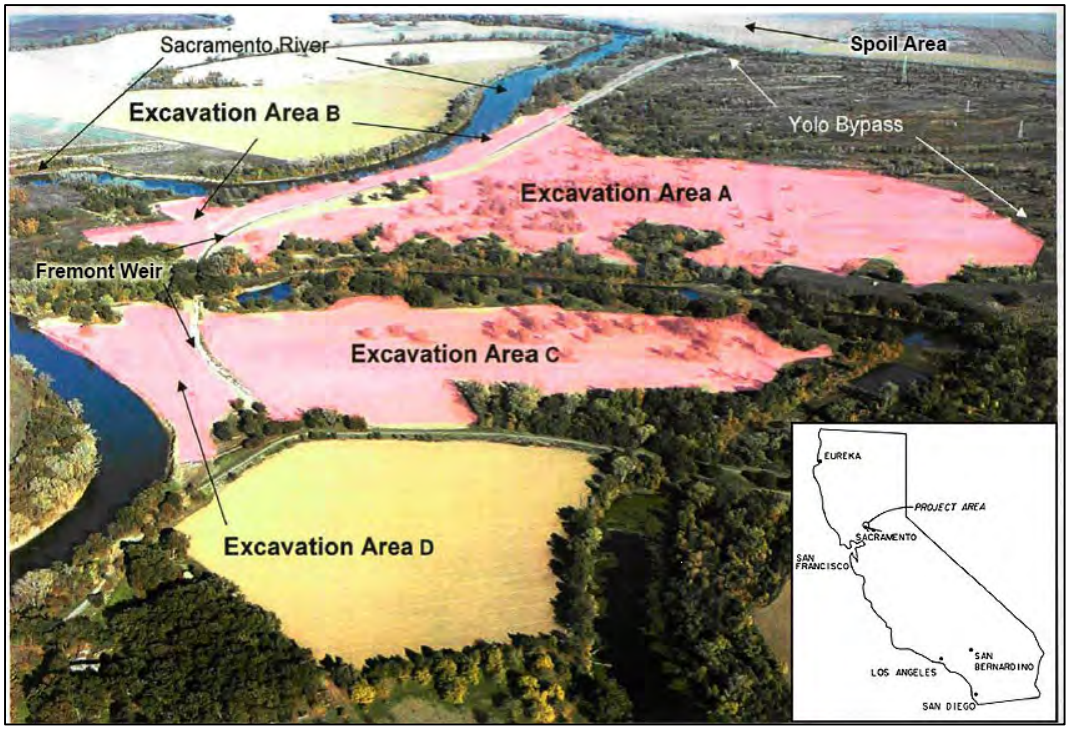


**Figure 1. Fremont Weir Sediment Removal Project**

*Source: Project Geology Report (DWR, 2007a).*

**Table 1. Fremont Weir Sediment Removal Project Costs[1]**

| Category | Cost |
|---|---|
| **Engineering Design, Management, Surveys** | $679,132 |
| **Real Estate** | $13,146 |
| **Environmental Compliance** | $149,239 |
| **Administration** | $201,893 |
| **Construction** | $6,007,096 |
| **Total (2007 dollars)** | $7,050,506 |
| **Total (2014 dollars)** | $8,989,395 |
| **Total Cubic Yards Removed** | 919,372 |
| **Cost Per Cubic Yard Removed** | $9.78 |

*Source: Fremont Weir Sediment Removal Project Cost Summary (DWR, 2007b).*
Note:
1 Project costs were spread over several years, from fiscal year 04/05 to fiscal year 06/07.

Economic conditions and the resultant availability of contractor assistance are major drivers in overall project costs. Costs in 2006 were greater than what was seen the following year, when approximately 1.7 million cubic yards of sediment were removed from Tisdale Bypass at a cost of $5.63 per cubic yard. Costs including contractor bids were significantly lower in 2007 given a slowdown in the housing market and associated relative increase in available equipment and manpower.

Table 2 shows the costs for a variety of projects across the basin since the early 1980s. It should be recognized that permitting costs were relatively minor until very recently.

**Table 2. Historical Sediment Removal Costs in the Sacramento River Basin**

| Location | Year | Cubic Yards Removed | Cost Per Cubic Yard[1] |
|---|---|---|---|
| Colusa Bypass and weir | 1983 | 1,008,000 | $2.68 |
| Colusa Bypass and weir | 1983 | 140,000 | $6.46 |
| Colusa Bypass and weir | 1984 | 254,000 | $2.85 |
| Tisdale Bypass and weir | 1984 | 244,000 | $2.81 |
| Deer Creek | 1984 | 36,000 | $4.30 |
| Tisdale Bypass and weir | 1985 | 211,000 | $2.86 |
| Deer Creek | 1985 | 11,500 | $4.27 |
| Colusa Bypass and weir | 1986 | 1,023,000 | $4.86 |
| Tisdale Bypass and weir | 1986 | 1,301,000 | $3.15 |
| Fremont weir and Yolo Bypass | 1986 | 56,000 | $25.84 |
| Deer Creek | 1986 | 33,400 | $4.14 |
| Colusa Bypass and weir | 1987 | 1,450,000 | $4.42 |
| Tisdale Bypass and weir | 1987 | 270,000 | $3.16 |
| Fremont weir and Yolo Bypass | 1987 | 931,000 | $2.53 |
| Deer Creek | 1987 | 35,000 | $4.04 |
| Cherokee Canal | 1988 | 184,000 | $2.99 |
| Cherokee Canal | 1989 | 110,000 | $4.71 |
| Fremont weir and Yolo Bypass | 1991 | 1,446,000 | $2.30 |
| Fremont weir and Yolo Bypass | 1991 | 529,000 | $2.30 |
| Cherokee Canal | 1996 | 325,000 | $4.65 |
| Mud Creek | 1998 | 9,000 | $10.15 |
| Colusa Bypass and weir | 1999 | 2,432,000 | $2.33 |
| Fremont weir and Yolo Bypass | 2006 | 919,372 | $9.78 |
| Tisdale Bypass and weir | 2007 | 1,712,800 | $5.63 |
| Sacramento Bypass and weir | 2009 | 38,600 | $18.77 |
| Sycamore Creek | 2010 | 64,000 | $5.77 |

Note:
1 Costs escalated to 2014 dollars using the Engineering News-Record Construction Cost Index).

Additional large-scale sediment removal events within the SPFC will continue to be required over the next 50 years and are anticipated to be commensurate with the amount and scale of flood events.

## Delta

Sedimentation in the Delta is a complex physical process that is affected by many factors. Hydraulic mining, the construction of levees for land reclamation and flood control, the construction of dams, water export projects, and channel dredging have all affected how sediments are distributed and transported throughout the Delta. Removal of sediment is generally addressed by dredging material from the channel bottom, a process that has become less frequent because of stricter water quality and environmental regulations, and a sediment deficit; the wave of hydraulic mining sediment has moved through the Delta, and the primary constraints to sediment movement are dams and dam operations (see Figure 2). Dredging sediment material is often large scale and can require significant permitting. USACE is generally responsible for dredging projects in the Delta because of their charge as custodians of navigable U.S. waters, as stated in Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act, which grant USACE jurisdiction over dredging projects. In general, sediment removal within the Delta is not typically a flood prevention and/or O&M issue for most LMAs.

**Figure 2. Sidedraft-Clamshell Dredge Used in Original Levee Construction**

*Source: http://www.water.ca.gov/levees/history/.*

## San Joaquin River Basin

Sediment removal in the San Joaquin River Basin is typically addressed by LMAs as specified in various O&M manuals. Sediment removal requirements and approaches differ across the three regions within the basin on the basis of different hydraulic conditions and operations, including the need to clean sediment basins, remove material at various control structures (for example, Sand Slough Control Structure), and maintain channels. Removal of material is handled by both districts and landowners in accordance with agreements. Similar to the Sacramento River Basin, the cost for sediment removal in the San Joaquin River Basin varies and is driven by rain events, market conditions, and geographic location. Cost estimates for sediment removal range from

$2.50 to $5.00/cubic yard. The San Joaquin River has a sand-dominated channel bed downstream from Gravelly Ford (San Joaquin River Restoration Program, 2011). Removal and sale of this sand can assist in offsetting some O&M costs for some districts, although this is not typical and does not represent the norm for the entire San Joaquin River Basin. Flood control channels in and around Stockton are typically maintained by San Joaquin County Channel Maintenance Division with sediment removal costs averaging $5.00/cubic yard. The *Flood Control System Status Report* (DWR, 2011) contains status maps and inspection ratings for shoaling and sedimentation in channels in the San Joaquin River Basin. Berenda Slough and Ash Slough are both currently rated as unacceptable and inactive in Public Law 84-99, and various other channels are rated minimally acceptable.

## References

California Department of Water Resources (DWR). 2007a. Final Construction Geology Report Fremont Weir Sediment Removal. January.

———. 2007b. Fremont Weir Sediment Removal Project Cost Summary. March 31.

———. 2011. Flood Control System Status Report. December.

DWR. *See* California Department of Water Resources.

Mid and Upper Sacramento River Regional Flood Management Plan. November 10, 2014.

San Joaquin River Restoration Program. 2011. Bed Sediment Sampling Attachment, Draft Geomorphology, Sediment Transport, and Vegetation Assessment Appendix. April.

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# Issue Summary #8
# Three Amigos Nonstructural Alternative Project at the San Joaquin River National Wildlife Refuge

*There is some infrastructure we can no longer maintain and we need to divest it from the portfolio by either dismantling it or returning it to the locals or the state. Therein lies a significant challenge. What we're doing currently is unsustainable.*

***Interview with Lt. Gen. Thomas P. Bostick, U.S. Army Corps of Engineers. 2013. Defense Media Network. November 22.***

The proposed Three Amigos project is located in Stanislaus County adjacent to the San Joaquin River National Wildlife Refuge (SJRNWR) near Vernalis. The project was originally conceived in the late 1990s in response to severe flooding in January 1997 (see Figure 1). The project would involve a modification of the Lower San Joaquin River and Tributaries Project and Maintenance Unit 012 to remove the State's obligation to maintain the levees within former Reclamation Districts (RDs) 2099, 2100, and 2102 (the "Three Amigos"). Levees within these districts were damaged in the 1997 floods, and the site was identified as the nation's first ever nonstructural alternative (NSA) flood management project. U.S. Fish and Wildlife Service (USFWS) acquired the lands, underlain by Natural Resources Conservation Service floodplain easements, within these districts from willing sellers and has restored over 2,500 acres of former floodplain from agricultural fields back to native wildlife habitat. The lands were added to SJRNWR and currently support populations of several special-status wildlife species of State and federal importance. Once fully completed, the project is intended to reduce local maintaining agencies' operations, maintenance, repair, rehabilitation, and replacement costs, as well as protect and restore riverine and riparian habitat along the San Joaquin River.

**Figure 1. Before and During Flooding in the SJRNWR**

*Source: http://www.riverpartners.org/where-we-work/projects-san-joaquin/.*

## Project History

Following the flood and subsequent failure of many levees in the San Joaquin River Basin in 1997, U.S. Army Corps of Engineers (USACE) evaluated 17 failed levees and identified 3 with promising potential for a "nonstructural" rehabilitation approach (Central Valley Flood Protection Board [CVFPB], 2014). To move forward with potential NSAs, landowners within local reclamation districts were required to negotiate sales agreements with USFWS and Natural Resources Conservation Service who co-purchased the land titles (DWR, 2013).

After the land purchases, USACE continued to play a role in the process by offering to construct ring levees around the structures that would be more at risk to flooding after implementation of the NSAs. However, at the request of USFWS, these ring levees were not constructed. A ring levee was also suggested to protect the West Stanislaus Irrigation District's main pump station located west of the Three Amigos, but the district instead accepted the construction of a headwall to prevent flood waters from entering their pump house (which has since been relocated). Additionally, USACE offered flowage easements to owners of land located outside of Three Amigos as a way of ensuring that those owners would be compensated in the event of unintended flood damages. USACE has secured all but one of the proposed flowage easements and is considering its options at this time.

A preliminary agreement was signed by USACE, USFWS, and the California State Reclamation Board (now the Central Valley Flood Protection Board or CVFPB) in February 1998, which supported the NSA proposal and established a path forward. A Memorandum of Agreement was executed in June 2000 between USACE and USFWS (River Partners, 2013). The Memorandum of Agreement required both the flowage easements and a modification to the maintenance in the operations and maintenance manual that eliminated levee maintenance from the CVFPB (and, in turn, the defunct reclamation district obligations). Project costs as of October 2014 have been over $50 million (CVFPB, 2014).

## San Joaquin River National Wildlife Refuge

The proposed Three Amigos project site is located on a portion of the San Joaquin River that runs directly through SJRNWR. This refuge was established in 1987 and now spans over 7,000 acres in central California, at the confluence of the San Joaquin, Tuolumne, and Stanislaus rivers (USFWS, 2006). As a result of this location, the benefits to the SJRNWR are a major consideration in project development.

In an effort to improve the SJRNWR's habitability, the nonprofit restoration organization, River Partners, has assisted in the restoration of 2,500 acres of riparian habitat since 2002 (River Partners, 2013). The SJRNWR now offers the potential to recover a number of currently endangered species, including Central Valley steelhead, Chinook salmon, least Bell's vireo, riparian brush rabbit, riparian woodrat, valley elderberry longhorn beetle, western yellow-billed cuckoo, and yellow warbler (River Partners, 2012). During times of flooding, native fish and salmonids would have access to habitat that offers rich foraging. The habitat restoration effort is also intended to improve recreational opportunities in the area (River Partners, 2013). A 4-mile walking path has been developed through restored habitats within former RD 2099 – the Pelican

Nature Trail. Additionally, the restoration supports diverse wildlife populations that enhance recreational experiences along the lower Tuolumne, Lower Stanislaus, and San Joaquin rivers.

Since the acquisition of the Three Amigos properties, over 2,000 acres of additional lands were acquired by River Partners in 2012 and 2013 for similar purposes. These purchases included the Dos Rios and Hidden Valley ranches that comprised the entirety of floodprone lands within RD 2092 (Maintenance Unit 005 of the Lower San Joaquin River and Tributaries Project). These properties are currently undergoing habitat restoration, which is anticipated to be phased over the next 8 to 10 years.

## Project Benefits

Because of the site's soil characteristics, the 3,200-acre project site is expected to hold an estimated 30,000 acre-feet of transient water during times of flooding. This water has been proposed to be made available to increase water supplies and decrease pressure from local agricultural demand by eliminating the need for up to 20,000 acre-feet of annual riparian water diversions. Additionally, the project is intended to route and disperse flood water more quickly to prevent potentially stagnant water from reaching temperatures that are deadly to the local fish and plant communities.

The proposed floodplain restoration effort is also intended to provide important ecological functions to the area, including increasing percolation to push salts farther into the soil profile. This process would reduce topsoil salinity levels and increase the site's ability to trap sediment and reduce erosion. The project may also potentially sequester an estimated 1 million tons of carbon dioxide over the course of its lifetime.

## Project Challenges and Moving Forward

Because of the scale of Three Amigos and the number of organizations and stakeholders involved, numerous challenges have arisen over the 18 years since the project's inception, despite the fact that the NSA is widely supported among associated local, State, and federal agencies. A key impediment has been the acquisition of flowage easements, which were offered and accepted by three local landowners, and rejected by one whose land may be at a higher risk of flooding following implementation. USACE is currently working with the remaining landowner.

USACE will present the CVFPB with a revised project operations and maintenance manual that will dissolve any further State levee maintenance obligation. USACE will also develop a maintenance agreement directly with USFWS to preserve flow capacity across the site. Actions required on the State side include completing California Environmental Quality Act compliance; dissolving maintenance agreements between the CVFPB and RDs 2099, 2100, and 2102; and CVFPB determining whether existing property rights to the Sacramento-San Joaquin Drainage District levees' underlying easements will be conveyed to USFWS or retained. Any action taken to modify the levees will also require CVFPB encroachment permits as levee modifications will affect the State's designated floodway.

## References

California Department of Water Resources (DWR). 2013. Hidden Valley Purchase Strengthens Region's Floodwater Overflow, Wildlife Enhancement Goals, News for Immediate Release. Available at <http://www.water.ca.gov/news/newsreleases/2013/110613b.pdf>. Accessed October 12, 2015.

Central Valley Flood Protection Board (CVFPB). 2014. Nonstructural Alternative at the Three Amigos Site. *Informational Briefing.* Available at <http://www.cvfpb.ca.gov/meetings/2014/docs/Briefing_Summaries/20141024/Item14C_Three_Amigos_BriefingSummary.pdf>. Accessed October 12, 2015.

CVFPB. *See* Central Valley Flood Protection Board.

DWR. *See* California Department of Water Resources.

River Partners. 2012. River Partners Journal, Volume 8, Dos Rios Ranch Acquisition. December.

———. 2013. Progress on Three Amigos: Moving Levee Breaching from Concept to Reality. Available at <http://www.riverpartners.org/news-and-events/newsletters/201312_ProgressOnThreeAmigos.html>. Accessed October 13, 2015.

U.S. Fish and Wildlife Service (USFWS). 2006. San Joaquin River National Wildlife Refuge, Final Comprehensive Conservation Plan. September 29.

USFWS. *See* U.S. Fish and Wildlife Service.

# Issue Summary #9
# District Governance: Consolidation Opportunities and Challenges

*Floods have the potential to inflict damage on anyone residing in the river basin. Everyone must be involved in flood mitigation in one way or another in the form of self-help, mutual-help or public support. However, individuals or organizations acting independently in an uncoordinated manner will result in delays in decision-making, duplication of measures and amplification of negative impacts to others.*

***IWRM Guidelines at River Basin Level – Part 2-2: The Guidelines for Flood Management 2012.***

Hundreds of local maintaining agencies (LMAs), including reclamation districts (RDs), levee districts (LDs), irrigation districts, State Maintenance Areas (MAs), and local flood control agencies across the State are tasked with the operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) of levees, weirs, and other State Plan of Flood Control facilities. OMRR&R costs for these entities can be significant, and sources of funding are limited. As shown on Figure 1, many LMAs are responsible for flood system maintenance for areas that vary in size. Where adjacent LMAs conduct similar activities, consolidation (ranging from sharing of individual services or equipment up to full merging of all district activities) opportunities include the potential to decrease and share costs by allowing districts to prepare joint applications for audits and grants; combine permitting activities; and/or share staff, facilities, equipment, and planning and engineering services. Barriers to consolidation activities/actions can include levee condition concerns and the resulting liability of inheriting a poor levee, competing landowner interests, and the difficulty of reassessing taxes within a new district due to Proposition 218 requirements. Examples of consolidation efforts in the Sacramento and San Joaquin River basins and the Sacramento-San Joaquin Delta (Delta) are provided below.

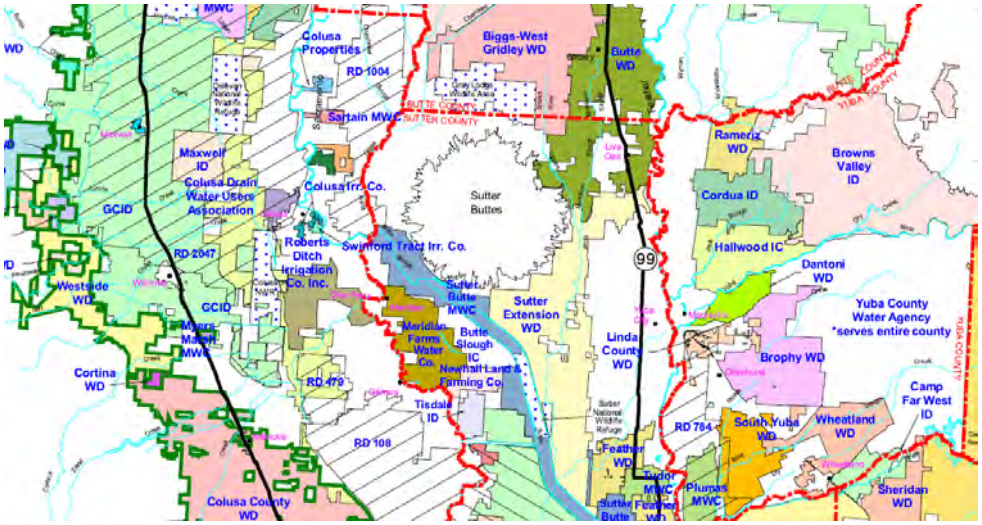


**Figure 1. LMA Jurisdictional Boundaries within Portion of Sacramento River Basin**

## Sacramento River Basin

As of 2015, multiple consolidation efforts are being evaluated in the northern Sacramento River Basin. Two of these involve both annexations and mergers between LMAs. In Sutter County, LD 1 (Sutter County) is one of five LMAs in the Sutter Basin protecting rural, small communities and the Yuba City urban area. The basin also includes LD 9 (Yuba City) and MAs 3, 7, and 16. These LMAs operate and maintain levees being improved as part of the Sutter Butte Flood Control Agency's (SBFCA's) Feather River West Levee Improvement Project with the goal of providing 200-year protection to Yuba City. As part of the Feather River West Levee Improvement Project, SBFCA has been evaluating measures that will reduce OMRR&R costs in the basin after the project is complete. Currently, each of the five LMAs has different maintenance practices, staffing, and funding for these activities. In addition, historical flood fights in the basin have often been led by LD 1 due to limited resources within LD 9 and MA 3. As a result, SBFCA is working with LD 1 to evaluate the potential annexation of some or all of the MAs and the consolidation of LD 9 into one LMA for the entire basin. This evaluation is in the early stages, but shows promise for realizing some cost savings within the basin.

A second consolidation near Wheatland is being evaluated. RDs 817 and 2103 maintain the Dry Creek and Bear River levees, which protect Wheatland and neighboring agricultural areas. The basin is not hydraulically separable, meaning that failure of the RD 817 levee would affect residents of RD 2103 and vice versa, very similar to the Sutter Basin area described above. Efforts are under way to evaluate and implement a process to consolidate these two areas into one LMA for the entire basin.

Although cost savings associated with economies of scale and avoidance of duplicating resources can be realized through consolidation, these efforts may be difficult. Issues associated with available condition of facilities, revenue sources, reserve funds, and political differences among rural, small, and urban communities offer some unique challenges. Where complete consolidation introduces concerns with liability and differing assessment practices, cost sharing can be a more viable option in some cases.

In the Sacramento River Basin, RD 108 leads a cost-sharing relationship among LMAs. Shared-use agreements among RD 108, the Knights Landing Ridge Drainage District, and the Sacramento River West Side Levee District allow RD 108 to provide facilities, administration, operations and maintenance (O&M), emergency preparedness, insurance, and policy planning for all three districts. The two districts then reimburse RD 108 for the services and materials provided, as laid out by contract. Successful cooperation is ultimately dependent on trust and effective communication, including agreement on how costs are equitably shared (Bair, 2015, pers. comm.).

## Delta

It is common practice for LMAs in the Delta to share resources and services. The majority of the islands and tracts within the Delta are governed individually. LMAs in populated areas must provide higher levels of protection and, thus, generally have greater OMRR&R costs than agricultural LMAs. Well-financed LMAs in the Delta are occasionally used as private

contractors by other LMAs. An example is Yolano (RD 2068), which has a broad spectrum of equipment such as trucks, cranes, graders, and tractor mowers. Some of Yolano's equipment is used by Cache Hass (2098) as part of their annual maintenance that is claimed under the California Department of Water Resources (DWR) Delta Levees Maintenance Subventions Program (Delta Subventions Program). These two reclamation districts, which are maintaining project levees, have also been sharing the salary of a superintendent position for both of their areas. If there is not suitable equipment from a nearby reclamation district, then the reclamation district may rent private farming equipment, which is paid at the standard California Department of Transportation rate upon acceptance of the subventions claim by DWR. The use of equipment and staff is not by formal agreement, but only through invoicing and on an as-needed basis. Sharing of resources lessens the financial burden for both districts (Evenson, 2015, pers. comm.).

Barriers to full consolidation stem largely from liability and contractual issues. Islands are protected by both federal project and non-project levees. Management and maintenance of federal levees require much higher overhead, as they are held to tighter standards. Thus, mergers between project and non-project levees are unlikely, as no district would want to adopt tighter regulations.

Many LMAs in the Delta participate in the Delta Subventions Program, which provides a State cost share for LMAs annually. Participation in the Delta Subventions Program facilitates collaboration among LMAs. The Delta Stewardship Council is in the process of updating the levee investment policy that could influence the way Delta Subventions Program and other levee investment funds are allocated. Depending on the details of the updated policy, further partnerships between Delta LMAs may emerge.

## San Joaquin River Basin

The state of governance and potential consolidation of LMA OMRR&R activities varies across the San Joaquin River Basin. The following focuses on consolidation efforts under way in the Mid San Joaquin River Region.

Most of the RDs in the Mid San Joaquin River Region area are rural districts that encompass agricultural lands. Accordingly, there are limited or no assessments, with individual landowners generally funding and performing necessary levee maintenance. The maintenance activities are guided by inspection results from DWR and U.S. Army Corps of Engineers. Because of the relatively lower value of protected farmland relative to increasing maintenance costs, poor condition of the levees, low levels of protection provided by the levees, and funding and regulatory constraints, many landowners are interested in eliminating their levee maintenance responsibilities. Additionally, some leveed areas are now owned by wildlife management agencies and managed in flood-compatible wildlife habitat that would benefit from modification or degradation of the levees. As funding through assessments is limited, it is more practical for many landowners to allow their lands to flood periodically than maintain their levees to O&M manual standards. Because of the reduction in landowner desire for flood protection from levees, landowners along the Mid San Joaquin River are pursuing the elimination of their levee maintenance responsibilities.

The administrative burdens and institutional barriers associated with modifications to the federal levees, and rising costs for maintenance have lead some LMAs to consider consolidation or collaboration on maintenance and administration – pooling resources and sharing expertise to maintain levees and promote levee modifications. The projects identified in the Mid San Joaquin River Regional Flood Management Plan included one project to consolidate interested LMAs (Consolidation of O&M) and another to provide a shared staffing position to support LMA fulfillment of maintenance responsibilities within the region. The shared staffing role would include support for LMAs who are interested in consolidating (Regional Maintenance Technical Support).

Where some landowners are trying to limit their costs, conservationists see an opportunity to join forces with farmers to restore habitat along the San Joaquin River corridor while also improving the flood safety of the entire region. Following the floods of 1997, U.S. Fish and Wildlife Service acquired all lands within RDs 2099, 2100, and 2102 (the Three Amigos) from willing sellers for inclusion in the San Joaquin River National Wildlife Refuge, partnering with U.S. Army Corps of Engineers, DWR, and Central Valley Flood Protection Board to modify the levees there for wildlife habitat enhancement and improved flood management. The nonprofit organization, River Partners, has purchased farmland, executed flood easements, and evaluated levee modifications with the objective of optimizing riparian channels and floodways to meet environmental, economic, and flood purposes through their Dos Rios Ranch and Hidden Valley Ranch projects. The locations of both projects are shown on Figure 2. To date, 2,100 acres have been purchased from willing sellers comprising the entirety of floodprone lands within RD 2092 for the complementary purposes of improved flood management, habitat restoration, and flood damage reduction (Rentner, 2015, pers. comm.).

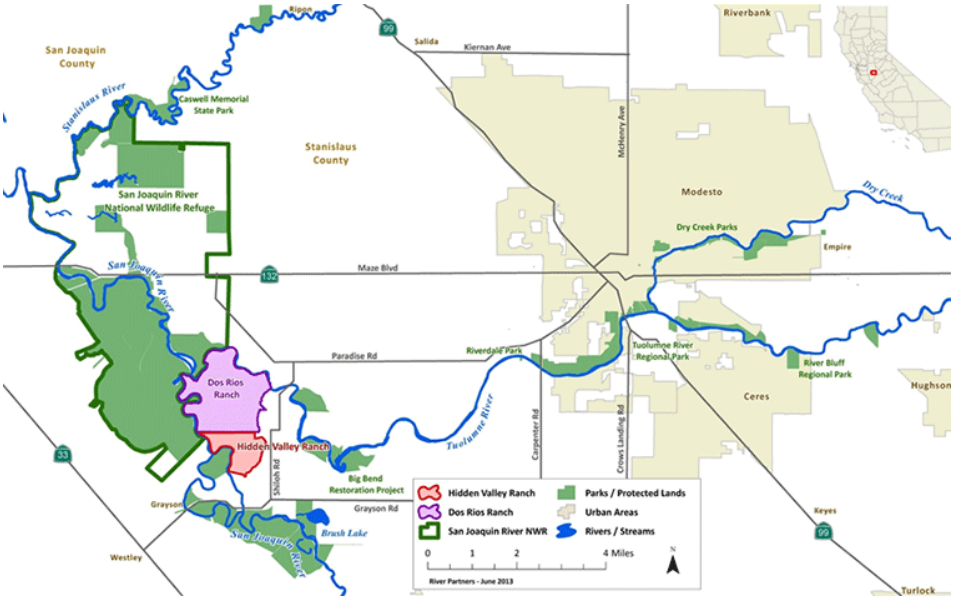


**Figure 2. Dos Rios Ranch and Hidden Valley Ranch Locations**

## References

Evenson, Nathan. 2015. Water Resources Engineer. California Department of Water Resources, Delta Levees and Environmental Engineering, Sacramento, California. Email and Telephone Call to Natasha Nelson of DWR regarding subvention claims' invoices and office protocol for approving costs. October.

Bair, Lewis. 2015. General Manager. Reclamation District 108. Telephone conversation with Mark Oliver of CH2M HILL regarding consolidation opportunities and Reclamation District 108 operations. August.

Rentner, Julie. 2015. Central Valley Regional Director. River Partners. Written comments on October 29, 2015, draft of Issue Summary #9, District Governance: Consolidation Opportunities and Challenges. November 11.

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# Issue Summary #10
# Lessons Learned from Hurricane Katrina – Redesigning Cities

*Since when is the status quo as good as it gets?*

***Dr. G. Paul Kemp, Associate Research Professor, Center for Coastal Energy and Environmental Resources, Louisiana State University.***

Immediately after the 2005 storm, two major planning reports were released to guide New Orleans' recovery and redevelopment efforts. The most significant of these were reports by the Urban Land Institute, issued in November 2005, and Mayor Ray Nagin's Bring New Orleans Back Commission, released in January 2006. The Urban Land Institute report recommended selective rebuilding of areas that had minimal storm damage and further evaluating areas with extensive storm and flood-related damage. The Mayor's Commission recommended rebuilding the levees that protect New Orleans and made a vague call for coastal wetland restoration to reduce the ferocity of future storm surges. The city also evaluated ways to improve drainage from inside the levees during large rain events. Both the drainage and flood control systems work hand-in-hand to prevent flooding of the city (see Figure 1 for an example of a typical configuration). However, these reports lacked designs to improve the lives of all those living in New Orleans and tended to focus on areas with high income levels. As the system currently is configured, some low-income neighborhoods do not have access to the shoreline of Lake Pontchartrain or the banks of the drainage canals. These initial steps were just Band-Aid approaches that were not creating the social changes needed for innovative planning to take ahold nor a new way of "valuing floodwaters" in the community consciousness.

In 2010, State and federal funds were allocated to the firm of Waggonner and Ball to lead a team of local and international water management experts to develop a Greater New Orleans Urban Water Plan. The in-depth plan, "Living with Water," calls for a radically different game plan for how water should be incorporated into the city's infrastructure. Taking a completely different tack, the Living with Water plan recommends designing a new system that does not automatically eject the water when it rains. Instead, the new ideas focus on rethinking the use of water and integrating it more into the fabric of the city. In addition, planners continue to look at alternatives to rebuild the federal levees in ways that give access for recreation – widening levees and working with other right-of-way owners (such as railways) for safe passage of pedestrians. The city planners and the levee districts are currently hampered by a lack of engineering staff.

If and when there are "Living with Water" city designs in place, New Orleans could see a major shift away from traditional operations and maintenance practices. The new planning paradigm would urge levee engineers to take a fully integrated and multi-benefit view of their project investments. In doing so, a "least-cost approach" can include factors not currently made part of the economic analysis of a project's design. For instance, alternative project drainage designs could be ranked on avoided costs (for example, avoiding impacts on water quality) and how well

they leverage dollars from nontraditional sources for maintenance budgets. Some examples of the nontraditional sources include community sponsorship of landscaping, carbon trading of wetland areas integrated into the project, and city-run volunteer programs. This can lead to reduced cost burdens for the city to maintain interior drainage projects in perpetuity and benefit the quality of life for the community and the environment. Having alternative funding sources for the drainage components could free up funds that are desperately needed to maintain the levees, gate, and pumps built as part of the Hurricane and Storm Damage Risk Reduction System in partnership with U.S. Army Corps of Engineers (see Issue Summary #11, Lessons Learned from Hurricane Katrina – Spreading the Cost).

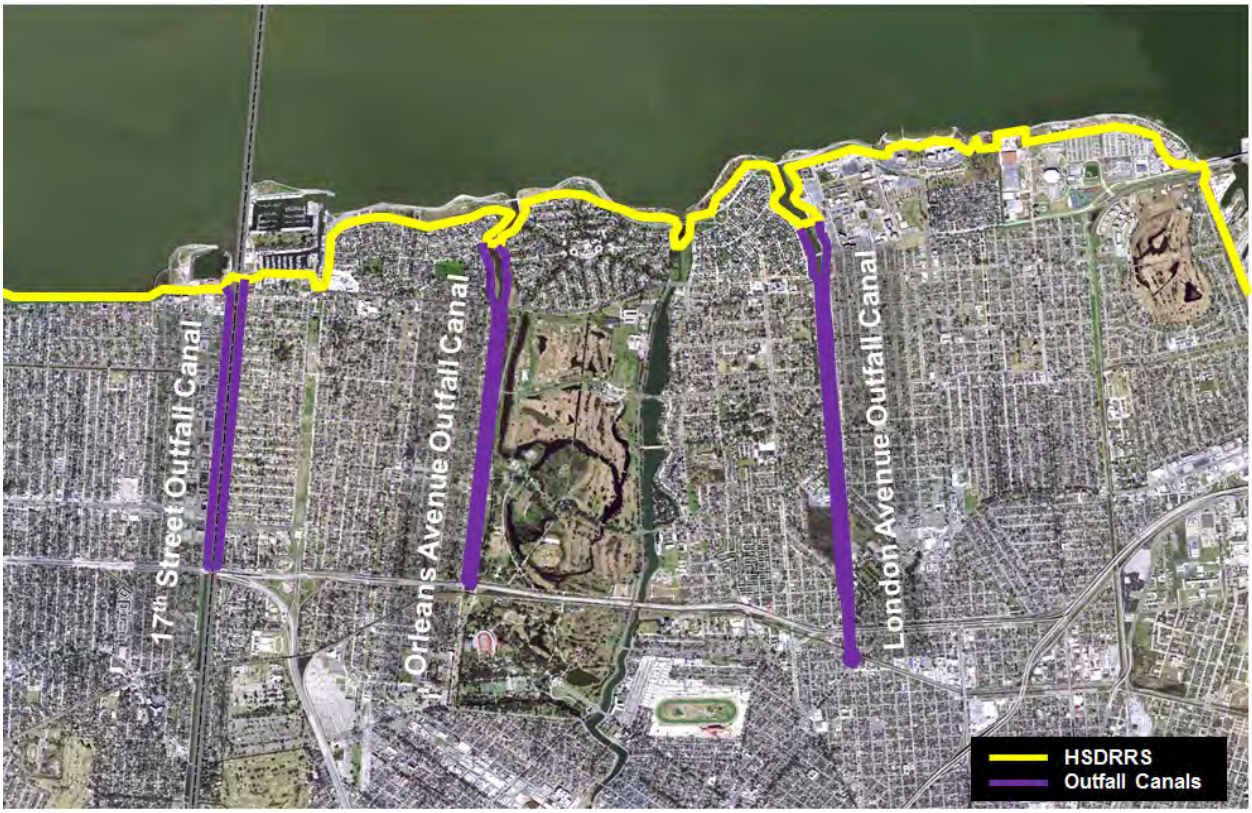


**Figure 1. Orleans District's Outfall Canals**

Note: Pumping rainfall out to Lake Pontchartrain over the federal levee known as Hurricane and Storm Damage Risk Reduction System is a necessary flood risk management feature. These particular canals are also part of the federal system.

# Issue Summary #11
# Lessons Learned from Hurricane Katrina – Spreading the Cost

*We can't dump $15 billion in new assets into these communities and operate them under financial structures created decades ago.*

***Coastal Protection and Restoration Authority's Chairman Garret Graves.***

Located in an area similar to a shallow bowl between Lake Pontchartrain and the Mississippi River, New Orleans depends on a complex system of more than 300 miles of levees, drainage canals, and massive pumps to stay dry. The city's floodgate and levee system is now run by three flood protection authorities with several districts grouped under each. The cost of maintaining this system has become a common financial burden to the local residents and businesses.

One of the three flood protection authorities, the Southeast Louisiana Flood Protection Authority – East (SLFPAE), formed in 2007, covers three consolidated districts in eastern New Orleans: East Jefferson Levee District, Orleans Levee District, and Lake Borgne Basin Levee District (LBBLD; see Figure 1). As construction of post-hurricane infrastructure began to wrap up in 2011, SLFPAE anticipated new operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) work would increase 25 percent in costs (see Table 1). Specifically, the costs of floodgate maintenance for the surge barrier in just the Lake Borgne Basin were anticipated to increase from $64,000 per year to $424,000 per year (a six-fold increase) according to an architecture, engineering, construction, operations, and management study in 2012 (AECOM, 2012).

Prior to the New Orleans levee break in 2005, the true extent of financial loss and human despair that could be imposed from a levee failure was nearly invisible to all those living in the community. The direct and indirect social benefits provided by the flood risk management system were not understood as a "common good" that relies on keeping the weakest link from breaking. Nearly 6 years after Hurricane Katrina, the New Orleans flood protection authorities began to anticipate how to equally spread costs for operation and maintenance (O&M) for the works constructed in cooperation with U.S. Army Corps of Engineers (a nearly $15 billion investment). Some portions are much more expensive to operate and maintain than others, especially the gates within the Inner Harbor Navigation Canal surge barrier (see Figure 1). Flood protection authorities are stymied by antiquated taxation rules that do not allow for equitably sharing the burden of the flood protection system. Money cannot be transferred between levee districts for O&M.

Under the current system of levee tax, St. Bernard (served by LBBLD) and New Orleans (served by East Jefferson and Orleans) residents alone would be required to pay for the higher O&M of the Inner Harbor Navigation Canal surge barrier (see Figure 2), including gates, because the barrier lies within those parishes. In 2014, a proposed tax increase was introduced to pay for the

SLFPAE at an annual tax rate of 18.6 mills, which would add $2.6 million a year to the $3.4 million produced by the existing millage to the budget. In December 2014, the mill tax failed to receive enough votes (only 66 percent voted yes) and was voted on again May 5, 2015, under an emergency request from SLFPAE. The vote in May resulted in a second failure to raise the property tax rate in St. Bernard parish. As a result of the second failure, and as a short-term solution, LBBLD is now eliminating positions from payroll, and remaining staff are assigned to man three of their pump stations less often. Cuts were necessary to ensure operating expenses do not exceed annual revenue, but are likely to result in increased flooding during heavy rains.

**Figure 1. Areas Served by Southeast Louisiana Flood Protection Agency – East with Location of the Inner Harbor Navigation Canal Surge Barrier in the St. Bernard Parish**

The specter of increased costs, the view of the system as a "common good," and the lack of local voter support is forcing the SPFLAE to consider how to create innovative regional cost sharing. In addition, to cover budget shortfalls in some districts, SPFLAE is facilitating loans to cover costs until the new revenue sources are approved by the voters.

Following are examples of SLFPAE's O&M budget projections for the post-Katrina system:

- $855,000 would allow SLFPAE to hire four pump operators and an operations manager for the pump stations and levees. It also would pay for maintenance and future capital expenses at pump stations.

- Replacing one pump station engine would cost about $1 million. That is just one example of the high price tag for properly maintaining the flood protection system.

- Another $830,000 of the increased revenue would be used for maintaining levees, floodwalls, and canals. In addition to daily costs, floodgates at Bayou Dupre and Caernarvon Canal will need to be overhauled every 10 years. That work is expected to cost $1.5 million for each gate.

**Table 1. O&M Budgets for Floodgates and Levee Systems Operated by SLFPAE (2012 Study by AECOM) – in Millions**

| Name | Pre-Katrina Budget (in 2011 dollars) | Post-Katrina Work Budget (in 2011 dollars) | Difference (percent) |
|---|---|---|---|
| East Jefferson Levee District | $6.8 | $7.6 | $0.8 (+12%) |
| Lake Borgne Basin Levee District | $4.4 | $5.5 | $1.1 (+25%) |
| Orleans Levee District | $13.3 | $17.4 | $4.1 (+31%) |
| **TOTALS** | **$24.5** | **$30.5** | **$6.0 (average + 25% increase)** |

Note:
Currently, LBBLD receives revenue from three dedicated property taxes.

## Figure 2. The Great Wall of Louisiana

Note: Nearly 2 miles long, this 26-foot-high barrier was constructed to block the deadly surge from Lake Borgne that ravaged the Lower 9th Ward. Three gates used for barges and fishing boats are open unless a storm threatens.

*(Photo by David Grunfeld, Nola.com | The Times-Picayune)*

## References

AECOM. 2012. Jerry Preau presentation to SLFPA-E Operations Committee titled "O&M Cost Study."

# Appendix B
# LMA Questionnaire

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# Long Term OMRR&R Workgroup
# Local Maintaining Agency Questionnaire

| | |
|---|---|
| Local Maintaining Agency Name | |
| Number of Miles Maintained | |
| Contact Name | |
| Contact Phone Number | |

---

Please fill out the following form to the best of your ability. Space has been provided on page three and under select questions for any additional information you would like to provide.
**Please provide a copy of your approved line-item budgets and, if available, actual expenditures for the last two fiscal years.**

1. What is the approximate height range of your levees? _____

2. Do you maintain drainage and/or irrigation facilities? ◯ Yes ◯ No
   a) If yes, how many pump stations? _____
   b) How many miles of drainage ditches/canals ? _____

3. How many permanent employees do you have? _____

4. How many part-time employees do you use for routine maintenance? _____

5. Do you own or lease any equipment? ◯ Yes ◯ No Which? _____ _____

6. Do you have centralized office space? ◯ Yes ◯ No The space is: _____

7. Do you contract out any routine operation and maintenance services? Check all that apply.
   - ☐ Mowing
   - ☐ Grazing
   - ☐ Spraying
   - ☐ Burning
   - ☐ Trimming
   - ☐ Road Maintenance
   - ☐ Dragging
   - ☐ Other _____
   - ☐ We do not contract out any of these services.

8. Do you currently maintain any closure structures? Check all that apply. Include the number of each if more than one.
   - ☐ Gates _____
   - ☐ Weirs _____
   - ☐ Stop logs _____
   - ☐ Retaining walls _____
   - ☐ Flood walls _____
   - ☐ Other _____
   - ☐ We do not maintain any closure structures.

9. Do you have any of the following? Check all that apply. Include the number of each if more than one.
   - ☐ Relief wells _____
   - ☐ Piezometers _____
   - ☐ Monitoring wells _____
   - ☐ We do not have any relief wells, monitoring wells, or piezometers.

10. Typical maintenance activities. Check all that apply. Include how often and over how many miles where applicable.

a) Vegetation management activities

- ☐ Mowing _____ times per year _____ miles per year
- ☐ Prescribed fire _____ miles per year
- ☐ Grazing _____ times per year _____ miles per year
- ☐ Herbicide application _____ times per year _____ miles per year
- ☐ Tree/large vegetation trimming and removal _____ miles per year

b) Slope repair activities

- ☐ Blading/track-walking _____ times per year _____ miles per year
- ☐ Dragging _____ times per year _____ miles per year
- ☐ Rock placement for erosion _____ times per year _____ feet per year

c) Rodent control activities

Do you coordinate baiting with local landowners? ◯ Yes ◯ No

- ☐ Bait Stations
- ☐ Broadcast baiting

Which of the following do you do for rodent damage repair?

☐ Grouting ☐ Backfilling ☐ Other _____

Do you hold any depredation permits? ◯ Yes ◯ No

For which species? _____

d) Road maintenance activities

- ☐ Annual levee crown grading _____ miles per year
- ☐ Gravel/road base replacement _____ miles per year

Are any of your levee crowns paved? ◯ Yes ◯ No _____ miles per year

Do any of your levee crowns have City/County maintained roads? ◯ Yes ◯ No _____ miles per year

Other activities _____

11. Do you perform maintenance on any minor structures? Check all that apply

☐ Fences ☐ Gates ☐ Signs ☐ Other _____

☐ We do not maintain any minor structures.

12. Do you currently utilize any Routine Maintenance Agreements or special environmental permits for routine maintenance activities? ◯ Yes ◯ No

Please provide a list and/or brief description of permits:

_____

_____

13. Do you do any routine channel maintenance? ◯ Yes ◯ No

Please briefly describe:

_____

_____

Please use the following space to provide any additional information on your operations and maintenance activities that you feel may be relevant.

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# Appendix C
# Breakdown of Total Projected Annual OMRR&R Costs by RFMP Region and River Basin

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# Appendix C: Breakdown of Total Projected Annual OMRR&R Costs by RFMP Region and River Basin

## C.1 Summary of Projected Annual Costs by Region

The total projected State Plan of Flood Control (SPFC) Operations, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) costs are approximately $131,130,000 per year. Table 1 and Figure 1 provide a breakdown by Regional Flood Management Plan (RFMP) region.

**Table 1. Projected Regional Annual OMRR&R Cost**

| Region | Estimated Annual Cost by Region |
|---|---|
| Mid-Upper Sacramento River (MUSR) | $29,788,800 |
| Feather River (FR) | $21,382,600 |
| Lower Sacramento River / Delta North (LSRDN) | $38,626,300 |
| Lower San Joaquin River / Delta South (LSJRDS) | $16,735,000 |
| Mid-San Joaquin River (MSJR) | $3,636,850 |
| Upper San Joaquin River (USJR) | $20,957,550 |
| **Total** | **$131,127,100** |

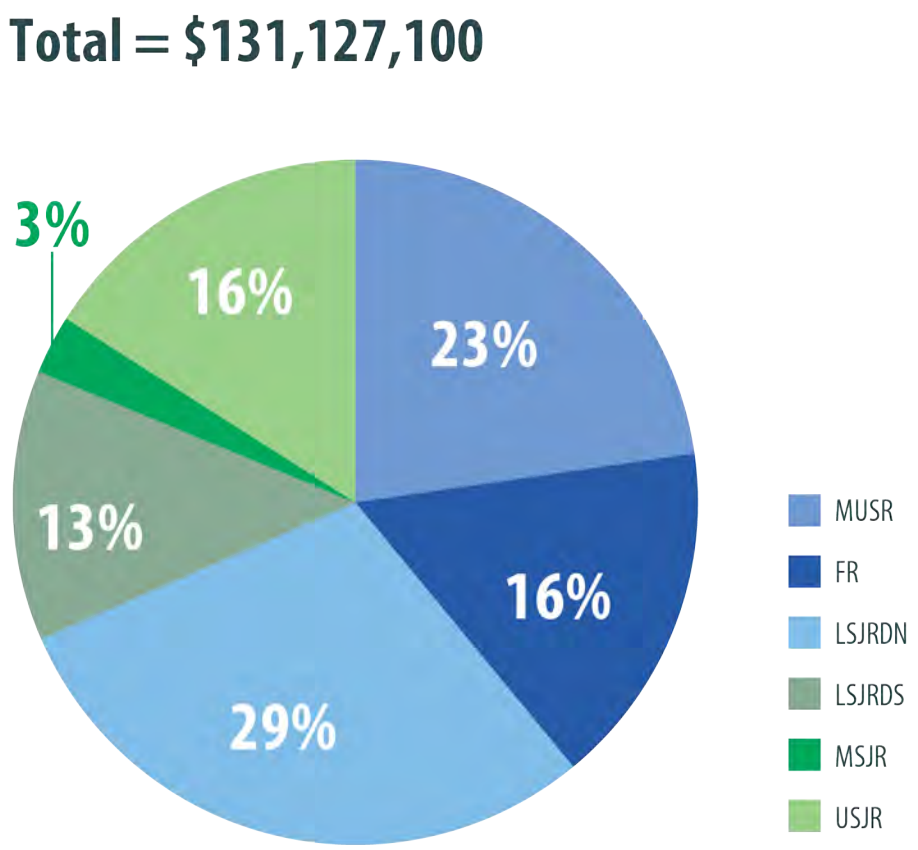


**Figure 1. Estimated Annual Cost per RFMP Region**

## C.2 Summary of Projected Annual Costs by Basin and Facility

The information presented below summarizes the annual OMRR&R cost estimates by basin and facility. Table 2 summarizes and identifies the sources of data that were used to develop multipliers to arrive at overall annual projected costs.

**Table 2. Long-Term SPFC OMRR&R Unit Cost Multipliers**

| Description | Source | Multiplier | Unit |
|---|---|---|---|
| Sacramento River Urban Levee Miles | GIS files from DWR Flood Projects Office – Technical Support Branch. | 260.2 | Miles |
| Sacramento River Non-Urban Levee Miles | GIS files from DWR Flood Projects Office – Technical Support Branch. | 829.9 | Miles |
| Sacramento River Sediment Removal | FMO historical data for sediment removal events from 1983–2010 with emphasis on 2006–2010. | 550,000 | CY |
| Sacramento River Channel Maintenance Acreage | FMO data for channel maintenance vegetation and debris removal from 2010. | 4,500 | Acres |
| San Joaquin River Urban Levee Miles | GIS files from FMO Flood Projects Office – Technical Support Branch. | 74.8 | Miles |
| San Joaquin River Non-Urban Levee Miles | GIS files from FMO Flood Projects Office – Technical Support Branch. | 528.7 | Miles |

**Table 2. Long-Term SPFC OMRR&R Unit Cost Multipliers**

| Description | Source | Multiplier | Unit |
|---|---|---|---|
| San Joaquin River Sediment Removal | LMA-provided volume of sediment loads removed from their area of responsibility from 2006–2014. | 110,000 | CY |
| San Joaquin River Channel Maintenance Acreage | Channel vegetation and debris removal in the San Joaquin River Basin should be approximately 900 acres per year. | 900 | Acres |

*Source: Developed by OMRR&R Work Group.*
Key:
CY = cubic yard
DWR = California Department of Water Resources
FMO = Flood Maintenance Office
GIS = geographic information system
LMA = Local Maintaining Agency
Notes:
1 For pipe penetrations multipliers table see Section 5.2.5, Minor Structures O&M by Region and Section 5.3.5, Minor Structures RR&R, Pipe Penetrations, by Region.
2 For giant reed multipliers table see Section 5.3.4, Channel RR&R – Giant Reed.

## C.2.1 SPFC Annual OMRR&R Cost Estimate – Sacramento River Basin

Table 3 and Figure 2 summarize the estimated annual cost of OMRR&R across the Sacramento River Basin. Total levee OMRR&R is estimated to cost $68,739,300. Channel OMRR&R is estimated to cost $10,488,400, and structures OMRR&R is estimated to cost $10,570,000.

**Table 3. Estimated Annual Cost of OMRR&R across the Sacramento River Basin**

| Description | Unit | Unit Quantity | Annual Cost |
|---|---|---|---|
| Urban Levee O&M | Mile | 260.2 | $15,091,600 |
| Non-Urban Levee O&M | Mile | 829.9 | $38,175,400 |
| Channel Sediment Removal | CY | 550,000.0 | $5,500,000 |
| Channel Vegetation / Debris Removal | Acre | 4,500.0 | $4,500,000 |
| Small Structures O&M | Pipe | 696.0 | $278,400 |
| Large Structures O&M | Year | 1.0 | $530,000 |
| Urban Levee RR&R | Mile | 260.2 | $4,683,600 |
| Non-Urban Levee RR&R | Mile | 829.9 | $10,788,700 |
| Channel RR&R | Acre | 51.0 | $570,000 |
| Small Structures RR&R | Pipe | 1,210.0 | $9,680,000 |
| Large Structures RR&R | NA | | |
| **Sacramento River Basin Total** | | | **$89,797,700** |

Key:
O&M = operations and maintenance
RR&R = repair, rehabilitation, and replacement

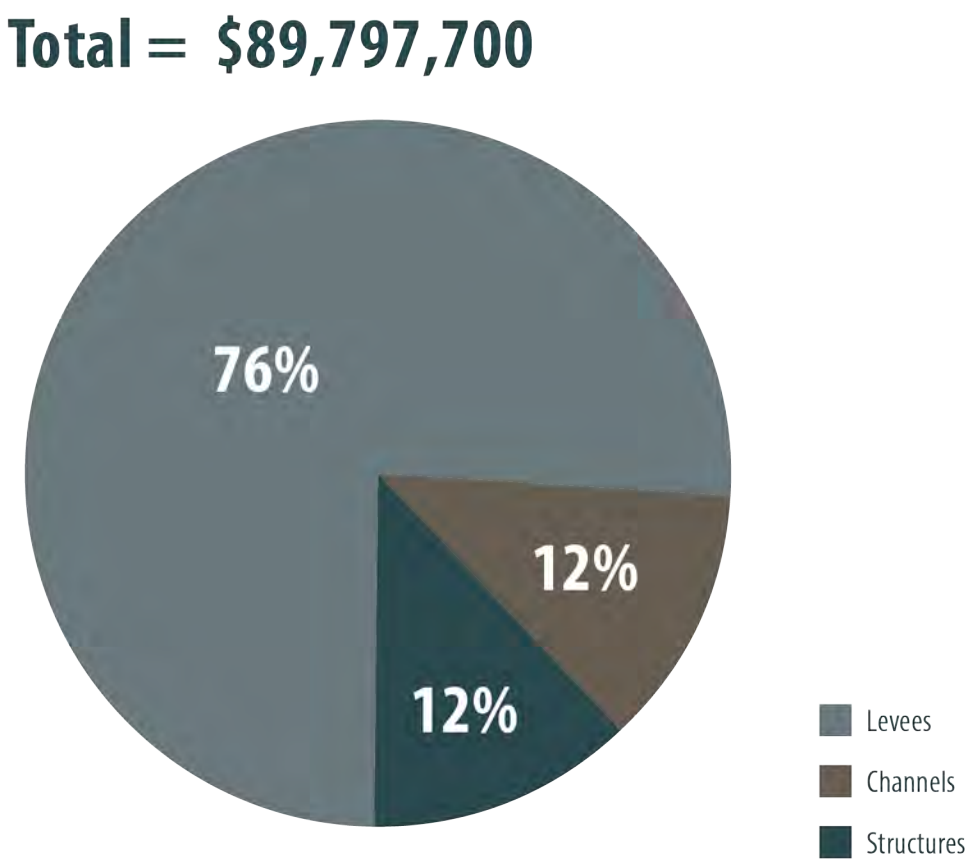


**Figure 2. Total Estimated Sacramento River Basin OMRR&R Costs**

### C.2.2 SPFC Annual OMRR&R Cost Estimate – San Joaquin River Basin

Table 4 and Figure 3 summarize the estimated annual cost of OMRR&R across the San Joaquin River Basin. Total levee OMRR&R is estimated to cost $29,406,600. Channel OMRR&R is estimated to cost $2,962,500, and structures OMRR&R is estimated to cost $8,960,300.

**Table 4. Estimated Annual Cost of OMRR&R across the San Joaquin River Basin**

| Description | Unit | Unit Quantity | Annual Cost |
|---|---|---|---|
| Urban Levee O&M | Mile | 74.8 | $3,740,000 |
| Non-Urban Levee O&M | Mile | 528.7 | $17,447,100 |
| Channel Sediment Removal | CY | 110,000.0 | $1,512,500 |
| Channel Vegetation / Debris Removal | Acre | 900.0 | $900,000 |
| Small Structures O&M | Pipe | 818.0 | $327,200 |
| Large Structures O&M | Year | 3.0 | $121,100 |
| Urban Levee RR&R | Mile | 74.8 | $1,346,400 |
| Non-Urban Levee RR&R | Mile | 528.7 | $6,873,100 |
| Channel RR&R | Acre | 22.0 | $550,000 |
| Small Structures RR&R | Pipe | 1,064.0 | $8,512,000 |
| Large Structures RR&R | Not applicable | | |
| | | **San Joaquin River Basin Total** | **$41,329,400** |

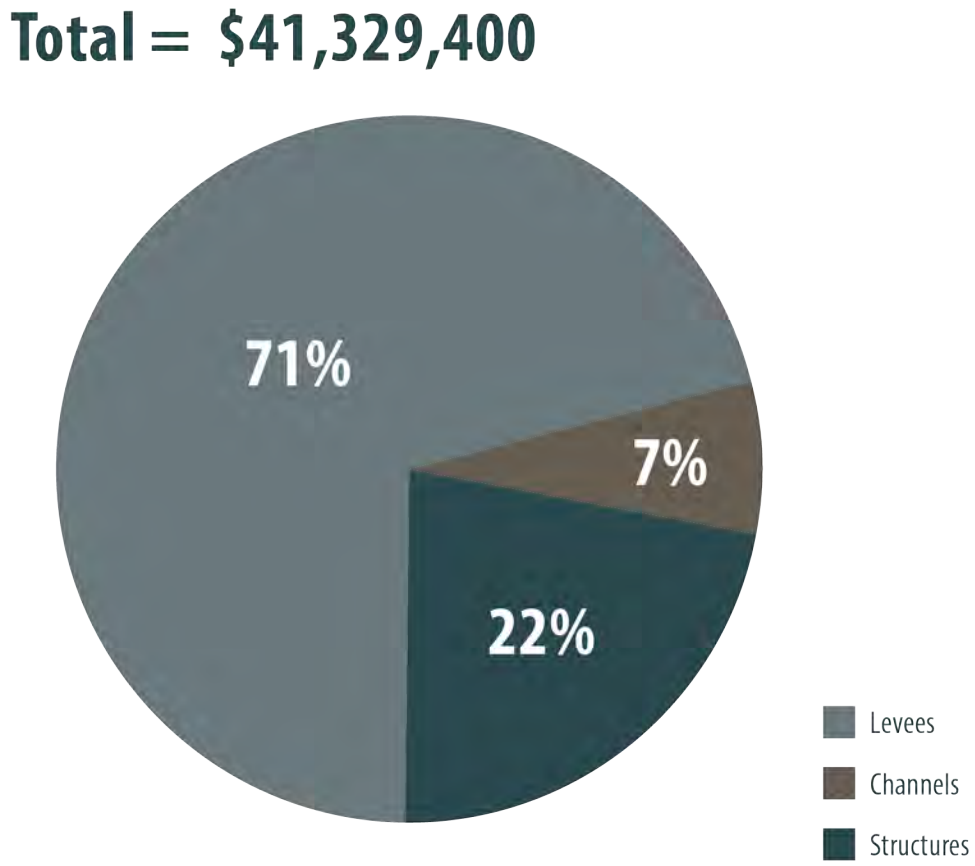


**Figure 3. Total Estimated San Joaquin River Basin OMRR&R Costs**

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES