Merced Integrated Regional Water Management Plan

Existing Regional Flood Management Summary

Prepared for: RMC *August 31, 2012*

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INTRODUCTION

The City of Merced, County of Merced, and Merced Irrigation District are currently leading the preparation of an Integrated Regional Water Management Plan (IRWMP). Part of this effort is to summarize flood management issues and identify opportunities to integrate flood management into the overall water system management for the region.

The purpose of this technical memorandum (TM) is to summarize findings from studies previously prepared in the Merced IRWM planning area, as well as laws, standards, and regulations which impact the Region. System vulnerabilities and gaps in available information will also be presented. This information will be used to inform the flood management portion of the IRWMP.

BACKGROUND

The Merced IRWM planning area generally consists of Merced County north/east of the San Joaquin River and is part of the Upper San Joaquin Region, as defined by the California Department of Water Resources (DWR).

Flood management and planning has significantly shaped the Merced region's history. Flooding in the San Joaquin River basin is typically characterized by infrequent severe winter storms, combined with snowmelt runoff from the foothills east of the region. Runoff from these storm events traverses the region via numerous creeks and rivers, ultimately draining to the San Joaquin River. The relatively flat topography of the region causes floodwaters to exceed the banks of these rivers and streams to spread out over large areas. Figure 1 on the following page illustrates the many streams and rivers which traverse the Region.

The Merced County Stream Group (MSG) project, originally authorized by the Flood Control Act of 1944, aimed to provide flood protection as part of the comprehensive flood management plans for the Sacramento and San Joaquin Basins. Numerous subsequent projects have also been undertaken to address the problem of regional flooding. To date, the MSG is mostly complete, but a key feature intended to protect downtown Merced has not been built.

Unfortunately, a significant portion of the Merced Region is still subject to flooding. According to FEMA, approximately 380,000 acres in Merced County are located within a 100 year floodplain. Figure 2 on the following page illustrates the extent of FEMA flood zones in the region.

FIGURE 1 – Merced IRWM Streams

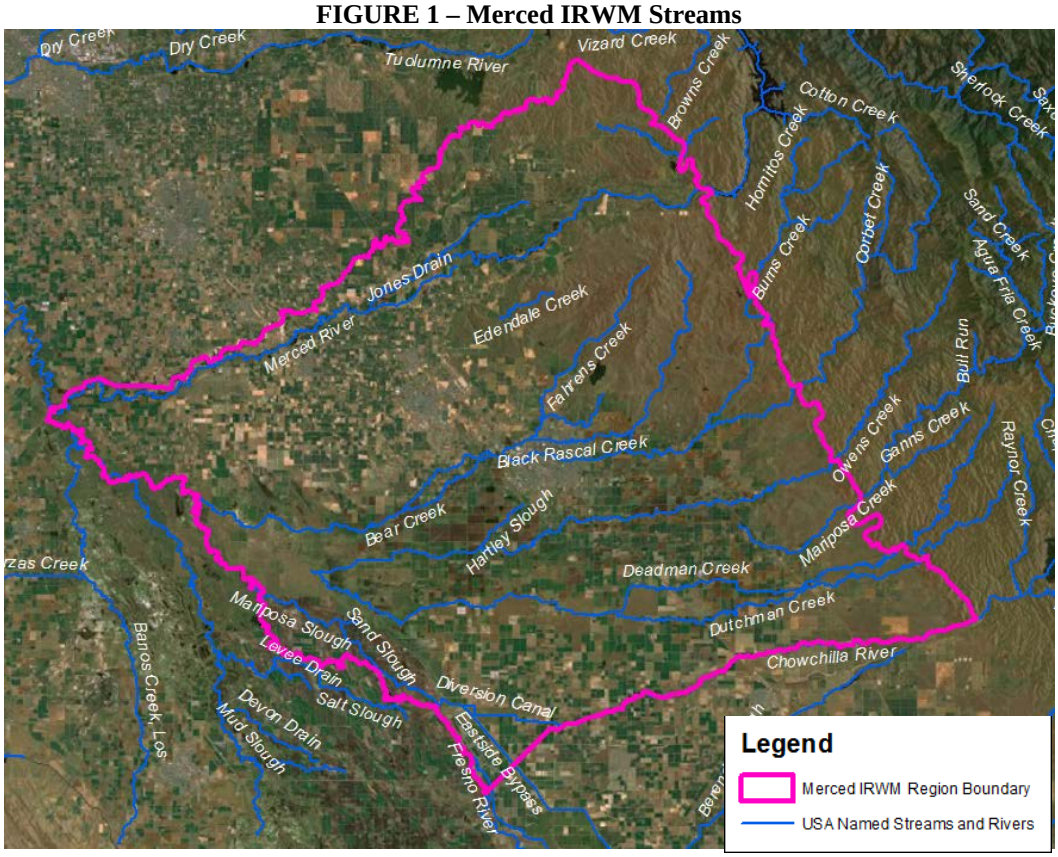
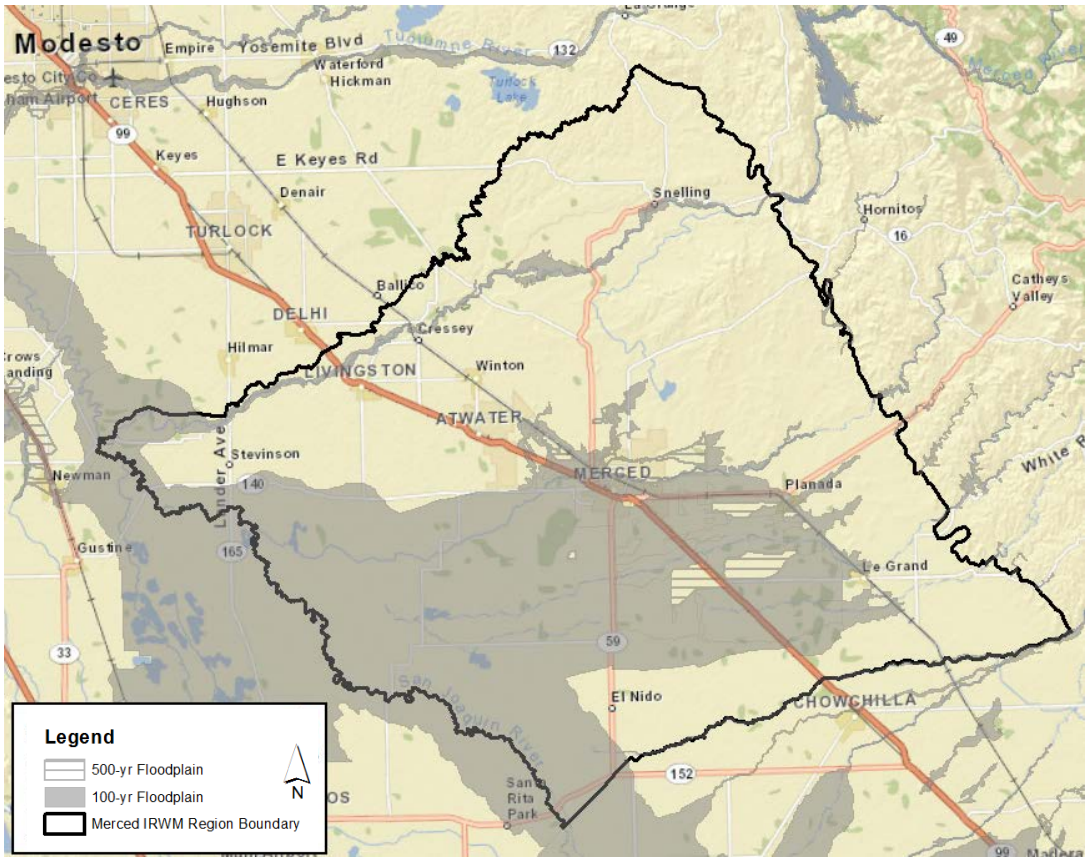


FIGURE 2 – Merced IRWM Floodzones



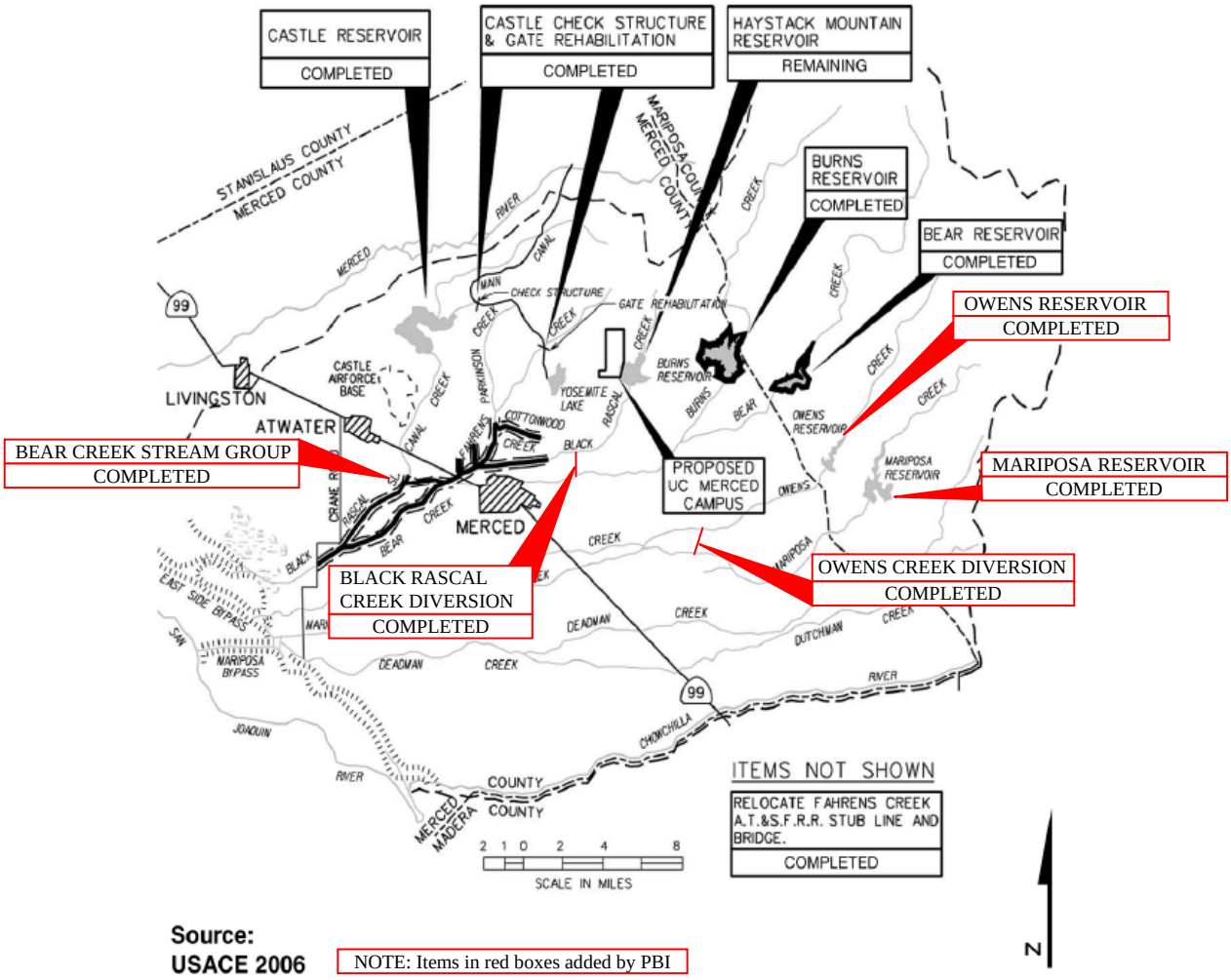
Recent flood events occurred in the Region in 1997, 1998, 2000, 2001, 2002, 2005, 2006, and 2007. The frequency of flooding events illustrates the fact that many areas in the Region are prone to flooding from storm events less severe than a 100-year event. These floods prompted numerous lawsuits over residential structural damage due, in part, to alleged lack of flood control improvements.

Floodplain development in the Region is regulated and enforced by Merced County. Merced County is also responsible for maintenance of levees on Black Rascal Creek, Black Rascal Creek Diversion, Burns Creek, Mariposa Creek, Miles Creek, sections of Owens Creek, Owens Creek Diversion, sections of Bear Creek, and Canal Creek. The Merced Irrigation District performs maintenance of Castle Dam.

REGIONAL FLOOD CONTROL PROJECTS

As previously noted, flood control projects in the Region date back to 1944 with the Merced County Streams Group (MSG) project. In 1970, the original project proposed by the United States Army Corps of Engineers (USACE) was updated to include a dam on Black Rascal Creek, known as Haystack Dam. However, the USACE later determined that environmental issues might be a significant challenge to implementing the Haystack Dam. The MSG effort continues to this day as the USACE is studying feasible alternatives for a flood control structure on Black Rascal Creek. The figure below summarizes the USACE progress implementing the MSG projects.

FIGURE 3 – Merced County Streams Group Project Status



Source:
USACE 2006

NOTE: Items in red boxes added by PBI

In addition to the reservoir projects shown in Figure 3 on the previous page, improvements along Black Rascal Creek, Bear Creek, Burns Creek, Miles Creek, Owens Creek, and Mariposa Creek were completed as part of the MSG. Although channels were improved, very few levees were constructed, and the incised channels are subject to periodic overflows, causing widespread but relatively shallow flooding.

The MSG is only one of several USACE flood control projects in the Region. Figure 4 below illustrates USACE project levees in the Region. Figure 5 on the following page outlines State Plan of Flood Control (SPFC) levees in the Region.

FIGURE 4 – USACE Project Levees in the Merced Region

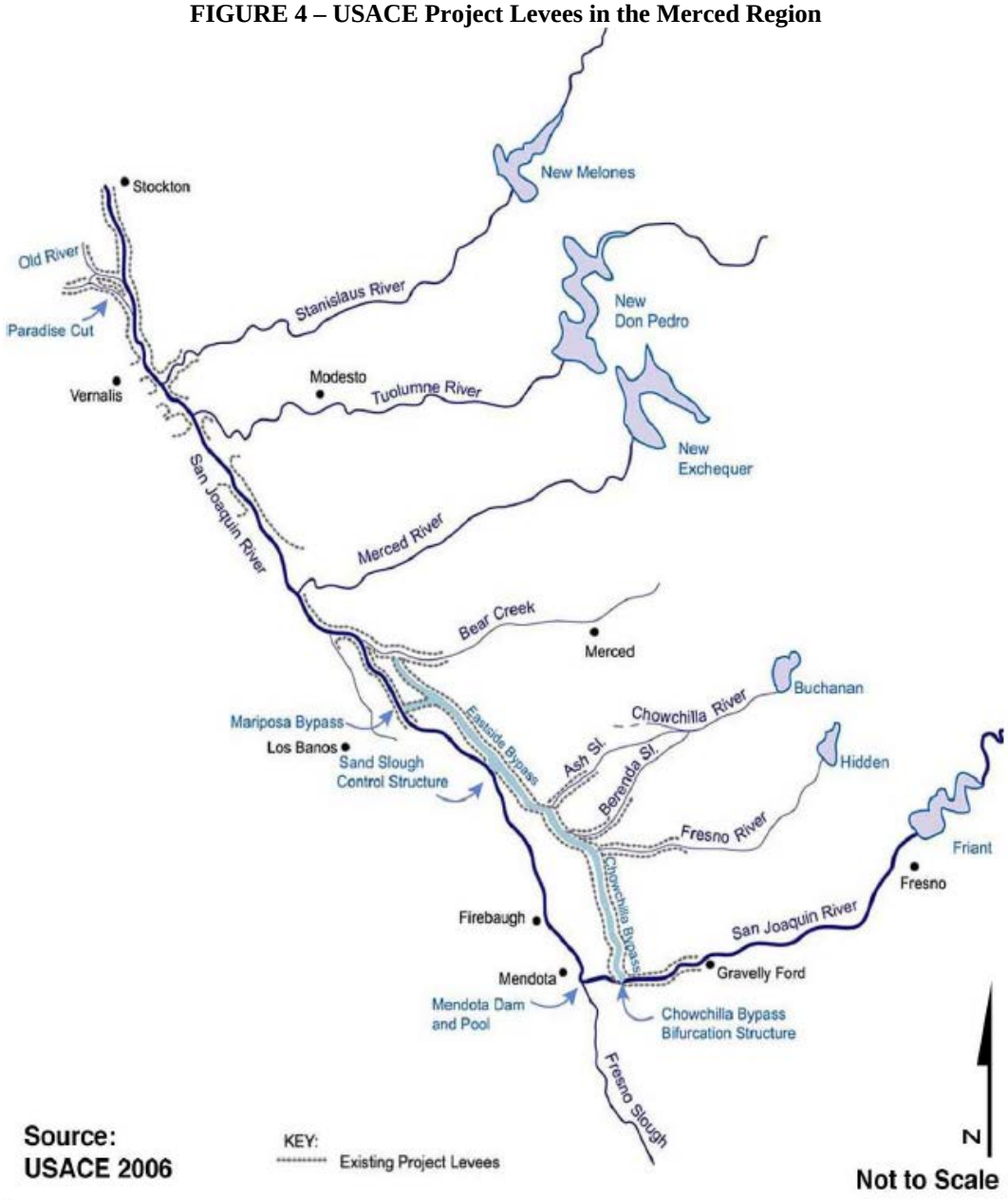
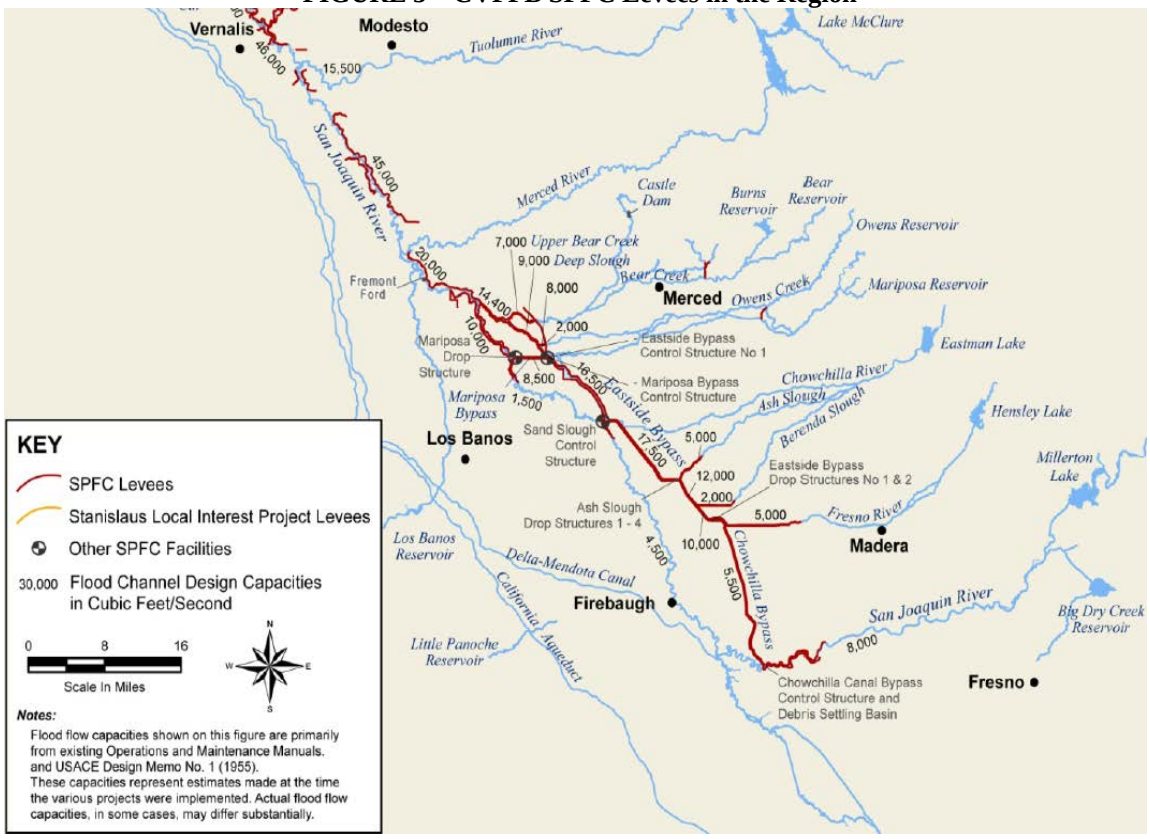


FIGURE 5 – CVFPB SPFC Levees in the Region



REGULATIONS

Structural flood control projects are only one method of managing flood risk. Development restrictions and policies also play an important role in helping Merced County manage flooding impacts to Regional businesses and residents. Various Federal, State, and local development restrictions are summarized below.

FEMA

FEMA oversees floodplains and manages the National Flood Insurance Program (NFIP). These programs place growth limiting measures in areas mapped as 100-year floodplains. FEMA incentivizes cities and counties, through reduced NFIP insurance rates, to restrict development in the floodplain. Merced County and the incorporated cities within Merced County participate in the NFIP and therefore must meet FEMA standards for floodplain protection facilities and floodplain management.

STATE REGULATIONS

In 2006, DWR started the "FloodSAFE" initiative. This program is a collaborative statewide effort designed to accomplish five broad goals: reduce the chance of flooding, reduce the consequences of flooding, sustain economic growth, protect and enhance ecosystems, and promote sustainability. DWR proposes to achieve these goals by helping local agencies to improve flood management systems, O&M programs, and emergency response.

Following DWR's initiative, Senate Bill 5 (SB5) was passed in 2007 which restricts land development within California's Central Valley. Under SB5, the State (DWR and CVFPB) was obligated to develop and adopt a comprehensive Central Valley Flood Protection Plan (CVFPP) for regional flood control by 2012 (Cal. Water Code § 9614.). This plan was recently approved by

the CVFPB in June 2012. All cities and counties in the Central Valley must incorporate the CVFPP into their general plans within 24 months and into their zoning ordinances within 36 months (July 2014 and 2015, respectively) (Cal. Gov't Code §§ 65302.9, 65860.1.).

Under SB5, development in a moderate or high flood hazard zone would only be allowed if Merced County can find, based on substantial evidence in the record, that urban or urbanizing areas will be protected to a 200-year-flood level. This applies to all developed areas with population of at least 10,000 (or with plans to reach 10,000 within 10 years), overlain by FEMA Zones A, B, or shaded X. Therefore, as of mid-2015, Central Valley cities and counties will be prevented from entering into development agreements, approving discretionary permits that would result in construction of a residence, and approving subdivision maps in urban or urbanizing areas without a finding of 200-year- flood-level protection. This is more restrictive than FEMA regulations.

As of the date of this TM, there is legislation awaiting action from the Governor, which will modify SB5. This legislation is known as Senate Bill 1278 (SB1278). On August 23, 2012, SB1278 passed the State Senate, as amended, with a unanimous vote of 37-0. SB1278 is awaiting action from the Governor, but will become law by default on 9/23/12 if action is not taken sooner.

SB1278 proposes to extend the requirement for communities to incorporate the CVFPP into their general plans and zoning ordinances by 12 months (July 2015 and 2016, respectively). More importantly for the Merced region, SB1278 limits Urban Level of Flood Protection (ULOP) requirements to leveed riverine systems. SB1278 also proposes to remove local drainage and "shallow" flooding from ULOP requirements, thus easing SB5 requirements on Merced. Future legislation aims to define "shallow" and modify other concerns with SB5.

ULDC/ULOP

The Urban Levee Design Criteria (ULDC) was developed by DWR in May of 2012 to provide criteria and guidance for design, evaluation, operation, and maintenance of levees and floodwalls in urban and urbanizing areas. The ULDC was developed pursuant to SB5, and provides the standards levees need to meet in order to justify a "finding" of 200-yr flood protection.

The Urban Level of Flood Protection Criteria (ULOP) is currently under development by DWR, and provides the process by which land use authorities make a "finding" of an urban level of protection. A draft ULOP exists, which is slated to be revised and adopted later in 2012. This draft presents a rather involved process which must be repeated every 20 years, with O&M revisions every 5 years.

LOCAL RESTRICTIONS

According to the Merced County General Plan, Merced County is responsible for implementing FEMA floodplain management regulations in the region. The Merced County Zoning Code contains specific requirements limiting and conditioning development in various flood zones. For instance, lowest finished floors must be elevated 1-foot above the base (100-yr) flood elevation. The County also requires construction of individual storm water detention basins for new development to limit peak flows to pre-project conditions.

Merced County also has a significant amount of vernal pool habitat, which can directly impact new development and flood control projects. The USFWS designated approximately 148,000 acres in Merced County as critical habitat for listed vernal pool crustaceans and vernal pool plants in 2005. These listed species have become a major consideration of the MSG project, and will likely impact flood control projects contemplated in hilly terrain in the future.

PREVIOUS STUDIES

MERCED COUNTY STREAMS GROUP

The original Merced County Stream Group (MSG) project was authorized by the Flood Control Act of 1944 as part of the comprehensive plan for flood control for the Sacramento and San Joaquin River Basins. The project consisted of four flood control reservoirs on Burns, Bear, Owens, and Mariposa creeks and was completed in 1957.

A 1970 authorization provided for enlargement of the four original reservoirs, construction of three additional reservoirs (Castle, Haystack, and Marguerite), and channel improvements on Bear and Mariposa creek systems. These channel improvements included two diversions: Black Rascal Creek to Bear Creek (3,000 cfs capacity) and Owens Creek to Mariposa Creek (400 cfs). Re-evaluation and technical studies later modified the design to include only the construction of Castle and Haystack Reservoirs, enlargement of the Bear Reservoir, and about 33 miles of channel improvements along Bear Creek.

The Haystack reservoir is the only component of the MSG not completed at this time. Changes in population, downstream development, and new environmental compliance issues have prompted a new analysis, which is being completed by the USACE as the Merced County Streams Group Feasibility Study. This study is intended to evaluate options to increase flood protection along Black Rascal Creek and Bear Creek to increase the current level of flood protection beyond a 50-year level of protection, but this study has not started due to lack of Federal funding.

BLACK RASCAL CREEK FEASIBILITY STUDY

Flooding along Bear Creek and Black Rascal Creek near the City of Merced has historically been problematic. In 2008, Merced County completed a local feasibility study evaluating several alternatives for a proposed detention basin upstream of the Black Rascal Creek Diversion. The goal of this study was to identify a preferred alternative which would reduce the flows in the diversion to less than 3,000 cfs, which the County felt might significantly reduce flooding within the city of Merced. This study was updated in 2009 to evaluate 200-yr flood protection.

Two primary challenges were identified in this study. The first is that each of the proposed dams would be larger than the minimum size dam subject to California Division of Safety of Dams (DSOD) permitting authority. According to DSOD requirements, dams greater than 25’ tall, or dams which store more than 50 acre feet of water are subject to DSOD jurisdiction. The other major challenge is sensitive biological resources (i.e. vernal pools) which would be impacted by all the alternatives. The apparent recommendation from this study was to further evaluate environmental permitting challenges associated with three of the four alternatives.

CENTRAL VALLEY FLOOD PROTECTION PLAN (CVFPP)

The DWR authored and the CVFPB adopted the CVFPP which is intended to be a sustainable, integrated flood management plan that describes and addresses flood risk in the Sacramento and San Joaquin River watersheds. The authorization for CVFPP originates in SB5, known as the Central Valley Flood Protection Act of 2008. The CVFPP guides implementation activities by local, State, and federal agencies for subsequent feasibility studies, environmental compliance, design, and construction activities.

The CVFPP’s primary goal is to improve flood risk management. Its supporting goals include improving O&M, promoting ecosystem functions, improving institutional support, and promoting multi-benefit projects. The CVFPP desires to improve the existing flood management system within its existing footprint, to protect high flood risk communities, and enhance flood system capacity. As noted in Figure 5 of this technical memorandum, SPFC projects are primarily located along the San Joaquin River and do not extend along many of the creeks traversing east to

west through the Region. The CVFPP describes the current physical condition of SPFC facilities at a system-wide level as determined by the Flood Control System Status Report (FCSSR). The findings from the FCSSR are presented in the following section.

Between now and 2017, the CVFPB will work with each of nine regions within the Central Valley to create Regional Flood Management Plans, which will help inform two Basin-Wide Feasibility Studies prepared by DWR. The Merced IRWM planning area is part of the Flood SAFE Upper San Joaquin Region and will be contained within the San Joaquin Basin Feasibility Study.

KNOWN SYSTEM DEFICIENCES

Flood control system deficiencies within the Region can be divided into two categories: local, or non-SPFC system deficiencies, and SPFC system deficiencies. As noted previously, SPFC deficiencies were noted in the FCSSR and incorporated in the 2012 CVFPP.

SPFC SYSTEM DEFICIENCIES

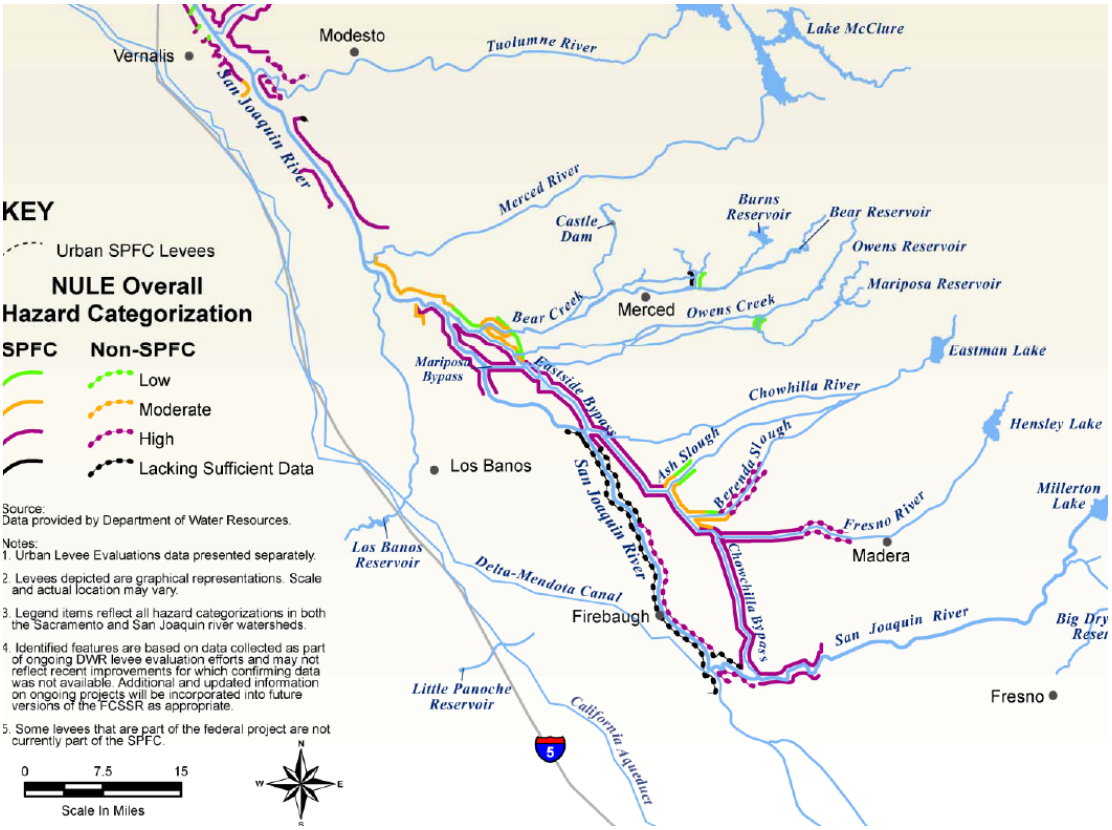
Many SPFC flood control structures were designed and constructed between 1940 and 1970 (or earlier) and have not been upgraded to meet current design criteria. Many of the structures are near (or beyond) the end of their expected service lives and some structures show significant visible age-related damage and other problems.

The FCSSR provides the physical condition of levees, hydraulic structures, and channels at a system wide level in order to identify weaknesses within current SPFC facilities. The following components are considered in the FCSSR evaluation.

- Levee geometry, seepage, structural instability, erosion, settlement, penetrations, levee vegetation, rodent damage, and encroachments
- Channel conveyance, vegetation, and sedimentation
- Structural deficiencies
- Overall system condition

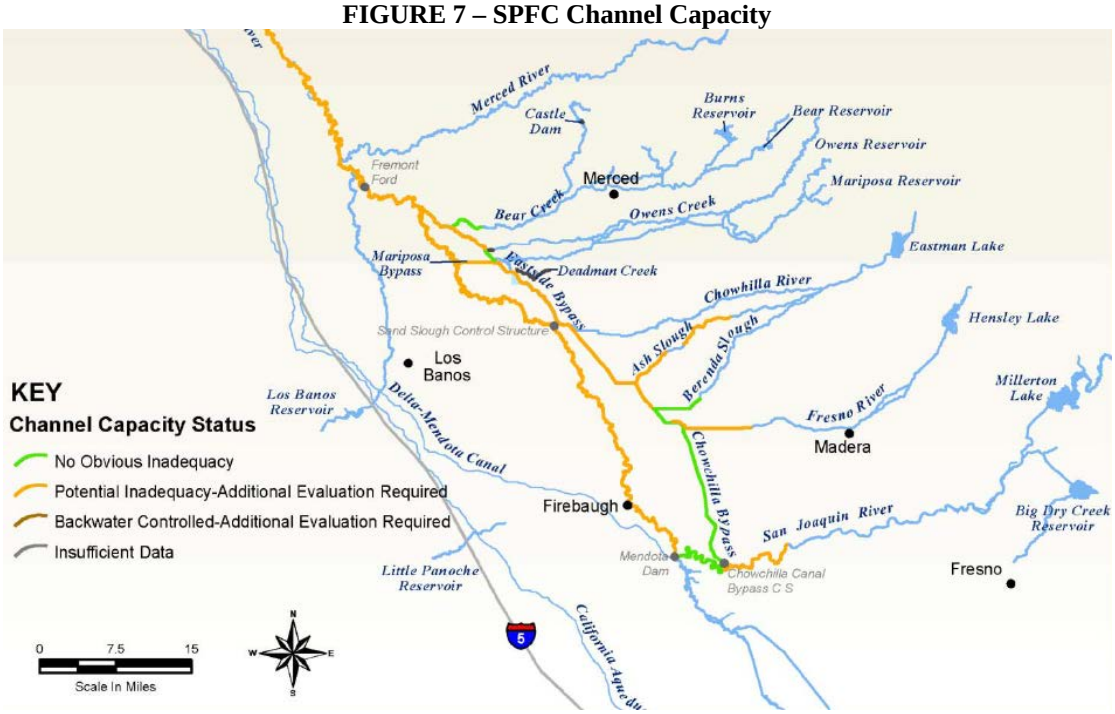
According to the FCSSR, a significant portion of the Merced IRWM planning area has levees which represent moderate and high hazards. The purpose of this information is to help guide future inspection, evaluation, reconstruction, and improvement of SPFC facilities. Figure 6 below summarizes the overall findings of the FCSSR.

FIGURE 6 –Levee Conditions



SPFC channel conveyance capacity has been estimated based on the ability of a channel to pass original design flood flows. There are potential inadequate channel conveyance capacities along the San Joaquin River, Mariposa Bypass, Eastside Bypass, Ash Slough and the Fresno River as shown in the figure below.

FIGURE 7 – SPFC Channel Capacity



In addition to levee and channel deficiencies, deficiencies to SPFC flood control structures are listed in the FCSSR in the categories of hydraulic structures, pumping plants, and bridges.

SPFC hydraulic structures include weirs, drop structures, control structures, drainage structures, and outfall structures. The Black Rascal Creek drop structure, Bear Creek diversion structure, San Joaquin River structure and Sand Slough structure, San Joaquin River and Chowchilla Canal Bypass control structure, and Fresno River drainage structure are rated minimally acceptable for structural integrity according to the FCSSR. The Owens Creek overflow structure is rated unacceptable for structural integrity.

The Owens Creek siphon structure, San Joaquin River structure and Sand Slough structure, Ash Slough drop structure #4, and Fresno River diversion structure are rated minimally acceptable for vegetation and obstruction conditions.

The Owens Creek siphon structure and Ash Slough drop structure #4 are rated minimally acceptable for encroachment conditions. Finally, the Owens Creek siphon structure is rated minimally acceptable for erosion, bank caving, shoaling, and sedimentation.

NON-SPFC SYSTEM DEFICIENCIES

The flood management system of the San Joaquin also relies on many non-SPFC flood control structures to convey floodwaters. The primary deficiency is the capacity of Bear Creek and the Black Rascal Creek diversion, although severe flooding has occurred along Fahrens Creek and along the San Joaquin River. FEMA freeboard requirements are not met by the levees on Bear Creek and the east levee of the Black Rascal Diversion Channel. Solutions to these deficiencies have been studied over the past few decades and continue to face environmental challenges.

The Region's extensive canal system is vulnerable to failure, more so during excessive storm events due to a lack of significant flood control improvements. Deadman Slough, Duck Slough (Mariposa Creek) Miles Creek, and Owens Creek lack adequate capacity to convey 100-year flows according to the Merced County General Plan.

INTEGRATED FLOOD MANAGEMENT OPPORTUNITIES

This technical memorandum has focused on flood management issues within the Region. However, another water challenge faced by the Region is a groundwater basin overdraft as discussed in other IRMWP Sections.

The Region has expressed interest in focusing the IRWM on alternatives for addressing the historical flooding on Bear Creek and Black Rascal Creek and coordinating these solutions with storage and groundwater recharge, or direct beneficial use.

Coordinating proposed flood management solutions with potential beneficial use and/or groundwater recharge sites may help achieve this goal. Merced Irrigation District is investigating the feasibility of directing flow from the main creeks on the east side of the region to the west to in an effort to reduce flooding while enhancing recharge in the southeastern part of the Region. Similar options are also being investigated for the dry creek watershed.

FUNDING OPPORTUNITIES

The DWR has made several programs available to assist communities with flood management planning and projects. These programs are supported by funds from by Propositions 1E and 84 (2009).

Currently available proposition 1E funds are aimed at Storm Water Flood Management projects which are not part of the SPFC and require a 50% local match of funds. $92M is available under this program, with a maximum grant of $30M allowed per project. In order to qualify for Prop. 1E funds, the project must be consistent with the IRWM for the Region, be consistent with the Regional Water Quality Control Plan for the Basin, must reduce stormwater runoff & damage, and yield multiple benefits. Guidelines for Prop. 1E funds are being finalized in August 2012 with applications being accepted in October.

Currently available proposition 84 funds are intended for implementation of projects identified in the Region's IRWM, must include multiple benefits, and require a 25% match of local funds. The San Joaquin Region has $8.3M available, but only one application per Region will be accepted. Guidelines for Prop. 84 funds are being finalized in August 2012 with applications being accepted in October. Funding under these programs will give preference to projects which address Regional water management issues, resolve conflicts between Regions, and address water needs of disadvantaged communities.

Finally, DWR has recently announced funding for regions to complete Regional Flood Management Plans as part of the next phase of the CVFPP. DWR has authorized $5 million for the program to be divided among nine Regions. Merced County is part of the Upper San Joaquin Region. Applications will be accepted this fall, with RFMPs being completed by December 2013.

Glossary

CVFPB—Central Valley Flood Protection Board

CVFPP—Central Valley Flood Protection Plan

DSOD—California Division of Safety of Dams

DWR—California Department of Water Resources

FCSSR—Flood Control System Status Report

FEMA—Federal Emergency Management Agency

IRWMP—Integrated Regional Water Management Plan

MSG—Merced County Stream Group

NFIP—National Flood Insurance Program

O&M—Operations and Maintenance

RFMP—Regional Flood Management Plans

SB5—Senate Bill 5

SB1278 —Senate Bill 1278

SPFC—State Plan of Flood Control

TM—Technical memorandum

ULDC—Urban Levee Design Criteria

ULOP—Urban Level of Flood Protection

USACE—United States Army Corps of Engineers

USFWS—U.S. Fish and Wildlife Service

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Merced Integrated Regional Water Management Plan

Preliminary Flood Management Strategies

Prepared for: RMC *November 6, 2012*

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Reviewed by: Dave Peterson, P.E.

INTRODUCTION

The City of Merced, County of Merced, and Merced Irrigation District are currently leading the preparation of an Integrated Regional Water Management Plan (IRWMP). Part of this effort is to summarize flood management issues and identify opportunities to integrate flood management strategies into the overall water system management for the region.

The purpose of this technical memorandum (TM) is to summarize IRWMP objectives related to flood management and identify potential projects and policies which meet these objectives. Planning level cost estimates for preferred projects and programs have also been included. These concepts will then be screened by the Regional Advisory Committee (RAC) to determine which concepts are most appropriate for the region. This information will be used to inform the flood management portion of the IRWMP.

INTEGRATED FLOOD MANAGEMENT OPPORTUNITIES

The Regional Advisory Committee (RAC) has established an IRWM objective to manage flood flows for public safety, water supply, recharge, and natural resource management. Performance measures for this objective include: occurrence of flooding at the Bear Creek, Black Rascal Creek diversion, Deadman Creek, Dry Creek, Fahrens Creek, Lake Yosemite, Mariposa Creek, Merced River, and San Joaquin River; volume of flood water stored and / or recharged; and flood-related damages (extent and frequency). Coordinating proposed flood management solutions with potential beneficial use and/or groundwater recharge sites may help achieve this goal.

Merced Irrigation District is investigating the feasibility of directing flow from the main creeks on the east side of the region in an effort to reduce flooding risk while enhancing recharge in the southeastern part of the Region. Similar options are also being investigated for the dry creek watershed. The projects listed on the following pages are concepts the RAC may consider implementing in the IRWMP.

POTENTIAL PROJECTS TO ADDRESS IRWM OBJECTIVES

This section presents a preliminary list of potential projects and policies for improving flood risk management in the Merced Region. The projects and policies were evaluated on whether they provide the following benefits:

- Meet IRWM Objectives
- Improved flood protection (reduces flood related damages)
- Increased sustainability of flood and water management systems
- Enhanced floodplain ecosystem
- Improved emergency preparedness & response
- Improved integration and coordination among stakeholders
- Wise use of the floodplain

To reduce flood-related damages, the Merced Region has three primary options:

1. Reduce the flow
2. Contain the flow
3. Get out of the way of the flow

The following is a summary and brief overview of the potential projects and policies that may be available for mitigating flood risk in the Region. Note that the planning level cost estimates prepared for each project are preliminary and were prepared using the best available information.

These projects are presented to the IRWM RAC for review and consideration on which projects represent the interests of the Region. It is noted that a combination of any or all of these is possible.

Options to Reduce the Flow Entering Merced

- Black Rascal Creek Dam (Haystack Reservoir)
- Black Rascal Creek Detention Basin
- Route Flood Flows to Agricultural Lands East of Merced
- Ecosystem Restoration Along Waterways
- Bear Creek Detention Basin/Groundwater Recharge Facility
- Bear Creek Diversion Channel (Feasibility Study)

Options to Contain the Flow Through Merced

- Levees along Channels
- Channel Dredging and/or Vegetation Removal

Options to get out of the way of the flow

- Modify Land Use
- Develop Emergency Response Plans
- Ring Levees around Flood-Prone Areas
- Increase Public Awareness of Flooding
- Establish a Regional Flood Control District

BLACK RASCAL CREEK DAM (HAYSTACK RESERVOIR)

PLANNING LEVEL COST ESTIMATE = $TBD from USACE

A dam along Black Rascal Creek, known as Haystack Reservoir, was first proposed by the US Army Corps of Engineers (USACE) as part of the Merced County Streams Group (MSG) project. The USACE later determined that environmental issues might be a significant challenge to implementing the project. Changes in population, downstream development, and new environmental compliance issues have prompted a new analysis, which is being completed by the USACE under the Merced County Streams Group Feasibility Study. However, this study has not yet started due to a lack of Federal funding.

The Haystack Reservoir, as originally proposed by the USACE, would provide approximately 6,500 acre-feet of new storage for flood control purposes.

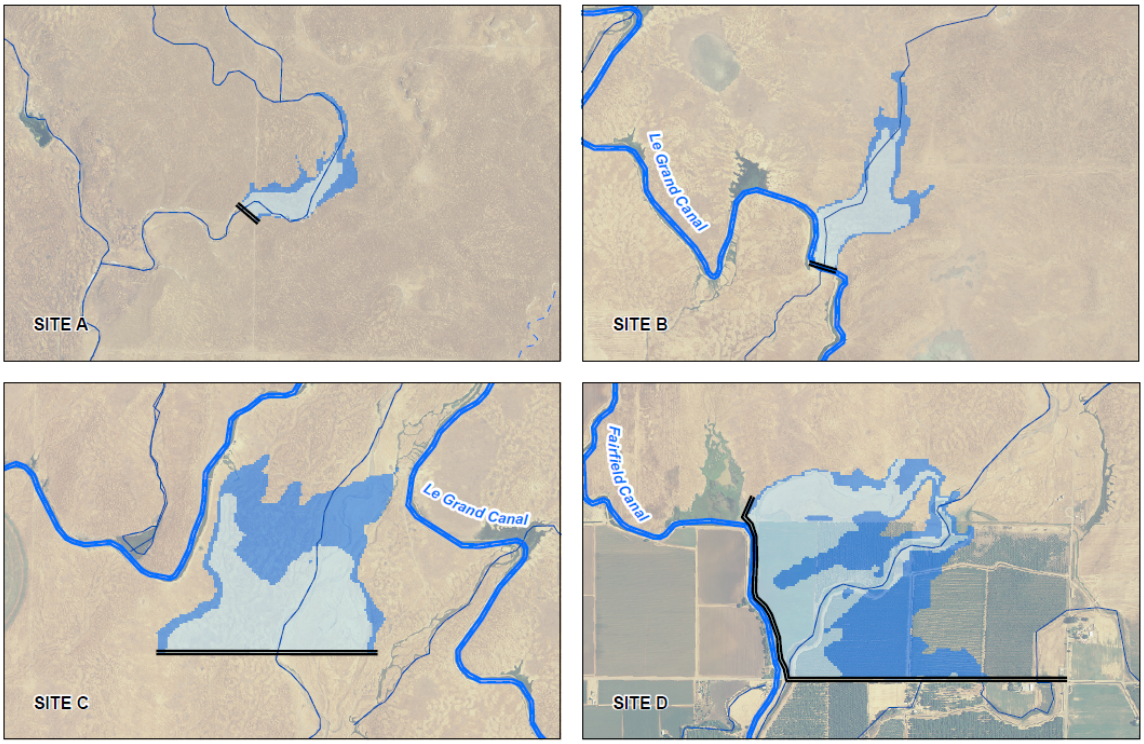
BLACK RASCAL CREEK DETENTION BASIN

PLANNING LEVEL COST ESTIMATE = $10 - $30 Million

Based upon initial review of existing information, reducing flood flows in Black Rascal Creek at the Yosemite Ave. diversion to less than about 3,000 cfs by use of upstream detention will substantially reduce the flooding in the City of Merced. A flood control structure on Black Rascal Creek could also offer protection to other areas situated along Bear Creek.

Merced County retained URS Corporation to investigate the feasibility of alternative flood control improvements, including alternative operation procedures and infrastructure improvements to the Lake Yosemite facilities, to reduce the peak flows at the Black Rascal Creek diversion. The study identified four different sites along Black Rascal Creek for construction of a detention basin. The amount of new storage provided by the various detention basins ranged from 300 to 2,500 acre-feet. The planning level cost estimate for this project is based upon the costs presented in the URS report.

FIGURE 1 – Black Rascal Creek Detention Basin Alternatives



Source: Black Rascal Creek Flood Control Feasibility Study, URS Corporation, 2008

DIVERT FLOOD FLOWS TO AGRICULTURAL LANDS

PLANNING LEVEL COST ESTIMATE = $20,000 - $50,000 per acre

Diverting flood flows out of Bear Creek, east of Merced onto nearby agricultural land could decrease peak flows within the channels. This is essentially a "no-action" alternative since it already occurs for much of the existing floodplain south of Bear Creek. Historically, flood flows in excess of the Bear Creek channel capacity spill over the south bank of Bear Creek about 6 miles east of Merced. These flows do not return to the channel and much of the water ends up making its way into the City. These phenomena may be induced more often by reducing the capacity of Bear Creek upstream of Merced.

Depending on the topography, the types of crops, and the willingness of the landowners, agricultural land could be utilized as detention basins where excess flood flows would be temporarily stored until water percolates back into the ground. Agricultural lands would be temporarily flooded and the waters would be routed back into the channel after the high flows recede. Berms, ditches and weirs could be constructed to optimize the process and to delineate the extents of agricultural flooding.

ECOSYSTEM RESTORATION ALONG WATERWAYS

PLANNING LEVEL COST ESTIMATE = $50,000 per Acre

An alternative, similar to routing flood flows onto agricultural land, would be to acquire riparian areas of agricultural land and restore natural floodplains. This type of flood control project could be implemented as an ecosystem mitigation bank. A secondary benefit to this option would be the direct recharge of groundwater. This type of project may be feasible for reaches of Bear Creek located upstream and downstream of Merced. Costs would vary on the number of parcels acquired, willingness of landowner to sell all or part of their property, and environmental impacts.

BEAR CREEK RETENTION BASIN/GROUNDWATER RECHARGE FACILITY

PLANNING LEVEL COST ESTIMATE = $400 per Acre-Foot

Direct groundwater recharge is achieved by diverting excess flood flows into a shallow retention basin and allowing the water to percolate into the ground. Direct groundwater recharge projects typically involve the installation of new diversion and storage facilities. There are large parcels of agricultural land located along Bear Creek upstream of Merced that, if available, may be suitable as a detention basin/direct recharge site. A challenge of this option is sediment-laden flood flow. If bank overtopping is used to direct flood flows to a recharge site, this challenge is decreased.

In addition to direct groundwater recharge, in-lieu groundwater recharge may also be achieved with the implementation of this type of project. In-lieu recharge is achieved by providing farmers with a water supply that they use 'in-lieu' of pumping directly from the groundwater basin. The project typically includes the installation of pumping and conveyance facilities in order to transport water to agricultural areas that are currently served by wells. In-lieu recharge would help alleviate the subsidence in the area that is being caused by excessive groundwater pumping from below the Corcoran clay layer. The project would recharge the groundwater levels located above the Corcoran clay layer and limit the amount of water that is pumped from below. A secondary benefit to this project is the improved integration among stakeholders, where multiple banking partners can often benefit through water entitlement exchange. The planning level cost estimate associated with this project is representative of the average cost (per 1,000 acre-feet of annual groundwater recovery) for the Kern Water Bank, located in Kern County, California.

FIGURE 2 – Direct Groundwater Recharge Site (Kern County, California)

FIGURE 3 – In-Lieu Groundwater Recharge Facility (Kern County, California)

BEAR CREEK DIVERSION CHANNEL FEASIBILITY STUDY

PLANNING LEVEL COST ESTIMATE = $100,000

Based upon review of existing information, a diversion channel located upstream of Merced may be able to significantly reduce flood risk within the City. The diversion channel would run in a south/southwest direction from Bear Creek. Because of the many different options involved in this type of project, it is recommended that a Feasibility Study be first prepared to further define the benefits and applicability of such a project. The planning level cost estimate represents the estimated amount to develop the Feasibility Study report for this project.

CONSTRUCT LEVEES ALONG CHANNELS/WIDEN EXISTING CHANNELS

PLANNING LEVEL COST ESTIMATE = $2,000 – $4,000 per Lineal Foot

Based on a review of the available information, Bear Creek, Black Rascal Creek/Slough/Diversion, Deadman Creek, Dry Creek, Fahrens Creek, and Mariposa Creek are subject to flooding. Stream capacities and estimated 100-yr storm flow rates were found for Bear Creek, Black Rascal Creek/Slough, and Miles Creek. For the other streams, either the capacity or peak flows were not available in the referenced information.

Specific levee heights needed to contain the 100-yr storm flows were estimated for segments of Bear Creek and Black Rascal Creek/Slough. For areas where preliminary calculations yielded unrealistic freeboard deficiencies (i.e. needed levee heights >9 feet), a combination of channel widening and decreased levee heights were explored.

Levees may be suitable for select reaches adjacent to urbanized development. For agricultural areas, the RAC may limit these expenditures. For example, Miles Creek currently cannot convey the 100-yr storm flows within its banks. However, the estimated $167M to fully improve this creek may not be as economically feasible as improvements elsewhere in the Region. Figure 5 on page 9 illustrates possible locations of channel improvements.

Table 1 – Summary of Channel Capacity Deficiencies and Estimated Levee Construction Costs

Stream	Current Estimated Channel Capacity (cfs)	Est. 100-Yr Flow in Creek (cfs)	Estimated Capacity Deficiency (cfs)	Estimated Increased Levee Height Needed to Contain 100-yr Flow (ft)	Est. Cost to Construct Levees to Contain 100-yr Flow[8]
Bear Creek					
Bear Creek (U/S of Diversion)	4,000[1]	10,000[6]	6,000	7	$29M
Bear Creek (U/S HWY 99)	7,000[1]	14,000[2]	7,000	12	$145M
Bear Creek (D/S HWY 99)	3,100[1]	6,150[2]	3,050	15	$142M
Black Rascal Creek/Slough					
Black Rascal Creek (U/S of Diversion)	3,500[4]	3,500[3]	N/A	N/A	N/A
Black Rascal Diversion	3,000[1]	3,500[5]	500	6	$10M
Black Rascal Creek (D/S of Diversion)	Not Available	Local Flow Only	N/A	N/A	N/A
Black Rascal Creek (U/S of Bear Creek)	Not Available	5,720[2]	Not Available	7 (Estimated)	$18M
Black Rascal Slough	3,900[1]	7,100[2]	3,200	14	$143M
Other Creeks					
Fahrens Creek	Not Available	5,400[2]	Not Available	7 (Estimated)	$18M
Mariposa Creek	1,250[1]	Not Available	Not Available	Not Available	N/A
Miles Creek	1,000[1]	3,400[2]	2,400	15	$410M

1. Information obtained from the Merced County Stream Group Study.
2. Information obtained from FEMA FIS.
3. Information obtained from the Merced County Feasibility Study for the Black Rascal Creek Flood Control Project.
4. Information estimated from inspection of FIS profiles.
5. Information estimated since FEMA FIS indicates only local drainage exists in Black Rascal Creek D/S of Diversion.
6. 100-Yr flow estimated based on FIS flows in other reaches of Bear Creek.
7. According to FEMA FIS, only local drainage is in Black Rascal Creek between the Diversion and the confluence with Fahrens Creek.
8. Cost Includes Design, Construction, and "Average" Environmental Costs. Does not include right-of-way or real estate costs.

Table 2 – Summary of Channel Capacity Deficiencies and Estimated Widening and Levee Construction Costs

Stream	Current Estimated Channel Capacity (cfs)	Est. 100-Yr Flow in Creek (cfs)	Estimated Capacity Deficiency (cfs)	Channel Widening & Levee Alternatives		
				Estimated Possible Channel Widening Width (ft)	Estimated Levee Height ft)	Est. Cost to Widen the Channel and Construct Smaller Levees[8]
Bear Creek						
Bear Creek (U/S of Diversion)	4,000[1]	10,000[6]	6,000	-	-	-
Bear Creek (U/S HWY 99)	7,000[1]	14,000[2]	7,000	20	8	$92M
Bear Creek (D/S HWY 99)	3,100[1]	6,150[2]	3,050	10	9	$75M
Black Rascal Creek/Slough						
Black Rascal Creek (U/S of Diversion)	3,500[4]	3,500[3]	N/A	-	-	-
Black Rascal Diversion	3,000[1]	3,500[5]	500	-	-	-
Black Rascal Creek (D/S of Diversion)	Not Available	Local Flow Only	N/A	-	-	-
Black Rascal Creek (U/S of Bear Creek)	Not Available	5,720[2]	Not Available	-	-	-
Black Rascal Slough	3,900[1]	7,100[2]	3,200	10	8	$73M
Other Creeks						
Fahrens Creek	Not Available	5,400[2]	Not Available	-	-	-
Mariposa Creek	1,250[1]	Not Available	Not Available	-	-	-
Miles Creek	1,000[1]	3,400[2]	2,400	20	7	$167M

1. Information obtained from the Merced County Stream Group Study.
2. Information obtained from FEMA FIS.
3. Information obtained from the Merced County Feasibility Study for the Black Rascal Creek Flood Control Project.
4. Information estimated from inspection of FIS profiles.
5. Information estimated since FEMA FIS indicates only local drainage exists in Black Rascal Creek D/S of Diversion.
6. 100-Yr flow estimated based on FIS flows in other reaches of Bear Creek.
7. According to FEMA FIS, only local drainage is in Black Rascal Creek between the Diversion and the confluence with Fahrens Creek.
8. Cost Includes Design, Construction, and "Average" Environmental Costs. Does not include right-of-way or real estate costs.

FIGURE 4 – Location of Possible Levee and/or Channel Widening Projects

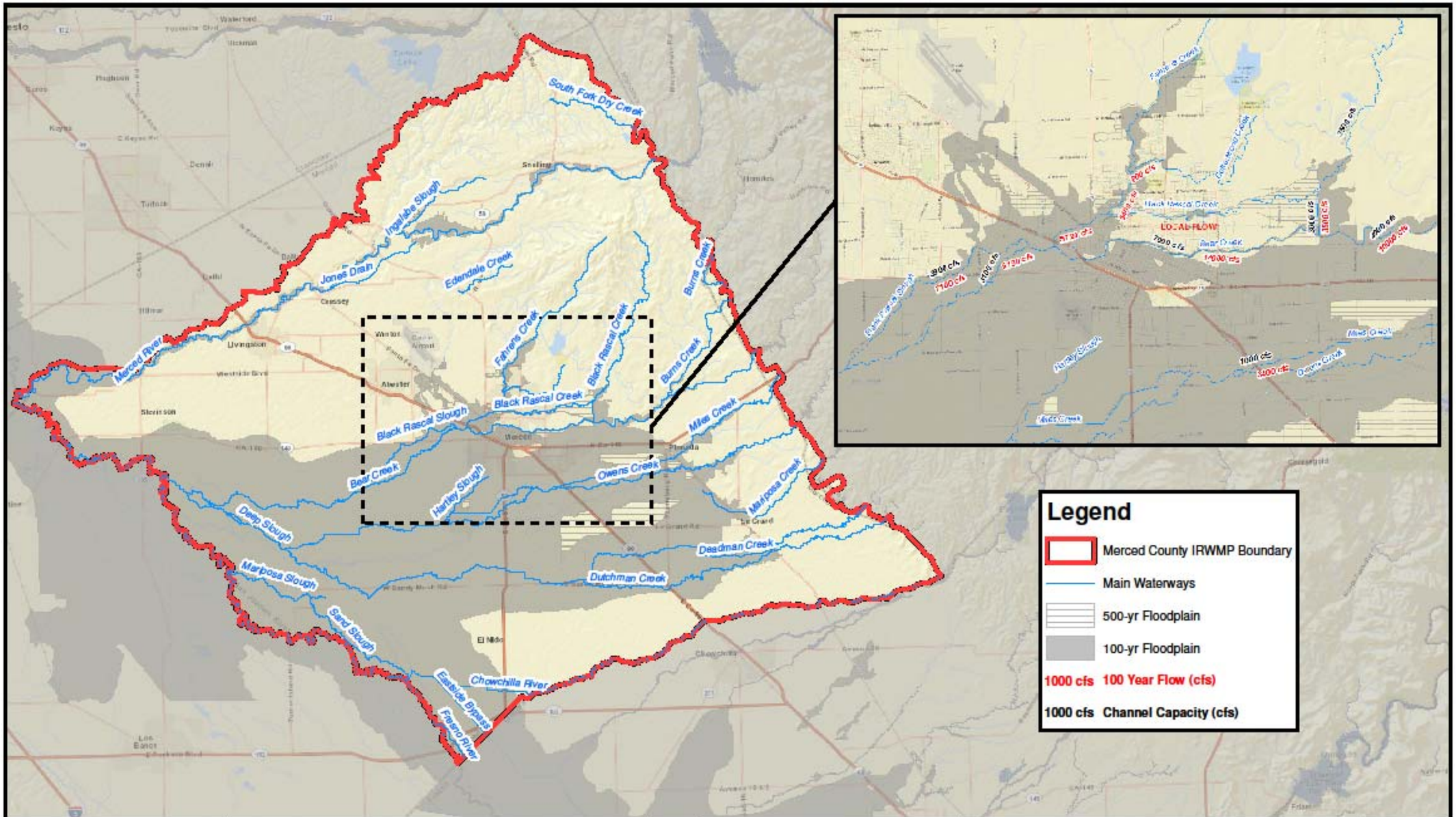


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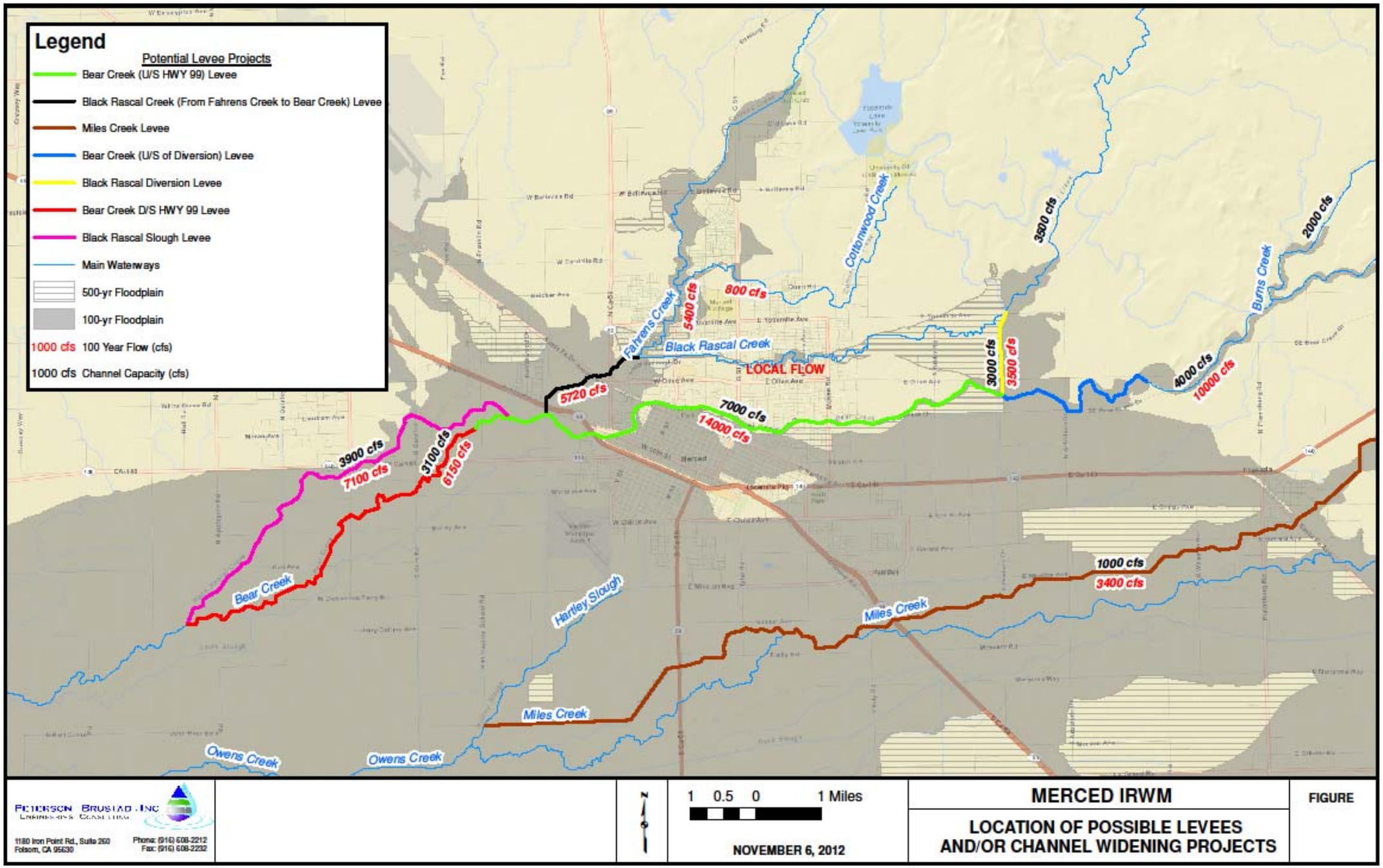
FIGURE 5 – Location of Possible Levee and/or Channel Widening Projects



CHANNEL DREDGING AND/OR VEGETATION REMOVAL

PLANNING LEVEL COST ESTIMATE = $50k per River-Mile

Streams, creeks, and rivers within the Merced Region are periodically choked with vegetation causing channel capacities to be exceeded during major floods. Removing some of this vegetation and/or excavating the channel would increase the carrying capacity and decrease the flood risk for select areas. This option may benefit reaches of Bear Creek, Black Rascal Creek, and Black Rascal Slough where current channel capacities are well below the 100-year level. This option may be implemented as a capital improvement project, or implemented via current Operations and Maintenance activities.

MODIFY LAND USE

PLANNING LEVEL COST ESTIMATE = N/A

Merced County currently imposes development restrictions for Special Flood Hazard Areas (Chapter 18.34 of the County Code) in accordance with FEMA and the NFIP. Merced County's Floodplain Land Use Ordinance also provides formal primary and secondary floodplain zones along streams and describes limitations on land uses in these zones. In addition, City of Merced ordinances prohibit encroachment on land between Bear Creek.

Modifications to the existing land use designations within the Merced Region could be direct growth outside of the floodplain. New options include: imposing elevation requirements for new development within the 200-yr or 500-year floodplain, limiting or restricting new development within the 200-yr or 500-year floodplain in accordance with SB-5 requirements, or designating permanent agricultural zones. While this option may inhibit economic growth in floodplains, it may reduce residual flood risk and ultimately cost less than flood control system capital improvements.

DEVELOP EMERGENCY RESPONSE PLANS

PLANNING LEVEL COST ESTIMATE = $100,000

The objective of an emergency response plan is the prevent loss of life; reduce physical damage to public and private property (evacuation equipment, pre and post flood fight materials, etc.); plan for speedy recovery; and disaster management and communication. The development of emergency response plans are typically a low-cost/high benefit option for mitigating flood risk.

RING LEVEES AROUND FLOOD-PRONE AREAS

PLANNING LEVEL COST ESTIMATE = $3M-$10M per Levee Mile (Excludes ROW Costs)

A ring levee is a levee that completely encircles an area subject to inundation from all directions. These can effectively protect structures or areas from shallow flooding. Ring levees are generally less than 5-feet tall, and have minor impacts to the floodplain outside the ring.

Ring levees may be constructed around single facilities, or could encircle larger areas. For example, Marysville, CA is encircled by a ring levee. A recent residential subdivision on Hotchkiss Tract (RD799) included a ring levee to reduce the likelihood of flood damage to these structures. A key to the feasibility of ring levees, particularly on discrete facilities, is the availability of right-of-way and the acceptability of risk of remaining inside during a flood, with evacuation, and the acceptability of risk of remaining inside during a flood, with evacuation routes cut off.

INCREASE PUBLIC AWARENESS OF FLOODING

PLANNING LEVEL COST ESTIMATE = $50,000

Increasing the public's knowledge about flood risk is another non-structural alternative for mitigating flood risk. In addition to improving safety during floods, the efforts can also enhance public support of flood control projects. Typical forms of outreach include press releases, individual mailer brochures, website development, posters, "flood awareness month", and social networking site involvement. Note that the public outreach efforts can often be completed in conjunction with other related projects in order to reduce costs.

FIGURE 6 – Cover of DWR's First Annual Flood Risk Mailer (September 2010)

MERCED COUNTY FLOOD CONTROL DISTRICT

PLANNING LEVEL COST ESTIMATE = $100,000

In the past decade, established flood control agencies have had great success in mitigating flood risk throughout California, due to their singular focus. Examples include the Sacramento Area Flood Control Agency (SAFCA), the Sutter Butte Flood Control Agency (SBFCA), the San Joaquin Area Flood Control Agency (SJAFCA), and the San Joaquin County Flood Control and Water Conservation District (SJCFC & WCD). This option would involve the creation of the flood control agency for the region, either as an adjunct of Merced County, or as a joint powers authority. The agency would be responsible for planning, coordinating, and managing flood control projects for the region.

TABLE 3 – Summary of Project/Policy Evaluation

PROJECT	Improved Emergency Preparedness & Response	Reduces Flood Related Damages	Increased Sustainability of Flood & Water Management Systems	Enhanced Floodplain Ecosystems	Improved Coordination w/ Stakeholders	Meets IRWM Objectives	Wise Use of Floodplain
Black Rascal Creek Dam (Haystack Reservoir)		X	X			X	
Black Rascal Creek Detention Basin		X	X			X	
Existing Channel Excavation and/or Vegetation Removal		X	X			X	
Route Flood Flows to Agricultural Lands		X	X	X		X	X
Develop New Floodplains		X	X	X		X	X
Ring Levees Around Flood-Prone Facilities		X	X			X	X
Detention Basin/ Groundwater Recharge Facility		X	X		X	X	
Levees along Channels		X	X			X	
Modify Land Use		X	X	X		X	X
Emergency Response Plans	X	X	X		X	X	
Increase Public Awareness of Flooding	X	X	X		X	X	
Bear Creek Diversion Channel		X	X			X	
Establish a Regional Flood Control Agency	X	X	X		X	X	

TABLE 4 – Matrix of Project Creek/Stream Applicability

PROJECT	Bear Creek	Black Rascal Creek/Slough/Diversion	Fahrens Creek	Owens Creek, Miles Creek, Mariposa Creek	Other Streams
Black Rascal Creek Dam (Haystack Reservoir)		X			
Black Rascal Creek Detention Basin		X			
Existing Channel Excavation and/or Vegetation Removal	X	X	X	X	X
Route Flood Flows to Agricultural Lands	X			X	X
Develop New Floodplains	X			X	X
Ring Levees Around Flood-Prone Facilities	n/a	n/a	n/a	n/a	n/a
Detention Basin/ Groundwater Recharge Facility	X				X
Levees along Channels	X	X	X	X	X
Modify Land Use	X	X	X	X	X
Emergency Response Plans	X	X	X	X	X
Increase Public Awareness of Flooding	X	X	X	X	X
Bear Creek Diversion Channel	X				
Establish a Regional Flood Control Agency	X	X	X	X	X

GLOSSARY

CVFPB—Central Valley Flood Protection Board

CVFPP—Central Valley Flood Protection Plan

DWR—California Department of Water Resources

FCSSR—Flood Control System Status Report

FEMA—Federal Emergency Management Agency

IRWMP—Integrated Regional Water Management Plan

MSG—Merced County Stream Group

NFIP—National Flood Insurance Program

O&M—Operations and Maintenance

RFMP—Regional Flood Management Plans

SPFC—State Plan of Flood Control

TM—Technical memorandum

ULDC—Urban Levee Design Criteria

ULOP—Urban Level of Flood Protection

USACE—United States Army Corps of Engineers

USFWS—U.S. Fish and Wildlife Service

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