10. System-Wide Improvements

10.1. Overview

The 2012 Central Valley Flood Protection Plan (2012 CVFPP) describes the State System-wide Investment Approach (SSIA) which is the State's strategy for addressing flood risk reduction within the Central Valley (see Chapter 1 for a more detailed discussion of the 2012 CVFPP and the SSIA). The physical elements of the SSIA are organized into regional, and system-wide elements. The SSIA considers regional elements to be those physical actions or projects that provide local and regional benefits for urban areas, small communities, and rural agricultural areas. The SSIA considers system-wide elements to be those physical actions or projects which provide cross-regional benefits, and improve the overall function and performance of the State Plan of Flood Control. The system improvements discussed in the 2012 CVFPP and included in the SSIA, are largely related to expansions of the bypass and weir system. The 2012 CVFPP includes one new surface water storage project, the Folsom Dam Raise, which was authorized by the Energy and Water Development and Appropriations Act of 2004. The State intends to take the lead in developing and implementing the system improvements envisioned under the SSIA. It is anticipated that the State's Basin-Wide Feasibility Study for Sacramento River System will provide greater detail of the SSIA system improvements which the State intends to pursue.

Regional and local stakeholder have expressed concerns that the 2012 CVFPP suggested system improvements, such as expanded bypasses and associated large-scale ecosystem enhancements, were not thoroughly vetted at the local and regional level during development of the 2012 CVFPP. The purpose of this chapter is to discuss system-wide improvements which have the potential to impact MUSR RFPM areas. It is important to note that there are other actions discussed elsewhere in the MUSR RFMP which provide system-wide benefits. However, the intent of this chapter is to capture those additional actions which have not been discussed previously within the MUSR RFMP.

10.2. Surface Water Storage - Reservoirs, Detention Basins, Transitory Storage, and Groundwater Recharge

10.2.1. *Sites Reservoir*

The site of the proposed Sites Reservoir is located in north-central Colusa County and south-central Glenn County, approximately 10 miles west of the community of Maxwell. Water would be diverted from the Sacramento River to fill the reservoir and the proposed reservoir will primarily inundate grassland currently used for cattle grazing. The reservoir is in the Funks Creek and Stone Corral Creek watersheds (59,700 acres). The proposed project contains substantial fisheries enhancements such as increasing the Shasta Lake cold water pool. The project also includes modifications to the Glenn-Colusa Irrigation District intake and a potential new diversion opposite Moulton Weir (which would require a fish screen). A mean full pool elevation of 520 feet would inundate 14,000 acres and could store a maximum of 1.81 MAF.

The project is currently being evaluated under the North-of-the-Delta Offstream Storage (NODOS) feasibility studies, which are underway and being directed by the U.S. Bureau of Reclamation, DWR, and the Sites Joint Powers Authority.

Alternative reservoir sizes of 1.27 and 1.81 MAF are under consideration. At 1.27 MAF, six saddle dams and two major dams (Sites and Golden Gate Dams) would be required. At 1.81 MAF, Sites Reservoir would require the construction of two major dams (Sites and Golden Gate Dams) and nine saddle dams along the southern edge of the Hunters Creek watershed. Diversions from the Colusa Basin Drain (CBD), the Sacramento River, Stony Creek, and local tributaries would provide potential sources of water supply for the Sites Reservoir project.

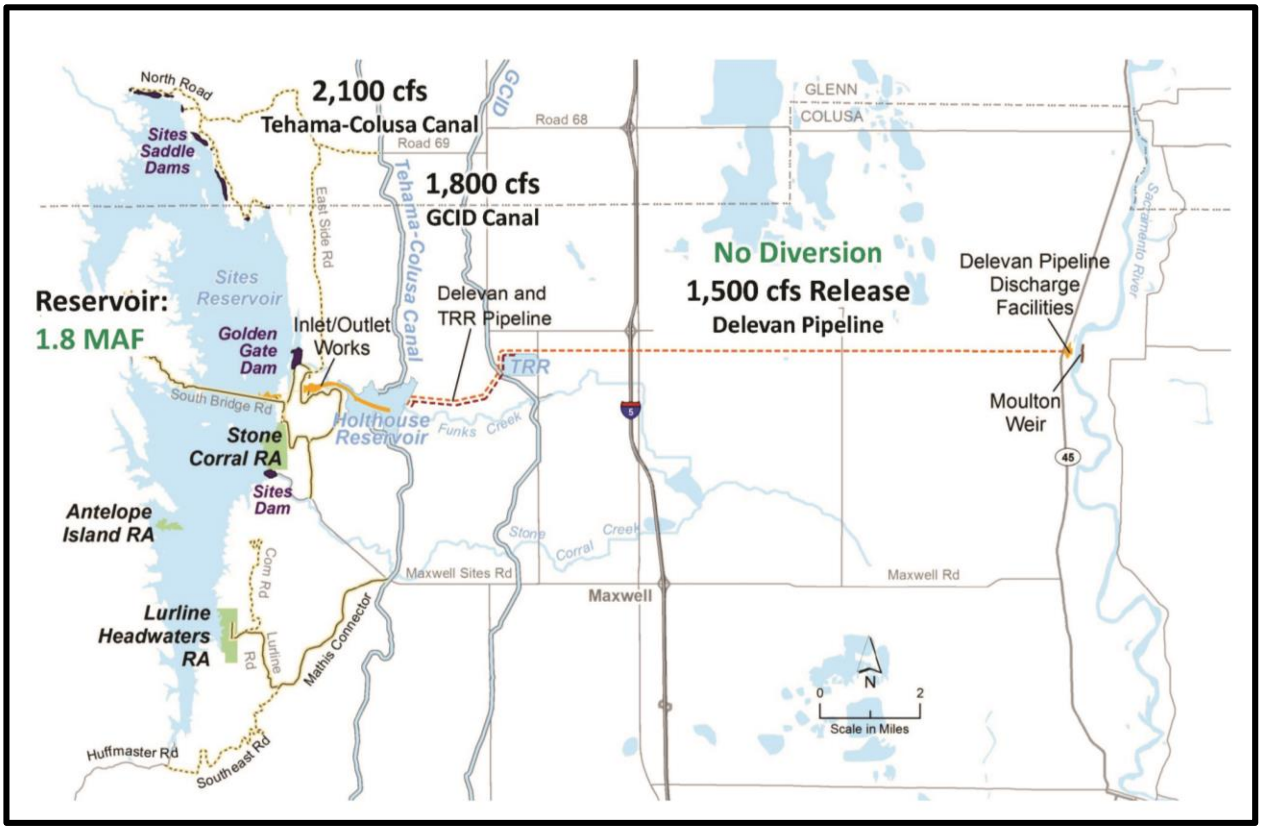
The total project cost is estimated at $2.3 to 3.2 billion depending on conveyance options. The annual costs for operations, maintenance and power are estimated at $10 to $21 million. These estimates are based on preliminary feasibility studies and include all capital costs for construction, engineering, administration, environmental compliance and mitigation (including the costs of relocating infrastructure), legal, real estate and contingencies.

Sites Reservoir will add flexibility to the state's water management system and can provide unique benefits which include, but not limited to:

- Enhanced water supply reliability for urban, agricultural, and environmental uses
- Improved Delta water quality
- Mitigation of snowpack storage losses due to climate change
- Contribute to flood damage reduction in the Central Valley
- Ecosystem restoration actions in the Sacramento River
- Dedicated storage that can be adaptively managed to respond to Delta emergencies and help with restoration actions

The NEPA/CEQA process is underway to identify potential environmental impacts and mitigation measures. After appropriation of state and federal funds, there will be a two-year design phase followed by a five to seven year construction phase, for a total of seven to nine years. The current planning schedule shows project construction to be completed in 2025.

Figure 10-1. One of the Configurations for the Proposed Sites Reservoir (Alternative B)



10.2.2. *Oroville Dam Improvements*

The State Water Project (SWP) of DWR operates Oroville Dam and Lake (Oroville). It is the second largest state reservoir in northern California (Shasta lake is the largest), with more than 167 miles of shoreline. It is also the tallest dam in the United States, measuring 770 feet high – 44 feet taller than Hoover Dam – and 6,920 feet across. The lake is located where the North, Middle, and South Forks, and the West Branches of the Feather River join. Lake Oroville is operated for multiple purposes, including flood control.

The reservoir captures drainage from a 3,611 square-mile watershed. It provides a full pool with 3,538,000 acre-feet of storage, up to 750,000 acre-feet of which is governed by flood control regulations. The emergency spillway at Oroville Dam is 1,730 feet long with a crest elevation of 901feet msl. Thermalito Afterbay (Thermalito) is located downstream from Oroville Dam. It has 45,000 acre-feet of reservoir storage space for re-regulation of Oroville power releases.

The operational flood control rules for Oroville are determined by the USACE (1970) and published in the Oroville Dam and Reservoir Flood Control Manual. The Flood Control Diagram (FCD) and Emergency Spillway Release Diagram (ESRD) contained in that manual together govern the flood control releases from Oroville. The operational flood rules dictate the amount of flood space that is required to be made available and provide criteria for determination of outflows from Oroville during a flood event.

The amount of flood control space in Oroville is a function of the time of the year and the seasonal accumulation of precipitation for the reservoir's drainage basin. No flood space is required from June 15 to September 15. During the peak flood season (October 15 – March 31), the flood control space varies between 375,000 and 750,000 acre-feet, depending on the accumulated precipitation parameter prescribed in the flood control manual.

There are several release restrictions on Oroville Dam and Reservoir:

- The first constraint is that maximum flood control releases should not exceed 150,000 cfs.
- The second constraint is that flows should not exceed 180,000 cfs flow just upstream of the mouth of the Yuba River. However, in practice, this rarely constrains operations since a combined 30,000 cfs contribution of local inflow to the Feather River (i.e., Honcut Creek, local accretions) between Oroville and Yuba City would be required in order to limit Oroville outflow to anything less than the release of 150,000 cfs.
- The next downstream condition that potentially limits the outflow from Oroville is the 300,000 cfs Feather River target flow below the mouth of the Yuba River. Regulating outflows for this requirement at Oroville implies a foreknowledge of the flow in the Yuba River at its mouth, and therefore, Oroville operations must rely on a forecast of the Yuba River flow at Marysville (the New Bullards Bar outflow and the unregulated South and Middle Yuba River flows) to meet this target. The Yuba River flow at its mouth must exceed 120,000 cfs before Oroville operations are affected.
- The final downstream peak flow constraint on Oroville outflow is the 320,000 cfs target for flow below the Bear River.

In addition, the rate of increase in releases and decrease in releases must not exceed 10,000 cfs and 5,000 cfs per two-hour period, respectively. The maximum rate-of-decrease criterion is the more influential of these two for large flood events. In some cases, the rapidly peaking flows of the Yuba River require cutbacks in Oroville releases to keep total flows below the combined flow targets downstream of the Yuba and Bear rivers, but the required cutback rates greatly exceed the 5,000 cfs per two-hour target. The only practical solution is to operate for a target flow of less than 300,000 cfs below the Yuba River. This condition would only exist for floods significantly larger than the 1997 flood.

The emergency spillway at Oroville was designed to pass a flood with a peak inflow of 718,000 cfs, yielding an outflow of 623,200 cfs operating with the use of the FCD and ESRD.

The ESRD computes a required release from Oroville based on the elevation and rate-of-rise of the reservoir. The ESRD becomes active when required releases under the ESRD become larger than the release specified by the FCD. It is important to note that this diagram uses the rate of rise criteria as a surrogate for reservoir inflow.

ESRD was created with the assumption that the Marysville Dam would be constructed on the Yuba River. With Marysville Reservoir in place, approximately 120,000 cfs would enter the Feather River from the Yuba River during major flood events. Since Marysville Reservoir has not been constructed, a large portion of the Yuba River flow is unregulated, and the Yuba River contribution to the Feather can exceed 200,000 cfs during flood events. Consequently, Oroville must reduce outflows to avoid exceeding its flow target downstream of Marysville-Yuba City under such a condition. The Flood Control Manual requires that, until Marysville Dam is constructed, Oroville's outflow gates be operated to hold 150,000 cfs while the reservoir surcharges up to the elevation of the emergency spillway. The reduced outflows from Oroville mean greater rates of rise in Lake Oroville levels. Consequently, the ESRD activates sooner, and could result in emergency releases that are larger than would be required if Marysville Dam was in place. The ESRD controls outflows at Oroville for floods larger than the 1 in 150 annual expectancy probabilities (AEP).

The spillway of the Oroville emergency spillway is an unprotected hillside, which would suffer severe erosion in the event that the emergency spillway is used. The hillside damage, as well as the downstream transport of eroded soil and rock, would both be operational concerns, leading to consideration of options for limiting such structural damage under large flood scenarios. Erosion of the hillside would also release large amounts of soil and rock into the channel downstream, with potential impacts on downstream channel capacity and environmental quality. Therefore, erosion protection for this hillside may be considered a long-term investment in the integrity and environmental quality of the channel system downstream of the dam. By eliminating this operational concern, there is a greater likelihood that DWR would elect to surcharge the reservoir rather than exceed the 150,000 cfs objective release during major flood events, such as occurred during the 1997 New Year's Flood.

There may also be opportunities to upgrade facilities, including gates, spillways, dam raises, and power plants to improve reliability, efficiency, capacity and performance.

10.2.3. *Shasta Dam & Lake Expansion*

Constructed between 1938 and 1945, Shasta Dam and Lake (Shasta Dam) serves multiple purposes, including navigation, flood control, irrigation and municipal and industrial water supplies, hydropower generation, and fish and wildlife conservation. These purposes significantly contribute to California's economy. In addition, through its extensive recreational resources, Shasta Dam is a critical component of the regional economy of Northern California.

Releases from Shasta Dam often are made for flood management. Releases for flood management occur either in the fall, beginning in early October, to reach the prescribed vacant flood space, or to evacuate space during or after a storm event to maintain the prescribed vacant flood space in the reservoir. During a storm event, releases for flood management occur either over the spillway during large events or through river outlets for smaller events. Between 1950 and 2006, flows over the spillway occurred in 12 years, or in 21 percent of years. During the same time interval, releases for flood management (either for seasonal space evacuation or during a flood event, and including spills over the spillway) occurred in about 37 years, or nearly 70 percent of the years.

Shasta Dam provides flood protection to the nearby communities of Redding, Anderson, Red Bluff, and Tehama, as well as to agricultural lands, industrial developments, and communities downstream along the Sacramento River. Shasta Dam is operated for an objective release of 100,000 cfs at Bend Bridge in Red Bluff, and the Reservoir capacity is 4,552 TAF. The end-of-September storage target for Shasta Lake is 1,900 TAF, except in the driest 10 percent of water years, to conserve sufficient cold water for meeting temperature criteria for the winter-run Chinook incubation period (summer to early fall). Storage levels are lowest by October to provide sufficient flood protection and capture capacity during the following wet months. The storage target gradually increases from October to full pool in May. Storage is then withdrawn for high water demand (i.e., municipal, agricultural, fishery, and water quality uses) during summer.

A storage space of up to 1.3 MAF below a full pool elevation of 1,067 feet is also kept available for flood management purposes in Shasta Lake in accordance with the *Shasta Dam and Lake Flood Control Diagram*, as prescribed by USACE (USACE 1977). Flood control diagrams are used to define the amount of vacant storage space is to be kept available for flood management purposes over a specified time interval. Under the Shasta Dam diagram, flood management storage space increases from zero on October 1 to 1.3 MAF (elevation 1,018.55) on December 1, and is maintained until December 23. From December 23 to June 15, the required flood management space varies according to parameters based on the accumulation of seasonal inflow. This variable space allows for the storage of water for conservation purposes, unless it is required for flood management based on basin wetness parameters and the level of seasonal inflow. Daily flood management operation consists of determining the required flood storage space reservation, and scheduling releases in accordance with flood operations criteria.

As discussed in Chapter 3, an increase to the storage capacity of Shasta Dam is currently proposed by the USBR and is currently in the Feasibility Analysis stage of project development. A draft feasibility report was released in February 2012, which recommended an 18.5 foot increase to the dam as the feasibility analysis shows this to have the greatest net economic benefits. The USBR released the project environmental impact statement (EIS) in July 2013 (USBR, 2013). The 14% (634,000 acre-feet) increase in storage capacity has primary objectives of anadromous fish survival and water supply reliability, with reduced flood damage being a secondary objective. The construction cost is estimated at $1.07 billion (USBR, 2013), and the current schedule shows potential construction beginning in 2020.

10.2.4. *Reservoir Reoperation (Forecast-Coordinated and Forecast-Based)*

The coordinated operation of Oroville and New Bullards Bar reservoirs required by the USACE reservoir operations practice for both reservoirs, led to the creation of the Forecast-Coordinated Operations (F-CO) program under FloodSAFE California in 2005. The F-CO Program seeks to coordinate flood releases from the reservoirs located in various tributaries of a major river to optimize the use of downstream channel capacity, the use of total available flood storage space in the system, and eventually to reduce overall peak floodflows downstream from these reservoirs (2012 CVFPP). The key elements of the program include the following.

- Improving flood forecasts;
- Closely integrating the reservoir flood operations to minimize peak downstream river flood flows;
- Identifying changes in operational procedures that would improve efficiency; and

- Providing operators and downstream emergency managers with real-time forecast information including uncertainty bounds associated with the flows at key locations in the flood system.

The 2012 CVFPP identified implementation of Forecast-Based Operations (F-BO) of Central Valley reservoirs as the next logical step in advancing the F-CO Program. The intended F-BO would involve the use of improved long-term runoff forecasting and operating within the parameters of an existing flood control diagram. Proactive reservoir management through the use of more flexible flood control diagrams would require extensive studies of the most feasible diagrams, environmental documentation for changing reservoir operations, and Congressional approval for new dynamic flood control diagrams. The SSIA includes implementation of both F-CO and F-BO for all reservoirs in the Central Valley and MUSR RFMP stakeholders would like the Basin-Wide Feasibility Study to evaluate how their implementation could be used to minimize proposed expansions of the system footprint.

10.2.5. *Cottonwood Creek Basin Reservoirs*

Cottonwood Creek is located approximately 100 miles northwest of Sacramento. It is the third largest watershed tributary west of the Sacramento River with 938 square miles and the largest undammed tributary in the upper Sacramento River basin (CALFED 1997). It has a north and middle fork with Beegum Creek as a major tributary. Average flows are 19,400 acre-feet/month during the summer, near the town of Cottonwood (Blodgett, Walters, Borchers 1982-85). The largest floods on record were March 1983 with 86,000 cubic feet per second and January 1974 with 70,000 cubic feet per second. In the watershed profile for the public draft recovery plan for the National Marine Fisheries Cottonwood Creek, salmon population is listed as dependent on larger populations from Deer and Mill Creek. (NOAA 2005)

Initial water development planning studies in the Cottonwood Creek Basin were conducted by the United States Bureau of Reclamation in the mid-1940s. Since then, both the U.S. Army Corps of Engineers and DWR have taken turns studying the potential of establishing reservoirs in the area. In July 1985, DWR started the first of a series of studies to evaluate the engineering and economic feasibility of the tributary reservoirs. The Corps terminated their work on the project in October 1985. In 1987, DWR reported on a two-year pre-feasibility study of the Dippingvat-Schoenfield Project on South Fork Cottonwood Creek and Red Bank Creek. The objective of the study was to develop information on the Dippingvat-Schoenfield alternative (Red Bank Project) comparable to that available on the other Cottonwood Creek tributary projects as a basis for selecting one project for further study at the feasibility level. In 1995, the CALFED Bay-Delta Program was established to develop a long-term, comprehensive plan that will restore ecological health and improve water management for beneficial uses of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Early in the process, CALFED compiled a list of 52 potential surface storage projects in the Central Valley and began an initial screening to reduce the number of sites to a more manageable number for more detailed evaluation. Forty storage sites were removed from the initial list. Of the remaining 12 storage sites, four were grouped under the heading "North of the Delta Offstream" storage alternatives. Those four alternatives are titled the Red Bank Project, the Thomes-Newville Project, the Colusa Project, and the Sites Project.

The Red Bank Project was originally proposed with two major dams to create 350 thousand acre-feet of storage in Dippingvat Reservoir on South Fork Cottonwood Creek and Schoenfield Reservoir on Red Bank Creek. Two small dams and reservoirs, Lanyan and Bluedoor, would be part of the conveyance from Dippingvat to Schoenfield. Most of the water supply for this project would come from South Fork Cottonwood Creek. Floodflows would be diverted for short-term storage in Dippingvat, and then diverted to Schoenfield, the main storage reservoir. Study of the Red Bank Project was ultimately discontinued under the CALFED effort, but members of the MUSR RFMP stakeholders group believe the project should be reconsidered in light of the Central Valley Flood Protection Act of 2008, and the 2014 Governors California Water Action Plan (GCWAP) called for expanded water storage capacity and increased flood protection. The Cottonwood Creek storage project could achieve both of these goals.

10.2.6. *Colusa Basin Drainage District Detention Basins*

The Colusa Basin drainage area consists of 1,036,000 acres (1,620 square miles) in northern California within Glenn, Colusa and Northern Yolo Counties. Within this area, the Colusa Basin Drainage District included more than 600,000 acres of the Sacramento Valley, spanning from Knights Landing in the south northward to the City of Orland, with the Sacramento River and the foothills forming the east and west boundaries. Most of the land within the District is devoted to agricultural production including irrigated crops, orchards, vineyards and grazing lands. Total irrigated land is approximately 466,000 acres. The Colusa Basin contains 13 significant watersheds that drain winter storm runoff into the basin's main drainage facility, the Colusa Basin Drain.

The Colusa Basin Drain was constructed by RD2047 to collect and reuse irrigation return flows in a manner that reduced flooding problems downstream from the irrigated areas. The Colusa Basin Drain was originally designed to carry summer and fall irrigation return flows, not winter and spring flood flows. The Colusa Basin Drain extends from its junction with Willow Creek south to the vicinity of Colusa and then follows the alignment of the RD108 Back Levee, terminating at the Knights Landing Outfall Gates on the Sacramento River in Yolo County. The Outfall Gates were installed in 1913 separating the Colusa Basin Drain from the Sacramento River and to allow releases up to 1,450 cfs from the Colusa Basin Drain to the Sacramento River when the Sacramento River stage is lower than the Colusa Basin Drain stage.

The Knights Landing Ridge Cut was constructed to provide an alternate outlet for Colusa Basin Drain and Colusa Basin Watershed flood waters. The Ridge Cut provides drainage down valley to the Yolo Bypass in the winter and spring when releases to the Sacramento River are generally prevented by high stage. The Ridge Cut provides an alternate gravity outlet for lower Colusa Basin floodwaters. It reduces the duration of flooding, but it does not prevent flooding; when the Yolo Bypass stage is high, the backwater effect can extend upstream as far as College City. This also creates an additional backwater effect in the lower reaches of the Colusa Basin Drain

The Colusa Basin drainage area has suffered repeated damage from winter flooding, and the Colusa Basin Drainage District (CBDD) was created in 1987 to deal with flooding that occurs within the Colusa Basin Watershed. (CBDD does not manage the Colusa Basin Drain.) Currently, flooding in the Colusa Basin Watershed typically takes place between October and

April. The primary cause of flooding is inadequate conveyance capacities in the Colusa Basin Drain and in the many ephemeral streams throughout the watershed. Flood flows from the foothill streams are extremely flashy and flow swiftly into the Colusa Basin Drain during rain events. MUSR RFMP stakeholders that are familiar with the local flooding patterns agreed that current flood control efforts should begin in the foothills on the west side of the watershed. They expressed the need to slow water down in the foothills in order to reduce flooding in the valley.

Beginning in 1991, CBDD commissioned a series of studies and investigations culminating in reports that assessed potential methods to reduce the potential for flood damage while improving overall watershed health. CBDD has identified measures to accomplish these goals including: increasing populations of perennial vegetation in the foothills to create a "sponge effect," allowing streams to reconnect to flood plains, and creating detention basins in or adjacent to streams. CBDD's studies have determined that detention basins can be used to control the magnitude and timing of the peak runoff from the watershed to reduce flooding. Potential detention basin locations in the Upper Watershed (Wilson Creek and South Fork Willow Creek) were identified based on favorable topography, land use, and soils.

For these detention basin, embankments would be constructed at locations along the creeks where topographic conditions allow for a maximum height and resulting storage. During storm events, water exceeding a threshold flow would be held back by the embankments, resulting in decreased downstream flooding. The water that is temporarily stored in the detention basins would then be released slowly after the flood event has subsided. Therefore, the lands in the detention basins would only be inundated for relatively short periods (up to several days) after major storm events. The design of the detention basins could include habitat creation. These practices would also afford multiple natural resource benefits such as groundwater recharge, enhanced habitat, reduced erosion and sedimentation and a reduction of residual chemicals coming out of the foothills during heavy rain events.

10.2.7. *Butte Sink and Colusa Drain Transitory Storage*

10.2.7.1. Butte Sink:

The Butte Basin (also referred to as the Butte Sink) is a natural overflow area that extends south of Big Chico Creek to the Sutter Buttes. Located along the western boundary of Butte County and the eastern boundary of Glenn County, it is bisected by State Highway 162 and located approximately halfway between State Highways 99 and 45.

Degradation of the 3 B's weir has resulted in increased frequency and volume of flooding in the middle and lower parts of the Butte Basin watershed (see more detailed discussion in Section 10.3.1). The increased frequency of flooding has particularly become an issue for agricultural production lands and associated facilities, and for the human-inhabited reaches such as the residential areas along the middle section of Butte Creek and Cherokee Canal. Limited road access is very problematic for emergency response and evacuation planning in this area. Major roadways, such as Ord Ferry Road and Highway 162, become inundated when flood waters enter the basin and bridge crossings over the Sacramento River become inaccessible. In addition, when water levels rise in the Butte Sink, backwater effects have far reaching impacts, such as limiting the flow conveyance of Cherokee Canal and limiting the interior drainage capabilities for the areas southwest of Chico and for the northwestern areas of the Sutter Basin. Also it can be a source for attracting and entraining salmonids from Butte Creek.

The Butte Sink is a critical component of the Sacramento River Flood Control System and it provides essential storage which detains and attenuates peak flood flows. However, there is currently a relative lack in definition of this existing system-wide benefit. No established flood flowage easements currently exist and no compensation is currently received by existing landowners who are inundated and impacted by the high water flooding within the Butte Basin. In addition, there are no existing mechanisms in place to protect this essential function from further growth and future development. Recognizing, quantifying, and establishing an approach for protecting the system-wide transitory storage benefits which are already provided by private property agricultural lands within the Butte Sink is important.

10.2.7.2. Colusa Basin Drain:

Similar to the Butte Sink, the Colusa Basin Drain is a critical component of the Sacramento River Flood Control System and it provides essential storage which detains and attenuates peak flood flows. Colusa Basin Drain extends from its junction with Willow Creek south to the vicinity of Colusa and then follows the alignment of RD 108's back levee, terminating at the Knights Landing Outfall Gates in Yolo County.

The Colusa Basin Drain was originally constructed to provide drainage for agricultural production, not to provide conveyance for winter flood prevention. As agricultural production and volumes of applied irrigation water have expanded, the drain has also been shown to be undersized in places for handling summer irrigation return flows. The typical pattern of flooding occurring along the Colusa Drain is primarily the result of runoff from foothill streams during the winter and releases of irrigation water from rice fields during the summer. Its original capacity was approximately 1,450 cfs with 1 foot of freeboard; current capacity is about 2,100 cfs at Highway 20 and approximately 12,450 cfs at Knights Landing.

When water levels rise in the Yolo Bypass, the resulting hydraulic barrier prevents the Knights Landing Ridge Cut and other areas upstream from effectively draining. The water that runs off of the western foothills thus runs up against the Colusa Drain levees and forms an unintentional lake which threatens the City of Colusa, major commerce/evacuation routes (such as Interstate 5 and Highway 20), along with homes and agricultural infrastructure up and down the basin. Also, the Colusa Drain can be a source of attracting and entraining salmonids from the Sacramento River.

The locally preferred option for reducing the flood risks posed by the Colusa Basin includes the construction of flood control reservoirs in the western foothills, in combination with other watershed management practices, such as the potential establishment of transitory storage agreements with existing stakeholders.

10.2.8. *Transitory Flood Water Storage & Flowage Easements*

Although specifically applicable to areas within the Butte Sink and Colusa Basin Drain, transitory flood water storage areas and flowage easements may become a significant element of future flood management planning efforts. The terms "transitory flood water storage areas", and "flowage easement areas" need to be clearly defined and subject to broad stakeholder agreement. If these concepts are pursued through the Basin-Wide Feasibility Study effort, they should be done so with the principle that they need to support the continued capability of agricultural operations to diversify and remain flexible to meeting changing market demands and crop production technology. The concepts and distinctions of each require an unambiguous and clearly characterized description.

Transitory storage areas should be defined as areas negotiated and mutually agreed to as suitable and designated to provide temporary flood water storage relief on private or public properties, which have been strategically identified in the flood control system and utilized during times of extraordinary and/or emergency storm or flood events. Transitory storage should be undertaken in a planned and coordinated manner with all affected landowners, including compensation and post-flooding recovery plans developed to the satisfaction of all parties. Additional notes regarding some of the common types of transitory storage agreements is provided below.

- The involved agency(ies) must consider, discuss, and identify such areas in an early, transparent, and open manner with the affected landowner(s), and with the participation of the local flood control agency(ies)
- Fair value for such areas must recognize the public desire and need of such areas or properties for the overall system-wide benefit of functioning as emergency flood control and protection of the urban areas
- Identify areas with minimal human occupation and activity
- Identify areas with minimal number of ownerships or larger single ownership properties
- Identify areas with minimal costly farming or agricultural support infrastructure
- Identify areas with minimal cropping diversity such as large common field crop production fields
- Identify areas with least cost and easily established, required, and implementable farming reconstitution needs and recovery efforts
- Appropriate easements must be perfected and consummated to identify and secure such properties (i.e.; include timeframe of storage use, responsibilities of parties, etc.)

Flowage Easements should be defined as areas negotiated and mutually agreed to as the most suitable for existing or expanded flood conveyance, and which are strategically located with the following considerations:

- The involved agency(ies) must consider, discuss, and identify such areas in an early, transparent, and open manner with the affected landowner(s), and with the participation of local flood protection governing agency(ies)
- Fair value for such areas must recognize the public desire and need of such areas or properties for the overall system wide benefit

- Identify property areas that are easily separated physically and naturally from other properties in the basin area and other impacted areas
- Identify areas with minimal human occupation and activity
- Identify areas with minimal costly farming or agricultural support infrastructure
  The easement should be designed to maximize the owner's continued future use of the property while still being consistent with the purpose and need for the easement.
- Payments to compensate for the reduced usefulness of the property should be flexible enough to be provided to the owner in a revenue stream that best meets their particular needs.
- In some cases, there will be a large up-front payment with smaller payments over the years to reflect the more limited use of the property. In other cases, it may be a smaller up-front payment with a more substantial residual payment stream. The payment stream should also recognize larger balloon payments to compensate the owner for property damage and restoration costs after a flood event.

10.3. Conveyance Improvements

10.3.1. *3B's Weir Improvements*

The 3B's is one of the three low points on the east side of the Sacramento River where floodwater flows away from the main river channel during high flows. The 3B's is critical to the operation of the Butte Basin but was never designed or constructed to operate as a Flood Relief Structure (FRS), and is not actively maintained. The result is that head cuts allow overflows into the Butte Basin when the Sacramento River is well below flood stage, resulting in damages to infrastructure and agriculture and reducing the storage capacity of Butte Basin for a major storm event. Modifications of the existing 3B's area for proper weir design, maintenance and operation would have the dual benefits of reducing the frequency of flood damages in the Butte Basin, while reserving transitory storage capacity for major storm events.

The State Plan of Flood Control relies on the 3B's weir to reduce peak flows downstream on the Sacramento River as overflow in the Butte Basin is essential to the success of the downstream flood management system along the Sacramento River. The Central Valley Flood Protection Board requires the elevation of 3B's weir to remain at or below the elevation required for flood flows to overtop when the gage at Ord Ferry Bridge reaches 114 feet (NGVD29), which is roughly equivalent to a flood flow of 100,000 cfs. However, based upon information from local stakeholders, the weir currently overtops when the gage reaches an elevation of ~110 feet (NGVD29). Restoring the 3B's to elevation 114 feet and developing and implementing a plan for long-term maintenance and operation would help to preserve the flood storage capacity of the Butte Basin for major storm events and would help eliminate the unnecessary damage that occurs to roads, property, agriculture, and infrastructure.

10.3.2. *Colusa, Moulton, and Tisdale Weir Improvements*

The Sutter bypass and the Butte Sink, in combination with their associated control features – the Moulton, Colusa, and Tisdale weirs function as the central backbone of the Sacramento River Flood Control Project for the MUSR region, redirecting damaging floodflows away from the main channel of the Sacramento River. In the 2012 CVFPP, DWR proposed to investigate during development of the Basin-Wide Feasibility Study, modifying the function and operation of these weirs. Concepts mentioned in the 2012 CVFPP included physically lowering crests of overflow weirs and modify operations so that bypasses carry flows earlier and for longer durations during high river stages, and improving fish passage. Generally MUSR stakeholders are supportive of weir improvements that would reduce flood stage in the Sacramento River, and improve fish passage, and look forward to the reviewing the Basin-Wide Feasibility Study proposals for these facilities.

10.3.3. *Fremont Weir/Yolo Bypass Modifications*

DWR is working with a number of stakeholders in evaluating the modifications to the Fremont Weir (lengthening) and Yolo Bypass (widening) proposed in the 2012 CVFPP. Generally, stakeholders within the Mid and Upper Sacramento River Regions are supportive of improvements to the Fremont Weir and Yolo Bypass which have the potential to provide a direct benefit to stakeholders in the Regions by lowering stages in the Sutter Bypass and Sacramento River. In addition, modifications which lower the stage and decrease the duration of high water in the Yolo Bypass would benefit the areas affected by the backwater flooding of the Colusa Drain as the Knights Landing Ridge Cut does not effectively drain when there are high stages in the Yolo Bypass. Therefore, the Yolo Bypass enhancements must be carefully planned since water can flow backward (to the north) through the Cut if the water in the bypass becomes higher than that in the Colusa Basin. This can affect lands as far north as the City of Colusa, which is commonly threatened by backwater of the Colusa Drain during times of flooding.

10.3.4. *Cherokee Canal*

Cherokee Canal is a channelized portion of Dry Creek that flows southwesterly from central Butte County to the Butte Sink. Tributaries of Dry Creek/Cherokee Canal include Clear Creek, Gold Run Creek, and Cottonwood Creek. Cherokee Canal is mainly used for irrigation, drainage, and protection of agricultural lands, buildings, and homes. Cherokee Canal flows into the Butte Sink, forms the majority of the northern boundary of the Sutter Basin area, and is surrounded by highly productive rice cultivation.

Cherokee Canal is a component of the SPFC that conveys floodwater originating in the foothills north of the Thermalito Forebay and Afterbay complex. The contributing watershed includes the site of the former Cherokee hydraulic gold mine. During active hydraulic mining of the Cherokee Mine between 1854 and 1916, approximately 51 million cubic yards of sediment were washed into Dry Creek (the un-channelized upper reach of Cherokee Canal). There is accumulated sediment in the creek and valley downstream of Highway 70 that is presently being commercially mined for sand and gravel.

The SPFC facilities consist of levees along Cherokee Canal, the lower reaches of Cottonwood Creek and Gold Run Creek. The facilities reduce flood risk to Richvale, agricultural lands, area transportation facilities, and irrigation canals. The facilities are maintained by DWR as Maintenance Area 13.

Downstream of Highway 99, Cherokee Canal is constrained within relatively narrow levees, creating a floodway that, when subject to flood flows, exceeds minimum freeboard relatively frequently. The right-bank levee along Dry Creek and Gold Run Creek extends about 5.2 miles from high ground to the confluence with Cottonwood Creek. The left-bank levee extends about 3.5 miles from high ground to the confluence with Cottonwood Creek. The design capacity of this reach is about 8,500 cfs with 3 feet of freeboard, based on the O&M manual.

The lower reach of Cottonwood Creek has a design capacity of about 3,500 cfs. Right- and left-bank levees, each about 1.3 miles long, extend from high ground to the connection with the Cherokee Canal levees.

Downstream from Cottonwood Creek, the Cherokee Canal has a design capacity varying from 11,500 cfs to 12,500 cfs, based on the O&M manual. The right-bank levee extends about 14 miles. The left-bank levee is about 17 miles long. About midway along this reach, to allow flow to enter from the east, the left-bank levee is broken into two parallel segments for approximately 1.5 miles.

10.3.4.1. Issues

Original Design Deficiencies:
The Cherokee Canal was designed and built in its current location by the USACE in 1960 under the authorization of the Flood Control Act of 1944. The design flow of 11,500 cfs is to be passed through the lower portion of the project (downstream of Cottonwood Creek) at or below the 1957 design flood profiles. Recent studies (ESA PWA, 2011) have been conducted to assess conveyance of the original design. Results show that the original as-designed conditions do not provide 3 feet of freeboard at the design capacity of 11,500 cfs.

Also, based on recently-observed stage and discharge data, as well as modeling of existing and as-designed conditions, the original design assumptions related to channel and floodplain roughness (e.g., the assumption of “bare ground”) were unrealistic and are unmaintainable—particularly given the current regulatory constraints associated with prohibiting vegetation removal (ESA PWA, 2011).

Capacity:
DWR is required to maintain the project so that the channel can pass the design flow of 11,500 cfs at or below the 1957 design flood profiles. Typically in Cherokee Canal, this means having 3 feet of freeboard at the design discharge.

Based on hydraulic assessments completed using a calibrated HEC-RAS model for existing conditions (ESA PWA, 2011):

- Conveyance of the design flow of 11,500 cfs breaks the 1957 design flood profiles, with overtopping located immediately downstream of the Richvale Highway bridge.
- The maximum capacity for existing conditions is 10,140 cfs.
- The discharge at which 3 feet of freeboard is attained is 5,030 cfs.

History of Failures:
Major floods have occurred along Cherokee Canal in 1964, 1986, 1989, 1996, and 1997, with numerous reports of water at the levee crown. Cherokee Canal levees were overtopped in 1989, 1996, and 1997. In 1986, the Cottonwood Creek levees broke at the confluence with Cherokee Canal. The right bank breach was approximately 20 feet to 30 feet wide and the breach caused ponding in the area northeast of the Cottonwood/Cherokee confluence. The left bank also failed in 1986 into the Richvale-Butte Canal. The canal contained the breach and flooding did not occur southward.

In March 1989, the left-bank (east) levee just upstream from the Nelson-Shippee Road was overtopped and failed when debris blocked a portion of the Nelson-Shippee Road bridge. The west levee was overtopped at the Richvale Highway in January 1996. On January 22, 1997, the north levee on Gold Run Creek and the south levee on Cottonwood Creek were overtopped at several locations. In December 1997, the levee was sandbagged to prevent overtopping at the Richvale Irrigation District's main canal, located approximately 1 mile upstream of Butte City-Biggs Highway.

Sedimentation:
In the following years after initial construction, sediment from historic hydraulic mining began to accumulate within the canal. As a result, flood flows reached or exceeded flood stage on numerous occasions in the 1960's. Sediment deposition is a major maintenance issue for much of the length of Cherokee Canal, due to the continued discharge of sediment from gravel pits and the Cherokee Hydraulic Mine on Dry Creek and Gold Run Creek.

Past studies show that a 2-year storm event delivers approximately 23,000 tons of sediment to the canal and a 100-year storm event delivers approximately 103,000 tons; the addition of this sediment to the Cherokee Canal between the Cottonwood Creek junction and Highway 162 bridge has reduced this section's original design hydraulic capacity by 30 to 40 percent (URS, 2003).

However, sediment data collected by USGS (United States Geological Service) in 2010 at Nelson Road suggests that the sediment supply and transport through the valley reaches of Cherokee Canal may be decreasing. There is still a substantial amount of hydraulic mine-derived sediment in the upper reaches of Dry Creek (upstream of Clark Road/Highway 191 and downstream of Highway 70), but these areas are being mined for sand and aggregate and future changes in the magnitude of mining activities or a change in mining practices could influence future sediment supply to downstream reaches.

DWR has removed large quantities of sediment accumulation from the canal as part of its ongoing maintenance activities and is continuing to refine its maintenance practices in attempt to restore and maintain channel capacity while retaining the wildlife habitat values of the channel. However, these efforts have become increasingly challenging through time, primarily due to the high costs and time constraints of environmental mitigation associated with Giant Garter Snake habitat, along with the costs associated with the long-distance trucking (and associated air quality impacts) of removed sediment.

In June of 2009, the California Department of Water Resources (DWR) published the Proposed *Mitigated Negative Declaration and Draft Initial Study for the Cherokee Canal Corridor Management Strategy (CMS) Pilot Project: Phase 1 Sediment Removal*. This study assessed the existing channel habitat and geomorphology and evaluated the potential environmental effects of a proposed CMS Pilot Project. The study proposed to remove approximately 750,000 cubic yards of accumulated sediment in the Cherokee Canal for the four mile section between the Cottonwood Creek confluence and the UPRR Bridge. Conversations with DWR staff note that the Cherokee Canal CMS project was put on hold because of two primary reasons: 1) because of cost overruns on environmental compliance and 2) because of the inclusion of a Feather River bypass component in the 2012 CVFPP.

Vegetation:
Volunteer riparian vegetation grows quickly on the deposited sediment. The combination of mineral soil, suitable topography, and inflows of water from the contributing watershed and agricultural return has created ideal conditions for germination and growth of riparian vegetation. Typical riparian species within the canal are cottonwoods, willows, and alders. Increased riparian vegetation makes it difficult and expensive to maintain channel capacity.

DWR is responsible for maintaining the canal for flood management purposes. Portions of the Cherokee Canal and its levee slopes are mowed, burned, or sprayed with herbicides on an annual or more frequent basis in an effort to maintain the required capacity of the canal. Under the terms and conditions of a Memorandum of Understanding issued to DWR by the California Department of Fish and Wildlife (CDFW), DWR maintenance crews do not currently remove trees greater than 4-inches diameter at breast height (DBH). CDFW agreed to DWR maintaining the floodway to include a 15 foot riparian buffer along the low-flow channel; however, because annual maintenance budgets are not consistent, if trees expand beyond this buffer width and grow to exceed the 4-inch DBH size, then those trees outside the buffer area may not be removed. This has occurred, and existing vegetation in the floodway is excessive in some locations and removal as a part of normal channel maintenance as permitted by CDFW is not viable. Thus, removal must be done as a part of a dedicated effort that includes mitigation for the impacts to riparian habitat, and it is therefore difficult and expensive to remove vegetation to increase channel capacity.

Bridge Crossings:
Numerous bridge crossings pose additional hurdles for potential channel modifications. From upstream to downstream, the main bridge crossings include:

1. Nelson Road Bridge
2. Nelson-Shippee Road Bridge
3. Richvale Highway Bridge
4. UPRR Bridge
5. Highway 162 Bridge

During high water events, there are issues with debris buildup at the bridge crossings, particularly at the UPRR bridge. This railroad trestle is aligned at an approximate 45 degree skew from normal flow, and the piers of the trestle are aligned perpendicular to the track. Thus, the floodway, as considered from the vantage of looking downstream, is almost completely obstructed and, according to DWR maintenance staff, the trestle acts like a 'debris net' during floods.

Levee Height:

There are issues regarding the elevation of the right bank levee near the Richvale Highway bridge crossing. This section of levee protects major infrastructure including the small community of Richvale, high value agriculture processing and storage facilities, wastewater treatment facilities, local public water supply wells, and a local fertilizer plant. Locals have expressed the concern that if overtopping of the levee were to occur, it would occur here first and thus result in the flooding of the only major infrastructure in the area.

10.3.4.2. Potential Solutions

The 2012 CVFPP discussed the possibility of expanding and extending the Cherokee Canal to act as a Feather River Bypass (see additional discussion in Section 10.4 below). Significant concerns regarding redirected hydraulic impacts, were raised during MUSR RFMP development by local property owners and stakeholders. Therefore the physical and operational elements recommended in the MUSR RFPM do not include expansion of the Cherokee Canal as a locally preferred project. Instead there are a number of locally preferred alternatives including:

- Develop a long-term Corridor Management Plan that establishes a regular schedule for managing vegetation and removing sediment. The CMP should identify consistent and reliable O&M funding source, and it should examine the entire system of the Cherokee Canal and not revolve around a 'segment by segment' approach. Cost saving options should be explored for contracting with locals to perform maintenance activities. The CMP should recognize and protect the benefits and value of existing Giant Garter Snake habitat provided by adjacent private property rice lands, in addition to the habitat concept of 'quality' over 'quantity'. Options may also exist to coordinate rice field operations with the local rice growers association (i.e. do not flood specific rice fields during the fallow season to improve GGS habitat), or to restore areas just outside of the canal, in exchange for less restrictive permitting requirements inside the levees.
- Construct upstream detention basins to control hydraulic mining sediment deposits, potentially incorporating a groundwater recharge component.
- In addition to in-channel maintenance to increase conveyance, levee raises/repairs should be implemented—either as a part of the channel maintenance or separately. The right bank reach upstream of the Richvale Highway Bridge downstream to the UPRR trestle should be the priority area, as this stretch of levee protects existing infrastructure including the small community of Richvale, high value agriculture processing and storage facilities, wastewater treatment facilities, local public water supply wells, and a local fertilizer plant. Existing studies show that by simply continuing the grade from the 1974 levee raise (i.e., use the same slope and tie in to the downstream elevation of the levee

raise) from the Richvale Highway Bridge to the UPRR would likely solve the issue of overtopping in this area.
- Construct an overflow relief weir along left bank levee to limit water stages within the canal during times of high flow and secure flood flowage easements on local agricultural areas which become inundated as a result. Preliminary review of existing studies indicates that overflows escaping outside of the channel would flow somewhat adjacent to the existing canal and eventually end up in the Butte Sink. This option could direct flood impacts away from existing infrastructure, however, it should only be implemented with the willing consent of impacted local landowners.
- Construct flow conveyance improvements at the various bridges, particularly to the UPRR railroad crossing and Richvale Highway Bridge.
- Continue to monitor sediment transport and supply into the project area, and explore potential changes to existing upstream mining activities (i.e., extraction in-channel versus floodplain; BMP alternatives).
- Identify and develop a process for the beneficial reuse of sediment extracted from the canal (material management planning).
- Improved flood depth mapping (See Chapter 7).

10.4. Bypass Systems

The Sutter and Yolo bypasses, in combination with their appurtenant control features, the Moulton, Colusa, Tisdale, Fremont, and Sacramento weirs/bypasses – function as the central backbone of the Sacramento River Flood Control Project. Floods from storms centered within different tributary watersheds of the Sacramento River Basin have different characteristics, and the 2012 CVFPP proposed bypass system expansion as a way to increase the overall capacity and to accommodate greater system flexibility in managing large flood events. The DWR led Sacramento River Basin-Wide Feasibility Study is expected to describe in more detail how bypass system expansion will be accomplished and what benefits will be achieved. This section discusses the 2012 CVFPP bypass system expansions as they relate to the MUSR RFMP planning area.

10.4.1. *Sutter Bypass*

The Sutter Bypass was constructed to create a bypass flood channel for the Sacramento River system as a component of the State Plan of Flood Control. The Sutter Bypass conveys overflow flood waters in a southeasterly direction away from the Sacramento River at a capacity substantially greater than the Sacramento River. As such, it is an integral part of the existing integrated flood management system, which helps protect the small agricultural legacy communities of Colusa, Meridian, Grimes, Robbins, Kirkville, and Knights Landing. The Sutter Bypass originates southwest of the Sutter Buttes, downstream of Butte Slough, and terminates at Fremont Weir, 35 miles downstream.

The Bypass receives flood flows from the Butte Basin overflow area near Ord, from Moulton Weir, Colusa Weir, Tisdale Weir, Butte Creek, Cherokee Canal, local drainage from the western portion of the Sutter Buttes, local drainage from the eastern portion of the Sutter Buttes via Wadsworth Canal, and local drainage from the Sutter Basin via pump stations.

The Sutter Bypass is a wide flat channel dropping less than 30 feet over a distance of over 35 miles and varying in width from approximately 4,000 feet in its upper reaches to 6,200 feet along its furthest downstream reach between Nelson and Sacramento sloughs where the bypass parallels the Feather River channel.

The West Borrow and East Borrow canals were excavated parallel to the bypass levees to supply the borrow materials needed to construct the bypass channel levees. Both canals convey water year round. Small weirs with fish bypass facilities control the water levels in the canals to facilitate irrigation of the agricultural lands within the bypass.

USACE design flows for the Sutter Bypass increase in the downstream direction, from 150,000 cfs at its upstream starting point at Butte Slough near State Route 20 to the Wadsworth Canal, to 155,000 cfs between the Wadsworth Canal and the Tisdale Weir. Further downstream the Sutter Bypass was designed to pass 180,000 cfs between Tisdale Weir and Nelson Slough and then 380,000 between Nelson Slough and the confluence with the Sacramento River at Verona.

In the 2012 CVFPP, DWR recommended consideration of increasing the capacity of the Sutter Bypass to convey larger flood events. This expansion would likely require building a new levee for about 15 miles along one side of the bypass to widen the bypass for increased flow capacity. DWR used a 1,000-foot increase in the bypass width for 2012 CVFPP planning purposes, with 75 percent of the new width allocated to agricultural use and 25 percent allocated to habitat restoration. Modifications to the Colusa and Tisdale weirs and the Butte Basin overflow areas from the Sacramento River would be considered as part of the expansion. The expansion may also require rebuilding some SPFC facilities, such as weirs and pumping stations. The bypass widening was shown as the eastern side in the 2012 CVFPP, but during development of the Basin-Wide Feasibility Study DWR will be evaluating east and west side widenings.

A 1,000 foot wide expansion of the Sutter Bypass is predicted to convert 2,459 acres of land into the active floodplain. Land uses currently in the expansion zone are comprised of 90% productive agricultural land and 10% habitat. Incorporating a 2,000 foot wide expansion on the east side of the Sutter Bypass would move an estimated 5,324 acres of land, which is 91% productive agricultural land and 9% habitat, into the active floodplain.

A recent study (California Polytechnic State University, 2013) analyzed the economic impact from the annual loss of agricultural production from widening the Sutter Bypass. Direct impacts include the initial change in expected economic activity from lost wages and agricultural expenditures over a thirty-year horizon. Indirect impacts include the local "business-to-business" transactions necessary to support the direct activity, for instance, local purchase of farm machinery, hiring of agricultural consultants, and other goods purchased from supporting industries. Additional induced impact occur when wages generated by the direct and indirect economic activity are spent on local goods and services; for example, when agricultural laborers or farm proprietors use earnings to purchase food, clothing, automobiles, real estate, education, and health and social services.

The California Polytechnic State University Study's draft finding include:

- A 1,000 foot wide expansion of the Sutter Bypass is estimated to result in:
  - an annual loss of 45 job-years;
  - a total annual economic impact of $4,687,888;
  - a total economic impact over a thirty-year horizon of $141 million.
- A 2,000 foot wide expansion of the Sutter Bypass is estimated to result in:
  - an annual loss of 106 job-years;
  - an annual economic impact of $10,589,883; and
  - an economic impact over a thirty-year horizon of $318 million.

The estimated economic losses over a 30-year horizon are substantial in relation to the combined economic productivity of Sutter County. For the 1,000 foot wide expansion scenario, this amounts to a one-time payment of approximately $1,480 for every person residing in Sutter County, or $4,438 per household. For the 2,000 foot wide expansion scenario, this amounts to a one-time payment of approximately $3,343 for every person residing in Sutter County, or $10,032 per household. Considering that the median household income in Sutter County was $50,010 in 2009, the economic losses resulting from widening the East side of the Sutter bypass are significant.

Detailed study of the proposed Sutter Bypass expansion is beyond the scope of the MUSR RFMP; DWR intends to further analyze the Sutter Bypass Expansion in the Sacramento River Basin-Wide Feasibility Study. A recent hydraulic analysis of the Sutter Bypass prepared for the CVFPB (CH2M Hill, 2013) found that the Sutter Bypass cannot pass the 1957 design flow at the design stage along a cumulative distance of 22 miles, primarily due to sedimentation and vegetation growth.

Given its importance in conveying flood flows for the Sacramento River Flood Control Project, MUSR RFMP stakeholders are concerns about the incremental loss of channel capacity over time due to sediment accumulation and vegetation growth. While sediment is occasionally removed by DWR from the bypass channels of Moulton Weir, Colusa Weir, and Tisdale Weir, the Sutter Bypass itself is losing depth and capacity over time due to sediment buildup.

The 2013 CVFPB hydraulic analysis found that vegetation growth within the Sutter National Wildlife Refuge (SNWR) has a significant impact on water surface elevations within the Bypass. DWR has been assisting USFWS address this vegetation growth issue with the SNWR and significant progress has been made recently. However there is no permanent funding mechanism in place that ensures current maintenance levels will be maintained long term.

In the 2012 CVFPP, DWR proposed to work with local maintaining agencies to examine opportunities and local agency support for legislative action that would allow DWR to assume full operations and maintenance responsibility for Sutter Bypass and the Moulton, Colusa, Tisdale weirs (the State currently has responsibility for maintaining a portion of these facilities under the California Water Code). Before assuming full operations and maintenance responsibilities DWR will require funding augmentation. To facilitate a dialogue on the transfer of operations and maintenance responsibility, the MUSR regions recommends that a long-term Comprehensive Bypass Management Plan be developed which at a minimum would:

- Establish a program for regular sediment removal;
- Establish a program for managing vegetation with the bypass system. The vegetation management program should assess the value of maintaining trees parallel to the levees to act as wave breaks to reduce wave action;
- Establish an active enforcement program to ensure compliance with existing flood flowage easements;
- Identifies strategies for providing operations and maintenance funding;
- Recognize and protect the benefits and value of existing habitat provided by adjacent private property agricultural lands. This habitat should be considered when evaluating impacts from managing the bypass to convey flood flows;
- Promote ‘flood bypass appropriate’ habitat enhancement which maximizes habitat values without adversely impacting flood flow conveyance; and
- Incentivize and encourage wildlife-friendly, flood flow neutral, farming practices within the Sutter Bypass since the majority of the Bypass is privately-owned and actively farmed.

In addition to the developing a Comprehensive Bypass Management Plan, potential solutions that were brought forth locally for future study consideration in the Basin-Wide Feasibility Study effort as alternatives to a Sutter Bypass expansion include:

- Construct and/or expand upstream reservoirs to increase capacity and improve system flexibility. Specific potential locations (discussed previously) include: Sites Reservoir, Shasta Dam Raise, Oroville Dam, and Cottonwood Creek Reservoirs.
- Implement Forecast-Coordinated Operations (F-CO) to improve system flexibility. F-CO seeks to improve the management of reservoir flood control pools to reduce peak flood flows downstream through the use of improved watershed and river forecasting and the coordination of releases during flood operations. Opportunities exist for coordinating the releases from Shasta Dam (Bureau of Reclamation), Black Butte Dam (USACE), Oroville Dam (DWR), and Bullard’s Bar Dam (Yuba County Water Agency) to improve upon the management of flows through the Sutter Bypass.
- Implement repairs to the 3B’s overflow weir, along with other improvements to the Butte Basin (see Section 10.2.7) to reserve its transitory storage capacity and allow for better detainment of peak flood flows. Opportunities may also exist for integrating the improved management of flows within the Butte Sink with F-CO of Shasta Dam and Black Butte Dam.
- In addition to in-channel maintenance to increase conveyance, levee raises/repairs should be implemented—either as a part of the channel maintenance or separately, in order to re-

establish the bypass to its original design capacity, and to reduce the flood risk on the adjacent lands protected by the Sutter Bypass levees. Raising the existing levees should also be explored as a way to increase capacity and improve system flexibility.

- Channelization could be performed throughout the Sutter Bypass to create a larger low-flow channel which may provide a more rapid drainage of the Butte Basin. This could potentially reserve the transitory storage capacity of the Butte Basin and allow better detainment of peak flood flows. There also may be potential within the CMP to balance the results of regularly dredging a channelized bypass to accommodate a continuous path of quality habitat.
- Identify and develop a process for the beneficial reuse of sediment (material management planning)

10.4.2. *Feather River Bypass*

The 2012 CVFPP proposed evaluating the feasibility of constructing a new bypass from the Feather River to the Butte Basin to improve flood protection along the Feather River south of Thermalito. The new bypass would require construction of about 16 miles of new levees across the northern end of the Sutter Basin

In adopting the 2012 CVFPP, the CVFPB voiced serious concerns about the proposed Feather River Bypass in that it: (a) could have adverse, unmitigated hydraulic effects on downstream landowners; and (b) is unlikely to be found economically justifiable. Therefore, in its adoption resolution the CVFPB removed the Feather River Bypass from the CVFPP and advised DWR to instead:

- Consider improving Cherokee Canal to its original design capacity; and
- Consider alternatives to the Feather River Bypass with alternatives being evaluated on an equal footing.

The CVFPB did allow that the Feather Bypass may be brought forward again in the 2017 update of the CVFPP.

As with the proposed Sutter Bypass expansion, study of the Feather River Bypass is beyond the scope of the MUSR RFMP; DWR intends to further analyze the Feather River Bypass in the Sacramento River Basin-wide Feasibility Study. However, serious concerns have been raised by local stakeholders during MUSR RFMP development regarding redirected hydraulic impacts. In lieu of constructing the a new Feather River bypass, MUSR RFMP local stakeholders have strongly urged that the Basin-wide Feasibility Study fully evaluate other alternatives such as expanding surface water storage, developing and implementing a plan for effective operation and maintenance of the current Cherokee Canal, implementing Forecast-Coordinated Operations to improve system flexibility, improving the use of the Oroville Wildlife Area for retaining peak flood flows, and others.