Section 3: Existing and Future Conditions

This section describes the existing and expected future conditions for the Region that are relevant to creating an integrated water management plan. The description includes information about key water management infrastructure (both constructed and naturally occurring), summarizes and presents important data, introduces some of the major challenges, and offers observations about the current water management system based on available data. The information is organized and presented as it relates to the topics of water quantity, water quality, flood protection, environmental resources, and the potential affects from climate change.

A region the size of Westside Sacramento is extremely complex and the operational aspects of managing water and the associated infrastructure and other resources within the Region require extensive knowledge of many important details. The amount of data and information related to water management that one could consider across the Region can be overwhelming. In keeping with the goals for the IRWM planning process described in Section 1.3.1, this Plan section presents strategic information in a synthesized way designed to help promote understanding and support decision makers and stakeholders to work together more effectively in ways that benefit the Region as a whole.

A great deal of technical reports and other information was reviewed and coalesced to provide a meaningful message throughout this IRWM Plan. A summary of the technical analysis aspect of this plan, focusing on the water balance framework described in Section 3.1 below is provided in Appendix C.

3.1 Water Quantity

In order to plan for improved water management within a region one needs to understand how much water is (or will be) available and when, where the water originates, how the water is used (or will be used in the future), and how it moves through the system. As a result, the authors of this Plan employed a simple approach called a water balance to help present a high-level representation of the quantity of water that enters, moves, is consumed, and leaves the Region under specific conditions. See Figure 3-1 for a schematic that illustrates which hydrologic interactions were evaluated and summarized.

If data exists for each of the hydrologic components considered, then a water balance can be completed and will show that the quantity of water entering an area for a given amount of time minus the quantity of water exiting the same area during the same amount of time must equal the change in the quantity of water stored within the specific area. There is not sufficient data available for some components represented in the water balance for this Region, so the authors of the Plan were not able to "close" the water balance. Nonetheless, comparing the information that is available for the planning areas and the Region as a whole is instructive. (See Appendix C for the specific missing information within the water balances.)

The water balances shown below include assumptions made about supply and demand throughout the planning period (through 2040). The water balances illustrate the diversified nature of surface water and groundwater supplies and offer a reasonable estimate of demand within the Region. The information summarized in the water balance can be used to help identify potential areas for improving water management, especially opportunities to collaborate more or improve the balance between supplies and demands. Water balances were prepared for the entire Region, the Upper Cache, Upper Putah, and Valley Floor Planning Areas to explore and illustrate the differences and interrelationships across the Region.

Water moves through the Region in a complex process. Users within the Region access many different sources of water, take advantage of a variety of ways to store water for later use, and apply that water for a variety of beneficial uses. Some specific data and information about various aspects of how water moves through the Region currently do not exist. Much of the missing information correlates with the historical agricultural practices within the Region. The majority of the water used within the Region is applied for agricultural production, and agricultural practices within the Region result from thousands of independent choices made by individual landowners and farmers. The agricultural community (when considered in aggregate) seems to have adapted their practices to accommodate significant annual fluctuations in the availability of water supplies in some areas of the Region.

Many of the water users within the Region conjunctively use water supplies, meaning that they have some flexibility to use different surface water supplies and groundwater supplies, but some water users rely on a single source of supply. The following subsections contain descriptions of the major water balance components illustrated in Figure 3-1.

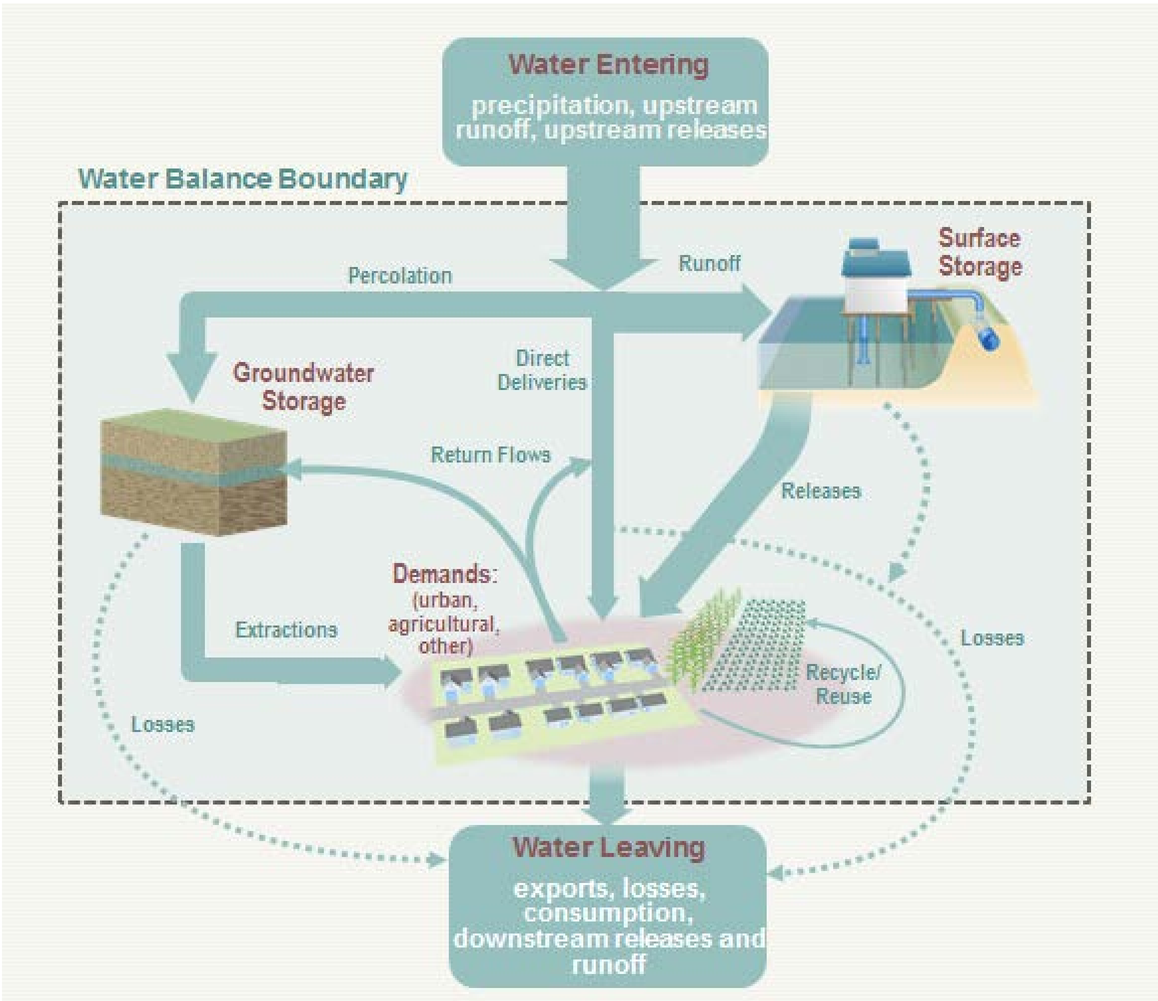


Figure 3-1: Water Balance Schematic

The water balances were prepared using water supply and demand information available at 5-year intervals through the planning horizon for two scenarios: an average water year condition (representing normal conditions) and a dry water year (representing potential drought conditions). Only hydrologic data that was available in a consistent format across the entire region was used. Available hydrologic data for the years 1980 through 2000 was averaged to represent an average water year condition, and the data for 1988 was selected as a representative dry water year for the Region, based on feedback received from the Water Balance Subcommittee participants.

The significant hydrologic difference between an "average" and "dry" water year can be seen in Figure 3-2 in comparing the average rainfall in the Upper Cache Creek watershed of 27.6 inches per year (based on data between 1954 and 2006 (errors in the data occurred between 2006-2016)) with a low of 8.17 inches of precipitation recorded during 1976.

A water balance based on data from a single year can provide a useful "snapshot" of water management conditions, but does not depict some important long-term management factors such as changes in groundwater and surface water storage. Development of a complete water balance for multiple dry years drought scenarios may be beneficial for users within the Region in future Plan updates, but was not prepared in this IRWM Plan due to the absence of needed information.

Since the 2013 Westside IRWM Plan, California experienced a drought lasting from 2012-2016. A U.S. Geological Survey (USGS) review of the six droughts in California since 1895 shows that, although it led to significant agricultural, geophysical, and environmental impacts, this drought is comparable to the 1928-34 and 1987-92 droughts.[1]

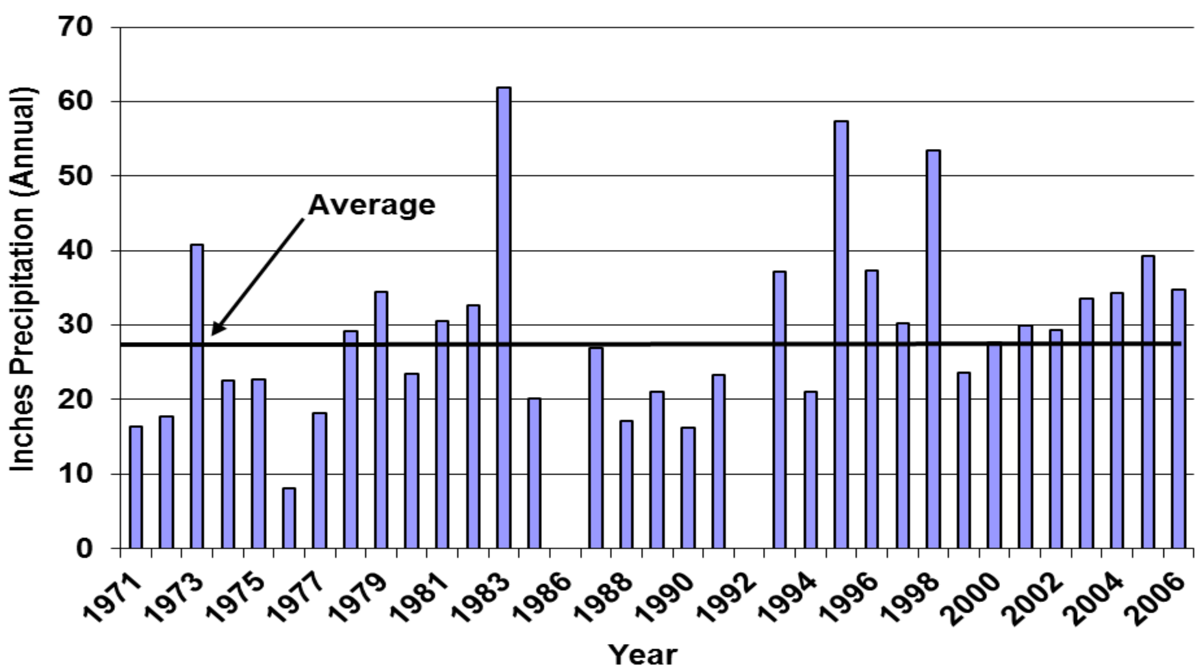


Figure 3-2: Precipitation Data for Upper Cache Creek Planning Area

Source: Gage Station 041806 (http://www.wrcc.dri.edu/)

Water years with more than 26 days missing within a given month are not shown.

[1] https://ca.water.usgs.gov/california-drought/california-drought-comparisons.html

3.1.1 Water Entering

Water enters the Region from multiple sources including precipitation (mostly rainfall with some snowfall) and water imported from a number of sources outside the Region boundary. The low-lying valley floor areas receive approximately 18 inches of precipitation on average per year, while the higher elevations in the Coastal mountain range on the western side of the Region can receive more than 70 inches of rain annually. Much of the precipitation that falls within the Region flows across the landscape into small streams and creeks that enter major lakes and reservoirs. Some percentage of the precipitation percolates into the soil and is consumed by plants or eventually flows into one of the many groundwater aquifers underlying the Region. Some of the precipitation also evaporates or flows downstream out of the Region boundary (refer to Section 3.1.3).

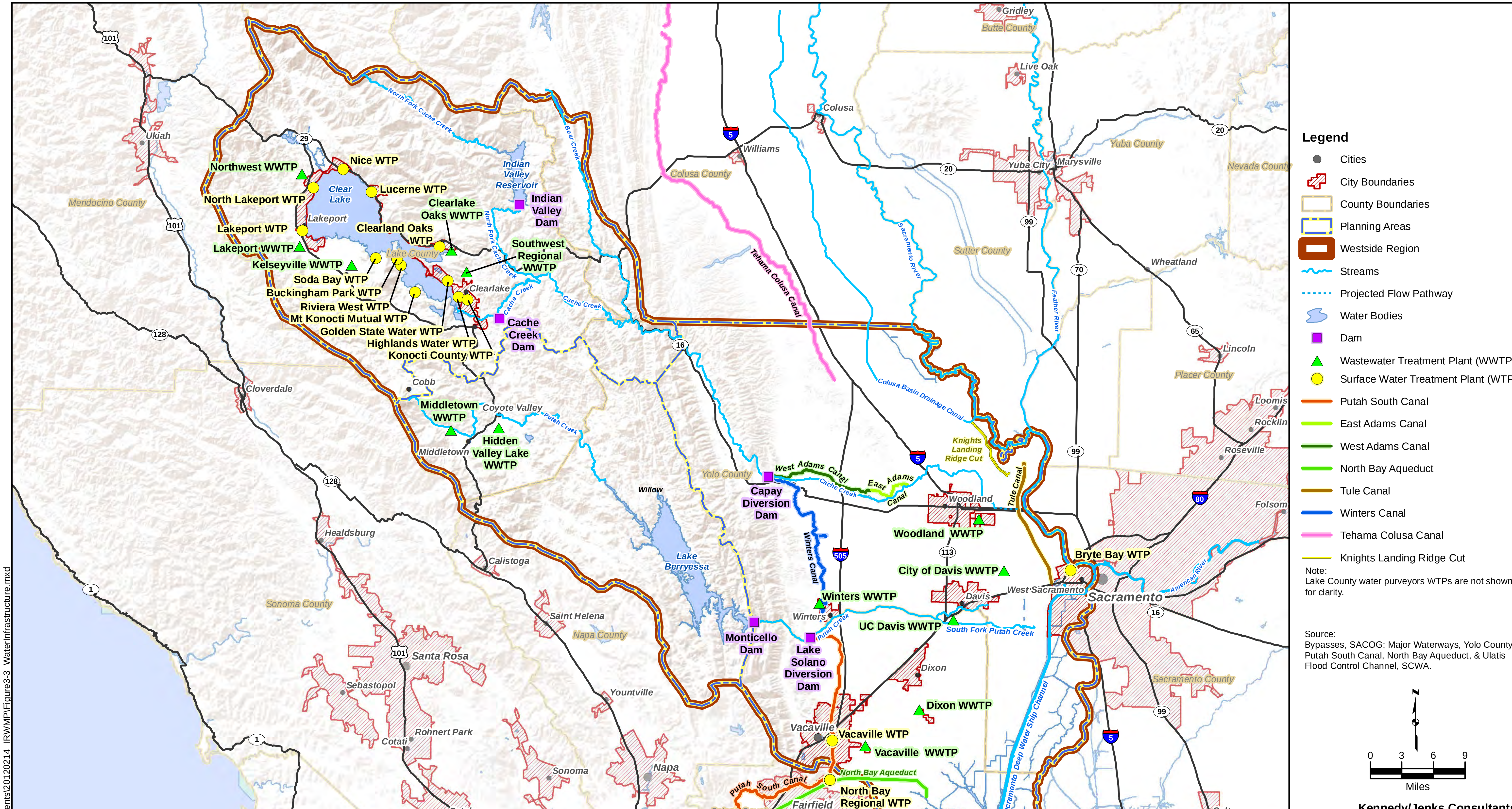
For the purposes of this analysis, water that enters the Region from a watershed wholly or partly outside of the Westside Region is considered an *imported water supply*. For example, water diverted from the Sacramento River and Delta is labeled as imported, even though the Sacramento River and Delta share a common boundary with the eastern boundary of the Westside Region. Imported surface water supplies play an important role in the beneficial activities within the Region. While considerable water supplies originate from within the Region in the Cache and Putah Creek watersheds, local surface and groundwater supplies are not sufficient to meet the extensive agricultural, urban, municipal, and domestic demands for water.

Cache Creek

Imported water is made available through a number of different water rights and contracting mechanisms. Some of the imported water is provided to local agencies from the State of California State Water Project (SWP) operated by DWR, or the United States Bureau of Reclamation's Central Valley Project (CVP). Some key import facilities include the SWP's North Bay Aqueduct (NBA) in Solano County and the CVP's Tehama-Colusa Canal in Yolo County. Some individual landowners also have rights to divert surface waters from the Sacramento River and Delta. Figure 3-3 shows the locations of major water management infrastructure, including those used for importing water into the Region.

For the purpose of this analysis, water that enters the lower watershed from upper watershed sources is labeled either *upstream runoff* or *upstream releases*. *Upstream runoff* includes water entering a planning area due to unregulated stream or overland flows from upstream watersheds. *Upstream releases* include water entering a Planning Area through regulated releases from upstream storage facilities. An example of a source of upstream runoff is winter storm flows from the Upper Cache Creek that flow downstream into the Valley Floor Planning Area (PA). An example of an upstream release is runoff from the North Fork Cache Creek watershed that is captured and stored in Indian Valley Reservoir, and later released into the Valley Floor PA to meet irrigation demands.

Note that there are no upstream runoff or upstream releases into the Upper Cache and Upper Putah areas in the water balances because no significant runoff or releases occur into the upper watersheds from outside the watershed. Upstream runoff and releases comprise a major percentage of the water entering the Valley Floor PA. Runoff on the Valley Floor PA was not quantified due to the lack of a consistent estimate of runoff across the subwatersheds in the PA. This could be a refinement and information that could be estimated if the water balance is updated in the future.



Kennedy/Jenks Consultants

WESTSIDE SAC IRWM

Water Infrastructure

K/J 1770033.00

Figure 3-3

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3.1.2 Water Within

Once water enters the water balance boundary it can be directed in several different ways. As shown conceptually in Figure 3-1, much of the water entering the Region flows into one of several surface storage reservoirs in the upper watersheds as runoff from local precipitation. The remaining water that does not flow into surface storage reservoirs either percolates into shallow groundwater aquifers or is routed for direct delivery to meet demands (urban, agricultural, other). Water can be released from the surface reservoirs to help meet demands. Groundwater can also be pumped from the aquifers to help meet demands. Urban wastewater can be recycled/reused. Applied water (from any source) that is not consumed during the intended use becomes a return flow that can be reused to help meet demand or that can percolate into aquifers for use at a future time.

3.1.2.1 Surface Water

Deliveries from surface water (1,050 thousand acre-feet per year [TAFY]) represent approximately 66 percent of the total water applied to meet demands (1,610 TAFY) in the Westside Region in an average year (Table 3-6). Some of the surface water that enters the Region percolates into aquifers and enters groundwater storage. Runoff from precipitation that remains at the surface is either diverted to end users (called *direct deliveries* in the water balance), flows into one of the major lakes and reservoirs and is stored for potential future use, or flows out of the Region.

Most of the runoff from precipitation in the upper watersheds is captured and stored in lakes and reservoirs. The major lakes and reservoirs within the Region include Clear Lake, Indian Valley Reservoir, and Lake Berryessa. These lakes and reservoirs provide numerous benefits including water supply, flood protection, hydropower generation, habitat, and recreation. Table 3-1 contains some of the key facts about the reservoirs.

Some water users divert water directly from the lakes and reservoirs, but most of the surface water used within the Region is released from storage for use at a location downstream of the lake or reservoir. The surface storage facilities within the Region provide many benefits within the water management system. One of the key benefits is the carryover storage (water captured in one year and held for potential use in future years) that adds resiliency to the water management system and helps to reduce the negative impacts of droughts. However, the amount of carryover storage typically available within the Region is not always sufficient to meet all water demands during periods of multiple dry years.

When large rainfall events occur during the winter season, flood releases may be made from the dams into Cache and Putah Creeks, which flow into the lower watershed and ultimately to the Yolo Bypass, Sacramento River and the Sacramento-San Joaquin Delta.

Surface water supplies can be distributed within the Region through an intricate network of canals, sloughs, and pipelines to end users. Hundreds of miles of surface water conveyance infrastructure spread throughout the Region. Figure 3-2 shows the location of major regional water supply infrastructure including facilities such as major diversion structures, canals, surface water treatment plants, and wastewater treatment plants.

Table 3-1: Major Lakes and Reservoirs

Lake/Reservoir	Net Usable Capacity (AF)	Dam	Dam Owner/Operator	Hydroelectric Generation Capacity	Owner of Hydroelectric Power Plant
Indian Valley Reservoir	300,600	Indian Valley Dam	YCFCWCD (both)	3,000 kW	YCFCWCD
Clear Lake	313,000	Cache Creek Dam	YCFCWCD (both)	1,750 kW[(a)]	YCFCWCD
Lake Berryessa	1,602,000	Monticello Dam	USBR (owner) SCWA (operator)	11.5 MW	SID

(a) Not currently in operation.

Flood protection infrastructure also affects surface water within the Region (see Section 3.3.1 for more details). Some of the flood protection infrastructure, such as the Yolo Bypass and Ulatis Flood Control Project serves multiple purposes and also can be used to convey wastewater discharges, water supply, and provide habitat.

3.1.2.2 Groundwater

Water stored in groundwater aquifers also serve as a key water supply source in the Region. For many water users, groundwater is the only readily accessible supply source. Thousands of groundwater wells exist within the Region, and most of these groundwater wells are used to supply individual domestic demands or small agricultural operations. Some of the larger towns and cities also operate municipal wells to meet or help meet urban, municipal, and industrial demands. Some of the communities within the Region such as Rio Vista, and Dixon currently rely on groundwater as their sole supply source. Solano Irrigation District and Vacaville also pump groundwater to supplement their surface water deliveries. Maintaining sustainable groundwater aquifers that yield high quality groundwater will be crucial to meet the long-term water demands within the Region.

Characteristics of the groundwater aquifers vary considerably throughout the Region. The aquifers in the upper watersheds tend to be smaller and more variable than the aquifers located beneath the valley floor. Experts have identified fourteen distinct groundwater basins in the upper Cache Creek and Putah Creek watersheds. The geologic and hydrologic characteristics of each groundwater basin differ considerably including the aquifer permeability and material composition, sources of recharge, distribution over area and depth, and presence of boundaries or faults that limit groundwater flow.

Groundwater users in the upper watersheds may extract groundwater from these basins from shallow alluvial deposits, fractured sedimentary and metamorphic rock within the Franciscan Formation, or the Clear Lake volcanic deposits. Among the fourteen identified groundwater basins, the major basins used for supply in the upper watersheds include Big Valley, Scotts Valley, and Upper Lake Valley. Significant information exists for the major alluvial aquifers in the upper watersheds, but very little information has been gathered for the fractured bedrock and volcanic aquifers.

The Valley Floor PA overlies two subbasins of the Sacramento Valley Groundwater Basin, the Yolo Subbasin and Solano Subbasin. The water bearing formations of these basins generally have very high storage capacities and are essentially contained within two stratigraphic units: (1) the deeper, older, thick alluvial and river sediments of the Tehama formation, and (2) the younger shallower sediments, floodplain deposits, and stream channel deposits that overlie the Tehama formation. The sustainable yield of these important groundwater subbasins is not yet fully understood.

3.1.2.3 Water Demands (Applied Water)

The term "demand" is used in this Plan to represent the quantity of water various water users choose to use for one or more beneficial uses according to the cost required for them to use that water. Economists have demonstrated that demand for water can most accurately be described as a function that relates the quantity of water a user will purchase/use based on the marginal unit cost of water. However, the information required to estimate specific economic functions of demand within the Region are not readily available at this time.

Therefore, this Plan presents approximations of water demand using estimates of applied water quantities based on historic information and expected urban trends in lieu of economic demand functions. Users apply water within the Westside Region to meet consumptive and non-consumptive uses. Consumptive water uses within the Region include municipal and industrial (M&I) applications and agricultural applied water. Non-consumptive water

Agricultural Irrigation

uses within the Region include hydropower, environmental and recreational flows.

These estimates for applied water include considerations of numerous factors including agricultural acreages, crop types, population, historical applied water data, and hydrologic conditions (water year type). Existing documents and studies documenting the current and projected applied water quantities were used whenever possible. Applied water amounts were calculated for the Planning Area, County, and Urban/Community levels where appropriate and grouped into classifications as data allowed (residential, commercial, agricultural, etc.). Despite some possible trends towards more permanent crops (such as vineyards and orchards) in parts of the Region, very little data is available for expected future agricultural cropping patterns within the Region, so applied water estimates for agriculture were assumed to remain constant at recent levels through 2040.

Table 3-2 and Table 3-3 contain estimated applied water demands in thousand acre-feet per year (TAFY) for 2010, 2020, 2030 and 2040 under average and dry hydrologic conditions, respectively. The expected demands increase in dry years due to decreased soil moisture from direct precipitation, increased evaporation and higher transpiration (plant water use) rates. Applied water demand is dominated by agricultural use in the Valley Floor Planning Area, accounting for approximately 95% of total demand within the Region in 2010.

Urban water suppliers (with more than 3,000 service connections or delivering more than 3,000 AFY) are required by DWR to prepare Urban Water Management Plans (UWMPs) and are now also required to develop gallon per capita day (GPCD) water use reduction targets in accordance with SBx7-7, the Water Conservation Act of 2009. Table 3-4 presents the Baseline GPCD, 2015 Interim Target, and 2020 Compliance Target that were included in the UWMPs. Please refer to each UWMP for a discussion of the data and calculation methods used to select each urban water supplier's GPCD targets. The M&I water use represented in Table 3-2 and Table 3-3 represents the projected water use including these reduction targets for the urban areas shown in Table 3-4. Because of the size of the water agencies within the upper watersheds, many smaller purveyors are not required to prepare an UWMP. However, estimated per capita water use in Lake County is 139 GPCD for an average year and 152 GPCD for a dry year (CDM, 2006b) which are among the lowest per capita water use rates in the region.

3.1.2.4 Recycled/Reuse Flows

Community wastewater collection, treatment, and disposal systems serve larger, more urbanized populations. The majority of domestic wastewater in the Westside Region is treated by community wastewater systems. Community wastewater systems influence how water moves within the Region and the availability of recycled water. Wastewater which is disposed of within the Region and is not currently consumptively used provides a source of water that could be captured for reuse. Table 3-5 summarizes the current disposal methods for the Region's wastewater treatment plants.

Wastewater treatment systems also serve an important function in protecting water bodies from water quality degradation. There are thousands of septic systems in the Region, including approximately 12,300 septic systems operating in the Clear Lake watershed (data as of 1996, County of Lake Department of Public Works, 2010). Areas where households in the Region are not serviced by community wastewater systems and use on-site wastewater treatment systems (OWTS or septic systems), usually consisting of a septic tank and associated leachfield(s), to store, treat, and dispose of domestic wastewater may be subject to an increased risk in contamination due to septic system leakage of aging and poorly maintained OWTS. Areas near surface waters pose a particularly high risk, and in the 2012 Clear Lake Watershed Sanitary Survey, it was reported that: "at least ten water utilities and Lake County expressed concerns about failing septic systems in the area impacting their source water quality [for surface water treatment plant intakes]. At least two of those utilities are considered particularly vulnerable to poor quality source water due to failing septic systems." (Forsgren Associates, 2012). In addition, individual domestic wastewater is not considered available for reuse.

Five WWTPs in the Upper Putah and Cache Creek PAs reuse treated wastewater for different types of land application and one WWTP uses a evaporation/percolation pond. The remaining four WWTPs in the Upper Putah and Cache Creek PAs export and reuse their effluent at the Geysers geothermal power generation project, which is located north of Middletown in Lake County and in Sonoma County to the west of the planning area boundary (geysers.com). Raw water is also pumped and exported from Clear Lake to supplement treated effluent supplies delivered to the Geysers (Yolo County Flood Control & Water Conservation District, 2012).

Wastewater discharges from the eleven wastewater treatment plants in the Valley Floor Planning Area provide multiple reuse and water recycling opportunities. Some of the wastewater is currently being discharged to managed wetlands to provide habitat and aquifer recharge benefits (City of Davis), while other wastewater effluent is discharged into local creeks where there is seasonal reclamation for agricultural use, such as at the City of Vacaville Easterly WWTP.

Table 3-2: Average Year Demands (Applied Water) Summary

	2010 (TAFY)			2020(TAFY)			2030 (TAFY)			2040 (TAFY)		
Applied Water Category	Valley Floor PA	Upper Cache Creek PA	Upper Putah Creek PA	Valley Floor PA	Upper Cache Creek PA	Upper Putah Creek PA	Valley Floor PA	Upper Cache Creek PA	Upper Putah Creek PA	Valley Floor PA	Upper Cache Creek PA	Upper Putah Creek PA
Agricultural	1,450	31	10	1,450	31	10	1,450	31	10	1,450	31	10
M&I	69	11	2	52	12	2	56	15	3	61	17	4
Total	1,519	42	12	1,502	43	12	1,506	46	13	1,511	48	14

Table 3-3: Dry Year Applied Water Summary

	2010 (TAFY)			2020 (TAFY)			2030 (TAFY)			2040 (TAFY)		
Applied Water Category	Valley Floor PA	Upper Cache Creek PA	Upper Putah Creek PA	Valley Floor PA	Upper Cache Creek PA	Upper Putah Creek PA	Valley Floor PA	Upper Cache Creek PA	Upper Putah Creek PA	Valley Floor PA	Upper Cache Creek PA	Upper Putah Creek PA
Agricultural	1,555	41	11	1,555	41	11	1,555	41	11	1,555	41	11
M&I	69	11	2	52	12	2	56	15	3	61	17	4
Total	1,624	52	13	1,607	53	13	1,611	56	14	1,616	58	15

Note: M&I outdoor demands may naturally increase during dry years although these increases are often balanced with voluntary and mandatory conservation measures; therefore M&I demands have not been adjusted in this table.

Table 3-4: 2015 UWMP Per Capita Water Use Targets

Urban Water Supplier	Baseline (GPCD)	2015 Interim Target	2015 Water Use (GPCD)	2020 Compliance Target
Vacaville	188	176	132	164
Rio Vista	310	279	158	248
Davis	215	194	119	172
Dixon	170	165	104	161
West Sacramento	293	264	183	234
Woodland	290	261	133	232

Table 3-5: Wastewater Treatment Plants and Disposal Methods

Planning Area/Facility	Disposal Method
Upper Putah Creek Planning Area	
Hidden Valley Lake WWTP	Land application - golf course
Middletown WWTP	Geothermal injection
Lake Berryessa Resort Improvement District WWTP	Land application – spray field
Napa Berryessa Resort Improvement District WWTP	Land application – spray field
Spanish Flat Water District WWTP	Evaporation/percolation ponds
Upper Cache Creek Planning Area	
Lakeport WWTP	Land application – pasture
Kelseyville WWTP	Land application – vineyards
Northwest Regional WWTP	Geothermal injection – exported outside Region
Southeast Regional WWTP	Geothermal injection – exported outside Region
Clearlake Oaks WWTP	Geothermal injection – exported outside Region
Valley Floor	
Davis WWTP	Willow Slough Bypass and Conaway Toe Drain (tributaries to or part of Yolo Bypass)
Easterly WWTP (Vacaville)	Alamo Creek (to Cache Slough to Delta)
Winters WWTP	Land application - native grasslands
UC Davis WWTP	Putah Creek to Yolo Bypass to Delta
Dixon WWTP	Land application - percolation/evaporation basins
Woodland WWTP	Unimproved channel to Tule Canal (Yolo Bypass)
Rio Vista - Beach Drive	Sacramento River
Rio Vista – Northwest	Sacramento River
West Sacramento WWTP	Export to Sacramento Regional County Sanitation District
Esparto Community Services District WWTP	Evaporation/percolation ponds
Madison Community Services District WWTP	Evaporation/percolation ponds

Sources: Lake County Inventory & Analysis, Appendix D, City of Davis Urban Water Management Plan, City of Vacaville Urban Water Management Plan, Winters Municipal Service Review, UC Davis NPDES No. CA0077895, City of Woodland Urban Water Management Plan, City of Rio Vista Urban Water Management Plan, City of West Sacramento Urban Water Management Plan; Lake Berryessa Region: Municipal Service Review; Madison Community Services District Municipal Service Review; Esparto Community Service District Municipal Service Review

3.1.2.5 Return Flows

Return flows include runoff from agricultural irrigation or outdoor landscape irrigation in developed areas that either reenter the surface water system or percolate into the ground to recharge the aquifers and are later potentially recoverable. The term *return flow* refers to the part of applied water that is not consumed by evapotranspiration and that migrates to an aquifer or surface water body. For the Westside Region, there are three types of return flows: agricultural, urban, and wastewater recycle/reuse return flows. Each of these is discussed in more detail in Appendix C.

The quantity of return flows available for reuse are a function of the water applied within the study area, the timing of releases, conveyance losses, and the location of diverters downstream relative to the return flow sources. In certain year types, especially during drier conditions, there may not be enough water available within the Region to supply the total applied water demand. When water is scarce, farmers typically plant fewer row and field crops in the Region, which reduces the demand for applied water, and subsequently reduces the quantity of available return flows.

3.1.3 Water Leaving

Water leaves the Region through several mechanisms including exports to neighboring Regions, downstream runoff to the Sacramento River or Sacramento-San Joaquin Delta, water consumption (which includes evapotranspiration), and other losses including evaporation and unrecoverable percolation. Between the PAs, the term do*wnstream runoff* is used to define water leaving a PA due to unregulated stream or overland flows from the PA and the term *downstream releases* is used to define water leaving a PA through regulated releases from storage facilities.

An example of exports from the Region is when Solano Project water from Lake Berryessa is conveyed via the Putah South Canal to serve areas in Solano County outside the Westside Region. Water consumption includes the portion of M&I and agricultural applied water that is not returned to the water system. Agricultural crops, native vegetation, and lawns and other plants in urban landscapes transpire water which is the major part of water consumption.

Water losses are an important component of the water balance and also one of the most difficult factors to determine. These losses include surface water evaporation, and unrecoverable subsurface groundwater flows. Evaporative losses occur on the expansive surface areas of the three major water bodies, irrigation canals, and ditches throughout the Region. Some water lost due to seepage from leaking pipelines and canals also percolates into the soil and shallow aquifer and contributes to groundwater recharge, but some unknown fraction is unrecoverable. Given the uncertainty present in much of the available water balance data, attempting to quantify these losses does not seem warranted at this time.

3.1.4 Observations from Water Balances

3.1.4.1 Westside Regional Water Balance

The observations for this subsection were made based on a review of the water balance for the entire Region. Sections 3.1.4.2 and 3.1.4.3 contain observations that relate more specifically to each Planning Area. Water balance information is presented in tabular format for the 2040 planning horizon in Tables 3-6 and 3-7. Much of the data needed to complete a full water balance for various hydrologic conditions does not currently exist. As shown in the figures and tables that follow, a number of items have not been quantified (NQ), and many of the other quantities have been reported with a low level of confidence in their accuracy. Considerable uncertainty exists about groundwater recharge and groundwater storage quantities. Investments and efforts to reduce this uncertainty may become warranted in the future since water users rely heavily on groundwater to adapt to changing availability of surface water from year to year, and existing data and information is not sufficient to estimate the quantity of groundwater available in any given year for many portions of the Region.

As stated before, the water management system within the Region is very complex. Tables 3-6 and 3-7 contain information to help quantify how water moves through the Region at a high level of aggregation. The water balances summarize the amount of water entering the Region, how water is used within the Region, and the amount of water leaving the Region. Most of the numbers shown are gross estimates that can provide a sense of scale for the movement of water through the Region's water systems.

The "Water Within" section of the water balances contains two subcategories: "Water Supplies" and "Applied Water Demands". Due to missing information in this water balance, annual changes in groundwater and surface storage were not estimated. Therefore, the water balance does not indicate whether the applied water demand in dry years can be met fully. The available supply from sources that are quantified is less than the expected demand for applied water, but this difference may (or may not) be available from surface or groundwater storage within the Region.

Although analysts determined that some of the information needed to complete a traditional water balance related to supply and demand does not exist, the process led to a number of useful observations as follows:

1. Agricultural water use dominates total water use within the Region. Approximately 92% of the Region's water demand (applied water) during an average year is for agricultural uses.
2. Overall, supply and demand are not managed for the Region as a whole, meaning that no centralized agency or organization has water management authority for the entire Region. A number of surface water supply sources (i.e. Solano Project, CVP, SWP, and YCFCWCD) that amount to approximately 70% of water applied in an average year, are managed independently within or outside the Region according to existing contracts or diverted directly from water courses or water bodies through riparian rights. The remaining 30% of water applied in an average year is extracted from a number of groundwater aquifers according to the choices and behaviors of thousands of independent groundwater pumpers.
3. Precipitation within the Region can vary considerably from year to year and in different parts of the Region, which affects the watersheds unimpaired flow (upstream runoff). For example, the average annual unimpaired flow in the upper Cache Creek watershed (above Rumsey) is 524 TAF, but has ranged from as little as 62 to as much as 1,964 TAF. The variability and timing in precipitation affects the amount of surface water that is captured and stored within the Region, and also affects the amount of water available to recharge the groundwater aquifers.
4. Much of the effects of the water supply variability for the Region are absorbed within the agricultural sector since they are the largest users of water in the Region. In areas of the Region where periodic shortfalls in agricultural water supplies occur, flexible agricultural crop choices have allowed many agricultural water uses to change their activities in a given year based on their expectation of the water that will be available. As a result, year-to-year water demand for agriculture within the region is not well understood. Recently, more permanent type crops have been planted that may make it more difficult to respond to the supply variability in the future without experiencing significant financial losses in water short areas of the Region.
5. Many areas throughout the Region have access to both groundwater and surface water supplies which provides a level of flexibility. However, there are some areas, including communities surrounding Clear Lake and some of the cities (Woodland, Davis, Dixon, and Rio Vista) that rely on a single source of supply and may experience shortages during dry periods. Significant areas of agricultural lands also currently rely on a single source of water and can experience considerable variability in their water supplies each year as a result.
6. Climate change impacts are still being determined, but likely will cause increased variability in temperature, annual precipitation and surface water runoff quantities, and changes in the timing and frequency of storms that affect the ability to store water for agricultural or municipal uses. These changes could lead to less groundwater recharge and more frequent and increased use of groundwater within the Region. Increased use and reduced recharge of groundwater could negatively impact areas that depend on groundwater for their supply.

Table 3-6: Regional Water Balance Summary – Average Year (2040)

	Planning Area			
Category	**Upper Cache**	**Upper Putah**	**Valley Floor**	**Total**
Water Entering (TAFY)				
Precipitation	693	455	NQ [a]	1,148
Upstream Runoff (upper watershed)	0	0	669	669
Upstream Releases (regulated releases)	0	0	306	306
Imported Water (outside watershed)	0	0	624	624
Total Water Entering	**693**	**455**	**1,599**	**2,747**
Water Within				
Water Supplies				
Direct Deliveries (TAFY)	0	0	944	944
Surface Water Storage (TAF)				
Surface Storage	1,062	1,103	0	2,165
Local Release Deliveries	25	NQ	0	25
Downstream Releases (see Water Leaving)				
Groundwater Storage (TAF)				
Groundwater Percolation (Recharge)	72	14	524	610
Return Flows (TAFY)				
Agricultural RF	8	2	362	373
Urban RF	2	1	15	18
Wastewater RF	0	0	3	4
Total Return Flows	10	3	381	394
Recycle/Reuse (TAFY)	1	0	21	23
Total Water Supplies	**119**	**NQ**	**1,869**	**1,988**
Applied Water Demand (TAFY)				
Applied Surface Water				
M&I	14	1	24	39
Agricultural	6	8	986	1,000
Total Surface Water Use	20	9	1,010	1,039
Applied Groundwater Extractions				
M&I	3	3	37	43
Agricultural	25	2	464	491
Total Groundwater Extractions	28	5	501	534
Total Applied Water	**48**	**14**	**1511**	**1573**
Water Leaving (TAFY)				
Consumption of Applied Water	35	10	1,151	1,195
Exports	8	0	56	64
Downstream Releases	153	153	0	306
Downstream Runoff	444	225	199	868
Wastewater Discharges	.4	0.1	6	7
Losses				
Surface Evaporation/Seepage [b]	15	102	NQ	117
Subsurface Aquifer	NQ	NQ	NQ	NQ
Other Unrecoverable Losses	NQ	NQ	NQ	NQ
Total Water Leaving	**655**	**491**	**NQ**	**1,146**

(a) NQ - Not Quantified
(b) Evaporation from Clear Lake not included because the unimpaired flows that were used to estimate precipitation accounted for evaporation at Clear Lake, thus including evaporation here would double count this water loss.

Table 3-7: Regional Water Balance Summary – Dry Year (2040)

	Planning Area			
Category	**Upper Cache**	**Upper Putah**	**Valley Floor**	**Total**
Water Entering (TAFY)				
Precipitation	218	123	NQ [a]	341
Upstream Runoff (upper watershed)	0	0	274	274
Upstream Releases (regulated releases)	0	0	236	236
Imported Water (outside watershed)	0	0	367	367
Total Water Entering	**218**	**123**	**877**	**1,218**
Water Within				
Water Supplies				
Direct Deliveries (TAFY)	0	0	606	606
Surface Water Storage (TAF)				
Surface Storage	935	965	0	1,900
Local Release Deliveries	25	NQ	0	25
Downstream Releases (see Water Leaving)				
Groundwater Storage (TAF)				
Groundwater Percolation (Recharge)	72	14	524	610
Return Flows (TAFY)				
Agricultural RF	10	3	389	402
Urban RF	2	0.5	15	18
Wastewater RF	0.4	0.1	3	4
Total Return Flows	13	3	407	423
Recycle/Reuse (TAFY)	1	0.4	21	23
Total Water Supplies	**99**	**NQ**	**1,558**	**1,657**
Applied Water Demand (TAFY)				
Applied Surface Water				
M&I	14	1	24	39
Agricultural	8	9	902	919
Total Surface Water Use	**22**	**10**	**926**	**958**
Applied Groundwater Extractions				
M&I	3	3	37	43
Agricultural	33	2	653	688
Total Groundwater Extractions	36	5	690	757
Total Applied Water	**58**	**15**	**1,616**	**1,689**
Water Leaving (TAFY)				
Consumption of Applied Water	43	11	1,229	1,283
Exports	0	0	56	56
Downstream Releases	84	152	0	236
Downstream Runoff	166	108	199	473
Wastewater Discharges	.4	0.1	10	14
Losses				
Surface Evaporation/Seepage [b]	15	102	NQ	117
Subsurface Aquifer	NQ	NQ	NQ	NQ
Other Unrecoverable Losses	NQ	NQ	NQ	NQ
Total Water Leaving	**308**	**374**	**NQ**	**682**

(a) NQ - Not Quantified
(b) Evaporation from Clear Lake not included because the unimpaired flows that were used to estimate precipitation accounted for evaporation at Clear Lake, thus including evaporation here would double count this water loss.

3.1.4.2 Upper Watersheds Water Balances

All of the water entering the Upper Cache and Upper Putah creek watersheds arrives in the form of rain or snowfall. The annual variability of rainfall produces wide fluctuations of runoff each year. The estimated quantity of water entering the upper watersheds is approximately 1,148 TAFY on average, and 341 TAFY in a dry year.

Figures 3-4 through 3-7 show the water balances for the Upper Cache and Upper Putah Planning Areas in the average and dry hydrologic years. Most of this water is captured in one of the three reservoirs and is eventually released, flowing downstream leaving the planning areas and entering the Valley Floor PA. Local water users within the Upper Cache and Upper Putah Planning areas primarily draw their supplies from the lakes and reservoirs and groundwater. Some riparian diversions occur from the streams and creeks, although the quantity of riparian diversions are unknown and are believed to represent a minor portion of the overall water flow. Approximately 75-95% of the water (depending on the type of water year) that enters the upper watersheds is either stored and then released downstream into Putah and Cache Creeks, or lost to surface evaporation on the lakes.

The process of creating water balances for the upper watersheds led to the following noteworthy observations:

1. Most water supply purveyors around Clear Lake receive surface water from the lake via contract with YCFCWCD. YCFCWCD is committed to ensure this supply is available to Clear Lake customers in all hydrologic year types.
2. Current limitations with water supply and/or water storage and delivery infrastructure recently have prevented the issuance of building permits in several areas around Clear Lake. Three County Service Areas and two private purveyors currently have or recently had moratoriums on new service connections.
3. Approximately 66 percent (27 TAFY) of agricultural water applied in the upper watersheds is supplied by groundwater. However, the sustainable yield of the fourteen groundwater basins in the planning areas is not well understood. Studies have indicated that a drought condition that has a 1 in 10 (10%) chance of occurring in any given year could result in insufficient groundwater quantities to meet expected demands in some portions of the Upper Cache Planning Area (1987 Lake County Resources Management Plan per Tom Smythe), although these estimates require updating as land and water use patterns have changed over time.
4. The currently available information suggests that M&I and agricultural demands may exceed available groundwater supplies in some years within the Upper Cache Planning Area. More detailed analysis of the expected demands and available supplies during multi-year dry hydrologic conditions for the Upper Cache Planning Area seems warranted.
5. The water users within the Upper Putah Planning Area are mostly rural and self-supplied. These rural users rely predominantly on groundwater. There is no indication that the groundwater supplies have not been sufficient to date. DWR periodically monitors the groundwater levels in the major aquifers in the Upper Putah Planning Area. As demands in this planning area grow, the local aquifers should be monitored for signs of stress.

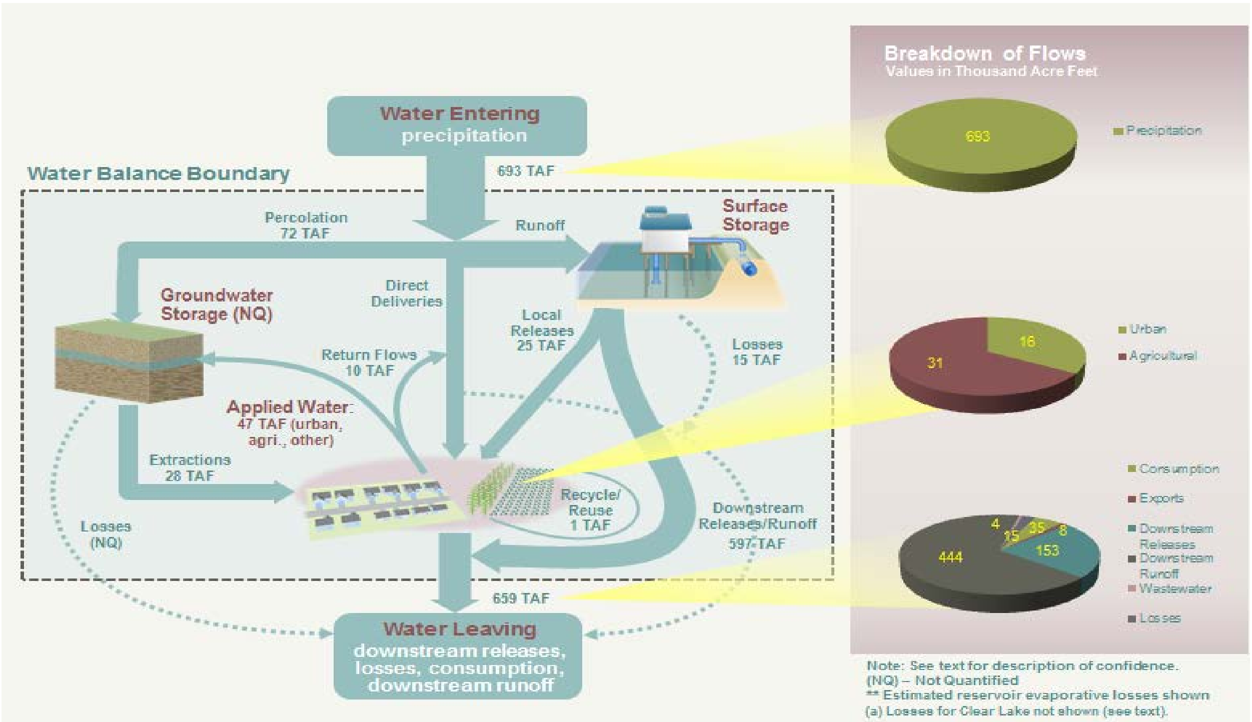


Figure 3-4: ***Average Year – Upper Cache Planning Area***

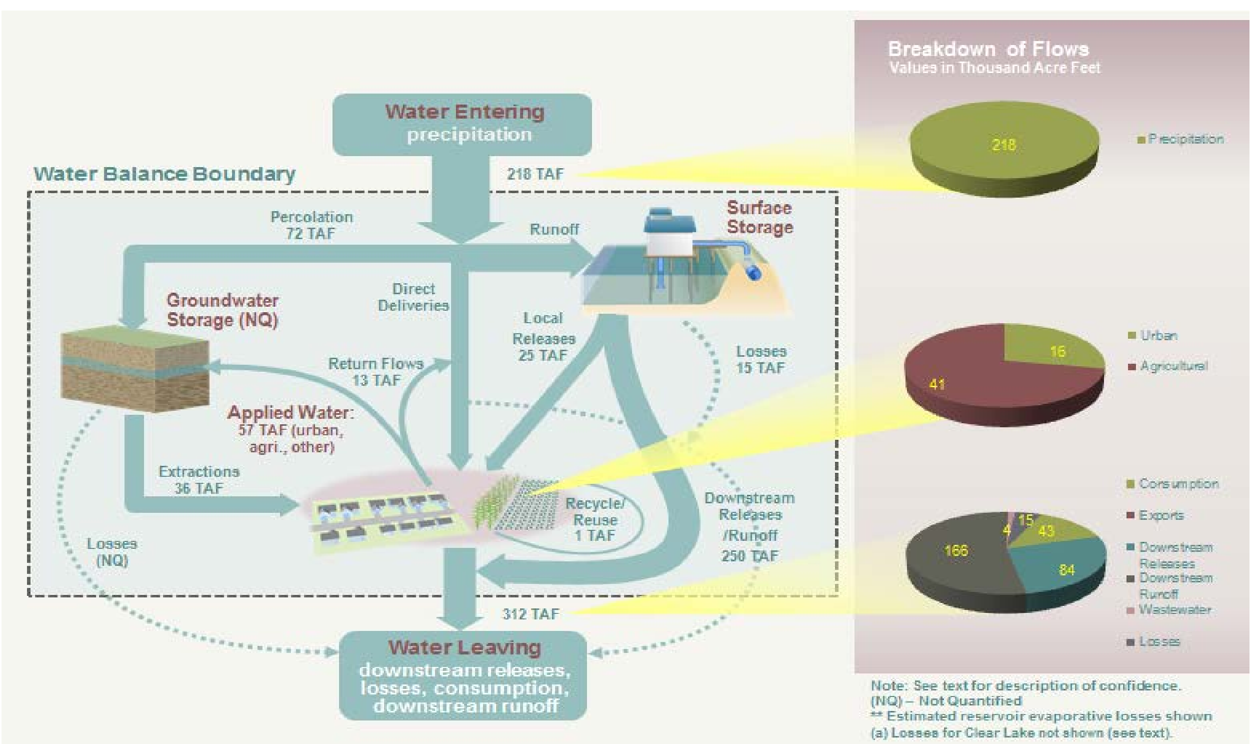


Figure 3-5: ***Dry Year – Upper Cache Planning Area***

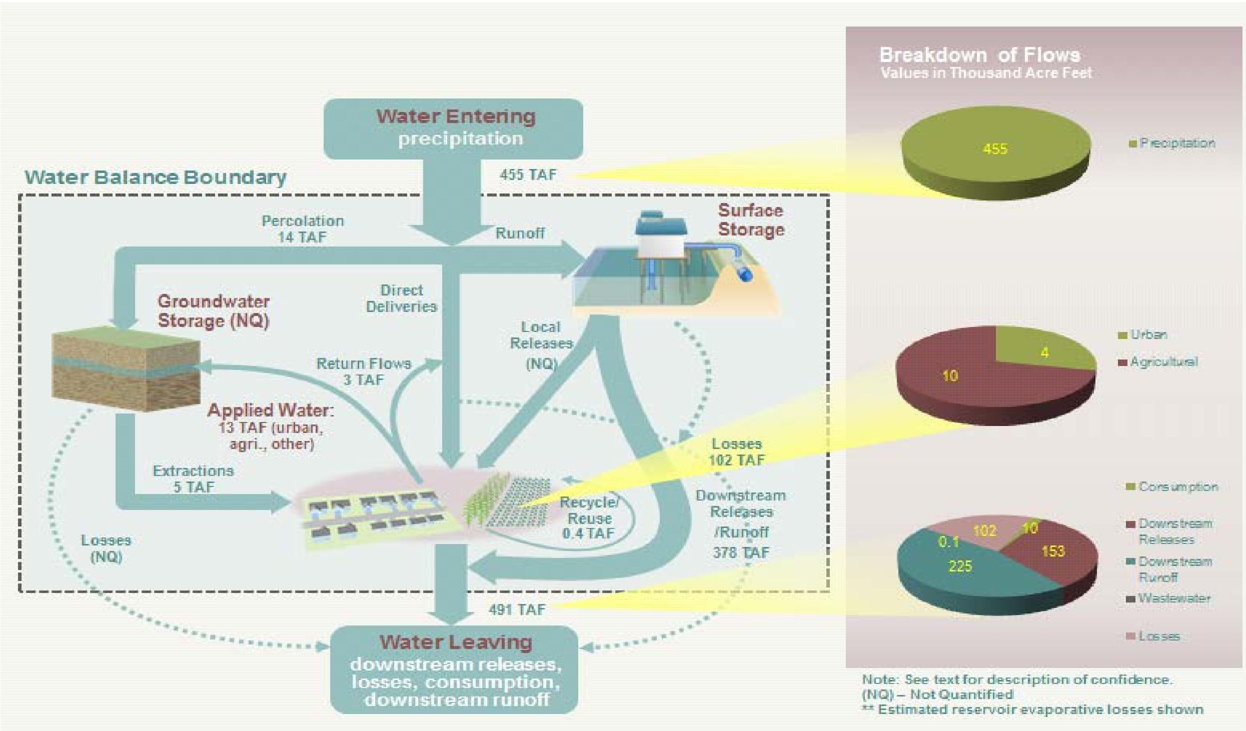


Figure 3-6: ***Average Year – Upper Putah Planning Area***

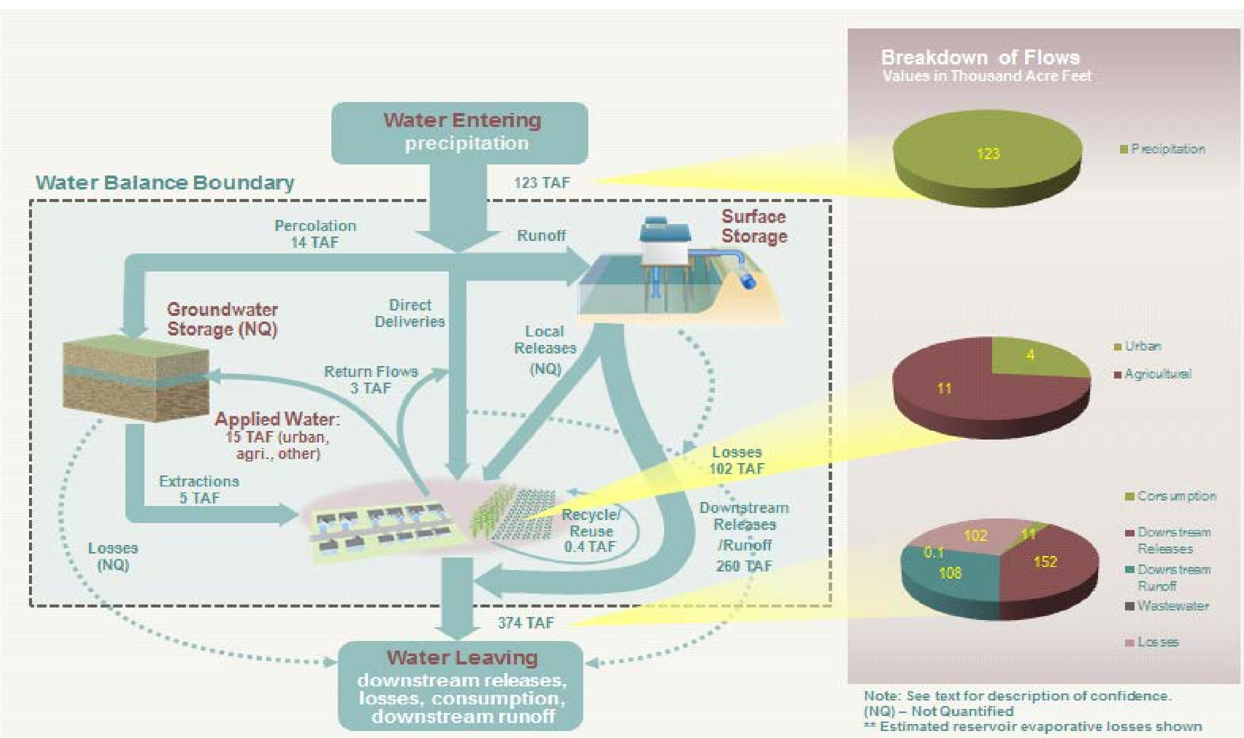


Figure 3-7: ***Dry Year – Upper Putah Planning Area***

3.1.4.3 Valley Floor Water Balance

The Valley Floor PA water balance is summarized in Figure 3-8 and Figure 3-9. Water is supplied to the Valley Floor PA from many different sources including flows from the two upper watershed Planning Areas, groundwater pumping, and extensive imported water infrastructure. Part of the reason that there are so many sources is the fact that that there are no major surface storage reservoirs in this generally flat-lying area and the lands along the valley floor support an active agricultural industry. The water balance schematic shows balancing reservoirs instead of surface storage. Balancing reservoirs include the water impounded by YCFCWCD's Capay Dam and SCWA's Solano Diversion Dam.

Most (over 95%) water use within the Westside Region occurs in the Valley Floor PA. It is estimated that there is approximately 1,600 TAF of applied water demand in the Valley Floor PA in an average year.

1. The process of creating water balances for the Valley Floor PA led to the following observations: Demand for applied water in the Valley Floor Planning Area (and the Region) is dominated by agricultural uses. However, the agricultural water demands are the least understood within the Region. Recent trends indicate that more growers are planting more permanent crops such as vineyards and olives, which may over time, contribute to demand hardening and changes in irrigation patterns. At present, approximately 15 percent of all crops are of a permanent type within the planning area. Projections for agricultural water demands are not currently available for this Region, but may be available in the near future as part of the California Water Plan 2013 Update.
2. Historical evidence suggests that the agricultural community (in aggregate) adjusts their planting decisions each year based on an assessment of the amount of water supplies available to them. For the water users supplied within Solano County, the agricultural supply and demand seems to be in balance and is expected to stay in balance over the planning horizon. For the other portions of this planning area, the information currently available is not sufficient to determine how the apparent trend towards more permanent crops may match up with the variability of supplies. As demands harden, the potential negative impacts that occur during years with less water supply increase.
3. M&I water supplies are described in UWMP's for the larger communities. Each community has their own water supply challenges with different programs and policies to address them, but no community expects to experience major shortages in M&I water supplies during the planning horizon. With the abundance of agriculture water use in the Planning Area, there are opportunities for collaborations such as transfers, exchanges and conjunctive use projects that could supplement M&I supplies. Conjunctive use is being practiced by some agencies within the region to improve water supply reliability, and this type of effort is expected to continue to develop going forward.
4. Municipalities and agricultural groundwater users would be able to make more informed long-term water management decisions if they had access to an improved understanding of the sustainable yield of shallow and deep aquifers in the Yolo and Solano subbasins. One area of particular uncertainty is the safe yield of the deep Tehama formation serving many of the larger urban areas (City of Davis, UC Davis, Woodland, and Vacaville). Users whom rely on particular aquifers as a major component of their supply may find it worthwhile to invest in improved characterization of specific aquifers to help ensure these resources are used sustainably.
5. Municipal recycled water use is currently negligible and is projected to account for about 1% of the water supply in the Valley Floor PA by 2020. Required upgrades to existing wastewater treatment plants (for example in the Cities of Vacaville and Davis) to meet regulatory treatment standards as issued by the Central Valley Regional Water Quality Control Board could result in additional recycled water becoming available for reuse to help meet agricultural or domestic demands if the distribution and application of the more highly treated wastewater is found to be locally cost-effective.
6. An imbalance in the availability of surface water exists across different parts of the Valley Floor PA. For example, some purveyors in northern Yolo County have no or limited access to surface water, especially during dry periods. Water users may be willing to support purveyors to

interconnect and leverage their shared resources to a greater extent across the Region in the future. Areas within the PA that could benefit from improved water movement/conjunctive use such as: Cities of Davis and Woodland, Portions of northern Yolo County that do not have access to surface water, such as Yolo-Zamora Water District, and other agricultural water users in Yolo and Solano Counties that do not have access to multiple supply sources.

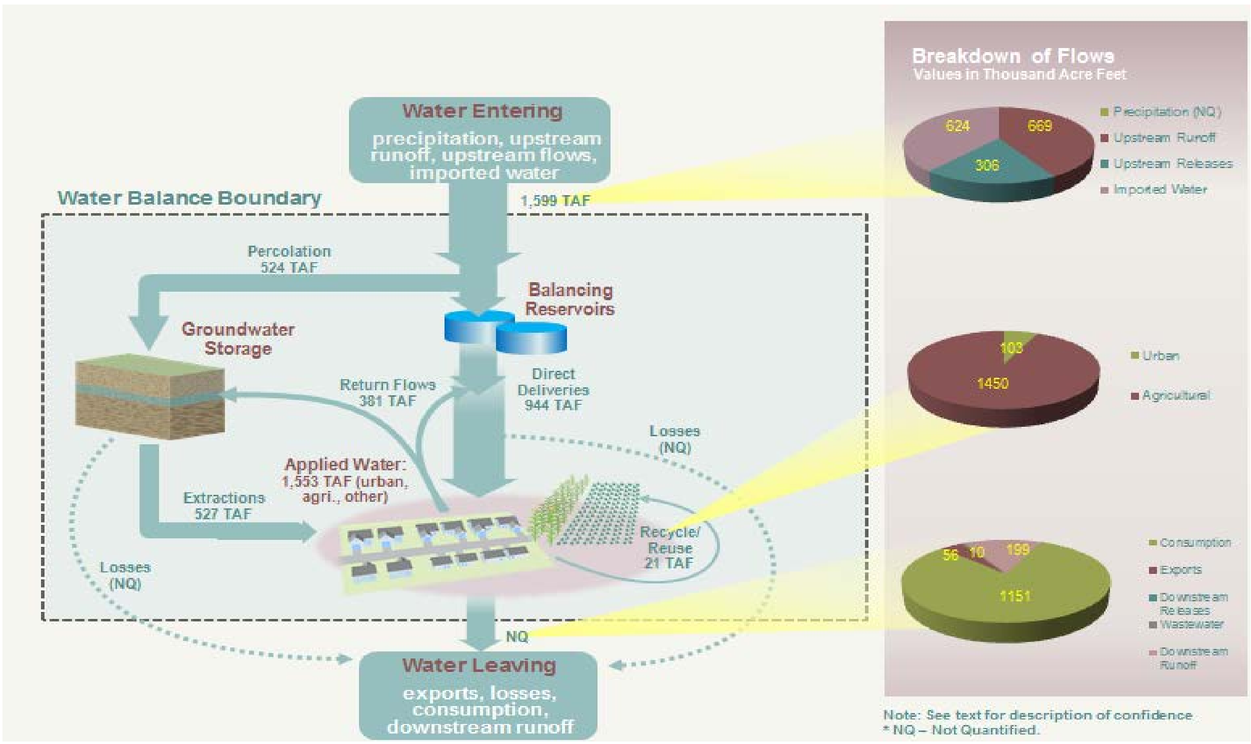


Figure 3-8: Average Year – Valley Floor Planning Area

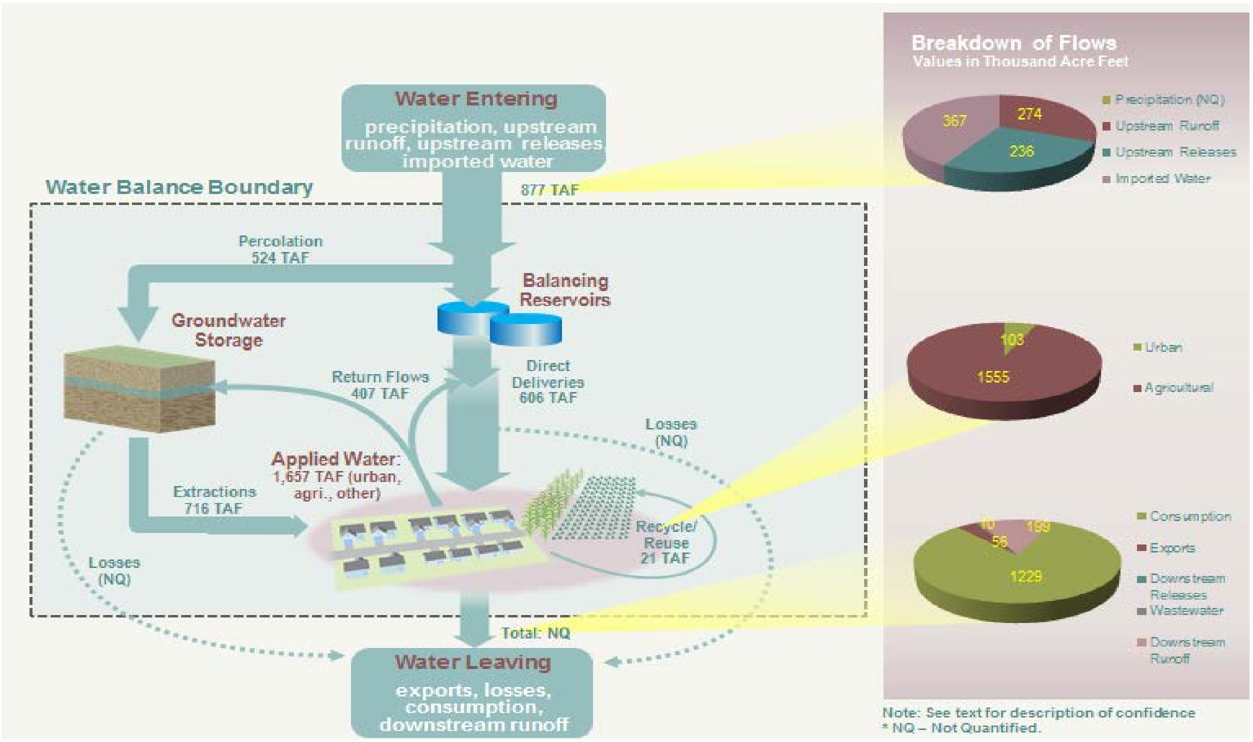


Figure 3-9: Dry Year – Valley Floor Planning Area

3.2 Water Quality

As shown above, water quantity is a major factor that influences the behavior of water users and water managers within the Region. However, water quality is also a dominant factor in influencing water management actions within the Region. The water quality of various surface and groundwater resources affects whether supplies for human uses and the environment will be sustainable. As a result, water managers and interested citizens throughout the Region strive to preserve, protect, and restore the water quality of reservoirs, creeks, aquifers, as well as imported supplies. A number of common challenges related to managing water quality exist within the Westside Region despite the large geographic extent. These shared challenges provide multiple opportunities for water managers and other stakeholders in the Westside Region to collaborate and cooperate to improve the water quality for all end users.

3.2.1 Water Quality Regulatory Framework

An extensive federal, state, and local regulatory framework has evolved to protect and improve water quality for all beneficial uses. Today, many of these regulations directly influence the water management actions in the Westside Region. The regulations are designed to support continued, long-term use of the Region's water supplies for drinking water, agricultural, and ecosystem benefits. The 1972 Federal Clean Water Act (CWA) established strategies for managing water quality including: requirements to establish and maintain at least a minimum level of pollutant management using the best available technology; and a water quality based approach that relies on evaluating the condition of surface waters and setting limitations on the amount of pollution that the water can be exposed to without adversely affecting the beneficial uses of those waters. Section 303(d) of the CWA bridges these two strategies. Section 303(d) of the CWA requires the identification of water bodies that do not meet, or are not expected to meet, water quality standards (i.e., impaired water bodies). The affected water body, and associated pollutant or stressor, is then prioritized in the 303(d) List. The CWA further requires the development of a Total Maximum Daily Load (TMDL) for each listing. The list is compiled based on the guidance outlined in the "Water Quality Control Policy for Developing California's Clean Water Act Section 303(d)". There are many resources that provide additional information on State and Federal water quality regulations, including the April 2002 California Legislative Report: "Addressing the needs to Protect California's Watersheds: Working with Local Partnerships."

The USEPA, SWRCB, and Regional Water Quality Control Boards (RWQCBs) have permitting, enforcement, remediation, monitoring, and watershed-based programs to prevent pollution through both the CWA as well as the California Porter-Cologne Water Quality Control Act. Pollution can enter a water body from point sources including wastewater treatment plants (WWTPs), storm water discharges and/or other industries that directly discharge to a water body and from nonpoint sources (NPS) over a broad area, such as runoff from agricultural farmland or grazing areas that can reach waterways. NPS pollution can include pollutants from urban and agricultural runoff and include heavy metals, oils and greases, herbicides, pesticides, and fertilizers. Preventing pollution from most point sources relies on a combination of source control and treatment, while preventing NPS pollution generally involves the use of best management practices (BMPs), efficient water management practices, and source control.

The Federal Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The SDWA applies to every public water system in the United States. SDWA authorizes the USEPA to set national health based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water. Originally, SDWA focused primarily on treatment as the means of providing safe drinking water at the tap. Amendments in 1996 greatly enhanced the existing law by recognizing source water protection, operator training, funding for water system improvements, and public information as important components of safe drinking water. Under the SDWA, technical and financial aid is available for certain source water protection activities. The California Department of Public Health (CDPH) is responsible for enforcing the SDWA and California-specific drinking water regulations as defined in Title 22 of the California Code of Regulations.

3.2.2 Surface Water Quality

The surface waters within the Westside Region support a variety of beneficial uses, including municipal and domestic supply, agriculture water supply, industrial water supply, recreation, commercial and sport fishing, freshwater habitat, migration and spawning of aquatic organisms and wildlife habitat for terrestrial species. Table 3-8 presents the beneficial use designations for major surface water bodies in the Region as identified in the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan). The Basin Plan does not identify beneficial uses for all water bodies in the Region; however the tributary streams of any specifically identified water body can generally be assumed to have the same beneficial use designations.

In compliance with Section 303(d) of the CWA, the Regional Water Quality Control Board (Regional Water Board) has identified surface waters within the Westside Region that contain pollutants which exceed water quality standards for one or more of their beneficial uses, and will eventually require development of a Total Maximum Daily Load (TMDL) for each listed pollutant/water body combination. Figure 3-10 illustrates the extent of these 303(d) listed surface waters. A table identifying the specific 303(d) listed water bodies and their sources of impairment is included in Appendix C.

In addition to identifying impaired water bodies, the Regional Water Board is required to develop a Total Maximum Daily Load (TMDL) for each pollutant/water body combination identified in the 303(d) listing. The TMDL is designed to control the amount of the pollutant entering the water body so that the beneficial use of the water body can be restored. The Regional Board has developed several TMDLs for the Region and has plans to develop more in the future. The completed TMDLs include: mercury in Clear Lake, Cache Creek, Bear Creek, Sulphur Creek and Harley Gulch; chlorpyrifos and diazinon in the Delta Waterways; and nutrients in Clear Lake.

Table 3-8: Westside Region Surface Water Bodies and Beneficial Uses

	Municipal and Domestic Supply	Agricultural Supply	Industrial Supply	Recreation	Commercial and Sport Fishing	Freshwater Habitat	Migration	Spawning	Wildlife Habitat
Clear Lake	X	X		X	X	X		X	X
Cache Creek	X	X	X	X	X	X		X	X
Lake Berryessa	X	X		X		X		X	X
Putah Creek	X	X	X	X		X		X	X
Colusa Basin Drain		X	X			X	X	X	X
Yolo Bypass		X	X	X	X	X	X	X	X
Sacramento San Joaquin Delta	X	X	X	X	X	X	X	X	X

Mercury is a significant source of water quality impairment throughout the Westside Region and is a legacy left by the extensive mining done within the Region. Erosion of naturally mercury-enriched soils, flows from geothermal springs and atmospheric deposition all contribute mercury to the watershed, but the major source of mercury is believed to be sediment runoff from historic mines (CVRWQCB, 2010). Numerous mercury mines were developed within the Region during the mid to late 1800s to support the gold rush. These mines were located primarily within the upper reaches of the Cache Creek and Putah Creek watersheds. Because mercury has discharged from the mines through runoff and leachate filters downstream, mercury contamination extends throughout the Westside Region and continues to present significant challenges for water resources managers through today.

One of the largest mines was the Sulphur Bank Mercury Mine. The former mercury mine is located near the southeastern end of Clear Lake's Oaks Arm. The mine, once one of the largest producers of mercury in California, has remained inactive since 1957. The area was mined for sulphur from 1856 to 1871, then intermittently mined for mercury from 1873 to 1905. From 1915 to 1957, the site was an open pit mercury mine. Mine tailings, waste rock, and the water-filled open pit, Herman Impoundment, are located on the property. Approximately two million cubic yards of mine wastes and tailings remain on the mine site. These mercury-contaminated mine wastes extend outside the mine site and are also detectable in Clear Lake sediment, in the wetlands to the north of the mine property, and at the Elem Indian Colony.

The soils and mine wastes at the mine property and in the surrounding area are contaminated with high levels of mercury and arsenic. Mercury is a neurotoxin, therefore people exposed to high levels may experience adverse health effects. Exposure to high levels of arsenic may also lead to adverse health effects, including cancer. EPA has found mercury in the surface water and groundwater that discharge from the Site, as well as in the sediment and biota of Clear Lake.

In 1990, the Sulphur Bank site, which lies along the lake shoreline, was listed on USEPA's National Priorities List under the Comprehensive Environmental Response, Compensation, and Liability Act, more commonly known as Superfund. Accordingly, USEPA has responded with long-term actions to remediate hazardous wastes at the site.

EPA has taken several actions to protect human health and limit the impacts of contamination on the environment. Currently, EPA conducts annual groundwater and surface water sampling at the Site. EPA also conducts semi-annual storm water monitoring, inspects all the stormwater culverts, and maintains site controls to keep unauthorized individuals from entering the site. EPA is working on both Operable Units at the same time, though they are at slightly different stages in the Superfund Process.

The selection of a remedial action is a two-step process and shall proceed in accordance with 300.515(e). First, the lead agency (US EPA), in conjunction with the support agency (State and Elem Indian Colony), identifies a preferred alternative and presents it to the public in a proposed plan, for review and comment. Second the lead agency shall review the public comments and consult with the state (and support agency) in order to determine if the alternative remains the most appropriate remedial action for the site or site problem. The lead agency, as specified in 300.515(e), makes the final remedy selection decision, which shall be documented in the Record Of Decision (ROD).

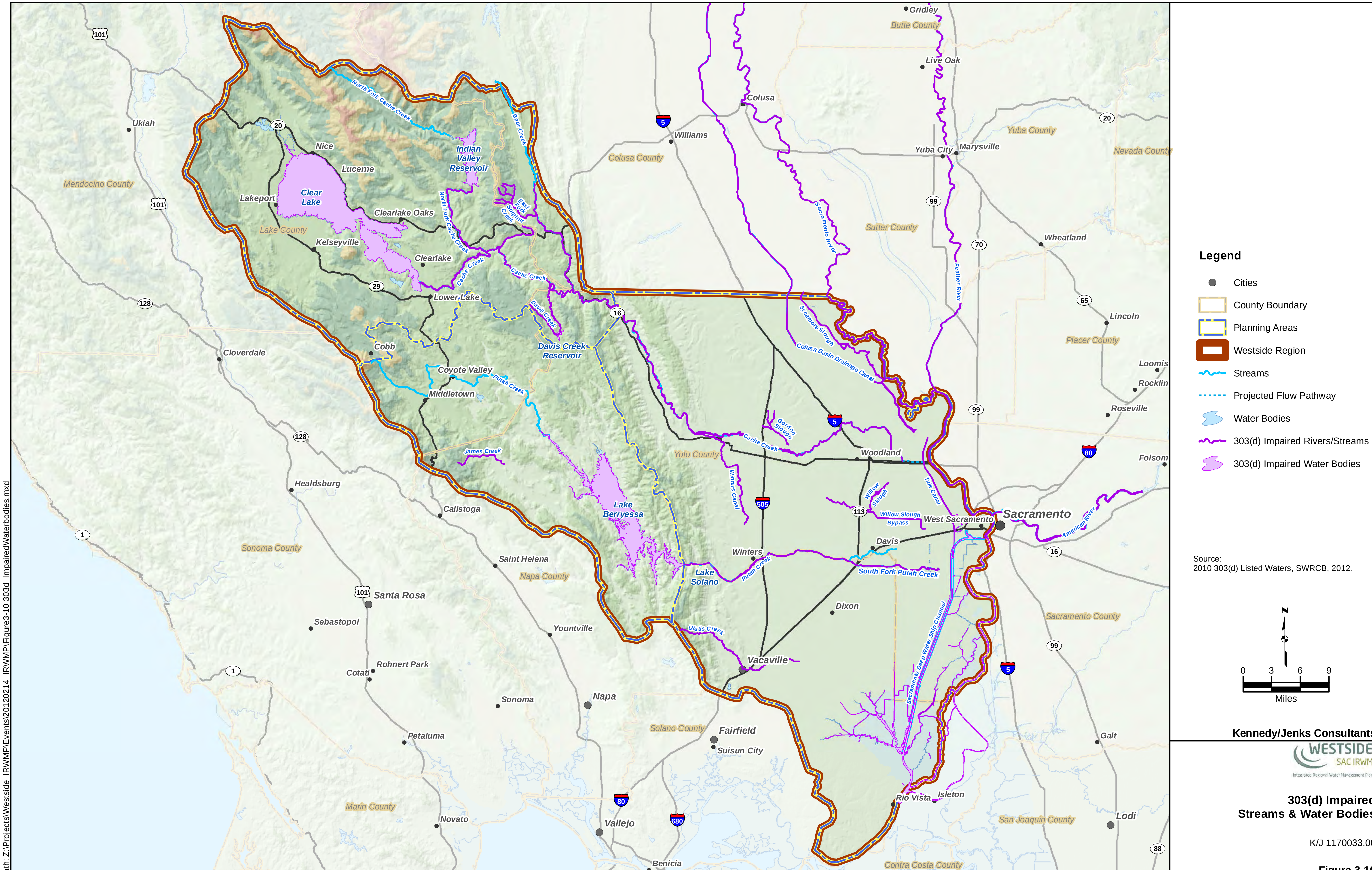
As described in the Basin Plan (CVRWQCB, 2011), the main concern with mercury in the watershed is bioaccumulation in aquatic systems. Mercury accumulates in the sediment of lakes and streams where bacteria convert it into methylmercury. Methylmercury is the most toxic form of mercury and accumulates within animals faster than it can be eliminated. Neurological, reproductive and other detrimental effects have been linked to methylmercury exposure. Beyond the harm caused to organisms within the environment, humans are also subject to harm if they ingest the contaminated organisms and therefore numerous streams in the Region have been listed as impaired for commercial and sport fishing. The Department of Public Health, Office of Environmental Health Hazards Assessment has issued a fish consumption advisory with guidelines for safe consumption of fish for Clear Lake, Cache Creek, Bear Creek, the Delta, Lake Berryessa, Putah Creek and the Sacramento River (www.oehha.ca.gov).

While the 303(d) listing for mercury in the Region is in response to human health concerns, accumulation of mercury in fish can also impact the health of wildlife that feed on fish. The impact to wildlife, particularly waterfowl, although not currently an area of regulatory attention is an issue that is being monitored by stakeholder groups such as the San Francisco Estuary Institute and may affect management actions in the future.

The mercury TMDLs that have been developed for Clear Lake, Cache Creek, Bear Creek, Harley Gulch and Sulphur Creek prescribe cleanup of inactive mines and erosion control measures to decrease the transport of mercury. While the mercury TMDLs for other creeks and lakes in the Westside Region are still under development, groups such as the Delta Tributaries Mercury Council and Tuleyome have been working to implement strategies to manage mercury and restore abandoned mercury mines in advance of mandated actions. The Cache Creek Settling Basin has been of particular interest to stakeholders and the focus of various studies. Designed to trap sediments before water from Cache Creek flows into the Yolo Bypass, the Cache Creek Settling Basin has accumulated significant concentrations of mercury. Researchers believe that about half the mercury that is transported down Cache Creek is deposited within the settling basin (CVRWQCB, 2008).


Erosive Streambank in the Westside Region

Boron is another common source of water quality impairment for the Region. Boron, a naturally occurring element in the soils of the region, dissolves in water and is carried into surface water bodies. While necessary to plant growth at low concentrations, boron in high concentrations is toxic to plants and can stunt their growth. Portions of Cache Creek, Putah Creek, Willow Slough, Willow Slough Bypass and the Tule Canal have been 303(d) listed for elevated boron concentrations that may be impairing agricultural water quality. In Putah Creek, boron has been delisted from the CVRWQCB's 2014 Integrated Report for 303(d). If approved by the EPA and SWRCB, Putah Creek will no longer have a required TMDL for boron. From an end use perspective, boron in surface water is mainly a concern for irrigators in the valley.



Kennedy/Jenks Consultants

WESTSIDE SAC IRWM

303(d) Impaired Streams & Water Bodies

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Figure 3-10

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Pesticides are another major concern related to water quality impairment for the Westside Region. Surface waters in the Valley Floor PA are 303(d) listed for a host of pesticides that impair freshwater habitat and commercial and sport fishing beneficial uses. The source of pesticides is runoff from agricultural applications. Although Clear Lake has not been listed as impaired by pesticides, the potential for pesticides to be carried by surface water runoff to Clear Lake is a concern that has been expressed by Native American communities as well as other community members such as the Clear Lake Advisory Committee.

Erosion and sedimentation that results from human activities on the landscape can also present a water quality concern primarily because of sediment impacts on habitat. Erosion and sedimentation are a necessary component in healthy geomorphic processes, but they also can reduce the quality of aquatic habitat by covering gravel needed for fish spawning, harming aquatic invertebrate and increasing biological oxygen demand through the introduction of organic matter and nutrients within the sediment.

Another impact of sediment deposition (even as a result of normal geomorphic processes) can be reduced channel conveyance capacity and a corresponding increased risk of flooding. Sources of sediment loading in the Region include runoff from agricultural lands, over-grazing, construction activities, erosion of unpaved roads and trails, silviculture and increased sedimentation from precipitation following wildfires. Reducing undesirable sediment loads can benefit habitat and reduce the risk of flooding. Reduction of channel conveyance capacity through sediment deposition is a challenge of particular concern in the Valley Floor Planning Area, where the Cache Creek Settling Basin is reaching its design capacity for storing captured sediment.

Clear Lake is highly eutrophic, and is listed on the 303(d) list as impaired by nutrients. Studies indicate that excess phosphorus contributes to the occurrence of nuisance blooms of blue-green algae in Clear Lake during summer and fall periods. Sediment, both natural and anthropogenic, is the primary source of phosphorus to Clear Lake. Sediment sources include erosion from agricultural and urban areas, instream channel erosion, timber harvesting, runoff from roads, construction, gravel mining, wildfires, control burns, off highway vehicle (OHV) use, and dredging and filling. Fertilizer use (both urban and rural) and sewer and septic overflows, which are exacerbated during flood conditions, may also contribute phosphorus to the lake. Essentially all municipal wastewater is land applied or pumped from the watershed and therefore should not be contributing phosphorus to Clear Lake.

Recent improvements in erosion control and watershed restoration have appeared to contribute to improved lake clarity however, more severe cyanobacteria blooms have occurred in the past four years indicating that other factors may be affecting the ecosystem within Clear Lake. While water resources managers and stakeholders generally agree that erosion control, riparian and wetland restoration upstream of Clear Lake will have the greatest beneficial impact on Clear Lake water quality, challenges remain to prioritize which specific actions are needed in which locations.

An emerging contaminant of concern for water quality within the Region is harmful cyanobacteria. Some species of cyanobacteria produce toxins, and these cyanotoxins have varying levels of toxicity to humans and wildlife. Identification of the harmful cyanobacteria and their health effects is a developing area of research. Given its toxicity, one species of cyanobacteria which has been the focus of much recent research is *microcystis aeruginosa*, which produces the toxin microcystin. Although many types of cyanobacteria can produce microcystin, the limited sampling in Clear Lake indicates that *microcystis aeruginosa* is likely the primary source of the toxin. Contact with microcystin can lead to skin irritation, and ingestion of the toxin can result in gastrointestinal discomfort, vomiting and liver damage in humans. Exposure to cyanotoxins has led to death in wildlife species, dogs and livestock. *Microcystis aeruginosa* as well as other harmful cyanobacteria are known to occur in Clear Lake and portions of the Delta (Mioni et al). The current distribution of the harmful cyanobacteria along with the potential for toxins from Clear Lake to be carried downstream to Yolo County through water releases from Clear Lake make this a contaminant of Regional concern.

3.2.3 Imported Water Quality

As described above, imported water is an important source to the Region, and therefore protection of water quality within these sources of imported water is key for the Westside Region. The City of Vacaville, City of Dixon and City of Rio Vista have contracts to import water from the State Water Project to the Region through the North Bay Aqueduct, although only the City of Vacaville currently imports water. The intake for the North Bay Aqueduct is located in the Barker Slough watershed in the Delta, which has the poorest water quality in the State Water Project system. The North Bay Aqueduct water supply suffers from high organic carbon and turbidity, principally during the winter runoff season, although baseline organic carbon is relatively high year round. The source of organic carbon is decaying organic material within the watershed and Delta waters. Turbidity principally comes from the watershed where the soil type results in long duration suspension of soil particles in the runoff. Natural and human induced erosion within the Barker Slough watershed contribute to high turbidity. Treatment of water with high organic carbon concentrations for distribution as drinking water can result in the formation of carcinogenic disinfection byproducts, and treatment of water with high turbidity to produce safe drinking water requires higher chemical use to remove the suspended particles. Due to these challenges, the Solano County Water Agency and Napa County Flood Control and Water Conservation District (which supplies water in Napa County outside the Westside Region) are investigating the possibility of constructing an alternate intake for the North Bay Aqueduct along the Sacramento River that would provide a higher quality supply source.

Dunnigan Water District, Colusa County Water District and River Garden Farms import water from the Central Valley Project (CVP) to the Region through the Tehama Colusa Canal and through multiple diversions from the Sacramento River (Water Resources Association of Yolo County, 2007). Water from the Tehama Colusa Canal is currently only used to supply agricultural uses and is of sufficient quality to meet the needs of those users. Previous investigations into the extension of the Tehama Colusa Canal to serve additional portions of the Region identified the use of aquatic pesticides in the canal as a potential concern for use to help meet municipal water demands (West Yost, 2012). CVP diversions from the Sacramento River meet all applicable water quality standards for current use by the City of West Sacramento.

Davis and Woodland also use water from the Sacramento River to help meet their municipal and industrial demands. Davis and Woodland formed the Woodland-Davis Clean Water Agency which has obtained post 1914 water rights for the Sacramento River through the SWRCB. This water right is subject to Term 91 curtailments during the summer months, so they have also made an agreement with Conaway Ranch to purchase water rights without Term 91 curtailments that will provide a water supply during the summer months (Bartkiewicz, 2011).

3.2.4 Groundwater Quality

Groundwater is used throughout the Region for drinking water and irrigation supplies. Impairment of groundwater can be assessed by comparing concentrations of constituents of concern in the groundwater against drinking water maximum contaminant levels (MCLs) and agricultural water quality parameters needed for specific crops. MCLs consist of primary and secondary MCLs. Primary MCLs are assigned to constituents for which a health-based risk is associated with consumption of water that exceeds a particular concentration. Secondary MCLs are assigned to constituents for which there is no health risk, but for which there may be aesthetic concerns above a particular concentration. Irrigation Water Quality Targets are research based standards that provide a recommended maximum constituent concentration in irrigation water based on quantities that will cause undesirable accumulations in plant tissue and growth reductions. Tolerance for water quality constituents vary by crop type, but general irrigation water quality standards have been developed based on literature review which were summarized in a paper put out by the Food and Agriculture Organization of the United Nations (Ayers, 1985). Table 3-9 identifies groundwater constituents of concern that have been identified in the various groundwater basins throughout the Region and their respective water quality targets.

The following sections describe the location and extent of these constituents of concern, summarizing information from previous studies as well as data from the on-line GEOTRACKER Groundwater Ambient Monitoring and Assessment Program (GAMA) database hosted by the State Water Board. Only public supply, and DWR- and State Water Board-regulated monitoring wells were evaluated.

Table 3-9: Groundwater Quality Constituents of Concern

Constituent (units) [a]	Drinking Water Quality Limit	Irrigation Water Quality Target[d]
Arsenic (ppb)	10	100
Boron (ppb)	N/A[b]	700
Chromium, Total (ppb)	50	N/A
Hexavalent Chromium (ppb)	N/A[c]	N/A
Iron (ppb)	300	5,000
Manganese (ppb)	50	200
Nitrate (ppm as N)	10	N/A
Perchlorate (ppb)	6	N/A
Total Dissolved Solids (ppm)	500	450

(a) Ppb – parts per billion; ppm – parts per million
(b) Boron has an established notification level set by the SWRCB of 1 ppm.
(c) The MCL for hexavalent chromium of 10 ppb was invalidated on May 31, 2017 and is currently not being enforced. A revised MCL will likely be adopted within the next few years.
(d) Ayers, 1985.

3.2.4.1 Arsenic

Arsenic is a naturally occurring element in groundwater. Ingestion of arsenic can result in short-term discomfort and long-term health effects such as skin discoloration, circulatory system impacts and increased cancer risks, and in high concentrations, arsenic consumption can lead to death. The California Department of Public Health (CDPH) has established a primary MCL of 10 ppb for arsenic. Arsenic can also be toxic to plants, but the toxicity varies depending on plant species. The 100 ppb irrigation water quality target is a research based recommendation published by the Food and Agriculture Organization that outlines recommendations for maximum levels of constituents in irrigation water such that the health of the plant is not negatively impacted.

According to the GAMA database, 21 percent of the groundwater wells across the Region report arsenic concentrations exceeding the MCL:

- In the Solano Subbasin, 89 of the 343 wells were reported at or over the MCL, ranging from 10 to 190 ppb. Of the 89 wells over the MCL, 61 appear to be located along Highway 113 and Highway 12. Additionally, within the Solano Subbasin there are two more wells over 5 ppb (half of the MCL) in Vacaville and Davis.
- In the Yolo Subbasin, concentrations of arsenic appear to increase with depth (Yolo County Flood Control & Water Conservation District, 2006). Ninety-four (94) of the 380 wells in the Yolo Subbasin were reported at or over the MCL, ranging from 10 to 410 ppb. The highest concentration of arsenic appears to be located in the eastern half of the Yolo Subbasin, specifically in west of Sacramento, north of Davis, Woodland, and along Highway 45 east of Dunnigan. Additionally, within the Yolo Subbasin, there are 15 more wells over 5 ppb (half of the MCL), the majority in Davis and a few in Dunnigan and Winters.
- In the Upper Putah Creek PA, 3 of 11 wells were reported at or over the MCL, ranging from 11 to 30 ppb. The highest concentration of arsenic appears to be located south of Lake Berryessa along Highway 121.
- In the Upper Cache Creek PA, 16 of the 241 wells were reported at or over the MCL, ranging from 10 to 34 ppb. The highest concentration of arsenic appears to be located around the perimeter of Clear Lake, and south of Clear Lake near Middletown. Additionally, within the Upper Cache Creek PA, there is one more well over 5 ppb (half of the MCL) on the north end of Lake Berryessa.

CDPH is considering lowering the arsenic MCL further in the future, which could require treatment for many municipal wells throughout the Region (Solano County Water Agency, 2010). Water providers will have to analyze the costs of removing arsenic through treatment, abandoning wells with arsenic levels above the MCL, or blending with water from an additional source. The City of Rio Vista has a treatment facility to remove arsenic from one (1) of their eight (8) wells.

3.2.4.2 Boron

Boron has no adverse health effects for humans or aesthetic concerns in drinking water. Boron is an unregulated contaminant in groundwater, but the SWRCB has established a notification level of 1 ppm. Plants have varying levels of tolerance to boron; boron is essential to plant growth in low concentrations, but at high concentrations can be toxic. The agricultural water quality target of 700 ppb is based on research by the Food and Agricultural Organization of the United Nations that indicate that this concentration can be tolerated by even the most sensitive crops.

Boron is a naturally occurring element found in high abundance in many of the soils within the Region, particularly in the Upper Cache Creek Planning Area around Clear Lake and Yolo Subbasin around Cache Creek and Cache Creek Settling Basin:

- Boron levels in groundwater along Cache Creek and Cache Creek Settling Basin have been reported range between 1 and 5 ppm (Bulletin 118, 2004). Elevated boron concentrations in groundwater in the Upper Cache Creek Planning Area is attributed to natural dissolution of boron into the groundwater and geothermal upwelling.
- Elevated boron concentrations in groundwater in the Valley Floor Planning Area is most likely the result of boron in surface water from the Upper Cache Creek Planning Area recharging the groundwater basins along Cache Creek.
- Elevated boron concentrations are also present in the southern and southeastern parts of the Solano groundwater subbasin (Solano County Water Agency, 2010).

3.2.4.3 Chromium

Chromium in groundwater can be the result of natural processes or industrial contamination. Chromium exists in different forms, and hexavalent chromium is the primary health concern. Hexavalent chromium is an emerging contaminant of concern. While this form of chromium was thought to be mainly a product of industrial processes, recent studies have shown that it can be produced naturally by the chemical alteration of trivalent chromium, and its occurrence in groundwater is not as rare as previously thought. In 2014, the SWRCB established a MCL for hexavalent chromium of 10 ppb that was withdrawn by the SWRCB in August 2017. Until a revised MCL is adopted by the SWRCB, to protect public health, the CDPH has established a primary MCL for total chromium of 50 ppb. CDPH established a Public Health Goal (PHG) of 0.02 ppb for hexavalent chromium; this PHG is not a regulatory requirement but is a step towards the development of a MCL. The detection limit for purposes of reporting is the former California state Notification Level (NL) 1 ppb.

The presence of hexavalent chromium in the Region is likely the result of natural transformation of trivalent chromium found in the serpentine rock formations. According to the GAMA database, 57 percent of groundwater wells across the Region report hexavalent chromium concentrations exceeding its NL:

- In the Solano Subbasin, 133 of the 194 wells were reported at or over the NL, ranging from 1 to 450 µg/L. The highest concentration of Hexavalent Chromium appears to be located near the cities of Davis and Dixon, and near the intersection of Highway 12 and Highway 113.
- In the Yolo Subbasin, measurements show that total chromium and hexavalent chromium levels decrease with depth in the aquifer (Yolo County Flood Control & Water Conservation District, 2006). One hundred ninety-four (194) of the 323 wells in the Yolo Subbasin were reported at or over the NL, ranging from 1 to 2800 µg/L. The highest concentration of hexavalent chromium appears to be near the cities of Davis and Woodland, and northeast of Davis toward the Yolo Bypass.
- In the Upper Cache Creek PA, 29 of the 103 wells were reported at or over the NL, ranging from 1 to 29 µg/L. The highest concentration of hexavalent chromium appears to be on the west end of Clear Lake and south of Clear Lake along Highway 175, with the highest concentration near Hidden Valley Lake.

Water providers within the Region are looking at various options to lower or remove hexavalent Chromium from the drinking water supply. The City of Vacaville has evaluated treatment solutions pilot studies and is currently designing a specialized hexavalent chromium treatment system at two wells. In the City of Davis, 12 wells were reported over the MCL, which was rectified by delivering surface water instead. In the City of Dixon, four (4) out of five (5) wells are in non-compliance with the MCL. The City of Dixon is studying methods to reduce hexavalent chromium to below MCL levels.

3.2.4.4 Manganese and Iron

Manganese and iron are groundwater constituents that are mainly a concern from a drinking water aesthetic standpoint; the presence of both of these constituents can cause taste and odor problems. CDPH has established secondary MCLs for manganese and iron of 50 ppb and 300 ppb, respectively. Research also suggests limiting the concentrations in irrigation water to 200 ppb and 5,000 ppb, respectively. Concentrations of manganese above the secondary MCL have been found in the eastern part of the Solano Subbasin (Solano County Water Agency 2010), Yolo Subbasin (Yolo County Flood Control & Water Conservation District, 2006), and Upper Lake, Scotts Valley, Coyote and Collayomi Valley Basins (CDM 2006a). Concentrations of iron above the secondary MCL have been detected in the same subbasin and basins as manganese as well as the Capay Valley Subbasin (Yolo County Flood Control & Water Conservation District, 2006 and CDM, 2006a). Both iron and manganese concentrations are shown to increase with depth in the Yolo Subbasin (Yolo County Flood Control & Water Conservation District, 2006).

3.2.4.5 Nitrate

Nitrate can be naturally occurring through the decay of organic matter, but is generally introduced to groundwater through leaching of nitrogen fertilizers, animal manure and septic systems. Nitrate is a health hazard for infants; the conversion of nitrate to nitrite can lead to reduced oxygen carrying capacity of blood. The established State MCL for nitrate is 10 ppm. Nitrate in irrigation water helps to stimulate plant growth; an irrigation water quality target for nitrate has not been established.

The concentration of Nitrate has been increasing and approaching the MCL throughout the Region. Two City of Davis wells were destroyed in 2002 due to high levels of TDS, nitrate and selenium (Water Resources Association of Yolo County, 2007). According to the GAMA database, 18 percent of groundwater wells across the Region report nitrate concentrations exceeding its MCL:

- In the Solano Subbasin, 122 of the 409 wells were reported at or over the MCL, ranging from 10 to 453 ppm. The highest concentration of Nitrate appears to be near the cities of Davis and Dixon, and along Highway 113. Additionally, within the Solano Subbasin there are 7 more wells over 5 pbm (half of the MCL) located along the eastern half of the Subbasin.
- In the Yolo Subbasin, 135 of 686 wells were reported at or over the MCL, ranging from 10 to 3,100 mg/L. The highest concentration of Nitrate, by far, appears to be in West Sacramento, followed by Woodland, Davis, northeast of Davis toward the Yolo Bypass, and Dunnigan. Additionally, within the Yolo Subbasin there are 19 more wells over 5 ppm (half of the MCL) located mostly near Winters, as well as along Highway 16 and in Dunnigan.
- In the Upper Cache Creek PA, 11 of the 369 wells were reported at or over the MCL, ranging from 10 to 176 mg/L. The highest concentration of Nitrate appears to be around the perimeter of Clear Lake. Additionally, within the Upper Cache Creek PA, there are 4 more wells over 5 ppm (half of the MCL) around the perimeter of Clear Lake.
- In the Upper Putah Creek PA there is one well over 5 ppm (half of the MCL) located south of Lake Berryessa near the intersection of Highway 128 and Highway 121.

Although nitrate concentrations remain below the primary MCL in most areas, the concentration has been increasing and approaching the MCL throughout the Region. Eight (8) public water supply wells in the Solano Subbasin have had confirmed nitrate detections over the MCL (Solano County Water Agency, 2010). Two City of Davis wells were destroyed in 2002 due to high levels of TDS, nitrate and selenium (Water Resources Association of Yolo County, 2007).

3.2.4.6 Perchlorate

Perchlorate can be naturally occurring or man-made and is most commonly introduced to groundwater through the use of explosives and rocket propellant. Perchlorate is a hazard to human health at low concentration. Perchlorate is highly soluble in water, highly mobile, and removing it from water and soil is costly. The established State MCL for perchlorate is 6 ppb.

Perchlorate concentrations exceeding the MCL were reported on the GAMA database in one area within the Region, the Solano Subbasin. In the Solano Subbasin, 20 of the 104 wells were reported at or above the MCL, ranging from 6 to 1,600 µg/L. The highest concentration, by far, appears to be near Rio Vista Junction (18 of the 20 wells), and near the cities of Dixon and Collinsville. Additionally, within the Solano Subbasin there is one (1) well over 6 ppb (half of the MCL) located near Vacaville.

In the Yolo Subbasin, the City of Davis has one (1) well over 6 ppb (half of the MCL). There are no other known perchlorate levels above the MCL in the Region.

There are no know municipal wells within the Region where perchlorate concentrations exceed the MCL. In the future, if perchlorate concentration levels do exceed the MCL, water providers within the Region will have to evaluate treatment, blending or alternative source options.

3.2.4.7 Total Dissolved Solids

Total dissolved solids (TDS) refer to the total dissolved mineral content in water. TDS concentrations in the groundwater are influenced by the chemistry of the aquifer and quality of water recharging the aquifer. TDS is not a health hazard, but can be an aesthetic issue and can shorten the useful life of pipes and water-based appliances in homes and businesses. The CDPH secondary MCL for TDS is 500 ppm. For irrigation, high TDS waters often have high sodium concentrations that cause low soil permeability and lead to increased irrigation requirements and/or reduced yields. The California EPA recommends a TDS target of 450 ppm for no effects on the most sensitive crops. TDS concentrations in groundwater appear to be increasing in the Region, and some areas are experiencing TDS concentrations in excess of 500 ppm. This trend is likely a result of increasing development and associated wastewater discharges and more intensive agriculture (Water Resources Association of Yolo County 2007).

3.2.5 Wastewater and Recycled Water Quality

3.2.5.1 Upper Cache Creek and Upper Putah Creek

There are a total of ten wastewater treatment plants in the upper watersheds: the Upper Cache Planning Area is served by five wastewater treatment plants as well as onsite individual septic systems and the Upper Putah Creek is served by five wastewater treatment plants as well as onsite individual septic systems. Wastewater discharges within both planning areas consist of land application and geothermal injection. For wastewater treatment plants that rely on land disposal, wet weather can increase soil saturation and decrease percolation rates, thereby leading to unintentional wastewater discharges. Injection of wastewater into the Geysers geothermal steam field is assisting in addressing wastewater storage capacity problems in Lake County while increasing geothermal power generation capability and reliability at the Geysers (Forsgren Associates, 2012). For the location of each wastewater treatment plant see Figure 3-3.

Community wastewater systems serve an important function in protecting Clear Lake from degradation. However, unauthorized wastewater releases due to inadequate infrastructure has the potential to impact Clear Lake in negative ways. Overflows from the sanitary sewer during the 2007-2011 period were estimated at 87,536 gallons (Forsgren Associates, 2012). It should be noted that not all of these overflows reached the lake. In 1994, it was estimated that less than 3% of the total phosphorus in Clear Lake came from community wastewater systems and overflows have since been reduced, therefore impacts to the Lake due to increased phosphorus content from wastewater overflows are minimal (University of California-Davis, 1994).

Septic system contamination of Clear Lake is also possible through leachfield overflow or percolation through groundwater of nutrients or disease-causing pathogens and coliform bacteria. There were 12,300 septic systems in Clear Lake watershed-mainly around Lower and Oak arms of Clear Lake as noted in the Clear Lake Integrated Watershed Management Plan as of 2006.

3.2.5.2 Valley Floor

Wastewater discharges from the eleven wastewater treatment plants in the Valley Floor PA provide multiple reuse and water recycling opportunities. Some of the wastewater is discharged to managed wetlands to provide habitat and aquifer recharge benefits (City of Davis), while other wastewater effluent is discharged into local creeks for later seasonal reuse to help meet agricultural water demands (City of Vacaville Easterly WWTP).

The Davis WWTP and Woodland WWTP are challenged by current discharge limitations for selenium and future restrictions on discharge of boron and salinity. The source of the selenium, boron, and salinity is the groundwater delivered for municipal potable supply. The selenium concentrations at times exceed the wastewater treatment plants effluent limitations, and based on current discharge concentrations, the boron and salinity, measured as electrical conductivity, will likely exceed future effluent limitations. While the wastewater discharger is ultimately responsible for complying with the regulations, measures taken to ensure discharge requirements are met may consider processes outside the wastewater treatment facility. In the case of the Davis WWTP and Woodland WWTP, changes in the water supply source are being investigated in order to help meet impending waste discharge requirements. The Dixon WWTP is addressing problems with salinity discharges.

3.3 Flood Management

Flood management represents another important aspect of water quantity, and can also affect water quality and environmental resources. A combination of hydrology, basin topography, land use, and natural and human caused geomorphic processes contribute to the flooding that occurs in the Westside Region. The Region contains several areas designated to be within the 100-year and 500-year floodplains as defined by the Federal Emergency Management Agency (FEMA) as shown in Figure 3-11. Lands within these flood-prone zones are private or publicly owned, contain mixed land use activities with differing land values. Reducing flood risk in these areas is a significant challenge in the Region. The two main areas of the Westside Region at risk for flooding are in and around Clear Lake in the Upper Cache Creek Planning Area and in the low lying areas along the Sacramento River in the Valley Floor Planning Area, both of which are discussed in greater detail below. Some flooding also occurs in the Upper Putah Creek Planning area as discussed below.

Flood management facilities have been constructed over the years and many studies have and continue to occur to address these areas by federal, state, and local agencies such as the US Army Corps of Engineers (USACOE), California Department of Water Resources (DWR), Lake County Watershed Protection District, County of Lake, Yolo County, Yolo County Flood Control and Water Conservation District (YCFCWCD), Solano County Water Agency, City of Lakeport, City of Clearlake, City of Woodland, and City of Vacaville. Most of the State and federal facilities in the Region are within the State Plan of Flood Control (SPFC) which encompasses areas within the Central Valley of California that are protected by State-federal facilities. Levees shown in Figure 3-11 and Figure 3-13 through Figure 3-15 are those that are accredited by FEMA or have been identified as providing some level of protection by local agency staff.

The Central Valley Flood Protection Board adopted the Central Valley Flood Protection Plan (CVFPP) (developed by DWR through a collaborative stakeholder process) in 2012. Areas subject to flooding within the Sacramento-San Joaquin Valley are now working with DWR to develop additional details for implementation to meet the objectives contained within the CVFPP. Portions of the Valley Floor PA are involved in regional flood management planning.

3.3.1 Flood Management Infrastructure

Flood management infrastructure helps provide valuable flood protection to residents and farmland throughout the Region. The infrastructure has been constructed by multiple private, local, state, and federal agencies responsible for flood management. Major flood protection infrastructure, including levees, bypasses, weirs and flood management systems are shown in Figure 3-12.

Some of the major runoff and flood control structures in the Westside Region are summarized below with the respective planning area where they are located:

- Middle Creek Flood Control Project – Upper Cache Creek
- Indian Valley Reservoir – Upper Cache Creek
- Monticello Dam (Lake Berryessa) – Upper Putah Creek
- Hidden Valley Lake Subdivision Levee – Upper Putah Creek
- Cache Creek Settling Basin – Valley Floor
- Knight's Landing Ridge Cut – Valley Floor
- Colusa Basin Drain – Valley Floor
- Yolo Bypass – Valley Floor
- Ulatis Flood Control Project – Valley Floor

This infrastructure is discussed within the context of the flood risk associated with each planning area in the sections that follow.

Indian Valley Reservoir

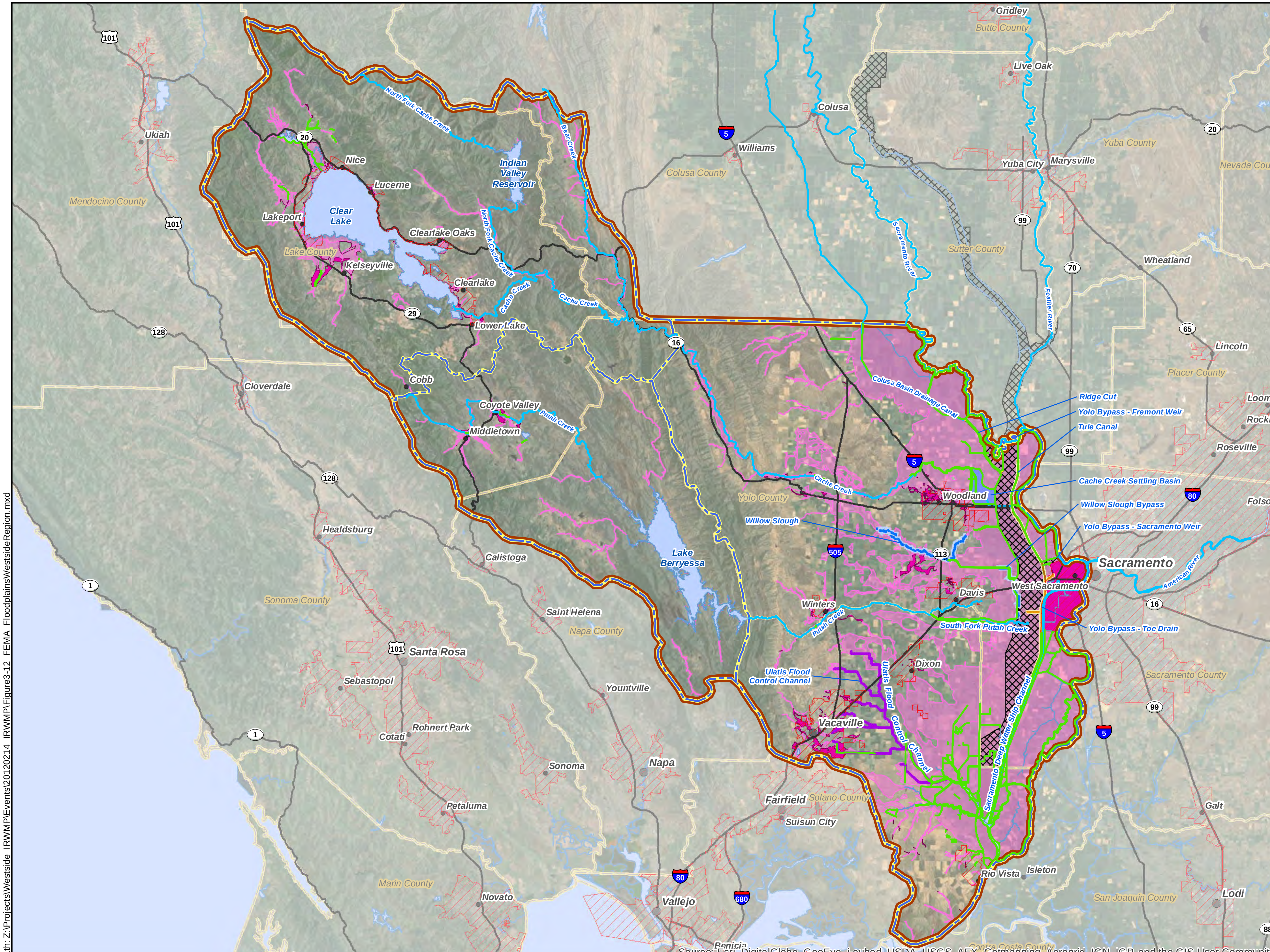
3.3.2 Upper Cache Creek

A more detailed figure showing the 100-year and 500-year flood plains in the Upper Cache Creek planning area can be found in Figure 3-13. GIS data from FEMA were used to estimate that there is approximately 22,350 acres within FEMA designated 100-year floodplains in the Upper Cache Creek portion of Lake County, the majority of which occur along the shores of Clear Lake or along the tributaries that drain to Clear Lake. These areas have a long history of flood events and repeated flood damage as described below. The Middle Creek Flood Control Project in Upper Lake is a part of the SPFC and has been evaluated as part of the Central Valley Flood Protection Plan described in Section 3.3.4. Cow Mountain, located on the western boundary of the Upper Cache Creek watershed, has an average annual precipitation in Upper Cache Creek of about 28 inches/year.

3.3.2.1 People and Property at Risk

Historically, more than fifteen damaging floods have occurred in the Upper Cache Creek watershed since 1938 with damage to agriculture, commercial, industrial, and residential areas (FEMA, 2011). Seven of these events have occurred since 1993. The Upper Cache Creek watershed is characterized by steep terrain surrounding valleys and lakes, where a majority of the flooding occurs. Flooding in the Upper Cache Creek watershed can occur within hours of the onset of heavy rains and is of short duration. Flooding on the shores of Clear Lake occurs relatively slowly as the lake level rises and can last for weeks, or even months at a time and can affect up to 2,500 structures. Due to the frequency of flooding and limited flood management infrastructure, flood damage has a significant impact on the local economy around Clear Lake. There are over 100 homes in the Upper Cache Creek watershed that suffer repetitive loss (i.e., 2 or more National Flood Insurance Program (NFIP) claims within 10-yr period). Damage can occur not only to homes and business structures, but also to recreational areas, piers, and boats. Damage can also be extensive to public infrastructure, including roads and utilities.

Flooding can also impact water quality by causing erosion/sedimentation from stream downcutting and loss of floodplain filtration and overloading wastewater pump stations/treatment plants as well as septic systems that can cause bacterial contamination.



Legend

- Cities
- City Boundaries
- County Boundaries
- Planning Areas
- Westside Region
- Streams
- Projected Flow Pathway
- Water Bodies
- Levees
- Ulatis Flood Control Channel
- Cache Creek Settling Basin
- Bypass

FEMA Flood Hazard Zones

- 500-Year
- 100-Year

Source:
FEMA DFIRM Database Effective Flood Hazard Zones (Colusa 5/2005; Lake 9/2005; Napa 9/2010; Solano 8/2012; Yolo 5/2012); Bypasses, SACOG.

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Kennedy/Jenks Consultants

WESTSIDE SAC IRWM

FEMA Floodplains Westside Region

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Figure 3-11

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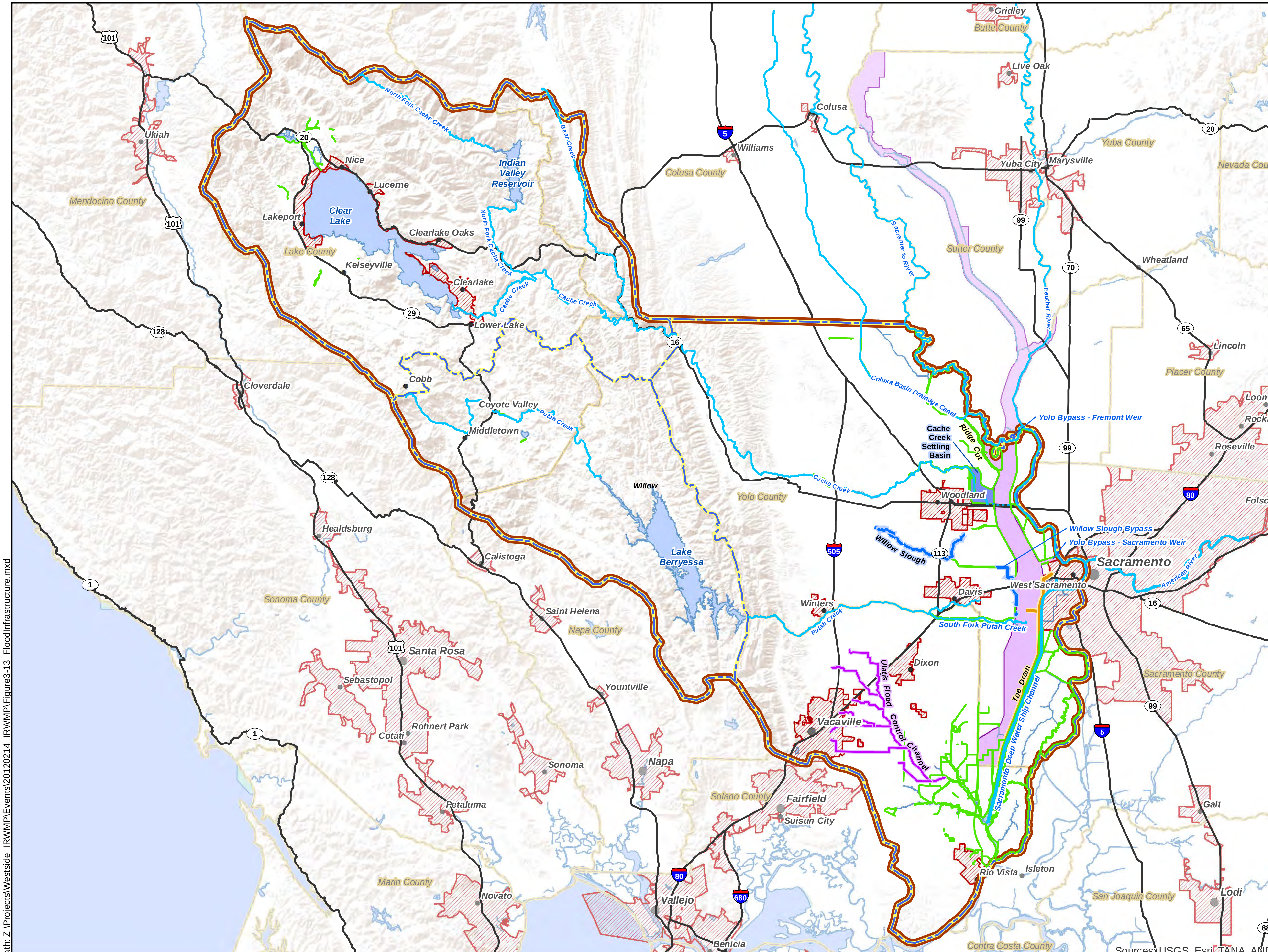

Legend

- Cities
- City Boundaries
- County Boundaries
- Planning Areas
- Westside Region
- Streams
- Projected Flow Pathway
- Water Bodies
- Ulatis Flood Control Channel
- Toe Drain
- Ridge Cut
- Willow Slough Bypass
- Levees
- Bypass
- Cache Creek Settling Basin

Source:
Bypasses, SACOG; Major Waterways, Yolo County; Putah South Canal, North Bay Aqueduct, & Ulatis Flood Conytrol Channel, SCWA.

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WESTSIDE SAC IRWM
Integrated Regional Water Management Plan

Flood Management Infrastructure

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Figure 3-12

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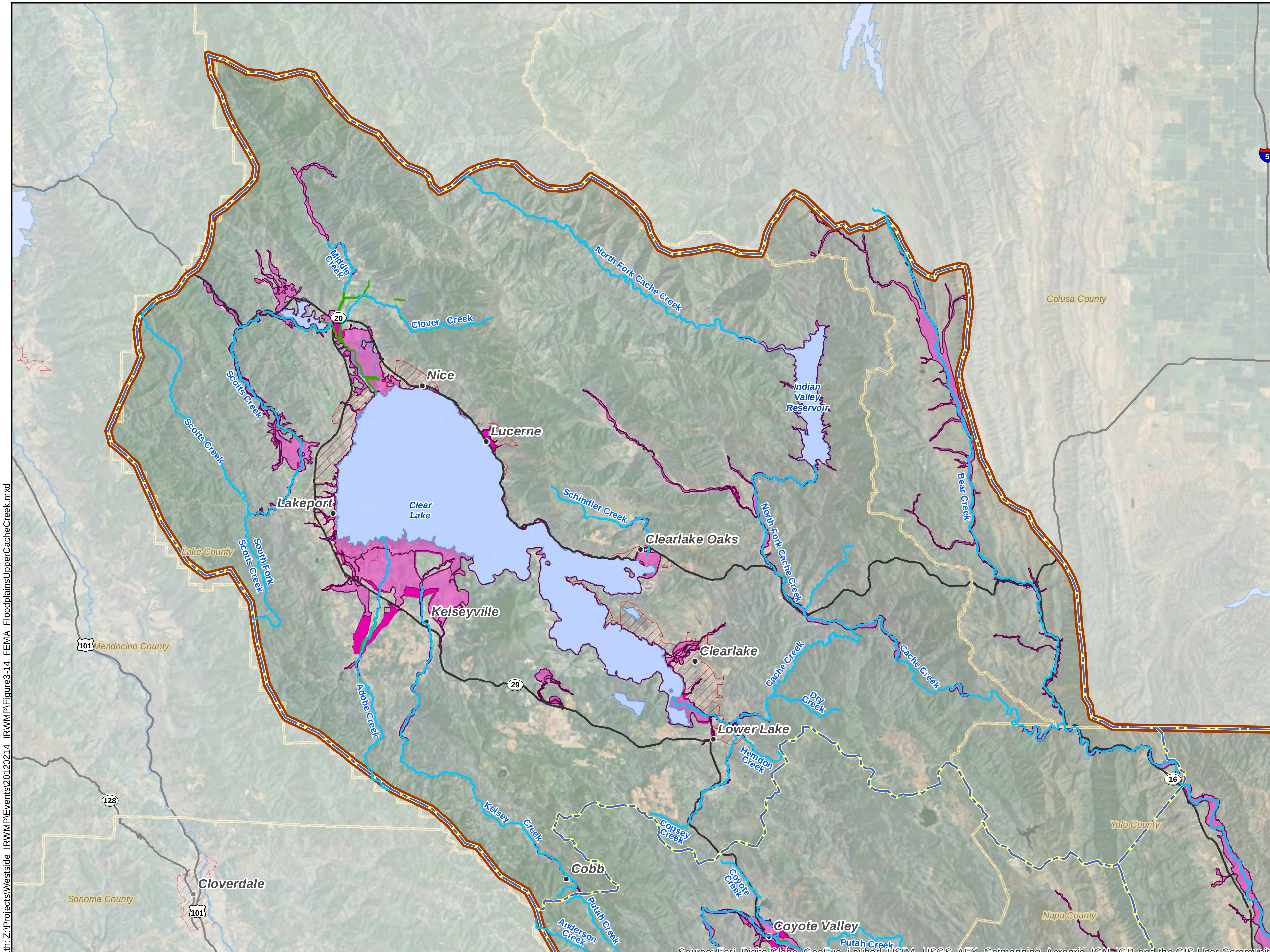

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Legend

- Cities
- City Boundaries
- County Boundaries
- Planning Areas
- Westside Region
- Streams
- Water Bodies
- Levees

FEMA Flood Hazard Zones

- 500-Year
- 100-Year

Source:
FEMA DFIRM Database Effective Flood Hazard Zones (Colusa 5/2005; Lake 9/2005; Napa 9/2010; Solano 8/2012; Yolo 5/2012); Bypasses, SACOG.

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WESTSIDE SAC IRWM
Integrated Regional Water Management Plan

FEMA Floodplains
Upper Cache Creek

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Figure 3-13

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Flooding also has occurred historically at the north end of Clear Lake at the confluence of Middle Creek and Scotts Creek which was reclaimed by construction of levees and pumping stations between 1900 and 1933 as part of the Upper Lake Reclamation Area, described in greater detail in the following section. Historically, floods damaged the 18 homes in the Upper Lake Reclamation Area as well as damaged or killed up 1,650 + acres of permanent agricultural crops such as grapes, pears, and walnuts, kept land out of production and damaged livestock as well as farm and ranch improvements. Levee failure could result in flooding in the northern portion of Clear Lake with associated damage to roadways along important transportation routes such as State Highway 20 and the Nice-Lucerne cutoff. Some PG&E electrical transmission lines are at risk of damage as well.

3.3.2.2 Description of Flood Hydrology and Facilities in Upper Cache Creek – Lake County

Flooding in the Upper Cache Creek planning area can occur in the summer and early fall from localized cloudburst storms or in the fall, winter, and spring from severe rain events within a longer duration storm. The watershed consists of relatively steep terrain that does not provide much attenuation of rainfall runoff and can quickly convey flood waters to the flatter areas around the lake.

Stream Flooding

Because of the mountainous terrain and relatively small watersheds, stream flooding occurs quickly and, in most cases, is of short duration; however, velocity of floodwaters is frequently high. A natural stream channel usually has a floodplain, which gets inundated every other year, on average. Humans have altered streams by dredging, straightening, widening and building levees to increase use within the floodplain. Dependent on the extent of these alterations, some streams still flood near their natural frequency and others have been enlarged to the extent they convey flood events greater than the one percent annual chance flood (100-year flood) without flooding. This has reduced the frequency and depth of flooding, allowing development in the historic floodplain. However, floods can still occur, causing damage to buildings, infrastructure and other improvements in the floodplain. The extent of damage depends on the amount and type of development in the modified floodplain and the magnitude of the flood when it occurs.

In many areas of the Upper Cache Creek, there has been limited infrastructure constructed to reduce flooding from streams in the watershed. However, some reservoirs such as Adobe Creek, Highland Creek and Indian Valley have been constructed with water supply and flood storage to significantly reduce downstream flooding. These reservoirs are highly regulated by the State and Federal governments due to the potentially disastrous flooding that would result from their failure. These structures are well constructed and maintained, therefore, their risk of failure is not thought to be high.

Levees were constructed to protect agricultural lands and properties in many areas of the watershed. Most of these agricultural levees only provide protection from the 5 to 20 percent annual chance flood event (20- to 5-year flood). While these levees help reduce flooding of agricultural lands, many rural homes have been constructed in the areas that receive some protection by the levees. Most of the areas behind these levees that receive some protection are mapped within FEMA designated floodplains, so the newer homes have been constructed with flood resistant materials. When these levees fail, the flooding can be rapid and deep. Because most of these levees are not maintained by a public agency, their upkeep and repair is problematic. They generally are not eligible for public disaster relief funding (FEMA) and responsibility for repair may lie with the property owner of the land where the levee failure occurred.

The Middle Creek Flood Control Project levees were constructed by the US Army Corps of Engineers (USACOE) in 1959 to reduce flooding in Upper Lake. These levees are a part of the State Plan of Flood Control and have been evaluated as part of the Central Valley Flood Protection Plan described in Section 3.3.4. These levees were designed to provide protection to Upper Lake from the 0.5 percent annual chance flood (200-year flood). When the Flood Insurance Study and Flood Insurance Rate Maps (FIRMs) were prepared by FEMA in the mid-1970's, these levees upstream of the confluence of Middle and Scotts Creeks (north) were accredited with providing protection to at least the one percent annual chance flood (100-year flood). Currently, observed levee seeps occur which indicates the levees probably do not provide the 100-year level of protection in the vicinity of Upper Lake. Upgrades will be necessary to provide the expected level of protection. The southern portion of the levee protects an area reclaimed from Clear Lake between 1900 and 1933. The levees were constructed on a substandard foundation and the USACOE estimates that the levees have a 28.6 percent chance of failure (less than a 4-year level of protection). A project to remove the levees and restore the protected land to shoreline lake habitat has been pursued since 1995. about half of the property has been acquired to date with additional investments needed for the remaining properties and land improvements.

Flooding also occurs along other tributaries to Clear Lake such as Laurel Dell Lake and Scotts Creek northeast of the lake, Copsey Creek near the southern end of the lake, and Kelsey Creek west of the lake (Lake County, 2009). Flood mechanisms in these tributaries are slightly different in that in some areas, lack of adequate drainage redirects flood waters down residential/commercial streets or results in ponding behind levees that cannot drain by gravity. In some areas, the relatively abrupt change in grade from the surrounding hillsides to the alluvial fans results in channels overtopping such as occurs in Cole Creek to south of Kelseyville. In other areas, such as upstream of Scotts Valley, extensive gravel mining has resulted in a destabilized creek channel with extensive downcutting which is exacerbated during flood events and threatens the road bed adjacent to the creek.

Lake Flooding

The lands surrounding Clear Lake have a long history of flooding. Lake level records from 1873 to the present show that a 7.56-foot Rumsey stage[2], which represents a full lake, has been exceeded 68 times and a 9-foot Rumsey stage has been exceeded 29 times. Elevations above 9 feet Rumsey generally result in significant flooding, and is considered flood stage. Some of the most damaging floods of recent times around Clear Lake have occurred in 1937-38, 1940, 1956, 1958, 1964-65, 1970, 1974, 1983, 1986, 1995 and 1998. The 1998 flood was the highest lake level recorded since the construction of the Cache Creek Dam in 1914. An event in 2011 was the first recorded lake level above flood stage since 1998 and has been followed by additional exceedances, including in 2017 when levels reached 10.6 feet Rumsey. The maximum known stage on Clear Lake, 13.66 feet, occurred in January 1890, prior to the construction of the dam and enlargement of the Cache Creek outlet channel.

Due to its size, Clear Lake water levels respond slowly to storm events and rise to flood stage only after prolonged storms. When this happens, Clear Lake's natural outlet, Cache Creek, is too small to allow floodwater to leave the lake as fast as it enters. Contrary to popular belief among residents near Clear Lake, the Cache Creek Dam, built in 1914, does not contribute to flooding around Clear Lake. The dam can release water much faster than Cache Creek can convey. The narrow, shallow Cache Creek channel restricts the release of water from Clear Lake during times of high lake levels. Cache Creek Dam is designed to release water at 21,000 cubic feet per second (cfs). However, Cache Creek can convey less than 4,700 cfs when Clear Lake levels are at 11 feet Rumsey (2 feet above flood stage).

The maximum peak inflow to Clear Lake is estimated by the USACOE to be about 81,000 cfs for a 500-year return interval event. Lake County staff calculated a peak 6-hour average inflow in excess of 50,000 cfs during the January 1995 storms. The limited conveyance capacity in Cache Creek causes Clear Lake to rise rapidly during heavy, prolonged rainstorms and does not lower lake levels very quickly after the rains have stopped. Wind effects may increase the depth and extent of shoreline flooding, but the most relevant factor to flooding around Clear Lake is the limited outlet capacity, which results in and high lake stages that diminish slowly.

Orders of the Superior Court of the State of California perpetually forbid either increasing the outlet capacity of Clear Lake (Bemmerly Decree, 1940) or raising the lake level above 7.56 feet on the Rumsey Gage (at which elevation the lower limit of shoreline flooding occurs with unfavorable windset conditions), except during storms and floods, for longer than 10 days, and in no event over 9 feet on the gage (Gopcevic Decree, 1920). It is not physically possible to operate within these limits because outflow is impaired by the Grigsby Riffle, a natural restriction for

[2] Rumsey is an assumed datum from which the level of Clear Lake has been measured since 1914. The gage datum is 1318.26 feet National Geodetic Vertical Datum 1929 (NGVD), and lake stages are converted to elevations above NGVD by adding this value.

the outlet channel upstream from the dam. In essence, one effect of the court orders that prevent increasing the outlet capacity of Clear Lake and restrict lake levels is to prolong flood stages surrounding Clear Lake and prevent their rapid reduction. Flood conditions along the lakeshore may continue for as long as 90 days.

Flooding of the lands surrounding Clear Lake is affected by both natural conveyance restrictions downstream of Clear Lake and legal limits placed on potential modifications to the Cache Creek channel as a result of the Gopcevic and Bemmerly Decrees discussed in Section 2. Pre-releases of water to create storage in Clear Lake in anticipation of storms are not always possible pursuant to the Decrees and with the limited channel capacity would provide minimal benefit. In combination with the high desirability of private ownership of lands along the lake shoreline, these restrictions have made reducing flood damages around Clear Lake challenging. Extensive studies by the USACOE through the latter part of the 20th century have indicated the most cost-effective solution to the flooding may be implementation of non-structural flood damage reduction measures such as purchase of lands in flood zones.

3.3.3 Upper Putah Creek

A more detailed figure showing the 100-year and 500-year flood plains in the Upper Putah Creek planning area is shown in Figure 3-14. GIS analysis of FEMA FIRM information indicates that about 3,550 acres are located within the FEMA designated 100-year flood plain in unincorporated Lake County and 2,300 acres in the Napa County portion of this planning area. The Upper Putah Creek planning area is characterized by steep terrain that surrounds flatter valleys and lakes. Flooding occurs in the valleys as water that flows from the steep terrain spreads out quickly. Flooding can occur within hours of the onset of heavy rains and is typically of short duration.

3.3.3.1 People and Property at Risk in Upper Putah Creek – Napa and Lake Counties

As a rural community, development within designated floodplains in the Upper Putah Creek planning area is mostly agricultural except for the portion of Middletown subject to overflow from Putah Creek tributaries and around Hidden Valley Lake, a small water body surrounded by residences and a golf course. The agricultural nature of development within the floodplains in this planning area keeps the flood risk lower than if urban developments occur within the floodplain due to the discrepancy in economic consequences when floods occur. However, as agriculture converts to higher value permanent crops, flood risk increase commensurate to the increase in economic assets placed in harm's way. In the Putah Creek basin, the principal flood problems occur in Coyote Valley and Collayomi Valley (the area around Middletown) as can be seen in Figure 3-14. Scour and erosion of creek channels during high flows also can have a negative impact on water quality.

3.3.3.2 Description of Flood Hydrology and Facilities in Upper Putah Creek- Napa and Lake Counties

Precipitation of almost 44 inches (annual mean) occurs at the Napa River watershed divide to 80 inches in the highest areas of the Putah Creek basin, which contributes to localized flooding as well as the productivity of the watershed for water storage in Lake Berryessa.

There are limited flood control improvements in the Putah Creek sector of the planning area. The USACOE has studied flood problems and potential solutions in the Upper Putah Creek basin (FEMA, 2011). The study was completed in 1976 and concluded that no improvements in this watershed were economically feasible. Selected reaches were restudied to apply FEMA policy to a levee built around a portion of the Hidden Valley Lake subdivision and golf course within the old Coyote Creek floodplain. Coyote Creek diverts around the development before emptying into Putah Creek. An 8-foot-high levee called the Hidden Valley Lake levee, which is not certified by any governmental entity, exists on the left banks of both Coyote Creek and Putah Creek. The hydraulic analysis assumed that the left-bank levee along Putah and Coyote Creeks will fail under a 100-year flood event. There are approximately 260 properties at risk from flooding up to 10 feet deep in this area.

3.3.4 Valley Floor

Flood risk on the Valley Floor has been and is continuing to be extensively studied as part of a range of State and federal programs and actions. The Sacramento River Flood Control Project is comprised of extensive federal flood control facilities including the Yolo Bypass and was completed in 1924 on the south and west side of the Sacramento River. The Cache Creek Settling Basin was initially completed in 1938 with several subsequent improvements as late as 1992, and the Colusa Basin Drain was completed in the 1920s to address agricultural irrigation return flow issues. These facilities were constructed to help protect the City of Sacramento because the Sacramento River is estimated to convey only 18 percent of the flow generated by a 100-year flood event in the Sacramento Valley. These facilities provide limited flood risk reduction benefits to the Westside Region, primarily to the City of West Sacramento. These facilities as well as the FEMA designated 100-year and 500-year floodplains are shown in Figure 3-15. GIS analysis of FEMA FIRM information indicates that about 360,000 acres are located within the FEMA designated 100-year flood plains in Yolo County.

Currently, many of these facilities and others are being evaluated as part of DWR's FloodSAFE California program which includes the Central Valley Flood Management Planning program which resulted in the preparation of three key documents that are intended to guide improvement of integrated flood management. These documents are: the SPFC Descriptive Document which inventories State and federal facilities; the Flood Control System Status Report (FCSSR) that evaluates SPFC facility integrity; and the Central Valley Flood Protection Plan that describes a system-wide approach to improving flood management for areas currently receiving protection from the SPFC. Regional planning intended to develop implementation details to fulfill the objectives of the CVFPP is underway with Yolo and Solano County interests participating with Sacramento County interests to provide local perspectives and preferences for implementation of the CVFPP. The FCSSR indicates that many urban and non-urban levees within the SPFC in the Valley Floor Planning Area pose a high or medium hazard.

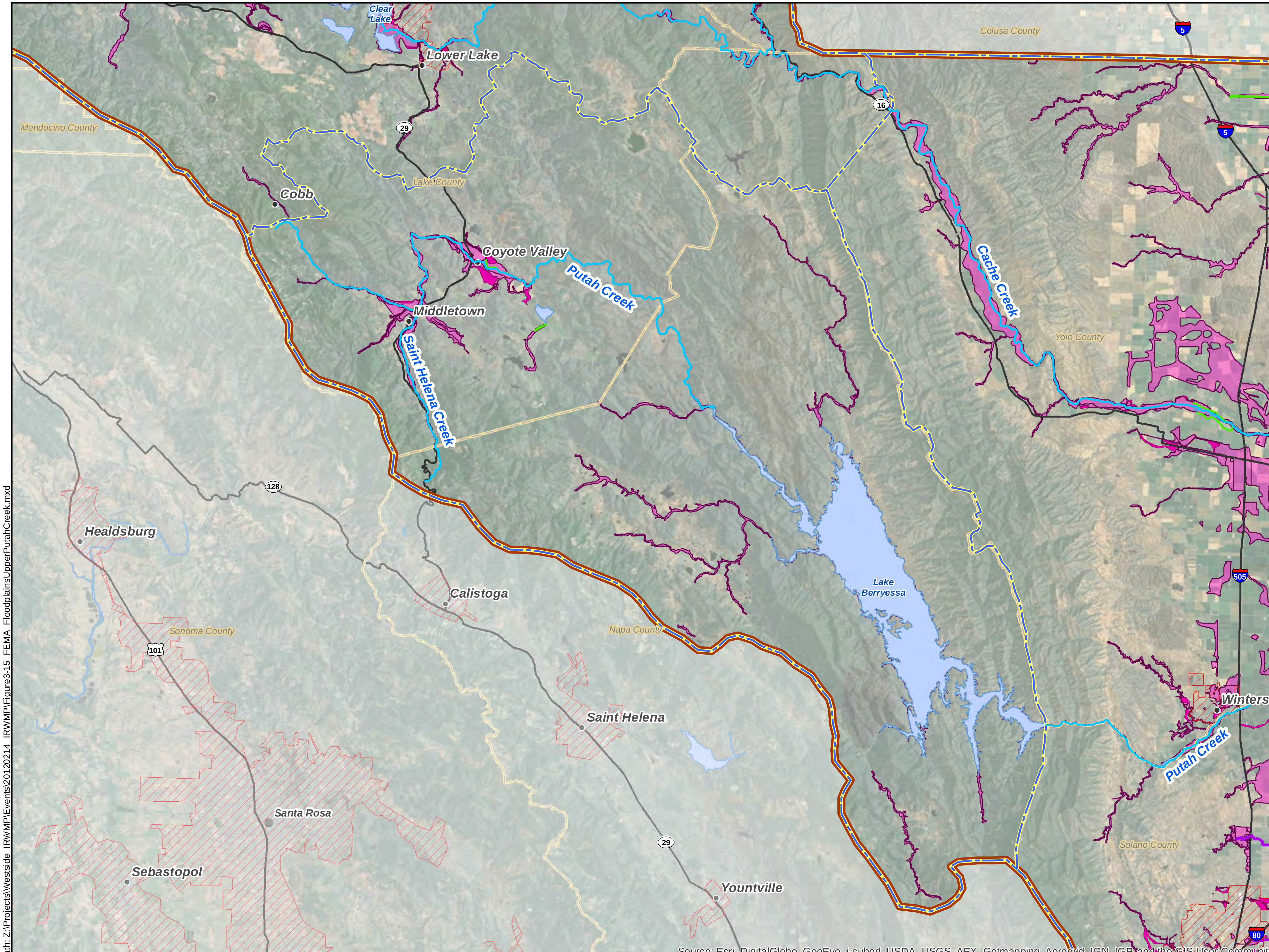
A locally focused program is the FloodSAFE Yolo pilot program which included elements of public outreach, flood emergency preparedness, watershed assessment, flood hazard mitigation, and project implementation and maintenance. However, it should be noted that many of the man-made and natural channels in the Valley Floor that are not part of the SPFC have not been evaluated for their capacity to convey flows resulting from large storm events. As these levees may not have been constructed for flood control purposes, they likely cannot convey 100-year storm events and are not constructed to withstand high flow conditions.

One of the many complexities of managing flood risk on the Valley Floor is integrating the extensive efforts already being made to manage flood risk and in coordination with drainage/agricultural conveyance facilities that occurs in both the lower Cache Creek and Lower Putah Creek drainages that occur in the Northern Valley Floor and Southern Valley Floor, respectively. Each of these drainages is discussed separately in the narrative that follows.

3.3.4.1 People and Property at Risk in the Northern Portion of the Valley Floor – Yolo County

The northern portion of the Valley Floor is contained within Yolo County. Much of the flooding in this portion of the Valley Floor Planning Area generally occurs in the relatively flat agricultural lands in the eastern two thirds of Yolo County. Most of the runoff that causes flooding originates outside Yolo County either from the Upper Sacramento River watershed or Upper Cache Creek. Major flooding has occurred in Yolo County 13 times since 1937 with recent flooding occurring in Capay Valley from Cache Creek overflow, the low lying areas of the Hungry Hollow watershed (tributary to Cache Creek) and in Woodland.

Rural areas around Woodland have experienced shallow flooding as recently as 1995 and 1998 (return-interval unknown) and portions of Woodland are in the FEMA designated 100-year and 500-year floodplains. Portions of Woodland are estimated to have 10-year level of protection because of deficiencies in the existing Cache Creek levees and previously planned facilities in Upper Cache Creek have not been constructed. Upstream of Woodland, Cache Creek has overflowed its banks on several occasions with flows approaching Woodland along the elevated roadbed of I-5. Federal, state, and local agencies monitor and patch areas of dangerous seepage along levees to try and prevent levee breaks during periods of high flows.



Legend

- Cities
- City Boundaries
- County Boundaries
- Planning Areas
- Westside Region
- Streams
- Water Bodies
- Levees

FEMA Flood Hazard Zones

- 500-Year
- 100-Year

Source:
FEMA DFIRM Database Effective Flood Hazard Zones (Colusa 5/2005; Lake 9/2005; Napa 9/2010; Solano 8/2012; Yolo 5/2012); Bypasses, SACOG.

0 2 4
Miles

Kennedy/Jenks Consultants

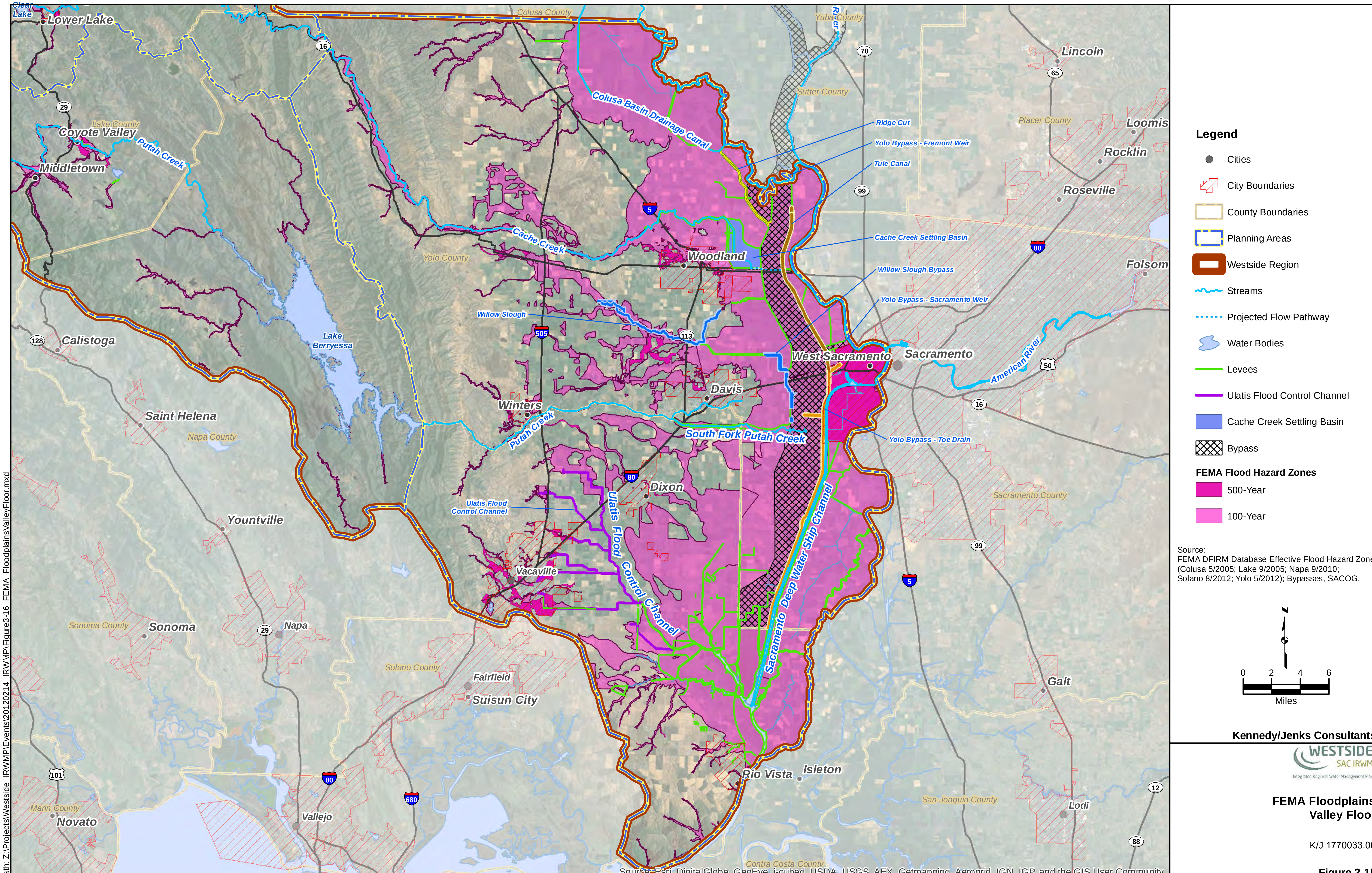
WESTSIDE SAC IRWM
Integrated Regional Water Management Plan

FEMA Floodplains Upper Putah Creek

K/J 1770033.00

Figure 3-14

Path: Z:\Projects\Westside_IRWMP\Events\20120214_IRWMP\Figure3-15_FEMA_FloodplainsUpperPutahCreek.mxd



FEMA Floodplains
Valley Floor

K/J 1770033.00

Figure 3-15

Path: Z:\Projects\Westside IRWMP\Events\20120214 IRWMP\Figure3-16 FEMA FloodplainsValleyFloor.mxd

The City of West Sacramento is surrounded by levees on all sides including the Yolo Bypass and the Sacramento River. Facilities at risk include: Union Pacific main railroad line, US-50, I-80, the regional United States Postal Service (USPS) mail processing center, the regional Department of Water Resources flood fight facility, the California Highway Patrol Academy (a key facility in state emergencies), and the Port of West Sacramento. Work is currently underway to construct setback levees to modern engineering standards to improve flood protection in West Sacramento.

Other areas that experience flooding include Yolo – Zamora near the Colusa Basin Drainage Canal, and Esparto, Madison, and West Plainfield, which are periodically flooded from runoff from the Cottonwood-Willow Slough watersheds. DWR's Flood Control System Status Report has identified several locations where State-federal levee instability and lack of freeboard along the Sacramento River and Yolo Bypass exists and may represent additional vulnerability to flooding for areas within the Region.

3.3.4.2 Description of Flood Hydrology and Facilities in Northern Portion of the Valley Floor – Yolo County

Even with the 40,000 acre-foot flood storage pool available in Indian Valley Reservoir, flood water from other tributaries to Cache Creek can cause flooding in the Capay Valley area which has experienced peak flows at Rumsey (upstream end of Capay Valley) as high as 59,000 cfs in 1965. This is close to the estimated 100-year flood flow of 61,810 cfs (with Indian Valley Reservoir). Further downstream on Cache Creek near Yolo (northwest of Woodland) peak flood flows have been measured as high as 41,400 cfs in 1956 whereby the estimated 50-year flood flow is about 57,100 cfs. Cache Creek is indirectly connected to the Sacramento River as it flows through the Cache Creek Settling Basin before overflowing into the Yolo Bypass which flows south and connects to the Sacramento River upstream of Rio Vista.

The Sacramento River forms the boundary of the Lower Cache Creek watershed and Yolo County's entire eastern boundary. Yolo County is 1,034 square miles (3.8 percent) of the 26,960 square mile Sacramento River Hydrologic Region and is located near the most downstream part of the Sacramento River before it flows into San Francisco Bay. Average annual flow on the Sacramento River at Verona (Northeast of Woodland) is about 14 million AF from 1924 – 2002 with a peak runoff of about 28 million AF in 1983. As described earlier, efforts to reduce flooding in the City of Sacramento and City of West Sacramento resulted in construction of the Yolo Bypass and the Cache Creek Settling Basin, each of which are described below.

The Yolo Bypass is a 41-mile-long stretch of agricultural land within Yolo and Solano Counties that is generally bounded by levees 7,000 to 16,000 feet apart. Completed in 1924 as part of the Sacramento River Flood Control Project, the Yolo Bypass is an important component of flood protection for the Sacramento River watershed. It conveys floodwaters diverted from the Sacramento River through Yolo and Solano Counties and reconnects with the Sacramento River a few miles upstream of Rio Vista.

The Cache Creek Settling Basin, which reduces sediments from Cache Creek entering the Yolo Bypass, makes Woodland area drainage difficult while offering limited benefit to Yolo County. The Colusa Basin Drain is a drainage channel that collects and conveys irrigation from a drainage area of nearly 1,620 square miles within Glenn, Colusa and Yolo Counties.

Numerous natural and man-made changes have occurred in the lower portion of Cache Creek including naturally occurring shifts of the stream channel due to eroding banks and large storm events. Man-made changes include embankment maintenance to reduce flood damage, irrigation and gravel mining. Furthermore, in some areas in Yolo County closest to the Sacramento River, tidal influences and lower land surfaces resulting from subsidence of peat soils behind levees, some of which can be attributed to groundwater pumping, contribute to flood risk.

3.3.4.3 People and Property at Risk in the Southern Portion of the Valley Floor – Yolo and Solano Counties

The southern portion of the Valley Floor Planning Area includes portions of both Yolo and Solano Counties and similar to the northern portion of the Valley Floor, experiences periodic flooding. Flooding in this portion of the Valley Floor occurs especially in the areas of the Delta on the banks of the Sacramento River downstream of the discharge of the Yolo Bypass, occasional flooding in portions of the City of Davis, Dixon, Rio Vista, Winters, and Vacaville and in agricultural areas as described further below. Some flood risk along lower Putah Creek was reduced with the construction of Monticello Dam and the formation of Lake Berryessa which has controlled large upstream flows, although Lake Berryessa is not operated specifically for flood protection.

As agricultural lands represent much of the lands in the southern portion of the Valley Floor, major flooding can damage orchards, vineyards, pasturelands, and crop lands; deposit debris on agricultural land; destroy livestock and poultry; and damage farm equipment and agricultural improvements such as fences and irrigation systems. In more urbanized areas, floodwater has entered dwellings and commercial structures and deposited debris on lawns and gardens. Both urban streets and rural roads have been flooded with associated damage to bridges, roadbeds and culverts. Stream channels and flood protection facilities have also eroded. A small population within unincorporated Solano County is reported to experience repetitive flooding based on unknown return interval storms.

The City of Rio Vista is located on the banks of the Sacramento River and has experienced flooding since as early as 1892 when the town was washed away from a location 3 miles upstream from its current site. Local drainage surrounding Rio Vista is by Marina Creek and tributary and Industrial Creek that all flow towards the Sacramento River. Low ground elevations in parts of the City, high tides, combined with large stream outflow and onshore winds contribute to flood impacts. The most recent flood of February 1986 caused serious damage to the City. Rio Vista is particularly at risk under climate change conditions whereby flood stages are likely to be higher; high flood waters will be further exacerbated by higher tides that are expected to occur with climate change.

Based on the Federal Emergency Management Agency (FEMA) Flood Insurance Study for Yolo County California, the City of Davis is expected to experience periodic flooding near the F Street culvert to the pump stations near H Street and Covell Boulevard and in areas south of Covell Boulevard west of the Southern Pacific Railroad near the H Street pump station. The City of Dixon does not have a well-documented flood history but minor flooding has been reported to occur in 1955, 1958 and 1965, but no damage has been reported. The City of Winters experiences flooding from overflow from Dry Creek, runoff from the Moody Slough watershed north and west of the City and runoff from business and residential areas south of Highway 128.

The City of Vacaville is drained by the Ulatis Flood Control Project which was constructed in 1964 by the Natural Resources Conservation Service (NRCS) and has significantly reduced flooding and damage. Flood events in 1967 and 1973 are considered the largest in recent years and resulted in street and lawn flooding, stranded residents, deposition of debris and garbage, and evacuation of several homes/apartments when flood waters covered lower floors. More recent storms have also caused damage to homes in certain flood prone areas of Vacaville as described in the Solano IRWM Plan, the Ulatis Flood Control project faces increased runoff from urban development; encroachment from residences; increased flow and debris from poorly maintained streams and ditches; increased liability associated with multi-purpose use; and environmental concerns especially for maintenance. The Solano IRWM Plan identified that Flood control infrastructure in rural areas is not adequate and resident's awareness of flood hazards needs to be improved.

3.3.4.4 Description of Flood Hydrology and Facilities in the Southern Portion of the Valley Floor – Yolo and Solano County

As noted earlier, the construction of Monticello Dam in 1957 to form Lake Berryessa with a storage capacity of 1.5 million AF has reduced the risk of overbank flooding along lower Putah Creek even though the Dam is not operated specifically for flood management. Urbanization has increased areas of impervious coverage from roads, parking lots and buildings in Vacaville and other areas along I-80. These additional impervious areas have intensified flood problems by increasing the volume and peak flow of water and reduced the open land available to infiltrate rain and runoff.

The Ulatis Flood Control Project has provided some additional flood protection in the Vacaville area. Originally developed to improve protection of agricultural lands, portions of the Ulatis Flood Control Project within the City of Vacaville have been upgraded to provide 100-year protection. Rio Vista faces further uncertainty as the Central Valley Flood

Protection Plan describes potential improvements along the Yolo Bypass that may change conditions upstream of Rio Vista that could affect flood protection for Rio Vista.

3.4 Environmental Resources

The Westside Region's vast ecosystem offers innumerable natural resources and supports a wealth of wildlife and special habitats, including important fisheries and waterfowl areas. Significant changes to the natural ecosystem function began to occur in some areas as the Region developed. Agricultural lands began to displace native habitat, and agricultural and urban land uses resulted in disturbance of habitats including aquatic and other water-dependent habitats. The changes to habitats types affect native species in the area and allow for spread of non-native, invasive species. Conservation efforts by entities throughout the Region help to preserve these existing resources and also aid in restoring important habitats.

3.4.1 Fisheries

Fisheries have been greatly influenced by the construction of dams, flood control facilities and other infrastructure in the Region. Current populations of anadromous fish that attempt to access the creeks of the Region for spawning must access the Region through the Yolo Bypass. The Yolo Bypass provides habitat for a variety of resident and seasonal fish species, including steelhead, spring-run and winter-run Chinook salmon, splittail, and delta smelt. Structures in the bypass, such as agricultural impoundments and road crossings, reduce hydrologic connectivity and present significant barriers to fish passage into Cache and Putah Creeks. Modifications to the Yolo Bypass to increase the frequency, duration, and magnitude of floodplain inundation have been discussed as part of a conservation plan addressing the Sacramento-San Joaquin River Delta region. These changes in floodplain management would improve passage and habitat conditions for splittail, Chinook salmon, sturgeon, lamprey and possibly steelhead (California Natural Resources Agency).

3.4.1.1 Cache Creek Fisheries

Historically the Cache Creek supported small populations of anadromous fish species including fall-run Chinook salmon, steelhead, Pacific lamprey and river lamprey. Because Cache Creek was historically an intermittent stream, it probably never supported a large run of salmon. At present the barriers to fish passage in the Yolo Bypass combined with the complete barrier imposed by Capay Dam hinder migration and spawning of these species.

Dams have served as impediments to both native and non-native migration. The Capay Dam has helped to keep non-native fish species, which are not intentionally introduced to the system, from spreading to the upstream reaches of Cache Creek. In Clear Lake, some non-native fish species have intentionally been introduced to support sport fishing. Introduction of non-native species has impacted the native species through predation and competition for food. Populations of native species such as the Clear Lake hitch and roach have been reduced through predation by bass and catfish that have been introduced to the system, and the Clear Lake splittail is believed to have become extinct from competition over food (Lake County, 2010). The introduction of non-native game fish has improved recreational opportunities, but must be balanced with desires to maintain native populations. Of special concern is the Clear Lake hitch, a fish endemic to Clear Lake. The Clear Lake hitch has been identified by the California Department of Fish and Wildlife as a threatened species and is being considered for federal listing by the US Fish and Wildlife.

3.4.1.2 Putah Creek Fisheries

Historically, the lower reaches of Putah Creek was surrounded by extensive riparian forest, covering the area from the Coast Ranges to the Yolo Basin. With the arrival of European settlers and the development of agricultural lands, the riparian vegetation began to be removed, and vegetation in the stream channel was also removed for flood control purposes. These changes resulted in warming of the water, and the altered environment favored warm water species over the native species.

Another significant change to the fish communities in Putah Creek came with the completion of the Solano Project in 1959, which segregated the creek into three reaches: the upper watershed reach upstream of Monticello Dam, the interdam reach between Monticello Dam and the Putah Diversion Dam, and the lower Putah Creek downstream of the Putah Diversion Dam. When Monticello Dam was built in 1957, hundreds of miles of suitable habitat for anadromous fish in the upper watershed were disconnected from Sacramento River Basin. At the same time Department of Fish and Wildlife introduced largemouth bass, smallmouth bass and red-eared sunfish to Lake Berryessa. Over the years, cold-water species such as silver salmon, brown trout and rainbow trout and additional warm water species including channel catfish, white crappie and black crappie have been introduced to the lake. The Department of Fish and Wildlife now emphasizes warm water fish and trout populations in Lake Berryessa (Watershed Information Center & Conservancy of Napa County, 2005).

In the interdam reach, cold water releases from Lake Berryessa transformed this warm water reach to a cold water reach, and the availability of year-round flows and the lack of vegetative clearing have created some of the best riparian habitat in the Region. Native fish that still occur in the interdam reach include hitch, California roach, Sacramento pikeminnow, Sacramento sucker, three-spine stickleback, and riffle sculpin. These native fish persist in the interdam reach, despite management of this reach as a trout fishery.

In the lower Putah Creek, flow regulation that resulted from the implementation of Solano Project created a flow regime that reduced winter flood flows and provided some additional water during other times of the year. However during drought periods the required releases did not always provide for a flowing creek and there were instances of dewatering of portions of the creek resulting in fish die-offs. This resulted in litigation that was ultimately settled. In 2000, the Putah Creek Accord was established to create a release schedule that provided more flows to the Creek to benefit fish communities. Native special status species that still occur or have the potential to occur in Putah Creek include Steelhead – Central Valley Evolutionary Significant Unit (ESU), Sacramento splittail, Pacific lamprey, Sacramento-San Joaquin roach, hardhead and Sacramento Perch. The flow regime that was established favors native resident fish and anadromous fish. While flows have improved, the lack of suitable gravel spawning sites remains a challenge, and agricultural impoundments continue to present obstacles. The Los Rios Check Dam, is a seasonal check dam that allows for increased water impoundment for irrigation use and for flooding of the Yolo Basin Wildlife Area. This check dam is the first major obstacle to fish passage along the Putah Creek. Operation of the Los Rios Check Dam is currently being managed in conjunction with releases from the Putah Diversion Dam to improve migration of fall-run Chinook salmon into the lower Putah Creek (EDAW, 2005).

3.4.2 Waterfowl

Clear Lake, Lake Berryessa, the Yolo Bypass and the Colusa Basin support a wide variety of seasonal and resident water fowl. In Clear Lake, some of the impressive birds to observe include American white pelicans, osprey, western and Clark's grebes, and great blue herons; these birds forage for fish, invertebrates, and plants in the lake, nest in emergent vegetation such as tules, and use the lake as a stopover during migration (Lake County, 2010). The Lake Berryessa area provides habitat for numerous bird species, of which the greatest concentration are found along the shoreline of Lake Berryessa and its tributaries. The Yolo Bypass provides migratory and nesting habitat for numerous species of birds. Shorebirds migrating along the Pacific Flyway arrive in July and depart for northern nesting areas in March. Various species of raptors overwinter in the Yolo Bypass, and Neotropical migrant birds have begun to use the Yolo Bypass as a stop between their northern breeding grounds and wintering grounds in tropical America. The Colusa Basin is also a resting stop for millions of migrating waterfowl along the Pacific Flyway (Water Resources Association of Yolo County, 2007).

3.4.3 Important Ecologic Areas and Conservation Efforts

Various habitat and wildlife areas have been established by federal, state and local entities for the protection of the Region's ecologic resources. Among these protected lands are:

- **Yolo Bypass Wildlife Area** – The Yolo Bypass Wildlife Area is managed by the California Department of Fish and Wildlife (CDFW) to promote an increase in waterfowl and other bird populations in the Region. The area consists of 16,770 acres of wildlife habitat and agricultural land in the Yolo Bypass. The wildlife habitat is a mix of restored seasonal and permanent wetlands, grasslands and riparian forests, and the agricultural land consists of CDFW managed crops such as rice, corn and safflower which are grown for the benefit of the numerous waterfowl and upland bird species that inhabit the area. The Yolo Bypass Wildlife Area also serves as an important environmental education function through programs that are offered to schools and the general public through the Yolo Basin Foundation.

- **Cache Creek Natural Area/Cache Creek Wilderness Area** – The Cache Creek Natural Area is made up of 74,700 acres of lands managed by the Bureau of Land Management (BLM), State and Count and covers 35 miles of the main fork of Cache Creek and 2.5 miles of the north fork. Within the Cache Creek Natural Area is 27,245 acres of land designated the Cache Creek Wilderness Area. The area is managed for the protection of wildlife habitat and rare plants. Wildlife species found in the area include the bald eagle and tule elk. The tule elk population is one of the last free roaming herds in California. Low impact recreational activities such as hiking, hunting, fishing, wildlife viewing and river rafting are allowed throughout the Cache Creek Natural Area.
- **Clear Lake Wildlife Area** – At 97 acres, the Clear Lake Wildlife Area, located to the north of Clear Lake adjacent to Rodman Slough, is not an extensive preserve; however, it protects one of the most diverse regions of Lake County. The area consists of a mix of oak woodland, tule marsh and riparian habitat, which provide habitat for a variety of aquatic and terrestrial species including herons, red-tailed hawks, osprey, songbirds, waterfowl, deer, gray fox, bobcat and coyote. The area is also an important breeding and nursery area for fish species (www.dfg.ca.gov).
- **Rodman Preserve** – The preserve consists of 240 acres, owned by the Lake County Land Trust (132) and the Department of Fish and Wildlife (108), as well as an additional 40 acres owned by Lake County. The main purpose for the preserve is to facilitate the continued health and existence of the many nesting, breeding, and feeding areas for wildlife. (www.lakecountylandtrust.org)
- **Mendocino National Forest** – The Region encompasses the southern end of the Mendocino National Forest. The entire forest covers 913,306 acres and is notable for being the only national forest in California that is not crossed by a paved road or highway. The U.S. Forest Service (USFS) manages the resources of the Mendocino National Forest in order to maintain healthy watersheds and fire-adapted plant and animal communities.
- **Anderson Marsh State Park** – This Park is made up of 630 acres of oak woodlands, grass-covered hills and tule marsh. This state historic park is located in the Upper Cache Creek Planning Area in Lake County along the southeast corner of Clear Lake between the cities of Lower Lake and Clearlake.
- **McLaughlin Natural Reserve** – This reserve is located in Upper Cache and Putah Creek PAs and is made up of 6,940 acres of old McLaughlin gold mine property. The reserve is one of few sites in California that protects unusual serpentine habitats and the rare and endemic plants that they support. The reserve is managed by UC Davis and owned in part by the University of Homestake Mining Company.
- **CDFW Knoxville, Cedar Rough, Lake Berryessa, and Putah Creek Wildlife Areas** – These wildlife areas are located in Yolo, Lake and Napa Counties within the vicinity of Lake Berryessa. Knoxville Wildlife Area (21,417 acres) is located to the north of Lake Berryessa, Cedar Roughs Wildlife Area (413 acres) is located west of Lake Berryessa, Lake Berryessa Wildlife Area (2,000 acres) is located along the edge of Lake Berryessa along the eastern side of the lake, and Putah Creek Wildlife Area (670 acres) is located south of Lake Berryessa Wildlife Area. These habitat areas are owned by the California Department of Fish and Wildlife and have varying types of habitat including riparian, brush covered canyons, serpentine grasslands and oak woodlands (www.dfg.ca.gov).

An area that stakeholders in the Region are currently working to place into a National Conservation Area is the Berryessa Snow Mountain, which is comprised of 321,000 acres of federal public lands stretching from Lake Berryessa to the Mendocino National Forest. This area is one of the largest areas of public lands in California that has remained relatively undisturbed, and stakeholders are working to maintain the area in its natural state. Goals for the Berryessa Snow Mountain National Conservation Area are protection of the diversity of the region through the maintenance of its natural processes, core habitats and migratory corridors; better management of recreational opportunities; and sustaining economic opportunities for neighboring communities. Among the core habitats that would be protected in Berryessa Snow Mountain is habitat supporting the second largest population of wintering bald eagles in the state.

Past stakeholder efforts were successful in adding Cache Creek to California's Wild and Scenic Rivers. The Wild and Scenic River designation is granted to rivers that possess extraordinary scenic, recreation, fishery or wildlife values and is designed to maintain free flowing conditions on these rivers and preserve the immediate environment around the rivers. The Wild and Scenic designation for Cache Creek applies to 31 miles of the river starting below Clear Lake dam and continuing to the upper end of the Capay Valley in Yolo County. The listing prohibits new dams and water diversions from being constructed along this portion of Cache Creek and mandates protection of the habitats along Cache Creek. Passage of the Cache Creek Wild and Scenic Rivers bill included provisions that allow for continued efforts to remove non-native vegetation and mercury contaminants along the creek.

Protection of the Region's important environmental resources extends beyond the formation of dedicated conservation areas. Current, large-scale planning efforts that address the interplay between water resource management and environmental resources of the area include the Solano Habitat Conservation Plan (HCP), Yolo Natural Heritage Program HCP/Natural Communities Conservation Plan (NCCP), and the Bay Delta Conservation Plan (BDCP).

3.4.4 Non-Native Species

Non-native species are species that have been introduced both intentionally and unintentionally into the Region. The major problem with some non-native species is they are often very successful at using the new habitat they are placed in. They have few or no natural controls on their populations and they can often out-compete the native species for the same habitat. Non-native species are classified as invasive when they pose challenges to the management of the Region's resources.

Invasive plant species that are common throughout the Region are: Giant reed (Arundo donax), Hoary cress (Cardaria draba), Water hyacinth (Eichhornia crassipes), Perennial pepperweed (Lepidium latifolium), Eurasian water milfoil (Myriophyllum spicatum), Himalayan blackberry (Rubus discolor), Ravenna grass (Saccharum ravennae), Scotch broom (Sarothamnus scoparius) and Tamarisk (Tamarix ssp.). An analysis of the risk associated with each of the invasive plant species found in the Region is provided in Appendix C.

Invasive wildlife species, specifically aquatic invertebrates, present a significant challenge for management of the Region's water resources because they are extremely difficult to remove or control. The invasive species of greatest concern currently in the Region are quagga mussels, zebra mussels and New Zealand mud snails. They reproduce by tiny microscopic larvae that are transported with the flow of water to every interconnected water body and water user. There are currently no known treatments or pesticides that can remove these invasive invertebrates from an infested water body. Once the invertebrates secure themselves to a stationary object they can be removed, but the costs are very high and the invertebrates can easily re-colonize the cleared areas. In addition, the adult invasive mussels are very effective filter-feeders and strip the water bodies of food and particulates, thereby extensively altering the food chain, starving out competing native species, and promoting growth of unwanted nuisance species of cyanobacteria.

The invasive mussel species are not known to inhabit Regional water bodies currently, but the threat is extreme from the many boaters that use Regional lakes and can bring in these invasives. There are New Zealand mud snails in Lake Berryessa and they can spread by boat also. The current risks associated with the introduction and spread of these species include severe displacement and elimination of existing fish and wildlife, greatly increased costs of water supplies due to mussel-clogged delivery systems, and severe impacts to the quality of life adjacent to and recreational use of area water bodies.

A number of species of fish have been introduced to the Region and have now taken up residence in the local waterways including: Threadfin shad (Dorosoma petenense); Goldfish (Carassius auratus); Common carp (Cyprinus carpio); Red shiner (Cyprinella lutrensis); Fathead minnow (Pimephales promelas); White catfish (Ameierus catus); Black bullhead (Ameiurus melas); Brown bullhead (Ameiurus nebulosus); Channel catfish (Ictalurus catus); Western mosquitofish (Gambusia affinis); Inland silverside (Menidia beryllina); Bigscale logperch (Percina macrolepida); Bluegill (Lepomis macrochirus); Redear sunfish (Lepomis microlophus); Green sunfish (Lepomis cyanellus); Black crappie (Pomoxis nigromaculatus); White crappie (Pomoxis annularis); Largemouth bass (Micropterus salmoides); Smallmouth bass (Micropterus dolomieui) and Spotted bass (Micropterus punctulatus). Many of these species are not identified by the Department of Fish and Wildlife as invasive, as they are maintained as game fish or bait fish. However, the current risks associated with the introduction and spread of these species are similar to those of invasive species and include severe displacement and elimination of existing fish and wildlife due to food competition or predation.

Regional efforts must be made to prevent and control the plant and invertebrate invasive species. There have been and must continue to be programs for eradication of invasive plants. For the aquatic invertebrates, Lake County has implemented an Invasive Mussel Protection Program which includes a Water Vessel Inspection Ordinance requiring screening of any water vessel prior to launching into Lake County waters. Similarly, the US Bureau of Reclamation has implemented a Quagga and Zebra Mussel Prevention Program that requires self-certification of boats launched in Lake Berryessa. These programs are, however, not 100% effective and more must be done given the gravity of the threats.

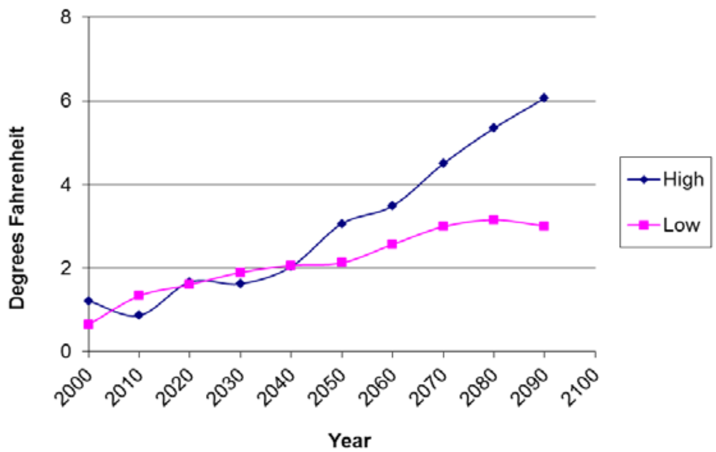
3.5 Vulnerability to Climate Change

This section provides a discussion of the projected climate change impacts in the Region as well as a summary of the key vulnerabilities of the Region to climate change. The more detailed Climate Change Vulnerability Checklist is found in Appendix C.

3.5.1 Projected Climate Change Impacts

Changing climate has the potential to have significant impacts in the Westside Region. The U.S. Bureau of Reclamation (Reclamation), State of California (Cal-Adapt.org), and others continue to study climate change and its potential impacts on water and other resources in the western states. Reclamation has completed a Global Climate Model, which includes modeling and hydrologic modeling steps and released the results for several western U.S. rivers including the Sacramento River. Cal-Adapt.org has used four general circulation models (GCM) of climate with 2 emissions scenarios for each model to project 15 parameters for the state of California. Because the Westside Region is a part of the Sacramento River Basin, the projections for future temperature and precipitation developed by Reclamation for the Sacramento River watershed are considered to be representative of the likely changes to the Westside Region while the CalAdapt.org modeling provides wildfire risk, precipitation, evapotranspiration, and other parameters.

Both Reclamation and CalAdapt project that temperature for the Sacramento River Basin will increase by 5 to 6 degrees Fahrenheit over the next 90 years as shown in Figure 3-16. The projected increases to temperature will likely result in a higher portion of rain over snow in the winter and earlier melting of the snowpack. While snow is not a significant part of the normal precipitation in the Westside Region, the Region is vulnerable to changes in snowfall patterns in the greater Sacramento River Basin. There is an overall decreasing trend in annual total precipitation and an increasing trend in winter time flows that could increase the flood flows entering the Region from the Sacramento River. Overall decreasing summer time flows resulting from earlier snowmelt could decrease the water available to users that rely on diversions from the Sacramento River and its tributaries. Increased temperature could lead to increased fishery stress, increased invasive species infestations, and increased wildfire risk, which is specifically shown in Figure 3-17. Additionally, increasing temperatures without an increase in precipitation could result in increased applied water requirements for crops, landscaping and instream ecosystems.



Note: cal-adapt.org. Based on average of 4 Climate Models for 2 Emission Scenarios (High Low) using Base Period, 1951-1990. Location projected near City of Clearlake.

Figure 3-16: Projected Annual Temperature Increases Summary of Climate Change Vulnerability Checklist

The Climate Change Vulnerability Checklist encompasses 7 major topic areas that include:

- Water Demand
- Water Supply
- Water Quality
- Sea Level Rise
- Flooding
- Ecosystem and Habitat Vulnerability
- Hydropower

Of these areas, flooding, water demand, water supply, water quality, and ecosystem and habitat vulnerability are likely to be of greatest concern to the Region. Hydropower was not found to be a considerable vulnerability to the Region and is therefore not discussed in detail in this section. The completed checklist can be found in Appendix C while a summary of the vulnerabilities in these 5 topic areas follows. The prioritization of these vulnerabilities is found in Section 6: Goals and Objectives.

3.5.1.1 Flooding

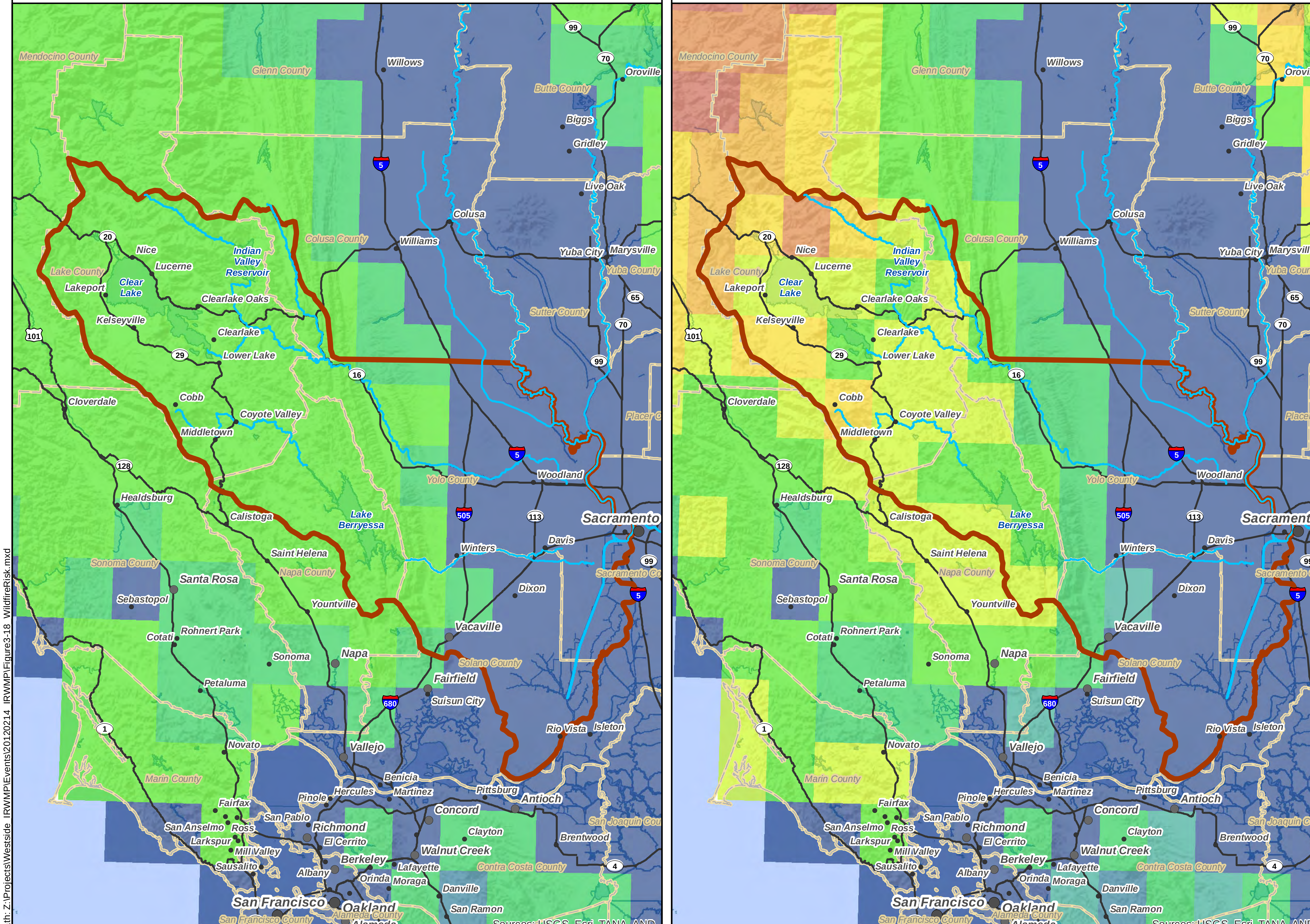
Peak flood flows are likely to increase under projected climate change conditions. The Region has urbanized areas in West Sacramento, Rio Vista, Vacaville, and in and around Clear Lake that lie in the 200-year and 100-year floodplains. Some of the critical facilities at risk in West Sacramento include a major interstate highway, main railroad line, California Highway Patrol Academy, the regional DWR Flood Fight Facility as well as a USPS Mail processing center. Other facilities at risk in the Region include roads and utilities such as pipelines and overhead electrical facilities as well as large areas of agricultural lands. In addition, in the Yolo and Solano County portions of the Region, if a flood event were coincident with a high-tide event, then for a short duration, the extent of flooding may be more widespread than predicted. A range of Federal agencies including US Army Corps of Engineers, state agencies including DWR and the Central Valley Flood Protection Board, as well as regional/local agencies are all working to improve flood protection and reduce flood risk in the Region. Flood risk can also be exacerbated through wildfires as a result of the removal of vegetation and alteration of soil conditions. Elevated risks would generally be expected within the burn and downstream areas.

3.5.1.2 Water Demand

As discussed in Section 3.1, about 95% of the water used in the Region is for agriculture which is seasonal and susceptible to the higher temperatures projected from climate change. Although it is difficult to quantify the expected climate-related changes to water demand, some changes are expected, most directly to the range of both annual and permanent agricultural crops in the area. There are a number of climate sensitive crops such as tomato, cucumber, sweet corn, and pepper, some of which may result in lower crop yields with higher summer temperatures; this is potentially balanced by higher winter temperatures that could favor winter crops that are not currently grown in the Region and/or a change to hotter season crops in the summer. Agriculture, in particular, has a range of water demand management options including fallowing fields of annual crops, changing water sources from surface water to groundwater, and/or changing the crop itself to one that may be less water intensive, yet economically viable.

2020

2085



Legend

- Cities
- County Boundaries
- Westside Region
- Streams
- Water Bodies

Projected Increase in Area Burned (Base Period 1961-1990)

- 0.25
- 0.5
- 0.75
- 1.0
- 1.25
- 1.5
- 1.75
- 2.0
- 2.25
- > 2.25

Source:
Fire Risk Data. PCM1; A2. UC Merced Climate Application Lab, 2008

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Miles

Kennedy/Jenks Consultants

WESTSIDE SAC IRWM
Integrated Regional Water Management Plan

Increased Wildfire Risk

K/J 1770033.00

Figure 3-17

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3.5.1.3 Water Supply

The Region relies on both imported CVP and SWP water for both agricultural and M&I water supplies, which are both snowmelt and climate-sensitive systems. The contract amounts for imported agricultural water is about 479,000 AFY and M&I contract amounts of about 95,000 AFY. In many parts of the Region, the availability of both imported as well as local surface water and groundwater improves the resilience of regional groundwater supplies. Local carryover storage in Indian Valley Reservoir and Lake Berryessa provide some measure of drought resiliency. However, the areas solely reliant on groundwater lack the resiliency of areas that can conjunctively manage surface supplies with groundwater. In addition, permanent crops, such as grapes and fruit and nut trees require more reliable water supplies because of the potential economic loss if sufficient water supply is not available. Sea Level Rise has the potential to impact imported SWP water supplies.

3.5.1.4 Water Quality

Increased threat of wildfire, more intense rain events, and resultant threat to water quality from sediments often containing mercury and nutrients are a significant vulnerability in the Region, although the water quality monitoring may not be sufficiently discrete to be able to discern trends. In addition, algal blooms and cyanobacterial toxins in Clear Lake with associated potential ecosystem impacts are already a recurring issue and are likely to be exacerbated with the expected increased temperatures.

3.5.1.5 Ecosystem and Habitat Vulnerability

Both terrestrial and aquatic invasive species pose a significant threat to the Region with water-consuming species such as giant reed, Himalayan Blackberry and tamarisk posing particular risks. Increased flows in aquatic habitats from increasingly intense precipitation events are likely to result in more erosion and sedimentation with associated negative impacts to fish habitats in the tributaries to Clear Lake which is home to the native Clear Lake hitch, a species of concern. Reduced spring runoff could impact Clear Lake Hitch spawning as well. Potential increases in temperature could impact fish survival for listed species such as steelhead and salmon as well as cold water fish such as trout in Clear Lake. Furthermore, warmer winters facilitate the spread of invasives, which would have typically died back in cooler winters.

Downstream tributaries of water storage reservoirs may be less vulnerable to high flood flows because of the controlled releases that occur from these facilities. Recreation flows from some of the storage reservoirs are currently managed in conjunction with hydropower and irrigation releases; however, changing priorities may require changes to operations in the future. Low lying estuarine areas in the Valley Floor may also be vulnerable to increasing salinity from sea level rise.