

## **CHAPTER V ECOSYSTEM RESTORATION OPPORTUNITIES**

This section includes a discussion of potential ecosystem restoration opportunities within the primary study area. These opportunities, or measures, represent potential structural and non-structural actions that could address the primary or secondary study objectives. The opportunities are based on candidate actions recommended by other programs that would also contribute to the goals and objectives of the SLWRI. Projects already under detailed development or scheduled for construction are not included in this list of potential measures.

The list of measures does not exhaust the potential application of certain types of restoration actions in other locations in the region, but includes those locations or applications that fall within the scope and influence of the SLWRI. Not all of the measures identified herein will become part of future alternatives. The potential measures will be compared against study planning objectives, criteria, constraints, and principles. The most promising opportunities will be carried forth in the planning process as potential alternative components. The alternative formulation process is described in greater detail in the MSMR.

Potential ecosystem restoration opportunities are grouped in relation to the two study sub-areas: the Shasta Lake and Tributaries sub-area, and the Shasta Dam to Red Bluff sub-area. Each potential measure is assigned an identification number for future reference.

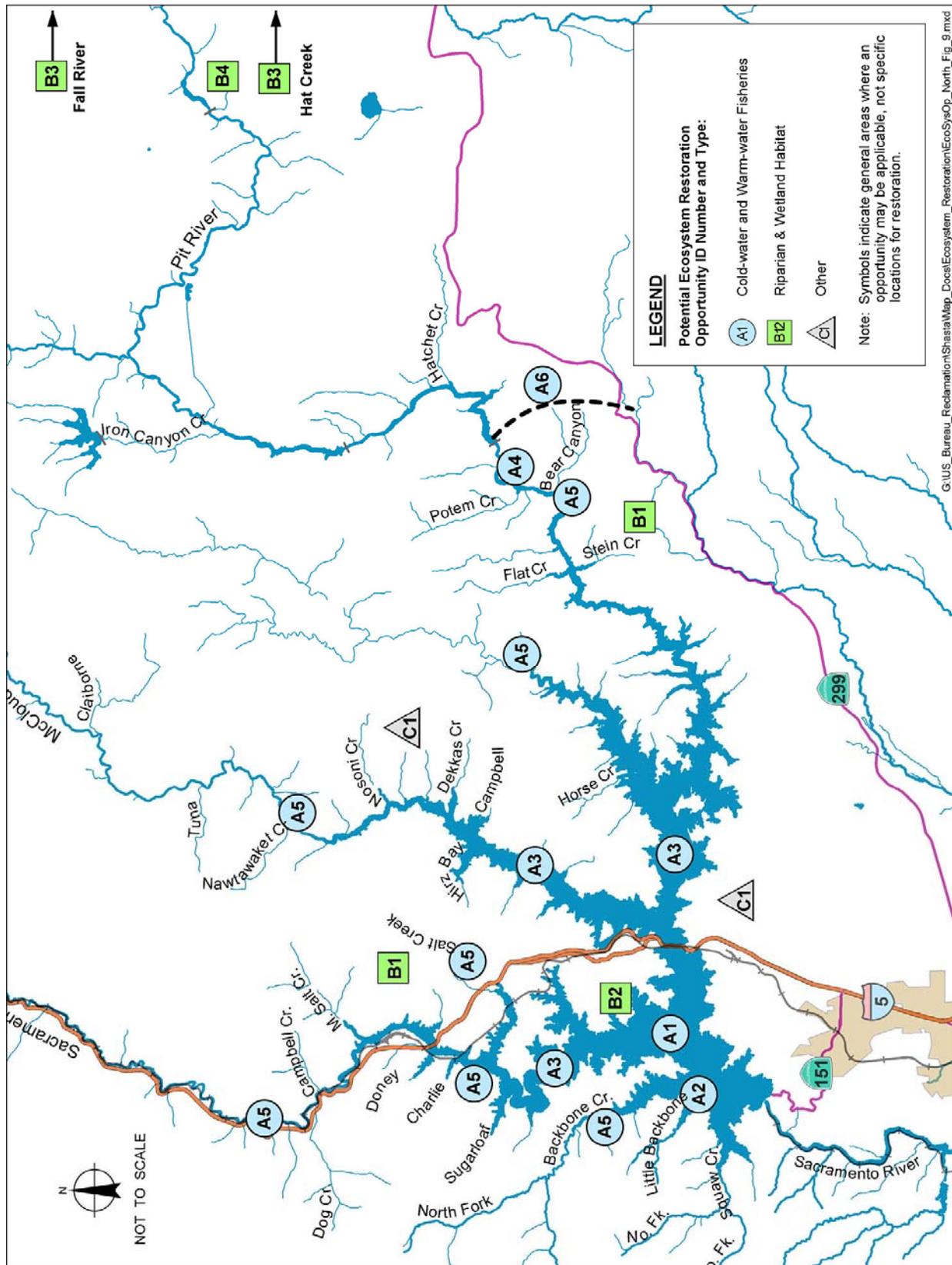
### **SHASTA LAKE AND TRIBUTARIES SUB-AREA**

The key environmental problems within the Shasta Lake and Tributaries sub-area that were summarized in Chapter III fall into two general categories: those related to warm-water and cold-water fisheries, and those related to wetlands and riparian habitat. Potential environmental restoration measures are grouped likewise below, with an additional category for other potential actions that may not fit strictly within either category. Approximate locations where each measure could be applied are shown in Figure 9.

#### **Cold-water and Warm-water Fisheries**

##### ***A1 – Construct Shoreline Fish Habitat around Shasta Lake***

There is an opportunity to improve shallow, warm-water habitat around the shoreline of Shasta Lake for resident fish species. There is a need for vegetation, large woody debris, or other aquatic ‘cover’ structures within the drawdown area of the lake. Most of the large, woody debris entering the lake from the tributaries during high flows is removed from the lake because it poses a boating hazard. Further, it is difficult for vegetation to become established in the drawdown area of the lake because banks tend to be steep and the area is subject to water level fluctuations, wave action, and erosion. The availability of cover for juvenile fish can significantly improve survival.



**Figure 9 – Potential Ecosystem Restoration Opportunities, Shasta Lake and Tributaries**

- **Actions** – Actions would include installation of artificial fish cover including anchored complex woody structures and boulders, and/or plantings of resistant vegetation within the reservoir drawdown area. Specific applications would be chosen as appropriate to shoreline conditions, including rates of erosion, proximity to tributaries or sediment inputs, bank slope, and presence of existing cover or vegetation. Structures would require monitoring after initial installation to determine which applications were most successful.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area. Increased shallow-water fish survival would also enhance recreational sport-fishing opportunities.
- **Implementation Issues and Cost** – DFG participates in fish stocking and monitoring in Shasta Lake and is a potential non-federal sponsor for this measure, possibly through the WCB. Potential implementation issues include the ability to gain access to restoration sites and creation of submerged hazards to boaters. This measure would complement potential measures to raise Shasta Dam because dam raises are likely to increase the shoreline drawdown area subject to erosion and degradation. The cost of this measure would be low relative to the cost of other measures identified herein. Long-term maintenance would not be required, but the effective life of the treatments could vary significantly depending upon site conditions.

#### ***A2 – Reduce Acid Mine Drainage Entering Shasta Lake***

There are opportunities to reduce the negative impacts of former mining operations on aquatic conditions in Shasta Lake and its tributaries. According to the Regional Water Quality Control Board, abandoned mines are a significant contributor of copper loads to Shasta Lake, and copper, cadmium, zinc, and other trace metals are transported to the Sacramento River downstream from the dam. The greatest contributors to acid mine pollution in Shasta Lake are the abandoned mines located to the west of the lake, tributary to Backbone, Little Backbone, and West Squaw creeks. Runoff from mines in this area continue to cause fish kills and impact water quality in Shasta Lake, and many of the tributary streams themselves are devoid of aquatic life. Remediation activities at several of these mines have been limited because they are located on private land.

- **Actions** – Actions would vary depending upon the mine sites chosen for remediation. Actions could include debris impoundment construction or improvements, capping and mine shaft closure, soil restoration at mines/smelters, and removal of tailings or other debris that can contribute to acid mine drainage. Candidates for further remedial actions include the Mammoth, Balaklala, Keystone, Shasta King, and Bully Hill mines, as described below.
  - **Mammoth Mine** – This large abandoned copper mine discharges acid drainage with average annual copper loads in excess of 30 kg/day to Little Backbone Creek and Shasta Lake, according to the USGS. The owner, Mining Remedial Recovery Company, has implemented a mine sealing program but results have been unsatisfactory according to the U.S. Geological Survey. Substantial modification of the sealing program or a new control strategy, such as collection and treatment, may be required to address the problem.

- **Balaklala, Keystone, and Shasta King Mines** – Drainage from the Balaklala, Keystone, and Shasta King mines have average annual copper loads of 9.0, 1.1, and 0.5 kg/day, respectively, according to the USGS. The owner, Alta Gold Company, has performed some remedial work but comprehensive restoration may be beyond their financial capability. There may be an opportunity for a public agency to purchase the property and utilize recreation-related fees to fund remedial actions.
- **Bully Hill** – The Bully Hill mine is the closest abandoned mine to the shoreline of Shasta Lake. Portions of the tailings are submerged when the reservoir is full; a dam raise would potentially inundate large portions of the extensive tailings and smelter waste piles. Additional remedial actions have been proposed at Bully Hill, including solid waste containment and portal sealing. Mine lands are privately owned.
- **Benefits** – Because toxic discharges into Shasta Lake from abandoned mines contribute to trace metal contamination in the Sacramento River downstream from Shasta Dam, remedial actions would support the primary study objective of increasing the survival of anadromous fish populations in the Sacramento River. This measure would also support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area by improving water quality and aquatic habitat in Shasta Lake and affected tributaries. Increased fish survival would also enhance recreational sport-fishing opportunities.
- **Implementation Issues and Cost** – There are numerous implementation issues associated with mine remediation, but the most significant is liability. The mines identified above as some of the greatest contributors to acid mine drainage in Shasta Lake are all located on private lands; it is difficult for public agencies to perform remediation on private lands due to liability concerns. This would make public sponsorship difficult. The cost for remediation at any of the mines identified above would be high to very high relative to the cost of other measures identified herein. Long-term maintenance costs would be associated with certain remedial actions.

### ***A3 – Reduce Motorcraft Access to Upper Reservoir Arms***

There is an opportunity to improve the spawning success of fish in Shasta Lake by restricting the use of motorcraft, to the greatest extent possible, in the upper reaches of reservoir arms. Many resident lake fish spawn and rear in the mouths of the lake's tributaries, which are also popular spots for boaters, fishermen, and personal watercraft users.

- **Actions** – This measure would involve imposing boating and personal watercraft restrictions in portions of Shasta Lake. Portions of the lake are already closed to water-skiing and personal watercraft during drawdown periods, and a 5mph speed limit is imposed within 100 feet of the shoreline throughout the lake. Additional restrictions could include reduced speed limits in upper reaches of reservoir arms or restricting access to portions of the lake during key spawning/rearing periods. Appropriate signage or restrictive buoys may be employed.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area by reducing juvenile fish mortality. Increased juvenile fish survival would enhance recreational sport-fishing opportunities, but boat access to near-shore fishing areas would be reduced.

- **Implementation Issues and Cost** – Boating on Shasta Lake is regulated by State and Federal boating laws, Shasta County, and the FS. The Shasta County Sheriff's department enforces boating regulations. It is likely that this measure could be implemented through an order issued by the supervisor of the Shasta-Trinity National Forest. The cost associated with such an order would be minimal, as boating regulations on Shasta Lake are updated and printed annually. The cost of enforcing additional boating regulations is expected to be minimal. The overall cost of this measure would be very low relative to other measures identified herein.

#### ***A4 – Increase Instream Flows on Pit River***

There may be opportunities to increase instream flows on the lower Pit River to benefit native fish and aquatic habitat. Flows on the Pit River are highly dependent upon hydropower operations, which divert flows through a complex series of bypasses and power stations. Increasing instream flows would enhance aquatic habitat, benefiting resident fish and birds of prey such as the endangered Bald Eagle.

- **Actions** – Actions could include power buy-outs, altering power generation operations, or removing selected water diversions or diversion facilities. The FERC license for hydroelectric facilities on the Pit River is scheduled for renewal in 2011; the relicensing process could provide opportunities for reoperation or increases to minimum flows. In addition, the Pit-McCloud Hydroelectric Project is among hydropower assets that PG&E has offered for sale.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area by improving conditions for native fish on the Pit River. The Pit River is a source of high-quality, cold water flows into Shasta Lake. Improving aquatic habitat on the lower Pit River would enhance recreational sport-fishing opportunities in the area.
- **Implementation Issues and Cost** – The Pit River project is owned and operated by PG&E, although it is an asset identified for potential divestiture/sale. The measure could negatively impact hydropower production. The cost of implementing this measure could vary significantly, from low to high relative to the other measures identified, depending upon the actions required to bring about increased flows. The least cost method of implementation would probably be achieved through modification of minimum flows associated with the FERC license renewal. The highest cost method of implementation would involve power or facilities buyouts; no potential non-federal sponsor has been identified for this method of implementation. Power buyouts would involve recurring costs.

#### ***A5 – Construct Instream Fish Habitat on Tributaries to Shasta Lake***

There is an opportunity to improve instream aquatic habitat along the lower reaches of the tributaries to Shasta Lake using various structural techniques to trap spawning gravels in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Both perennial and intermittent streams are potential candidates for structural habitat improvements.

- **Actions** – Structural treatments would vary depending upon stream conditions, but include the installation of gabions, log weirs, boulder weirs and other anchored structures. Rearing habitat can be created for juveniles by providing cover with large root wads and by the use of drop structures, boulders, or logs that cause scouring and help clean gravels. If sites chosen for restoration are not already in public ownership or protected under the NFP, easements or other real estate interests may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area by improving aquatic habitat conditions. Both native and non-native fish would benefit, including some lake fish that spawn in the tributaries. It could also benefit steelhead, as some natural reproduction occurs on the lower reaches of the tributaries to Shasta Lake. Improving aquatic habitat would also enhance recreational sport-fishing opportunities in the area.
- **Implementation Issues and Cost** – DFG, the Cantara Trust, and the McCloud River CRMP are potential non-federal sponsors for instream habitat restoration. Each have participated in similar activities in the past. The cost for this measure would be low to medium relative to other measures identified herein, depending upon the number of sites selected for restoration. Long-term maintenance would not be required after initial construction. However, habitat structures would require replacement periodically, depending upon site conditions. Monitoring would be beneficial to determine the effectiveness of various structural treatments.

#### ***A6 – Construct a Migration Corridor from Sacramento River to Pit River***

Potential opportunities have been suggested to provide access to spawning areas upstream from Shasta Dam via a manmade fish migration corridor. It has been suggested that anadromous fish in the Sacramento River could be provided with access to the Pit River via a combination of the natural channels of Cow Creek, Little Cow Creek, and other creeks and a manmade canal excavated in the lowest elevation saddle between the Cow Creek basin and Pit River basin.

- **Actions** – Major actions would include excavating a fish channel or large diameter tunnel between the Cow Creek basin and the Pit 7 Dam at the upstream end of Shasta Lake on the Pit River; constructing a fish barrier to prevent fish from entering Shasta Lake; installing fish screens and flow control structures at various locations along the natural and manmade migration route to prevent straying; and providing instream flows for fish attraction and survival. If the stream reaches and alignment chosen for the migration corridor is not already in public ownership, easements or other real estate interests may be required to implement the measure and ensure long-term operational performance.
- **Benefits** – This measure would support the primary study objective to increase the survival of anadromous fish populations in the Sacramento River by providing access to additional cold-water spawning habitat in the Pit River. The Pit River is one of the largest tributaries to Shasta Lake and a source of high quality, cold streamflows. However, the numerous hydropower facilities along the lower Pit River would limit the amount of spawning habitat that could be made available.

- **Implementation Issues and Cost** – The fish migration corridor would require a highly complex design and need to operate under a variety of streamflow conditions in order to prevent fish stranding and maintain attraction flows. For this reason, there is a great deal of uncertainty associated with the operational feasibility of this measure. It is likely that portions of the fish migration system would not be capable of passive operation (i.e., would require some type of manual or active control). Currently, water temperatures in the Cow Creek watershed are often higher than desired by migrating salmonids. It is likely that the system would not be capable of operation in dry and critically dry years. The cost of this measure would be high to very high relative to the other measures identified herein. There would be long-term costs associated with maintenance of the fish channel or tunnel, fish barrier, fish screens, and water control structures; a responsible party would need to be identified for long-term maintenance. Further, the amount of increased fish habitat on the Pit River would be limited due to the numerous flow restrictions, such as hydroelectric facilities.

## **Riparian and Wetland Habitat**

### ***B1 – Enhance Forest Management to Preserve Bald Eagle Nesting Habitat***

There are opportunities to improve habitat for bald eagles around Shasta Lake and along the lower Pit River. Mature nesting trees were damaged and killed in some areas by severe wildfires in the 1990s, and are threatened by pests, disease, and disturbance by recreational users. Silvicultural techniques could be applied to existing and potential nesting trees within about one mile of Shasta Lake and along the lower Pit River to maintain habitat health.

- **Actions** – Actions would include thinning, application of insecticides to reduce mortality from bark beetles and other pests, control stocking in conifer stands to encourage growth of large trees, and underbrush management to protect important stands from wildfires. Specific locations include Jones Valley on the Pit River arm, Hirz Bay on the McCloud River arm, and Flume Canyon and Frenchman Creek on the Squaw Creek arm.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area by improving habitat conditions for the endangered bald eagle. Shasta Lake supports the largest concentration of nesting bald eagles in California.
- **Implementation Issues and Cost** – This measure is within the purview of existing FS management programs. The cost for this measure would be low relative to other measures identified herein. Periodic monitoring and continuation of silvicultural treatments would be required to maintain long-term benefits.

### ***B2 – Remove and Control Non-Native Plants around Shasta Lake***

There is an opportunity to remove and control non-native species in various locations around Shasta Lake. Non-native vegetation has the potential to out-compete native vegetation and alter the suitability of habitat for native wildlife, including special status species. Candidate areas for exotic vegetation control include Wheeler Ranch (yellow star thistle) and Chirpchatter Campground (Himalayan blackberry).

- **Actions** – Actions include removal of invasive species around Lake Shasta, including Himalayan blackberry, scotch broom, and other aggressive plants. Removal methods could include herbicides, physical removal, or controlled burning.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area by improving overall habitat conditions and preventing conversion of native habitats.
- **Implementation Issues and Cost** – This measure is within the purview of existing FS management programs if implemented on National Forest lands. The California Department of Food and Agriculture and the Shasta County Department of Agriculture have also participated in noxious weed abatement programs on private lands in Shasta County. The cost for this measure would be low relative to other measures identified herein. Periodic monitoring and continuation of abatement actions would be required to maintain long-term benefits.

### ***B3 – Restore Wetlands along Fall River and Hat Creek***

There are opportunities to restore important marshlands and wetlands along Fall Creek and the Hat River, in the Pit River watershed. Such restoration actions could restore valuable marshland habitat and improve water quality in the Pit River system by helping to regulate water temperatures and sediment input.

- **Actions** – Actions would include structural measures such as log weirs, grade control structures, sediment traps, excavation and channel reconstruction; revegetation; and exclusive fencing to restrict cattle grazing in affected areas. If sites chosen for restoration are not already in public ownership, easements or other real estate interests may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area by improving wetland habitat conditions and the secondary values that wetlands support, including water quality and habitat diversity.
- **Implementation Issues and Cost** – The Fall River RCD and Pit River RCD have participated in similar wetland and marshland restoration projects in the watershed, and are potential non-federal sponsors. RCDs are uniquely positioned to implement this type of measure due to their working relationships with private landowners, but they usually rely on outside funding assistance to implement projects. The cost for this measure would be low relative to other measures identified herein.

### ***B4 – Preserve Upper Pit River Riparian Areas***

There are opportunities to install exclusive fencing around valuable riparian corridors to prevent damage from livestock. The majority of cattle grazing in the sub-area occurs in the eastern and southeastern portions of the upper Pit River watershed. Access to riparian areas in the lower reaches of tributary rivers and creeks is limited by provisions of the NFP.

- **Actions** – Actions would include obtaining a real estate interest, such as an environmental easement, installing fencing and natural vegetation barriers around riparian corridors affected by grazing animals. Specific sites have not been identified at this time. Unless the riparian areas selected are already in public ownership, easements or other real estate interests may be required to implement the measure and ensure that the livestock barriers remain in place.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area by improving riparian habitat conditions. Exclusive fencing provides a variety of benefits, including protection of water quality (turbidity, temperature, and fecal coliform) and maintenance of diverse riparian habitats.
- **Implementation Issues and Cost** – Resource conservation districts are potential non-federal sponsors for this measure due to their relationships with local landowners, but RCDs usually rely on outside funding assistance to implement projects. The cost for this measure would be low relative to other measures identified herein.

## Other

### *CI – Control Erosion and Restore Affected Habitat in Shasta Lake Area*

There are opportunities to restore highly erodible lands in the watershed that have been impacted by timber harvest, historic smelter blight, and other human activities. Accelerated erosion can have far-reaching impacts in a watershed, contributing to loss of wildlife habitat, turbidity and sedimentation in streams, stream morphology changes and aquatic habitat degradation, and increased rainfall runoff. Ore smelters that once operated in the region denuded hillsides of vegetation and lead to the loss of topsoil and formation of artificial gullies and other landforms that are still apparent today. Today, intense timber harvesting practices and severe wildfires have similar effects, increasing erosion and sedimentation in area streams, altering stream morphology and degrading habitat. It is often difficult for these areas to recover due to accelerated erosion and loss of topsoil.

- **Actions** – Actions would include sediment traps and barriers, natural erosion protection, sediment removal, and revegetation. Specific sites have not been identified at this time, but it is anticipated that they would be located on public lands. If sites chosen for restoration are not already in public ownership, easements or other real estate interests may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources in the Shasta Lake area by improving terrestrial and aquatic habitat conditions.
- **Implementation Issues and Cost** – Erosion control projects often fall within the purview of resource conservation districts or the FS, but local districts usually rely on outside funding assistance. The cost for this measure would be low to moderate relative to other measures identified herein, depending upon the extent and types of treatment employed.

## SACRAMENTO RIVER FROM SHASTA DAM TO RED BLUFF SUB-AREA

The key environmental problems within the Shasta Dam to Red Bluff sub-area that were summarized in Chapter III fell into two general categories: those related to anadromous fisheries, and those related to wetland and riparian habitat. Potential environmental restoration measures are grouped likewise below, with an additional category for other potential actions that may not fit strictly within either category. Approximate locations where each measure could be applied are shown in Figure 10.

### Anadromous Fisheries

#### *A7 – Restore Inactive Gravel Mines on Sacramento River*

There are opportunities to restore and reclaim inactive gravel mining operations along the Sacramento River. Abandoned gravel pits are the cause of fish stranding and high predation rates. Due to changes in flow regime and reductions in coarse sediment input, the river is not capable of refilling and restoring these pits naturally.

- **Actions** – The Shea Pits near Redding are separated from the river by levees; actions could include reconnection of the mining area to the river via removal of levees, filling and re-contouring the site, and restoring aquatic, riparian, and floodplain habitat alongside the Sacramento River. Similar opportunities exist at inactive mining sites near Anderson and Red Bluff. If sites chosen for restoration are not already in public ownership, easements or other real estate interests may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by eliminating stranding in abandoned gravel pits and creating new aquatic, riparian, and wetland habitat. Restoring stream habitat between Keswick Dam and Red Bluff is of high priority because it is one of the few remaining spawning areas available to anadromous fish. The measure also supports the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River through the restoration of riparian and floodplain habitat.
- **Implementation Issues and Cost** – DFG or DWR are potential non-federal sponsors for this measure. There appears to be a high degree of public agency and local interest for gravel pit restoration. This measure would complement potential measures to raise Shasta Dam because improved release flexibility would enable anadromous fish to take greater advantage of restored spawning areas. The cost for this measure would be moderate relative to other measures identified herein.

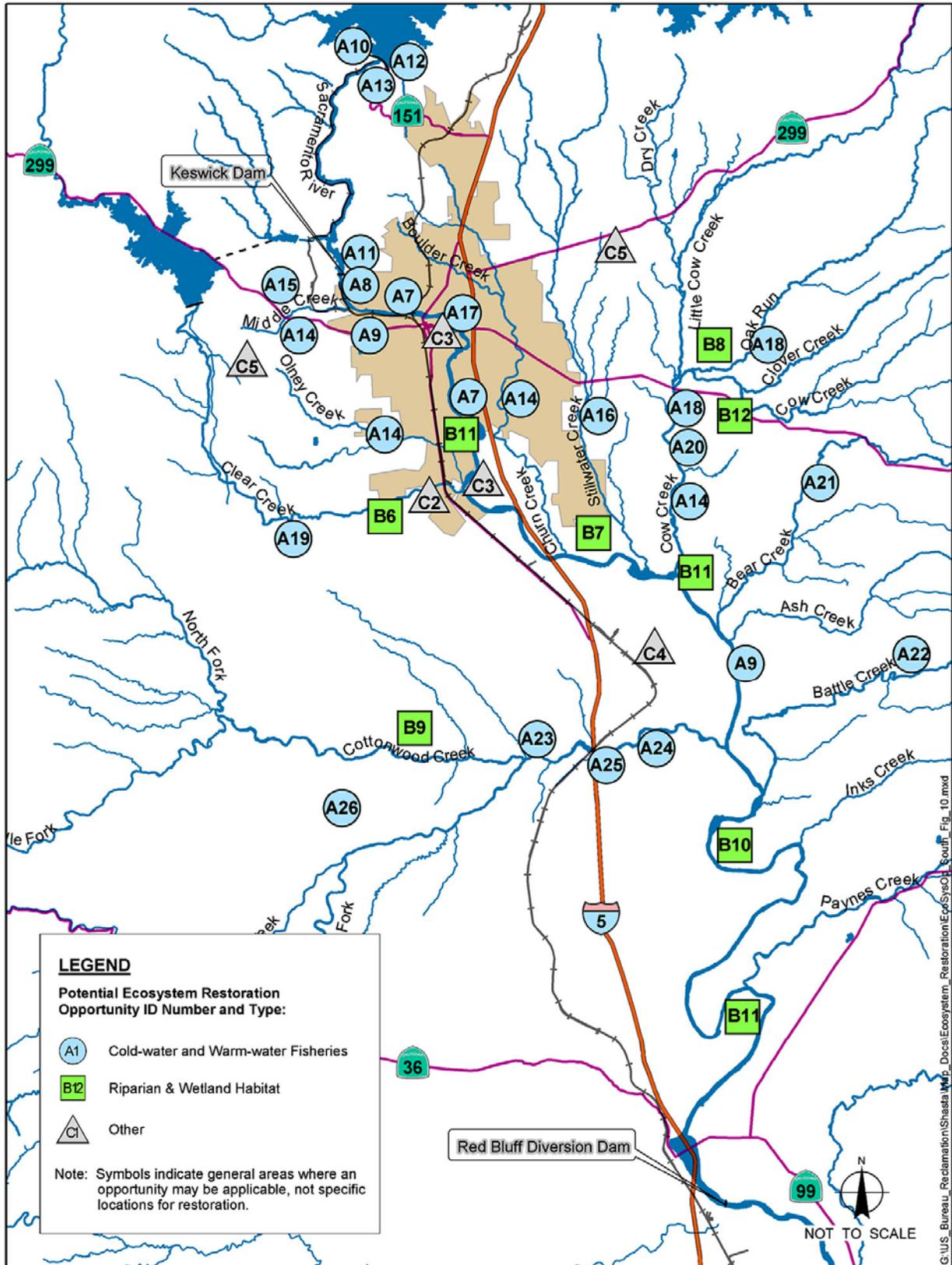


Figure 10 – Potential Ecosystem Restoration Opportunities, Shasta Dam to Red Bluff

### ***A8 – Construct Instream Habitat Downstream from Keswick Dam***

There are opportunities to construct complex instream habitat in the Sacramento River downstream from Keswick Dam. This reach of the river is entrenched in bedrock and has few sources of large woody debris, gravels, and instream structures providing complex fish habitat. However, the area attracts spawners because stream temperatures immediately below Keswick Dam typically remain favorable due to cold-water releases from Shasta Dam. Predation can be high due to the lack of cover.

- **Actions** – Actions could include constructing manmade instream structures using anchored root wads and other natural materials and strategic placement of large boulders. Such structures would improve the complexity of the aquatic habitat in this reach, help trap sediment, and benefit juvenile rearing. Additional actions include gravel replenishment and the construction of side channels for spawning and rearing immediately below Keswick Dam.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by restoring important spawning habitat below Keswick Dam. Restoring aquatic habitat between Keswick Dam and Red Bluff is of high priority because it is one of the few remaining spawning areas available to anadromous fish.
- **Implementation Issues and Cost** – DFG or DWR are potential non-federal sponsors for this measure. There may be a high degree of public agency interest for restoration in this reach. This measure would complement potential measures to raise Shasta Dam because improved release flexibility would enable anadromous fish to take greater advantage of restored spawning areas. The cost for this measure would be moderate relative to other measures identified herein. Operation and maintenance of this measure would be high compared to other measures.

### ***A9 – Replenish Spawning Gravel in Sacramento River***

There are opportunities to replenish spawning gravel in the Sacramento River and along the lower reaches of its tributaries. The reach immediately downstream from Keswick Dam has no natural gravel sources and provides marginal spawning habitat. The lower reaches of Sacramento River tributaries, including Clear Creek and Battle Creek, also provide valuable spawning habitat for salmonids. Instream gravel mining and the construction of dams and other barriers have reduced gravel recruitment in many of the tributaries. These gravel sources could be artificially replaced by gravel injections.

- **Actions** – Actions would include injecting suitable gravels into the Sacramento River immediately below Keswick Dam, and in tributaries that provide important spawning habitat such as Clear Creek and Battle Creek. Structural treatments may be required below Keswick Dam to prevent the gravel from being washed downstream prematurely by releases. Temporary construction easements could be required to gain access to injection sites.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by restoring spawning gravels in

stream channels that no longer have adequate gravel resources. After water temperature, the presence and quality of spawning gravel is probably the most important factor contributing to the reproductive success of anadromous fish. The availability of suitable spawning gravels may be a limiting factor in the restoration of anadromous fish populations in the Sacramento River.

- **Implementation Issues and Cost** – Spawning gravel replenishment programs have been successful along the Sacramento River in the past, inferring a high likelihood of effective implementation. DFG, DWR, and the Western Shasta RCD are potential non-federal sponsors for this measure. This measure would complement potential measures to raise Shasta Dam because improved release flexibility would enable anadromous fish to take greater advantage of restored spawning habitat. The cost for this measure would be moderate relative to other measures identified herein. Operation and maintenance of this measure would be very high compared to other measures.

#### ***A10 – Additional Modifications to Shasta Dam for Temperature Control***

There is an opportunity to improve water temperature conditions in the Sacramento River through additional structural modifications to the temperature control device (TCD) at Shasta Dam. Modifications in addition to those associated with the existing TCD could allow even greater flexibility in making cold-water releases during critical spawning periods and extend the area of suitable spawning habitat in the Sacramento River.

- **Actions** – Actions would include reducing leakage of warmer water at the existing TCD, increasing the capacity of the existing low-level outlets, and/or increasing the depth from which water can be released from the reservoir.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by improving the ability to provide desirable water temperatures for spawning, rearing, and out-migration. Water temperature is one of the most important factors contributing to the success of anadromous fish reproduction.
- **Implementation Issues and Cost** – This measure would complement potential measures to increase storage in Shasta Dam because additional temperature control improvements could be incorporated into the design of a dam raise and further improve cold-water releases. The cost for this measure would be high to very high relative to other measures identified herein.

#### ***A11 – Improve the Fish Trap below Keswick Dam***

There is an opportunity to improve the fish trap below Keswick Dam to increase the survival of anadromous fish captured at the facility, providing additional adults and increased egg production for fish hatchery operations. Fish trapped at Keswick Dam are transported to the Coleman National Fish Hatchery on Battle Creek.

- **Actions** – Actions would include reconstructing the existing fish trap and making channel improvements downstream from the trap.

- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by reducing mortality at the Keswick fish trap and increasing the number of adults available to the fish hatchery.
- **Implementation Issues and Cost** – The cost for this measure would be moderate to high relative to other measures identified herein.

#### ***A12 – Enlarge Shasta Lake Cold Water Pool***

There is an opportunity to increase the volume of the cold water pool in Shasta Lake to help maintain cooler releases for anadromous fish during certain periods by raising Shasta Dam and enlarging Shasta Reservoir. There are certain periods especially during dry and critically dry periods when meeting temperature needs for certain runs of anadromous fish is not possible. Increasing the cold water pool in Shasta Lake could help reduce these periods. There are certain periods when additional releases could be made from the enlarged lake storage space to help dilute acid mine drainage from Spring Creek. This measure could also help address the other primary planning objective and the secondary objectives. This measure is consistent with the objectives of the California Bay-Delta Authority (CALFED).

- **Actions** – Primary actions would include raising Shasta Dam. Low raises could be made with relatively minor required mitigation to reservoir area natural resources and infrastructure.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by improving temperature, flow, and aquatic habitat conditions. It could also benefit other primary and secondary planning objectives.
- **Implementation Issues and Cost** – This measure would be very costly. There may be little interest by a non-federal sponsor to share in the cost of this measure if it were accomplished solely for the objective of increasing the survival of anadromous fish.

#### ***A13 – Modify Storage and Release Operations at Shasta Dam***

This measure includes modifying reservoir storage and release operations at Shasta Dam to benefit anadromous fisheries. Releases from Shasta Dam are currently made with a major focus on maintaining temperature objectives downstream for anadromous fish. Release changes may have the potential to increase cold-water discharges during certain periods, which could extend the downstream reach of suitable habitat conditions for spawning by salmonids in the river. Changing the timing and magnitude of releases, especially from an increased pool (see A12), would have the potential to improve aquatic habitat by cleaning spawning gravels, and would improve attraction flows that cue in-migration and temperatures that cue out-migration. Releases could also be increased to dilute acid mine drainage from Spring Creek during periods of overspill.

- **Actions** – Actions would include revising reservoir release criteria to permit more flexibility in making releases beneficial to anadromous fish.

- **Benefits** – This measure could support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by improving temperature, flow, and aquatic habitat conditions. However, without mitigating features to account for potential reductions in water supply, it could adversely impact the primary objective of water supply reliability.
- **Implementation Issues and Cost** – This measure could have undesirable effects on water supply or hydropower production. However, it would complement measures to increase the height of Shasta Dam and capacity of Shasta Reservoir, which could offset hydropower or water supply impacts. The cost for this measure would be moderate relative to other measures identified herein, depending upon the cost of features to mitigate impacts to hydropower and/or water supply reliability.

#### ***A14 – Construct Instream Fish Habitat on Tributaries to Sacramento River***

There is an opportunity to improve instream aquatic habitat along the lower reaches of the tributaries to the Sacramento River using various structural techniques to trap spawning gravels in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Both perennial and intermittent streams are potential candidates for structural habitat improvements.

- **Actions** – Structural treatments would vary depending upon stream conditions, but include the installation of gabions, log weirs, boulder weirs, and other anchored structures. Rearing habitat can be created for juveniles by providing cover with large root wads and by the use of drop structures, boulders, or logs that cause scouring and help clean gravels. Candidates for aquatic habitat improvement include Middle, Olney, Churn, and Cow creeks. If the stream or creek reaches chosen for restoration were not in public ownership, easements could be required to implement the improvements.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations by enhancing aquatic conditions on tributaries that provide important spawning and rearing habitat.
- **Implementation Issues and Cost** – DFG is a potential non-federal sponsor for instream habitat restoration. The cost for this measure would be low to medium relative to other measures identified herein, depending upon the number of sites selected for restoration. Long-term maintenance would not be required after initial construction, though monitoring would be beneficial to determine the effectiveness of various structural treatments.

#### ***A15 – Remove Instream Sediment along Middle Creek***

There is an opportunity to implement a sediment removal and control program along Middle Creek, an intermittent tributary to the Sacramento River between Keswick Dam and Redding. Lower Middle Creek supports spawning runs of rainbow trout, steelhead, and salmon. Spawning gravels have been degraded by fine granitic sediment that erodes from streambanks and adjacent land. Sediment from the creek also impacts spawning habitat in the Sacramento River around the Middle Creek confluence.

- **Actions** – Actions include dredging the Swasey sediment basin, streambank and gully protection, and small sediment capture impoundments on tributaries. If the creek reaches chosen for restoration are not already in public ownership, land easements could be required to implement the improvements and to ensure the continued benefits of the measure.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations by enhancing aquatic conditions on tributaries that provide important spawning and rearing habitat.
- **Implementation Issues and Cost** – DFG is a potential non-federal sponsor for instream habitat restoration. The cost for this measure would be low to medium relative to other measures identified herein. There appears to be local support for actions on Middle Creek. Repeated sediment removal may be required to maintain long-term benefits.

#### ***A16 – Restore Instream Gravel Mines along Stillwater Creek***

There is an opportunity to rehabilitate and revegetate former instream gravel mining sites along Stillwater Creek. There are seven inactive gravel pits on Stillwater Creek that have depleted nearly all of the instream gravel resources in some reaches, leaving the channel scoured to bedrock. Stillwater Creek provides seasonal habitat for various anadromous and resident fish.

- **Actions** – Actions would include filling abandoned pits, re-contouring the channel and floodplain, and restoring aquatic, riparian, and floodplain habitat alongside the creek. If the instream sites chosen for restoration are not already in public ownership, easements or land acquisition could be required to implement the improvements and to ensure the continued benefits of the measure.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by eliminating stranding in abandoned gravel pits and restoring aquatic and riparian habitat. The measure also supports the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River through the restoration of riparian and floodplain habitat.
- **Implementation Issues and Cost** – DFG and DWR are potential non-federal sponsors for this measure. There appears to be a high degree of public agency interest in gravel pit restoration. The cost for this measure would be moderate relative to other measures identified herein. There would be initial short-term maintenance and monitoring costs associated with revegetation, but no long-term maintenance requirements are anticipated.

#### ***A17 – Modify ACID Diversion to Reduce Flow Fluctuations***

There is an opportunity to modify operations at the ACID diversion dam near Anderson to reduce flow fluctuations and resulting impacts to anadromous fish. Extreme fluctuations in Sacramento River flows result in fish stranding and juvenile fish mortality.

- **Actions** – Actions would include reconstructing the dam and diversion screens to facilitate flexibility in operation and reduce significant fluctuations in flow. The facility could also be

reoperated to maintain flows of 5,000 cfs to 5,500 cfs during the critical migration period from October through April.

- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by alleviating flow fluctuations that cause stranding and juvenile mortality.
- **Implementation Issues and Cost** – DFG and ACID are potential non-federal sponsors for this measure. This measure would complement the measures to enlarge the Shasta Lake cold water pool and to modify the storage and release operations at Shasta Dam (A12 and A13) by providing additional flexibility in regulating flows in the Sacramento River. The cost for this measure would be moderate to high relative to other measures identified herein.

#### ***A18 – Screen Diversions on Old Cow and Cow Creeks***

There is an opportunity to screen the diversion intakes in the Cow Creek watershed to reduce fish mortality. There are over 100 diversions from the Cow Creek watershed. While many are small agricultural diversions, larger diversions can entrain juvenile salmonids and other fish that utilize the spawning habitat provided by the watershed.

- **Actions** – Actions would include installing fish screens on diversions over five feet per second that are located within the range of spawning salmonids. Alternatively, multiple diversions could be consolidated and screened or alternative water supplies could be developed, such as groundwater. Potential diversions are listed in Table V-1. Construction easements would be required at the diversions chosen for screening.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by reducing salmonid mortality at diversions within the Cow Creek watershed.
- **Implementation Issues and Cost** – There appears to be significant local and agency interest in screening diversions in the Cow Creek watershed. This measure was recommended in the *Cow Creek Watershed Assessment*, 2001 and by the Western Shasta RCD. The cost for this measure would be moderate relative to other measures identified herein, depending upon the number of diversions selected for screening.

**TABLE V-1  
DIVERSIONS GREATER THAN FIVE CFS IN THE COW CREEK WATERSHED**

<b>Tributary</b>	<b>Location (miles up tributary)</b>	<b>Diversion Name</b>	<b>Diversion Rate (cfs)</b>
Old Cow Creek	24	Kilarc Powerhouse Ditch	58.0
Old Cow Creek	10	Bassett Ditch	27.6
Old Cow Creek	16	Brown Grover	14.0
Old Cow Creek	12	Parker Hufford Ditch	11.1
Glendenning	2.5	Neely Glendenning Creek Ditch	7.8
Old Cow Creek	6.5	Crowe Lower Ditch	7.8
Canyon Creek	N/A	East Canyon Creek Ditch	7.5
South Cow Creek	10.5	South Cow Creek Powerhouse Ditch	47.9
South Cow Creek	21	German Ditch	13.7
Mill creek	0	Mill Creek Ditch	13.5
South Cow Creek	6.5	Abbott Ditch	13.1
Atkins Creek	1.5	Worden Ditch	5.5
South Cow Creek	13.5	East Hufford Ditch	5.0

*Source: Cow Creek Watershed Assessment, 2001*  
*Note: Some of the diversions listed above may already be screened; specific diversions have not been selected for this measure.*

***A19 – Increase Instream Flows on Clear Creek by 150 to 200 cfs***

There is an opportunity to increase instream flows on Clear Creek during critical periods to support anadromous fish that spawn in the creek. The removal of McCormick-Saeltzer Dam has restored access to many miles of spawning habitat on Clear Creek. However, all but about 13 percent of flows in Clear Creek are diverted to the Spring Creek Powerplant above Whiskeytown Dam, leaving insufficient flows during dry and critically dry years to support significant spawning runs.

- **Actions** – Increasing minimum flows by 150 to 200 cfs would require modifications to diversion operations at Whiskeytown Dam to allow more water to remain in Clear Creek.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by increasing the amount of suitable tributary spawning habitat available on Clear Creek during dry and critically dry years. This measure would complement recent aquatic habitat restoration programs along lower Clear Creek.
- **Implementation Issues and Cost** – This measure was recommended in the CALFED ERP. The measure would require changes to the operation of Whiskeytown Dam, which currently diverts Clear Creek flows to the Spring Creek Powerplant. There could be negative impacts associated with hydropower generation. The cost for this measure would be moderate relative to other measures identified herein, depending upon the impacts to power production at Spring Creek.

***A20 – Increase Instream Flows on Cow Creek by 25 to 50 cfs***

There is an opportunity to increase instream flows on Cow Creek to support anadromous fish during critical periods. Increasing flows would increase the quality of instream habitat and help reduce water temperatures, a factor limiting the use of Cow Creek by anadromous fish.

- **Actions** – Minimum flows would be increased by 25 to 50 cfs during critical spawning periods (May through October) and dry years. These increases could be achieved through voluntary agreements with local agricultural water users or by providing an alternate water supply, such as groundwater, during critical flow periods. Groundwater wells could be developed to replace the spring and summer diversions of the larger agricultural water users.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by increasing the amount of suitable tributary spawning habitat available on Cow Creek.
- **Implementation Issues and Cost** – This measure was recommended in the CALFED ERP. The measure would require agreements with numerous agricultural water diverters on Cow Creek. The cost for this measure would be low to moderate relative to the other measures identified herein, depending upon the need for and availability of alternate agricultural water sources.

***A21 – Increase Instream Flows on Bear Creek by 10 to 20 cfs***

There is an opportunity to increase instream flows on Bear Creek to support anadromous fish during critical periods. Increasing flows would increase the quality of spawning habitat and help reduce water temperatures.

- **Actions** – Minimum flows would be increased by 10 to 20 cfs during critical spawning periods and dry years. These increases could be achieved through voluntary agreements with local agricultural water users or by providing an alternate water supply, such as groundwater, during critical flow periods. Groundwater wells could be developed to replace the spring and summer diversions of the larger agricultural water users.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by increasing the amount of suitable tributary spawning habitat available on Bear Creek.
- **Implementation Issues and Cost** – This measure was recommended in the CALFED ERP. The measure would require agreements with agricultural water diverters on Bear Creek. The cost for this measure would be low to moderate relative to the other measures identified herein, depending upon the need for and availability of alternate agricultural water sources.

***A22 – Remove or Screen Diversions on Battle Creek***

There are opportunities to remove or screen diversions and other water control facilities on Battle Creek to allow full use of the watershed's high-quality, cold-water spawning habitat. Several projects have been implemented on lower Battle Creek to improve access and spawning success,

but large portions of the upper Battle Creek watershed remain inaccessible to anadromous fish due to diversions.

- **Actions** – Actions identified for Battle Creek include installing fish screens and fish ladders at North Fork diversions below the North Fork Battle Creek Feeder; installing screens and ladders on all South Fork diversions; and installing additional fish screens and fish ladders above Eagle Canyon. It may also be possible to remove or consolidate some diversions. Construction easements would be required at diversions selected for screening or modification.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by providing access to high-quality spawning habitat in the upper Battle Creek watershed. Battle Creek’s cool flows and gravel resources make this tributary system an important spawning and rearing resource for salmonids.
- **Implementation Issues and Cost** – There appears to be significant local and agency interest in additional anadromous fish restoration projects in the Battle Creek watershed. The cost for this measure would be moderate relative to other measures identified herein, depending upon the number of diversions selected.

#### ***A23 – Restore Instream Gravel Mines along Cottonwood Creek***

There is an opportunity to rehabilitate and revegetate several inactive instream gravel mines along lower Cottonwood Creek, which provides valuable spawning and rearing habitat for anadromous fish. Cottonwood Creek is also an important source of spawning gravel to the Sacramento River.

- **Actions** – Actions would include filling abandoned pits and re-contouring the channel and floodplain, and restoring aquatic, riparian, and floodplain habitat alongside the creek. If the lands chosen for restoration are not already in public ownership, land acquisition and/or easements may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by restoring tributary spawning habitat on Cottonwood Creek. The measure also supports the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River through the restoration of riparian and floodplain habitat.
- **Implementation Issues and Cost** – DFG and DWR are potential non-federal sponsors for this measure. There appears to be a high degree of public agency interest in gravel pit restoration and growing local interest for restoration on Cottonwood Creek. The cost for this measure would be moderate relative to other measures identified herein.

#### ***A24 – Restore Streambed near ACID Siphon on Cottonwood Creek***

There is an opportunity to restore the streambed near the ACID siphon on Cottonwood Creek to prevent degradation of this anadromous fish migration corridor. Erosion and channel down-

cutting at the siphon has altered the streambed and may prevent migration up Cottonwood Creek during low flow periods.

- **Actions** – Actions would include excavating and replacing the existing ACID siphon followed by re-contouring and armoring the streambed to prevent future erosion. Some vegetation replacement may be required. If the stream reach is not already in public ownership, easements may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by restoring tributary spawning habitat on Cottonwood Creek.
- **Implementation Issues and Cost** – DFG and the local RCD are potential non-federal sponsors for this measure. There appears to be growing local interest in fisheries restoration projects on Cottonwood Creek. This action was recommended in the recently completed *Cottonwood Creek Watershed Assessment, 2001*. The cost for this measure would be low relative to other measures identified herein.

#### ***A25 – Construct Fish Barrier at Crowley Gulch on Cottonwood Creek***

There is an opportunity to construct a fish barrier at the mouth of Crowley Gulch on Cottonwood Creek to eliminate adult fall-run chinook stranding. Intermittent flows in Crowley Gulch attract spawners to the waterway but they often become trapped when flows decrease.

- **Actions** – Actions would include constructing a physical barrier within the Crowley Gulch stream channel to prevent fish from entering the stream during low flows. The barrier could be passive or active in operation, depending upon stream flow and channel conditions. A passive barrier would likely be earthen in nature and employ culverts or shallow flow weirs. An active barrier would employ flashboards or other temporary barriers that would need to be put in place annually and removed following critical spawning periods. If the area chosen to construct the barrier is not already in public ownership, land acquisition and/or easements may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by preventing stranding mortality on Cottonwood Creek.
- **Implementation Issues and Cost** – DFG and the local RCD are potential non-federal sponsors for this measure. There appears to be growing local interest in fisheries restoration projects on Cottonwood Creek. This action was recommended in the recently completed *Cottonwood Creek Watershed Assessment, 2001*. The cost for this measure would be low relative to other measures identified herein.

#### ***A26 – Construct Storage Facility on Cottonwood Creek to Augment Spring Flows***

There is an opportunity to construct an onstream or offstream storage facility on upper Cottonwood Creek to support flows for spring-run chinook salmon. A storage facility would

provide the means to make late-spring and summer releases to increase streamflows for spring-run chinook salmon, and improve overall seasonal aquatic conditions.

- **Actions** – Actions would include constructing an onstream or offstream dam and reservoir to capture winter flows for release in the late spring and summer. An onstream reservoir would be constructed along the existing channel of upper Cottonwood Creek or one of its tributaries; an offstream facility would be constructed adjacent to Cottonwood Creek and be filled via diversion from one or more Cottonwood tributaries. Significant land acquisition and construction easements at the proposed reservoir site would be required to implement this measure.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by supporting spring-run chinook salmon on Cottonwood Creek. This measure may also provide residual flood control benefits, supporting the secondary study objective to reduce flood damages along the Sacramento River.
- **Implementation Issues and Cost** – There would be significant environmental impacts associated with constructing a dam and reservoir in this otherwise undeveloped watershed; there is a potential to impact vernal pools and other sensitive grassland habitats. The cost for this measure would be high to very high relative to other measures identified herein. There would be moderate long-term maintenance costs associated with the dam and reservoir.

### **Riparian and Wetland Habitat**

#### ***B5 – Restore Riparian and Floodplain Habitat on Lower Clear Creek***

There is an opportunity to continue the floodplain and riparian habitat restoration work being performed on lower Clear Creek. Several additional phases of Western Shasta RCD's Clear Creek Project have not been funded to date, and present an opportunity to continue riparian habitat restoration along this important spawning corridor.

- **Actions** – Actions include channel relocation and revegetation at two historic gravel mining locations; spawning gravel injection; and erosion control at the former McCormick-Saeltzer dam site and the Sunrise Bluffs. Some work would be performed instream and some would be performed within adjacent floodplains. If the lands chosen for restoration are not already in public ownership, land acquisition and/or easements may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the primary objective to increase the survival of anadromous fish populations in the Sacramento River by improving conditions for anadromous fish that spawn and rear along lower Clear Creek. Gravel injections would eventually reach and benefit the Sacramento River. Similarly, erosion control measures on Clear Creek could also benefit sediment conditions at the confluence with the Sacramento River.
- **Implementation Issues and Cost** – This measure has been proposed by the Western Shasta RCD, indicating a high degree of local support. The cost for this measure would be low to moderate relative to other measures identified herein.

### ***B6 – Restore Offstream Gravel Mines near Sacramento River***

There are opportunities to restore inactive offstream gravel pits along the Sacramento River and its tributaries. Restoration provides the opportunity to develop a variety of valuable wetland, riparian, floodplain, and upland habitats.

- **Actions** – Actions include partial or complete filling of former pits, re-contouring and grading floodplain areas, reconnection with area drainages or streams, and revegetation. Ten inactive gravel mines were identified by DWR in *Use of Alternative Gravel Sources for Fishery Restoration*, 1994, although it is likely that not all of these sites are suitable for restoration and some may be located on private land. If the lands chosen for restoration are not already in public ownership, land acquisition and/or easements may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by restoring and/or creating wetland, riparian, floodplain, and upland habitat near the Sacramento River.
- **Implementation Issues and Cost** – The cost for this measure would be moderate relative to other measures identified herein, depending upon the number of sites selected for restoration.

### ***B7 – Remove and Control Non-native Vegetation in Cow Creek Watershed***

There is an opportunity to implement exotic vegetation abatement in the Cow Creek watershed. Noxious weeds and other non-native invasive plants threaten the limited riparian corridors and diminishing native grassland habitats in Cow Creek.

- **Actions** – Actions include removal of invasive species from riparian corridors, including arundo (giant reed), Himalayan blackberry, Scotch broom, pampas grass, and other aggressive species. Removal methods could include herbicides, physical removal, or controlled burning. Construction easements would be required to implement this measure.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by preserving native riparian habitat. Riparian habitat also contributes to the quality of instream aquatic habitat, providing shade and a source of woody debris; therefore, this measure may also support the primary study objective to increase the survival of anadromous fish that spawn and rear along Cow Creek.
- **Implementation Issues and Cost** – No non-federal sponsor has been identified for this measure. The cost for this measure would be low relative to other measures identified herein, depending upon the extent of vegetation removal and type of control methods. Periodic monitoring and reapplication of control measures would be required to maintain long-term benefits and effectiveness.

### ***B8 – Remove and Control Non-native Vegetation along Cottonwood Creek***

There are opportunities to implement exotic vegetation abatement in the Cottonwood Creek watershed. Noxious weeds and other non-native invasive plants threaten the limited riparian corridor along Cottonwood Creek.

- **Actions** – Actions include removal of invasive species from riparian corridors, including arundo, Himalayan blackberry, Scotch broom, and other aggressive species. Removal methods could include herbicides, physical removal, or controlled burning. Construction easements would be required to implement this measure.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by preserving native riparian habitat. Riparian habitat also contributes to the quality of instream aquatic habitat, providing shade and a source of woody debris; therefore, this measure may also support the primary study objective to increase the survival of anadromous fish that spawn and rear along Cottonwood Creek.
- **Implementation Issues and Cost** – This measure was recommended by the *Cottonwood Creek Watershed Analysis*, 2001, indicating growing local support for work on Cottonwood Creek. No non-federal sponsor has been identified for this measure. The cost for this measure would be low relative to other measures identified herein, depending upon the extent of vegetation removal and type of control methods. Periodic monitoring and reapplication of control measures would be required to maintain long-term benefits and effectiveness.

### ***B9 – Promote Great Valley Cottonwood Regeneration on Sacramento River***

There is an opportunity to support Great Valley Cottonwood regeneration along the Sacramento River. Cottonwood regeneration has significantly decreased over the last century due to flow and stream morphology changes, urban encroachment, gravel mining, and rock revetment. Cottonwoods add to the complexity of riparian habitat and support a more diverse ecosystem.

- **Actions** – Actions include replacing lost floodplain sediment, regrading or recontouring floodplains that have been disconnected from the river, and revegetating floodplain areas that could support Great Valley Cottonwoods. Specific areas for restoration have not yet been identified. If the sites chosen for restoration are not already in public ownership, land acquisition and/or easements may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by preserving native riparian habitat. Riparian habitat also contributes to the quality of instream aquatic habitat, providing shade and a source of woody debris; therefore, this measure may also support the primary study objective to increase the survival of anadromous fish on the Sacramento River.
- **Implementation Issues and Cost** – The low rate of Cottonwood regeneration was identified by the SRCA forum as one of the factors threatening remaining riparian habitat along the Sacramento River. There appears to be some local support for this type of restoration project

along the Sacramento River, particularly near urban areas that are beginning to place more value on natural habitats for recreation and general public enjoyment. The cost for this measure would be low to moderate relative to other measures identified herein, depending upon the extent of restoration actions taken. There would be initial short-term monitoring and maintenance associated with revegetation.

### ***B10 – Riparian and Floodplain Restoration along Sacramento River***

There is an opportunity to perform riparian and floodplain habitat restoration along the Sacramento River to promote the health and vitality of the river ecosystem. Locations near tributary confluences that are inundated by floods on a fairly frequent basis would be targeted for restoration to maximize the potential for long-term success and benefits.

- **Actions** – Actions would include replacing lost floodplain sediment, regrading or recontouring floodplains that have been disconnected from the river, removal of berms or levees (as appropriate), and revegetating floodplain and adjacent riparian areas. Locations for restoration would be in areas with a 20 percent to 50 percent chance of flooding in any year to ensure riparian habitat growth and regeneration. If the lands chosen for restoration are not already in public ownership, land acquisition and/or easements may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by restoring native riparian habitat and associated floodplain lands. Riparian habitat also contributes to the quality of instream aquatic habitat, providing shade and a source of woody debris; therefore, this measure may also support the primary study objective to increase the survival of anadromous fish on the Sacramento River.
- **Implementation Issues and Cost** – There appears to be local support for this type of restoration project along the Sacramento River, and the importance of restoring habitat at tributary confluences has been highlighted by several studies and programs. The cost for this measure would be low to moderate relative to other measures identified herein, depending upon the extent of restoration actions taken. There would be initial short-term monitoring and maintenance associated with revegetation.

### ***B11 – Preserve Riparian Vegetation on Cow Creek***

There is an opportunity to protect valuable riparian corridors in the Cow Creek watershed that are impacted by cattle grazing. Damages caused by grazing include loss of vegetation, increased erosion, and contamination of waterways with bacteria and fecal coliform. These impacts, in turn, degrade water quality by increasing turbidity and water temperature.

- **Actions** – Actions include obtaining a real estate interest, such as an environmental easement, installing exclusive fencing, developing natural vegetation barriers, and replanting streamside grasses, shrubs, and trees that have been harmed by grazing livestock. No specific sites have been identified at this time.

- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by preserving native riparian habitat along Cow Creek. Riparian habitat also contributes to the quality of instream aquatic habitat, providing shade and a source of woody debris; therefore, this measure may also support the primary study objective to increase the survival of anadromous fish that spawn and rear along Cow Creek.
- **Implementation Issues and Cost** – This measure was identified by the Western Shasta RCD in the *Cow Creek Watershed Assessment*, 2001. The cooperation of local landowners would be required, but could be facilitated through the Cow Creek Watershed Management Group and/or the Western Shasta RCD. Depending upon the magnitude of real estate interest required and the extent of restoration action taken, the cost for this measure could be low relative to other measures identified herein.

## Other

### *C2 – Create a Parkway along Lower Clear Creek*

There is an opportunity to create a public parkway and habitat corridor along the urbanizing portion of lower Clear Creek, near the confluence with the Sacramento River. Urban expansion from the nearby City of Redding threatens the quality and quantity of valuable riparian and aquatic habitat along lower Clear Creek.

- **Actions** – Actions would include establishing a parkway or other public easement that would prevent further urban encroachment on the river and preserve riparian habitat while providing for appropriate public uses and access. Land would be acquired from private owners on a willing seller basis either through fee purchase or conservation easements. Long-term management of the parkway could be placed with the City of Redding and/or a local parkway foundation.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by preserving native riparian habitat. Riparian habitat also contributes to the quality of instream aquatic habitat, providing shade and a source of woody debris; therefore, this measure may also support the primary study objective to increase the survival of anadromous fish that spawn and rear along lower Clear Creek.
- **Implementation Issues and Cost** – There appears to be a high degree of local interest in establishing parkways and preserving the natural values of river corridors in the Redding area; successful examples include the Sulphur Creek Greenway and Turtle Bay projects. The cooperation of local landowners would be required, but could be facilitated through existing parkway groups, the City of Redding, and/or the Western Shasta RCD. The cost for this measure would be moderate relative to other measures identified herein, depending upon the quantity of land acquired and the type of acquisition (fee or easement). A local entity would need to be identified to take responsibility for long-term management.

### ***C3 – Create a Parkway along Sacramento River***

There is an opportunity to develop a parkway and wildlife corridor along the Sacramento River around the urbanized Redding and Anderson areas. Urban encroachment in Redding, Anderson, and expanding suburban areas has significantly reduced riparian habitat, with development immediately adjacent to the river channel in some areas. Remaining habitat could be preserved and protected, and some urbanized areas could be restored to improve habitat connectivity along this important river corridor.

- **Actions** – Actions would include establishing a parkway or other public easement that would prevent further urban encroachment on the river and preserve riparian habitat while providing for appropriate public uses and access. Land would be acquired from private owners on a willing seller basis either through fee purchase or conservation easements. It may be possible to purchase developed land immediately adjacent to the river for later restoration or development of park facilities. Connections could be made with existing conservation and parks lands, such as Turtle Bay, the Redding Arboretum, and the Sulphur Creek Greenway. Long-term management of the parkway could be placed with the Cities of Redding and Anderson and/or a local parkway foundation.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by preserving native riparian habitat. Riparian habitat also contributes to the quality of instream aquatic habitat, providing shade and a source of woody debris; therefore, this measure may also support the primary study objective to increase the survival of anadromous fish in the Sacramento River.
- **Implementation Issues and Cost** – There appears to be a high degree of local interest in establishing parkways and preserving the natural values of river corridors in the Redding area; successful examples include the Sulphur Creek Greenway and Turtle Bay projects. The cooperation of local landowners would be required, but could be facilitated through existing parkway groups, the Cities of Redding and Anderson, and/or the Western Shasta RCD. Success of this measure would depend on acquiring significant amounts of private lands, which may limit Federal interest. The cost for this measure would be moderate to high relative to other measures identified herein, depending upon the quantity of land acquired and the type of acquisition (fee or easement). A local entity would need to be identified to take responsibility for long-term management.

### ***C4 – GIS for Shasta Dam to Red Bluff Reach***

There is an opportunity to develop a geographic information system (GIS) for the Sacramento River and tributaries between Shasta Dam and Red Bluff. The system would include information about the geology, topography, habitat, and other features of the reach to assist future restoration studies and projects.

- **Actions** – Actions would include developing a comprehensive GIS for the reach that could be accessed and utilized by federal, state, and local restoration groups. The system would include the following types of information: topography; hydrography; aerial photography; habitat mapping; land use; geology; extent of sensitive species; dams, diversions and other

infrastructure; historic flow data; locations of instream and offstream gravel mines; and locations of past and current restoration projects.

- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by providing a resource or tool for future restoration studies and projects. Restoration programs often duplicate data collection efforts, and smaller studies may be unable to collect detailed watershed information; this system would provide a centralized data resource for future projects.
- **Implementation Issues and Cost** – A non-federal sponsor has not been identified for this measure. The cost for this measure would be low to moderate relative to other measures identified herein, depending upon the extent and nature of the data selected for inclusion in the GIS. A responsible entity would need to be identified for long-term maintenance and updating of the system.

### ***C5 – Erosion Control in Tributary Watersheds***

There is an opportunity to perform local erosion control projects in watersheds tributary to the Sacramento River to prevent loss of key floodplain and riparian habitat, and preserve the quality of aquatic habitat impaired by excessive sediment input. Much of the fine sediment in the Sacramento River is derived from smaller tributary drainages.

- **Actions** – Actions would include revegetation of eroding banks, armoring the toe of streamside landslide areas, removing or enlarging culverts under roads, outsloping roads or installing waterbars, mulching and planting bare slopes, and other land management treatments. Specific sites have not been identified at this time. If sites chosen for restoration are not already in public ownership, easements or other real estate interests may be required to implement the measure and ensure continued benefits.
- **Benefits** – This measure would support the secondary objective to preserve and restore ecosystem resources along the upper Sacramento River by preserving floodplain, riparian, and aquatic habitat impacted by accelerated erosion. This measure would also support the primary study objective to increase the survival of anadromous fish by reducing siltation of spawning gravels along the lower reaches of Sacramento River tributaries.
- **Implementation Issues and Cost** – A non-federal sponsor has not been identified for this measure. The cost for this measure would be low to moderate relative to other measures identified herein, depending upon the extent and nature of erosion control projects selected.

## COMPARISON AND EVALUATION

Tables V-2 and V-3 summarize the potential ecosystem restoration opportunities in the Shasta Lake and Tributaries sub-area and Shasta Dam to Red Bluff sub-area, respectively. The tables also identify potential implementation issues and present a preliminary comparison and screening of potential measures based on the following elements:

- **Objective Fulfillment** – Indicates whether the measure fulfills the primary and/or secondary study objectives.
- **Physical Implementability** – Indicates the relative likelihood of physical implementation, taking into consideration any design or construction challenges, regulatory issues, etc. A “High” rating indicates a high probability that the action can be physically performed.
- **Consistency and Reliability** – An estimate of the ability of the action to provide consistent and reliable benefits, compared against the other measures proposed. For example, a “High” rating would be given to a measure that is extremely likely to produce the anticipated benefit (such as an action that has proven highly successful in past applications). Measures are assigned a “Low” rating if there is significant uncertainty associated with the ability of the action to perform as intended or consistently produce the intended benefits.
- **Future Actions** – Indicates the degree to which future actions will be required to achieve or maintain the anticipated benefits of the measure. For example, the degree to which long-term O&M will be required to maintain functionality, or the degree to which actions will need to be taken by others to produce long-term benefits.
- **Redirected Impacts** – Indicates the potential for a measure to negatively impact an existing beneficial use (such as water supply, the environment, flood control, or hydropower) or create significant mitigation obstacles.
- **Efficiency** – A measure of the efficiency of the action based on relative cost and accomplishments, compared against the other measures proposed. For example, a measure with a high cost that produces a relatively small benefit would be assigned a “Low” rating.
- **Potential Non-Federal Sponsor(s)** – Identifies potential non-federal sponsor(s) for the measure.

The tables also list a preliminary measure status – either retained for further study or deleted from consideration at this time – based on the elements listed above. Measures retained for further study are discussed in Chapter VI.

**TABLE V-2  
POTENTIAL RESTORATION MEASURES IN THE SHASTA LAKE AND TRIBUTARIES SUB-AREA**

ID No.	Measure	Area of Influence	Objective Fulfillment		Potential Implementation Issues	Physical Implementability	Consistency and Reliability	Future Actions (Including O&M)	Redirected Impacts	Efficiency		Potential Non-Federal Sponsor(s)	Status	Reason
			Primary	Secondary						Relative Cost	Cost Efficiency			
<b>Cold-water and Warm-water Fisheries</b>														
A1	Construct Shoreline Fish Habitat around Shasta Lake	Shasta Lake	No	Yes	Creation of potential submerged hazards to boaters.	High	Med	Med	No	Low	Med	DFG through WCB	Retained	Would complement measures to increase pool in Shasta Lake.
A2	Reduce Acid Mine Drainage Entering Shasta Lake	Shasta Lake and various tributaries	No	Yes	Some mines on privately owned lands (liability issues); long-term maintenance req.	Med	Med	High	No	High	Low	None	Deleted	Long-term monitoring and liability issues; low likelihood for non-federal sponsor.
A3	Reduce Motorcraft Access to Upper Reservoir Arms	Shasta Lake	No	Yes	Negative recreation impacts.	High	High	Med	No	Low	High	None	Deleted	Already under the purview of Forest Service; negative recreation impacts.
A4	Increase Instream Flows on Pit River	Pit River	No	Yes	Require agreements or buy-outs with PG&E due to potential negative hydropower impacts.	Low	Med	Low	No	High	Low	None	Deleted	Negative impacts to benefits of Shasta Dam and Reservoir project.
A5	Construct Instream Fish Habitat on Tributaries to Shasta Lake	Major & minor Shasta Lake tributaries	No	Yes	Specific sites on lands within Federal ownership have not been identified.	High	Med	Low	No	Low	Med	DFG, Cantara Trust, McCloud CRMP	Retained	Would complement measures to increase pool in Shasta Lake; high likelihood for local support.
A6	Construct a Migration Corridor from Sacramento River to Pit River	Pit River, Sacramento River, Cow Creek	Yes	Yes	Difficult to design & operate; limited spawning habitat available on the Pit River; conflict with primary objective.	Low	Low	High	Yes	Very High	Low	None	Deleted	Uncertain potential to consistently and reliably operate over a range of flow conditions (overall low feasibility); low likelihood for non-federal sponsor; conflicts with primary objective.
<b>Riparian and Wetland Habitat</b>														
B1	Enhance Forest Management to Preserve Bald Eagle Nesting Habitat	Shasta Lake, lower Pit River	No	Yes		High	Low	Low	No	Low	Med	None	Deleted	Already within purview of existing FS management programs.
B2	Remove and Control Non-Native Plants around Shasta Lake	Shasta Lake & vicinity	No	Yes	Actions would likely need to be repeated to maintain benefits.	Med	Low	Med	No	Low	Low	None	Deleted	Already within purview of existing FS management programs.

**TABLE V-2 (CONT.)  
POTENTIAL RESTORATION MEASURES IN THE SHASTA LAKE AND TRIBUTARIES SUB-AREA**

ID No.	Measure	Area of Influence	Objective Fulfillment		Potential Implementation Issues	Physical Implementability	Consistency and Reliability	Future Actions (Including O&M)	Redirected Impacts	Efficiency		Potential Non-Federal Sponsor(s)	Status	Reason
			Primary	Secondary						Relative Cost	Cost Efficiency			
B3	Restore Wetlands along Fall River and Hat Creek	Pit River watershed	No	Yes	Limited benefits lower in the Pit River system.	High	Med	Med	No	Low	Low	Fall & Pit River RCDs	Deleted	Significantly removed from the primarily study area.
B4	Preserve Upper Pit River Riparian Areas	Upper Pit River watershed	No	Yes	Specific sites have not been identified.	High	Med - High	Med	No	Low	Med	Local RCDs	Deleted	Significantly removed from the primary study area.
<b>Other</b>														
C1	Control Erosion and Restore Affected Habitat in Shasta Lake Area	Shasta Lake & vicinity	No	Yes	Some lands may be privately owned.	Med	Low	High	No	Low - Med	Low - Med	Local RCDs	Deleted	Already within the purview of existing FS management programs.

**TABLE V-3  
POTENTIAL ECOSYSTEM RESTORATION MEASURES IN THE SHASTA DAM TO RED BLUFF SUB-AREA**

ID No.	Measure	Area of Influence	Objective Fulfillment		Potential Implementation Issues	Physical Implementability	Consistency and Reliability	Future Actions (Including O&M)	Redirected Impacts	Efficiency		Potential Non-Federal Sponsor(s)	Status	Reason
			Primary	Secondary						Relative Cost	Cost Efficiency			
<b>Anadromous Fish</b>														
A7	Restore Inactive Gravel Mines on Sacramento River	Sacramento River	Yes	Yes	Acquiring land rights.	High	High	Low	No	Med	High	DFG, DWR, local groups	Retained	High potential for success and likelihood for non-federal sponsor.
A8	Construct Instream Habitat Downstream from Keswick Dam	Sacramento River	Yes	Yes	Acquiring land rights and high O&M.	Med	Med	High	No	Med	High	DFG; local groups	Tentatively Retained	Spawning habitat would be highly valuable in this reach.
A9	Replenish Spawning Gravel in Sacramento River	Sacramento River	Yes	Yes	High O&M and concerns over downstream impacts.	High	Med	Very High	No	Med	High	DFG, DWR, local groups	Tentatively Retained	Demonstrated benefits that continue as gravel moves downstream.
A10	Additional Modifications to Shasta Dam for Temperature Control	Sacramento River	Yes	No	Raising Shasta Dam may reduce benefits or need for this measure.	Med	Med	Low	No	High – Very High	Low – Med	None	Retained	Potential for combination with other measures to modify Shasta Dam for other objectives.
A11	Improve Fish Trap below Keswick Dam	Sacramento River	Yes	No	Likely require expansion of Coleman Fish Hatchery.	High	Med	High	Yes	Med – High	Med	None	Deleted	Low potential for ancillary facilities and non-federal sponsorship.
A12	Enlarge Shasta Lake Cold Water Pool	Sacramento River	Yes	Yes	Reservoir rim area impacts.	Med	Med	Low	No	Very High	Low	CALFED	Retained	High potential for combination with other measures and support by CALFED.
A13	Modify Storage and Release Operations at Shasta Dam	Sacramento River	Yes	No	Potential impacts to hydropower or water supply.	Med	Med	Low	No	Low – Med	Med	CALFED	Retained	High potential for combination with other objectives.
A14	Construct Instream Fish Habitat on Tributaries to Sacramento River	Middle, Olney, Churn, and Cow creeks	Yes	No	Acquiring land rights.	High	Med	Med	No	Low – Med	Med	DFG	Deleted	Not directly related to Upper Sacramento River.
A15	Remove Instream Sediment along Middle Creek	Middle Creek, Sacramento River confluence	Yes	No	Acquiring land rights.	High	Med	High	No	Med	Low	DFG, local RCD	Deleted	Not directly related to a modification of Shasta Dam; repeated sediment removal would be required to maintain benefits long-term.
A16	Restore Instream Gravel Mines along Stillwater Creek	Stillwater Creek	Yes	No	High local benefits, but diminished benefits to Sacramento River.	High	High	Low	No	Med	High	DFG, DWR, local RCD	Deleted	Not directly related to a modification of Shasta Dam; diminished benefits to Sacramento River.

**TABLE V-3 (CONT.)  
POTENTIAL ECOSYSTEM RESTORATION MEASURES IN THE SHASTA DAM TO RED BLUFF SUB-AREA**

ID No.	Measure	Area of Influence	Objective Fulfillment		Potential Implementation Issues	Physical Implementability	Consistency and Reliability	Future Actions (Including O&M)	Redirected Impacts	Efficiency		Potential Non-Federal Sponsor(s)	Status	Reason
			Primary	Secondary						Relative Cost	Cost Efficiency			
A17	Modify ACID Diversion to Reduce Flow Fluctuations	Sacramento River	Yes	No	Would require participation of ACID; potential water supply delivery impacts.	High	Med	Low	No	Med – High	Low – Med	ACID, DFG	Deleted	Potential water supply impacts.
A18	Screen Diversions on Old Cow and Cow Creeks	Cow Creek watershed; anadromous fish migrating from Sacramento R	Yes	No		High	Med – High	Med	No	Med – High	Med	Local groups	Deleted	Not directly related to a modification of Shasta Dam.
A19	Increase Instream Flows on Clear Creek by 150 to 200 cfs	Clear Creek; anadromous fish migrating from Sacramento R	Yes	No	Would require changes to the operation of Whiskeytown Dam; potential hydropower impacts.	Low – Med	Med – High	Low	No	Med	Med	None	Deleted	Not directly related to a modification of Shasta Dam; low likelihood for non-federal sponsor.
A20	Increase Instream Flows on Cow Creek by 25 to 50 cfs	Cow Creek; anadromous fish migrating from Sacramento R	Yes	No	Would require agreements with numerous agricultural users; potential water supply impacts.	High	Med	Low	No	Low – Med	Low – Med	None	Deleted	Not directly related to a modification of Shasta Dam; low likelihood for non-federal sponsor.
A21	Increase Instream Flows on Bear Creek by 10 to 20 cfs	Bear Creek; anadromous fish migrating from Sacramento R	Yes	No	Would require agreements with numerous agricultural users; potential water supply impacts.	High	Med	Low	No	Low – Med	Low – Med	None	Deleted	Not directly related to a modification of Shasta Dam; low likelihood for non-federal sponsor.
A22	Remove or Screen Diversions on Battle Creek	Battle Creek; anadromous fish migrating from Sacramento R	Yes	No	Potential hydropower impacts.	Med	Med – High	Med	No	Med	Med	Local groups	Deleted	Not directly related to a modification of Shasta Dam.
A23	Restore Instream Gravel Mines along Cottonwood Creek	Cottonwood Creek; anadromous fish migrating from Sacramento R	Yes	No	Some reaches of Cottonwood Creek are still actively mined; acquiring land rights.	High	Med	Low	No	Med	Med	DFG, DWR, local RCID	Deleted	Not directly related to a modification of Shasta Dam.

**TABLE V-3 (CONT.)  
POTENTIAL ECOSYSTEM RESTORATION MEASURES IN THE SHASTA DAM TO RED BLUFF SUB-AREA**

ID No.	Measure	Area of Influence	Objective Fulfillment		Potential Implementation Issues	Physical Implementability	Consistency and Reliability	Future Actions (Including O&M)	Redirected Impacts	Efficiency		Potential Non-Federal Sponsor(s)	Status	Reason
			Primary	Secondary						Relative Cost	Cost Efficiency			
A24	Restore Streambed near ACID Siphon on Cottonwood Creek	Cottonwood Creek; anadromous fish migrating from Sacramento R	Yes	No	Would require cooperation of ACID.	High	Med	Med	No	Low	Med	DFG, local RCD	Deleted	Not directly related to a modification of Shasta Dam.
A25	Construct Fish Barrier at Crowley Gulch on Cottonwood Creek	Cottonwood Creek; anadromous fish migrating from Sacramento R	Yes	No	Barrier may also prevent use of Crowley Gulch by resident fish; acquiring land rights/ easements.	High	Med	Med	No	Low	Med	DFG, local RCD	Deleted	Not directly related to a modification of Shasta Dam.
A26	Construct Storage Facility on Cottonwood Creek to Augment Spring Flows	Cottonwood Creek; anadromous fish migrating from Sacramento R	Yes	No	Environmental impacts; undesirable water temperature in reservoir; land acquisition.	Med	Med	High	No	High - Very High	Low	None	Deleted	Potential significant negative environmental impacts; low cost efficiency.
<b>Riparian and Wetland Habitat</b>														
B5	Restore Riparian and Floodplain Habitat on Lower Clear Creek	Clear Creek; anadromous fish migrating from Sacramento R	Yes	Yes	Land acquisition or easements.	High	Med - High	Low	No	Low - Med	Med - High	Local RCD	Deleted	Not directly related to a modification of Shasta Dam.
B6	Restore Offstream Gravel Mines near Sacramento River	Floodplains and Uplands adjacent to Sacramento River	No	Yes	Acquiring land rights (restoration sites may be located on private lands).	High	Med	Low	No	Med	Low	None	Deleted	Not directly related to a modification of Shasta Dam; low cost efficiency.
B7	Remove and Control Non-native Vegetation in Cow Creek Watershed	Riparian areas along Cow Creek	No	Yes	Access to private lands.	Low	Low	Med	No	Low	Low	None	Deleted	Not directly related to a modification of Shasta Dam; no non-federal sponsor identified; low potential to provide long-term benefits.

**TABLE V-3 (CONT.)  
POTENTIAL ECOSYSTEM RESTORATION MEASURES IN THE SHASTA DAM TO RED BLUFF SUB-AREA**

ID No.	Measure	Area of Influence	Objective Fulfillment		Potential Implementation Issues	Physical Implementability	Consistency and Reliability	Future Actions (Including O&M)	Redirected Impacts	Efficiency		Potential Non-Federal Sponsor(s)	Status	Reason
			Primary	Secondary						Relative Cost	Cost Efficiency			
B8	Remove and Control Non-native Vegetation along Cottonwood Creek	Riparian areas along Cottonwood Creek	No	Yes	Access to private lands.	Low	Low	Med	No	Low	Low	None	Deleted	Not directly related to a modification of Shasta Dam; low potential to provide long-term benefits.
B9	Promote Great Valley Cottonwood Regeneration on Sacramento River	Sacramento River	No	Yes	Specific sites have not been identified; some uncertainty as to long-term success.	Med	Low – Med	Med	No	Med	Med	None	Deleted	No non-federal sponsor identified; large Cottonwood stands were probably not common in this reach historically.
B10	Riparian and Floodplain Restoration along Sacramento River	Sacramento River	No	Yes	Acquiring land rights (restoration sites may be located on private lands).	High	Med – High	Low	No	Med	High	DFG, DWR, local RCD	Retained	Strong potential for addressing secondary objectives and for local sponsorship.
B11	Preserve Riparian Vegetation on Cow Creek	Cow Creek watershed	No	Yes	Access to private lands (easements).	High	Med	Med	No	Low	Med	None	Deleted	Not directly related to a modification of Shasta Dam.
<b>Other</b>														
C2	Create a Parkway along Lower Clear Creek	Clear Creek	No	Yes	Would require land acquisition and/or easements; need a long-term parkway manager.	Med	High	Med	No	Med – High	Med	None	Deleted	Not directly related to a modification of Shasta Dam.
C3	Create a Parkway along Sacramento River	Sacramento River	No	Minor	Would require high land acquisition and/or easements; need a long-term parkway manager.	Med	High	Med	No	Med – High	Med – High	City of Redding; local groups	Deleted	Low potential to meet objectives and high real estate requirements.
C4	GIS for Shasta Dam to Red Bluff Reach	Sacramento River & tributaries	No	Yes	Long-term maintenance and updates would be required to maintain effectiveness.	High	Med – High	Low	No	Low – Med	Low	None	Deleted	Not directly related to a modification of Shasta Dam; long-term maintenance and periodic updates would be required.
C5	Erosion Control in Tributary Watersheds	Sacramento River & tributaries	No	Yes	Specific sites have not been identified; land acquisition.	Med	Low	Med	No	Low – Med	Low	None	Deleted	Not directly related to a modification of Shasta Dam; low cost efficiency.

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