

Revised Habitat Restoration and Other Stressors Conservation Measures

Working Draft March 24, 2010

*[Note to Reviewers: These materials include revised working drafts of habitat restoration and other stressors conservation measures for evaluation in the full Effects Analysis as agreed to at the Jan 29, 2010 Steering Committee meeting. Most of the measures have been fully revised, but some still need more information to complete. The additional detail provided in these working drafts allow for better understanding of the measures, information to conduct the effects analysis, and information to assess implementation costs. Note that this handout does **not** include the many other important sections of Chapter 3 Conservation Strategy, namely goals & objectives, water operations conservation measures, monitoring and research plan, adaptive management plan, and terrestrial resources conservation measures. All of these other sections are in the process of revision and will be provided to the SC as they are drafted.]*

This draft also does not include the important related actions identified at the Jan 29, 2010 Steering Committee meeting. Important related actions include ammonia load reduction, endocrine disruptor load reduction, agricultural pesticide load reduction, urban run-off load reduction, non-native species introduction reduction, non-native predator harvest increase, splittail harvest restrictions, mark-select fisheries implementation, and non-project diversion entrainment reduction. The effects of these important related actions on BDCP covered species are currently undergoing evaluation]

3.4.2 CM2. Stockton Deep Water Ship Channel Dissolved Oxygen Levels

[Note to Reviewers: SAIC is currently in discussion with DWR regarding the results of their ongoing dissolved oxygen demonstration project. Due to the recent bond spending freeze, results of this demonstration project are not anticipated to be available until fiscal year 2010/2011. This conservation measure will be updated as new information becomes available.]

The purpose of this conservation measure is to maintain dissolved oxygen concentrations above levels that impair covered fish species in the Stockton Deep Water Ship Channel during periods when covered fish species are present. The BDCP Management Entity will operate and maintain an oxygen aeration facility in the Stockton Deep Water Ship Channel to increase dissolved oxygen concentrations between Turner Cut and Stockton to meet Total Maximum Daily Load (TMDL) objectives established by the CVRWQCB (2005) (above 6.0 mg/L from September 1 through November 30 and above 5.0 mg/L at all times). The existing aeration facility will be modified as necessary and, if necessary, additional aerators and associated infrastructure would be added to optimize oxygen delivery to the river, contingent upon results of an ongoing demonstration project conducted by DWR.

The BDCP Management Entity will be responsible for developing annual work plans in coordination with Fishery Agencies that specify the extent of dissolved oxygen improvements to be implemented and will be responsible for monitoring the effectiveness of dissolved oxygen enhancement measures in improving dissolved oxygen levels.

Problem Statement

1 The Stockton Deep Water Ship Channel has been identified as an impaired waterway by the
2 State Water Resources Control Board because of low dissolved oxygen concentrations during
3 late summer and early fall (CVRWQCB 2005). The combination of low flows, high loads of
4 oxygen-demanding substances (algae from upstream, effluent from the City of Stockton
5 Regional Wastewater Control Facility, and other unknown sources), and channel geometry
6 contribute to low oxygen levels in the Stockton Deep Water Ship Channel (CVRWQCB 2005).
7 The Stockton Deep Water Ship Channel often fails to meet water quality objectives established
8 by the Regional Board for dissolved oxygen (CVRWQCB 2007b). The 7.5 mile low dissolved
9 oxygen area of the ship channel creates a barrier for upstream migration of adult fall-run
10 Chinook salmon and Central Valley steelhead on the mainstem of the San Joaquin River
11 (Hallock et al. 1970). Further, low dissolved oxygen levels can cause physiological stress on and
12 mortality of fish, including Chinook salmon and steelhead (Jassby and Van Nieuwenhuysse
13 2005), and other aquatic organisms (CVRWQCB 2007b). Once spring-run Chinook salmon are
14 re-established in the San Joaquin River under the San Joaquin River Litigation Settlement,
15 dissolved oxygen sags in the Deep Water Ship Channel will likely have similar effects on this
16 run if sags were to occur during their adult migration period (expected to be approximately
17 March-September). In addition, juvenile white sturgeon, which rear in the San Joaquin River,
18 exhibit reduced foraging and growth rates at dissolved oxygen levels below 58% saturation (=
19 5.8 mg/l at 15 °C) (Cech and Crocker 2002).

20 One potential solution to dissolved oxygen sags in the Stockton Deep Water Ship Channel, a
21 dissolved oxygen aeration system, has been installed and is currently undergoing field testing by
22 DWR. Limited analysis of 2008 results suggests that the aeration facility was effective at raising
23 dissolved oxygen levels in much of the channel. This oxygen aeration project has been funded
24 with Proposition 13 money, which can only be used for demonstration purposes. Long-term
25 funding for operations and maintenance has not yet been secured and there are currently no
26 mandates by the CVRWQCB that require contributors to the sag to fund the project. Under this
27 conservation measure, the BDCP would share in funding the long term O&M costs associated
28 with the project.

29 ***Hypothesized Benefits***

30 Increasing dissolved oxygen concentrations in the Stockton Deep Water Ship Channel in
31 accordance with TMDL objectives is hypothesized to result in:

- 32 • Reduced delay and inhibition of upstream and downstream migration of fall-run Chinook
33 salmon, steelhead, and, once they are re-established in the San Joaquin River, spring-run
34 Chinook salmon (Hallock et al. 1970); and
- 35 • Reduced physical stress and mortality of fall-run Chinook salmon, steelhead, white
36 sturgeon, and, once they are re-established in the San Joaquin River, spring-run Chinook
37 salmon.

38 ***Adaptive Management Considerations***

39 Implementation of this conservation measure by the Management Entity will be informed
40 through effectiveness monitoring that will be conducted as described in Section 3. , *Monitoring
41 and Research Plan*, and the adaptive management process described in Section 3. , *Adaptive
42 Management Plan*. Results from monitoring of dissolved oxygen levels at various distances

1 from the diffuser(s) will be used to assess the performance of the facilities operations at
2 achieving the water quality objective. The BDCP Management Entity will use effectiveness
3 monitoring results to determine whether aeration facility operations result in measurable benefits
4 to covered fish species.

5 Based on review of performance and effectiveness monitoring results, the BDCP Management
6 Entity will adjust funding levels, oxygen diffuser methods, or other related aspects that will
7 improve the performance and/or biological effectiveness of the project through the BDCP
8 adaptive management process as appropriate. Such changes will be effected through the BDCP
9 adaptive management process and would be included in the subsequent annual work plans.

10 If results indicate that aeration facility does not substantially and cost-effectively benefit covered
11 fish species, the BDCP Management Entity in coordination with Fishery Agencies may terminate
12 this conservation measure. If terminated, remaining funding will be deobligated from this
13 conservation measure and reallocated to augment funding for other more effective conservation
14 measures identified in coordination with the Fishery Agencies through the BDCP adaptive
15 management process.

16 **3.4.3 CM3. Illegal Harvest**

17 The purpose of this conservation measure is to reduce illegal harvest of Chinook salmon, Central
18 Valley steelhead, green sturgeon, and white sturgeon in the Delta, bays, and upstream
19 waterways. The BDCP will provide funding over the term of the BDCP to increase the
20 enforcement of fishing regulations in the Delta and Bays to reduce illegal harvest of covered
21 salmonids and sturgeon. The BDCP Management Entity will provide funds to DFG to hire and
22 equip 17 additional Game Wardens and 5 supervisory and administrative staff in support of the
23 existing field wardens assigned to the Delta-Bay Enhanced Enforcement Program (DBEEP) over
24 the term of the BDCP.

25 The Delta-Bay Enhanced Enforcement Program (DBEEP) is a 10-Warden squad that was formed
26 specifically to increase enforcement on poaching of anadromous fish species in Bay-Delta
27 waterways. The program is funded by water contractors through the Delta Fish Agreement. The
28 BDCP would contribute directly to this existing program by expanding its size to improve
29 enforcement against poaching of covered species.

30 The BDCP Management Entity will enter into Memoranda of Agreement (MOAs) or similar
31 binding instruments with DFG as described in Section 3.

32 **Problem Statement**

33 California has the lowest Game Warden to population ratio in the nation with fewer than 200
34 field Wardens for the entire state. The Delta is a particular hot spot for poaching because of the
35 large number of sport fish, particularly gravid female white sturgeon, whose roe are used for
36 caviar (Lt. L. Schwall, pers. comm.). Illegal harvest is thought to have high impacts on sturgeon
37 populations, particularly white sturgeon (Beamsderfer et al. 2007). Illegal harvest of juvenile
38 and adult Chinook salmon and steelhead in the Delta and bays is also common (DBEEP 2007).

39 **Hypothesized Benefits**

1 It is hypothesized that enhanced enforcement on poaching will reduce mortality, and potentially
2 increase population sizes, of green sturgeon (Beamesderfer et al. 2007, CDFG unpublished,
3 Boreman 1997, D. Tanner pers. comm., DFG 2007b, Appendix X, *DRERIP Evaluations*); white
4 sturgeon (Bay-Delta Oversight Council 1995, Boreman 1997, Schaffter & Kohlhorst 1999,
5 Beamesderfer et al. 2007, DFG 2007b, DFG 2008c, M. Gingras pers. comm., Z. Matica pers.
6 comm., CDFG unpubl. data, Appendix X, *DRERIP Evaluations*); Chinook salmon (all races)
7 (Bay-Delta Oversight Council 1995, Williams 2006); and steelhead (DFG 2007b, DFG 2007c,
8 DFG 2008d, Moyle et al. 2008, Appendix X, *DRERIP Evaluations*). Spring-run Chinook salmon
9 are hypothesized to experience the greatest benefit because they are more susceptible to
10 poaching than other runs due to over summer holding and ease of locating them (Appendix X,
11 *DRERIP Evaluations*).

12 Magnitudes of population-level benefits of this measure are expected to vary inversely with the
13 population size of each covered species (Bay-Delta Oversight Council 1995, Begon et al. 1996,
14 Futuyma 1998, Moyle et al. 2008).

15 **Adaptive Management Considerations**

16 Implementation of this conservation measure by the Management Entity will be informed
17 through effectiveness monitoring that will be conducted as described in Section 3. , *Monitoring*
18 *and Research Plan*, and the adaptive management process described in Section 3. , *Adaptive*
19 *Management Plan*. The BDCP Management Entity will coordinate with DFG to adjust
20 enforcement strategies and funding levels through the BDCP adaptive management process as
21 appropriate based on review of DBEEP annual reports.

22 **3.4.4. CM4. Hatchery and Genetic Management Plans**

23 *[Note to Reviewers: SAIC is in discussion with hatchery coordinators to determine the funding*
24 *needs for this conservation measure. This measure will be updated as new information becomes*
25 *available via continued coordination with CDFG.]*

26 The purpose of this conservation measure is to develop and implement hatchery and genetic
27 management plans to minimize the potential for genetic and ecological impacts of hatchery-
28 reared salmonids on wild salmonid stocks. The BDCP Management Entity will minimize
29 potential adverse effects of hatchery-reared salmonids on wild salmonid stocks by supporting the
30 accelerated development and implementation of Hatchery and Genetic Management Plans
31 (HGMPs) for all state Chinook salmon and steelhead hatcheries in the Central Valley. HGMPs
32 would be implemented to reduce adverse ecological and genetic effects of hatcheries on wild fish
33 and to be consistent with conservation and protection for listed fish species.

34 The BDCP Management Entity will provide funding to:

- 35 • Expand and finalize steering groups for each hatchery HGMP process, in part to aid in
36 determining the hatchery's function;
- 37 • Support DFG staff and their contractors to prepare HGMPs under Department and
38 NOAA direction;

- 1 • Staff a DFG HGMP Coordinator, a position dedicated to coordinating HGMPs from
2 beginning through implementation. HGMP implementation and adaptive management
3 will be an ongoing task for the life of each hatchery;
- 4 • Staff hatcheries sufficiently to carry out changes necessary to meet ESA requirements
5 including providing regional support for fishery biologists at each hatchery;
- 6 • Improve efforts to minimize several categories of hatchery impacts including trucking,
7 inter-basin egg transfers, genetic stock management, monitoring (especially hatchery
8 natural proportions and impacts of hatcheries on natural stocks), and conservation
9 hatcheries; and
- 10 • Provide support for staffing and analysis associated with a genetic parental-based tagging
11 system.

12 Funding of these efforts will be higher during development of the plans and should decline as
13 plans are completed. The BDCP Management Entity will enter into binding Memoranda of
14 Agreement (MOAs) or similar instruments with DFG as described in Section 3. ■.

15 **Problem Statement**

16 Hatchery-reared Chinook salmon and steelhead are believed to have negative effects on wild
17 Chinook salmon and steelhead, including competition for space and food as juveniles and for
18 spawning habitat as adults. Fish reared in hatcheries can be selected for traits that are different
19 from those in nature, such as those that allow them to survive in an artificial, contained
20 environment (e.g., fast growth, large size). This could result in reduced genetic isolation of
21 hatchery fish from wild fish. It is thought that these hatchery fish out compete their smaller
22 wild-reared conspecifics for food and space in natural waterways (Williams 2006). Also, as
23 adults, straying by hatchery-reared salmon into natural spawning grounds may lead to genetic
24 introgression, where offspring of wild salmon are “genetically polluted” with hatchery-selected
25 genes, thereby reducing the fitness of wild population (ISAB 2003, Goodman 2005, Hey et al.
26 2005).

27 To address these concerns, hatcheries have begun reforming their management practices to
28 minimize the effects that hatchery fish may have on wild fish. HGMPs serve as the foundation
29 of hatchery management and reform to minimize genetic and ecological impacts to wild fish.
30 HGMPs are developed to devise and evaluate practices of a hatchery to ensure the hatchery
31 contributes to the conservation and recovery of listed salmonids.

32 Although required, the development of HGMPs in Central Valley hatcheries has been slow to
33 date. The following provides a summary of the status of the progress made toward completion
34 of HGMPs at Central Valley hatcheries (M. Lacy pers. comm.):

- 35 • Nimbus Hatchery - Draft HGMPs for both fall Chinook salmon and winter steelhead
36 have been completed. Updates and minor revisions were made during 2008 to initial
37 drafts. Reclamation and DFG staff are currently reviewing subsequent drafts.
- 38 • Feather River Hatchery - Draft HGMPs for spring and fall Chinook salmon and Central
39 Valley steelhead were completed in late 2008. DWR is reviewing the spring Chinook
40 salmon draft HGMP; fall Chinook salmon and steelhead HGMPs are both still in

1 development by consultant staff. Updates and DWR comments are being incorporated
2 into all drafts as appropriate.

- 3 • Mokelumne River Hatchery - A revised draft HGMP for the steelhead program was
4 completed at the end of 2008 and has been reviewed by hatchery staff. A draft HGMP
5 for the fall Chinook salmon is 50 percent complete.
- 6 • Merced River Hatchery - There has been no progress towards beginning work on this
7 HGMP.
- 8 • Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery - All of
9 the necessary HGMP information for Coleman and Livingston Stone National Fish
10 Hatcheries are contained in the 2001 Biological Assessment (plus a subsequent
11 addendum for Section 10 coverage for winter Chinook and amendments to respond to
12 operational changes at Coleman National Fish Hatchery) submitted to NMFS. The
13 Biological Opinion, including updates to the BA, is in process.

14 **Hypothesized Benefits**

15 Accelerating the development and implementation of HGMPs at Central Valley hatcheries is
16 hypothesized to:

- 17 • improve the genetics and fitness of wild salmonids (ISAB 2003, Goodman 2005, Hey et
18 al. 2005); and
- 19 • reduce competition for rearing and spawning habitat and food with hatchery-reared
20 salmonids (Flagg et al. 2000, Goodman 2005).

21 **Adaptive Management Considerations**

22 Implementation of this conservation measure by the Management Entity will be informed
23 through effectiveness monitoring that will be conducted as described in Section 3. , *Monitoring*
24 *and Research Plan*, and the adaptive management process described in Section 3. , *Adaptive*
25 *Management Plan*. The BDCP Management Entity will review annual reports or other relevant
26 reports to assess the performance of the HGMP teams in the accelerated development and
27 implementation of HGMPs. The BDCP Management Entity will coordinate with the individual
28 hatcheries to adjust HGMP strategies and funding levels through the BDCP adaptive
29 management process as appropriate, based on review of performance monitoring results and
30 other relevant reports.

31 The BDCP Management Entity will use effectiveness monitoring results to determine whether
32 HGMP development and implementation results in measurable benefits to covered fish species
33 and to identify adjustments to funding levels or other related aspects of the program that would
34 improve the biological effectiveness of the program. Such changes will be effected through the
35 BDCP adaptive management process and will be included in the subsequent annual work plans.

36 If results of review indicate that HGMP development and implementation does not substantially
37 and cost-effectively benefit covered fish species, the BDCP Management Entity in coordination
38 with Fishery Agencies may terminate this conservation measure. If terminated, remaining
39 funding will be deobligated from this conservation measure and reallocated to augment funding

1 for other more effective conservation measures identified in coordination with the Fishery
2 Agencies through the BDCP adaptive management process.

3 **3.4.5 CM5. Conservation Hatcheries**

4 The purpose of this conservation measure is to establish new and expand existing conservation
5 propagation programs for delta and longfin smelt. The BDCP Management Entity will support:
6 (1) the development of a delta and longfin smelt conservation hatchery by the USFWS to house a
7 delta smelt refugial population and provide a source of delta and longfin smelt for
8 supplementation or reintroduction, if deemed necessary by Fishery Agencies, and (2) the
9 expansion of the refugial population of delta smelt and establishment of a refugial population of
10 longfin smelt at the University of California, Davis Fish Conservation and Culture Laboratory to
11 serve as a population safeguard in case of a catastrophic event in the wild.

12 The new facility proposed by the USFWS will house genetically-managed refugial populations
13 of delta and longfin smelt (Clarke 2008). Further, the facility will provide fish to supplement the
14 wild population and provide fish stocks for reintroduction, as necessary and appropriate. State-
15 of-the-art genetic management practices will be implemented to avoid hatchery produced fish
16 becoming genetically different from wild fish. The facility will be designed with the ability to
17 add other species if necessary in the future. Specific rules will be established to discontinue
18 housing refugial populations of delta and longfin smelt at the hatchery if and when populations
19 of these species are considered recovered by the Fishery Agencies.

20 In addition, the UC Davis Fish Conservation and Culture Laboratory (FCCL) is in need of
21 additional space and funds to expand the refugial population of delta smelt and establish a
22 refugial population of longfin smelt. The FCCL and the Genomic Variation Laboratory (GVL)
23 at UC Davis are and will be, the primary entities developing and implementing genetic
24 management of the delta smelt refugial population over the period 2009-2015 or longer and may
25 then play a secondary role in keeping a back-up population(s).

26 At both facilities, genetic management practices will be implemented to maintain wild genetic
27 diversity, minimize genetic adaptation to captivity, minimize mean kinship, and equalize family
28 contributions. Furthermore, genetic monitoring of wild populations will proceed to minimize
29 risks such as: genetic swamping from the hatchery population, reduction in effective population
30 size, and changes in the census population-to-breeder population ratio over time.

31 The BDCP Management Entity will enter into binding Memoranda of Agreement (MOAs) or
32 similar instruments with the USFWS and University of California, Davis similar to that
33 described in Section 3.4.3.1. In addition, if and when populations of these species are considered
34 recovered by the Fishery Agencies, the BDCP Management Entity will terminate funding for the
35 propagation of the species and either fund propagation of an additional BDCP covered fish
36 species if necessary and feasible or deobligate funds to this conservation measure and reallocate
37 them to augment funding other conservation measures identified in coordination with the Fishery
38 Agencies through the BDCP adaptive management process.

39 **Problem Statement**

40 Populations of both delta and longfin smelt have dramatically declined recently (IEP 2008a,b).
41 Although a variety of stressors are suspected, there is not a clear understanding of why these

1 populations have declined (IEP 2008a,b). There is evidence that delta smelt continue to decline
2 and that very low population size could result in an Allee effect causing an even more rapid
3 decline of the species (Mueller-Solger 2007). As a result, the risk of extinction of delta smelt is
4 hypothesized to be increasing. Longfin smelt abundance has followed a similar trend to delta
5 smelt (IEP 2008a,b).

6 **Hypothesized Benefits**

7 Artificial propagation and maintenance of refugial populations of delta and longfin smelt are
8 hypothesized to:

- 9 • provide a safeguard against the possible extinction of delta and/or longfin smelt by
10 maintaining a captive population that is genetically similar to the wild population (Lande
11 1988, Hedrick et al. 1995, Sveinsson & Hara 1995, Carolsfeld 1997, Sorensen 1998,
12 USFWS 1998, 2003, Hedgecock et al. 2000, Kowalski et al. 2006, Turner et al. 2007,
13 Nobriga 2008, Turner & Osborne 2008, B. Clarke, pers. comm., (Appendix X, *DRERIP*
14 *Evaluations*);
- 15 • improve the knowledge base regarding threats to and management of delta and longfin
16 smelt by increasing the ability to study the effects of various stressors on these species
17 using hatchery-reared specimens (Appendix X, *DRERIP Evaluations*); and
- 18 • contribute to increasing population sizes of delta smelt (Lande 1988, Deblois & Leggett
19 1991, Sveinsson & Hara 1995, Carolsfeld 1997, Sorensen 1998, USFWS 1998, 2003,
20 Flagg et al. 2000, Richards et al. 2004, Kowalski et al. 2006, Purchase et al. 2007,
21 Nobriga 2008, B. Clarke, pers. comm.) and longfin smelt (Sveinsson & Hara 1995,
22 Carolsfeld 1997, Sorensen 1998, USFWS 1998, 2003, Flagg et al. 2000, Richards et al.
23 2004, Kowalski et al. 2006, Nobriga 2008) to self-sustaining levels in the wild when
24 combined with effective habitat restoration and other measures to improve conditions in
25 their natural environment.

26 **Adaptive Management Considerations**

27 Implementation of this conservation measure by the Management Entity will be informed
28 through effectiveness monitoring that will be conducted for this conservation measure as
29 described in Section 3.1, *Monitoring and Research Plan*, and the adaptive management process
30 described in Section 3.2, *Adaptive Management Plan*. Based on review of performance and
31 effectiveness monitoring results in USFWS and UC Davis annual reports, the BDCP
32 Management Entity in coordination with Fishery Agencies and UC Davis will adjust funding
33 levels, hatchery operations, or other related aspects that will improve the performance and/or
34 biological effectiveness of the program through the BDCP adaptive management process as
35 appropriate. Such changes will be effected through the BDCP adaptive management process and
36 would be included in the subsequent annual work plans.

37 **3.4.6 CM6. Predator Control**

38 The purpose of this conservation measure is to reduce local effects of predators on covered fish
39 species by conducting focused predator control in high predator density locations. The BDCP
40 Management Entity will reduce the local effects of predators on covered fish species by

1 conducting focused predator control using a variety of methods in locations in the Delta that are
2 known to have high densities of predators (“predator hot spots”).

3 The BDCP Management Entity will examine existing fish monitoring data, bathymetry data, and
4 radio and acoustic tagging study results to determine the locations and causes of predator hot
5 spots throughout the Delta (Figure 3.##). Locations of hot spots in which focused predator
6 control will occur include:

- 7 1. old structures in or hanging over Delta waterways, such as pier pilings or other man-
8 made structures, that are no longer functional or have been abandoned but affect flow
9 fields and provide shade (target: 10-20 structures removed per year);
- 10 2. boats that have been abandoned throughout in the Delta (target: 5-10 boats removed per
11 year);
- 12 3. new intake structures of the North Delta Diversions (target: daily focused removal when
13 sensitive lifestages of covered fish species are present);
- 14 4. the deep hole just downstream of the Head of Old River in the San Joaquin River (target:
15 daily focused removal when sensitive lifestages of covered fish species are present.
16 Additional control efforts may be needed in conjunction with operation of non-physical
17 barriers, as described in CM7);
- 18 5. specific locations in Georgiana Slough, as identified by fishery agencies (target: daily
19 focused removal in up to 3 specific locations when sensitive lifestages of covered fish
20 species are present);
- 21 6. specific locations in Sutter and Steamboat sloughs, as identified by fishery agencies
22 (target: daily focused removal of predators in up to 2 specific locations per slough when
23 sensitive lifestages of covered fish species are present); and
- 24 7. release sites of salvaged fish from CVP/SWP facilities (target: weekly focused removal at
25 each salvage release site when sensitive lifestages of covered fish species are being
26 salvaged). *[Note to Reviewers: this action will be updated when DWR finishes its report*
27 *on salvage release site predation]*

28 The BDCP Management Entity will use a variety of methods to control predator populations in
29 hot spots, including removal of predator hiding spots, including modification of channel
30 geometry, targeted removal of predators, and/or other focused methods as dictated by site-
31 specific conditions and intended outcome/goal. Preference for which hot spots to address will be
32 given to areas of high overlap with covered fish species, such as major migratory routes or
33 spawning and rearing habitats.

34 Site specific control plans will be developed in consultation with the Fishery Agencies, which
35 include expected benefits, methods, and a monitoring design that will provide information
36 necessary to determine the effectiveness of the action.

37 **Problem Statement**

38 Although a natural part of the estuarine ecosystem, predation in the Delta has been identified as a
39 stressor to BDCP covered fish species (DRERIP models). Habitat for fish predators generally
40 consists of a specific suite of attributes that allow them to forage more efficiently, such as dark

1 locations adjacent to light locations or deep pools that allow the predator to hide and ambush
2 their prey. There are multiple locations in the Delta that contain these physical attributes and
3 attract predatory fish that prey upon covered fish species.



4 **Hypothesized Benefits**

5 Conducting localized predator control at hot spots in the Delta using a variety of control methods is
6 expected to reduce local predator abundance, thus reducing localized predation mortality of
7 Chinook salmon (Temple et al. 1998, Lindley and Mohr 2003), steelhead (Temple et al. 1998),
8 Sacramento splittail (Moyle et al. 2004), and delta smelt (Stevens 1966, Thomas 1967, Moyle
9 2002), and possibly longfin smelt (Nowak et al. 2004), green sturgeon (J. Israel pers. obs.), and
10 white sturgeon.

11 Within the Columbia River system, a predator removal program was investigated in the 1980's
12 for the control of juvenile salmonid predators benefiting from the existence of multiple hydro
13 power dams located along this system. The principle predators for juvenile salmonids within the
14 Columbia River are the northern pikeminnow (*Ptychocheilus oregonensis*), and two
15 nonindigenous species; smallmouth bass (*Micropterus dolomieu*), and walleye (*Sander vitreus*).
16 Northern pikeminnow greater than ~10 inches were considered the primary predator of juvenile
17 salmonids in slower moving portions of the Columbia River (i.e. near hydro power facilities).
18 The program, designed to reduce predation rates in these areas utilizing a bounty program, net
19 fisheries, professional fishers, and fishing areas adjacent to hatcheries was initiated in 1990. The
20 bounty program targets the removal of 10-20% of the larger pikeminnow to control size classes
21 that have the greatest juvenile salmonid predation rates, while still maintaining a sustained
22 pikeminnow population. By maintaining a sustained pikeminnow population, the program was
23 designed to avoid compensatory responses of other juvenile salmonid predators in the system
24 (smallmouth bass and walleye) filling the void created by pikeminnow removal. Through the
25 first 16 years of the program there were no indications of compensatory responses. In 2006,
26 however, there were possible indications of localized responses, due to the number of potential
27 factors affecting these observations (e.g. water year/temperature/operations, increasing shad
28 abundance, etc.), although there is insufficient data to determine whether there is a system-wide
29 compensatory response (Takata et al. 2007; Van Dyke 2010).


30 Prior to the initiation of this program, Beamesderfer et al. (1996) estimated that approximately
31 16.4 million juvenile salmonids of the estimated 200 million downstream migrants were
32 consumed by northern pikeminnow in the Columbia system. Another study estimated that
33 northern pikeminnow accounted for 10-20 percent of juvenile salmonid mortality (as cited in
34 Young 1997). Predation rates are greatest in the vicinity of each of the eight Columbia and
35 Snake River reservoirs ("pools"). Within the John Day pool it was estimated that a northern
36 pikeminnow exploitation rate of 10-20 percent could reduce their predation on juvenile
37 salmonids by 50 percent (as cited in Young 1997). From 1990 through 2008, the Northern
38 Pikeminnow Sports Reward Fishery removed 3.3 million reward-sized (≥ 9 inches) northern
39 pikeminnow from the Columbia system. From 1991-1998, system wide exploitation rates of
40 northern pikeminnow averaged 11.7 percent (Hankin and Richards 2000). The removal program
41 estimates northern pikeminnow predation has been reduced by 37 percent (Northern Pikeminnow
42 Sports Reward Fishery 2009). Although the program does not provide an estimated annual
43 number of juvenile salmonids "spared" due to predator removal, model estimates for a reduction
44 of 50 percent predation rate range from 5.2 to 8.2 million juvenile salmonids annually (Hankin
45 and Richards 2000).

1 **Adaptive Management Considerations**

2 Implementation of this conservation measure by the Management Entity will be informed
3 through effectiveness monitoring that will be conducted as described in Section 3. , *Monitoring*
4 *and Research Plan*, and the adaptive management process described in Section 3. , *Adaptive*
5 *Management Plan*. Monitoring will consist of assessing the abundance, distribution, and size of
6 predator species before and immediately after implementation of predator control actions in each
7 hot spot to determine the performance of the action. In addition, potential changes in survival
8 rate of covered species will be monitored using acoustic tagging studies where possible or
9 similar techniques.

10 The BDCP Management Entity in consultation with the Fishery Agencies will use results of
11 effectiveness monitoring to determine whether the action result in measurable benefits to covered
12 fish species and to identify adjustments to funding levels, methods, or other related aspects of the
13 program that would improve its biological effectiveness. Such changes, once approved through
14 the adaptive management decision making process, will be effected through subsequent annual
15 work plans. If results of monitoring indicate that the action does not substantially and cost-
16 effectively benefit covered fish species, the BDCP Management Entity, in coordination with
17 Fishery Agencies, may terminate this conservation measure. If terminated, remaining funding
18 will be deobligated from this conservation measure and reallocated to augment funding for other
19 more effective conservation measures identified in coordination with the Fishery Agencies
20 through the BDCP adaptive management process.

21 **3.4.7 CM7. Non-Physical Fish Barriers**

22 The purpose of this conservation measure is to improve the survival of outmigrating juvenile
23 salmonids by using non-physical barriers to re-direct them away from channels in which survival is
24 lower. The BDCP Management Entity will install non-physical barriers at the junction of channels
25 with low survival of outmigrating juvenile salmonids to deter fish from entering these channels¹.
26 Non-physical barrier placement locations will include the Head of Old River, the Delta Cross
27 Channel, Georgiana Slough, and could possibly include Turner Cut, Columbia Cut, the Delta
28 Mendota Canal intake, and Clifton Court Forebay (Figure 3. ). Other locations may be
29 considered in the future by the BDCP Management Entity if, for example, future research
30 demonstrates differential rates of survival in Sutter and Steamboat Sloughs relative to the
31 mainstem Sacramento River or in the Yolo Bypass relative to the mainstem Sacramento River.
32 Non-physical barriers will include a combination of sound, light, and bubbles similar to the three-
33 component non-physical barrier used in the 2009 DWR Head of Old River Test Project (Bowen et
34 al. 2009). Non-physical barriers will be installed and operated during October to June or when
35 Fishery Agencies monitoring determines that salmonid smolts are present in the areas when
36 barriers are to be installed. Non-physical barrier placement may also be accompanied by methods
37 to reduce local predator abundance described in CM 6 above if monitoring finds that barriers
38 attract predators. Barriers will be removed and stored off-site while not in operation (M.
39 Holderman pers. comm.).

¹ Previous evidence suggests that, under a non-physical barrier configuration that was effective in deterring salmon smolts, the non-physical barrier was not effective in deterring delta smelt (Bowen et al. 2008). It is currently not known whether this was a result of the configuration (e.g., sound frequency) of the non-physical barrier or the poor swimming ability of delta smelt that was swamped by high flows (Bowen et al. 2008). USBR is currently studying whether there are sound frequencies that deter Delta smelt (M. Holderman pers. comm.). If demonstrated to be effective in deterring delta smelt and longfin smelt and deemed necessary by the Fishery Agencies, non-physical barriers could also be installed at the mouths of Old and Middle Rivers and in Three Mile Slough (if salinity manipulation is not also needed) to deter these species from moving into these channels where survival is thought to be lower when present, as determined by Fishery Agencies monitoring.

1 **Problem Statement**

2 Juvenile salmonids experience low survival rates while migrating through the Delta towards the
3 ocean. Survival rates vary among routes taken through the Delta (Brandes & McLain 2001,
4 Holbrook et al. 2009, Perry and Skalski 2008, 2009, Perry et al. 2010) as a result of differential
5 exposure to predation, entrainment mortality at state and federal water export facilities and small
6 agricultural diversions, and other factors (SJRG 2006, J. Burau pers. comm.). Survival for
7 routes through the interior Delta was at most 35% that of survival for fish remaining in the
8 Sacramento River (Perry et al. 2010). Such low probability of survival when migrating through
9 the interior Delta indicates that significant population level impacts could result if a sizable
10 portion of the salmon population passed through this area. Perry and Skalski (2009) found that
11 19.8 to 34.5 percent of tagged salmon used Sutter and Steamboat Sloughs to migrate, while 26.7
12 percent to nearly one third of the population entered the interior area. Low survival probabilities
13 and high proportions of the population migrating through the interior Delta combine to
14 significantly reduce salmon survival through the Delta during migration. Physical barriers have
15 been used in the Delta, such as the Delta Cross Channel gates and the rock barrier at the Head of
16 Old River, to prohibit the entry of fish into channels where survival rates are low. Physical
17 barriers are effective at prohibiting entry of salmonids into channels, but also alter flow
18 dynamics in these channels, likely affecting tidal flows, sediment loads, bathymetry, water
19 supply reliability, potential for noxious algal blooms, toxic concentrations, and other water
20 quality parameters. However, operation of non-physical barriers is predicted to cause smaller
21 changes in the physical configuration of the channel, thus reducing flow-related effects, while
22 improving survival of salmonids by deterring them from entering channels with a higher risk of
23 mortality.

24 **Hypothesized Benefits**

25 Installation and seasonal operation of non-physical barriers is hypothesized to improve survival
26 of juvenile salmonids migrating downstream by guiding fish into channels in which they
27 experience higher survival rates (Welton et al. 2002, Bowen et al. 2009). The three component
28 non-physical barrier has shown promising results in laboratory experiments on Chinook salmon
29 emulating the Sacramento River/Georgiana Slough flow split (Bowen et al. 2008) and a field
30 experiment on Atlantic salmon (*Salmo salar*) smolts in the River Frome, UK (Welton et al.
31 2002). In addition, preliminary evidence suggests that the three-component barrier was effective
32 in deterring acoustically-tagged Chinook salmon juveniles from entering the head of Old River
33 during a 2009 pilot study (Bowen et al. 2009). Non-physical barriers that utilize only one
34 component, such as sound or light, have demonstrated only limited success in deterring fish
35 during field trials. For example, out of 25 separate single-component sound and light systems
36 placed in 21 different locations in Europe and the United States to affect the behavior of
37 salmonids near water intakes and canals, fewer than 50 percent were effective in altering fish
38 behavior (USBR 2006). The three-component Non-physical Barrier Test Project at the
39 confluence of Old River and the San Joaquin River in the Sacramento-San Joaquin Delta has
40 demonstrated greater success, successfully deterring 81.4 percent of tagged Chinook salmon
41 smolts from entering Old River compared to conditions without the barrier operating that
42 deterred 25.4 percent of tagged salmon smolts (Bowen et al. 2009). Sound is known to affect the
43 behavior of salmonids (Vanderwalker 1967, Knudsen et al. 1992, 1994).

44 **Adaptive Management Considerations**

1 Implementation of this conservation measure by the Management Entity will be informed
2 through effectiveness monitoring that will be conducted as described in Section 3. **■**, *Monitoring*
3 *and Research Plan*, and the adaptive management process described in Section 3. **■**, *Adaptive*
4 *Management Plan*. The BDCP Management Entity will conduct and review monitoring to assess
5 the effectiveness of using non-physical barriers. The BDCP Management Entity will use results
6 of effectiveness monitoring to determine whether operations of non-physical barriers result in
7 measurable benefits to juvenile salmonids and to identify adjustments to funding levels, methods,
8 or other related aspects of the program that would improve the biological effectiveness of the
9 program. Uncertainty regarding the potential attraction of predators to non-physical barriers and
10 the effectiveness of barriers in higher flow areas must be resolved. Such changes, once approved
11 through the adaptive management decision making process, will be effected through subsequent
12 annual work plans. If results of monitoring indicate that operations of non-physical barriers do
13 not substantially and cost-effectively benefit covered fish species, the BDCP Management
14 Entity, in coordination with Fishery Agencies, may terminate this conservation measure. If
15 terminated, remaining funding will be deobligated from this conservation measure and
16 reallocated to augment funding for other more effective conservation measures identified in
17 coordination with the Fishery Agencies through the BDCP adaptive management process.

18 **3.4.8 CM8. Methylmercury**

19 The purpose of this measure is to minimize the methylation of inorganic mercury in BDCP
20 habitat restoration areas caused by BDCP restoration actions. The BDCP Management Entity
21 will minimize to the extent practicable any increase in mercury methylation associated with
22 habitat restoration conservation measures through the design and implementation of restoration
23 projects (see Section 3.4. **■**). The BDCP Management Entity will work with DWR and the
24 Central Valley Regional Water Quality Control Board (CVRWQCB) to identify and implement
25 methods for minimizing the methylation of mercury in BDCP restoration areas.

26 *[Note to reviewers: A more detailed discussion of methods to reduce the methylation of mercury*
27 *in BDCP habitat restoration areas will be added here]*

28 **Problem Statement**

29 High concentrations of methylmercury in the Delta cause adverse effects to BDCP covered fish
30 and wildlife species. Methylmercury, the bioavailable and toxic form of mercury,
31 bioaccumulates within an individual and biomagnifies up the food chain, causing an increase in
32 the manifested effects in upper-trophic-level organisms. Fish are exposed to methylmercury
33 primarily through consumption, and secondarily through direct exposure to high concentrations
34 in the water column, although the latter is substantially lower than the former (Alpers et al.
35 2008). Effects of dietary methylmercury on fish include, but are not limited to, endocrine and
36 reproductive problems (Friedmann et al. 2002, Hammerschmidt et al. 2002), liver necrosis (de
37 Oliveira Ribeiro et al. 2002), brain lesions (Berntssen et al. 2003), and altered behavior that can
38 result in an increase risk of predation (Webber and Haines 2003). Tidal marsh sediments may
39 have elevated methylmercury production relative to those in unvegetated open-water areas
40 (Marvin-DiPasquale et al. 2003).

41 There is limited available evidence regarding the extent to which covered species in the Delta are
42 directly affected by acute or chronic exposure to methylmercury, and it is unknown to what
43 extent changes in hydrology (with operation of an isolated conveyance facility) would affect

1 methylation of mercury (see Appendix X, *DRERIP Evaluations*). The reproductive potential in
2 white sturgeon can be limited by exposure to methylmercury (Webb et al. 2006a). Also, Pacific
3 lamprey ammocoetes can absorb methylmercury at high rates relative to other species (Bettaso
4 and Goodman 2008), although effects on the species is unknown. Methylmercury effects have
5 also been demonstrated in other species that reside in the Delta, such as fathead minnows (Devlin
6 and Clary 1998, Hammerschmidt et al. 2002, Devlin 2006, Sandheinrich and Miller 2006,) and
7 golden shiners (Webber and Haines 2003).

8 Adverse effects of exposure to methylmercury have been observed in species that are closely
9 related to covered species. Hara et al. (1976) found reduced olfactory performance in rainbow
10 trout (*Salmo gairdneri*). Further, Berntssen et al. (2003) found that Atlantic salmon (*Salmo*
11 *salar*) exposed to several levels of methylmercury had numerous sublethal internal effects,
12 although there were no signs of mortality or reduced growth.

13 High concentrations of methylmercury also have negative effects on birds and terrestrial wildlife
14 (Wolfe et al. 1998). Deleterious effects on bird species from methylmercury consumption
15 include reproductive impairment and juvenile survival (Heinz 1979, Evers et al. 2004, Albers et
16 al. 2007, Ackerman et al. 2008). Effects on mammals from methylmercury consumption include
17 anorexia, ataxia, and death (Wren et al. 1987, O'Connor and Nielsen 1981).

18 Another major concern of methylmercury involves human health. An estimated 10,000 to
19 20,000 fishermen in the Delta and their families are presently eating fish that are at more than ten
20 times the recommended methylmercury reference dose, the US EPA's maximum acceptable oral
21 dose of a toxic substance (see Appendix X, *DRERIP Evaluations*). Effects on humans from
22 methylmercury consumption include loss of coordination, slurred speech, and mental
23 disturbances (Bakir et al. 1973, Marsh 1987). Methylmercury toxicity in developing human
24 fetuses can result in cerebral palsy and/or mental retardation (Harada 1978, Marsh et al. 1980
25 and 1987, Matsumoto et al. 1964, Snyder 1971). The Office of Environmental Health Hazard
26 Assessment has published health advisories urging limited human consumption of black basses
27 for multiple Delta waterways (see <http://www.oehha.ca.gov/>).

28 **Hypothesized Benefits**

29 Minimizing the increase in mercury methylation in habitat restoration areas as a result of BDCP
30 restoration actions is hypothesized to provide benefits to a number of fish species, the Delta
31 ecosystem, and human health. Specifically, this conservation measure is hypothesized to:

- 32 • Reduce fish exposure to methylmercury in habitat restoration areas and other Delta
33 waterways;
- 34 • Reduce deleterious side effects of dietary methylmercury on fish in the Delta waterways;
- 35 • Potentially reduce effects of methylmercury exposure on the reproductive potential of
36 white sturgeon; and
- 37 • Reduce exposure of BDCP terrestrial covered species to methylmercury in habitat
38 restoration areas and other Delta waterways.

39 **Adaptive Management Considerations**

1 Implementation of this conservation measure by the Management Entity will be informed
2 through effectiveness monitoring that will be conducted as described in Section 3. **■**, *Monitoring*
3 *and Research Plan*, and the adaptive management process described in Section 3. **■**, *Adaptive*
4 *Management Plan*. The BDCP Management Entity will coordinate with the CVRWQCB to
5 adjust methylmercury minimization strategies and funding levels through the BDCP adaptive
6 management decision making process as appropriate based on results of effectiveness monitoring
7 and review of CVRWQCB monitoring and other relevant reports. The BDCP Management
8 Entity would use results of effectiveness monitoring to determine whether reducing mercury
9 methylation results in measurable benefits to covered fish species and to identify adjustments to
10 funding levels, control methods, or other related aspects of the program that would improve the
11 biological effectiveness of the program. Such changes would be effected through the BDCP
12 adaptive management process and would be included in the subsequent annual work plans.

13 If results of monitoring indicate that minimizing methylation of mercury does not substantially
14 benefit covered fish species, the BDCP Management Entity in coordination with Fishery
15 Agencies may terminate this conservation measure. If terminated, remaining funding would be
16 deobligated from this conservation measure and reallocated to augment funding for other more
17 effective conservation measures identified in coordination with the Fishery Agencies through the
18 BDCP adaptive management process. If results of monitoring indicate that BDCP habitat
19 restoration activities increase loads of methylmercury in the Delta, this conservation measure
20 will not be terminated and may be amended to include additional activities to mitigate any
21 increase in loads of methylmercury attributable to restoration of BDCP habitats.

22 **3.4.9 CM9. Non-Native Aquatic Vegetation Control.**

23 The BDCP Management Entity will control the growth of Brazilian waterweed (*Egeria densa*),
24 water hyacinth (*Eichhornia crassipes*), and other non-native submerged and floating aquatic
25 vegetation (SAV and FAV) in BDCP tidal habitat restoration areas. To implement this
26 conservation measure, the BDCP Management Entity will apply existing methods used by the
27 Department of Boating and Waterways *Egeria densa* and Water Hyacinth Control Programs,
28 such as applying herbicides as specific as possible to these species, conducting mechanical
29 removal, and/or using other methods of removal as dictated by site-specific conditions and
30 intended outcome/goal. Application of herbicides or other means to control SAV/FAV will be
31 timed to eliminate or minimize potential negative effects of SAV/FAV removal on covered
32 species.

33 ***Problem Statement***

34 Although the historical extent of native SAV and FAV in the Delta ecosystem is unknown, non-
35 native invasive SAV and FAV species have recently invaded large areas of the Delta (Brown
36 2003, DFG 2008a, Ustin et al. 2008) and the invasion is continuing to expand into a greater
37 proportion of channels and new areas (IEP 2008b). The widest spread non-native FAV species,
38 water hyacinth, was introduced into the Delta over 100 years ago and severe infestations were
39 experienced by the 1980s. The majority of the surface cover of SAV detected through the recent
40 use of airborne hyperspectral imagery is Brazilian waterweed, although the SAV vegetation
41 frequently contains a mixture of three invasive non-native species: Brazilian waterweed,
42 *Potamogeton crispus* (curlyleaf pond weed), and *Myriophyllum spicatum* (Eurasian
43 watermilfoil) (Ustin et al. 2008). Of the 55,000 acres of the Delta surveyed in 2007, SAV cover

1 has been estimated to be between 5,500 and 10,000 acres (Ustin et al. 2008). Non-native SAV
2 and FAV are thought to cause multiple negative effects on the Delta ecosystem, including
3 providing habitat for non-native predators of covered fish species (Brown 2003, Nobriga et al.
4 2005), reducing food abundance and feeding ability of covered fish species by reducing light and
5 turbidity (Brown and Michniuk 2007), and blocking rearing habitat for juvenile salmon and
6 splittail (IEP 2008a).

7 The DBW's Water Hyacinth Control Program, which began in 1982, has been effective in
8 reducing hyacinth from Delta waterways by using chemical and mechanical removal methods.
9 DBW has developed and operated the *Egeria densa* Control Program (EDCP) since 2001 in
10 response to AB 2193, which amended the Harbors and Navigation Code to designate DBW as
11 the lead agency for the control of Brazilian waterweed in the Delta (DBW 2006, 2008). Initially,
12 the program focused control efforts in a number of locations where Brazilian waterweed
13 impeded navigation, tested a range of mechanical and chemical control techniques, and
14 conducted an extensive suite of toxicology and water quality tests and sampling that were
15 required by the terms of its National Pollution Discharge Elimination System (NPDES) permit
16 and under biological opinions issued by USFWS and NOAA Fisheries (DBW 2008). In 2006,
17 DBW concluded that its current approach was not effective at stopping the expansion of SAV in
18 the Delta and proposed expanding the treatment area to sites across most of the legal Delta
19 between 2006-2010 and concentrating on Franks Tract between 2006-2008 (DBW 2006).



20 **Hypothesized Benefits**

21 Removing non-native SAV and FAV from tidal habitat restoration areas is hypothesized to
22 provide benefits to covered fish species through the following mechanisms.

- 23 1. Reducing predation mortality on juvenile salmon, steelhead, and splittail by reducing
24 habitat for non-native predatory fish (see Appendix X, *DRERIP Evaluations*). SAV
25 provides relatively high quality habitat for non-native piscivores and is spread across
26 large portions of the Delta in or adjacent to significant migration corridors and pelagic
27 and subtidal open water habitat for covered species (see Figure 3.8). The interior of SAV
28 stands is good habitat for larval and juvenile centrarchids (Brown and Michniuk 2007),
29 whereas adult striped bass forage immediately outside of the SAV bed and feed on
30 juvenile Chinook salmon, steelhead, splittail, delta smelt, and longfin smelt (Stevens
31 1966, Temple et al. 1998, Nobriga and Feyrer 2007, 2008);
- 32 2. Reducing predation mortality of delta smelt by increasing turbidity levels (IEP 2008a,
33 Appendix X, *DRERIP Evaluations*). SAV and FAV are thought to reduce local flow rates
34 and cause suspended solids to precipitate out of the water column, resulting in a localized
35 reduction in turbidity levels (Grimaldo and Hymanson 1999). An increase in turbidity is
36 hypothesized to improve the predator avoidance abilities in delta and longfin smelt. In
37 addition, improved turbidity may reduce the hunting efficiency of non-native piscivores
38 (Nobriga et al. 2005);
- 39 3. Increasing food consumption by delta and longfin smelt by increasing turbidity levels.
40 SAV and FAV are thought to reduce local flow rates and cause suspended particles to
41 precipitate out of the water column, resulting in a localized reduction in turbidity levels
42 (Grimaldo and Hymanson 1999). A reduction in turbidity is hypothesized to reduce the
43 foraging ability of delta and longfin smelt;

- 1 4. Increasing rearing habitat for juvenile salmon (all races), steelhead, and splittail (see
2 Appendix X, *DRERIP Evaluations*). Dense patches of SAV and FAV physically obstruct
3 covered fish species' access to habitat (IEP 2008a) that would become available with
4 SAV and FAV removal and control; and
- 5 5. Increasing food availability for all covered fish species near removal locations by
6 increasing light levels below vegetation. Phytoplankton growth is hypothesized to be
7 light-limited in the Delta (Cole and Cloern 1984). The presence of SAV/FAV is more
8 light-limiting for phytoplankton growth, through shading, than anticipated increases in
9 water turbidity resulting from SAV/FAV removal. The reduction in light levels near non-
10 native SAV and FAV are thought to reduce local growth of phytoplankton, which can
11 affect the local abundance of zooplankton that forms the food base for covered fish
12 species near patches of SAV and FAV.

13 ***Adaptive Management Considerations***

14 Implementation of this conservation measure by the Management Entity will be informed
15 through effectiveness monitoring that will be conducted as described in Section 3. , *Monitoring*
16 *and Research Plan*, and the adaptive management process described in Section 3. , *Adaptive*
17 *Management Plan*. The BDCP Management Entity will monitor the effectiveness of BDCP-
18 funded elements of the non-native aquatic vegetation control in successfully controlling SAV
19 and FAV. The BDCP Management Entity will review monitoring results to assess the
20 effectiveness of the program for controlling non-native aquatic vegetation in the Delta. The
21 BDCP Management Entity will adjust control strategies and funding levels through the BDCP
22 adaptive management process as appropriate based on review of program reports.

23 The BDCP Management Entity will use results of effectiveness monitoring to determine if
24 controlling SAV and FAV results in measurable benefits to covered fish species and to identify
25 adjustments to funding levels, control methods, or other related aspects of the program that
26 would improve the biological effectiveness of the program. Such changes, once approved
27 through the adaptive management decision making process, will be effected through subsequent
28 annual work plans.

29 If results of monitoring indicate that removing and controlling SAV and FAV does not
30 substantially and cost-effectively benefit covered fish species, the BDCP Management Entity, in
31 coordination with Fishery Agencies, may terminate this conservation measure. If terminated,
32 remaining funding would be deobligated from this conservation measure and reallocated to
33 augment funding for other more effective conservation measures identified in coordination with
34 the Fishery Agencies through the BDCP adaptive management process.

35 **3.4.10 CM10 Tidal Habitat Restoration**

36 The BDCP will provide for the restoration of 65,000 acres of freshwater and brackish tidal
37 habitat within the BDCP ROAs (Figure 3.1). The extent of restored tidal habitat includes a
38 contiguous habitat gradient encompassing restored shallow subtidal aquatic habitat², restored
39 tidal mudflat, restored tidal marsh plain habitat³, and adjoining transitional upland habitat. This

² Restored shallow subtidal habitat extends approximately from the mean lower low water [MLLW] elevation to 9 feet below the MLLW elevation.

³ Restored tidal marsh plain extends from the MLLW elevation to the mean higher high water [MHHW] elevation.

1 upland habitat will accommodate approximately 3 feet of sea level rise that will function as tidal
2 marsh plain at some future time. Additional upland habitat, however, would be protected and
3 enhanced to provide habitat for terrestrial species.

4 Of the 65,000-acre restoration target, 22,000 acres will be distributed among the ROAs as
5 described below in *Minimum Restoration Targets for Freshwater Tidal Habitat in ROAs* and
6 *Minimum Restoration Target for Brackish Tidal Habitat in the Suisun ROA*. The remaining
7 43,000 acres of the target total will be distributed among the ROA's at the discretion of the
8 Management Entity based on land availability, biological value, and practicability
9 considerations. The freshwater and brackish tidal habitat restoration targets will be achieved on
10 the following time schedule:

- 11 • 14,000 acres developed⁴ within the first 10 years of plan implementation;
- 12 • 25,000 acres (cumulative) developed by year 15 of plan implementation; and
- 13 • 65,000 acres (cumulative) developed by year 40 of plan implementation.

14 Anticipated actions to restore freshwater and brackish tidal habitat, as appropriate to site-specific
15 conditions, will include:

- 16 • acquiring lands, in fee-title or through conservation easements, suitable for restoration of
17 tidal habitats and protecting sufficient adjacent uplands to accommodate 3 feet of future
18 sea level rise;
- 19 • breaching and lowering levees and dikes to reintroduce tidal exchange to currently leveed
20 and diked former tidelands;
- 21 • reconnecting disconnected remnant sloughs to Suisun Bay and removing remnant slough
22 dikes to reintroduce tidal connectivity to slough watersheds;
- 23 • constructing new or enhancing existing levees and dikes to provide flood protection for
24 adjacent landowners and protecting existing land use against seepage and erosion of
25 existing levees;
- 26 • constructing new levees to isolate deeply subsided lands from tidal flooding;
- 27 • restoring natural remnant meandering tidal channels;
- 28 • excavating channels to encourage the development of dendritic channel networks within
29 restored marsh plain;
- 30 • modifying ditches, cuts, and levees to encourage more natural tidal circulation and better
31 flood conveyance based on local hydrology;
- 32 • restoring tributary stream functions to establish more natural patterns of sediment
33 transport to improve spawning conditions for delta smelt and other fish and
34 macroinvertebrates;
- 35 • prior to breaching, scalping higher elevation land to provide fill for placement on
36 subsided lands to raise surface elevations suitable for establishment of marsh;

⁴ In achieving these targets the term "developed" means the completion of reintroduction of tidal inundation to areas expected to develop as tidal habitat. These target values represent the habitat area developed at the points in time identified. Development of fully functioning restored habitat may take years subsequent to initial tidal inundation through the effects of natural processes on the constructed surface.

- 1 • prior to breaching, importing dredge or fill in shallowly subsided areas to raise ground
2 surface elevations to a level suitable for establishment of marsh plain;
 - 3 • prior to breaching, farming tules for long periods to raise subsided ground surface to
4 elevations suitable to support marsh plain and breaching levees when target elevations are
5 achieved; and
 - 6 • designing levee and dike breaches to maximize the development of tidal marsh plain and
7 minimize hydrodynamic conditions that favor non-native predatory fish.
- 8 Measures for addressing the potential for methylation of mercury in restored tidal habitats will be
9 addressed through implementation of CM8, *Methylmercury*.

10 **Freshwater Tidal Habitat Restoration**

11 Freshwater tidal habitats will be restored to provide the ecological benefits for covered species
12 described under *Supporting Hypotheses* below. Freshwater tidal habitats will be restored by
13 breaching or removing levees along Delta waterways to reestablish tidal connectivity to
14 reclaimed lands. Tidal habitat restored on deeply subsided Delta tracts and islands may require
15 construction of cross levees or berms to isolate deeply subsided lands from inundation, avoiding
16 the creation of large areas of subtidal habitats that could favor non-native predator/competitor
17 species and disfavor covered fish species. Where required, levees or berms will be constructed
18 to prevent inundation of adjacent lands. Where practicable and appropriate, portions of
19 restoration sites will be raised to elevations that will support tidal marsh vegetation. Depending
20 on the degree of subsidence and location, lands may be elevated by grading higher elevations to
21 fill subsided areas, importing dredged or fill material from other locations, or planting tules or
22 other appropriate vegetation to raise elevations in shallowly subsided areas over time through
23 organic material accumulation. Surface grading will provide for a shallow elevation gradient
24 from the marsh plain to the upland transition habitat. Based on assessments of local
25 hydrodynamic conditions, sediment transport, and topography, restoration activities may be
26 designed and implemented in a manner that accelerates the development of tidal channels within
27 restored marsh plains. Following reintroduction of tidal exchange, tidal marsh vegetation is
28 expected to establish naturally at suitable elevations relative to the tidal range. Depending on
29 site-specific conditions and monitoring results, patches of native emergent vegetation may be
30 planted to accelerate the establishment of native marsh vegetation on restored marsh plain
31 surfaces. A conceptual illustration of restored freshwater tidal habitat is presented in Figure
32 3. ■.

33 Restoration variables that will be considered by the Management Entity in the design of restored
34 freshwater tidal habitat include:

- 35 • spatial distribution of restored tidal marsh habitats within the Delta;
- 36 • extent, location, and configuration of restored tidal habitat areas;
- 37 • predicted tidal range at tidal habitat restoration sites following reintroduction of tidal
38 exchange;
- 39 • size and location of levee breaches;
- 40 • cross sectional profile of tidal habitat restoration sites (elevation of marsh plain,
41 topographic diversity, depth, and slope); and

1 • density and size of restored tidal habitat channels appropriate to each restoration site.
2 Restored freshwater tidal habitats will be designed to support habitat for covered species listed in
3 Table 3.1. Restoration design considerations for freshwater tidal habitat will include the
4 following.

5 **Marsh Plain Vegetation.** To provide for high functioning habitat, restored tidal marsh plains
6 will be vegetated primarily with tules and other native freshwater emergent vegetation to reflect
7 the historical composition and densities of Delta tidal marshes. Following establishment of tidal
8 exchange, restored habitat will be monitored to assess the establishment of invasive non-native
9 plants. If indicated by monitoring results, the Management Entity will implement invasive plant
10 control measures to help ensure the establishment of native marsh plain plant species.

11 **Hydrodynamic Conditions.** Tidal habitat restoration will be designed, within restoration site
12 constraints, to produce sinuous, high density, dendritic networks of tidal channels that promote
13 effective tidal exchange throughout the marsh plain and provide foraging habitat for covered fish
14 species. Effective tidal exchange is expected to enhance ecological functions that support
15 covered species, including:

- 16 • the export of productivity from the marsh plain into adjacent Delta waterways in support
17 of aquatic food web processes;
- 18 • production and export of phytoplankton and zooplankton from tidal channels into
19 adjacent Delta waterways in support of the aquatic food web; and
- 20 • maintenance of cooler localized water temperatures preferred by covered fish species
21 through nocturnal thermal exchange on marsh plains.

22 Marsh channels and levee breaches will also be designed to maintain flow velocities that
23 minimize conditions favorable to the establishment of non-native submerged and floating aquatic
24 vegetation and habitat for non-native predatory fish.

25 **Environmental Gradients.** As determined by site-specific constraints, tidal habitat restoration
26 actions will be designed to provide an ecological gradient among subtidal, tidal mudflat, tidal
27 marsh plain, riparian, and upland habitats to accommodate the movement of fish and wildlife
28 species and provide flood refuge habitat for marsh-associated wildlife species during high water
29 events. In addition, by protecting higher elevation lands adjacent to restored marsh plains, these
30 areas will be available for future marsh establishment that may occur as a result of sea level rise.

31 **Shallow subtidal aquatic habitat.** Restored shallow subtidal aquatic habitat is expected to
32 support, depending on location, delta smelt, longfin smelt, juvenile salmonid rearing, sturgeon,
33 and lamprey habitat. Shallow freshwater subtidal aquatic habitat in some portions of the Delta
34 support large numbers of non-native predatory fish and extensive beds of non-native submerged
35 aquatic vegetation that adversely affect covered fish species. In other portions of the Delta,
36 shallow subtidal habitat provides suitable habitat for native species, such as delta smelt in the
37 Liberty Island/Cache Slough region, and does not promote the growth of non-native submerged
38 aquatic vegetation. Because it may generate habitat for non-native predators, it is not a goal of
39 the BDCP to restore areas of shallow subtidal aquatic habitat; rather, shallow subtidal aquatic
40 habitat will result a part of the restoration of freshwater tidal marsh plain where land surface
41 elevations within restoration sites are subsided below elevations that would support tidal marsh
42 vegetation. Tidal habitat restoration projects will be designed to minimize the likelihood of

1 establishment of non-native submerged aquatic vegetation, which may serve as habitat for non-
2 native predators. Early restoration projects will be monitored to assess the response of non-
3 native species to restoration designs and local environmental conditions. This information will
4 be used to modify restoration designs and implementation methods, if necessary, over time to
5 further improve habitat conditions for covered fish species. As described in *CM9Control Non-*
6 *Native Submerged and Floating Aquatic Vegetation from BDCP Restoration Areas*, the BDCP
7 Management Entity will engage in active removal of submerged aquatic and floating aquatic
8 vegetation in subtidal portions of tidal restoration sites to reduce the levels of establishment of
9 non-native predators.

10 **Minimum Restoration Targets for Freshwater Tidal Habitat in ROAs.** At a minimum, the
11 BDCP Management Entity will restore at least the following amounts of tidal habitat in each of
12 the Delta ROAs as described below (see Figure 3.1).

13 **Restore at least 5,000 acres of freshwater tidal habitat within the Cache Slough**
14 **Complex ROA.** The BDCP Management Entity will restore a minimum of 5,000 acres
15 of freshwater tidal habitat in the Cache Slough Complex ROA. Areas suitable for
16 restoration include, but are not limited to, Haas Slough, Hastings Cut, Lindsey Slough,
17 Barker Slough, Calhoun Cut, Liberty Island, Little Holland, the Westlands property
18 (“Yolo Ranch”), Shag Slough, Little Egbert Tract, and Prospect Island. The Cache
19 Slough Complex has been recognized as possibly the best functioning existing tidal
20 habitat area of the Delta. The complex includes Liberty Island, which is likely the best
21 existing model for freshwater tidal habitat restoration in the Delta for native fishes. The
22 Complex supports multiple covered fish species and is presumably one of the last known
23 areas where Delta smelt spawn and rear successfully. Restoring the target amount of
24 freshwater tidal habitat within the Cache Slough Complex ROA and protecting associated
25 upland habitat is expected to benefit multiple covered species and the Delta ecosystem.
26 In conjunction with floodplain enhancement in the Yolo Bypass, the habitat restoration in
27 the Cache Slough ROA will re-establish the ecological gradient from river to floodplain
28 to tidal estuary and to provide tidal wetland adjacent to open channel habitat that is
29 characteristic of less altered estuaries. Preliminary hydrodynamic modeling indicates that
30 increased tidal exchange in the Cache Slough area resulting from 5,000-10,000 acres of
31 tidal habitat restoration will reduce bidirectional flows in Steamboat and Sutter Sloughs
32 and the mainstem Sacramento River compared to tidal action under present conditions,
33 thus significantly enhancing movement of juvenile salmonids through these waterways
34 and potentially reducing their exposure to predators.

35 Additionally, the Cache Slough Complex encompasses a substantial area of land with
36 elevations suitable for freshwater tidal habitat restoration that would involve few impacts
37 on existing infrastructure or permanent crops relative to other areas of the north Delta.
38 The Cache Slough Complex provides an excellent opportunity to expand habitat
39 supporting multiple aquatic and terrestrial covered species. Restoration of freshwater
40 tidal habitat will be designed to support the physical and biological attributes that benefit
41 covered species. Based on existing land elevations, approximately 21,000 acres of public
42 and private lands in the area are potentially suitable for restoration of tidal habitat. Areas
43 for restoration would be identified by working with interested landowners.

Restore at least 1,500 acres of freshwater tidal habitat within the

Cosumnes/Mokelumne ROA. The BDCP Management Entity will restore a minimum of 1,500 acres of freshwater tidal habitat in the Cosumnes/Mokelumne ROA. Areas suitable for restoration within the Cosumnes/Mokelumne ROA (see Figure 3.1) include McCormack-Williamson Tract, New Hope Tract, Canal Ranch Tract, Bract Tract, Terminous Tract north of State Highway 12, and lands adjoining Snodgrass Slough, South Stone Lake, and Lost Slough. Depending on site-specific conditions, levees may be constructed to avoid inundation of deeply subsided lands.

Restore at least 2,100 acres of tidal habitat within the West Delta ROA. The BDCP Management Entity will restore a minimum of 2,100 acres of freshwater tidal habitat in the West Delta ROA. The west Delta includes multiple small areas where tidal habitat can be restored. Areas suitable for restoration include Dutch Slough, Decker Island, portions of Sherman Island, Jersey Island, Bradford Island, Twitchell Island, Brannon Island, Grand Island, and along portions of the north bank of the Sacramento River where elevations and substrates are suitable. The purpose of restoring tidal habitat in the west Delta is to provide a continuous reach of tidal marsh and subtidal aquatic habitat associated with food productivity between current and future restored habitats in the Cache Slough Complex and Suisun Marsh and Bay and to provide tidal marsh plain habitat within the anticipated future eastward position of the biologically important low salinity zone of the estuary with sea level rise.

Restore at least 5,000 acres of tidal habitat within the South Delta ROA. The BDCP Management Entity will restore a minimum of 5,000 acres of freshwater tidal habitat in the South Delta ROA. To maximize benefits associated with restoration of tidal habitat in the south Delta, tidal habitat will not be restored until the north Delta diversion facilities become operational. Potential sites for restoring freshwater tidal habitat include Fabian Tract, Union Island, Middle Roberts Island, and Lower Roberts Island. Sites selected for restoration would be dependent on the location and design of the selected conveyance pathway and operations for the through-Delta component of the dual conveyance facility. Selected sites would be those that would provide substantial species and ecosystem benefits with the selected through-Delta conveyance configuration and most effectively avoid adverse affects of south Delta SWP/CVP operations. In conjunction with dual conveyance operations, tidal habitat restoration in the South Delta ROA may support the expansion of the current distribution of delta smelt into formerly occupied habitat areas.

Restore at least 1,400 acres tidal habitat within the East Delta ROA. The BDCP Management Entity will restore a minimum of 1,400 acres of freshwater tidal habitat in the East Delta ROA. Areas suitable for restoration in the East Delta ROA (see Figure 3.1) include Terminous Tract south of State Highway 12, Shin Kee Tract, Rio Blanco Tract, and Bishop Bract. Depending on site-specific conditions, levees may be constructed to avoid inundation of deeply subsided lands.

Restored tidal habitat will be designed to an ecological gradient that supports a mosaic of tidal marsh, tidal mudflat, shallow subtidal aquatic, and transitional upland and riparian habitats as appropriate to specific restoration sites.

Problem Statement

1 The majority of historical freshwater tidal marsh in the Sacramento/San Joaquin Delta and
2 Suisun Bay system has been lost. Historically, approximately 350,000 acres of tidal marsh was
3 present in the Delta, of which approximately 10,000 acres of freshwater tidal marsh remains.
4 This loss of tidal marsh has greatly reduced the availability and quality of spawning and rearing
5 habitat for many native species, by reducing the input of organic and inorganic material and food
6 resources into adjoining deep water habitats (sloughs and channels) and the downstream bay and
7 estuary.

8 *Hypothesized Benefits*

9 Restoration of freshwater tidal habitat is hypothesized to provide a range of ecosystem and
10 covered species benefits. These anticipated benefits are described below for the freshwater tidal
11 habitat restoration proposed in each of the ROAs. As described in Appendix , *DRERIP*
12 *Evaluations*, however, there are a number of uncertainties regarding the level of benefits that
13 may be provided by tidal habitat restored in each of the ROAs as well as risks for adverse
14 consequences. These uncertainties will be addressed through effectiveness monitoring, research,
15 and the adaptive management program (see Sections 3. and 3.).

16 Restoring freshwater tidal habitat within the Cache Slough ROA is expected to:

- 17 • increase rearing habitat area for Chinook salmon, Sacramento splittail, white sturgeon,
18 and green sturgeon (Healey 1991, Brown 2003, Appendix X, *DRERIP Evaluations*);
- 19 • increase the local production of food for rearing salmonids, splittail, delta smelt, green
20 and white sturgeon (Kjelson et al. 1982, Siegel 2007);
- 21 • increase the export of food in the Delta downstream of Rio Vista available to juvenile
22 salmonids, splittail, delta smelt, white sturgeon, and green sturgeon by exporting organic
23 material from the marsh plain and phytoplankton, zooplankton, and other organisms
24 produced in tidal channels into the Delta and Suisun Marsh (Siegel 2007);
- 25 • expand habitat available for colonization by Mason's lilaepsis, Suisun Marsh aster,
26 Delta mudwort, and Delta tule pea; and
- 27 • expand habitat for tricolored blackbird, California black rail, and giant garter snake (in
28 locations with a muted tidal range).

29 Restoring freshwater tidal habitat within the Cosumnes/Mokelumne River ROA is expected to:

- 30 • increase rearing habitat area for Cosumnes/Mokelumne fall-run Chinook salmon,
31 steelhead, delta smelt, and Sacramento splittail (Healey 1991, Brown 2003);
- 32 • increase the local production of food for Cosumnes/Mokelumne fall-run Chinook salmon,
33 steelhead, delta smelt, and Sacramento splittail migrating to and from the Cosumnes and
34 Mokelumne Rivers (Kjelson et al. 1982, Siegel 2007);
- 35 • increase the availability and production of food in the east and central Delta available to
36 juvenile salmonids, splittail, delta smelt, white sturgeon, and green sturgeon by exporting
37 organic material from the marsh plain and phytoplankton, zooplankton, and other
38 organisms produced in tidal channels into the Delta (Siegel 2007);
- 39 •

- 1 • increase the extent of habitat available for colonization by Mason’s lilaeopsis, Suisun
2 Marsh aster, and Delta tule pea; and
- 3 • expand habitat for tricolored blackbird, California black rail, and giant garter snake (in
4 locations with a muted tidal range).

5 Restoring freshwater tidal habitat in the West Delta ROA is expected to:

- 6 • increase rearing habitat area for Chinook salmon, Sacramento splittail, and possibly
7 steelhead (Healey 1991, Brown 2003);
- 8 • improve future rearing habitat areas for delta smelt and longfin smelt within the
9 anticipated eastward movement of the low salinity zone with sea level rise;
- 10 • increase the local production of food for rearing salmonids, splittail, and other covered
11 species (Kjelson et al. 1982; Siegel 2007);
- 12 • increase the availability and production of food in the western Delta and Suisun Bay by
13 exporting organic material via tidal flow from the marsh plain and organic carbon,
14 phytoplankton, zooplankton, and other organisms produced in tidal channels into adjacent
15 open water areas (Siegel 2007);
- 16 • provide an important linkage between current and future upstream restored habitat with
17 downstream habitat in Suisun Marsh and Bay;
- 18 • provide additional refugial habitat for migrating and resident covered species;
- 19 • increase the extent of habitat available for colonization by Mason’s lilaeopsis, Suisun
20 Marsh aster, Delta mudwort, and Delta tule pea; and
- 21 • expand habitat for tricolored blackbird, California black rail, and giant garter snake (in
22 locations with a muted tidal range).

23 Restoring freshwater tidal habitat in the South Delta ROA is expected to:

- 24 • increase rearing habitat area for Sacramento splittail, Chinook salmon produced in the
25 San Joaquin River and other eastside tributaries, and possibly steelhead (Healey 1991,
26 Brown 2003);
- 27 • increase the local production of food for rearing salmonids, splittail, and other covered
28 species (Kjelson et al. 1982, Siegel 2007);
- 29 • increase the availability and production of food in the Delta and Suisun Bay by export
30 from the south Delta of organic material via tidal flow from the new marsh plain and
31 organic carbon, phytoplankton, zooplankton, and other organisms produced in new tidal
32 channels (Siegel 2007);
- 33 • increase the extent of habitat available for colonization by Mason’s lilaeopsis, Delta
34 mudwort, and Delta tule pea; and
- 35 • expand habitat for tricolored blackbird, California black rail, and giant garter snake (in
36 locations with a muted tidal range).

37 Restoring freshwater tidal habitat within the East Delta ROA is expected to:

- 1 • increase rearing habitat area for Sacramento splittail and San Joaquin Chinook salmon
2 and possibly steelhead (Healey 1991, Brown 2003);
- 3 • increase the local production of food for rearing salmonids, splittail, and other covered
4 species (Kjelson et al. 1982, Siegel 2007);
- 5 • increase the availability and production of food in the east and central Delta by exporting
6 organic material from the marsh plain and phytoplankton, zooplankton, and other
7 organisms produced in tidal channels into the Delta (Siegel 2007);
- 8 • increase the extent of habitat available for colonization by Mason's lilaeopsis, Suisun
9 Marsh aster, Delta mudwort, and Delta tule pea; and
- 10 • expand habitat for tricolored blackbird, California black rail, and giant garter snake (in
11 locations with a muted tidal range).

12 ***Adaptive management considerations***

13 Implementation of freshwater tidal habitat restoration actions and subsequent management of
14 restored tidal habitats by the Management Entity will be informed through effectiveness
15 monitoring that will be conducted for this conservation measure as described in Section 3.█,
16 *Monitoring and Research Plan*, and the adaptive management process described in Section 3.█,
17 *Adaptive Management Plan*. Based on analysis of monitoring results, likely elements of this
18 measure that could be adjusted through the adaptive management process include considerations
19 for selecting restoration locations and sequencing restoration of tidal habitat among the ROAs;
20 methods for establishing marsh plain vegetation, including the establishment of marsh-associated
21 covered plant species; methods and designs for elevating subsided land surfaces to increase
22 restored marsh plain area; design and location of levee breaches; designs for encouraging the
23 development of a high functioning network of tidal channels; and non-native vegetation and
24 wildlife control techniques.

25 ***Brackish Tidal Habitat Restoration***

26 Brackish tidal habitat will be restored within Suisun Marsh ROA in coordination with the Suisun
27 Marsh Habitat Restoration and Management Plan, currently under development. Brackish tidal
28 habitat will be restored to provide the ecological benefits for covered species described under
29 *Hypothesized Benefits* below. Brackish tidal habitat will be restored by breaching or removing
30 dikes along Montezuma and other Suisun Marsh sloughs and channels and Suisun Bay to
31 reestablish tidal connectivity to reclaimed lands. Tidal habitat restored adjacent to farmed lands
32 or lands managed as freshwater seasonal wetlands may require construction of dikes to maintain
33 those land uses. Where appropriate, portions of restoration sites will be raised to elevations that
34 would support tidal marsh vegetation. Depending on the degree of subsidence, location, and
35 likelihood for natural accretion through sedimentation, lands may be elevated by grading higher
36 elevations to fill subsided areas, importing dredged or fill material from other locations, or
37 planting tules or other appropriate vegetation to raise elevations in shallowly subsided areas over
38 time through organic material accumulation prior to breaching dikes. Surface grading will be
39 designed to result in a shallow elevation gradient from the marsh plain to the upland transition
40 habitat. Remnant disconnected tidal channels will be restored if present within restoration sites to
41 accelerate development of marsh functions. Existing tidal channels may also be deepened and or
42 widened if necessary to increase tidal flow. Based on assessments of local hydrodynamic

1 conditions, sediment transport, and topography, restoration sites may be graded to accelerate the
2 development of tidal channels within restored marsh plains. Following reintroduction of tidal
3 exchange, tidal marsh vegetation would be expected to naturally establish at suitable elevations
4 relative to the tidal range. Depending on site-specific conditions and monitoring results, patches
5 of native emergent vegetation may be planted to accelerate the establishment of native marsh
6 vegetation on restored marsh plain surfaces. A conceptual illustration of restored brackish tidal
7 habitat is presented in Figure 3.█.

8 Restoration variables that will be considered by the Management Entity in the design of restored
9 brackish tidal habitat include:

- 10 • extent, location, and configuration of other existing and proposed restored tidal habitat
11 areas;
- 12 • distribution of restored tidal habitats along salinity gradients to optimize the range of
13 habitat conditions for covered species and food production;
- 14 • predicted tidal range at tidal habitat restoration sites following reintroduction of tidal
15 exchange;
- 16 • size and location of dike breaches;
- 17 • cross sectional profile of tidal habitat restoration sites (elevation of marsh plain,
18 topographic diversity, depth, and slope);
- 19 • density and size of tidal marsh plain channels appropriate to each restoration site; and
- 20 • potential hydrodynamic and water quality effects on other areas of the Delta.

21 Restoration actions for brackish tidal habitats will be designed to support habitat for covered
22 species listed in Table 3.█. Restoration design considerations for brackish tidal habitat include
23 the following.

24 **Marsh Plain Vegetation.** To provide high functioning habitat, restored tidal marsh plains will be
25 dominated by native brackish marsh vegetation (e.g., pickleweed, saltgrass) appropriate to marsh
26 plain elevations, mimicking the composition and densities of historical Suisun Bay brackish tidal
27 marshes. Vegetated marsh plains will also be expected to filter non-point source pollution from
28 surface or subsurface infiltration that otherwise would flow into Suisun Bay. Following
29 establishment of tidal exchange, restored habitat will be monitored to assess the establishment of
30 invasive non-native plants. If indicated by monitoring results, the Management Entity will
31 implement invasive plant control measures to help ensure the establishment of native marsh plain
32 plant species.

33 **Hydrodynamic Conditions.** Restored brackish tidal habitat will be designed to provide
34 hydrodynamic conditions similar to those described for freshwater tidal habitat. In addition to
35 desired biological and ecological attributes, the selection and design of restored tidal habitat in
36 Suisun Marsh will need to consider potential hydrodynamic and water quality effects of the
37 proposed restoration, including the effect on salinity intrusion, tidal mixing, and Delta salinity.

38 **Environmental Gradients.** Restored brackish tidal habitat will be designed to provide
39 environmental gradients similar to those described for freshwater tidal habitat. Because land
40 surface elevations within Suisun Marsh are relatively homogenous, opportunities to provide

1 linkages to upland habitats are limited to restoration sites that are located along the fringe of
2 Suisun Marsh. Dikes constructed to restore tidal habitat in the interior of Suisun Marsh will be
3 designed with low gradient slopes supporting high marsh and upland vegetation to provide flood
4 refuge habitat. Where appropriate, higher elevation islands of upland habitat within restored
5 tidal habitat may also be created to provide flood refuge for marsh wildlife.

6 ***Minimum Restoration Targets for Brackish Tidal Habitat in Suisun ROA.*** The BDCP
7 Management Entity will restore at least the following amount of brackish tidal habitat in the
8 Suisun Marsh ROA.

9 **Restore at least 7,000 acres of brackish tidal habitat within the Suisun Marsh**
10 **Restoration Opportunity Area.** The BDCP Management Entity will restore a minimum
11 of 7,000 acres of brackish tidal habitat in the Suisun Marsh ROA. Restored brackish tidal
12 habitat will be designed to support the physical and biological attributes described in
13 above in *Brackish Tidal Marsh Habitat Restoration*. Restored tidal habitat will be
14 designed to create ecological gradients that support a mosaic of tidal marsh, tide flat,
15 shallow subtidal aquatic, and transitional upland habitats as appropriate to specific
16 restoration sites. The Suisun Marsh ROA encompasses a substantial area with elevations
17 suitable for tidal habitat restoration that would have minimal effect on infrastructure or
18 permanent crops relative to other suitable lands within the Delta.

19 The Suisun Marsh Habitat Restoration and Management Plan (currently under development) will
20 include an evaluation of alternatives, including options that contemplate the restoration of up to
21 7,000 acres of brackish tidal habitat. Much of Suisun Marsh is currently at elevations that could
22 be restored to tidal habitat.

23 Hydrodynamic modeling conducted for the Suisun Marsh Restoration Plan (J. DeGeorge pers.
24 comm.) indicates that restoring tidal habitat north of Montezuma Slough would shift the low
25 salinity zone westward and restoring tidal habitat at sites adjacent to Suisun Bay would shift the
26 low salinity zone eastward, potentially adversely affecting delta smelt habitat and water quality
27 in the west Delta. Consequently, implementation of tidal habitat restoration projects in north and
28 south Suisun Marsh will be sequenced such that these potential effects would be minimized.

29 As described in *Section 3.1, Water Operations Conservation Measures*, future reoperation or
30 removal of the Montezuma Slough Salinity Control Gate will increase the benefits of restoring
31 brackish tidal habitat in Suisun Marsh by increasing access for covered fish species to existing
32 and restored tidal aquatic habitat within a large area of Suisun Marsh.

33 ***Problem Statement***

34 Suisun Marsh is the largest brackish water marsh complex in the Western United States. The
35 majority of historical brackish tidal marsh has been lost, of which approximately 8,300 acres
36 remains in Suisun Marsh. This loss of tidal marsh has greatly reduced the availability and quality
37 of spawning and rearing habitat for many native species, by reducing the input of organic and
38 inorganic material and food resources into adjoining deep water habitats (sloughs and channels)
39 and the downstream bay and estuary.

40 ***Hypothesized Benefits***

1 Restoration of brackish tidal habitat in Suisun Marsh is hypothesized to provide a range of
2 ecosystem and covered species benefits. As described in Appendix X, *DRERIP Evaluations*,
3 however, there are a number of uncertainties regarding the level of benefits that may be provided
4 by tidal habitat restored as well as risks for adverse consequences. These uncertainties will be
5 addressed through effectiveness monitoring, research, and the adaptive management program
6 (see Sections 3.█ and 3.█).

7 Restoring brackish tidal habitat within the Suisun Marsh ROA is expected to:

- 8 • increase rearing habitat area for Chinook salmon, Sacramento splittail, and possibly
9 steelhead (Healey 1991, Siegel 2007);
- 10 • increase the local production of food for rearing salmonids, splittail, and other covered
11 species (Kjelson et al. 1982);
- 12 • provide an important linkage between current and future upstream restored habitat, such
13 as Yolo Bypass/Cache Slough with Suisun Marsh/Bay;
- 14 • increase the availability and production of food in Suisun Bay for delta and longfin smelt
15 by exporting organic material via tidal flow from the marsh plain and phytoplankton,
16 zooplankton, and other organisms produced in tidal channels into the Bay;
- 17 • locally provide areas of cool water refugia for delta smelt (C. Enright pers. comm.);
- 18 • reduce periodic low dissolved oxygen events associated with the discharge of waters
19 from lands managed as seasonal freshwater wetlands that would be restored as brackish
20 tidal habitat (Siegel 2007, C. Enright pers. comm.);
- 21 • increase the extent of habitat available for colonization by Suisun marsh aster and soft-
22 bird's beak; and
- 23 • enhance and increase the extent of salt marsh harvest mouse, California clapper rail, and
24 California black rail habitat.

25 *Adaptive management considerations*

26 Implementation of brackish tidal habitat restoration actions and subsequent management of
27 restored brackish tidal habitats by the Management Entity will be informed through effectiveness
28 monitoring that will be conducted for this conservation measure as described in Section 3.█,
29 *Monitoring and Research Plan*, and the adaptive management process described in Section 3.█,
30 *Adaptive Management Plan*. Based on analysis of monitoring results, likely elements of this
31 measure that could be adjusted through the adaptive management process include considerations
32 for selecting restoration locations and sequencing restoration of tidal habitat within Suisun Marsh
33 to maintain desirable salinity gradients; methods for establishing marsh plain vegetation,
34 including the establishment of marsh-associated covered plant species; methods and designs for
35 elevating subsided land surfaces to increase restored marsh plain area; design and location of
36 dike breaches; designs for encouraging the development of a high functioning network of tidal
37 channels; and non-native vegetation and wildlife control techniques.

38 **3.4.11 CM11 Channel Margin Habitat Enhancement**


1 The BDCP Management Entity will provide for the enhancement of 20 linear miles of channel
2 margin habitat in the Delta. This conservation measure is directed at improving habitat
3 conditions for covered fish species along Delta channel banks (as measured along one bank line
4 of channels) by improving channel geometry and restoring riparian, marsh, and mudflat habitats
5 along levees. Channel margin habitat will be enhanced only along channels that serve as
6 important rearing and outmigration habitat for juvenile salmonids. Although channel margin
7 enhancements are intended to provide specific benefits for salmonids, enhancement of these
8 habitats is also expected to improve or restore habitat for other species that inhabit channel
9 margin habitats. This measure will be implemented along channels protected by Project and/or
10 non-Project levees within the BDCP Planning Area. Based on results of effectiveness
11 monitoring for this conservation measure, the Management Entity may enhance up to an
12 additional 20 miles of channel margin through the adaptive management decision making
13 process. Any channel margin habitat enhanced above the 20 miles identified in this conservation
14 measure will be funded through surplus funds available through Plan implementation
15 efficiencies.

16 The following are the temporal targets for implementation of channel margin habitat
17 enhancements:

- 18 • At least 5 miles enhanced by year 10 of Plan implementation.
- 19 • At least 5 miles enhanced by year 20 of Plan implementation.
- 20 • At least 5 miles enhanced by year 25 of Plan implementation.
- 21 • At least 5 miles enhanced by year 30 of Plan implementation.

22 Actions to enhance channel margin habitats, as appropriate to site-specific conditions include,
23 but are not limited to:

- 24 • modifying levees or setting back levees to create low benches designed with variable
25 surface elevations to create hydrodynamic complexity and that support emergent
26 vegetation to provide an ecological gradient of habitat conditions, and higher elevation
27 benches that support riparian vegetation;
- 28 • planting riparian and emergent vegetation on created benches;
- 29 • installing large woody material (e.g., tree trunks and stumps) could be anchored into
30 constructed low benches or into existing riprapped levees to provide similar habitat
31 functions;
- 32 • removing riprap from channel margins where levees are setback to restore seasonally
33 inundated floodplain habitat (see cm 12); and
- 34 • modifying channel geometry in unconfined channel reaches or along channels where
35 levees are setback to restore seasonally inundated floodplain habitat (see cm 12) to create
36 backwater salmonid and splittail rearing and splittail spawning habitat.

37 A conceptual depiction of how channel margin habitat may be enhanced is presented in Figure
38 3. .

39 Because channel margin habitat enhancement is expected to require modification of levees that
40 serve flood control functions, channel margin habitat enhancements will be implemented such

1 that flood control functions are maintained or improved. The BDCP Management Entity will
2 coordinate channel margin habitat enhancement planning with the flood control planning efforts
3 of USACE, DWR, the Central Valley Flood Protection Board, and other flood control agencies
4 to assess the desirability and feasibility for channel modifications. Channel margin habitat
5 enhancements will be designed to support the ecological benefits for covered species described
6 below in *Hypothesized Benefits*.

7 Restoration variables that will be considered in the location and design of enhanced channel
8 margin habitat include:

- 9 • the length of habitat that can be practicably enhanced along channel margins;
- 10 • connectivity with existing channel margin habitats supporting high functioning salmonid
11 rearing habitat;
- 12 • the cross sectional profile of enhanced channels (elevation of habitat, topographic
13 diversity, width, variability in edge and bench surfaces, depth, and slope);
- 14 • the amount and distribution of installed woody debris along enhanced channel margins;
15 and
- 16 • the extent of shaded riverine aquatic overstory and understory vegetative cover needed to
17 provide future input of large woody debris.

18 Channel margin enhancement actions will be located along channels that serve as primary
19 rearing and outmigration habitat for juvenile salmonids. These locations include the Sacramento
20 River between Freeport and Walnut Grove, the San Joaquin River between Vernalis and
21 Mossdale, and Steamboat and Sutter Sloughs that are protected by Federal levees and salmonid
22 migration channels in the interior Delta, such as the North and South Forks of the Mokelumne
23 River, that are protected by non-Project levees. At least 5 miles of the 20 miles of channel
24 margin enhancement would be located along the Sacramento River and at least 5 miles along the
25 San Joaquin River. The remaining 10 miles of channel margin enhancement will be distributed
26 among the channels described above.

27 ***Problem Statement***

28 Primary Delta channels serve as movement corridors for the covered fish species and support
29 splittail spawning and salmonid, sturgeon, and splittail rearing habitat. These channels are now
30 leveed and, as such, channel margin habitats lack the diversity and complexity of habitat
31 conditions associated with unmodified channels. Increasing the diversity and complexity of
32 channel margin habitats is expected to increase their function as habitat for covered fish species.

33 ***Hypothesized Benefits***

34 Enhancement of channel margin habitat is hypothesized to provide the following ecosystem and
35 covered species benefits. As described in Appendix ■, *DRERIP Evaluations*, however, there
36 are a number of uncertainties regarding the level of benefits that may be provided by enhancing
37 channel margin habitat as well as risks for adverse consequences. These uncertainties will be
38 addressed through effectiveness monitoring, research, and the adaptive management program
39 (see Sections 3.■ and 3.■).

1 Enhancing channel margin habitats is expected to:

- 2 • increase the quality of rearing habitat area for Chinook salmon, sturgeon, and possibly
3 steelhead (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004,
4 Feyrer et al. 2006);
- 5 • reducing the risk for predation on covered fish species by non-native fish predators;
- 6 • increase the extent of shaded riverine aquatic cover and increase instream cover by
7 through contributions of instream woody material (USFWS 2004);
- 8 • increasing connectivity among salmonid rearing and outmigration habitat areas;
- 9 • provide inputs of organic material (e.g., leaf and twig drop) in support of aquatic
10 foodweb processes;
- 11 • increase production and export of terrestrial invertebrates into the aquatic ecosystem
12 (Nakano and Murakami 2001);
- 13 • create additional spawning habitat for Sacramento splittail by creating low velocity
14 backwater habitats (Sommer et al. 2001a, 2002, 2007b, 2008, Moyle 2002, Moyle et al.
15 2004, Feyrer et al. 2006); and
- 16 • create tidal mudflat substrate suitable for the establishment of Suisun Marsh aster,
17 Mason's lileopsis, delta mudwort, and delta tule pea.

18 Restoration of riparian forest and scrub that is incorporated into channel margin enhancements is
19 also expected to support habitat for Swainson's hawk, white-tailed kite, and potentially,
20 depending on vegetative structure and patch size, yellow-breasted chat and least Bell's vireo.

21 ***Adaptive Management Considerations***

22 Implementation of channel margin habitat enhancement actions by the Management Entity will
23 be informed through effectiveness monitoring that will be conducted for this conservation
24 measure as described in Section 3. **■**, *Monitoring and Research Plan*, and the adaptive
25 management process described in Section 3. **■**, *Adaptive Management Plan*. Based on analysis
26 of monitoring results, likely elements of this measure that could be adjusted through the adaptive
27 management process include adjusting the design of subsequent channel margin restoration
28 actions to improve habitat functions for covered fish species and increasing the effectiveness of
29 emergent and riparian vegetation establishment techniques.

30 **3.4.12 CM12. Riparian Habitat Restoration**

31 The BDCP Management Entity will restore at least 5,000 acres of riparian forest and scrub. It is
32 anticipated that riparian forest and scrub will be restored primarily in association with the
33 restoration of tidal and floodplain habitats and channel margin habitat enhancements. The
34 following are the temporal targets for riparian restoration:

- 35 • 1,300 acres restored within 10 years of Plan implementation
- 36 • 2,300 acres (cumulative) restored by year 15 of Plan implementation
- 37 • 5,000 acres (cumulative) restored by year 40 of Plan implementation

1 Anticipated actions to restore riparian forest and scrub, as appropriate to site-specific conditions,
2 include, but are not limited to:

- 3 • acquiring lands, in fee-title or through conservation easements, suitable for restoration of
4 riparian forest and scrub;
- 5 • allowing for the natural establishment of riparian vegetation;
- 6 • site preparation, planting of native riparian vegetation, and maintenance of plantings;
- 7 • irrigation of plantings; and
- 8 • control of non-native plants.

9 Patches of restored riparian forest and scrub are expected to support the range of riparian habitat
10 conditions necessary to support habitat for each of the riparian-associated covered wildlife
11 species. Once established, it is expected that restored riparian forest and scrub will be self-
12 sustaining and will be monitored to determine if subsequent management actions may be
13 required to ensure successful regeneration of native riparian plant species.

14 ***Riparian Restoration in Restored Floodplains***

15 To the extent consistent with flood control requirements, restored floodplain habitat areas (see
16 Figure 3.█ and CM 13) will allow for the natural establishment and growth of woody riparian
17 vegetation on portions of restored floodplains that support appropriate soils and hydrology and
18 along channels within restored floodplains. Restored floodplain riparian vegetation are expected
19 to establish in large extensive patches relative to the typically narrow stringers of riparian
20 vegetation that exist along channels and agricultural water conveyance features within much of
21 the Planning Area. Native riparian vegetation (e.g., Fremont cottonwood, Goodings' willow,
22 box elder) will be planted if site-specific restored floodplain conditions indicate that such
23 plantings will substantially increase the establishment of riparian forest and scrub. Elderberry
24 shrubs will be a component of such plantings to provide habitat for the longhorn elderberry
25 beetle. The development of riparian vegetation will be monitored to determine if non-native
26 vegetation needs to be controlled to facilitate the establishment of native riparian vegetation or if
27 restoration success could be improved with supplemental plantings of native riparian vegetation.
28 If indicated by monitoring, non-native vegetation control measures and supplemental plantings
29 will be implemented.

30 ***Riparian Restoration in Restored Tidal Habitats.***

31 Woody riparian vegetation will be allowed to naturally reestablish along the upper elevation
32 margins of restored tidal marsh habitats within ROAs (see Figure 3.█ and CM10) where soils
33 and hydrology are suitable, including segments of stream channels that drain into restored
34 marshes. Suitable soils for restoration are expected to be most extensive in the
35 Cosumnes/Mokelumne, East Delta, West Delta, and South Delta ROAs. In these ROAs, riparian
36 vegetation is expected to generally form as a band of riparian forest and scrub of variable width
37 depending on site-specific soil and hydrologic conditions between high marsh vegetation and
38 herbaceous uplands. Soil salinity in the Suisun Marsh ROA and extensive clayey soils in the
39 Cache Slough ROA are expected to limit the extent of riparian vegetation that will become
40 established. In these ROAs, riparian vegetation is expected to generally establish in narrow
41 stringers (e.g., along dikes) and small patches where suitable soil conditions are present.

1 Additionally, where conditions are appropriate woody riparian vegetation will be planted on new
2 levees that are constructed by the Management Entity within ROAs to provide for the restoration
3 of tidal habitat. As described for riparian restored in floodplains, native riparian vegetation may
4 planted to initiate establishment of riparian forest and scrub and restoration areas will be
5 monitored to determine the need for vegetation control and supplemental plantings.

6 ***Riparian Restoration on Channel Margins***

7 Where compatible with site-specific channel margin habitat objectives, native woody riparian
8 vegetation, including elderberry shrubs, will be planted established along channel margins of
9 existing levees (see Figure 3. [redacted] and CM11) to enhance covered fish species habitat. Riparian
10 vegetation restored in these locations is expected to form narrow stringers of riparian forest and
11 scrub along enhanced channel margins.

12 ***Directed Riparian Restoration.*** At least 100 acres of the 5,000 acres of restored riparian forest
13 and scrub will be located in Conservation Zone 7 (see Figure 3. [redacted]) within or contiguous with
14 occupied riparian brush rabbit habitat along the San Joaquin River, Old River, and/or Middle
15 River. This restored habitat will be designed and managed to specifically support riparian scrub
16 with an open overstory that includes dense brush and thickets of wild rose, wild grape, and
17 blackberry that supports this species habitat.

18 ***Problem Statement***

19 Substantial reduction in the extent, distribution, and condition of Valley/foothill riparian
20 communities that historically occurred along the upper elevational margins of the Delta and
21 along natural levees along Delta and Suisun Marsh channels has reduced the extent and diversity
22 of valley/foothill riparian habitats for associated covered and other native species. Most existing
23 levees were not designed (e.g., steep banks, rip-rap) to incorporate riparian vegetation that
24 support habitat for covered fish and wildlife species and have created increased habitat for non-
25 native predatory fish and thus contribute to increased predation losses of covered fish species. A
26 lack of riparian habitat associated with existing and restored tidal aquatic and marsh habitats
27 limits the ecological benefits to fish and wildlife by limiting important ecological gradients and
28 ecosystem functions that a full suite of these habitats would provide. Restoring Valley/foothill
29 riparian habitats to establish a more natural ecological gradient extending from shallow subtidal
30 aquatic to upland transitional habitats is expected, along with BDCP conservation of other
31 natural communities, to increase the abundance and distribution of associated covered and other
32 native species, improve connectivity among habitat areas within and adjacent to the Planning
33 Area and Suisun Bay, improve genetic interchange among native riparian-associated species'
34 populations, and contribute to the long-term conservation of riparian-associated covered species.

35 ***Hypothesized Benefits***

36 Restoration of riparian forest and scrub is hypothesized to provide the following ecosystem and
37 covered species benefits described below. As described in Appendix [redacted], *DRERIP Evaluations*,
38 however, there are a number of uncertainties regarding the level of benefits that may be provided
39 by restored riparian habitats as well as risks for adverse consequences. These uncertainties will
40 be addressed through effectiveness monitoring, research, and the adaptive management program
41 (see Sections 3. [redacted] and 3. [redacted]).

1 Restoring riparian forest and scrub is expected to:

- 2 • provide inputs of organic material (e.g., leaf and twig drop) where riparian forest and
3 scrub is restored adjacent to channels resulting in increased production of phytoplankton,
4 zooplankton, and macroinvertebrates that serve as or support production food for covered
5 fish species;
- 6 • increase the extent of shaded riverine aquatic cover and increase instream cover where
7 riparian forest and scrub is restored adjacent to channels through contributions of
8 instream woody material (U.S. Fish and Wildlife Service 2004);
- 9 • increase in the production and export of terrestrial invertebrates into the aquatic
10 ecosystem (Nakano and Murakami 2001) where riparian forest and scrub is restored
11 adjacent to channels; and
- 12 • increase the extent of riparian brush rabbit, Swainson's hawk, white-tailed kite, yellow-
13 breasted chat, and valley elderberry longhorn beetle habitat; and
- 14 • increase the extent of least Bell's vireo, western yellow-billed cuckoo, and riparian
15 woodrat for potential future occupancy by these species through future expansion of their
16 range.

17 **Adaptive Management Considerations**

18 Implementation of riparian restoration actions and subsequent management of restored riparian
19 habitats by the Management Entity will be informed through effectiveness monitoring that will
20 be conducted for this conservation measure as described in Section 3.■, *Monitoring and*
21 *Research Plan*, and the adaptive management process described in Section 3.■, *Adaptive*
22 *Management Plan*. Based on analysis of monitoring results, likely elements of this measure that
23 could be adjusted through the adaptive management process include riparian vegetation
24 establishment methods, locations selected for restoration of riparian forest and scrub, and post-
25 restoration management actions that may be need to be implemented to ensure that intended
26 habitat functions of restored riparian habitats are maintained over time.

27 **3.4.13 CM13 Seasonally Inundated Floodplain Restoration**

28 The BDCP Management Entity will provide for the restoration of at least 10,000 acres of
29 seasonally inundated floodplain habitat within the north, east, and/or south Delta. Because of the
30 long-lead time needed to plan for and implement floodplain restoration it is not expected that
31 new floodplain would be restored in the first 10 years of Plan implementation. The following are
32 the temporal targets for seasonally inundated floodplain restoration:

- 33 • At least 1,000 acres restored by year 15 of plan implementation.
- 34 • 10,000 acres (cumulative) restored by year 40 of plan implementation.

35 Although seasonally inundated floodplain may be restored along channels in many locations in
36 the north, east, and south Delta, the most promising opportunities for large-scale restoration are
37 in the south Delta along the San Joaquin River, Old River, and Middle River channels based on
38 benefits to covered fish species, practicability considerations, and compatibility with potential
39 flood control projects. Criteria that will be considered in selecting seasonally inundated
40 floodplain restoration sites include:

- 1 • relative importance of the adjacent channel as migration pathways for juvenile salmonids;
- 2 • estimated frequency and duration of inundation periods; and
- 3 • compatibility with flood control programs and level of flood control benefits provided
- 4 relative to other potential restoration sites.

5 Actions to restore seasonally inundated floodplain habitats, as appropriate to site-specific
6 conditions, include but are not limited to:

- 7 • acquiring lands, in fee-title or through conservation easements, suitable for restoration of
- 8 seasonally inundated floodplain;
- 9 • setting back levees along the selected river corridor and removing the existing levees or
- 10 sections of the existing levees;
- 11 • removing existing riprap along channel banks to allow for channel meander between the
- 12 set-back levees through the natural processes of erosion and sedimentation;
- 13 • grading restored floodplain surfaces to provide for drainage of over bank flood waters
- 14 such that the potential for fish stranding is minimized ;
- 15 • lowering the elevation of restored floodplain surfaces to increase inundation frequency
- 16 and duration and to establish elevations suitable for the establishment of riparian
- 17 vegetation;
- 18 • discontinuing farming within the setback levees and allowing riparian vegetation to
- 19 naturally establish on the floodplain;
- 20 • where farming is continued consistent with achieving biological and flood control
- 21 objectives, engaging in farming practices and crop types that provide high benefits for
- 22 covered fish species; and
- 23 • actively establishing riparian habitat where necessary to accelerate formation of habitat
- 24 for specific covered species (see the description of CM 12).

25 Measures for addressing the potential for methylation of mercury in restored tidal habitats will be
26 addressed through implementation of CM8, *Methylmercury*.

27 A conceptual illustration of restored seasonally inundated floodplain is presented in Figure
28 3. Because restoration requires modification of levees that serve flood control functions,
29 restored floodplain habitats will be implemented such that flood control functions are maintained
30 or improved. The BDCP Management Entity will coordinate floodplain restoration planning
31 with the flood control planning efforts of USACE, DWR, the Central Valley Flood Protection
32 Board, and other flood control agencies to assess the desirability and feasibility for setting back
33 levees in potentially suitable locations. Seasonally inundated floodplain habitat will be designed
34 to support the physical and biological attributes described below in *Seasonally Inundated*
35 *Floodplain Habitat Restoration Concepts* and to provide the ecological benefits for covered
36 species described below in *Hypothesized Benefits*.

37 ***Seasonally Inundated Floodplain Habitat Restoration Concepts***

38 Restoration variables that will be considered in the design of restored seasonally inundated
39 floodplain habitat include:

- 1 • modeled timing, duration, interannual frequency, and spatial extent of inundation;
- 2 • connectivity with tidal marsh and channel habitats,
- 3 • accessibility to migrating fish,
- 4 • stranding risk and effects on fish passage,
- 5 • vegetation type and cover,
- 6 • dry season land use (compatible farming practices), and
- 7 • topography and slope.

8 Restored seasonally inundated floodplain habitats would be designed to support habitat for the
9 covered species indicated in Table 3.1. Restoration design considerations for seasonally
10 inundated floodplain habitat include the following.

11 **Floodplain Topography.** Where appropriate, the topography of restored floodplains would be
12 sculpted to reduce the risk for fish stranding by improving drainage and to provide topographic
13 variability to increase hydrodynamic complexity. **Connectivity.** Where suitable landform is
14 present, restored floodplains will be located and designed such that flows exiting the floodplain
15 would pass through existing or restored tidal marsh to recreate historical landscape relationships
16 and to provide for connectivity with adjacent uplands that result in transitional habitats and
17 accommodate species movement.

18 **Dry Floodplain Conditions.** Restored floodplains will be managed for ongoing agricultural uses
19 or to support native wildlife habitats. Farmed floodplains will be managed to minimize the use
20 of persistent herbicides and pesticides that are toxic to aquatic organisms and to provide structure
21 and types of residual crop biomass to provide cover and hydrodynamic complexity for fish and
22 provide sources of organic carbon in support of aquatic food web processes during inundation
23 periods. To the extent consistent with floodplain land uses and flood control requirements, if
24 applicable, woody riparian vegetation will be allowed to naturally establish. Established woody
25 riparian vegetation would support habitat for riparian-associated covered species and provide
26 cover and hydrodynamic complexity for covered fish species during inundation periods.
27 Riparian vegetation would also serve as sources of instream woody material for fish habitat,
28 organic carbon in support of the aquatic food web, and macroinvertebrates (e.g., insects) that
29 provide food for covered fish species.

30 **Problem Statement**

31 Extensive channelization and levee construction has disconnected river channels from their
32 historical floodplains over much of the Central Valley, including the Planning Area, resulting in
33 substantial reduction in the availability of high functioning spawning and rearing habitats that
34 historically support several of the covered fish species. Restoring connectivity of Delta river
35 channels to their historical floodplains will substantially increase the extent of floodplain that can
36 be inundated by overbank flows, thus restoring high functioning spawning and rearing habitat for
37 Sacramento splittail and rearing habitat for salmonids.

38 **Hypothesized Benefits**

1 Restoration of seasonally inundated floodplain habitat is hypothesized to provide the ecosystem
2 and covered species benefits described below. As described in Appendix **■**, *DRERIP*
3 *Evaluations*, however, there are a number of uncertainties regarding the level of benefits that
4 may be provided by restored floodplain habitats as well as risks for adverse consequences.
5 These uncertainties will be addressed through effectiveness monitoring, research, and the
6 adaptive management program (see Sections 3. **■** and 3. **■**).

7 Restoring seasonally inundated floodplain habitat is expected to:

- 8 • increase spawning habitat for Sacramento splittail by expanding floodplain habitat area
9 and providing in-channel spawning habitat by creating backwaters (Sommer et al. 2001a,
10 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006);
- 11 • depending on the location of restored floodplain, increase rearing habitat for Sacramento
12 and San Joaquin Basin runs of Chinook salmon, Sacramento splittail, and possibly
13 steelhead (Sommer et al. 2001a,b, 2002, 2007, 2008, Moyle 2002, Moyle et al. 2004,
14 Feyrer et al. 2006);
- 15 • increase the production of food for rearing salmonids, splittail, and other covered species
16 (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al.
17 2006);
- 18 • increase the availability and production of food in Delta channels downstream of restored
19 floodplain habitat for delta smelt, longfin smelt, and other covered species by exporting
20 organic material and phytoplankton, zooplankton, and other organisms produced from the
21 inundated floodplain into Delta channels (Mitsch and Gosselink 2000, Moss 2007); and
- 22 • depending on the location of restored floodplain, increase habitat area for the
23 establishment of slough thistle and delta button-celery.

24 **Adaptive Management Considerations**

25 Implementation of seasonally inundated floodplain restoration actions and subsequent
26 management of restored floodplain habitats by the Management Entity will be informed through
27 effectiveness monitoring that will be conducted for this conservation measure as described in
28 Section 3. **■**, *Monitoring and Research Plan*, and the adaptive management process described in
29 Section 3. **■**, *Adaptive Management Plan*. Based on analysis of monitoring results, likely
30 elements of this measure that could be adjusted through the adaptive management process
31 include modifications to floodplain surfaces to increase inundation frequency and duration,
32 reduce the potential for fish stranding, and changes in floodplain vegetation to increase functions
33 related to food production and habitat conditions during periods of inundation.

34 **3.4.14 CM14. Fremont Weir/Yolo Bypass Habitat Improvements**

35 This conservation measure is to develop and implement a plan to enhance the Yolo Bypass as
36 floodplain habitat for spawning and rearing splittail and rearing habitat of juvenile Sacramento
37 River salmonids, by modifying the Fremont Weir and Yolo Bypass and operate the Fremont
38 Weir to increase the availability of floodplain habitat, increase food production on and
39 downstream of the Yolo Bypass, and improve fish passage in and near the Yolo Bypass. The
40 plan will be prepared with input from local stakeholders. The Fremont Weir and Yolo Bypass
41 (Figure 3. **■**) will be physically modified and operated to: (1) improve rearing and spawning

1 habitat for splittail and rearing habitat for salmonids, (2) provide for a higher frequency and
2 duration of inundation of the Yolo Bypass and (3) improve fish passage into Putah Creek
3 through the Yolo Bypass, and past the Fremont and/or Sacramento weirs. There are 9 specific
4 physical modifications aimed at achieving one or more of these purposes:

- 5 1. Fremont Weir Elevation Reduction. To increase the interannual frequency and duration
6 of inundation of floodplain habitat in the Yolo Bypass, approximately 900 feet of the
7 Fremont Weir will be removed and soil beneath it will be excavated to an elevation of
8 17.5 feet (NAVD88). The remaining notch will be fitted with operable “inundation
9 gates” that will allow controlled flow into the Yolo Bypass when the Sacramento River
10 stage at the weir exceeds 17.5 feet (Figure 3.█). The operable gates will be designed
11 and operated to provide for the efficient upstream and downstream passage of salmonids,
12 sturgeon, and lamprey between the Yolo Bypass and the Sacramento River. An
13 “inundation channel” will be excavated from the Sacramento River to the new inundation
14 gates and from the inundation gates to the Tule Canal to convey water from the
15 Sacramento River, through the gates, and to the Tule Canal. A guidance structure in the
16 Sacramento River in the vicinity of the inundation channel may be constructed, if needed,
17 to encourage the passage of juvenile salmonids migrating down the Sacramento River
18 into the Bypass.

19 Infrastructure associated with operations of and access to Fremont Weir gates may
20 include electrical connectivity, gravel road and parking lot improvements, and a bridge
21 over gates. In addition, levee improvements may be needed to ensure that channel
22 deepening adjacent to existing levees do not undermine the levees. If necessary, lands
23 will be acquired, in fee-title and through conservation or flood easements.

- 24 2. Deep Fish Passage Channel. To enhance adult fish passage at Sacramento River stage
25 below 17.5 feet, the bottom elevation of the “inundation channel,” a much smaller section
26 of the Fremont Weir will be removed and the soil beneath it will be excavated to an
27 elevation of 11.5 feet (NAVD88) (Figure 3.█). The remaining notch will be fitted with
28 operable “fish passage gates” that will allow controlled flow into the Yolo Bypass when
29 the Sacramento River stage is between 11.5 and 17.5 feet (NAVD88). A deeper “fish
30 passage channel” will be excavated to convey water from the Sacramento River to the
31 new fish passage gates, and from the fish passage gates to the Tule Canal to convey water
32 from the Sacramento River, through the gates, and to the Tule Canal.

- 33 3. Yolo Bypass Modification. Grading, removal of existing berms, levees, and water
34 control structures, construction of berms or levees, re-working of agricultural delivery
35 channels, and earthwork or construction of structures to reduce Tule Canal/Toe Drain
36 channel capacities will occur to the extent necessary to improve the distribution (e.g.,
37 wetted area) and hydrodynamic characteristics (e.g., residence times, flow ramping, and
38 recession) of water moving through the Yolo Bypass. These actions would allow water
39 to inundate in certain areas to maximize biological benefits and keep water away from
40 other areas to reduce stranding of covered fish species in isolated ponds, minimize
41 impacts to terrestrial covered species, including giant garter snake, and accommodate
42 other existing land uses (e.g., wildlife, public, and agricultural use areas). If necessary,
43 lands will be acquired, in fee-title and through conservation or flood easements.

- 1 4. Fremont Weir Fish Ladder Replacement. The existing Fremont Weir Denil fish ladder
2 will be removed and replaced with new experimental fish passage facilities designed to
3 allow for the effective passage of adult salmonids from the Yolo Bypass past the Fremont
4 Weir and into the Sacramento River when the river overtops the weir.
- 5 5. Experimental Sturgeon Ramps. ■ experimental ramps will be constructed at the
6 Fremont Weir to allow for the effective passage of adult sturgeon and lamprey from the
7 Yolo Bypass over the Fremont Weir and into the Sacramento River when the river
8 overtops the weir by approximately 3 feet (Figure 3.■). Specific design criteria of ramps
9 have not yet been determined.
- 10 6. Stilling Basin Modification. Modifications will be made to the existing Fremont Weir
11 stilling basin to ensure that the basin drains sufficiently into the deep fish passage
12 channel. Effective drainage of the stilling basin will prevent stranding of juvenile and
13 adult fish that are attracted to pooled water in the stilling basin during drainage of the
14 floodplain.
- 15 7. Sacramento Weir Improvements. Improve the Sacramento Weir structure to reduce
16 leakage and therefore reduce attraction of fish from the Yolo Bypass to the weir.
17 Evaluate in the plan development process and determine the benefits and necessity of
18 constructing fish passage facilities at the Sacramento Weir to reduce juvenile fish
19 stranding and improve upstream adult fish passage. This action may require excavation
20 of a channel to convey water from the Sacramento River to the Sacramento Weir and
21 from the Sacramento Weir to the Tule Canal/Toe Drain, construction of new gates at a
22 portion of the weir, and minor modifications to the stilling basin of the weir to ensure
23 proper basin drainage.
- 24 8. Tule Canal/Toe Drain Improvements. In the context of providing passage as part of a
25 Fremont Weir notch or improvements to the Sacramento Weir, improve the hydrologic
26 connectivity of the Tule Canal/Toe Drain by identifying and modifying passage
27 impediments, including road crossings and agricultural impoundments, to reduce the
28 delay, stranding, and loss of immigrating and emigrating Chinook salmon and steelhead,
29 and emigrating green and white sturgeon in the Yolo Bypass. Three existing structures at
30 the northern end of the Tule Canal will be replaced by bridges or other structures to allow
31 fish passage. Lisbon Weir will be redesigned to improve fish passage while maintaining
32 or improving water capture efficiency for irrigation.
- 33 9. Lower Putah Creek Improvements. Lower Putah Creek will be realigned to improve
34 upstream and downstream passage of Chinook salmon and steelhead in Putah Creek and
35 floodplain habitat will be restored to provide benefits of seasonal floodplain habitat
36 identified in CM13.

37 To implement this conservation measure, the BDCP Implementing Entity will coordinate with
38 the U.S. Army Corps of Engineers, DWR, reclamation districts, and other flood control entities,
39 as appropriate, to ensure that fish passage improvements, bypass improvements, and Fremont
40 Weir improvements and operations are compatible with the flood control functions of the Yolo
41 Bypass. The BDCP Implementing Entity will coordinate with Yolo and Solano counties in
42 developing the design of Fremont Weir and Yolo Bypass modifications.

1 Sacramento River flow that enters the Yolo Bypass at Fremont Weir re-enters the Sacramento
 2 River in the Cache Slough area near Rio Vista. Thus, operation of new weir gates affect flows
 3 that support environmental benefits in the mainstem Sacramento River between the Fremont
 4 Weir and Rio Vista, Sutter and Steamboat sloughs, and the Central Delta via the Delta Cross
 5 Channel and Georgiana Slough. Proposed operations are intended to provide substantial benefits
 6 from increasing the frequency and duration of Yolo Bypass inundation with a minimum of
 7 potential adverse effects from lower flows in the mainstem Sacramento River between and its
 8 distributaries.

9 **Operational Criteria and Adaptive Limits**

10 The modified Fremont Weir will be operated to manage the timing and increase the frequency
 11 and duration of inundation of a portion of the Yolo Bypass (Figure 3.4) with Sacramento River
 12 flows via the Fremont Weir to support the physical and biological attributes described in CM13.

13 The principal concept for operating the Fremont Weir is to allow the hydrology of the
 14 Sacramento River system to drive inundation timing, frequency, and duration in the Yolo Bypass
 15 within the period of December 1 through March 31 (with occasional extension to May 15,
 16 depending on hydrologic conditions and measures to minimize land use and ecological conflicts)
 17 at the reduced weir elevation of 17.5 feet. Target flows into the bypass will be 3,000-6,000 cfs.
 18 Gates will be operated to limit spills to a maximum of 6,000 cfs when the Sacramento River is
 19 not spilling over the 33 foot crest of the weir. However, no management of the gates will occur
 20 to limit lower flows (e.g., <3,000 cfs) except under rare situations as determined by the BDCP
 21 Implementing Entity when inundation could cause more harm than benefit to covered species.
 22 Gates would remain closed in such situations.

23 The criteria for non-flood stage operation of new Fremont Weir inundation and fish passage
 24 gates are described in Table 3.##.

25 Preliminary Hydrologic Engineering Centers River Analysis System (HEC-RAS) modeling
 26 indicates that flow rates of 3,000-6,000 cfs will inundate between 11,000-21,500 acres of
 27 floodplain habitat in the Bypass in its current condition to an average depth of 2.6-3.9 feet and a
 28 mean velocity of 1.26-1.77 ft/s (Table 3.##, Figure 3.##). The frequency of Fremont Weir spills
 29 of at least 30 days at 3,000 cfs between 1984 and 2007 would be over 100% greater with a
 30 modified weir height of 17.5 feet (NAVD88) compared to the existing weir height of 33 feet
 31 (NAVD88) (current weir height: 9 times [8 water years] in 25 water years; weir with proposed
 32 elevational change: 19 times [14 water years] in 25 water years) (Table 3.##). Once the targeted
 33 duration of inundation is achieved and the river is below the top of the Fremont Weir, the weir
 34 gates could be operated to reduce diversion of flow from the Sacramento River to allow for
 35 drainage of the Bypass while still allowing for fish passage. The basic flood control functions of
 36 the Fremont Weir will not be changed; at flood stage, the weir will overtop as it does currently.

Table 3.##. HEC-RAS model results for depth, area mean velocity and travel time for flows between 3,000 and 6,000 cfs at the modified Fremont Weir.

<i>Flow (cfs)</i>	<i>Mean Depth¹ (ft)</i>	<i>Surface Area² (Acres)</i>	<i>Mean Velocity (ft/s)</i>	<i>Travel Time (d)</i>
3,000	3.9	11,000	1.77	4.2
4,000	2.8	15,900	1.49	4.2
5,000	2.6	18,600	1.32	4.0

6,000	2.6	21,500	1.26	3.9
<i>Notes:</i> 1. Calculated for the Entire Yolo Bypass, including the Toe Drain/Tule Canal 2. Calculated from GIS mapping				

Table 3.##. Number of events (number of water years¹ in which events took place in parentheses) with consecutive spills producing² at least 3,000 cfs over the Fremont Weir under current (elevation = 33 ft NAVD88) and weir with proposed elevational change (elevation 17.5 ft NAVD88) conditions.

	<i>Events during Water Years 1984-2008³</i>		<i>Events during Water Years 1929-2008³</i>	
	Current Weir	Proposed Notch	Current Weir	Proposed Notch
Less than 30 days	17 (10)	42 (20)	48 (29)	137 (62)
At least 30 days	9 (9)	18 (14)	11 (10)	70 (52)
At least 45 days	4 (4)	11 (11)	5 (5)	46 (41)
<i>Notes:</i> 1. Water Year is defined as August 1 of the previous year through July 31 of the current year. For example, Water Year 2005 is August 1, 2004 to July 31, 2005. 2. Assumes no more than a 7 day gap in flooding to count as the same event 3. Flows between October 1, 1929 and December 31, 1983 have been reconstructed from the hydrologic record				

1 **Problem Statement**

2 The majority of historical floodplain in the Sacramento and San Joaquin River systems have
 3 been lost, particularly floodplains that flow directly into the Delta. This loss of floodplains has
 4 resulted in a reduction of highly productive rearing habitat for juvenile salmon and spawning and
 5 rearing habitat for other native species such as splittail. Loss of floodplain habitat has reduced
 6 the seasonal input of organic and inorganic material and food resources into adjoining riverine
 7 habitat and the downstream bay and estuary. Inundation of the Yolo Bypass from the
 8 Sacramento River is currently limited to times when the Fremont Weir is overtopped, limiting
 9 the availability of habitat for covered fish species and inputs to the food web from the Yolo
 10 Bypass.

11 Many aspects of the current configuration of the Yolo Bypass and Fremont Weir create passage
 12 impediments for Chinook salmon, steelhead, green and white sturgeon, and river and Pacific
 13 lamprey and stranding hazards for juvenile Sacramento splittail, Chinook salmon, and steelhead.
 14 First, the Denil fish ladder at the Fremont Weir, designed for adult salmonid passage, is not
 15 effective at passing adult sturgeon and lamprey. Second, the stilling basins downstream of the
 16 Sacramento and Fremont weirs have higher stranding rates of juvenile Chinook salmon than do
 17 earthen ponds as floodwater recedes (Sommer et al. 2005). Third, there are road crossings and
 18 agricultural impoundments in the Tule Canal/Toe Drain that block hydrologic connectivity, and
 19 therefore, fish passage. Fourth, the Lisbon Weir, which was built to impound agricultural water
 20 in the Toe Drain upstream of the weir, creates a passage impediment for fish at low stage when
 21 riprap is exposed or shallowly submerged.

22 Putah Creek is used for spawning habitat by a small population of Chinook salmon and
 23 steelhead. The Los Rios Check Dam, an irrigation impoundment structure, is seasonally
 24 removed but remains in place for several months while adult salmon and steelhead are
 25 attempting to migrate upstream. The reach of channel downstream of the check dam runs
 26 through a straight ditch to the Toe Drain. Putah Creek often breaks through its bank a short

1 distance upstream of the Los Rios Check Dam, requiring periodic road maintenance at the Yolo
2 Bypass Wildlife Area.

3 **Hypothesized Benefits**

4 Modifying the Fremont Weir and its operations and improving fish passage will reduce the
5 adverse effects of stressors related to food availability, habitat availability, passage, harvest,
6 stranding, predation, and entrainment for the covered fish species. Specifically, this conservation
7 measure will:

- 8 • create additional spawning habitat for Sacramento splittail (Sommer et al. 2001a, 2002,
9 2007b, 2008, Moyle 2002, Moyle et al. 2004, Feyrer et al. 2006). Because splittail are
10 primarily floodplain spawners, successful spawning is predicted to increase with
11 increased floodplain inundation;
- 12 • create additional juvenile rearing habitat for Chinook salmon, Sacramento splittail, and
13 possibly steelhead (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al.
14 2004, Feyrer et al. 2006). Growth and survival of larval and juvenile fish is higher in the
15 floodplain compared to those rearing in the mainstem Sacramento River (Sommer et al.
16 2001b);
- 17 • increase downstream juvenile passage of Chinook salmon, Sacramento splittail, river and
18 Pacific lamprey, and possibly steelhead. An inundated Yolo Bypass is used as an
19 alternative to the mainstem Sacramento River for downstream migration of salmonids,
20 splittail, river lamprey, and sturgeon. Sommer et al. (2003, 2004a) found that, other than
21 steelhead and Pacific lamprey, juveniles from all of these species inhabit the Yolo Bypass
22 during periods of inundation. Based on the timing and life history traits of steelhead
23 relative to Chinook salmon, steelhead likely also benefit from inhabiting the Yolo
24 Bypass. Similarly, based on the timing and life history traits of Pacific lamprey relative
25 to river lamprey, Pacific lamprey likely also benefit from inhabiting the Yolo Bypass
- 26 • increase adult upstream passage of fall-, late fall-, winter-, and spring-run Chinook
27 salmon, steelhead, green and white sturgeon, and river and Pacific lamprey. It is thought
28 that an inundated Yolo Bypass is used as an alternative route by upstream migrating
29 adults of these species;
- 30 • increase food production for rearing salmonids, splittail, and other covered species on the
31 floodplain (Sommer et al. 2001a,b, 2002, 2007b, 2008, Moyle 2002, Moyle et al. 2004,
32 Feyrer et al. 2006). During periods when the bypass is flooded, there is relatively high
33 production of zooplankton and macroinvertebrates that serve, in part, as the forage base
34 for many of the covered fish species (Benigno and Sommer 2008);
- 35 • increase the availability and production of food in the Delta, Suisun Marsh, and bays
36 downstream of the bypass, including restored habitat in Cache Slough, for delta smelt,
37 longfin smelt, and other covered species by exporting organic material and
38 phytoplankton, zooplankton, and other organisms produced from the inundated
39 floodplain into the Delta (Schemel et al 1996, Jassby and Cloern 2000, Mitsch and
40 Gosselink 2000, Moss 2007, Lehman et al. 2008). The co-occurrence of suitable food
41 supplies (zooplankton) and various life stages of delta smelt (e.g., larval and juvenile life
42 stages) has been identified as an important factor affecting delta smelt survival and

1 abundance (Feyrer et al. 2007b, Miller 2007b). The relationship between longfin smelt
2 abundance and Delta outflow has experienced two step-declines: one after the invasion of
3 *Corbula* and one during the POD years, although the slope of the relationship has not
4 changed, suggesting that longfin smelt are food-limited (Baxter et al. 2008). Hobbs et al.
5 (2006) found evidence of food limitation in early-stage juvenile longfin smelt, although
6 spatially and temporally variable;

- 7 • increase the duration that the floodplain is inundated during periods that the Yolo Bypass
8 is receiving water from both the Fremont Weir and the westside tributaries (e.g., Cache
9 and Putah Creeks);
- 10 • reduce losses of adult Chinook salmon, sturgeon, and other fish species to stranding and
11 illegal harvest by improving upstream passage at the Fremont Weir. When flows in the
12 Sacramento River recede, the Fremont Weir stops spilling, trapping fish downstream of
13 the weir. Many of these fish remain in the shallow water near the weir, providing easy
14 access to illegal harvesters. Under this conservation measure, the Fremont Weir will be
15 modified to avoid stranding if Sacramento River flows recede;
- 16 • reduce the exposure and risk of outmigrating juvenile fish migrating from the Sacramento
17 River into the interior Delta through the Delta Cross Channel and Georgiana Slough, thus
18 decreasing the risk for predation losses (Brandes and McLean 2001);
- 19 • reduce the exposure of outmigrating juvenile fish to entrainment at intakes of the
20 proposed north Delta water diversion facilities by passing juvenile fish into the Yolo
21 Bypass upstream of the proposed intake locations; and
- 22 • improve fish passage, and possibly increase and improve seasonal floodplain habitat
23 availability, by retrofitting Los Rios Check Dam with a fish ladder, or creating another,
24 fish-passable route for water from Putah Creek to reach the Toe Drain.

25 Increasing the frequency and duration of inundation within the Yolo Bypass is the largest
26 opportunity for enhancing inundated floodplain habitat in the north Delta. The Yolo Bypass
27 provides the only opportunity for increasing the frequency and duration of inundation of a
28 floodplain in the Planning Area without restoration of historical floodplain surfaces presently in
29 more highly developed, year-round land uses.

30 ***Adaptive Management Considerations***

31 Implementation of this conservation measure by the Management Entity will be informed
32 through effectiveness monitoring that will be conducted as described in Section 3. , *Monitoring*
33 *and Research Plan*, and the adaptive management process described in Section 3. , *Adaptive*
34 *Management Plan*. Results of both biological and operational monitoring in the Yolo Bypass
35 and the mainstem Sacramento River will be used within the BDCP adaptive management
36 framework to refine and modify Fremont Weir operations and fish passage improvements.