APPENDIX I

California Department of Fish and Wildlife

Proposal for Project Alternative 4

ALTERNATIVE 4 – ALTERNATIVE SUMMER-FALL ACTION

This alternative decribes operations for Delta smelt habitat during the summer and fall that would replace the summer-fall action described in Section 3.3.3 of the Proposed Project. The objective of this alternative is to provide continuous habitat availability in areas of Suisun Bay and Suisun Marsh where complex habitat features and cooler waters can be readily accessed and utilized by Delta smelt.

The IEP-MAST (2015) conceptual model describes the transition probability between life stages of Delta smelt. The transition probability of juveniles to subadults is hypothesized to be driven by specific habitat attributes including water temperature, predation risk, toxicity from harmful algal blooms, and food availability and quality. These same habitat attributes are hypothesized to drive the transition probability from subadults to adults in the fall period, in addition to toxicity related to contaminants and the size and location of the low salinity zone. As the low salinity zone moves westward, stress associated with these habitat attributes during the summer and fall generally decreases.

As referenced in the IEP-MAST (2015), water temperature is known to affect the survival of juvenile and sub adult Delta smelt through the summer and fall periods. Komoroske, Connon et al. (2014) found that juveniles exhibit lower warming tolerance compared to other life stages. During the summer months juveniles are exposed to water temperatures closer to their Critical Thermal Maximum (CTM) and Maximum Chronic Lethal Temperature (CLT) and can be exposed to temperatures above their CTM in the wild. Komoroske, Connon et al. (2014) also found that proportional survival of adults in the laboratory begins to rapidly decline as water temperatures exceed 25°C, with lethal temperatures occurring at approximately 28^{o}C. These results indicate that small differences in temperature (± 1^{o}C) under warmer conditions can have substantial impacts on survival.

In addition, recent findings demonstrate that Delta smelt may be experience sub-lethal impacts when exposed to temperatures lower than 25-28^{o}C. In laboratory conditions Delta smelt exhibited potentially deleterious behavioral responses when exposed to persistent elevated temperatures greater than or equal to 21°C (Davis, Hansen et al. 2019), indicating that sublethal effects can begin to occur before water temperatures reach 25^{o}C. Findings from a retrospective analysis of historic temperature data (1975-2012) show that the coolest average and maximum temperatures occurred in Suisun Bay and San Pablo Bay during the July to August period (average 19-21^{o}C, maximum 24^{o}C) while the western Delta was slightly warmer (average 21-23 °C, maximum 25 °C) (IEP-MAST 2015). These data indicate that the western portions of Suisun will generally provide the coolest water temperatures relative to other upstream regions.

Turbidity is also an important Delta smelt habitat attribute during the summer and fall. Increased turbidity has been hypothesized to increase survival and reduce Delta smelt predation risk. Turbidity is generally hypothesized to be higher in Suisun relative to upstream regions where dynamic variables, such as wind (Rhul and Schoellhamer 2004), interact with high levels of baythmetric complexity and increased erodible sediment supply (Brown, Baxter et al. (2014).

Salinity is also an important Delta smelt habitat attribute. Komoroske, Connon et al. (2014) found that Delta smelt mortality in the laboratory was greatest at high salinities (34 ppt) with little difference between 2 ppt and 18 ppt treatments. However, Baskerville-Bridges, Linderberg et al. (2004) found

that Delta smelt experienced increased osmoregulatory stress in the laboratory at salinities greater than 12 ppt, and optimal performance occurred at low salinities (0-6 ppt) and low turbidity (<120 NTU). In the wild, low salinity zone habitat for Delta smelt is defined as areas with salinities ≥ 0.5 PSU but ≤ 6 PSU. Although a subset of the population occupies fresh water regions of the Sacramento Deep Water Ship Channel, recent otolith analyses indicate that the majority of the Delta smelt population typically occupies habitats with salinities > 0.5 PSU during the summer-fall period of most years (Bush 2017). Therefore, managing the location of low salinity habitat during the summer and fall period is important for survival of the population, as it creates access to cooler waters with higher turbidities that are within a salinity range that aligns with optimal conditions for Delta smelt.

Alternative 4 is based on the conceptual model of Delta smelt life history described in the IEP MAST (2015) report and attempts to align low salinity habitat with downstream areas that maintain better conditions for Delta smelt, such as cooler water temperatures. This conceptual model is similar to that described in Brown, Baxter et al. (2014) where a mixture of stationary and dynamic habitat attributes interact to produce conditions which are preferable to Delta smelt during the fall. Alternative 4 also considers recent findings from the 2017 water year, where summer water temperatures became a limiting factor prior to implementation of the fall flow action. This alternative provides suitable habitat conditions for Delta smelt during summer months of most years when survival can be substantially influenced by relatively small changes in abiotic conditions, such as water temperature (Komoroske, Connon et al. 2014).

Table 5-ALT4 summarizes the environmental and operational requirements of Alternative 4 during different water year types.

Table 5-ALT4. Summary of Summer-Fall Actions Proposed for Alternative 4

Season Actions	Month	Critically Dry Water Year	Dry Water Year	Below Normal Water Year	Above Normal Water Year	Wet Water Year
Summer Actions	June	N/A	Up to 60 days of SMSCG operation	X2 < 80, monthly average and Up to 60 days of SMSCG operation	X2 < 80, 14-day average	X2 < 80, 14-day average
Summer Actions	July	N/A	Up to 60 days of SMSCG operation	X2 < 80, monthly average and Up to 60 days of SMSCG operation	X2 < 80 14-day average	X2 < 80, 14-day average
Summer Actions	August	N/A	Up to 60 days of SMSCG operation	X2 < 80, monthly average and Up to 60 days of SMSCG operation	X2 < 80 14-day average	X2 < 80, 14-day average
Fall Actions	September	N/A	N/A1	N/A1	X2 < 80, monthly average	X2 < preceding August, monthly average
Fall Actions	October	N/A	N/A1	N/A1	X2 <, monthly average	X2 < preceding August, monthly average

Notes: 1. SMSCG operation could be extended into September if within the 60 day of operations. October operations of the SMSCG would be as described in Section 3.1.2.5.

Expanded descriptions of the operational and environmental criteria included in Alternative 4 and the rationale for the proposed criteria are provided below by water year type.

Wet years

- **Summer Months:** X2 ≤ 80 km on a 14-day running average for the months of June, July, and August. The 14-day average begins to run on June 1.
- **Rationale**: An analysis of the last 10 years shows that summer flows are achieving these conditions for June-August. This criterion is intended to safeguard beneficial low salinity habitat from compensatory water management strategies related to implementing outflow measures in September and October.
- **Fall Months:** Average monthly X2 ≤ to what occurred in preceding August for the months of September and October.

Above Normal Years

- **Summer Months:** X2 ≤ 80 km on a 14-day running average for the months of June, July, and August. The 14-day average begins to run on June 1.
- **Rationale**: Similar to the rationale for wet years, existing flows during these months will generally meet this objective. This criterion is intended to safeguard beneficial low salinity habitat from compensatory water management strategies related to implementing outflow measures in September and October.
- **Fall Months:** Average monthly X2 ≤ 80 km for the months of September and October.

Below Normal Years

- **Summer and Fall Months:** Based on advice from a real-time working group, and as approved by CDFW, average monthly X2 ≤ 80 km for the months of June, July, and August or up to 60 days of operation of the SMSCG, or a combination of both. Action can be extended into the Fall if within the 60-days of SMSCG operations.
- **Rationale**: An analysis of the last 10 years shows that summer flows in Below Normal years are sometimes naturally achieving an X2 more downstream of 80 km during June, July and August. Therefore, a real-time working group would be established during Below Normal years and meet regularly to determine whether an X2 objective or operation of the SMSCG is appropriate for June, July and August.
- **Objective**: The objective of this criteria is to maintain contiguous habitat through the North Delta Arch, by maintaining salinity ≤ to 4ppt on a daily average in June, July, and August at Beldon's Landing during gate operations and meeting D-1641 outflow requirement.

Dry Years

- **Summer and Fall Months:** Operation of the SMSCG for a period at least 60 days for the months of June, July, and August. A real-time working group will form in Dry years and meet regularly to

determine when operation of the SMSCG is appropriate. Action can be extended into September if within the 60-days of SMSCG operations.

- **Objective**: The objective of this criteria is to maintain contiguous habitat through the North Delta Arch, by maintaining salinity ≤ to 4ppt on a daily average in June, July, and August at Beldon's Landing during gate operations and meeting D-1641 outflow requirement.

AQUATIC RESOURCES

- Algal blooms – not likely to be different from proposed project.
- Predation
- Habitat extent/location

OTHER RESOURCES

References:

Baskerville-Bridges, B., J. Linderberg and S. Doroshov (2004). The effect of light intensity, alga concentration, and prey density on the feeding behavior of delta smelt larvae. In American Fisheries Society Symposium 39, August 20-23 2003, Santa Cruz, CA. F. Feyrer, L. Brown, R. Brown and J. Orsi. American Fisheries Society, Bethesda, MD. pp 219-227.

Brown, L., R. Baxter, G. Castillo, L. Conrad, S. Culberson, G. Erickson, F. Feyrer, S. Fong, K. Gherts, L. Grimaldo, B. Herbold, J. Kirsch, A. Mueller-Solger, S. Slater, T. Sommer, K. Souza and E. Van Nieuwenhuyse (2014). Synthesis of Studies in the Fall Low-Salinity Zone of the San Fransisco Estuary, September - December 2011, U.S. Geological Survey Scientific Investigations Report. **2014-5041:** 136.

Bush, E. (2017). Migratory Life Histories and Early Growth of the Endangered Estuarine Delta Smelt. Masters of Science, University of California, Davis.

Davis, B., M. Hansen, D. Cocherell, T. Nguyen, T. Sommer, R. Baxter, N. Fangue and A. Todgham (2019). Consequences of temperature and temperature variability on swimming activity, group structure, and predation of endangered delta smelt, Freshwater Biology.

IEP-MAST (2015). An updated conceptual model of Delta smelt biology: our evolving understanding of an estuaarine fish. Interagency Ecological Program, Management, Anaylsis, and Synthesis Team (IEP). Sacramento, CA**:** 224.

Komoroske, L., R. Connon, J. Lindberg, B. Cheng, G. Castillo, M. Hasenbein and N. Fangue (2014). Ontogeny influences sensitivity to climate change stressors in an endangered fish, Conservation Physiology. **2**.