Chapter 6
Aquatic Biological Resources

The chapter is presented in its entirety from the Draft Environmental Impact Report (DEIR), with revisions to text presented as a strikethrough or underline. Text shown with a strikethrough has been deleted from the DEIR. Text that has been added is presented as single underlined. Deleted figures are shown with a dashed border. Added figures do not have unique formatting.

6.1 Environmental Setting

This section describes the environmental setting for fish and aquatic resources in the study area (additional background information is provided in Appendix 6A, "Environmental Setting Background Information"). For each waterway or waterbody, a description of the physical and biological attributes is provided, including a description of the fish species of management concern, habitat conditions, and existing environmental stressors.

6.1.1 Study Area

This section of the ~~Draft~~ Environmental Impact Report (~~DEIR~~ EIR) describes the aquatic biological resources within the geographic area potentially influenced by the Long-Term Operations of the State Water Project (SWP) facilities in the Sacramento-San Joaquin Delta (Delta), Suisun Marsh, and Suisun Bay (Proposed Project). It identifies potential direct and indirect impacts on special-status, recreationally important, and commercially important fish species resulting from the Proposed Project. The Project area for aquatic resources is delineated by the following waters:

- Sacramento River from its confluence with the Feather River downstream to the legal Delta boundary at the I Street Bridge in the city of Sacramento
- Delta
- Suisun Marsh and Bay

6.1.2 Fish and Aquatic Species of Management Concern

Fish and aquatic species were selected for analysis in this ~~DEIR~~ EIR based on their importance, vulnerability, and potential to be affected by operational activities and changes in SWP, and where appropriate Central Valley Project (CVP), operations implemented under the Proposed Project (Table 6-1). These fish species, referred to herein as the species of management concern, include species listed by state or federal agencies as endangered or threatened or listed by Moyle et al. (2015) as California Species of Special Concern (critical, high, or moderate status). Species of management concern also include species of Tribal, commercial, or recreational importance. In addition to the species listed in Table 6-1, southern resident killer whale (*Orcinus orca*, federally listed as endangered) is considered because of potential effects on its Chinook Salmon (*Oncorhynchus tshawytscha*) prey. The species of management concern for this ~~DEIR~~ EIR that are analyzed for potential impacts in this chapter are listed in Table 6-1. Species descriptions are provided in Appendix 6A, Section 6A.1, "Fish and Aquatic Resources Species Descriptions."

Table 6-1. Fish and Aquatic Species of Management Concern Potentially Affected by the Proposed Project

Species and *ESU/DPS*	Federal Status	State Status	Tribal[a], Commercial, or Recreational Importance
Winter-run Chinook Salmon *Sacramento River ESU*	Endangered	Endangered	Yes[b]
Spring-run Chinook Salmon *Central Valley ESU*	Threatened	Threatened	Yes[b]
Fall-run/late-fall-run Chinook Salmon *Central Valley ESU*	Species of Concern	Species of Special Concern	Yes[b]
Steelhead *Central Valley DPS*	Threatened	None	Yes
Delta Smelt	Threatened	Endangered	Yes
Longfin Smelt	~~Proposed~~ Endangered	Threatened	Yes
Green Sturgeon *Southern DPS*	Threatened	Species of Special Concern	Yes
White Sturgeon	None	~~Species of Special Concern~~ Candidate	Yes
Pacific Lamprey	Species of Concern	Species of Special Concern	Yes
River Lamprey	None	Species of Special Concern	Yes
Sacramento Hitch	None	Species of Special Concern	Yes
Sacramento Splittail	None	Species of Special Concern	Yes
Hardhead	None	Species of Special Concern	Yes
Central California Roach	None	Species of Special Concern	Yes
Starry Flounder	None	None	Yes [b]
Northern Anchovy	None	None	Yes [b]
Striped Bass	None	None	Yes
American Shad	None	None	Yes
Threadfin Shad	None	None	Yes
Black Bass (largemouth, smallmouth, spotted)	None	None	Yes
California Bay Shrimp	None	None	Yes

ESU = evolutionarily significant unit; DPS = distinct population segment.

[a] Tribal importance was noted based on Shilling et al. (2014:15–46).

[b] Commercially important species with essential fish habitat under the Magnuson-Stevens Fishery Conservation and Management Act.

6.1.3 Habitat Conditions and Environmental Stressors

The sections below concern habitats with attributes, resources, and resource conditions needed to support the different life stages of the fish species of management concern that rely on the geographic area being evaluated. The major environmental stressors are factors that limit a habitat's capacity to support the life stages present. The descriptions focus on stressors that potentially would be affected by the Proposed Project. For example, turbidity may affect predation risk of fish species of management concern. Major environmental stressors potentially limiting turbidity include the supply of suspended sediment entering the Delta and invasive aquatic macrophytes slowing water velocity and allowing suspended sediment to settle.

6.1.4 Delta and Suisun Bay/Marsh

6.1.4.1 Description of Delta and Suisun Bay/Marsh

Ecologically, the Delta consists of three major landscapes and geographic regions: (1) the north Delta freshwater flood basins composed primarily of freshwater inflow from the Sacramento River system; (2) the south Delta distributary channels composed of predominantly San Joaquin River system inflow; and (3) the central Delta tidal islands landscape wherein the Sacramento, San Joaquin, and eastside tributary flows converge and tidal influences from San Francisco Bay are greater.

Suisun Bay and Marsh are ecologically linked with the central Delta, although with different tidal and salinity conditions than are found upstream (e.g., greater tidal and salinity influence in Suisun Bay than in the Delta). Suisun Bay and Marsh are the largest expanse of remaining tidal marsh habitat within the greater San Francisco Estuary ecosystem and include Honker, Suisun, and Grizzly bays; Montezuma and Suisun sloughs; and numerous other smaller channels and sloughs.

The Yolo Bypass conveys flood flows from the Sacramento Valley, including the Sacramento River, Feather River, American River, Sutter Bypass, and westside tributaries into the Delta a few miles north of Rio Vista.

6.1.4.2 Habitat Conditions and Environmental Stressors in Delta and Suisun Bay/Marsh

The following summary of habitat conditions and environmental stressors includes consideration of the Delta and Suisun Bay/Marsh as well as the Yolo Bypass.

Delta

Aquatic Habitat

Anthropogenic changes to flows in the Delta have resulted in alterations to aquatic habitat by (1) changing aspects of the historical flow regime (timing, magnitude, duration) that supported life history traits of native species; (2) limiting access to or quality of habitat; (3) contributing to conditions better suited to invasive, nonnative species (reduced spring flows, increased summer inflows and exports, and low and less-variable interior Delta salinity [Moyle and Bennett 2008] as a result of adopted regulations such as Delta water quality objectives for south Delta exports and in-Delta water users); and (4) causing net reverse flows in channels leading to project export facilities that can entrain fish (Mount et al. 2012). Native species of the Delta are adapted to and depend on variable flow conditions at multiple scales, which is influenced by the region's dramatic seasonal and interannual climatic variation. In particular, most native fishes evolved reproductive or outmigration timing associated with historical peak flows during spring (Moyle 2002).

A variety of researchers have studied the effects of water export on Delta flow and velocity using hydrodynamic models. The Salmonid Scoping Team (SST) recently provided a summary of these effects (Salmonid Scoping Team 2017). The SST concluded that the effect of the SWP and CVP water exports on Delta flow and velocity varied as a function of distance from the facility as well as a function of export volume, total Delta inflow, and tidal action. While export rates had a minimal effect on Georgiana Slough and no discernable effects on the Sacramento River above Georgiana Slough, a greater effect exists in the south Delta, particularly in Old River near the export facilities.

Water temperatures in the Delta follow a seasonal pattern of winter coldwater conditions and summer warmwater conditions, largely because of the region's Mediterranean climate with its alternating cool/wet and hot/dry seasons. Ambient air is the main driver of water temperature, with upstream effects such as reservoir releases having limited influence by the time the water reaches the Delta (Kimmerer 2004; Mount et al. 2012; National Research Council 2012:141; Wagner et al. 2011). Water temperatures in summer approach or exceed the upper thermal tolerances (e.g., 20 degrees Celsius [°C] to 25 °C) for coldwater fish species such as salmonids and Delta-dependent species such as Delta Smelt (*Hypomesus transpacificus*). This is especially true in parts of the south Delta and San Joaquin River (Kimmerer 2004), potentially restricting the distribution of these species and precluding previously important rearing areas (National Research Council 2012:144). Halverson et al. (2022) found that thermally unsuitable habitat for Delta Smelt, indicated by annual maximum water surface temperatures exceeding the critical thermal maximum temperature, increased by 1.5 square kilometers per year from 1985 to 2019, with unsuitable conditions for Delta Smelt observed in large portions of the Delta in 2017 (see also Flow Alteration–Management, Analysis, and Synthesis Team 2020:232). A recent study reaffirmed older observations that Chinook Salmon smolts must transit the Delta before water temperature reaches 20 °C or mortality will be nearly 100 percent (Nobriga et al. 2021).

Landscape-scale changes resulting from flood management infrastructure such as levees, along with flow modification, have eliminated most of the historical hydrologic connectivity of floodplains and aquatic ecosystems in the Delta and its tributaries, degrading and diminishing Delta habitats for native plant and animal communities (Mount et al. 2012). In addition, large-scale reclamation of tidal wetlands has also contributed to the degradation of habitat for Delta fishes. The large reduction of hydrologic variability and landscape complexity has supported invasive aquatic species that have further degraded conditions for native species (see, for example, discussion related to the submerged aquatic vegetation species *Egeria densa* by Conrad et al. 2016:251). Because of the combination of these and other factors, the Delta appears to have undergone ecological regime shifts generally represented by lower abundance of pelagic species, including natives such as Delta Smelt and Longfin Smelt (*Spirinchus thaleichthys*) (Mac Nally et al. 2010; Thomson et al. 2010; Stompe et al. 2020), and higher abundance of littoral species primarily made up of nonnatives (Mahardja et al. 2017).

In response to these landscape conditions, DWR is a lead partner in California EcoRestore (see also Section 6.2, "Regulatory Environment and Compliance Requirements") to advance the restoration of at least 30,000 acres of tidal wetland, floodplain habitat, and riparian habitat throughout the Delta. DWR is the lead agency on the majority of EcoRestore projects, including but not limited to projects such as Decker Island, Bradmoor Island, Lookout Slough Tidal Habitat Restoration and Flood Improvement Project, Winter Island, and the Tule Red Project (California Department of Water Resources 2019a); these examples are some of the projects required by federal mandates for continued operations of the SWP and CVP. These projects will be adaptively managed to improve habitat for Delta Smelt and other species. DWR is also working with other resource agencies, including the California Department of Fish and Wildlife (CDFW), to explore the feasibility of restoring a portion of Franks Tract to reduce invasive weeds and predation while increasing turbidity and fish food production (California Department of Fish and Wildlife 2018). This has led to a feasibility study (California Department of Fish and Wildlife 2020a). Recent research on the Sacramento Deep Water Ship Channel illustrated that longitudinal variations in tidal connectivity and exchange with adjacent areas lead to differing pelagic community and food web structure along the Channel, which informs restoration efforts (Young et al. 2021).

Salinity is a critical factor influencing the distribution of plant and animal communities in the Delta. Although estuarine fish species are generally tolerant of a range of salinity, this tolerance varies by species and life stage. Some species can be highly sensitive to excessively low or high salinity during physiologically vulnerable periods, such as reproductive and early life stages. Although the Delta is tidally influenced, most of the Delta contains fresh water year-round due to inflows from rivers and reservoir releases to maintain water quality standards (Hutton et al. 2015:04015069-6). However, the south Delta can have low levels of salinity greater than tidal fresh water because of salts in agricultural return water (Monsen et al. 2007:4). In addition, the tidally influenced low-salinity zone can move upstream into the central Delta, with distance upstream depending on freshwater outflow, tides, and other factors such as weather fronts influencing air pressure (Kimmerer 2004:27).

A measure of the spatial geography of salinity in the western Delta is X2, which is the distance in kilometers from the Golden Gate Bridge to the point where the salinity near the bottom of the water column is 2 parts per thousand (ppt). X2 is an index of the response of the San Francisco Estuary to freshwater flow (Kimmerer 2004:27), with X2 being influenced by freshwater inflow to the Delta, diversions within the Delta and at the south Delta export facilities, and other factors mentioned above (e.g., tides and weather fronts; Kimmerer 2004:27). X2 has been used to help define the extent of habitat available for oligohaline pelagic organisms and their prey and has been correlated with the abundance of some species and the amount of suitable habitat for Delta Smelt in fall (Feyrer et al. 2007, 2011; U.S. Fish and Wildlife Service 2008:235). Based on an analysis of historical monitoring data, Feyrer et al. (2007) defined the abiotic habitat of Delta Smelt as a specific envelope of salinity and turbidity that changes over the course of the species' life cycle. However, Murphy and Weiland (2019) suggest that the low-salinity zone is not a reliable indicator of Delta Smelt habitat and by extension the distribution of the species within the Delta, given that the species frequently occurs outside the zone or that large parts of the zone do not have Delta Smelt. This topic is controversial and has generated scientific debate (Manly et al. 2015; Feyrer et al. 2015a). Some analyses have shown no relationship of fall X2 (ICF International 2017) or the volume of the low-salinity zone (Polansky et al. 2021) with juvenile Delta Smelt abundance/survival, whereas Polansky et al. (2021) found some evidence for lower fall X2 being positively related with Delta Smelt recruitment in the following spring.[1] In recent decades, it has been suggested that lower outflows

[1] As illustrated by plots of the predicted relationship with associated credible intervals from statistical modeling (Polansky et al. 2021:Figures 1 and C.1), there is appreciable statistical uncertainty in the relationships, which are based on annual mean values across water years. September through November X2 thus was not included in the modeling effort by Smith et al. (2021), which focused only on the relationships found by Polansky et al. (2021) to have the most evidence of having an effect in the hypothesized direction.

have tended to shift X2 during fall farther upstream out of the wide expanse of Suisun Bay into the much narrower channels near the confluence of the Sacramento and San Joaquin rivers (near Collinsville), reducing the spatial extent of low-salinity habitat believed to be important for some species such as Delta Smelt (U.S. Fish and Wildlife Service 2008:235; Baxter et al. 2010). A recent study by Hutton et al. (2015) assessed trends in Delta outflow during pre-SWP (1922–1967) and post-SWP (1968–2012) time periods. Based on observed data, there was a statistically significant increase in X2 from 1922 through 2012 in November through June and a statistically significant decrease in X2 in August and September (Hutton et al. 2015:04015069-9). During the post-SWP period (1968–2021), there was a statistically significant increase in X2 from September through December (Hutton et al. 2015:04015069-9). Hutton et al. (2019) estimated the drivers of trends in Delta outflow based on flows in the Sacramento River at Rio Vista and flows in the lower San Joaquin River: for flows at Rio Vista, changes are primarily driven by nonproject (i.e., non-SWP/CVP) operations in spring (April–June) resulting in decreasing flow and project (i.e., SWP/CVP) storage resulting in increasing summer (July–September) flows, with changes in winter (January–March) resulting mostly from project storage; for flows in the lower San Joaquin River, decreases in flow are primarily driven by project exports in all seasons but spring, when nonproject operations are the primary driver.

Feyrer et al. (2007) conducted statistical modeling of fall midwater trawl (FMWT) fish and water quality data and found that water transparency (Secchi depth) and specific conductance were important predictors of occurrence for Delta Smelt and Striped Bass (*Morone saxatilis*), while specific conductance and water temperature were important for Threadfin Shad (*Dorosoma petenense*). Habitat suitability derived from model predictions exhibited long-term declines for each species, particularly in the southeast and western portions of the Bay-Delta (Feyrer et al. 2007). Further examination for Delta Smelt by Feyrer et al. (2011) found that an annual habitat index incorporating habitat quantity and quality based on salinity and water transparency decreased by 78 percent over the period from 1967 to 2008. Mac Nally et al. (2010) evaluated 54 potential relationships between the four pelagic organism decline (POD) species' declines and environmental factors and found that few covariate relationships were expressed clearly for more than one of the four declining fish species. X2 in spring had a strong negative relationship with indices of abundance for Longfin Smelt, spring calanoids, and mysids (i.e., indices of abundance increased as X2 decreased), but X2 in spring was not correlated with any of the other POD species, while X2 in fall was negatively related only to the Striped Bass index of abundance. Other factors, such as the introduction of nonnative clam species (Feyrer et al. 2003; Kimmerer et al. 1994), shifts in phytoplankton and zooplankton community composition (Winder and Jassby 2011; Glibert et al. 2011), expansion of invasive aquatic weeds (Hestir et al. 2016), and contaminants (Fong et al. 2016), also contribute to reducing habitat quality. The abundance indices of several taxa have been correlated with X2 (Jassby et al. 1995; Kimmerer 2002a, 2002b; Tamburello et al. 2019), suggesting that the quantity or suitability of estuarine habitat for some species may increase when outflows are high. However, analyses by Kimmerer et al. (2009) indicated that neither changes in area nor volume of low-salinity water (habitat) appear to account for this relationship, except for Striped Bass and American Shad, which suggests that X2 may be indexing other environmental variables or processes rather than simple extent of habitat (Baxter et al. 2010).

Nutrients and Food Web Support

Nutrients are essential components of terrestrial and aquatic environments because they provide a resource base for primary producers. Typically, in freshwater aquatic environments, phosphorus is the primary limiting macronutrient, whereas in marine aquatic environments, nitrogen tends to be limiting. A balanced range of abundant nutrients provides optimal conditions for maximum primary production, a robust food web, and productive fish populations. However, changes in nutrient loadings and forms, excessive amounts of nutrients, and altered nutrient ratios can lead to a suite of problems in aquatic ecosystems, such as low dissolved oxygen (DO) concentrations, un-ionized ammonia, excessive growth of toxic forms of cyanobacteria, and changes in components of the food web. Nutrient concentrations in the Delta have been well studied (Jassby et al. 2002; Kimmerer 2004; Van Nieuwenhuyse 2007; Glibert et al. 2011, 2014).

Estuaries are commonly characterized as highly productive nursery areas for numerous aquatic organisms. Nixon (1988) noted that there is a broad continuum of primary productivity levels in different estuaries, which affects fish production and abundance. Compared to other estuaries, pelagic primary productivity in the upper San Francisco Estuary is relatively poor, and a relatively low fish yield is expected (Wilkerson et al. 2006). In the Delta and Suisun Marsh, this appears to result from relatively high turbidity, clam grazing (Jassby et al. 2002), and nitrogen and phosphorus dynamics (Wilkerson et al. 2006; Van Nieuwenhuyse 2007; Glibert et al. 2011, 2014).

A significant long-term decline in phytoplankton biomass (represented by chlorophyll a) and phytoplankton primary productivity to low levels has occurred in the Suisun Bay region and the Delta (Jassby et al. 2002; Dahm et al. 2016). Shifts in nutrient concentrations, such as high levels of ammonium and nitrogen relative to phosphorus (i.e., the ratios of nitrogen to phosphorus and ammonium to nitrate), may contribute to the phytoplankton reduction and to changes in algal species composition in the San Francisco Estuary (Wilkerson et al. 2006; Dugdale et al. 2007; Lehman et al. 2005, 2008a, 2010; Glibert et al. 2011, 2014). However, a recent analysis concluded high ammonium loading is not a driver of low productivity in the Delta area (Strong et al. 2021). Low and declining primary productivity in the estuary may be contributing to the long-term pattern of relatively low and declining biomass of pelagic fishes (Jassby et al. 2002), although the statistical analyses by Mac Nally et al. (2010) and Thomson et al. (2010) found limited statistical evidence for a linkage between chlorophyll and pelagic fish.

The introductions of two clams from Asia have led to alterations in the food web in the Delta. Overbite clams (*Potamocorbula amurensis*; invaded in approximately the mid-1980s [Carlton et al. 1990]) are most abundant in the brackish and saline water of Suisun Bay and the western Delta, and Asian clams (*Corbicula fluminea*; invaded in approximately 1945 [Brown et al. 2007]) are most abundant in the fresh water of the central Delta. These filter feeders reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes such as Delta Smelt and young Chinook Salmon (Feyrer et al. 2007; Kimmerer 2002a; Kimmerer and Thompson 2014).

In addition, introduction of the clams, in particular *P. amurensis*, led to the decline of native copepods of higher food quality and the establishment of poorer-quality nonnative copepods. The clams have been associated with the decline in *Neomysis mercedis* (Orsi and Mecum 1996; Feyrer et al. 2003), the shift in distribution of anchovies (Kimmerer 2006) and young-of-the-year Striped Bass (Kimmerer et al. 2000; Feyrer et al. 2003; Sommer et al. 2007), as well as the decline in diatoms (Kimmerer 2005) and several zooplankton species (Kimmerer et al. 1994). The impact of the clams on chlorophyll a and the Delta ecosystem is also reflected by a shift in many of the original correlations between species abundance indices and X2, that occurred after the establishment of the clams (Kimmerer 2002b; Sommer et al. 2007). Thus, for example, the intercept of the statistical regression relationship between the Longfin Smelt FMWT abundance index and January–June X2 shifted downward following *P. amurensis* establishment in the mid-1980s, so that there was a lower abundance index for a given X2 (Kimmerer 2002b).

More recently, the cyclopoid copepod, *Limnoithona*, has rapidly become the most abundant copepod in the Delta since its introduction in 1993 (Hennessy and Enderlein 2013). This species is approximately one-tenth the size of other copepods and therefore may be less suitable prey for Delta Smelt, in addition to potentially competing with other copepods (Gould and Kimmerer 2010:175). This species was shown to be consumed by Delta Smelt and Striped Bass larvae less than 20 days old in proportion to its availability in the environment in a laboratory setting; once over 20 days old, the fish larvae shifted diet selection to larger copepods (*Pseudodiaptomus forbesi* and *Eurytemora affinis*; Sullivan et al. 2016). In the wild, Slater and Baxter (2014) found neutral or negative selection by Delta Smelt juveniles for *Limnoithona* during April through July. *Limnoithona* may have facilitated higher abundance of the copepod *Acartiella sinensis*, which through predation contributed to the reduction in the Delta Smelt copepod prey *P. forbesi* (Kayfetz and Kimmerer 2017). The overbite clam also has been implicated in the reduction of native mysid shrimp, a preferred food of Delta native fishes such as Sacramento Splittail (*Pogonichthys macrolepidotus*) and Longfin Smelt (Feyrer et al. 2003).

Several studies have documented or suggested food limitations for aquatic species in the San Francisco Estuary, including zooplankton (Mueller-Solger et al. 2002; Kimmerer et al. 2005, 2014), Delta Smelt (Bennett 2005; Bennett et al. 2008; Slater and Baxter 2014; Hammock et al. 2015), Chinook Salmon (Sommer et al. 2001a, 2001b), Sacramento Splittail (Greenfield et al. 2008), Striped Bass (Loboschefsky et al. 2012), and Largemouth Bass (Nobriga 2009). Recent analyses suggest that the combination of clam grazing and south Delta exports have negatively affected pelagic productivity in the San Francisco Estuary (Hammock et al. 2019[2]).

Turbidity

Turbidity is a measure of the relative clarity of water and is an important water quality component in the Delta that affects physical habitat through sedimentation and food web dynamics by means of attenuation of light in the water column. Light attenuation, in turn, affects the extent of the photic zone where primary production can occur and the ability of predators to visually locate prey and for prey to escape predation. Suspended solids affect turbidity and reflect the contribution of mostly inorganic materials (e.g., fine sediments) as well as a relatively small contribution from organic materials such as phytoplankton (Schoellhamer et al. 2012:4–5).

Turbidity has been declining in the Delta since the 1950s according to sediment data collected by the U.S. Geological Survey (Wright and Schoellhamer 2004). The decline has important implications for food web dynamics and predation. Higher water clarity is at least partially caused by increased water filtration and plankton grazing by highly abundant overbite clams and other benthic

[2] Note that Hammock et al.'s (2019) analysis simulated a scenario of historical water operations including south Delta exports compared to scenarios of historical water operations excluding south Delta exports or limiting south Delta exports to very low levels observed during the 1977 drought; however, the analysis did not account for other changes in water operations that would be associated with cessation or limitation of south Delta exports, in particular reductions in Delta inflow given ceased or limited demand for south Delta exports. Note also that Hammock et al. (2019) focused more on residence time effects as opposed to direct entrainment.

organisms (Kimmerer 2004; Greene et al. 2011) and potentially by filtration by high densities of aquatic vegetation (Hestir et al. 2016). High nutrient loads coupled with reduced sediment loads and higher water clarity were hypothesized to contribute to plankton and algal blooms and overall increased eutrophic conditions in some areas (Kimmerer 2004). Recent modeling examining future climate scenarios, however, predicts significant increases in large flow events and sediment loading to the Delta from the Sacramento River over the next century for two representative greenhouse gas concentration pathways, which could increase turbidity (Stern et al. 2020). Water clarity may affect detection of some pelagic fish species in the San Francisco Estuary as a result of the combined effects of turbidity on abundance (i.e., species being more abundant in more turbid conditions) and capture probability (i.e., species being less able to detect and avoid sampling gear in more turbid conditions) (Peterson and Barajas 2018:21). Higher turbidity has been shown to reduce predation risk, for example in Delta Smelt (Ferrari et al. 2014; Schreier et al. 2016).

The first high-flow events of winter create turbid conditions in the Delta, which can be drawn into the south Delta during reverse flow conditions in Old and Middle River (OMR). In general, Delta Smelt may follow turbid waters into the southern Delta, migrating upstream through use of tidal flows (Bennett and Burau 2015), potentially increasing their proximity to project export facilities and, therefore, their entrainment risk (U.S. Fish and Wildlife Service 2008:210; Grimaldo et al. 2009a, 2021). Investigations suggest that movement behavior is complex and may respond to turbidity and other cues such as changes in salinity (Gross et al. 2021; Korman et al. 2021). Monitoring of turbidity in the Delta is one of the main indicators (and surrogates) used to minimize south Delta entrainment risk through adjustments to south Delta operations under the U.S. Fish and Wildlife Service (USFWS) 2019 SWP/CVP Biological Opinion (BiOp) and CDFW (2020b) SWP Incidental Take Permit (ITP).

In response to the Delta Smelt Resiliency Strategy, DWR assessed the potential of adding sediment to increase turbidity in the low-salinity zone of the Delta to improve Delta Smelt habitat conditions. Computer modeling was performed to assess (1) whether sediment supplementation is a feasible action to effectively increase turbidity in the low-salinity zone, (2) the magnitude of sediment supplementation that would be required in order to have a measurable effect on turbidity in the low-salinity zone, and (3) the spatial and temporal extent over which supplementation would influence turbidity (Bever and MacWilliams 2018). The results of the modeling suggested that it was feasible to increase turbidity by sediment supplementation and showed that 3,550 cubic yards per day of sediment release was needed to increase turbidity by 10 nephelometric turbidity units between Emmaton and Mallard Island during May through September (Bever and MacWilliams 2018); this is a geographic area consistently occupied by Delta Smelt during all life stages (e.g., Murphy and Hamilton 2013). The modeled sediment supplementation occurred continuously in the form of batch slurry of approximately 180 cubic feet per second (cfs), from May through September, with little difference in turbidity in October after supplementation ceased and limited effects downstream of Mallard Island.

Contaminants

Contaminants can change ecosystem functions and productivity through numerous pathways. A large body of research has been conducted on contaminant occurrence and effects on aquatic organisms in the Delta (Johnson et al. 2010:1; Brooks et al. 2012; Fong et al. 2016). A wide array of contaminants, including pesticides, metals, pharmaceuticals, and personal care products, have been detected in Delta water and sediment. Recent monitoring programs are routinely detecting multiple pesticides in each water sample from the Delta (De Parsia et al. 2018, 2019; Jabusch et al. 2018).

Fong et al. (2016) reported that "[f]or example, 27 pesticides or degradation products were detected in Sacramento River samples, and the average number of pesticides per sample was six. In San Joaquin River samples, 26 pesticides or degradation products were detected, and the average number detected per sample was nine. Water quality objectives do not exist for most of these compounds. However, these were targeted chemical analyses, and hundreds of compounds have been detected in individual Delta water samples using other non-targeted techniques." The effects of chemical mixtures on aquatic organisms are generally unknown but many chemicals may have additive or synergistic effects. Anthropogenic toxins cause significant disruption to development, reduce growth and recruitment, and increase mortality (Johnson et al. 2010:73).

In addition to anthropogenic contaminants, natural toxins are associated with blooms of *Microcystis aeruginosa*, a cyanobacterium that releases a potent toxin known as microcystin. Toxic microcystins cause food web impacts at multiple trophic levels, and histopathological studies of fish liver tissue suggest that fish exposed to elevated concentrations of microcystins have developed liver damage and tumors (Deng et al. 2010; Lehman et al. 2005, 2008a, 2010; Acuña et al. 2012a, 2012b). Other potentially toxic cyanobacteria (*Aphanizomenon* and *Dolichospermum*) can occur with *Microcystis* in the Delta (Lehman et al. 2021).

There are longstanding concerns related to mercury and selenium in the Sacramento and San Joaquin watersheds, the Delta, and San Francisco Bay (Brooks et al. 2012). Conversion of inorganic mercury to toxic methylmercury occurs in anaerobic environments, including some wetlands, with greater amounts of methylmercury tending to occur in less frequently inundated areas (Alpers et al. 2008:1). DWR is conducting an additional study to determine imports and exports of mercury and methylmercury from freshwater tidal wetlands in the Delta and Suisun Marsh per the Sacramento San Joaquin Delta Methylmercury Total Maximum Daily Load (TMDL) and Basin Plan Amendment (Lee and Manning 2020; Wood et al. 2010). Current research shows that tidal wetlands do not export mercury or methylmercury in large amounts, although seasonal differences occur and imports and exports are heavily influenced by flow and whether the wetland is associated with a floodplain (Mitchell et al. 2012; Lee and Manning 2020:25–77). Methylmercury increases in concentration at each level in the food chain and can cause concern for people and birds that eat piscivorous fish (e.g., Striped Bass) and benthic fishes such as sturgeon. Studies summarized by Alpers et al. (2008) indicate that mercury in fish has been linked to hormonal and reproductive effects, liver necrosis, and altered behavior in fish. A study by Lee et al. (2011) on dietary methylmercury noted significant abnormalities in the liver and kidneys, lower growth rates, and higher mortality in both Green Sturgeon (*Acipenser medirostris*) and White Sturgeon (*Acipenser transmontanus*), but particularly in Green Sturgeon.

With regard to selenium, benthic foragers like diving ducks, sturgeon, and Sacramento Splittail have the greatest risk of selenium toxicity because of selenium presence in nonnative benthic bivalves. Beckon and Maurer (2008) suggest that salmonids are probably among the species that are most sensitive to selenium, while Delta Smelt are likely to be at low risk of selenium toxicity. The invasion of the nonnative bivalves (e.g., overbite clams) has resulted in increased bioavailability of selenium to benthivores in San Francisco Bay (Linville et al. 2002). A recent study of Sacramento Splittail based on otolith chemical composition has shown that juveniles acquired selenium toxicity while feeding in the fresh waters of the San Joaquin River but already started with significantly higher selenium burdens from maternal transfer by females maturing in the estuary (Johnson et al. 2020). Some White Sturgeon collected from the San Francisco Bay contained selenium levels in their livers that can be reproductively toxic in other fish species (Linares-Casenave et al. 2015).

Phytoplankton growth rates may be inhibited by localized high concentrations of herbicides (Edmunds et al. 1999), with recent laboratory studies indicating that among three tested herbicides (glyphosphate, imazomox, and fluridone), only fluridone inhibited phytoplankton at environmentally relevant concentrations (Lam et al. 2020). Toxicity to invertebrates has been noted in water and sediments from the Delta and associated watersheds (Kuivila and Foe 1995; Weston et al. 2004, 2014, 2019). The 2004 Weston study of sediment toxicity recommended additional study of the effects of the pyrethroid insecticides on benthic organisms. Undiluted drainwater from agricultural drains in the San Joaquin River watershed can be acutely toxic (i.e., quickly lethal) to fish (e.g., Chinook Salmon and Striped Bass) and have chronic effects on growth, likely because of high concentrations of major ions (e.g., sodium, sulfates) and trace elements (e.g., chromium, mercury, selenium) (Saiki et al. 1992).

A more recent synthesis of contaminant studies described multiple lines of evidence showing that contaminants negatively affect species of management concern in the Delta (Fong et al. 2016). Fong et al. (2016) reported that many contaminants detected in Delta waters exceed regulatory standards and most water samples contain multiple contaminants. They also summarize the multiple studies that have found sublethal, lethal, chronic, and acute toxicity of Delta water to test species and species of management concern in the Delta, including Delta Smelt and salmon.

Fish Passage and Entrainment

With its complex network of channels, low eastern and southern tributary inflows, and reverse currents created by pumping for water exports, the Delta presents a challenge for anadromous and resident fish during upstream and downstream migration. These complex conditions can lead to straying, extended exposure to predators, and entrainment during migration. Tidal elevations, salinity, turbidity, Delta inflow, meteorological conditions, season, habitat conditions, and project exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish passage success and survival (see, for example, the review by Salmonid Scoping Team 2017).

North Delta Fish Passage and Entrainment

In the north Delta (i.e., the Sacramento River and associated waterways), migrating fish have multiple potential pathways as they move to or from the Sacramento or Mokelumne River systems. Michel et al. (2015) used acoustic telemetry to examine survival of late-fall-run Chinook Salmon smolts outmigrating from the Sacramento River through the Delta and San Francisco Estuary. Survival was lowest in the Bays (defined as the region from Chipps Island to the Golden Gate Bridge), highest in the lower Sacramento River upstream of the Delta, and intermediate in the Delta and the upper Sacramento River portion of the migration route.

Outmigrating juvenile fish moving down the mainstem Sacramento River can enter CVP's Delta Cross Channel (DCC) when the gates are open and travel through the Delta via the Mokelumne and San Joaquin River channels. In the case of juvenile salmonids, this shifted route from the north Delta to the central Delta increases their mortality rate (Kjelson and Brandes 1989; Brandes and McLain 2001; Newman and Brandes 2010; Perry et al. 2010, 2012). Steel et al. (2012) found that the best predictor of which route was selected was the ratio of mean water velocity between the two routes. Salmon migration studies show losses of approximately 65 percent for groups of outmigrating fish that are diverted from the mainstem Sacramento River into the waterways of the central and south Delta (Brandes and McLain 2001; Vogel 2004, 2008; Perry and Skalski 2008). Perry and Skalski (2008) found that, by closing the DCC gates, total through-Delta survival of marked fish to Chipps

Island increased by nearly 50 percent for fish moving downstream in the Sacramento River system; subsequent studies have found the increase to be 25–50 percent depending on Sacramento River flow (Perry et al. 2018). Closing the DCC gates appears to redirect the migratory path of outmigrating fish into Sutter and Steamboat sloughs and the Sacramento River and away from Georgiana Slough, resulting in higher survival rates. Species that may be affected include juvenile Green Sturgeon, steelhead, and winter-run and spring-run Chinook Salmon (National Marine Fisheries Service 2009:404), although only the salmonids have had quantitative studies confirming this link (e.g., Singer et al. 2013; Perry et al. 2018). Singer et al. (2020) found the through-Delta migration pathway via Steamboat Slough to be of particular importance for juvenile Chinook Salmon outmigration survival during the 2013 through 2015 drought conditions.

Analysis by Perry et al. (2015, 2018) suggests, however, that the mechanisms governing route selection are more complex. Their analysis revealed the strong influence of tidal forcing on the probability of fish entrainment into the interior Delta. The probability of entrainment into both Georgiana Slough and the DCC was highest during reverse-flow flood tides, and the probability of fish remaining in the Sacramento River was near zero (with DCC open) or 5–10 percent (with DCC closed) during flow reversals (Perry et al. 2015:452). Perry et al. (2015:453) noted that the magnitude and duration of reverse flows at this river junction decrease as inflow of the Sacramento River increases. Consequently, reduced Sacramento River inflow increases the frequency of reverse flows at this junction (Perry et al. 2015:453), increasing the proportion of fish that are entrained into the interior Delta, where mortality is high (Perry 2010:172). In addition to influencing migratory pathways, Sacramento River flow is positively correlated with juvenile Chinook Salmon survival in river reaches transitioning from bidirectional (tidal) flow to unidirectional (downstream) flow with increased river flow (i.e., Sacramento River from Georgiana Slough to Rio Vista; Sutter and Steamboat Slough; and Georgiana Slough) (Perry et al. 2018).

The SWP Barker Slough Pumping Plant (BSPP), located on a tributary to Cache Slough, may cause larval fish entrainment. The intake is equipped with a positive barrier fish screen to prevent fish at least 25 millimeters (mm) in size from being entrained. CDFW found low levels of entrainment of larval Delta Smelt less than 20 mm at Barker Slough during the mid-1990s to mid-2000s, and more recent entrainment monitoring in the pump bays behind the fish screens in 2014–2016 only collected one Delta Smelt (Yip et al. 2019:29–30). Per the CDFW (2020b) SWP ITP and the USFWS (2019) SWP/CVP BiOp (for Delta Smelt), pumping rates are reduced when Longfin Smelt or Delta Smelt larvae are present in the vicinity to minimize entrainment into the North Bay Aqueduct (NBA).

Marston et al. (2012) studied stray rates for immigrating San Joaquin River Basin adult salmon that stray into the Sacramento River Basin. Results indicated that it was unclear whether reduced San Joaquin River pulse flows or elevated exports caused increased stray rates; the statistical results indicated that flow is the primary factor, but empirical data indicate that little if any pulse flow leaves the Delta when south Delta exports are elevated, so exports in combination with pulse flows may explain the elevated stray rates (Marston et al. 2012). The DCC, when open, can divert fish into the interior Delta from the Sacramento River as they outmigrate. Opening the DCC when salmon are returning to spawn to the Mokelumne and Cosumnes rivers is believed to lead to increased straying of these fish into the American and Sacramento rivers because of confusion over olfactory cues. Experimental DCC closures have been scheduled during the fall-run Chinook Salmon migration season for selected days, coupled with pulsed flow releases from reservoirs on the Mokelumne River, in an attempt to reduce straying rates of returning adults. These closures have corresponded with reduced recoveries of Mokelumne River Hatchery fish in the American River system and increased returns to the Mokelumne River Hatchery (East Bay Municipal Utility District 2012).

Water quality can also affect fish passage in the north Delta. Water quality in the mainstem Sacramento River and its distributary sloughs can be poor at times during summer, creating conditions that may stress migrating fish or even impede migration. These conditions include low DO and high water temperatures. For adult Chinook Salmon, DO concentration less than 3 to 5 milligrams per liter (mg/L) can impede migration (Hallock et al. 1970), as can mean daily water temperatures of 70 degrees Fahrenheit (°F) to 73 °F (approximately 21 °C to 23 °C), depending on whether water temperatures are rising or falling (Strange 2010). The U.S. Environmental Protection Agency (EPA) (2003:25) recommended a 68 °F maximum seven-day average of the daily maximums for salmon (including Chinook Salmon) and trout (including steelhead) migration for the Pacific Northwest. DO levels are generally greater than 5 mg/L throughout the Delta, but water temperatures can exceed these thresholds during summer and fall. Contaminants such as pesticides and copper at concentrations that have been detected in the Delta have also been found to impair olfactory responses in many fish, which can lead to straying (Fong et al. 2016; Sandahl et al. 2007; Tierney et al. 2010).

Central and South Delta Fish Passage and Entrainment

The south Delta intake facilities include the SWP and CVP export facilities; local agency intakes, including Contra Costa Water District (CCWD) intakes; and agricultural intakes. ~~Contra Costa Water District~~ CCWD intakes, the Rock Slough Intake at the Contra Costa Canal, and the City of Stockton intake include fish screens. There are also agricultural intakes in the central Delta, and most do not include fish screens. Water flow patterns in the south Delta are influenced by water diversion actions and operations, seasonal temporary barriers, and tides and river inflows to the Delta (Kimmerer and Nobriga 2008). Depending on hydrological conditions and water operations, around 20–60 percent of flow from the San Joaquin River enters the Head of Old River (Cavallo et al. 2015) and moves through the channels of the Old and Middle Rivers and Grant Line and Fabian-Bell Canals toward the south Delta intake facilities. When the net flow of water north of the diversion points for the two facilities moves southward (upstream), the net flow is negative (toward) the pumps. When seasonal temporary barriers are installed from May through November to improve water levels for diverters in the south Delta, internal reverse circulation is created within the channels isolated by the barriers from other portions of the south Delta. These conditions are most pronounced during late spring through fall when San Joaquin River inflows are low and water diversion rates are typically high. Drier hydrologic years in combination with water diversions from the Delta also reduce the frequency of net downstream flows in the south Delta and mainstem San Joaquin River. While Delta flows are tidal and naturally reverse twice daily, Delta diversions can create net reverse flows, which may draw some fish toward Project facilities (Arthur et al. 1996; Kimmerer et al. 2008; Grimaldo et al. 2009a; see also discussion of tidal variation by Kimmerer 2004:26).

A portion of fish that enter the Jones Pumping Plant approach channel and the Clifton Court Forebay (CCF) are salvaged at screening and fish salvage facilities, transported downstream by trucks, and released. Fish are lost during salvage because of factors such as predation or passing through screening louvers, with regulatory assumptions made regarding loss rates of salmonids being made (Kimmerer 2008). Thus, for example, calculated loss rates in water years (WY) 2009–2022 for fall-run Chinook Salmon based on the salvage-density data discussed later in this chapter result in a mean loss to salvage ratio of 4.4 (i.e., over four fish lost for each fish salvaged) at the SWP export facility and a mean loss to salvage ratio of 0.7 for the CVP export facility (i.e., seven fish lost for every 10 fish salvaged). Calculation of losses includes an assumption of 10 percent loss at release as a result of predation, which does not account for other potential effects of the salvage process such as injury and increased risk for disease contraction suggested by CDFW (2020b, Attachment 8:66).

Mark-recapture experiments indicate that many fish are probably subject to predation prior to reaching the fish salvage facilities (e.g., in the CCF) (Gingras 1997; Clark et al. 2009:4; Castillo et al. 2012; Miranda 2019). Aquatic organisms (e.g., phytoplankton and zooplankton) that serve as food for fish also are entrained and removed from the Delta (Jassby et al. 2002; Kimmerer et al. 2008; Brown et al. 1996). Fish entrainment and salvage historically were noted to be higher in dry years when the distributions of young Striped Bass, Delta Smelt, Longfin Smelt, and other migratory fish species may shift closer to the Project facilities (Stevens et al. 1985; Sommer et al. 1997), although the USFWS (2019) SWP/CVP BiOp and CDFW (2020b) SWP ITP limit the potential for entrainment.

Salvage estimates reflect the number of fish entrained by project exports from surrounding waterways and sampled at the fish salvage facilities, but these numbers alone do not account for other sources of mortality related to the export facilities. These numbers alone do not include prescreen losses that occur in the waterways leading to the diversion facilities, which may in some cases reduce the number of salvageable fish (e.g., losses within the SWP's CCF) (Gingras 1997; Clark et al. 2009:4; Castillo et al. 2012; Miranda 2019). Prescreen losses are estimated to account for most adult and juvenile Delta Smelt mortality at the SWP export facility (Castillo et al. 2012). In addition, larval fish are not salvaged because they cannot be diverted from the export facilities by existing fish screens. The number of fish salvaged also does not include losses of fish that pass through the louvers intended to guide fish into the fish collection facilities or the losses during collection, handling, transport, and release back into the Delta. The USFWS (2019) and NMFS (2019) SWP/CVP BiOps and CDFW (2020b) SWP ITP collectively limit the potential for entrainment of listed fish through restrictions on south Delta export pumping during life stages that are vulnerable to entrainment.

While swimming through south Delta channels, fish can be subjected to stress from poor water quality (seasonally high temperatures, low DO, high water transparency, and *Microcystis* blooms) and low water velocities, which create lacustrine-like conditions. Any of these factors can cause elevated mortality rates by weakening or disorienting the fish and increasing their vulnerability to predators (Vogel 2011).

Considerable debate remains regarding the relationship between ratios of exports and inflow on the survival of fall-run Chinook Salmon and Central Valley steelhead. The SST evaluated data from multiple studies for the effects of spring ratios of San Joaquin River inflow to exports (I:E) and through-Delta survival of San Joaquin River fall-run Chinook Salmon. The SST summarized their findings as follows:

- Coded-wire-tagged Chinook Salmon data show increased through-Delta survival for higher levels of I:E, up to approximately I:E=3, in the presence of a physical barrier at the head of Old River, but no relationship in the absence of the barrier.
- Acoustically tagged Chinook Salmon data show a similar pattern for I:E less than 3, but mostly in the absence of a physical barrier at the head of Old River.
- Both coded-wire-tagged and acoustically tagged Chinook Salmon data show more variable but mostly lower through-Delta survival estimates for I:E between 3 and 5, all in the absence of a physical barrier at the head of Old River.
- Few observations from tagging data are available for I:E greater than 5, and all are from coded-wire-tagged data.

- Comparison of adult Chinook Salmon escapement to the San Joaquin River basin between 1951 and 2003 with San Joaquin River I:E two and a half years before adult return showed a positive association (1951–2012); I:E values ranged up to greater than 300 during this time period, although most observations were less than 10.
- Acoustically tagged [juvenile] Chinook Salmon data, in the absence of a physical barrier at the head of Old River, show a positive trend in survival between Mossdale and the Turner Cut junction with [increasing] I:E, a negative trend for survival between Turner Cut junction and Chipps Island, and no relationship for survival through the facilities to Chipps Island. (Salmonid Scoping Team 2017:E-105–E-106)

Buchanan and Skalski (2020) found that I:E ratio was positively correlated with juvenile Chinook survival in the south Delta but less well supported as a predictor of survival than various other flow and environmental measures. For steelhead, the SST's (2017) review of available data found survival in the south Delta tended to increase for higher levels of I:E, but observations are limited to two years of acoustic tag data available (2011 and 2012). Survival increased from the Turner Cut junction to Chipps Island, and overall from Mossdale to Chipps Island, as the April to May I:E increased. However, the pattern was weaker than the survival pattern observed for inflow based on SST scatterplots. Survival estimates from Mossdale to the Turner Cut junction were similar regardless of I:E based on SST scatterplots. Survival from the CVP trash rack through the facility to Chipps Island, and from the CCF radial gates to Chipps Island, increased with I:E for fish released during April and May (Salmonid Scoping Team 2017). They further concluded that the high correlation between inflow and exports limits the ability to evaluate survival over a range of I:E ratios. Although not directly comparable, this contrasts with the results of Zeug and Cavallo (2012), who also found little evidence that large-scale water exports or inflows influenced coded-wire tag recovery rates in the ocean from 1993 to 2003.

Delaney et al. (2014) reported results of a mark-recapture experiment examining the survival and movement patterns of acoustically tagged juvenile steelhead outmigrating through the central Delta and south Delta following release at Buckley Cove in the lower San Joaquin River at Stockton. Their results indicated that most tagged steelhead remained in the mainstem San Joaquin River (77.6 percent). However, approximately one quarter (22.4 percent) of tagged steelhead entered Turner Cut. Route-specific survival probability for tagged steelhead using the Turner Cut route was 27.0 percent. The survival probability for tagged steelhead using the mainstem route was 56.7 percent (Delaney et al. 2014:ES-3). Travel times for tagged steelhead also differed between these two routes, with steelhead using the mainstem route reaching Chipps Island significantly sooner than those that used the Turner Cut route. Travel time was not significantly affected by the limited OMR flow treatments examined in their study. While not significant, there was some evidence that fish movement toward each export facility could be influenced by the relative volume of water entering the export facility (Delaney et al. 2014:5-1).

Beyond considerations of just south Delta flows and exports, Cunningham et al. (2015) found a negative correlation between overall Delta export/inflow (E:I) ratio and the through-Delta survival of juvenile fall-run Chinook Salmon populations and a negative correlation of total Delta exports with the through-Delta survival of juvenile spring-run Chinook Salmon populations. Based on the Cunningham et al. (2015) statistical analysis, an increase in total February–April exports (including diversions/transfers, i.e., DAYFLOW output QEXPORTS) of 1 standard deviation from the 1967 to 2010 average is predicted to result in a 68.1 percent reduction in the survival of the Deer, Mill, and Butte Creek populations of spring-run Chinook Salmon (Cunningham et al. 2015:35). Similarly, the results of the statistical analysis suggested an increase in the mean February–May ratio of Delta water exports to Delta inflow of 1 standard deviation would reduce survival of the four fall-run Chinook Salmon populations by 57.8 percent (Cunningham et al. 2015:35). Note that the levels of Delta exports were relatively high during this historical period relative to current management under the NMFS (2019) and USFWS (2019) SWP/CVP BiOps and the CDFW (2020b) SWP ITP: the annual mean February–April Delta exports during 1967–2010 was approximately 6,000 cfs with a standard deviation of approximately 2,100 cfs (compared to approximately 3,800 cfs in 2020), the mean annual E:I during 1967–2010 was 0.21 with a standard deviation of 0.14 (compared to approximately 0.20 in 2020). Although a mechanistic explanation for the reduction in survival remains elusive, “direct entrainment mortality seems an unlikely mechanism given the success of reclamation and transport procedures, even given increased predation potential at the release site. Changes to water routing may provide a more reasonable explanation for the estimated survival influence of Delta water exports” (Cunningham et al. 2015).

Low DO levels have been measured in the San Joaquin River, in particular in the Deep Water Ship Channel from the Port of Stockton 7 miles downstream to Turner Cut (Lee and Jones-Lee 2003). These conditions are the result of increased residence time of water combined with high oxygen demand in the anthropogenically modified channel, which leads to DO depletion, particularly near the sediment-water interface (San Joaquin Tributaries Authority 2012:21). During the 1960s, Hallock et al. (1970) found that adult radio-tagged Chinook Salmon delayed their upstream migration whenever DO concentrations were less than 5 mg/L at Stockton. Peterson et al. (2017) found that upstream migration of adult fall-run Chinook Salmon into the Stanislaus River from 2003 through 2014 increased with increasing DO measured at Stockton and, consistent with Hallock et al. (1970), found very few fish migrated when DO was below 5 to 6 mg/L. Aeration facilities are operated by the Port of Stockton to ameliorate low DO conditions (Port of Stockton 2021). The aeration facilities and upgrades to the City of Stockton Regional Wastewater Control Facility in 2007 reduced the annual percentage of DO data points below the water quality objective (6 mg/L between Turner Cut and Stockton, September 1 through November 30) from more than 40 percent down to less than 1 percent (Central Valley Regional Water Quality Control Board 2014:3).

There are more than 2,200 diversions in the Delta (Herren and Kawasaki 2001). These irrigation diversion pipes are shore-based, typically small (30 to 60 centimeters pipe diameter), and operated via pumps or gravity flow, and most lack fish screens. These diversions increase total fish entrainment and losses and alter local fish movement patterns (Kimmerer and Nobriga 2008). Delta Smelt have been found in samples of typical Delta diversions (Nobriga et al. 2004). However, Nobriga et al. (2004) found that the low and inconsistent entrainment of Delta Smelt measured in their study of typical irrigation diversions reflected general offshore habitat use by Delta Smelt and the nearshore and relatively small hydrodynamic influence of the diversions. Concerns were expressed by Kneib (2019) about potential entrainment effects given the relatively limited study of entrainment by Nobriga et al. (2004), such as the need to consider cumulative losses at all diversions (Kneib 2019:13). Nobriga and Herbold (2009:25–26) expanded on the discussion by Nobriga et al. (2004) to conclude that irrigations at small diversions are not a major stressor to Delta Smelt because (1) as noted above, most diversions have very small hydrodynamic footprints and Delta Smelt tend to occupy offshore habitat away from the diversions, (2) many of the diversions are not diverting water every day, (3) many diversions are located in the south Delta, where habitat conditions are unsuitable for Delta Smelt during summer/fall, and (4) agricultural water demand has not increased since the 1930s. Citing some of these reasons, Baxter et al. (2010:41) considered small within-Delta irrigation diversions to be unlikely to have had an effect on

POD species, including Delta Smelt and Longfin Smelt. The temporal overlap of juvenile salmonid occurrence in the Delta with irrigation diversions is limited and therefore also not thought to be of population-level consequence (Vogel 2011:94).

Nonnative Invasive Species

Nonnative invasive species influence the Delta ecosystem by increasing competition and predation on native species, reducing habitat quality (as result of invasive aquatic macrophyte growth), and reducing food supplies by altering the aquatic food web. Not all nonnative species are considered invasive. CDFW defines invasive species as "species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat" (California Department of Fish and Game 2008:1). Some introduced species have minimal ability to spread or increase in abundance. Others have commercial or recreational value (e.g., Striped Bass, American Shad, Largemouth Bass).

Many nonnative fishes have been introduced into the Delta, for example, for sport fishing (game fish such as Striped Bass, Largemouth Bass, Smallmouth Bass, Bluegill [*Lepomis macrochirus*], and other sunfish), as forage for game fish (Threadfin Shad, Golden Shiner [*Notemigonus crysoleucas*], and Fathead Minnow [*Pimephales promelas*]), for vector control (Inland Silverside [*Menidia beryllina*], Western Mosquitofish [*Gambusia affinis*]), for human food use (Common Carp [*Cyprinus carpio*], Brown Bullhead (*Ameiurus nebulosus*), and White Catfish [*Ameiurus catus*]), and from accidental releases (Yellowfin Goby [*Acanthogobius flavimanus*], Shimofuri Goby [*Tridentiger bifasciatus*], and Shokihaze Goby [*Tridentiger barbatus*]) (Dill and Cordone 1997; Moyle 2002). Introduced fish may compete with native fish for resources and, in some cases, prey on native species.

Invasive species are among the environmental stressors implicated in the decline in abundance of native fishes throughout the region (Matern et al. 2002; Brown and Michniuk 2007; Sommer et al. 2007; Mount et al. 2012; Hamilton and Murphy 2018; Polansky et al. 2021). Habitat degradation, changes in hydrology and water quality, and stabilization of natural environmental variability are all factors that generally favor nonnative, invasive species (Mount et al. 2012; Moyle et al. 2012).

As described in the discussion of nutrients and food web support above, the introductions of two clams from Asia have led to major alterations in the food web in the Delta. *Potamocorbula* and *Corbicula* clams significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes, such as Delta Smelt and young Chinook Salmon (Feyrer et al. 2007; Kimmerer 2002b). The upstream distribution of *Potamocorbula* into the Delta increases with decreasing Delta outflow (e.g., drought conditions) and greater salinity, increasing overlap with *Corbicula* and greater overall clam grazing (Kimmerer et al. 2019).

Predation

Predation is an important factor that influences the behavior, distribution, and abundance of prey species in aquatic communities to varying degrees. Predation can have differing effects on a population of fish, depending on the size or age selectivity, mode of capture, mortality rates, and other factors. Predation is a part of every food web, and native Delta fishes were part of the historical Delta food web. Because of the magnitude of change in the Delta from historical times and the introduction of nonnative predatory fish, it is logical to conclude that predation may have increased in importance as a mortality factor for Delta fishes, with some observers suggesting that it is likely the primary source of mortality for juvenile salmonids in the Delta (Vogel 2011). NMFS (2014:27) rated predation of juvenile winter-run Chinook Salmon and spring-run Chinook Salmon during rearing and outmigration as a stressor of "Very High" importance. Predation occurs by fish, birds, and mammals, including sea lions.

A panel of experts was convened to review data on predation in the Delta and draw preliminary conclusions on the effects of predation on salmonids (Grossman et al. 2013). The panel acknowledged that the system supports large populations of fish predators that consume juvenile salmonids (Grossman et al. 2013:16). However, the panel concluded that because of extensive flow modification, altered habitat conditions, native and nonnative fish and avian predators, temperature and DO limitations, and the overall reduction in salmon population size, it was unclear what proportion of juvenile salmonid mortality could be attributed to predation. The panel further indicated that predation, while the proximate cause of mortality, may be influenced by a combination of other stressors that make fish more vulnerable to predation.

Striped Bass, Channel Catfish (*Ictalurus punctatus*), Largemouth Bass and other centrarchids, and silversides are among the introduced, nonnative species that are predators of early life stages or smaller-bodied fish species and juveniles of larger species in the Delta (Grossman 2016). Along with Largemouth Bass, Striped Bass are believed to be major predators on larger-bodied fish in the Delta. In open-water habitats, Striped Bass are most likely the primary predator of juvenile and adult Delta Smelt (California Department of Water Resources et al. 2013:11-205) and can be an important open-water predator on juvenile salmonids (Johnston and Kumagai 2012). Native Sacramento Pikeminnow (*Ptychocheilus grandis*) may also prey on juvenile salmonids and other fishes. Limited sampling of smaller pikeminnows did not find evidence of salmonids in the foregut of Sacramento Pikeminnow (Nobriga and Feyrer 2007) and none were found in more recent genetic studies by Brandl et al. (2021), but this does not mean that Sacramento Pikeminnow do not prey on salmonids in the Delta given that the species has been shown to prey on juvenile salmonids upstream of the Delta (Tucker et al. 1998).

Largemouth Bass abundance has increased in the Delta over the past few decades (Brown and Michniuk 2007). Although Largemouth Bass are not pelagic, their presence at the boundary between the littoral and pelagic zones makes it probable that they opportunistically consume mostly pelagic fishes, particularly during periods that pelagic species enter littoral zones (e.g., for spawning or as part of ebb tide inshore movement during tidal upstream migration in the case of Delta Smelt; Bennett and Burau 2015). The increase in salvage of Largemouth Bass occurred during the time period when Brazilian waterweed (*Egeria densa*) was expanding its range in the Delta (Brown and Michniuk 2007). The beds of Brazilian waterweed provide good habitat for Largemouth Bass and other species of centrarchids. Largemouth Bass have a much more limited distribution in the estuary than Striped Bass, but a higher per capita impact on small fishes (Nobriga and Feyrer 2007; although see also Michel et al. 2018). Increases in Largemouth Bass may have had a particularly important effect on Threadfin Shad and Striped Bass, whose earlier life stages occur in littoral habitat (Grimaldo et al. 2004; Nobriga and Feyrer 2007). Michel et al. (2018) estimated that during the 2014/2015 spring outmigration period of juvenile fall-run Chinook Salmon, Largemouth Bass consumed 3 to 5 Chinook Salmon per day per kilometer (0.011 salmon per predator per day), compared to 0 to 24 Chinook Salmon per day for Striped Bass (0.019 salmon per predator per day). Michel et al. (2018) also found Channel Catfish had a higher frequency (27.8 percent) of juvenile Chinook Salmon in their stomachs than Striped Bass, Largemouth Bass, or White Catfish (2.8–4.8 percent). Genetic studies of stomach contents have suggested a more limited role for Largemouth Bass predation of native fishes than Striped Bass in the Delta (Weinersmith et al. 2019; Brandl et al.

2021). Although much focus has been on Largemouth Bass, other predatory black bass species (Smallmouth Bass and Spotted Bass [*Micropterus punctulatus*]) occur in greater abundance in the more riverine sections of the Delta (e.g., Sacramento River in the north Delta; California Department of Water Resources 2016:3-256–3-260)

Invasive Mississippi Silverside (*Menidia audens*) is another potentially important predator of larval fishes in the Delta. This introduced species was not believed to be an important predator on Delta Smelt, but studies using DNA techniques detected the presence of Delta Smelt in the guts of 12.5 percent of Mississippi Silversides sampled across a variety of habitats in the north Delta and found a greater probability of predation in less turbid, clearer water (Schreier et al. 2016). Schreier et al.'s (2016) study was consistent with an earlier study by Baerwald et al. (2012) that found a higher proportion of Mississippi Silversides in offshore habitats sampled by Kodiak trawling had preyed upon Delta Smelt. These findings may suggest that predation impacts could be significant, given the increasing numbers of Mississippi Silversides in the Delta (Mahardja et al. 2016) and decreasing trends in turbidity (Nobriga et al. 2008; although as noted above in "Turbidity," increases in suspended sediment/turbidity may occur in the future under climate change scenarios [Stern et al. 2020]), and as supported by recent statistical analyses examining the potential influence of Mississippi Silverside abundance on Delta Smelt population dynamics (Hamilton and Murphy 2018; Polansky et al. 2021).

Predation of fish in the Delta is known to occur in specific areas, for example at channel junctions and areas that constrict flow or confuse migrating fish and provide cover for predatory fish (Vogel 2011). Sabal (2014) found similar results at Woodbridge Dam on the Mokelumne River where the dam was associated with increased Striped Bass per capita salmon consumption, which decreased outmigrant juvenile salmon survival by 10–29 percent. CDFW identified subadult Striped Bass as the major predatory fish in the CCF (California Department of Fish and Game 1992). In 1993, for example, Striped Bass made up 96 percent of the predators removed (Vogel 2011). Cavallo et al. (2012) studied tagged salmon smolts to test the effects of predator removal on outmigrating juvenile Chinook Salmon in the south Delta. Their results suggested that predator abundance and migration rates strongly influenced survival of salmon smolts. Exposure time to predators has been found to be important for influencing survival of outmigrating salmon in other studies in the Delta (Perry et al. 2012). Michel et al. (2020) investigated factors affecting survival of juvenile Chinook Salmon using predation event recorders in the south Delta and found that increased predation risk was correlated with increasing water temperature, time of day (i.e., greatest risk within 50 minutes after sunset), closer proximity to predators, and increased river bottom roughness.

DWR examined the species distribution and abundance of salvaged fish at DWR's south Delta SWP pumping facilities to determine whether alternative release scenarios between salvaged Delta Smelt and predatory species would increase smelt survival (California Natural Resources Agency 2017). An initial evaluation of historical records on species distribution of salvaged fish led to the conclusion that adjusting DWR's salvage operations to stop returning predatory fish to the Delta would have little impact on Delta Smelt survival (California Natural Resources Agency 2017:3).

Aquatic Macrophytes

Aquatic macrophytes are an important component of the biotic community of Delta wetlands and can provide habitat for aquatic species, serve as food, produce detritus, and influence water quality through nutrient cycling and DO fluctuations. Whipple et al. (2012) described likely historical conditions in the Delta, which have been modified extensively, with major impacts on the aquatic macrophyte community composition and distribution. The primary change has been a shift from a high percentage of emergent aquatic macrophyte wetlands to open water and hardened channels.

The introduction of two nonnative invasive aquatic plants, water hyacinth (*Eichhornia crassipes*) and Brazilian waterweed, has reduced habitat quantity and value for many native fishes. Water hyacinth forms floating mats that greatly reduce light penetration into the water column, which can significantly reduce primary productivity and available food for fish in the underlying water column. Brazilian waterweed grows along the margins of channels in dense stands that prohibit access by native juvenile fish to shallow water habitat. In addition, the thick cover of these two invasive plants provides excellent habitat for nonnative ambush predators such as bass, which prey on native fish species. Studies indicate low abundance of native fish, such as Delta Smelt, Chinook Salmon, and Sacramento Splittail, in areas of the Delta where submerged aquatic vegetation infestations are thick (Grimaldo et al. 2004, 2012; Nobriga et al. 2005).

Invasive aquatic macrophytes are expanding within the Delta, and resulting habitat changes are ongoing (Conrad et al. 2020), with negative impacts on habitats and food webs of native fish species (Toft et al. 2003; Grimaldo et al. 2009b; Mahardja et al. 2017). Concerns about invasive aquatic macrophytes are centered on their ability to form large, dense growth that can clog waterways, block fish passage, increase water clarity, provide cover for predatory fish, and cause high biological oxygen demand. DWR is actively engaged in a program of aquatic weed control. Building on the state's existing herbicide treatment program, DWR targeted 200 acres of Delta Smelt habitat at Decker Island in the western Delta and the Cache Slough complex in the north Delta. Recent field studies investigated the effect of herbicide treatment on Delta Smelt habitat (California Natural Resources Agency 2017). For example, studies of water hyacinth treatment have found that while hyacinth may lower DO and increase turbidity in and near hyacinth, herbicide treatment of the hyacinth restores conditions to those representative of the broader region (Tobias et al. 2019). Conrad et al. (2020:3) concluded that recent science demonstrates that current treatment methods and monitoring for submerged aquatic vegetation are not sufficient for reducing coverage, particularly in habitats similar to those targeted for restoration. It is unknown whether management of nutrients could reduce the distribution and coverage of invasive aquatic macrophytes in the Delta (Dahm et al. 2016).

Long-term Status and Trend Monitoring Coordinated through the Interagency Ecological Program

DWR, in coordination with the U.S. Bureau of Reclamation (Reclamation), supports and funds a long-term status and trend monitoring for the Delta ecosystem. The monitoring program is coordinated under the Interagency Ecological Program (IEP). The IEP is a consortium of California State and U.S. federal agencies that guides and performs scientific research on the aquatic ecosystem of the Delta and San Francisco Bay. Beginning in 1970, the IEP has overseen a monitoring program that investigates the conditions of a number of ecosystem parameters, both biotic and abiotic. Information gathered from these investigations, along with modeling and related research, is synthesized for use by the consortium agencies for decision-making purposes. The monitoring program includes long-running surveys, some that have expanded in recent years in response to program reviews or new information needs (Table 6-2). Descriptions of these monitoring programs are provided by IEP (2023).

Table 6-2. DWR and Reclamation Coordinated Monitoring Programs

Monitoring Study or Survey	Responsible Entity
Fall Midwater Trawl Survey	CDFW
Summer Townet Survey	CDFW
Estuarine and Marine Fish and Crab Abundance and Distribution Survey (Bay Study)	CDFW
San Francisco Bay Salinity and Temperature Monitoring	USGS
Delta Flows Network	USGS
20-mm Delta Smelt Survey	CDFW
Yolo Bypass Fish Monitoring Program	DWR
Juvenile Salmon Monitoring Program (Delta Juvenile Fish Monitoring Program, DJFMP)	USFWS
Coleman National Fish Hatchery Late-Fall Run Production Tagging	USFWS
Mossdale Trawl	USFWS/CDFW
Environmental Monitoring Program	DWR
Central Valley Juvenile Salmon and Steelhead Monitoring (Knights Landing)	CDFW
Upper Estuary Zooplankton Sampling	CDFW
UC Davis Suisun Marsh Fish Monitoring	UC Davis
Smelt Larva Survey	CDFW
Operation of Thermographic Stations	USGS
Juvenile Salmon Emigration Real Time Monitoring (DJFMP)	USFWS
Tidal Wetland Monitoring Study	CDFW
Salmon Survival Studies (DJFMP)	USFWS
Enhanced Delta Smelt Monitoring	USFWS

CDFW = California Department of Fish and Wildlife; DWR = California Department of Water Resources; USFWS = U.S. Fish and Wildlife Service; USGS = U.S. Geological Survey.

Experimental Releases of Delta Smelt

Supplementation of Delta Smelt back into the Delta by 2024 was required under terms of the 2019 BiOp on the long-term operations of the federal CVP and the California State Water Project. Prior to supplementation, experimental releases of cultured Delta Smelt began in December 2021 to assess logistics and release strategies prior to full supplementation (Table 6-3).

Table 6-3. Experimental Releases of Delta Smelt, 2021–2024

Date	Location	Number Released
December 14–15, 2021	Rio Vista	12,800
January 11–12, 2022	Rio Vista	12,800
February 3, 2022	Sacramento Deep Water Ship Channel	6,400
February 9–10, 2022	Belden’s Landing, Suisun Marsh	12,800
February 16–17, 2022	Sacramento Deep Water Ship Channel	10,933
November 29–30, 2022	Rio Vista	13,140
January 18–19, 2023	Rio Vista	17,570
January 24–26, 2023	Sacramento Deep Water Ship Channel	12,995

Date	Location	Number Released
November 15, 2023	Rio Vista	14,104
December 12–14, 2023	Rio Vista	13,089
December 19–20, 2023	Rio Vista	12,691
January 10, 2024	Rio Vista	25,649
January 24–25, 2024	Rio Vista	12,778
January 30–31, 2024	Rio Vista	13,157

Suisun Bay/Marsh

Aquatic Habitat

Suisun Marsh is a brackish-water marsh bordering the northern edge of Suisun Bay. The description in this section draws largely on work by Siegel et al. (2010). Most of its marsh area consists of diked wetlands managed for waterfowl, and the rest of the acreage consists of tidally influenced sloughs and emergent tidal wetlands (Suisun Ecological Workgroup 2001:20–24). The central latitudinal location of Suisun Marsh within the San Francisco Estuary makes it an important rearing area for euryhaline freshwater, estuarine, and marine fishes. Many fish species that migrate or use Delta habitats are also found in the waters of Suisun Bay. Tides reach Suisun Bay and Suisun Marsh through the Carquinez Strait, and most freshwater flows enter at the southeast border of Suisun Marsh at the confluence of the Sacramento and San Joaquin rivers. The mixing of freshwater outflows from the Central Valley with saline tidal water in Suisun Bay and Suisun Marsh results in brackish water with strong salinity gradients, complex patterns of flow interactions, and generally the highest biomass productivity in the entire estuary (Siegel et al. 2010).

Flow, turbidity, and salinity are important factors influencing the location and abundance of zooplankton and small prey organisms used by Delta species (Kimmerer et al. 1998). The location where net current flowing inland along the bottom reverses direction and sinking particles are trapped in suspension is associated with the higher turbidity known as the estuarine turbidity maximum (Schoellhamer 2001). Zooplanktonic organisms maintain position in this region of historically high productivity in the estuary through vertical movements (Kimmerer et al. 1998).

Salinity in the Suisun Marsh and Bay system is a major water quality characteristic that strongly influences physical and ecological processes. Many fish species native to Suisun Marsh require low salinities during the spawning and rearing periods (Suisun Ecological Workgroup 2001:88; Kimmerer 2004; Feyrer et al. 2007, 2011; Nobriga et al. 2008). The Suisun Marsh and Bay usually contain both the maximum estuarine salinity gradient (i.e., greatest difference between high and low salinity) and the low-salinity zone. The overall estuarine salinity gradient trends from west (higher) to east (lower) in Suisun Bay and Suisun Marsh. The location of the low-salinity zone is influenced by outflow. Suisun Marsh also exhibits a persistent north-south salinity gradient. Despite low and seasonal flows, the surrounding watersheds have a significant water freshening effect because of the long residence times of freshwater inflows to the marsh, including discharges from the upper sloughs and wastewater effluent. The larger of these surrounding watersheds include Suisun, Green Valley, Ledgewood, Laurel, McCoy, and Union creeks (Siegel et al. 2010:1-18).

The Suisun Bay and Suisun Marsh system contains a wide variety of habitats such as marsh plains, tidal creeks, sloughs, channels, cuts, mudflats, and bays. These features and the complex hydrodynamics and water quality of the system have historically fostered significant biodiversity within Suisun tidal aquatic habitats, but these habitats, like the Delta, have also been significantly altered and degraded by human activities over the decades.

Categories of tidal aquatic waters include bays, major sloughs, minor sloughs, and the intertidal mudflats in those areas (Engle et al. 2010). These tidal waters total approximately 26,000 acres, with the various embayments totaling about 22,350 acres. Tidal slough habitat is composed of major and minor sloughs. Major sloughs of Suisun Marsh have a combined acreage of about 2,200 acres consisting of both shallow and deep channels. Minor sloughs are made up of shallow channel habitat and have a combined acreage of about 1,100 acres. Habitats in Suisun Marsh bays and sloughs support a diverse assemblage of aquatic species that typically use open water tidal areas for breeding, foraging, rearing, or migrating. As part of the SWP long-term operations authorized by the CDFW (2020b) ITP, the Suisun Marsh Salinity Control Gates (SMSCG) on Montezuma Slough are to be operated for up to 60 days (not necessarily consecutive) in June through October of Below Normal and Above Normal years, and for 30 days (not necessarily consecutive) in Dry years following Below Normal years. A number of tidal habitat restoration projects have been completed or are underway in Suisun Marsh (California Department of Water Resources 2019a).

Fish Entrainment

DWR and Reclamation constructed several facilities to provide lower-salinity water to managed wetlands in Suisun Marsh, including the Roaring River Distribution System (RRDS), Morrow Island Distribution System (MIDS), and Goodyear Slough Outfall. Other facilities constructed under the Suisun Marsh Preservation Agreement that could entrain fish include the Lower Joice Island and Cygnus Drain diversions.

The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 1 inch (approximately 25 mm). DWR monitored fish entrainment from September 2004 through June 2006 at the MIDS to evaluate entrainment losses at the facility. Monitoring took place over several months under various operational configurations and focused on Delta Smelt and salmonids. More than 20 species were identified during the sampling, but only two juvenile Chinook Salmon the size of fall-run Chinook Salmon were observed, at the South Intake of the Distribution System in 2006, and no Delta Smelt from entrained water were observed (Enos et al. 2007). The total number of Longfin Smelt collected in entrainment monitoring was nearly 120 in 2004/2005 and 6 in 2005/2006 (Enos et al. 2007:16). The Goodyear Slough Outfall system is open for free fish movement except near the outfall when flap gates are closed during flood tides (U.S. Bureau of Reclamation 2008:13-124). Conical fish screens have been installed on the Lower Joice Island diversion on Montezuma Slough.

Yolo Bypass

Aquatic Habitat

Aquatic habitats in the Yolo Bypass include stream and slough channels for fish migration and when flooded, seasonal spawning habitat and productive rearing habitat (Sommer et al. 2001a, 2001b; CALFED Bay-Delta Program 2000a:311; Takata et al. 2017). During years when the Yolo Bypass is flooded, it serves as an important migratory route for juvenile Chinook Salmon and other native migratory and anadromous fishes moving downstream. During these times, it provides juvenile anadromous salmonids an alternative migration corridor to the lower Sacramento River (Sommer et al. 2003) and, sometimes, better rearing conditions than the adjacent Sacramento River channel

(Sommer et al. 2001a, 2001b, 2005). Flooding of the Yolo Bypass occurs when the Sacramento River stage exceeds the existing weir elevation of approximately 32 feet North American Vertical Datum (NAVD)88, which occurs in approximately 60–70 percent of years depending on the historical time period examined (Acierto et al. 2014), with duration of flooding ranging from a few days to several months (Takata et al. 2017). When the floodplain is activated, juvenile salmon can rear for weeks to months in the Yolo Bypass floodplain before migrating to the estuary (Sommer et al. 2001a, 2001b). Research on the Yolo Bypass has found that juvenile salmon grow substantially faster in the Yolo Bypass floodplain than in the adjacent Sacramento River, primarily because of the greater availability of invertebrate prey in the floodplain (Sommer et al. 2001a, 2001b, 2005). Increased frequency and duration of connectivity between the Sacramento River and the Yolo Bypass may increase off-channel rearing opportunities that expand the life history diversity portfolio for Central Valley Chinook Salmon (Takata et al. 2017). When not flooded, the lower Yolo Bypass provides tidal habitat for young fish that enter from the lower Sacramento River via Cache Slough Complex—a network of tidal channels and flooded islands that includes Cache Slough, Lindsey Slough, Liberty Island, the Sacramento Deep Water Ship Channel, and the Yolo Bypass (McLain and Castillo 2009).

Sommer et al. (1997) found statistically significant correlations of Sacramento Splittail abundance indices with Yolo Bypass inundation, reflecting floodplains providing abundant food, spawning and rearing habitat, and possibly reduced losses of eggs and larvae to aquatic predators. Because the Yolo Bypass is dry during summer and fall, nonnative species (e.g., predatory fishes) generally are not present year-round except in perennial water sources (Sommer et al. 2003). In addition to providing important fish habitat, winter and spring inundation of the Yolo Bypass supplies phytoplankton and detritus that may benefit aquatic organisms downstream in the brackish portion of the San Francisco Estuary (Sommer et al. 2004; Lehman et al. 2008b).

The benefit of seasonal inundation of the Yolo Bypass has been studied by DWR as part of the Delta Smelt Resiliency Strategy, which was developed in 2016 by DWR and other state and federal resource agencies to boost both immediate- and near-term reproduction, growth rates, and survival of Delta Smelt (California Natural Resources Agency 2016; Mahardja et al. 2019). The Yolo Bypass has been identified as a significant source of phytoplankton and zooplankton biomass to the Delta in the winter and spring during floodplain inundation. However, little was previously known about its contribution to the food web during the drier summer and fall months.

One action taken by DWR under the Delta Smelt Resiliency Strategy is the food web enhancement projects in the Yolo Bypass. Under this action, DWR worked with farmers as well as irrigation and reclamation districts to direct water through the Yolo Bypass in the form of flow pulses during summer and fall (Frantzich et al. 2018). The first examination of off-season flow pulses occurred in 2016 when a flow pulse of 12,700 acre-feet (af) was released over two weeks in the summer. The second examination occurred during 2018 when a 19,821-af flow occurred over four weeks in the fall. These flow pulses were followed in turn by a significant increase in phytoplankton biomass in the Cache Slough Complex and further downstream in the lower Sacramento River (California Natural Resources Agency 2017; California Department of Water Resources 2019b). The increase in phytoplankton biomass was also found to enhance zooplankton growth and production, increasing food supplies for Delta Smelt and other Delta fish species. During the second year of flow pulses, a managed flow pulse was generated in fall 2018. The 2018 Fall North Delta Flow Action generated a flow pulse of 19,821 af over four weeks, which while not coinciding with a wave of phytoplankton moving through the Yolo Bypass, did result in an export of higher densities of zooplankton into downstream habitats of lower Cache Slough and the Sacramento River at Rio Vista (California Department of Water Resources 2019b).

Studies continued in 2019 on the issue of food web enhancement in the Yolo Bypass. Working with the Glenn-Colusa Irrigation District and other partners, DWR tested the benefit of passing water through the Yolo Bypass to enhance Delta Smelt habitat in the north Delta region (Davis et al. 2019). The action was expected to generate a seasonal positive flow pulse through the Yolo Bypass Toe Drain, which was expected to benefit the food web in downstream areas for fishery resources. DWR altered the operation of the Knights Landing Outfall Gates and Wallace Weir to direct agricultural return flows from the Colusa Basin Drain through Ridge Cut Slough and Wallace Weir into the Yolo Bypass between late August and late September. The results of this study were reported by Twardochleb et al. (2021:3): the quantity of plankton (fish food) in the Yolo Bypass increased, but not downstream in the lower Sacramento River. In addition, more nutritious diatoms grew in the Yolo Bypass after the flow pulse than before, providing food for zooplankton. Collaborator studies provided evidence that the 2019 flow action did not negatively affect growth or survival of Delta Smelt or Chinook Salmon. Despite these benefits to the food web, increased contaminant loads and low nutrient availability in the flow pulse water could have affected the magnitude of food web responses. Moreover, the 2019 flow action did not increase food availability downstream by as much as the 2016 flow action using diversions of Sacramento River water. Twardochleb et al. (2021:3) concluded that future studies, including repeating the 2016 flow action using Sacramento River water and an upcoming flow action synthesis comparing the results of managed flow pulses on the north Delta food web from 2011 to 2019, will help them assess the effects of source water (agricultural return flows vs. Sacramento River), and other mediating factors such as hydrology, to adaptively manage the flow action to maximize food availability downstream.

Potential negative effects of the north Delta food web enhancement action include straying of adult Chinook Salmon. Twardochleb et al. (2021:32) summarized the information related to the 2019 study. They noted CDFW monitored fish straying into the Yolo Bypass using gill nets, fyke trapping and the Wallace Weir Fish Rescue Facility data during and after the 2019 managed flow pulse. Around the timing of the end of the pulse, salmonids were caught in the Rescue Facility; however, this overlapped with the normal occurrence of straying, beginning around October or November. Of 363 salmonids caught and transported, there were 11 mortalities. This suggests that the flow pulse had only minor effects on salmon and showed that the fish rescue facility can help to mitigate natural straying and mortalities. DWR and CDFW plan to continue monitoring salmon during subsequent managed flow pulses and are currently conducting a synthesis of factors influencing straying.

Reclamation and DWR (2019) concluded that increases in Yolo Bypass floodplain inundation as a result of the notching of Fremont Weir under the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project would result in beneficial impacts on fish, which reflect mechanisms such as increased access for juveniles (Acierto et al. 2014), faster juvenile growth (Takata et al. 2017), and survival comparable to the mainstem Sacramento River (Hance et al. 2022; Pope et al. 2021).

Fish Passage

The Fremont Weir is a major impediment to fish passage and a source of migratory delay and loss of adult Chinook Salmon, steelhead, and sturgeon (National Marine Fisheries Service 2009:611; Sommer et al. 2014). The Fremont Weir creates a migration barrier for a variety of species, although fish with strong jumping capabilities (e.g., salmonids) may be able to pass the weir at higher flows. In 2018, DWR implemented the Fremont Weir Adult Fish Passage Modification Project. The project replaced an old, undersized, inefficient fish ladder in the center of the weir with a wider and deeper gate structure. The gate structure is equipped with two Adaptive Resolution Imaging Sonar (ARIS) cameras that aid in quantifying the structure's effectiveness. In 2019, DWR (2020a) recorded 261 hours of ARIS footage. This showed at least 70 sturgeon and more than 4,000 other adult fish volitionally passed through the structure, fish that would have most likely become stranded in the Bypass without the new fish passage structure (California Department of Water Resources 2020a:iii).

Some adult winter-run, spring-run, and fall-run Chinook Salmon and White Sturgeon migrate into the Yolo Bypass via the Toe Drain and Tule Canal when there is no flow into the floodplain over the Fremont Weir. Fyke trap monitoring by DWR has shown that adult salmon and steelhead migrate up the Toe Drain in autumn and winter regardless of whether the Fremont Weir spills (Harrell and Sommer 2003; Sommer et al. 2014). The Toe Drain does not extend to the Fremont Weir because the channel is fully or partially blocked by roads or other higher ground at several locations and fish are often unable to reach upstream spawning habitat in the Sacramento River and its tributaries (Harrell and Sommer 2003; Sommer et al. 2014). Other structures in the Yolo Bypass, such as the Lisbon Weir, and irrigation dams in the northern end of the Tule Canal may also impede upstream passage of adult anadromous fish (National Marine Fisheries Service 2009:611). Modifications to some of these structures were made as part of the Fremont Weir Adult Fish Passage Modification Project, and two agricultural road crossings were altered to improve fish passage.

In addition, sturgeon and salmonids attracted by high flows into the basin become concentrated behind the Fremont Weir, where they are subject to heavy illegal fishing pressure. Passage blockage of Green Sturgeon at Fremont Weir could have population-level consequences (Thomas et al. 2013).

Stranding of juvenile salmonids and sturgeon has been reported in the Yolo Bypass in scoured areas behind the weir and in other areas as floodwaters recede (National Marine Fisheries Service 2009:611; Sommer et al. 2005). However, Sommer et al. (2005) found most juvenile salmon migrated off the floodplain as it drained.

DWR and Reclamation have been working on the Yolo Bypass Habitat Restoration program, which is developing and implementing several restoration actions in the Yolo Bypass. Some of these actions are complete, including the Wallace Weir Adult Fish Rescue Facility Project and the Fremont Weir Adult Fish Passage Modification Project. The Agricultural Road Crossing #4 Fish Passage Project is currently at 95 percent design, with construction beginning in 2024. Preconstruction work for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (also known as the "Big Notch") occurred in fall 2021, with construction continuing through the summer of 2024. The initial operational period will be November 1, 2024, to March 15, 2025.

6.1.5 San Pablo and San Francisco Bays

6.1.5.1 Description of San Pablo and San Francisco Bays

Hydrologically, the Bay may be divided into two broad subdivisions with differing ecological characteristics: a southern reach consisting of South San Francisco Bay, and a northern reach composed of Central San Francisco, San Pablo, and Suisun Bays (The Bay Institute 1998:2-77; CALFED Bay-Delta Program 2000a). The southern reach receives little freshwater discharge, leading to high salinity and poor circulation (high residence time). It also has more extreme tides. The northern reach, which directly receives Delta outflow, is characterized by less extreme tides and a pronounced horizontal salinity gradient, ranging from near full marine conditions in Central Bay to near freshwater conditions in Suisun Bay. Central Bay and Suisun Bay contain large islands, features not present in San Pablo Bay and South Bay (The Bay Institute 1998; CALFED Bay-Delta Program 2000a). All of the bays except Central Bay include extensive marshlands. Suisun Bay is not treated in this section because it was covered with the Delta in a previous section.

Northern Reach—Central San Francisco and San Pablo Bays

In addition to tides and large-scale influences such as warmer/cooler regimes (e.g., North Pacific Gyre Oscillation; Feyrer et al. 2015b), ecological factors having the greatest influence on fish of Central San Francisco Bay and San Pablo Bay include freshwater inflow from rivers, wetlands, riparian vegetation, and aquatic habitat diversity. Habitats in these bays are tidal perennial aquatic habitat, tidal saline emergent wetland, seasonal wetland, perennial grassland, agricultural land, and riparian habitat. These habitats support a variety of native marine, estuarine, freshwater, and anadromous fish (CALFED Bay-Delta Program 2000a). San Francisco Bay is designated as a coastal estuary Habitat Area of Particular Concern and eelgrass (*Zostera marina*) is designated as seagrass Habitat Area of Particular Concern for Pacific groundfish species. Fish species that currently depend on tidal marshes and adjoining sloughs, mudflats, and embayments include Delta Smelt, Longfin Smelt, Chinook Salmon, Green Sturgeon, White Sturgeon, Pacific Herring (*Clupea pallasii*), Starry Flounder (*Platichthys stellatus*), Sacramento Splittail, American Shad, and Striped Bass (The Bay Institute 1998:2-83–2-84; CALFED Bay-Delta Program 2000a; Baxter et al. 2008:3-7). Other fish commonly found in Central Bay include Northern Anchovy (*Engraulis mordax*), California Halibut (*Paralichthys californicus*), Bay Goby (*Lepidogobius lepidus*), White Croaker (*Genyonemus lineatus*), Pacific Staghorn Sculpin (*Leptocottus armatus*), and marine surfperches. English Sole (*Parophrys vetulus*), Shiner Surfperch (*Cymatogaster aggregata*), Jacksmelt (*Atherinopsis californiensis*), Topsmelt (*Atherinops affinis*), Diamond Turbot (*Hypsopsetta guttulata*), and Speckled Sand Dab (*Citharichthys stigmaeus*) are common in shallow waters around Central Bay. The Leopard Shark (*Triakis semifasciata*), Sevengill Shark (*Notorynchus cepedianus*), and the Brown Smoothhound (*Mustelus henlei*) are abundant in the intertidal mudflats of the Central Bay. The sand substrate and rock outcrops in the Central Bay support recreational fish such as the California Halibut, Striped Bass, Rockfish, and Lingcod (*Ophiodon elongatus*).

Southern Reach—South San Francisco Bay

The southern reach receives far less freshwater runoff and does not generally exhibit the type of estuarine circulation that occurs in the northern reach (The Bay Institute 1998:2-78). Salinity is characteristically high, often similar to nearshore ocean levels, but is generally homogeneous. The reach is characterized by a much higher residence time of water, and on average is flushed at about one-fourth the rate of the northern reach (The Bay Institute 1998:2-78).

The South Bay supports a primarily marine fish assemblage owing to its saline water environment. Fish species include planktivorous Topsmelt, Jacksmelt, Bay Pipefish (*Syngnathus leptorhynchus*), Brown Rockfish (*Sebastes auriculatus*), surfperches, Surf Smelt (*Hypomesus pretiosus*), Longfin Smelt, Diamond Turbot, Arrow Goby (*Clevelandia ios*), and Staghorn Sculpin (The Bay Institute 1998:2-84). Evidence of Longfin Smelt spawning in the lower Coyote Creek watershed with successful recruitment in years of high freshwater outflow was recently found by Lewis et al. (2020). Anadromous salmonids produced in tributaries to the South Bay include steelhead and Chinook Salmon, the latter of which are considered hatchery-origin strays, although recent archaeological evidence suggests Chinook Salmon were historically native to the Guadalupe River watershed (Lanman et al. 2021).

6.1.5.2 Habitat Conditions and Environmental Stressors in San Pablo and San Francisco Bay Area

Environmental stressors for fish populations in San Francisco and San Pablo Bays include water and sediment quality, exposure to toxic substances, reduction in Delta outflows, legal and illegal harvest, food availability, reduction in seasonally inundated wetlands, wave and wake erosion, introduced nonnative plant and animal species, and competition for food resources with nonnative fish and macroinvertebrates (e.g., filter feeding by the nonnative mollusks) (CALFED Bay-Delta Program 2000a; Armor et al. 2005; Baxter et al. 2008:8).

6.2 Regulatory Environment and Compliance Requirements

6.2.1 Federal Plans, Policies, and Regulations

6.2.1.1 Federal Endangered Species Act

The federal Endangered Species Act (ESA) requires that both USFWS and NMFS maintain list of threatened and endangered species. An endangered species is defined as "…any species which is in danger of extinction throughout all or a significant portion of its range." A threatened species is defined as "…any species that is likely to become an Endangered Species within the foreseeable future throughout all or a significant portion of its range" (Title 16 U.S. Code [USC], Section 1532). Section 9 of the ESA makes it illegal to "take" (i.e., harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in such conduct) any endangered species of fish or wildlife, and regulations contain similar provisions for most threatened species of fish and wildlife (16 USC, Section 1538). The ESA also requires the designation of critical habitat for listed species. Critical habitat is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential for the conservation of the species, and those features may require special management considerations or protection; and (2) specific areas outside the geographic area occupied by the species if the agency determines that the area itself is essential for conservation of the species (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998; National Marine Fisheries Service 2009).

Section 7 (a)(2) of the ESA requires all federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat. To ensure against jeopardy, each federal agency must consult with USFWS or NMFS, or both, if the federal agency determines that its action might affect listed species. NMFS jurisdiction under the ESA is limited to the protection of marine mammals, marine fish, and anadromous fish; all other species are within USFWS jurisdiction.

If an activity proposed by a federal agency would result in take of a federally listed species, the consulting agency will issue a BiOp analyzing the impacts of the proposed action on listed species and an Incidental Take Statement if appropriate. The Incidental Take Statement typically requires various measures to avoid or minimize species take.

Where a federal agency is not authorizing, funding, or carrying out a project, take that is incidental to the lawful operation of a project may be permitted pursuant to Section 10(a) of the ESA through approval of a habitat conservation plan and issuance of an ITP.

Critical Habitat Designations

Critical habitat refers to areas designated by USFWS or NMFS for the conservation of their jurisdictional species listed as threatened or endangered under the ESA. When a species is proposed for listing under the ESA, USFWS or NMFS considers whether there are certain areas essential to the conservation of the species. Critical habitat is defined in Section 3, Provision 5(A), of the ESA as follows.

> (a) The term "critical habitat" for a threatened or endangered species means–
>
> (U) the specific areas within the geographical area occupied by a species at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and
>
> (b) (ii) specific areas outside the geographical area occupied by a species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential for the conservation of the species.

Delta Smelt critical habitat was designated on December 19, 1994 (59 *Federal Register* [FR] 65256), and includes "areas of all water and all submerged lands below ordinary high water and the entire water column bounded by and constrained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the Delta."

NMFS designated critical habitat for winter-run Chinook Salmon on June 16, 1993 (58 FR 33212). Critical habitat was delineated as the Sacramento River from Keswick Dam at River Mile (RM) 302 to Chipps Island (RM 0) at the westward margin of the Delta, including Kimball Island, Winter Island, and Brown's Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge. In the Sacramento River, critical habitat includes the river water column and substrate and the adjacent riparian zone. Westward of Chipps Island, critical habitat includes the estuarine water column and essential foraging habitat and food resources used by Sacramento River winter-run Chinook Salmon as part of their juvenile emigration or adult spawning migration.

Critical habitat was designated for Central Valley spring-run Chinook Salmon on September 2, 2005 (70 FR 52488). Critical habitat for Central Valley spring-run Chinook Salmon includes stream reaches such as those of the Feather and Yuba rivers; Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; the mainstem of the Sacramento River from Keswick Dam through the Delta; and portions of the network of channels in the northern Delta. Critical habitat includes the stream channels in these designated waters up to the ordinary high water line or bankfull elevation (elevation generally with a recurrence interval of one to two years).

Critical habitat was designated for steelhead in the Central Valley on September 2, 2005 (70 FR 41 52488). Critical habitat for Central Valley steelhead occurs within the Plan Area, and includes the stream channels to the ordinary high water line within the designated stream reaches, such as those of the American, Feather, and Yuba rivers and the Deer, Mill, Battle, Antelope, and Clear creeks in the Sacramento River Basin; the Calaveras, Mokelumne, Stanislaus, and Tuolumne rivers in the San Joaquin River Basin; and the Sacramento and San Joaquin rivers and the entire Delta.

Critical habitat was designated for the southern distinct population segment (DPS) of North American Green Sturgeon on October 9, 2009 (74 FR 52345). The designation includes the stream channels and waterways in the Delta to the ordinary high water line. The designation also includes the mainstem Sacramento River upstream from the I Street Bridge to Keswick Dam and the Feather River upstream to the fish barrier dam adjacent to the Feather River Fish Hatchery; the Yuba River upstream to Daguerre Point Dam; the Sutter and Yolo bypasses; and the estuaries of the San Francisco Bay, Suisun Bay, and San Pablo Bay.

Endangered Species Act Consultation on Operation of the CVP and SWP

DWR operates the SWP in compliance with the existing ESA authorizations for long-term SWP operations, including:

- NMFS 2019 BiOp on Long-Term Operation of the CVP and the SWP
- USFWS 2019 BiOp for the Reinitiation of Consultation on the Coordinated Long-Term Operations of the CVP and SWP

As a part of ongoing litigation, a federal court has issued orders temporarily modifying certain ESA operational requirements, with which DWR's SWP operations also comply.

Central Valley Project Improvement Act

The Reclamation Projects Authorization and Adjustment Act of 1992 (Public Law 102-575) includes Title 34, the Central Valley Project Improvement Act (CVPIA). The CVPIA amends the authorization of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes of the CVP having equal priority with irrigation and domestic uses of CVP water and elevates fish and wildlife enhancement to a level having equal purpose with power generation. Among the changes mandated by the CVPIA was dedication of 800 thousand acre-feet of CVP yield annually to fish, wildlife, and habitat restoration. The Department of the Interior's May 9, 2003 decision on implementation of Section 3406(b)(2) of CVPIA explains how Section 3406(b)(2) water will be dedicated and managed. Dedication of CVPIA 3406(b)(2) water occurs when Reclamation takes a fish and wildlife habitat restoration action based on recommendations of USFWS (and in consultation with NMFS and CDFW), pursuant to Section 3406 (b)(2). Water exports at the CVP pumping facilities have been reduced using (b)(2) water to decrease the risk of fish entrainment at the salvage facilities and also to augment river flows.

6.2.1.2 Collaborative Science and Adaptive Management Program

Since its inception in 2013, the Collaborative Science and Adaptive Management Program (CSAMP) has been focused on the management of CVP and SWP water project operations and how those operations affect listed fish species, particularly Delta Smelt and salmonids. CSAMP serves as a forum for communication, coordination, and engagement on matters associated with the conservation of listed fish within the Sacramento San Joaquin Bay-Delta Estuary and operations of the CVP and SWP. Information developed by CSAMP is intended to facilitate more effective management decisions, including regulatory decisions, but CSAMP does not directly engage in ongoing regulatory proceedings such as the consultation on Long-term Operation of the CVP and SWP or the Water Quality Control Plan (WQCP) update.

In February 2017, the CSAMP Policy Group adopted the following updated purpose statement:

> (a) Work with a sense of urgency to collaboratively evaluate current hypotheses and management actions associated with protection and restoration of species of concern, current and future federal and state regulatory authorizations for the SWP and CVP, and other local and state management actions, to improve performance from both biological and water supply perspectives.

The CSAMP is structured as a four-tiered organization comprised of a Policy Group consisting of agency directors and top-level executives from the entities that created CSAMP. The Collaborative Adaptive Management Team is made up of managers and senior-level scientists that serve at the direction of the Policy Group. Scoping Teams and Subcommittees are created on an as-needed basis to scope specific science studies or discuss study results. Investigators are contracted as needed to conduct studies.

6.2.1.3 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation Management Act, as amended by the Sustainable Fisheries Act (Public Law 104 to 297), was enacted primarily to establish a management system for conserving and managing commercial fisheries within the 200-mile federal waters boundary of the United States. The act also requires that all federal agencies consult with NMFS on activities or proposed activities authorized, funded, or undertaken by that agency that may adversely affect essential fish habitat (EFH) of commercially managed marine and anadromous fish species. EFH includes specifically identified waters and substrate necessary for fish spawning, breeding, feeding, or growing to maturity. EFH also includes all habitats necessary to allow the production of commercially valuable aquatic species, to support a long-term sustainable fishery, and to contribute to a healthy ecosystem (16 USC, Section 1802[10]).

The Pacific Fishery Management Council has designated the Delta, San Francisco Bay, and Suisun Bay as EFH to protect and enhance habitat for coastal marine fish and macroinvertebrate species that support commercial fisheries such as Pacific salmon. Because EFH only applies to commercial fisheries, this means that all Chinook Salmon habitats are included, but not steelhead habitat. There are three fishery management plans (for Pacific salmon, coastal pelagic, and groundfish species) issued by the Pacific Fishery Management Council that designate EFH within the Bay-Delta Estuary:

- Starry Flounder (*Platichthys stellatus*) identified as Actively Managed in the Pacific Coast Groundfish Fishery Management Plan (Pacific Fishery Management Council 2016a)
- Pacific Sardine (*Sardinops sagax*) identified as Actively Managed by the Coastal Pelagic Species Fishery Management Plan (Pacific Fishery Management Council 2019)
- Pacific salmon identified as Actively Managed by the Pacific Coast Salmon Plan (Pacific Fishery Management Council 2016b)
- Northern Anchovy (*Engraulis mordax*) is managed as a Monitored Species by the Coastal Pelagic Species Fishery Management Plan and is subject to EFH consultation as a result.

Although coastal pelagic species EFH does not occur in the Project area, the Project area is within the region identified as EFH for groundfish and Pacific salmon. Freshwater EFH for Pacific salmon (Sacramento River winter-run, Central Valley spring-run, and Central Valley fall-run and late fall-run Chinook Salmon) includes waters currently or historically accessible to salmon within the Central Valley ecosystems, as described by Myers et al. (1998).

6.2.1.4 Clean Water Act

The Clean Water Act (CWA) is a comprehensive set of statutes aimed at restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. The CWA is the foundation of surface water quality protection in the United States. Initial authority for the implementation and enforcement of the CWA rests with the EPA; however, this authority can be exercised by states with approved regulatory programs. In California, this authority is exercised by the State Water Resources Control Board (State Water Board) and the Regional Water Quality Control Boards (RWQCBs). The CWA contains a variety of regulatory and nonregulatory tools to significantly reduce direct pollutant discharges into waters of the United States, to finance municipal wastewater treatment facilities, and to manage polluted runoff. These tools (e.g., Section 303[d] List of Impaired Waters and Section 404 permitting process) are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Clean Water Act Section 303(d)

Section 303(d) of the federal CWA requires states to identify waterbodies that do not meet water quality standards and are not supporting their designated beneficial uses. These waters are placed on the Section 303(d) List of Impaired Waters. This list defines low-, medium-, and high-priority pollutants that require immediate attention by federal and state agencies. Placement on this list triggers development of a TMDL Program for each waterbody and associated pollutant and stressor on the list. The Central Valley RWQCB is responsible for implementing the TMDL Program in California. Completed or ongoing TMDL programs in the Delta region include chlorpyrifos and diazinon, DO, mercury and methylmercury, pathogens, pesticides, organochlorine pesticides, salt and boron, and selenium.

Clean Water Act Section 401

Section 401 of the CWA specifies that states must certify that any activity subject to a permit issued by a federal agency (e.g., the U.S. Army Corps of Engineers) meets all state water quality standards. In California, the State Water Board and the RWQCBs are responsible for certifying activities subject to any permit issued by the U.S. Army Corps of Engineers pursuant to Section 404 of the CWA or pursuant to Section 10 of the Rivers and Harbors Act of 1899.

6.2.2 State Plans, Policies, and Regulations

6.2.2.1 California Endangered Species Act

The California Endangered Species Act (CESA) (California Fish and Game Code [CFGC], Sections 2050 to 2089) establishes various requirements and protections regarding species listed as threatened or endangered under state law. California's Fish and Game Commission is responsible for maintaining lists of threatened and endangered species under CESA. CESA prohibits the take of listed and candidate (petitioned to be listed) species (CFGC, Section 2080). In accordance with Section 2081 of the CFGC, a permit from CDFW is required for projects "that could result in the incidental take of a wildlife species state-listed as threatened or endangered." "Take" under California law means to "… hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch capture, or kill…" (CFGC, Section 86). The state definition does not include "harm" or "harass," as the federal definition does. The measures required to minimize and fully mitigate the impacts of the authorized take must be roughly proportional in extent to the impact of the taking on the species, maintain the applicant's objectives to the greatest extent possible, and may be successfully implemented by the applicant (California Code of Regulations [CCR], Title 14, Section 783.4).

DWR operates the SWP in compliance with the existing CDFW (2020b) ITP for the Long-Term Operation of the SWP in the Delta (ITP No. 2081-2019-066-00).

6.2.2.2 Sacramento–San Joaquin Delta Reform Act of 2009

In late 2009, the California Legislature enacted a package of related water bills that included the Sacramento–San Joaquin Delta Reform Act of 2009 (Delta Reform Act). One of the many objectives of the Delta Reform Act is to "[r]estore the Delta ecosystem, including its fisheries and wildlife, as the heart of a healthy estuary and wetland ecosystem."

6.2.2.3 Delta Stewardship Council Delta Plan

The DSC was created by Senate Bill 1X7, largely codified in the Sacramento-San Joaquin Delta Reform Act of 2019. Among other responsibilities, the bill gave the DSC jurisdiction to hear appeals of state and local agency certifications of consistency for certain land use projects in the Delta or Suisun Marsh that qualifies as "covered actions". The DSC is composed of members who represent different parts of the state and offer diverse expertise in fields such as agriculture, science, the environment, and public service. Of the seven members, four are appointed by the governor, one each by the Senate and Assembly, and the seventh is the chair of the Delta Protection Commission. In addition, they are advised by a 10-member board of nationally and internationally renowned scientists.

The DSC is tasked with furthering the state's coequal goals for the Delta through development of a Delta Plan (California Water Code [CWC], Sections 85300[a], 85302[a]). As defined in the CWC, "coequal goals means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place" (CWC, Section 85054). The Delta Plan is a comprehensive, long-term management plan to further these goals for the Delta (CWC, Sections 85059, 85300[a], 85302[a]).

The Delta Plan generally covers five topic areas and goals: increased water supply reliability, restoration of the Delta ecosystem, improved water quality, reduced risks of flooding in the Delta, and protection and enhancement of the Delta. The DSC does not propose constructing, owning, or operating any facilities related to these five topic areas. Rather, the Delta Plan sets forth regulatory policies and recommendations that seek to influence the actions, activities, and projects of cities and counties and state, federal, regional, and local agencies toward meeting the goals in the five topic areas.

The DSC unanimously approved the Delta Plan on May 16, 2013. Subsequently, its 14 regulatory policies were approved by the Office of Administrative Law, a state agency that ensures the regulations are clear, necessary, legally valid, and available to the public. The Delta Plan became effective with legally enforceable regulations on September 1, 2013, and has since been updated in April 2018 with additional amendments in June 2022.[3] State and local agencies proposing covered actions that occur in whole or in part in the Delta or Suisun Marsh must file written certifications of consistency with the applicable Delta Plan policies before initiating implementation of such actions (CWC, Section 85225; CCR, Title 23, Section 5002). Any person may file an appeal with the DSC within 30 days, and the DSC must hold a public hearing within 60 days and issue written findings granting or denying the appeal within an additional 60 days (CWC, Sections 85225.10–85225.25). If the DSC grants an appeal, it must remand the certification to the action agency, and the agency may proceed with implementation only if it files a revised certification of consistency that addresses each of the DSC's findings (CWC, Section 85225.25).

6.2.2.4 Water Quality Control Plans

Water operations have changed substantially since the SWP and CVP were constructed. Operations were initially limited by physical capacity and available water. DWR and Reclamation's SWP and CVP operations changed significantly in 1978, with the issuance of the WQCP under the State Water Board Water Right Decision 1485 (D-1485). D-1485 imposed on the water rights for the CVP and SWP new terms and conditions that required DWR and Reclamation to meet certain standards for water quality protection for agricultural, municipal and industrial, and fish and wildlife purposes; incorporated a variety of Delta flow actions; and set salinity standards in the Delta while allowing the diversion of flows into the Delta during the winter and spring. Generally, during the time D-1485 was in effect, natural flows met water supply needs in normal and wetter years and reservoir releases generally served to meet export needs in drier years.

The D-1485 requirements applied jointly to both the SWP and CVP, requiring a joint understanding between the projects of how to share this new responsibility. To ensure SWP and CVP operations were coordinated, the Coordinated Operations Agreement (COA) was negotiated and approved by Congress in 1986, establishing terms and conditions by which DWR and Reclamation would coordinate SWP and CVP operations, respectively. The 1986 COA envisioned Delta salinity requirements but did not address export restrictions during excess conditions. The 1986 COA was amended in 2018.

In 1992, the CVPIA amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement as having an equal priority with power generation. The CVPIA included a number of other provisions that represented additional Congressional direction for CVP operations and overlaid a more complex statutory framework. These overlapping and sometimes competing requirements create challenges in how to address and balance the myriad of obligations Reclamation has in operating the CVP, and in how to coordinate with the SWP.

[3] Amended Chapter 4 regulatory policies will not take effect until rulemaking concludes.

In 1995, the State Water Board issued an update to the WQCP for the Delta. In 1999 (revised in 2000) the State Water Board issued D-1641 to implement those elements of the 1995 WQCP that were to be implemented through water rights. The 1995 WQCP and D-1641 included a new export to total Delta inflow (E:I) ratio of 35 percent from February through June, which represented a significant change from D-1485. The 1995 WQCP and D-1641 also imposed Spring X2 requirements and pumping limitations based on San Joaquin River flow, which in combination with the E:I ratio, reduced the availability of unstored flow for the SWP and CVP.

The State Water Board began work on its next update to the Delta WQCP in February 2009. Unlike previous Delta WQCP updates, this update addressed Delta water-quality issues in two phases. Phase One set water-quality and flow requirements for the Lower San Joaquin River and three of its tributaries: the Stanislaus, Tuolumne, and Merced rivers. Phase Two will set water-quality requirements for the Sacramento River watershed, the Delta's eastside tributaries (primarily the Calaveras, Consumnes, and Mokelumne rivers), and those parts of the Delta that were not addressed during Phase One.

The State Water Board began the Phase One update process in 2009. Following public review and comment on drafts, the State Water Board issued its final Phase One amendments and substitute environmental document on December 12, 2018. To date, however, the Phase One amendments have not been implemented. The Phase One amendments are being legally challenged, and the State Water Board has not yet issued a plan for implementation or issued a Phase One-related water-rights decision.

The State Water Board began work on its Phase Two amendments in 2012. The Board issued a draft Phase Two scientific basis report in 2016 and a final in 2017. In 2018, the Board issued the Framework for the Sacramento/Delta updates prior to the adoption of the updates for the Lower San Joaquin River and southern Delta. In September 2023, the State Water Board issued a Staff Report/Substitute Environmental Document in support of the Phase Two updates. The Board anticipates finalizing its Phase Two Staff Report and considering specific Phase Two amendments to the Delta Plan in late 2024.

In sum, Delta flow and salinity requirements continue to be governed by the 1995 WQCP and D-1641.

In parallel with the State Water Board WQCP update process, starting in 2017, state and federal agencies, including DWR and Reclamation, municipal and agricultural water suppliers, and others have undertaken extensive efforts to negotiate agreements to support the Healthy Rivers and Landscapes Program (HRLP), previously known as Voluntary Agreements. The HRLP agreements are a package of flow and non-flow measures, including habitat restoration, that are proposed for adoption by the State Water Board as an approach to implement the Bay-Delta Plan water quality objectives related to the protection of native fish species, including the covered species. The HRLP will offer a watershed-wide approach that includes new flows, habitat restoration, and a governance and science program that would be deployed adaptively.

On March 29, 2022, multiple water agencies including various SWP and CVP contractors, Reclamation, and state agencies including CDFW and DWR, signed a Memorandum of Understanding (MOU) Advancing a Term Sheet for the Voluntary Agreements to Update and Implement the Bay-Delta Water Quality Control Plan, and Other Related Actions MOU. The MOU attaches a term sheet identifying measures, including tributary flows, Delta outflows, habitat restoration, and fish passage in the Delta and its tributaries. These measures would provide spawning and rearing habitat for winter-run and spring-run Chinook Salmon, habitat restoration, and passage improvements to provide spawning, rearing, and food web support for Delta and Longfin Smelt. Additional parties have since signed MOU addendums, joining the HRLP effort. The MOU parties submitted draft agreements to support implementation of the HRLP for consideration by the State Water Board in April 2024.

6.2.3 Regional and Local Plans, Policies, and Regulations

6.2.3.1 CALFED Bay-Delta Program

The CALFED Bay-Delta Program (CALFED) was a collaborative effort of more than 20 federal and state agencies focusing on restoring the ecological health of the Delta while ensuring water quality improvements and water supply reliability to all users of the Delta water resources. CALFED included a range of balanced actions that are used in a comprehensive, multi-agency approach to managing Delta resources (CALFED Bay-Delta Program 2000a). The original objectives of CALFED are listed below:

- Provide good water quality for all beneficial uses.
- Improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species.
- Reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system.
- Reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees.

The program objectives have been implemented among numerous CALFED elements since the CALFED Program Record of Decision was issued in 2000 (CALFED Bay-Delta Program 2000b).

6.3 Threshold of Significance and Approach to Impact Assessment

6.3.1 Threshold of Significance

The Proposed Project would be considered to have a significant effect if it would result in any of the conditions listed below.

- Substantially reduce the habitat of a fish or aquatic species.
- Cause a fish or aquatic species' population to drop below self-sustaining levels.
- Threaten to eliminate a fish or aquatic species community.
- Substantially reduce the number or restrict the range of an endangered, rare, or threatened fish or aquatic species.
- Have a significant impact, either directly or through habitat modifications, on any fish or aquatic species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by CDFW or USFWS or NMFS.

- Have a significant impact on any sensitive aquatic natural community identified in local or regional plans, policies, regulations, or by the CDFW or USFWS.
- Interfere substantially with the movement of any native resident or migratory fish or aquatic species.

These thresholds are based primarily on the questions included in California Environmental Quality Act (CEQA) Guidelines Appendix G and on the mandatory findings of significance listed in CEQA Guidelines Section 15065. In general, the analysis assessed the potential for significant impacts by examining, where available, quantitative modeling results, such as CalSim 3 modeling outputs or quantitative biological modeling results, as well as qualitative information, as described in Sections 6.3.2, "Operations Effects," and 6.3.3, "Maintenance and Other Effects."

6.3.2 Operations Effects

Analysis of operations-related effects generally is presented by species and project activity based on relevant operations-related effects identified in conceptual models and supported by available studies, where available. Biological modeling methods are provided in Appendix 6B, "Biological Modeling Methods and Selected Results." Biological modeling relies largely on CalSim 3 and DSM2 modeling, for which descriptions and assumptions are described in Appendix 4A, "Model Assumptions," with hydrology and water quality modeling results provided in Appendix 4B, "Model Results."

Quantitative and qualitative analyses account for the SWP portion of impacts by considering factors such as entrainment only at SWP facilities (e.g., entrainment into the CCF). In some cases, such as effects based on Delta outflow, the analyses reflect SWP and CVP operations. Specifically, CalSim 3 and DSM2 simulations include operations of both the SWP and CVP because the models are simulating combined SWP and CVP operations. The specific effect of the Proposed Project was isolated by comparing the Proposed Project to Baseline Conditions, with the modeling assumptions for the CVP generally maintaining consistency between both. The CVP conditions in both the Proposed Project and Baseline Conditions generally exclude the CVP Delta 2023 Proposed Action that is being assessed in the Biological Assessment but include the 2019 BiOps, 2020 ITP, and Interim Operations Plan (Appendix 4A). OMR criteria for the Proposed Project also included the OMR criteria for the CVP Delta 2023 Proposed Action because OMR criteria are not readily isolated. For analyses in the sections below that use quantitative outputs reflecting these joint operations assumptions, the SWP proportional share contributing to the effect in each month is provided in Table 4A-7-1 of Attachment 7 to Appendix 4A. Cumulative effects accounting for both SWP and CVP, as well as other projects, are analyzed in Section 10.1, "Cumulative Impacts," of Chapter 10, "Other CEQA Discussions." As described further in Appendix 4M, "OMR Diversions Sensitivity Analyses," the modeling described in this chapter assumes CCWD diversions would be able to fill Los Vaqueros Reservoir using their Old and Middle River diversion locations during OMR management periods, whereas in reality their water right for filling Los Vaqueros is junior to the SWP and CVP water rights, which could preclude CCWD diversions at their Old and Middle River diversion facilities during OMR management periods. The sensitivity analysis provided in Appendix 4M demonstrates that by not allowing CCWD diversions for filling Los Vaqueros Reservoir when OMR is controlling, consistent with water right priority and past practice, that there are minimal differences in Delta flows and south Delta exports as a result of the different assumptions. These sensitivity analysis results indicate that the quantitative results described in this chapter are representative of the Proposed Project in relation to Baseline Conditions.

Comments on the DEIR from CDFW requested incorporation of sensitivity scenarios developed in support of the Proposed Project's ITP Application. Biological modeling results for these additional scenarios are provided in Appendix 6D, "Biological Results for Sensitivity Scenarios," with additional description of modeling assumptions provided in Appendix 4K, Attachment 1, "CalSim Model Assumptions Callouts." Appendix 6D also provides the results of a sensitivity scenario representing early implementation of the Delta Spring Outflow component of the Proposed Project. The results from this scenario were similar to the results for the Proposed Project as discussed in this chapter, e.g., as demonstrated by modeling for species whose indices of abundance positively correlate with spring Delta outflow, i.e.., Longfin Smelt, Starry Flounder, Striped Bass, and American Shad.

6.3.3 Maintenance and Other Effects

In addition to operations effects, maintenance and other effects of the Proposed Project are analyzed in the species-specific sections below, generally through qualitative discussions using sources such as available studies. Examples of other effects include Delta Smelt supplementation and CCF weed management.

6.4 Impacts of the Proposed Project

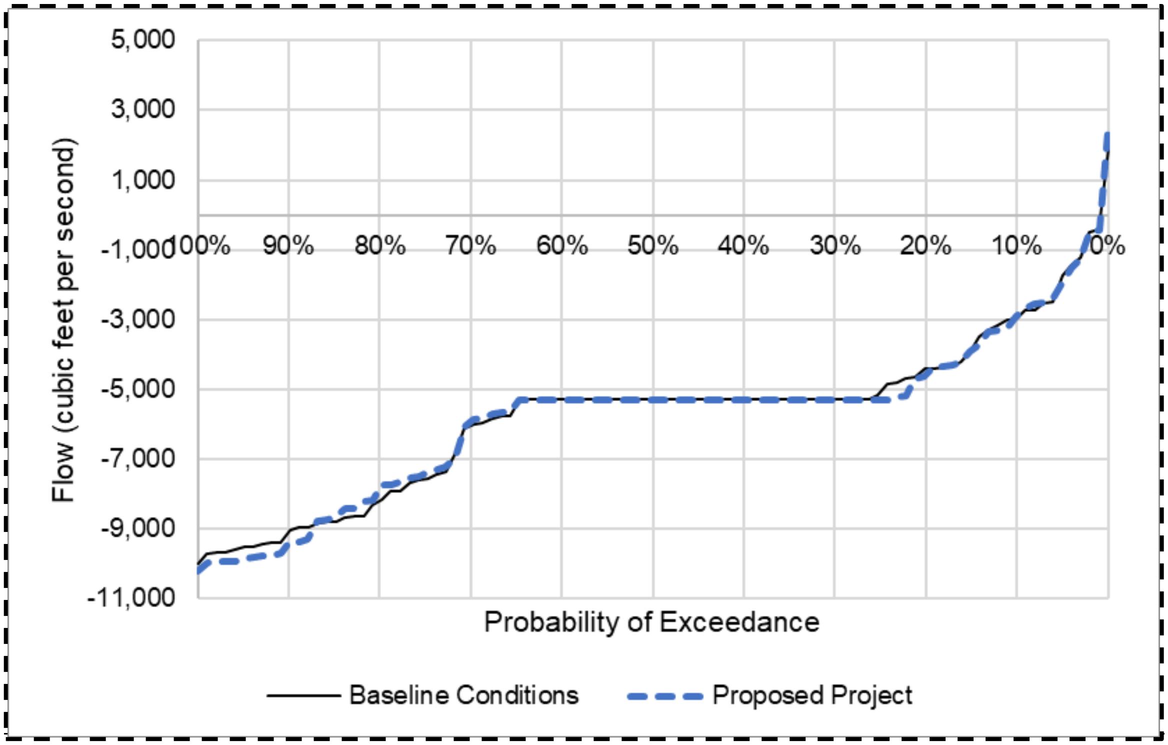
6.4.1 Delta Smelt

6.4.1.1 Delta SWP Facility Operations

Entrainment

Consideration of Old and Middle River Flows

OMR flows are an indicator of Delta Smelt south Delta entrainment risk (Grimaldo et al. 2009a, 2021). During the main period of adult entrainment risk (December–March; U.S. Fish and Wildlife Service 2019:140), CalSim 3 modeling indicates the Proposed Project would have generally similar OMR flows to the Baseline Conditions scenario (Figures 6-1, 6-2, 6-3, and 6-4). This suggests adult entrainment risk would be similar under both the Proposed Project and Baseline Conditions scenarios, when considering OMR flows. OMR management for adult Delta Smelt, including the Adult Delta Smelt Entrainment Protection Action (Turbidity Bridge), would be expected to result in low levels of entrainment loss. (Integrated effects of OMR management and other operations are discussed below in "Delta Smelt Life Cycle Modeling," generally showing little difference in population growth rate between scenarios.) Turbidity strongly influences entrainment risk but is not easily modeled; the CalSim 3 modeling reflects assumptions regarding management actions but does not fully account for real-time actions that could be triggered to minimize entrainment during high-risk conditions (see, for example, Section 4A-6.3, "Old and Middle River Flows" in Attachment 6 to Appendix 4A). As discussed in Section 6.4.1.4, "Delta Smelt Supplementation," supplementation of Delta Smelt would occur under the Proposed Project and will increase the likelihood of the species' ability to survive and reproduce in the wild. Release of cultured adult Delta Smelt is expected to occur within the North Delta Arc, including the Sacramento River, Suisun Marsh, and the Sacramento Deep Water Ship Channel. Release of cultured adult Delta Smelt at these core habitat locations will limit the potential for south Delta entrainment as broad-scale dispersal by the released individuals is anticipated to be minimized, with entrainment risk for any dispersing released individuals further limited by the OMR management actions. Timing and location of releases will be determined and coordinated through a multi-agency steering committee.



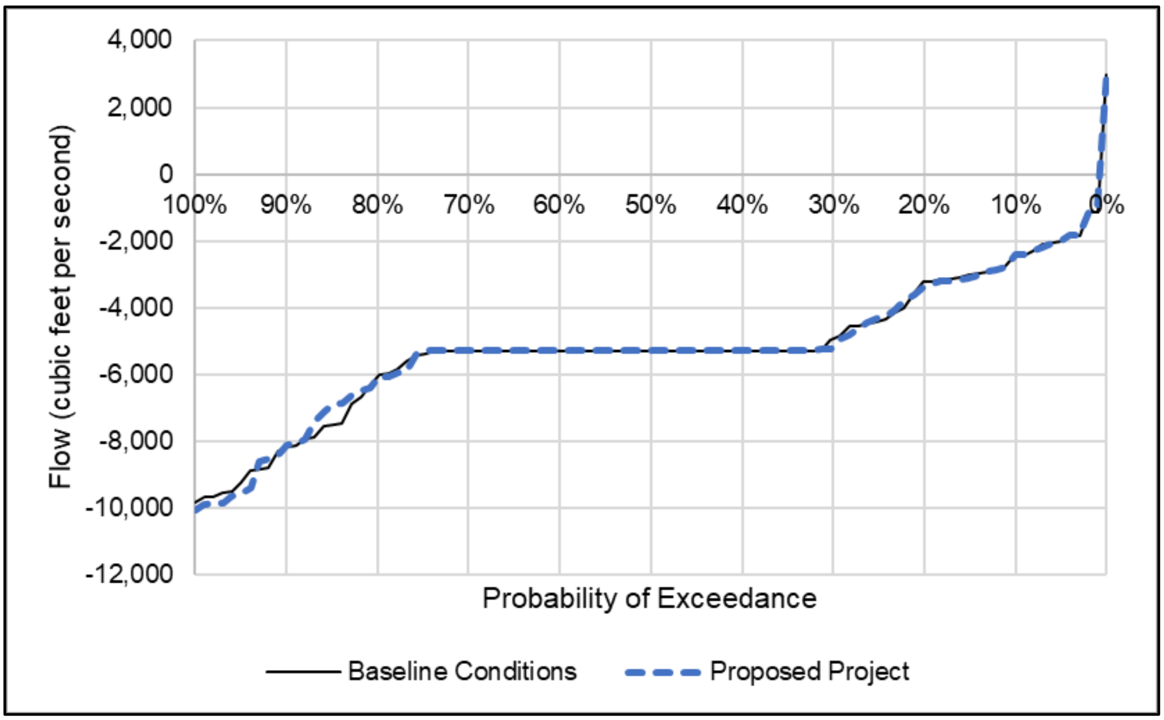


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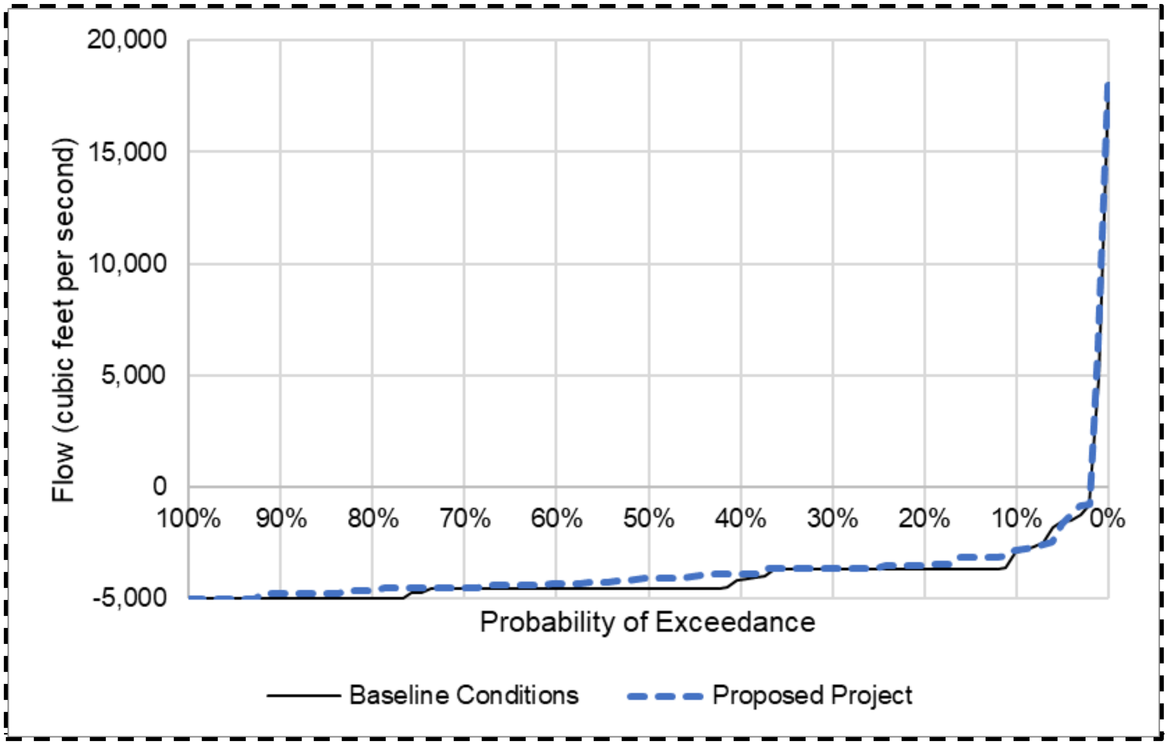
Figure 6-1. Mean Modeled Old and Middle River Flow, December



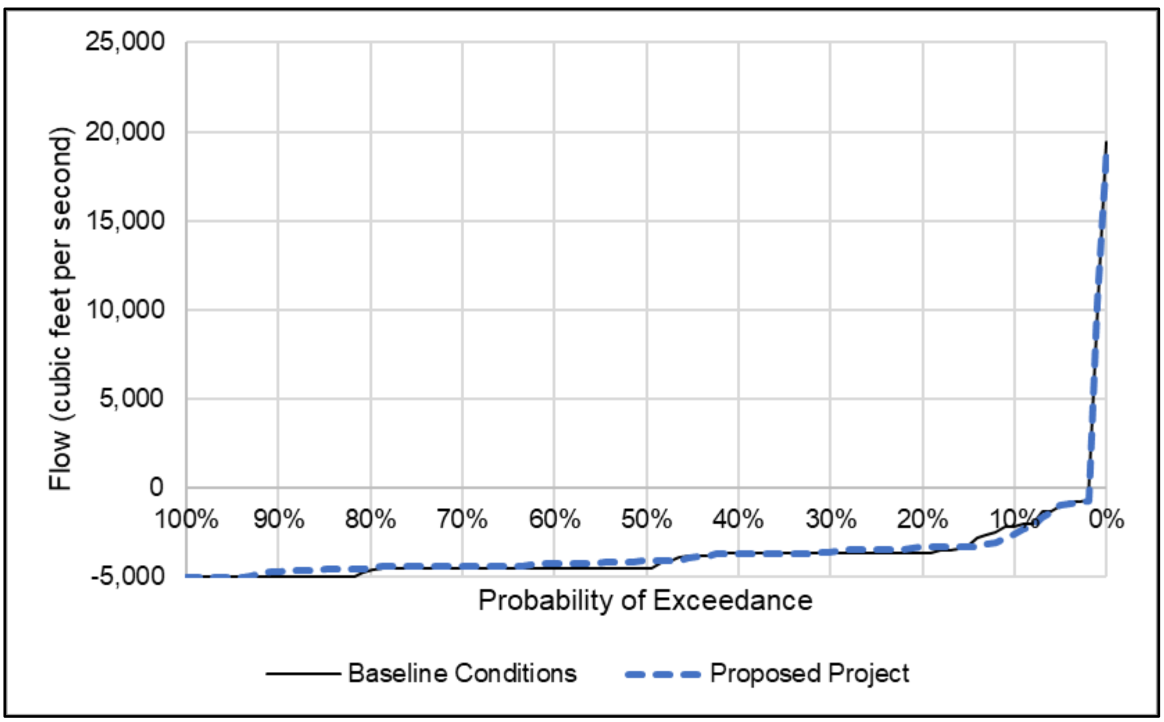


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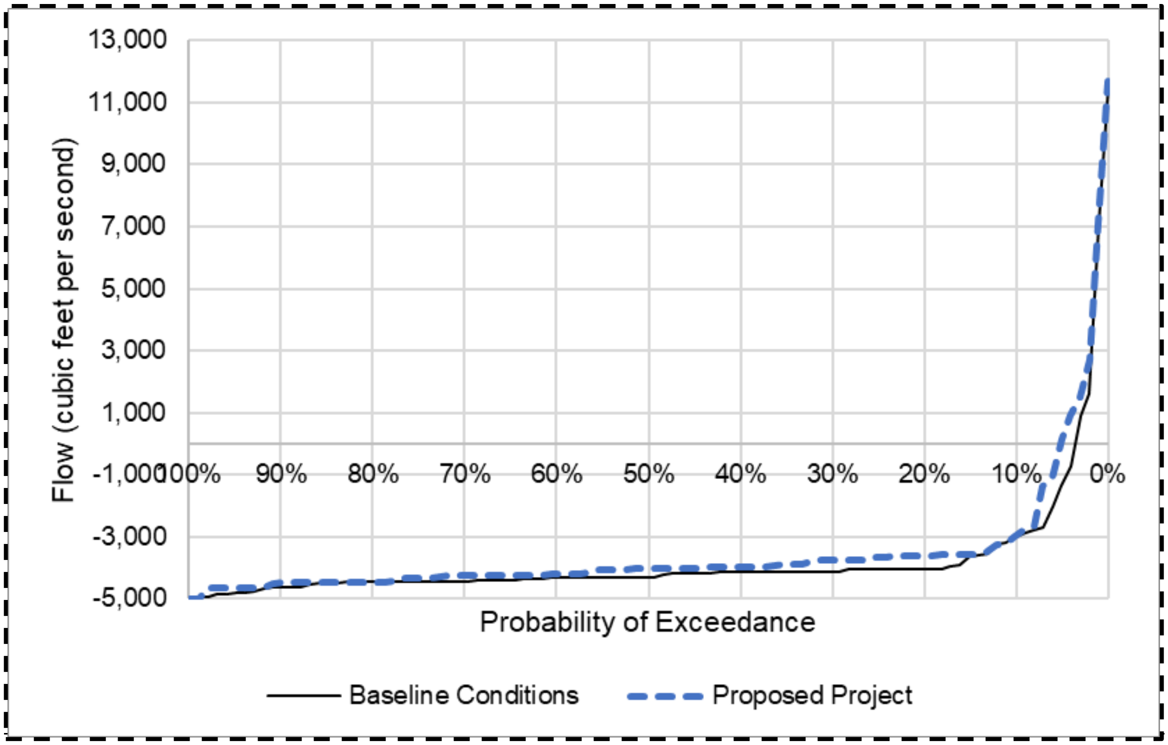
Figure 6-2. Mean Modeled Old and Middle River Flow, January



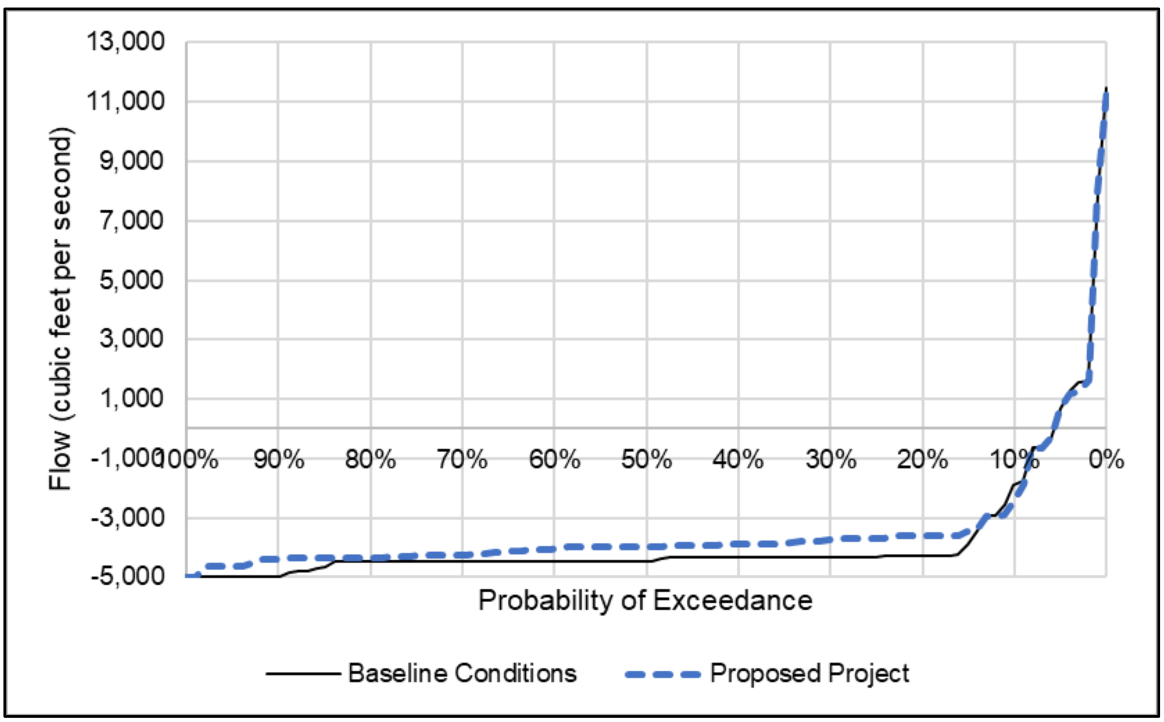


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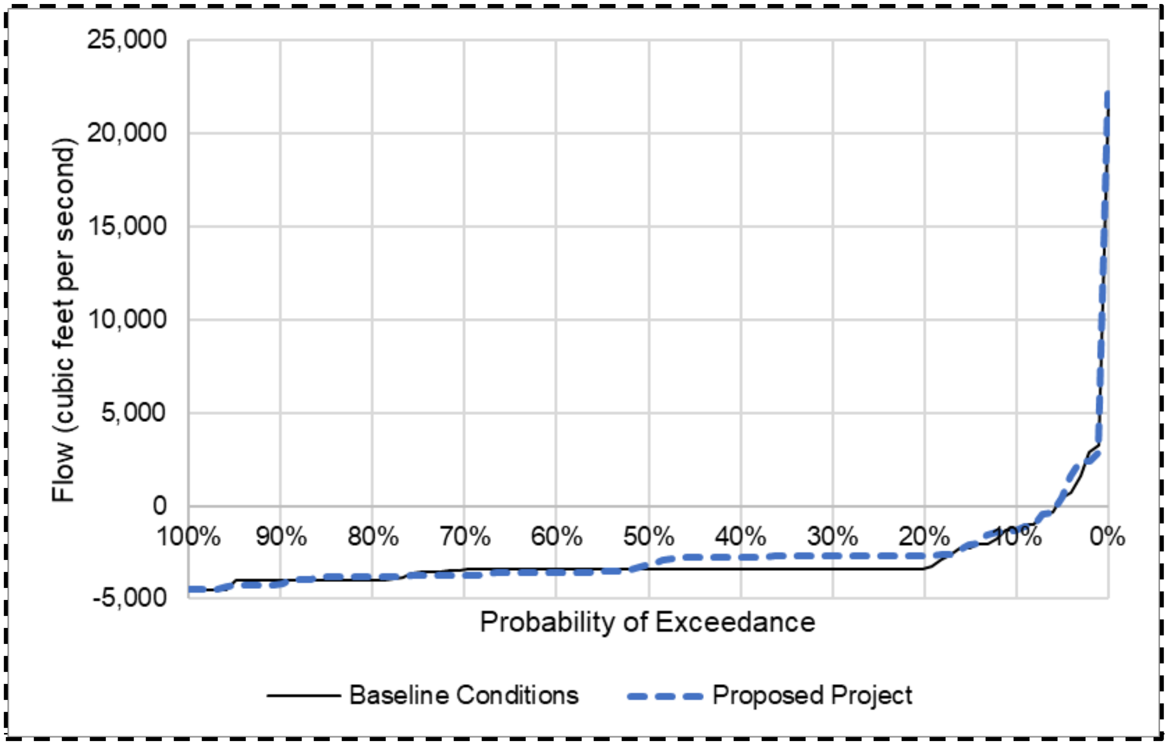
Figure 6-3. Mean Modeled Old and Middle River Flow, February



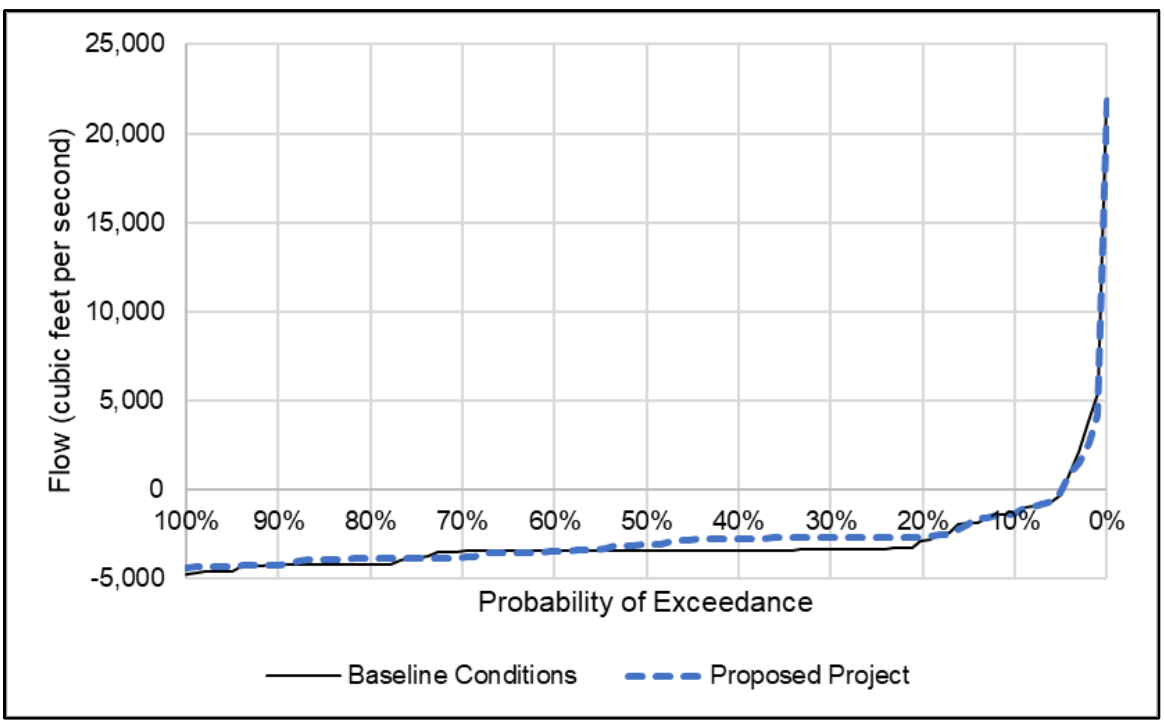


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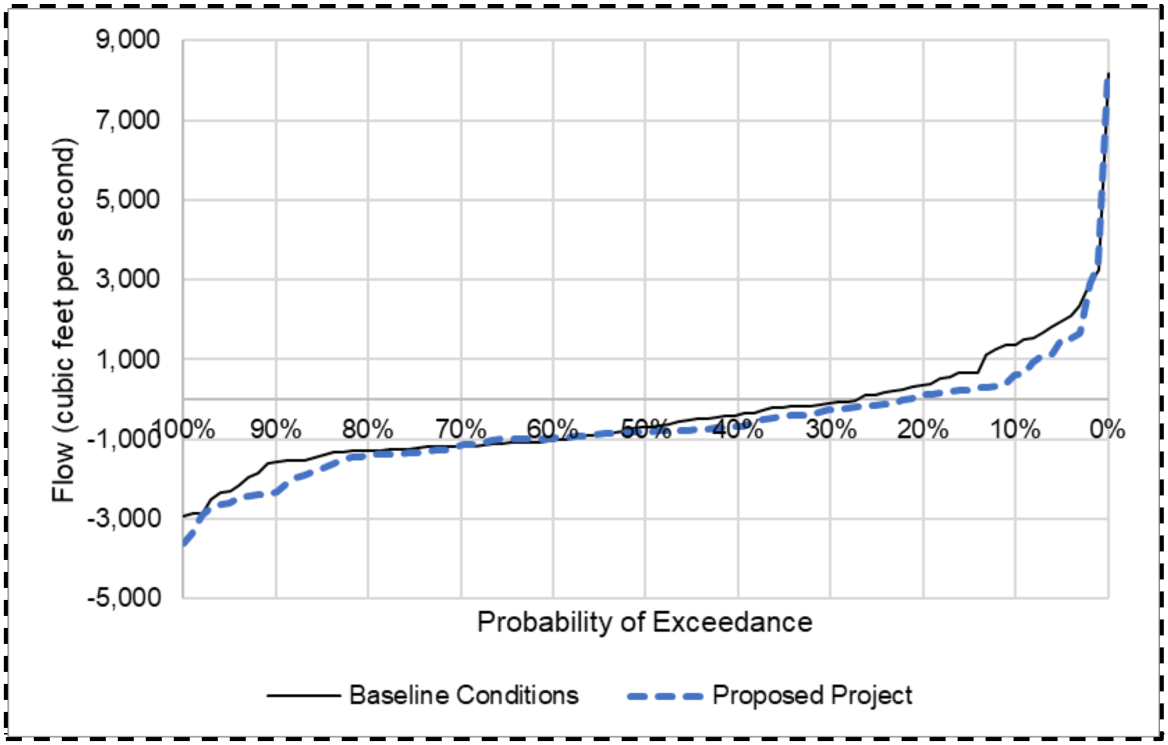
Figure 6-4. Mean Modeled Old and Middle River Flow, March

During the March–June period of concern for larval/juvenile Delta Smelt entrainment risk, OMR flows would tend to be more negative under the Proposed Project scenario, compared to the Baseline Conditions scenario in May, but relatively similar in the other months (Figures 6-4, 6-5, 6-6, 6-7). Differences between the scenarios reflect different operational criteria and their modeled representations. Spring outflow criteria differ between the Proposed Project and Baseline Conditions, which constrains exports more under Baseline Conditions (reflecting CDFW 2020 ITP Condition 8.17) than the Proposed Project. OMR flows under both scenarios would be above the -5,000 cfs inflection point at which entrainment tends to sharply increase (i.e., entrainment risk decreases at flows greater than -5,000 cfs, meaning flows less negative than -5,000 cfs) (Grimaldo et al. 2021). As noted for adult Delta Smelt, OMR flows from CalSim 3 modeling reflect assumptions regarding management actions, but do not fully account for real-time actions that would minimize entrainment risk. In this case, real-time actions intended to minimize entrainment risk in response to turbidity (i.e., the Larval and Juvenile Delta Smelt Protection Action) in the San Joaquin River upstream of Jersey Point and stations south of the lower San Joaquin River. (As noted above, integrated effects of OMR management and other operations are discussed below in “Delta Smelt Life Cycle Modeling”, generally showing little difference in population growth rate between scenarios based on modeling assumptions alone, without full representation of real-time management actions.) As shown below in the analysis of particle tracking modeling (PTM), conditions in March may lead to lower entrainment risk, affecting larval distribution in subsequent months in such a manner that minimizes entrainment risk not fully indicated by the modeling assumptions, with OMR flow management (Larval and Juvenile Delta Smelt Protection Action, as described in Chapter 2) minimizing entrainment risk.



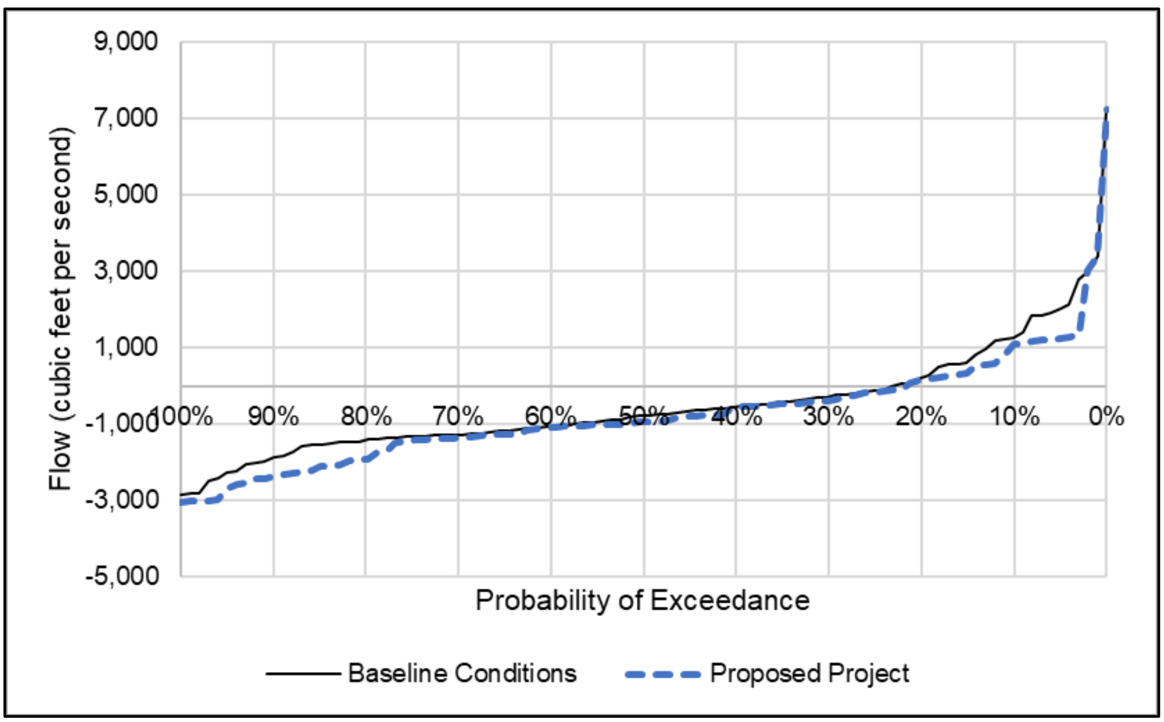


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Figure 6-5. Mean Modeled Old and Middle River Flow, April

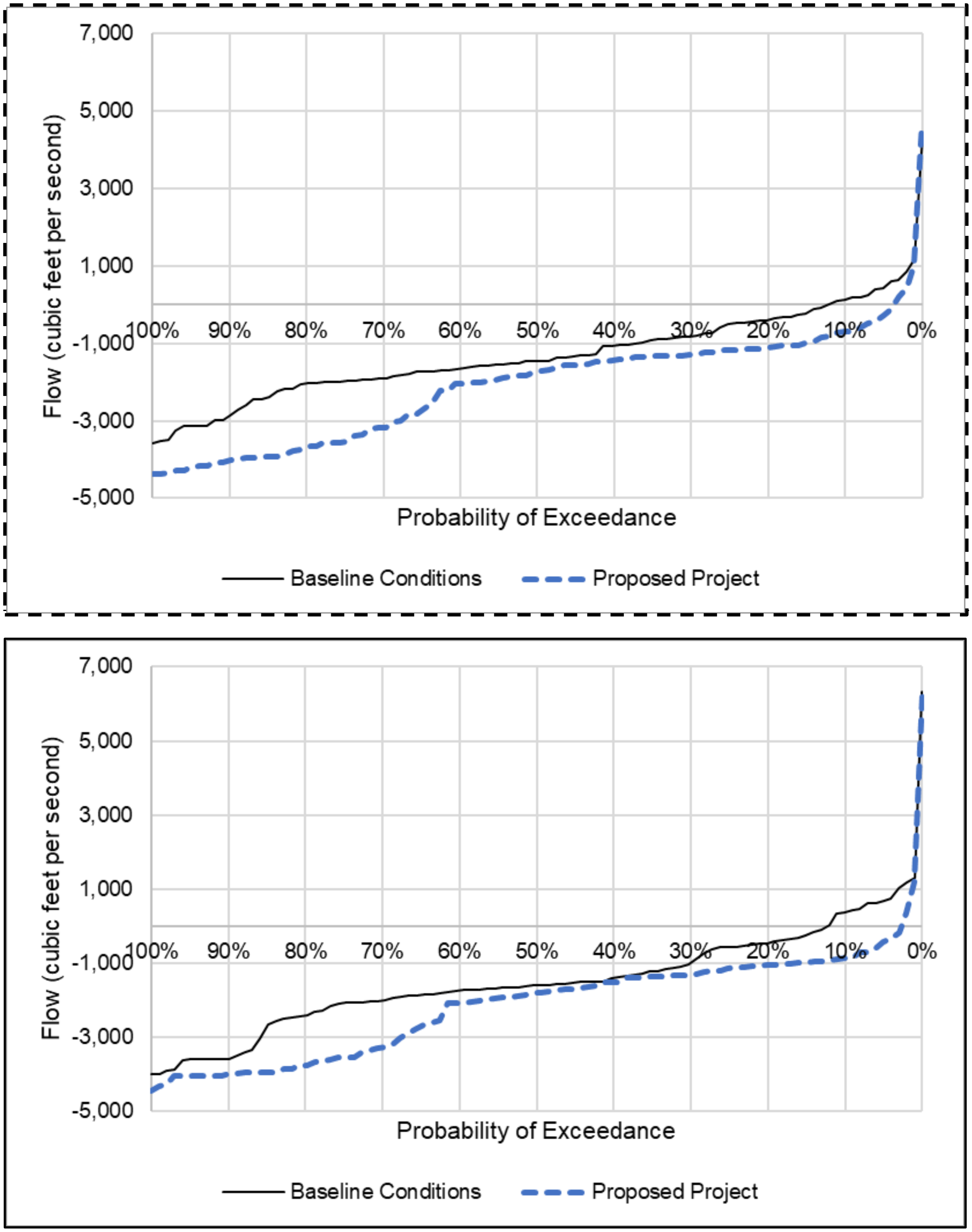

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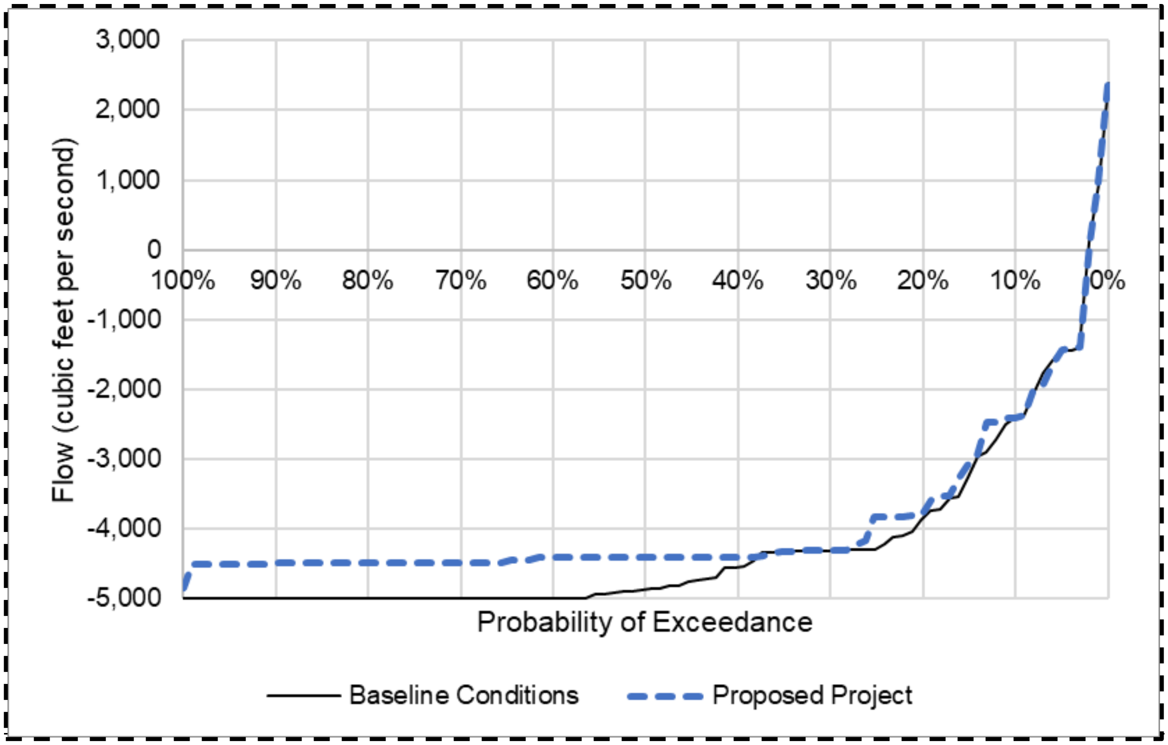
Figure 6-6. Mean Modeled Old and Middle River Flow, May



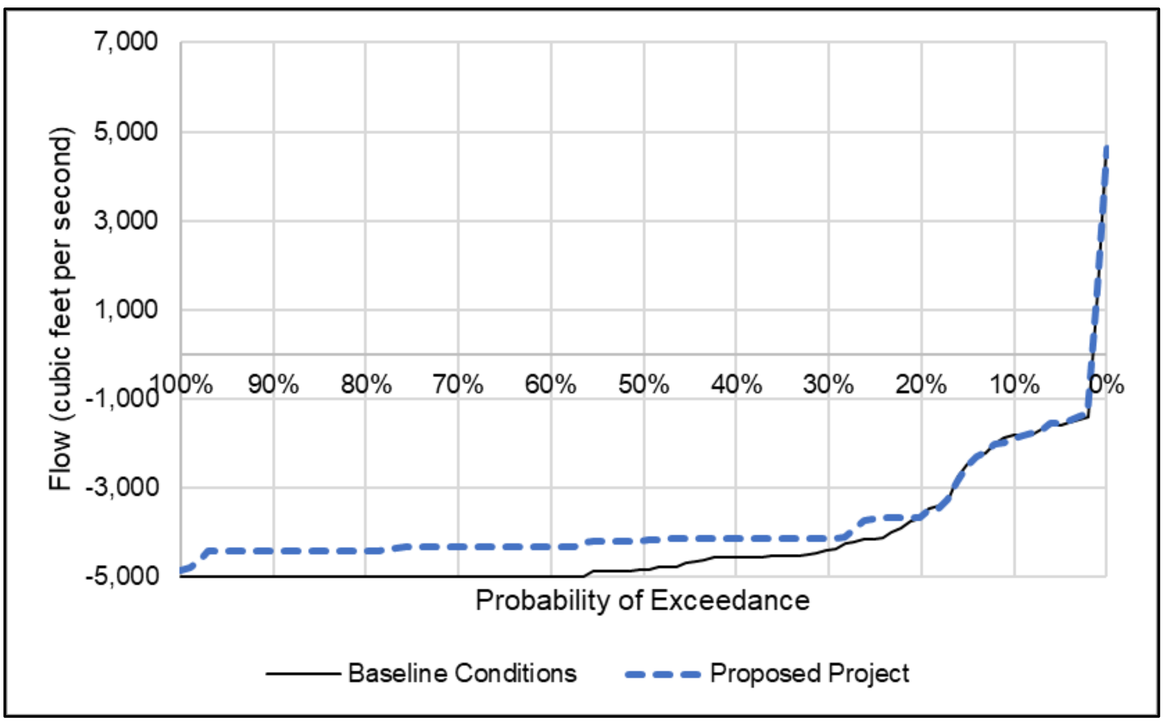


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Figure 6-7. Mean Modeled Old and Middle River Flow, June

Particle Tracking Modeling

For the present effects analysis, the most recent version of DSM2-PTM was used to illustrate potential differences in the percentage of Delta Smelt larvae entrained by the SWP water diversions (CCF and the NBA BSPP), considering only modeled flows. Detailed information regarding the method is provided in Appendix 6B, "Biological Modeling Methods and Selected Results," Section 6B.8, "Delta Smelt Larval Entrainment (DSM2 Particle Tracking Model)[4]." This approach generally assumed that the entrainment susceptibility of Delta Smelt larvae can be represented by entrainment of passive particles, based on existing literature (Kimmerer 2008, 2011). The results of the DSM2-PTM simulations do not represent the actual entrainment of larval Delta Smelt that could occur under the Baseline Conditions and Proposed Project scenarios; rather, they should be viewed as a comparative indicator of the relative risk of larval entrainment under the Baseline Conditions and Proposed Project scenarios without full consideration of real-time risk management measures put forth in the Proposed Project (see discussion in "Consideration of Old and Middle River Flows"). The latest version of DSM2-PTM allows agricultural diversions to be excluded as sources of entrainment (while still being included as water diversion sources). For this effects analysis, these agricultural diversions were excluded from both modeling scenarios, due to the relative coarseness of the assumptions in DSM2 related to specific locations of the agricultural diversions, the timing of water withdrawals by individual irrigators, and field observations showing the density of young Delta Smelt entrained by these diversions is relatively low (Nobriga et al. 2004) and not thought to be of population-level importance (Nobriga and Herbold 2009:25–26).

The DSM2-PTM analysis suggests the potential for appreciable relative increases in larval and early juvenile Delta Smelt entrainment at CCF in April and May under the Proposed Project scenario compared to the Baseline Conditions scenario (Table 6-4). This reflects greater differences in OMR flows during this time-period (see "Consideration of Old and Middle River Flows"). As noted for adult Delta Smelt, OMR flows from CalSim 3 modeling reflect assumptions regarding management actions but do not fully account for real-time actions that would minimize entrainment risk. Thus, the modeled increased entrainment is conservative and actual entrainment increases likely would be smaller than the DSM2-PTM analysis suggests. In this case, these real-time actions are intended to minimize entrainment risk in response to elevated turbidity (represented by Secchi disk depth) in the central and south Delta. Conditions in March may lead to lower entrainment risk, as reflected in the PTM (Table 6-4), affecting larval distribution in subsequent months in such a manner that minimizes entrainment risk, with OMR flow management (Larval and Juvenile Delta Smelt Protection Action, as described in Chapter 2) minimizing entrainment risk. (As noted above, integrated effects of OMR management and other operations are discussed below in "Delta Smelt Life Cycle Modeling", generally showing little difference in population growth rate between scenarios.)

[4] See also Appendix 4A, Attachment 4, "DSM2 PTM Documentation".

Table 6-4. Percentage of Particles Entrained Over 30 Days into Clifton Court Forebay

Month	Water Year Type	Baseline Conditions	Proposed Project
March	Wet	~~2.84~~ 1.42	~~2.98 (5%)~~ 1.39 (-2%)
March	Above Normal	~~3.32~~ 4.04	~~2.77 (-17%)~~ 3.38 (-16%)
March	Below Normal	~~8.42~~ 6.20	~~6.64 (-21%)~~ 4.68 (-24%)
March	Dry	~~8.66~~ 11.14	~~7.42 (-14%)~~ 8.80 (-21%)
March	Critically Dry	~~7.14~~ 6.58	~~7.21 (1%)~~ 6.46 (-2%)
April	Wet	~~1.46~~ 1.08	~~2.09 (44%)~~ 1.89 (75%)
April	Above Normal	~~4.07~~ 3.92	~~4.66 (14%)~~ 3.74 (-5%)
April	Below Normal	~~2.01~~ 1.96	~~2.34 (17%)~~ 2.12 (8%)
April	Dry	~~2.29~~ 2.96	~~2.44 (6%)~~ 2.79 (-6%)
April	Critically Dry	~~2.98~~ 2.88	~~3.28 (10%)~~ 3.15 (9%)
May	Wet	~~2.64~~ 2.78	~~4.62 (75%)~~ 4.35 (56%)
May	Above Normal	~~5.64~~ 3.17	~~9.13 (62%)~~ 6.96 (119%)
May	Below Normal	~~2.60~~ 3.41	~~8.19 (216%)~~ 8.93 (162%)
May	Dry	~~3.03~~ 2.00	~~3.81 (26%)~~ 2.78 (39%)
May	Critically Dry	~~4.64~~ 4.80	~~6.03 (30%)~~ 5.84 (21%)
June	Wet	~~8.67~~ 6.67	~~8.48 (-2%)~~ 6.02 (-10%)
June	Above Normal	~~9.43~~ 9.15	~~8.99 (-5%)~~ 8.24 (-10%)
June	Below Normal	~~8.92~~ 9.34	~~8.51 (-5%)~~ 8.78 (-6%)
June	Dry	~~9.58~~ 10.90	~~8.86 (-8%)~~ 9.46 (-13%)
June	Critically Dry	~~4.84~~ 4.14	~~4.45 (-8%)~~ 4.58 (11%)

Note: Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

The DSM2-PTM results generally suggest there would be little difference in the potential for entrainment of Delta Smelt at BSPP between the Baseline Conditions and Proposed Project scenarios (Table 6-5). As described in Chapter 2, "Project Description," BSPP would restrict spring diversions, based on cumulative catch of Delta Smelt in the 20-mm Survey. These restrictions would limit the potential for Delta Smelt entrainment. As discussed further in Section 6.4.1.7, "Barker Slough Pumping Plant," only one Delta Smelt larva was collected during recent entrainment monitoring in January–June 2015–2016 (Yip et al. 2019). These factors, the presence of a positive barrier fish screen (which may decrease entrainment risk for fish theoretically too small to be screened [Nobriga et al. 2004]), and low population abundance of Delta Smelt, suggest entrainment loss of larval Delta Smelt at BSPP would be limited.

Table 6-5. Percentage of Particles Entrained Over 30 Days into Barker Slough Pumping Plant

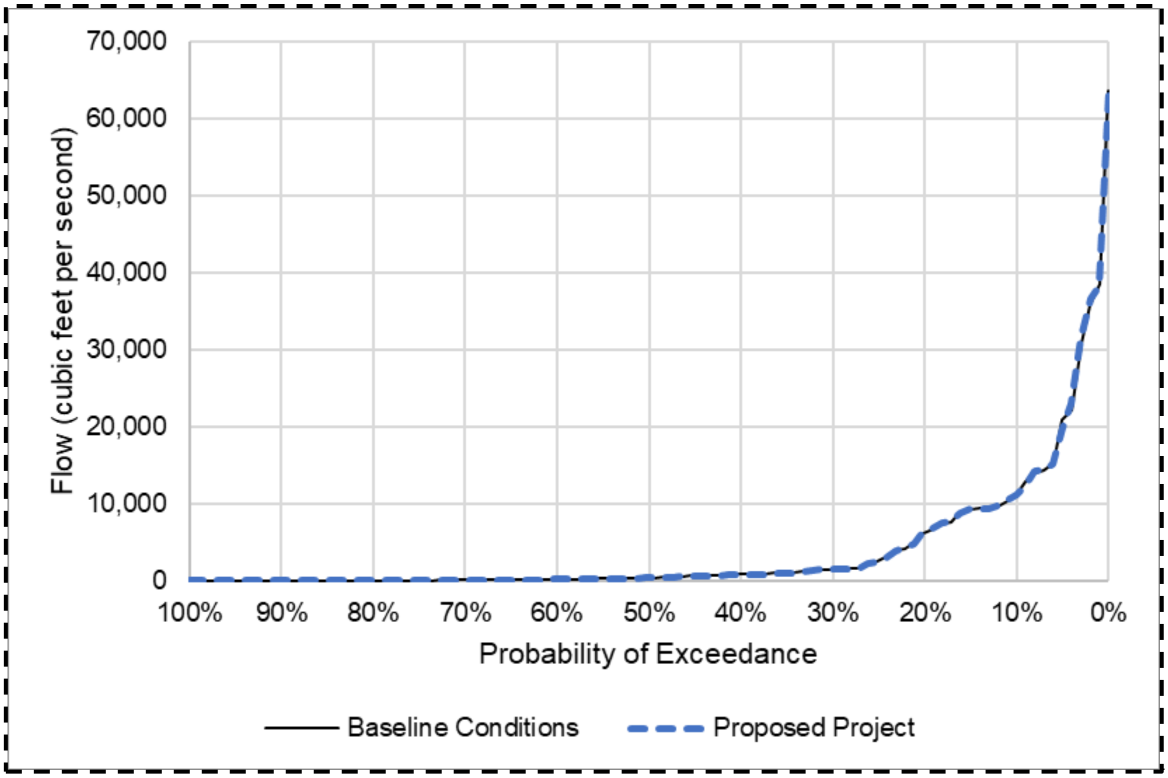
Month	Water Year Type	Baseline Conditions	Proposed Project
March	Wet	~~0.04~~ 0.02	~~0.04 (-1%)~~ 0.02 (7%)
March	Above Normal	~~0.01~~ 0.00	~~0.01 (-16%)~~ 0.00 (-1%)
March	Below Normal	~~0.09~~ 0.07	~~0.09 (0%)~~ 0.07 (4%)
March	Dry	~~0.09~~ 0.03	~~0.08 (-5%)~~ 0.03 (-1%)
March	Critically Dry	~~0.01~~ 0.05	~~0.01 (-2%)~~ 0.05 (1%)
April	Wet	~~0.03~~ 0.04	~~0.03 (3%)~~ 0.04 (4%)
April	Above Normal	~~0.02~~ 0.05	~~0.02 (3%)~~ 0.06 (13%)
April	Below Normal	~~0.20~~ 0.14	~~0.20 (0%)~~ 0.14 (-1%)
April	Dry	0.10	~~0.11 (6%)~~ 0.10 (0%)
April	Critically Dry	~~0.08~~ 0.09	~~0.07 (-4%)~~ 0.10 (7%)
May	Wet	~~0.08~~ 0.07	~~0.09 (2%)~~ 0.07 (3%)
May	Above Normal	~~0.08~~ 0.18	~~0.08 (-3%)~~ 0.19 (6%)
May	Below Normal	~~0.17~~ 0.18	~~0.17 (1%)~~ 0.18 (0%)
May	Dry	~~0.25~~ 0.32	~~0.24 (-5%)~~ 0.32 (-1%)
May	Critically Dry	~~0.12~~ 0.13	~~0.12 (-2%)~~ 0.13 (1%)
June	Wet	~~0.16~~ 0.21	~~0.17 (2%)~~ 0.21 (1%)
June	Above Normal	~~0.23~~ 0.20	~~0.25 (9%)~~ 0.20 (-2%)
June	Below Normal	~~0.27~~ 0.32	~~0.28~~ 0.32 (2%)
June	Dry	~~0.21~~ 0.21	~~0.21~~ 0.22 (1%)
June	Critically Dry	~~0.14~~ 0.16	~~0.14 (0%)~~ 0.16 (2%)

Note: Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Food Availability

Adults to Eggs and Larvae (December–March)

The Interagency Ecological Program Management, Analysis, and Synthesis Team (IEP MAST) (2015) conceptual model incorporates food availability in adults transitioning to spawning and egg production. This importance of food availability to adults has recently received statistical support from life cycle modeling by Smith et al. (2021). Inundation of the Yolo Bypass could increase food web productivity and benefit growth and survival of Delta Smelt adults occurring downstream of Yolo Bypass (California Department of Water Resources and U.S. Bureau of Reclamation 2019:8-117 to 8-118). Delta Smelt food sources and availability vary by region, and the proportion of Delta Smelt food originating in the Yolo Bypass is unclear. The analysis of Yolo Bypass inundation and resulting impacts on food availability for Delta Smelt are uncertain. Nonetheless, modeling suggests that there would be little difference in flow through the Yolo Bypass between the Proposed Project and Baseline Conditions scenarios (Figures 6-8 to 6-13), suggesting food availability would also be similar.



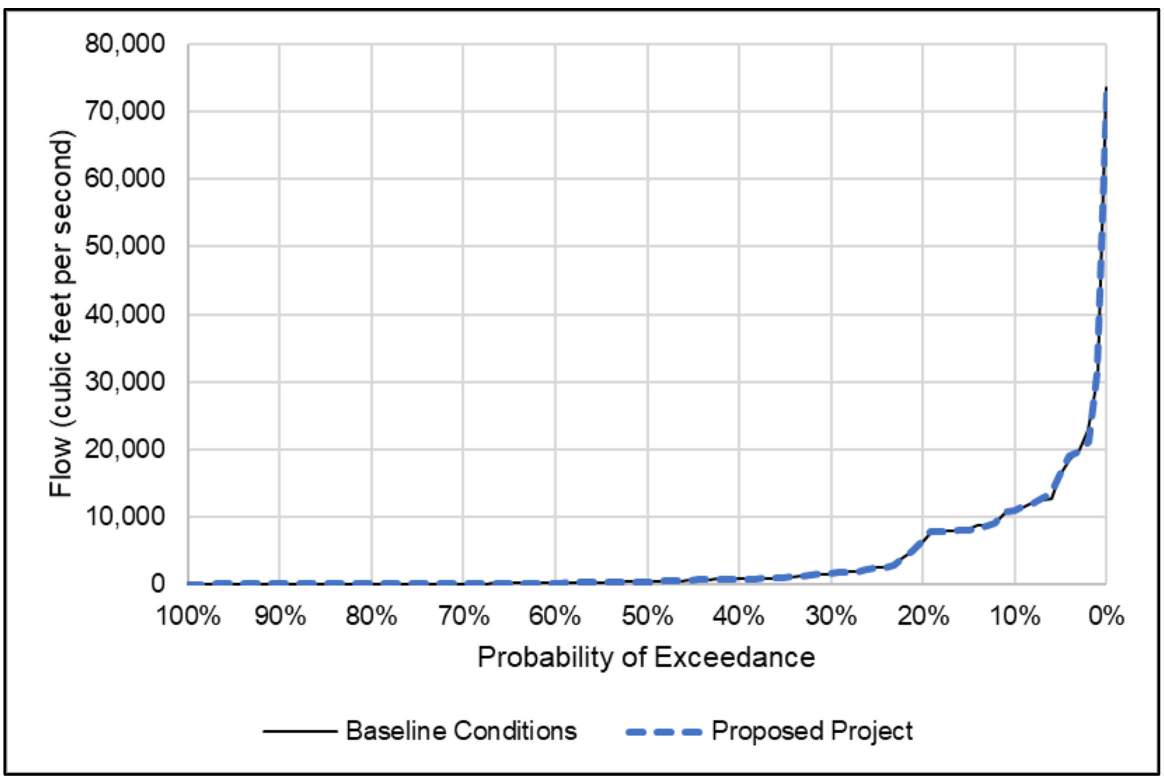


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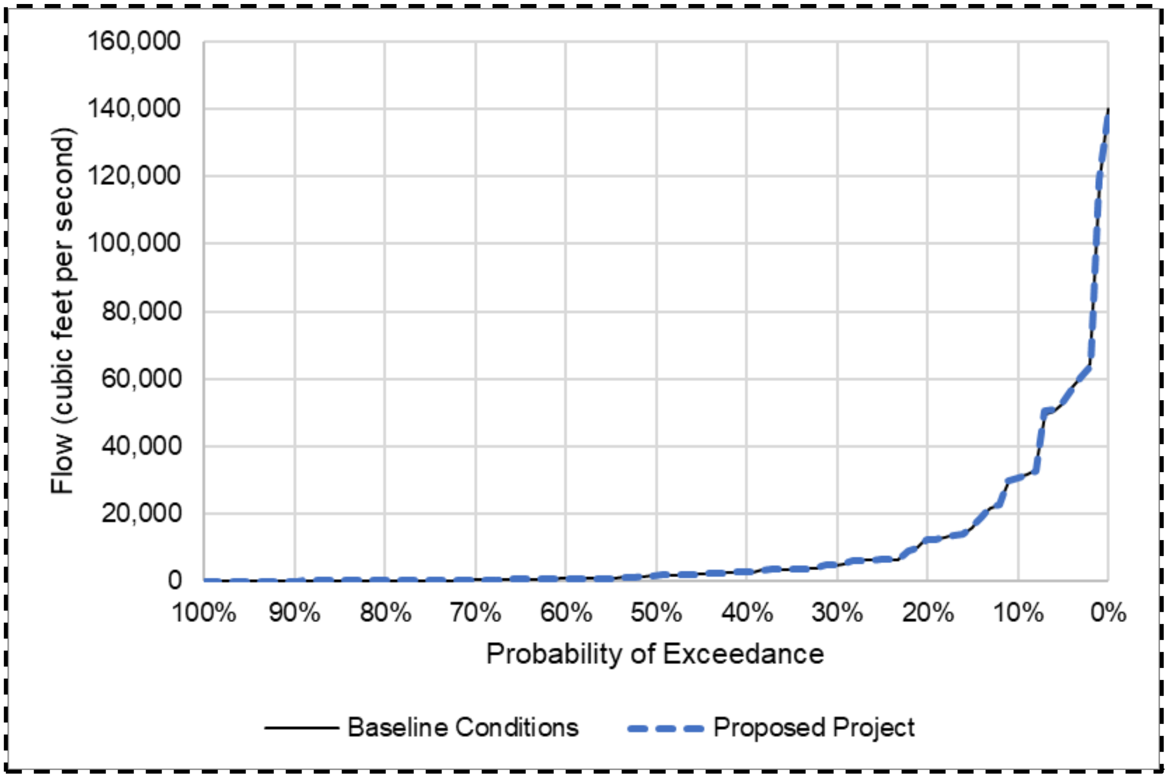
Figure 6-8. Mean Modeled Flow Through Yolo Bypass, December



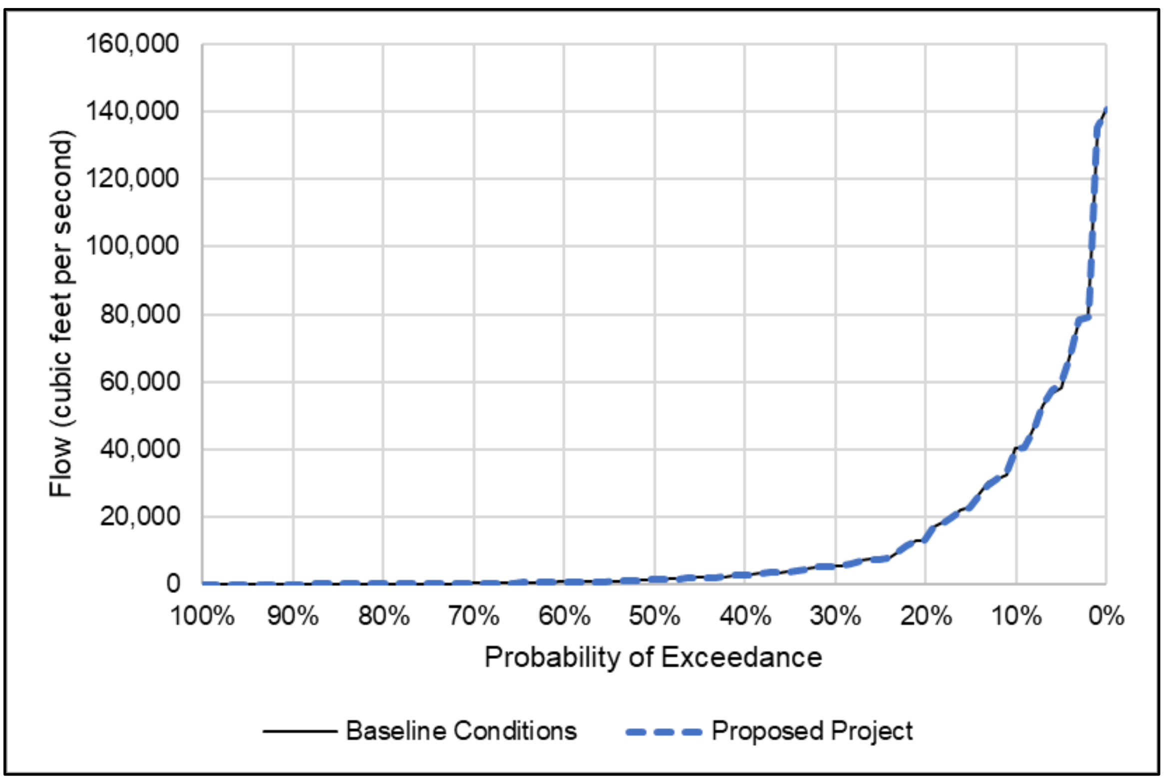


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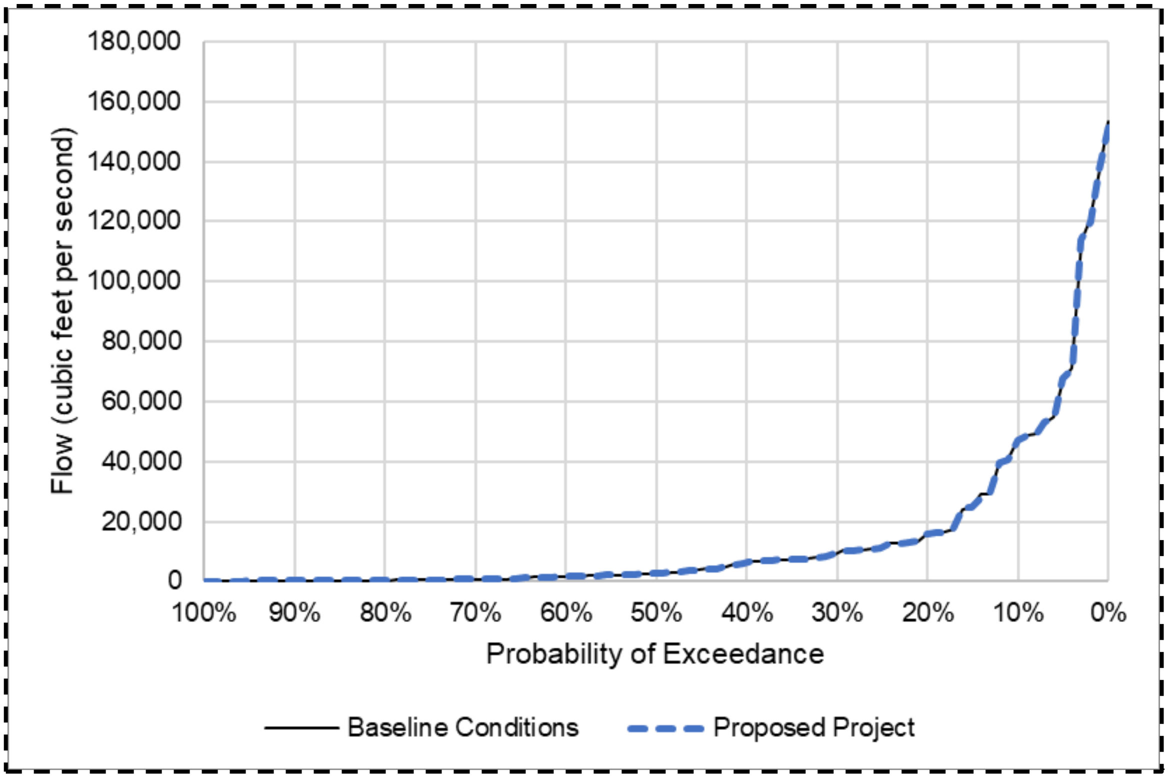
Figure 6-9. Mean Modeled Flow Through Yolo Bypass, January



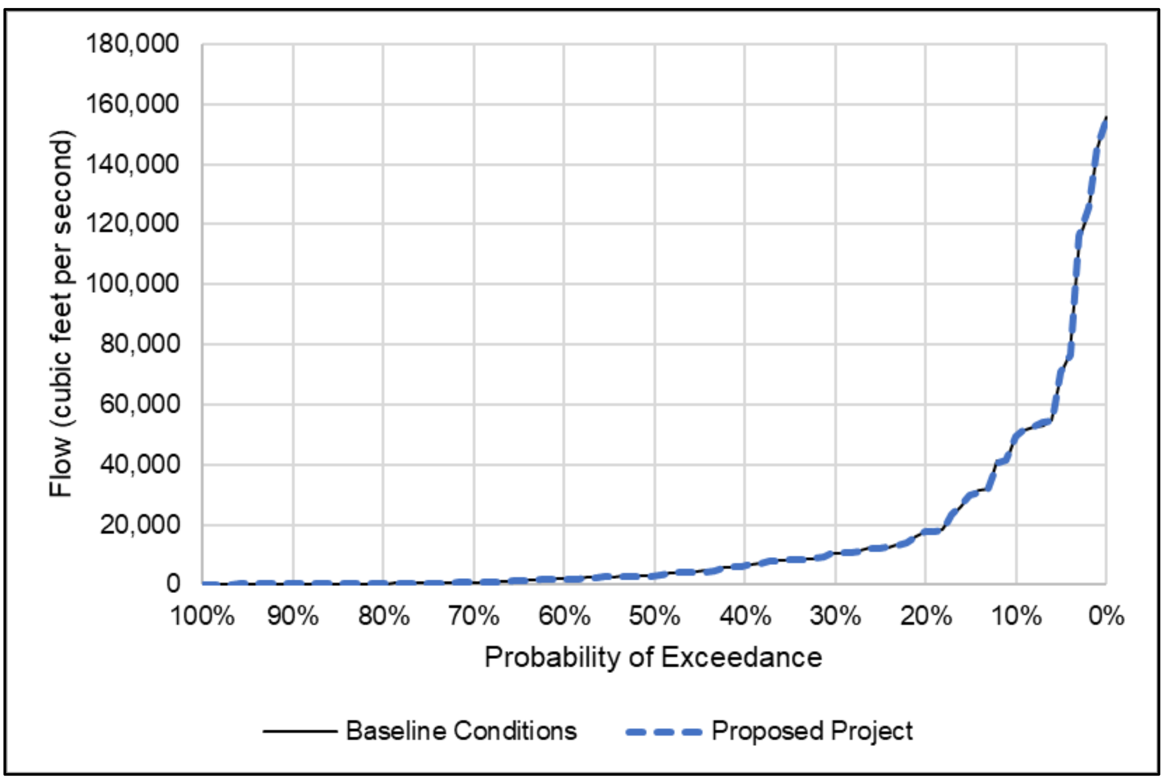


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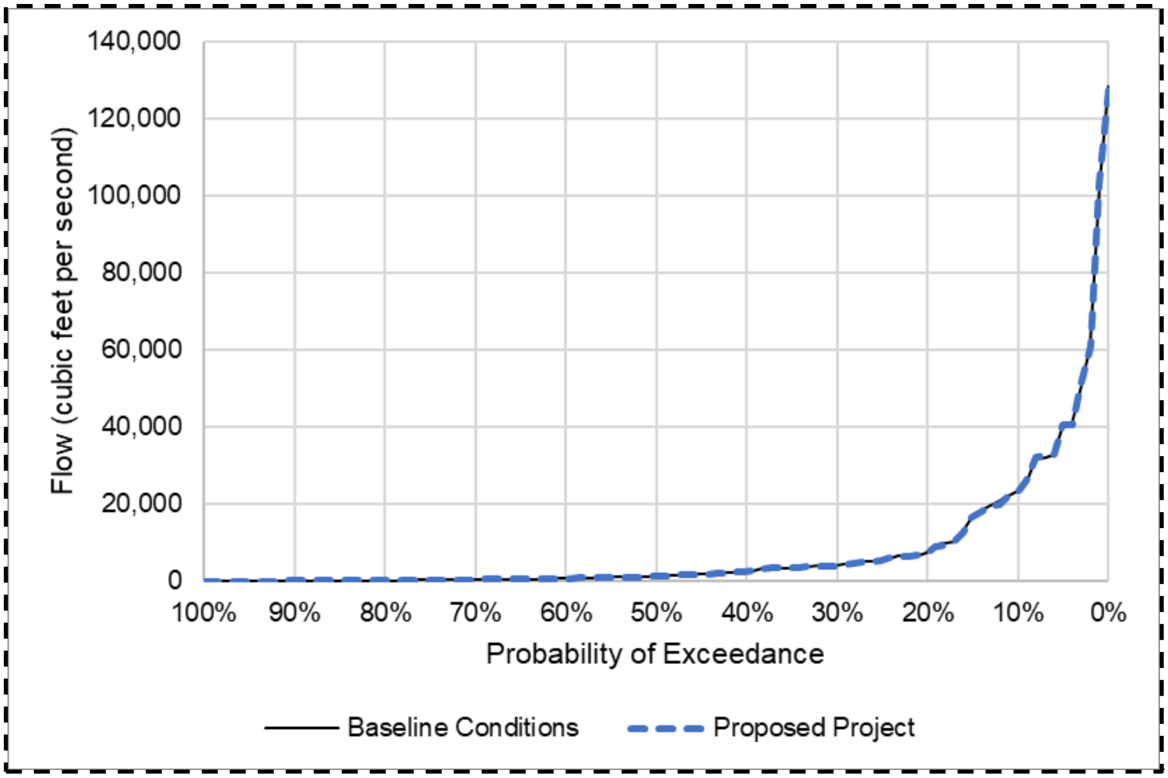
Figure 6-10. Mean Modeled Flow Through Yolo Bypass, February



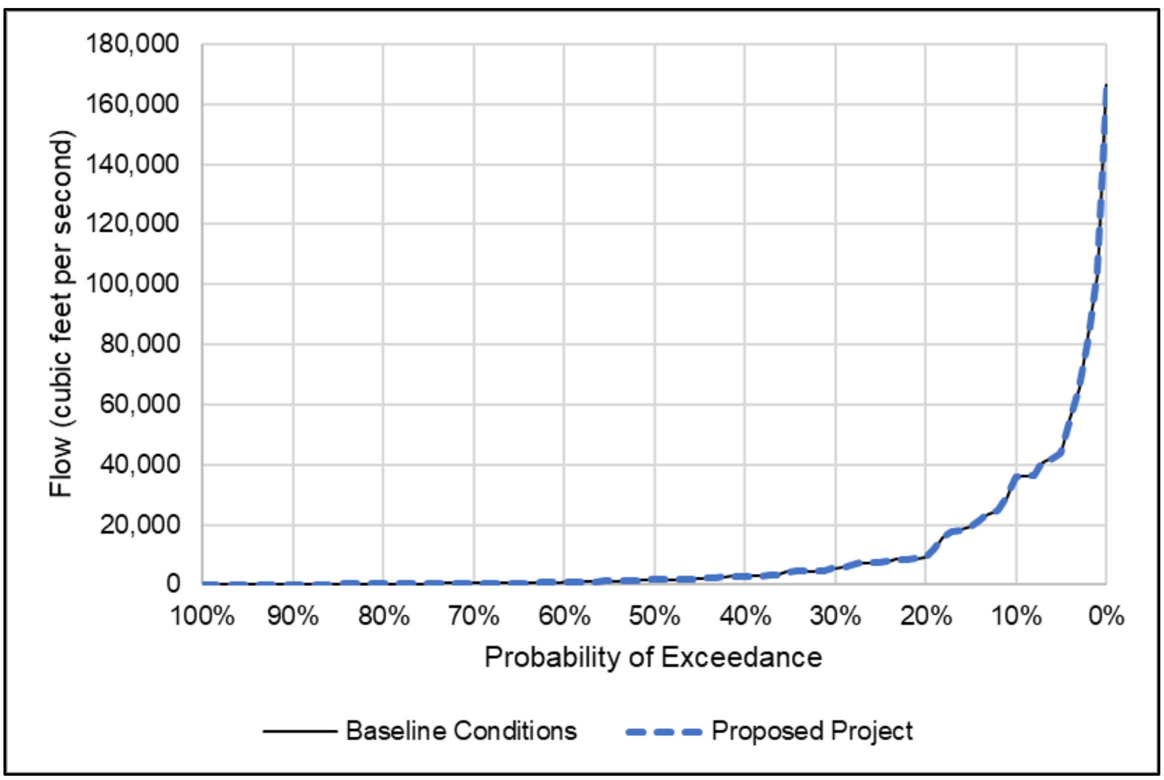


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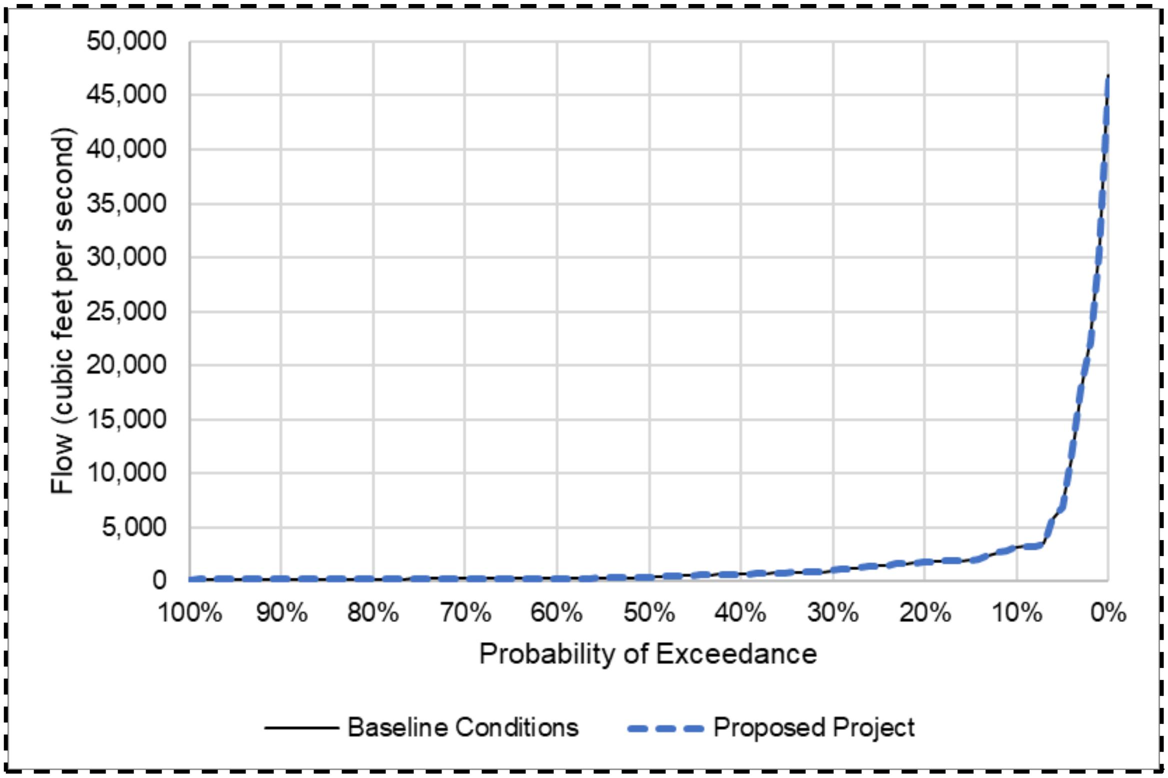
Figure 6-11. Mean Modeled Flow Through Yolo Bypass, March



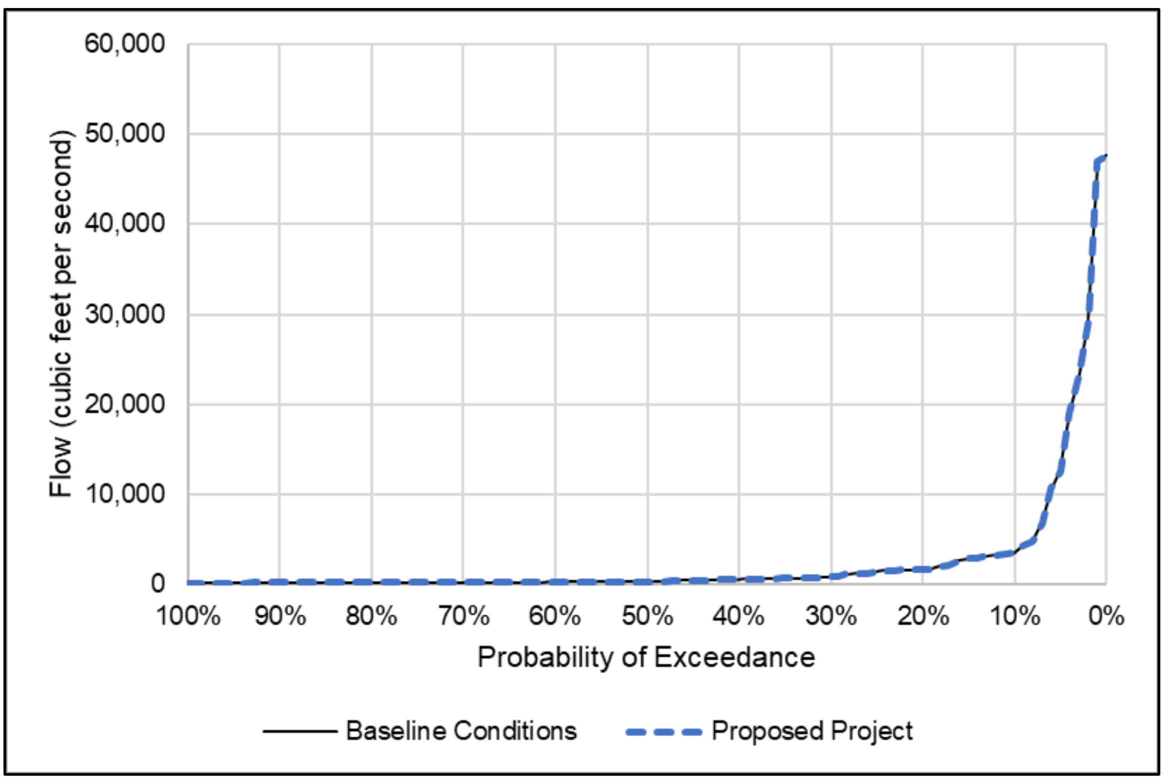


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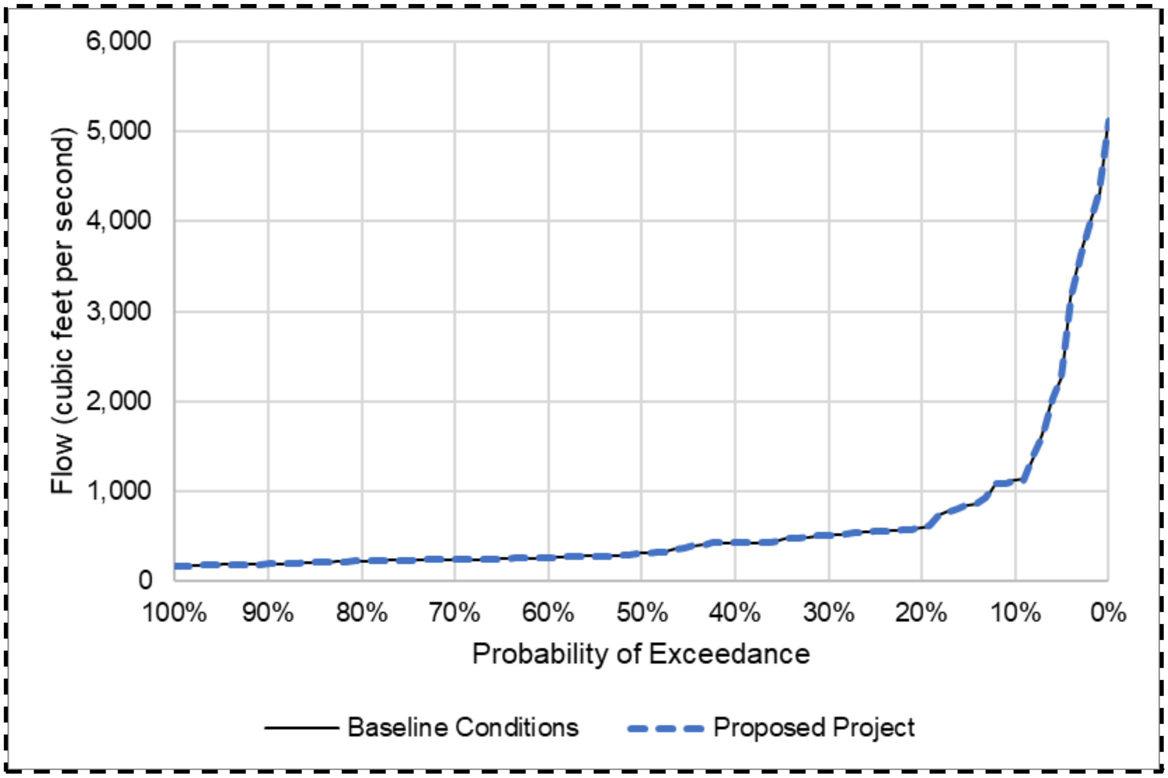
Figure 6-12. Mean Modeled Flow Through Yolo Bypass, April



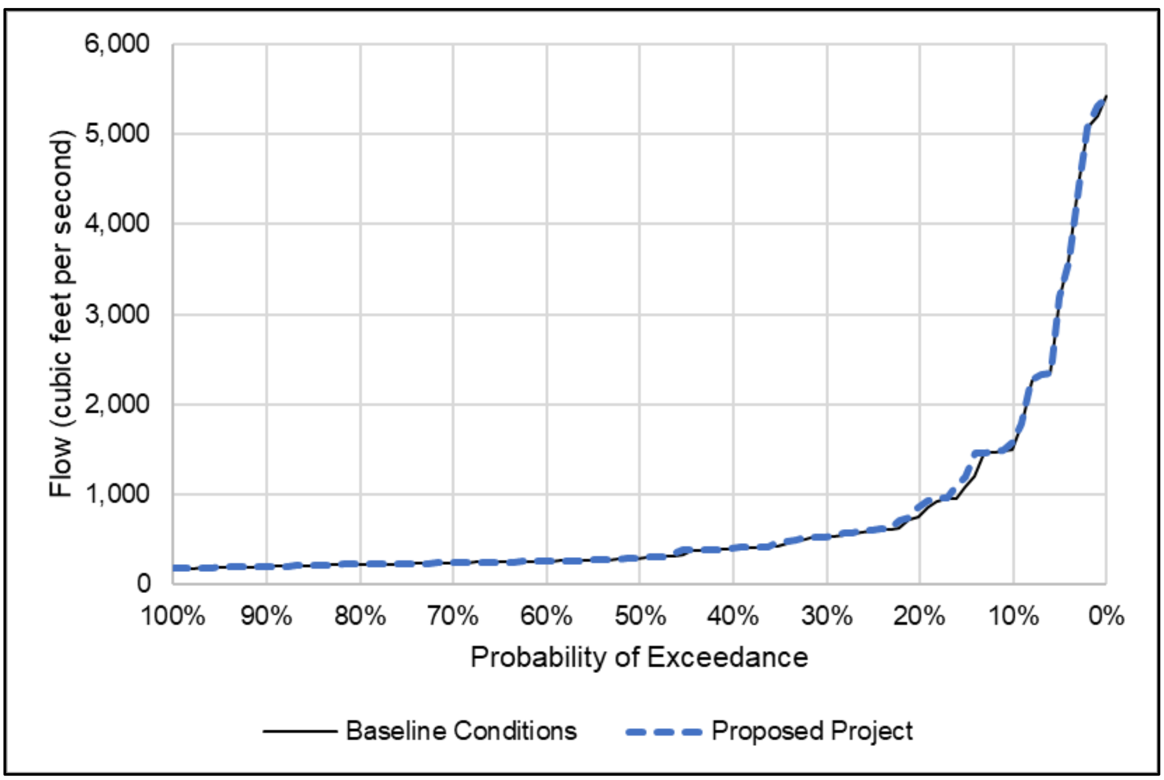


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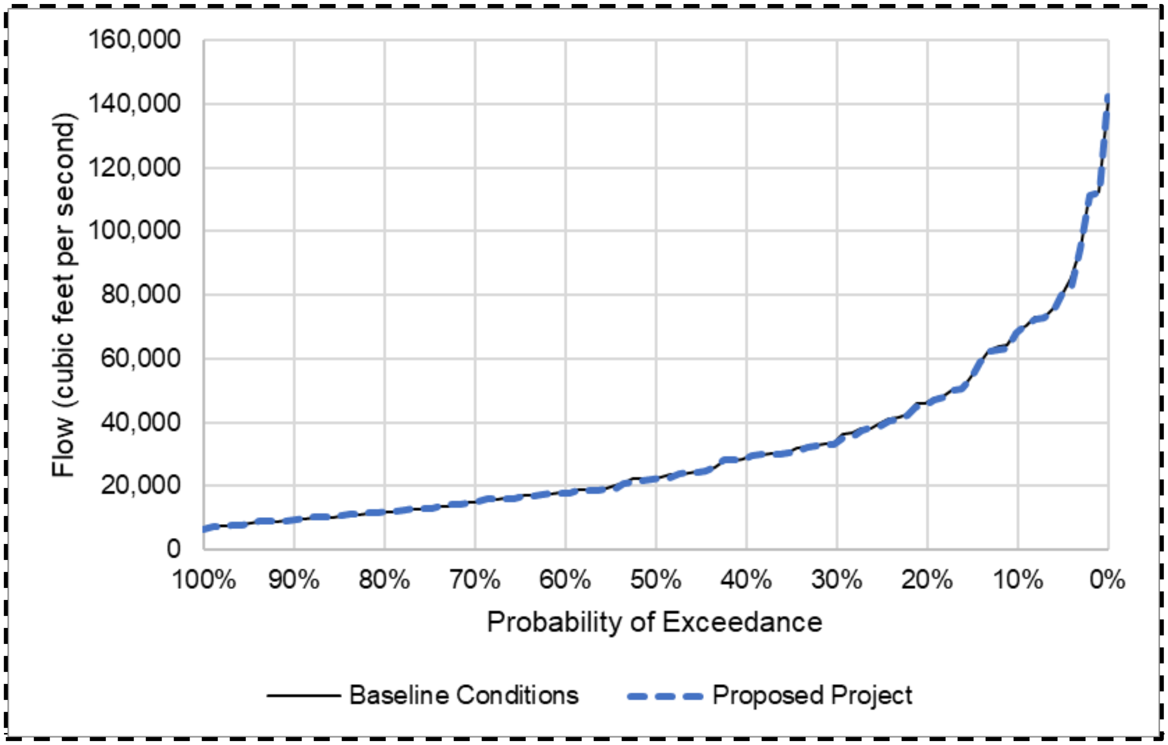
Figure 6-13. Mean Modeled Flow Through Yolo Bypass, May

Eggs and Larvae to Juveniles (March–June)

The IEP MAST (2015:88) conceptual model suggests Delta exports of water could affect food availability for larval Delta Smelt in spring. Delta exports likely influence food availability, as the springtime density of *E. affinis* and calanoid copepods in the low-salinity zone is positively correlated to Delta outflow (as indexed by X2) (March–May; Kimmerer 2002a; Greenwood 2018; Hamilton et al. 2020). Calanoid copepods and *E. affinis* are preferred prey for larval and juvenile Delta Smelt (Nobriga 2002; Slater and Baxter 2014). Spring (March–May) Delta outflow generally would be similar under the Proposed Project scenario and the Baseline Conditions scenario, with somewhat lower outflow in May due to greater SWP exports (Figures 6-14, 6-15, 6-16, and 6-17). Application of statistically significant regressions between Delta Smelt zooplankton prey in the low-salinity zone and March–May Delta outflow (see Appendix 6B, Section 6B.9, "Zooplankton–Delta Outflow Analysis") confirms there would be little difference in zooplankton density in the low-salinity zone between the Proposed Project and Baseline Conditions (Tables 6-6, 6-7, 6-8, 6-9, 6-10; Figures 6-18, 6-19, 6-20, 6-21, 6-22). The similarity in zooplankton density between Proposed Project and Baseline Conditions suggests individual Delta Smelt growth and survival would also be similar between the scenarios. CDFW (2020b Attachment 7: 93) suggested that operations of the SWP reduce feeding opportunities for Delta Smelt in the south Delta as a result of direct entrainment of food web resources and reduced residence times. Such effects would be expected to be minimally different between the Proposed Project and Baseline Conditions because few Delta Smelt would be found in the south Delta (see discussion of distribution in Appendix 6A) and Delta Smelt supplementation would occur in the North Delta Arc (see Section 6.4.1.4), which is geographically removed from such potential effects.



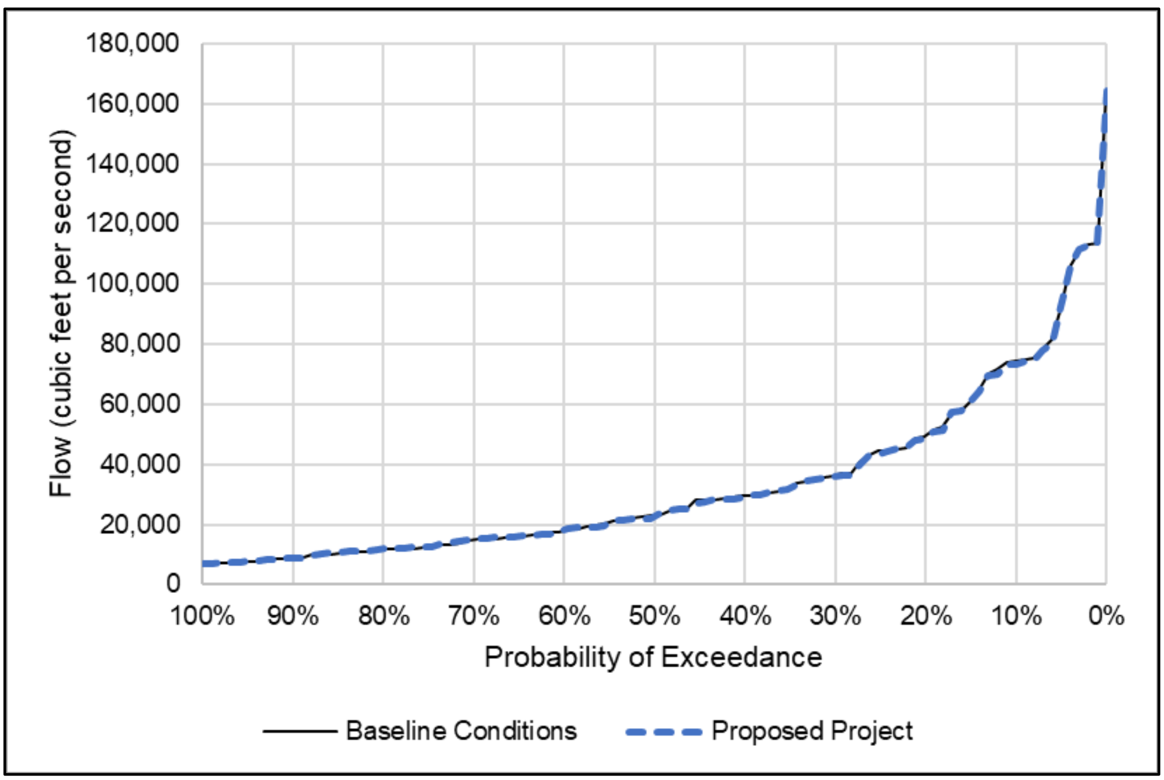


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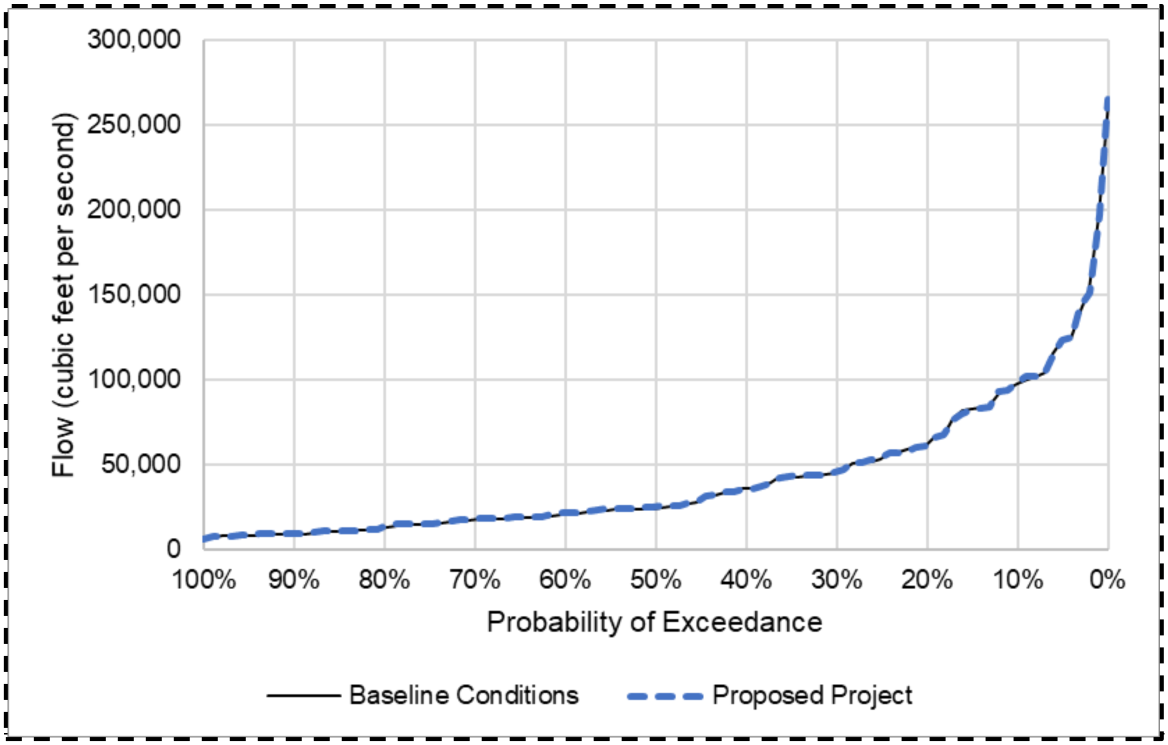
Figure 6-14. Mean Modeled Delta Outflow, March–May



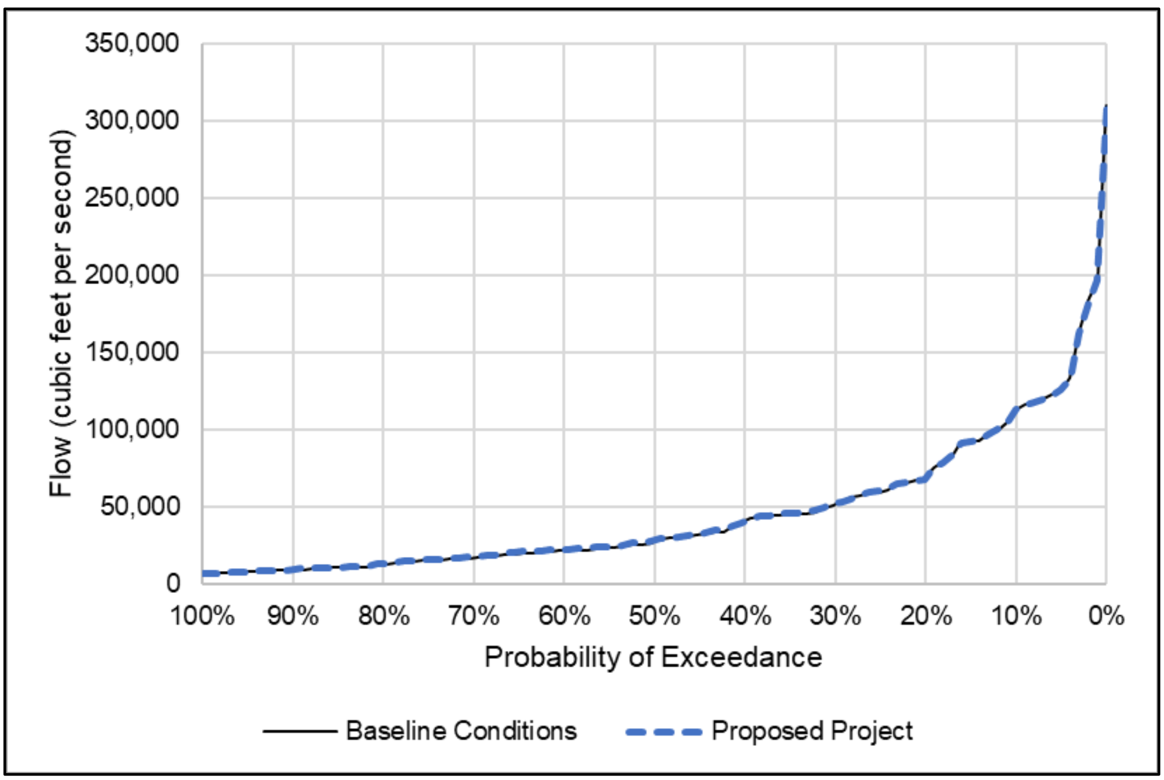


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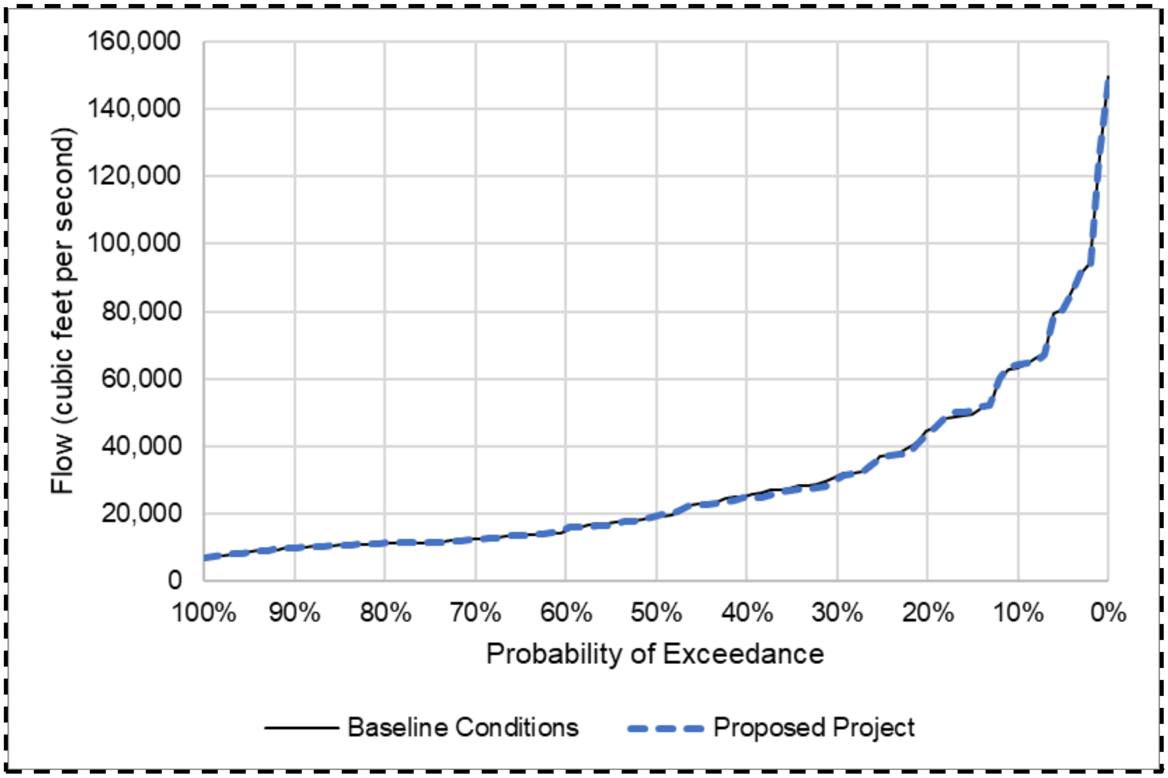
Figure 6-15. Mean Modeled Delta Outflow, March



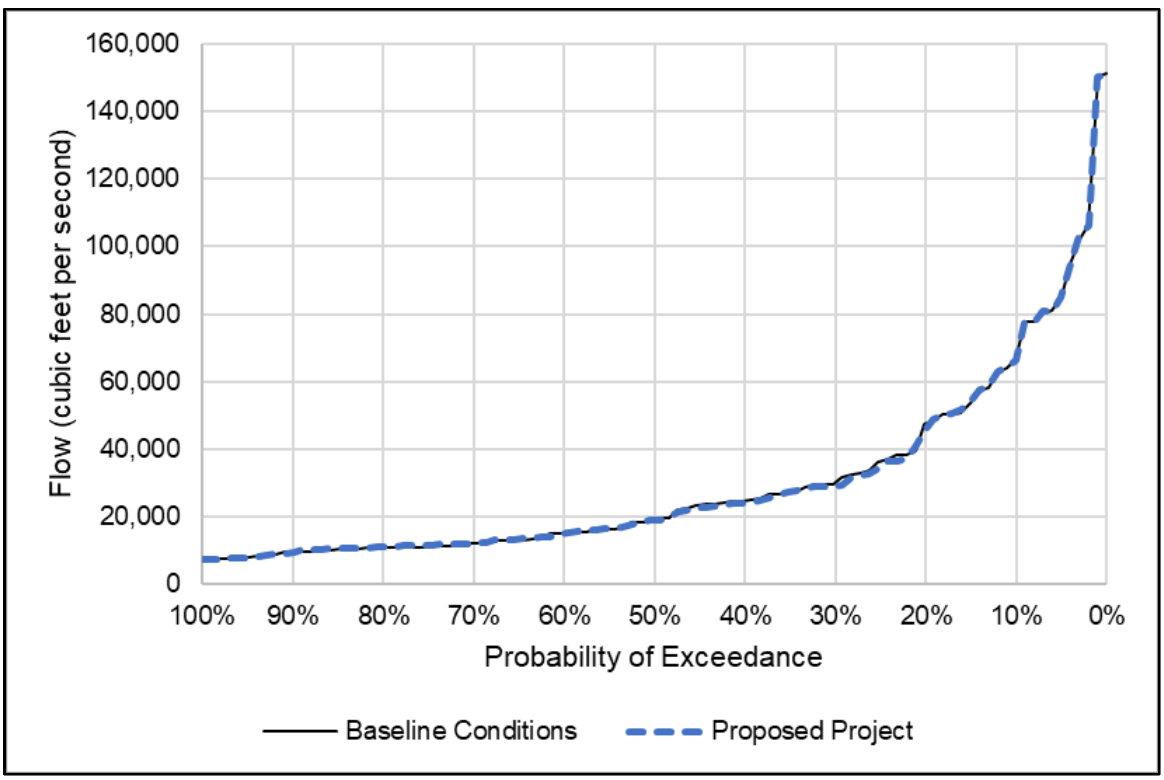


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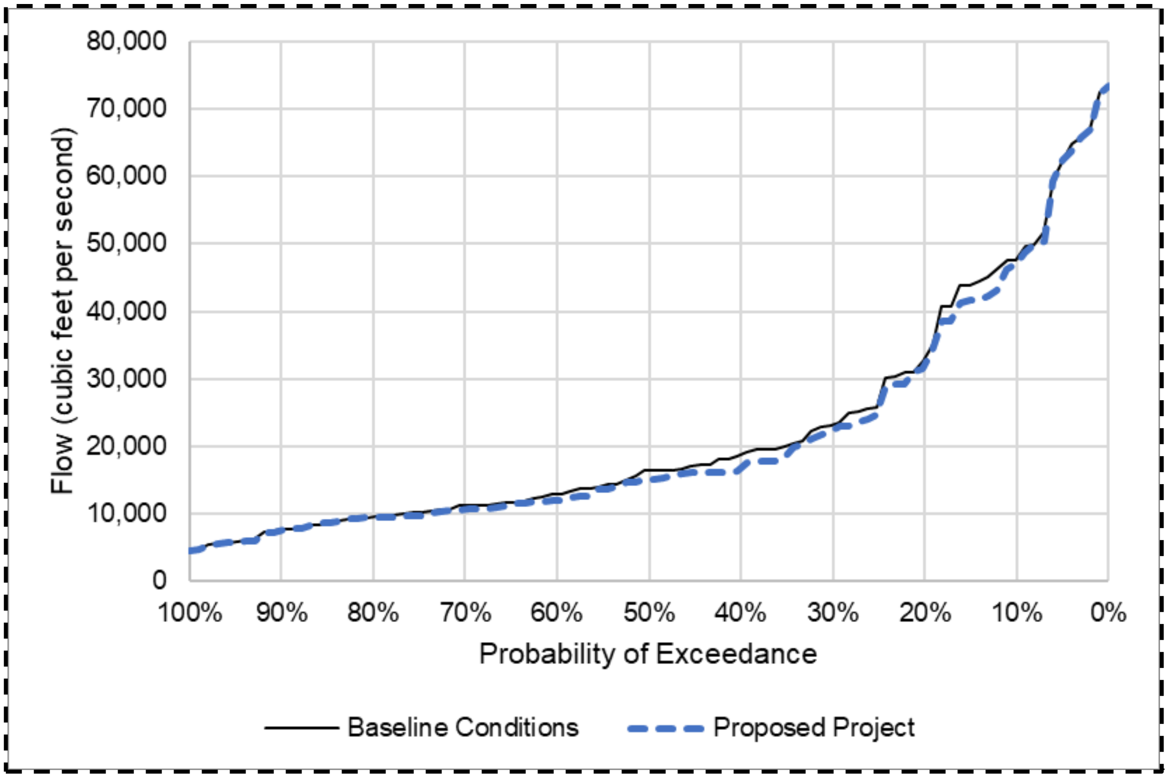
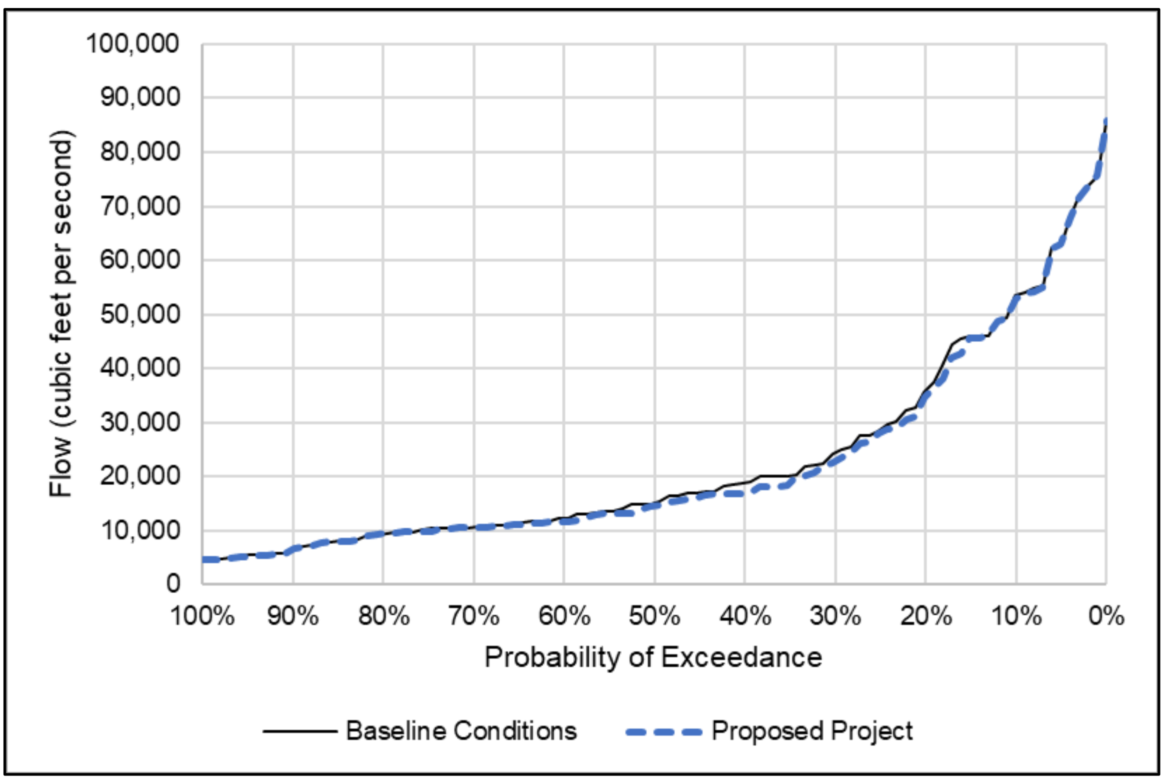
Figure 6-16. Mean Modeled Delta Outflow, April





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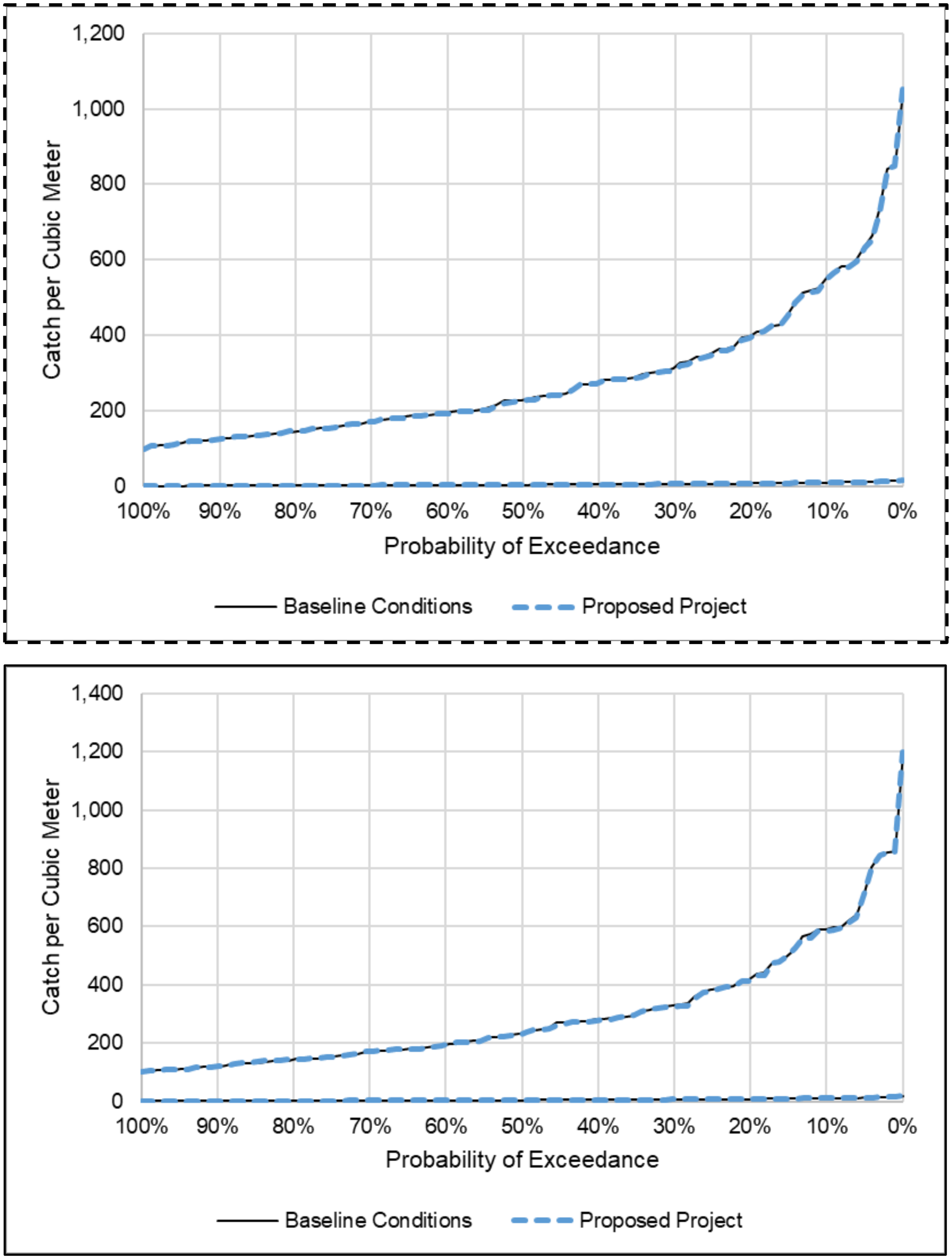
<DRAFT_TrendReport_MultiCalSim_rev12_FEIR_1_9bv2_12av2_7.23.xlsx>

Figure 6-17. Mean Modeled Delta Outflow, May

Table 6-6. Mean Predicted March–May Cladocerans (Except *Daphnia*) Catch per Cubic Meter in the Low Salinity Zone under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~69.6~~ 74.4	~~69.0 (-0.8%)~~ 73.9 (-0.7%)
Above Normal	~~49.9~~ 48.9	~~49.7 (-0.6%)~~ 48.7 (-0.4%)
Below Normal	~~35.1~~ 36.2	~~34.9 (-0.4%)~~ 36.2 (-0.2%)
Dry	~~25.2~~ 25.0	~~25.5 (1.2%)~~ 25.5 (2.0%)
Critically Dry	~~18.0~~ 17.6	~~17.8 (-1.0%)~~ 17.5 (-0.6%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-18 for 95% prediction intervals)



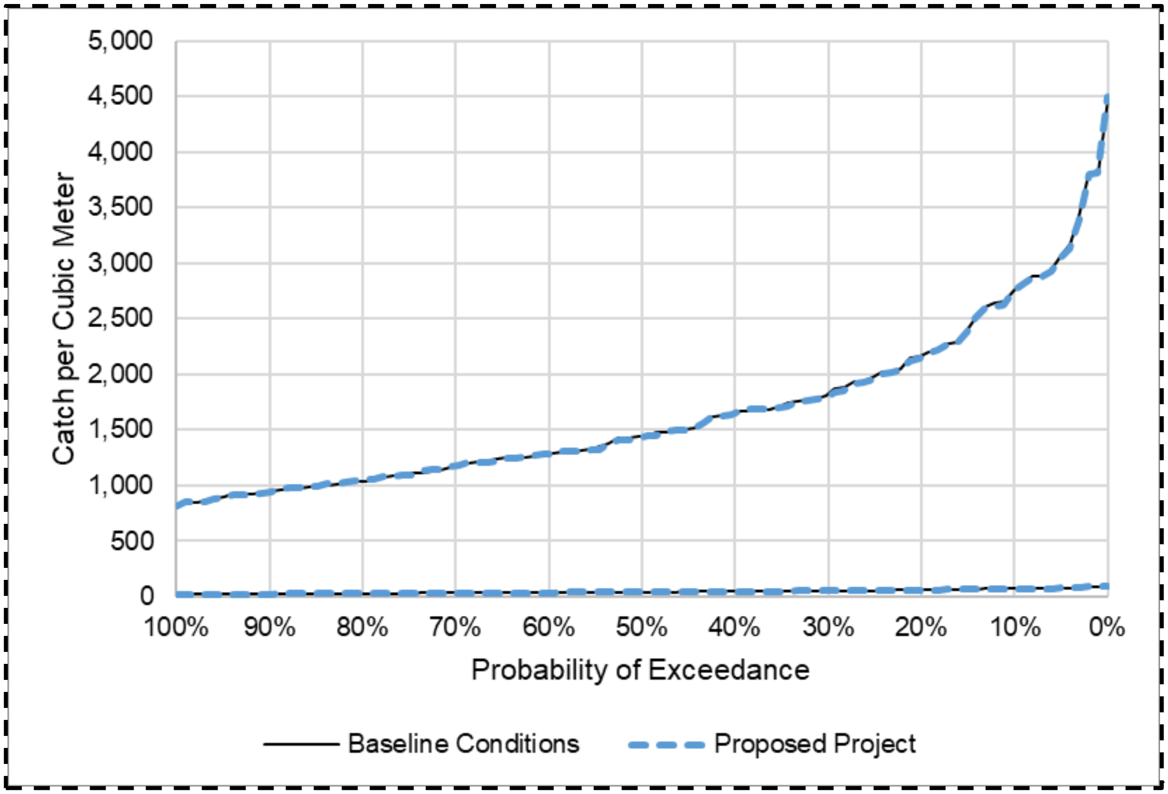
Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

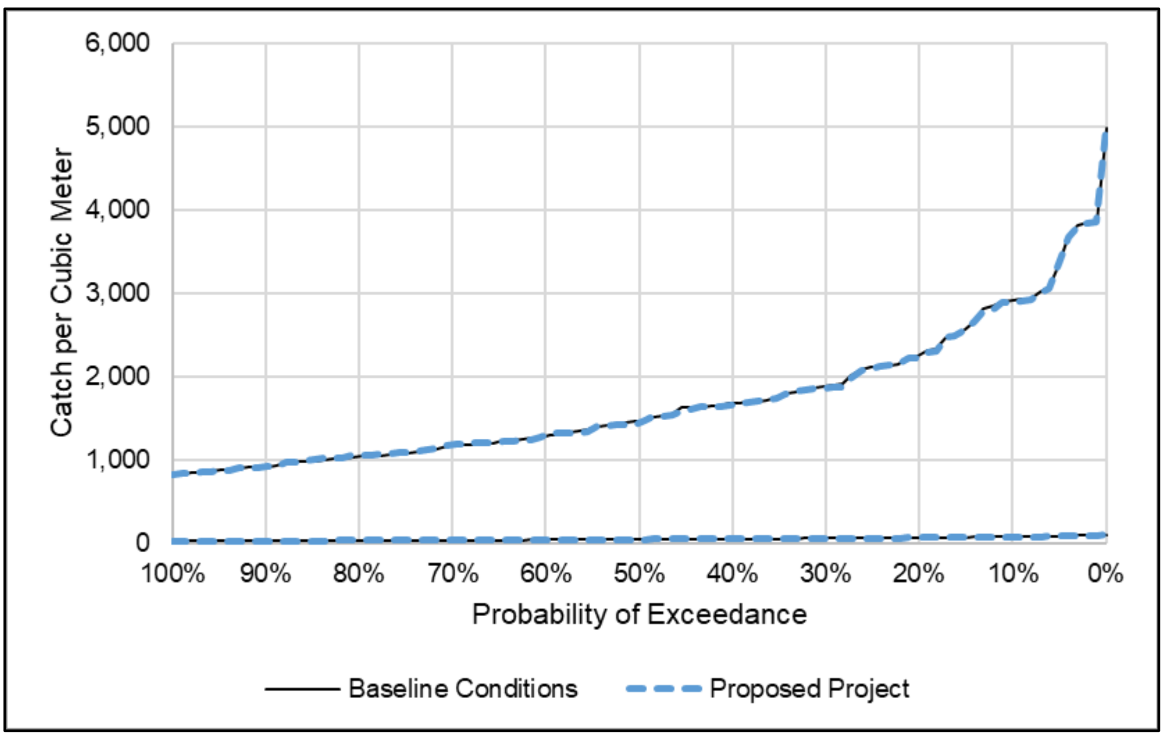
Figure 6-18. Exceedance Plot of March–May Cladocerans (Except *Daphnia*) Catch per Cubic Meter in the Low-Salinity Zone 95% Prediction Interval, for the 1922–2021 Modeled Period

Table 6-7. Mean Predicted March–May *Eurytemora affinis* Adults Catch per Cubic Meter in the Low-Salinity Zone under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~405.6~~ 426.0	~~403.0 (-0.7%)~~ 423.6 (-0.6%)
Above Normal	~~323.7~~ 318.9	~~322.4 (-0.4%)~~ 318.0 (-0.3%)
Below Normal	~~251.6~~ 257.3	~~250.8 (-0.3%)~~ 257.1 (-0.1%)
Dry	~~199.4~~ 198.4	~~201.1 (0.9%)~~ 201.2 (1.4%)
Critically Dry	~~158.1~~ 155.7	~~157.0 (-0.7%)~~ 155.0 (-0.4%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-19 for 95% prediction intervals)





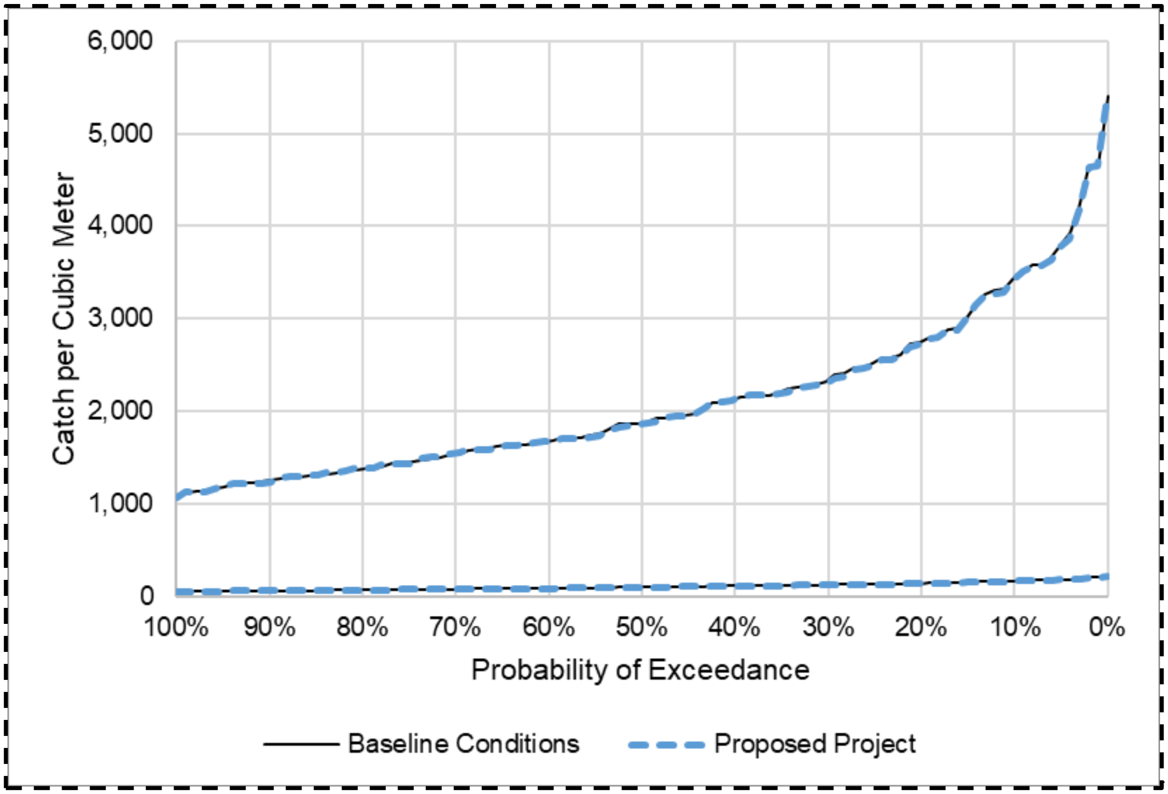
Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

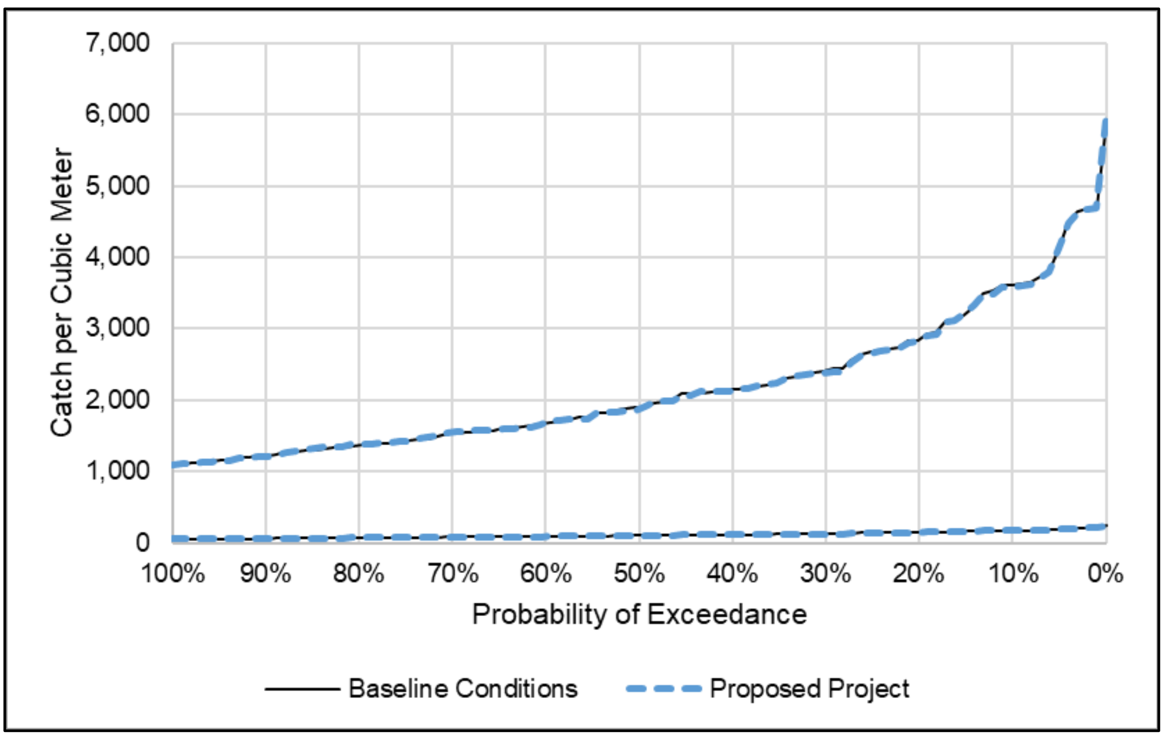
Figure 6-19. Exceedance Plot of March–May *Eurytemora affinis* Adults Catch per Cubic Meter in the Low-Salinity Zone 95% Prediction Interval, for the 1922–2021 Modeled Period

Table 6-8. Mean Predicted March–May Harpacticoid Copepods Catch per Cubic Meter in the Low-Salinity Zone under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~693.2~~ 726.2	~~688.8 (-0.6%)~~ 722.3 (-0.5%)
Above Normal	~~560.6~~ 552.7	~~558.5 (-0.4%)~~ 551.2 (-0.3%)
Below Normal	~~441.6~~ 451.1	~~440.3 (-0.3%)~~ 450.7 (-0.1%)
Dry	~~354.5~~ 352.7	~~357.3 (0.8%)~~ 357.5 (1.4%)
Critically Dry	~~284.6~~ 280.6	~~282.7 (-0.7%)~~ 279.4 (-0.4%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-20 for 95% prediction intervals)





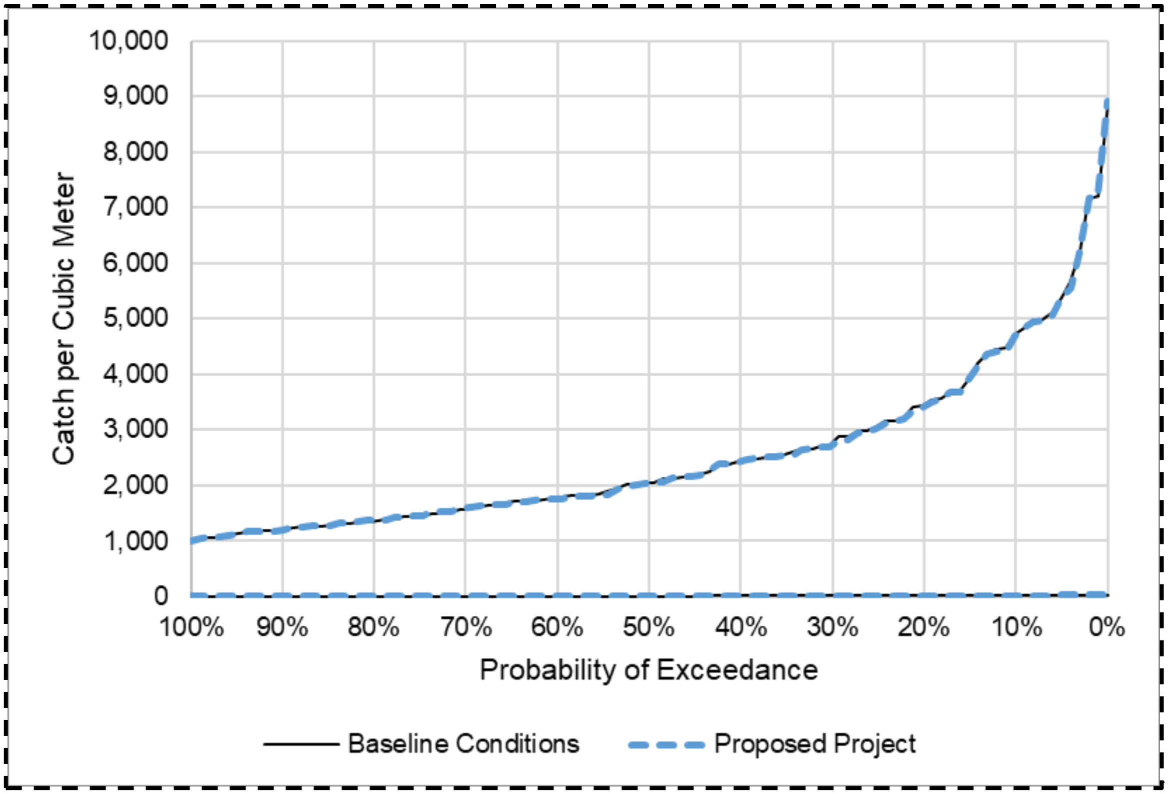
Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

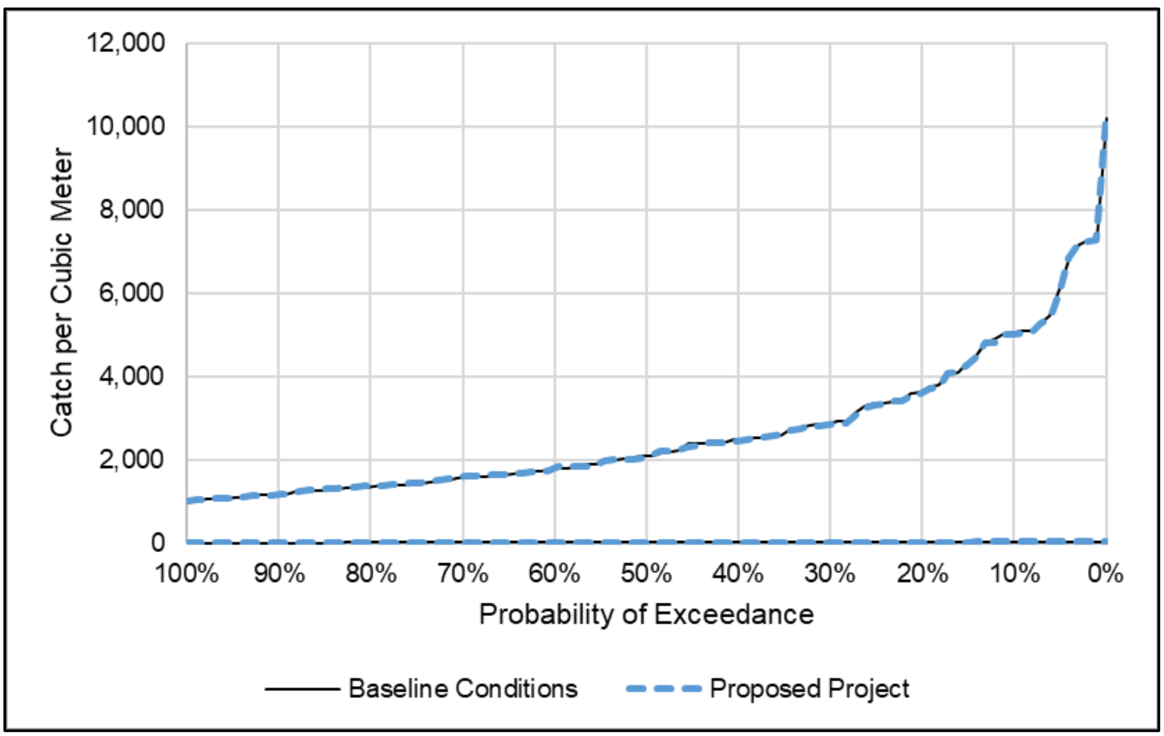
Figure 6-20. Exceedance Plot of March–May Harpacticoid Copepods Catch per Cubic Meter in the Low-Salinity Zone 95% Prediction Interval, for the 1922–2021 Modeled Period

Table 6-9. Mean Predicted March–May Other Calanoid Copepod Adults Catch per Cubic Meter in the Low-Salinity Zone under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~307.7~~ 327.2	~~305.3 (-0.8%)~~ 325.0 (-0.7%)
Above Normal	~~229.0~~ 224.7	~~227.8 (-0.5%)~~ 223.9 (-0.4%)
Below Normal	~~166.6~~ 171.4	~~166.0 (-0.4%)~~ 171.2 (-0.1%)
Dry	~~124.0~~ 123.2	125.4 ~~(1.1%)~~ (1.8%)
Critically Dry	~~92.2~~ 90.4	~~91.4 (-0.9%)~~ 89.9 (-0.6%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-21 for 95% prediction intervals)





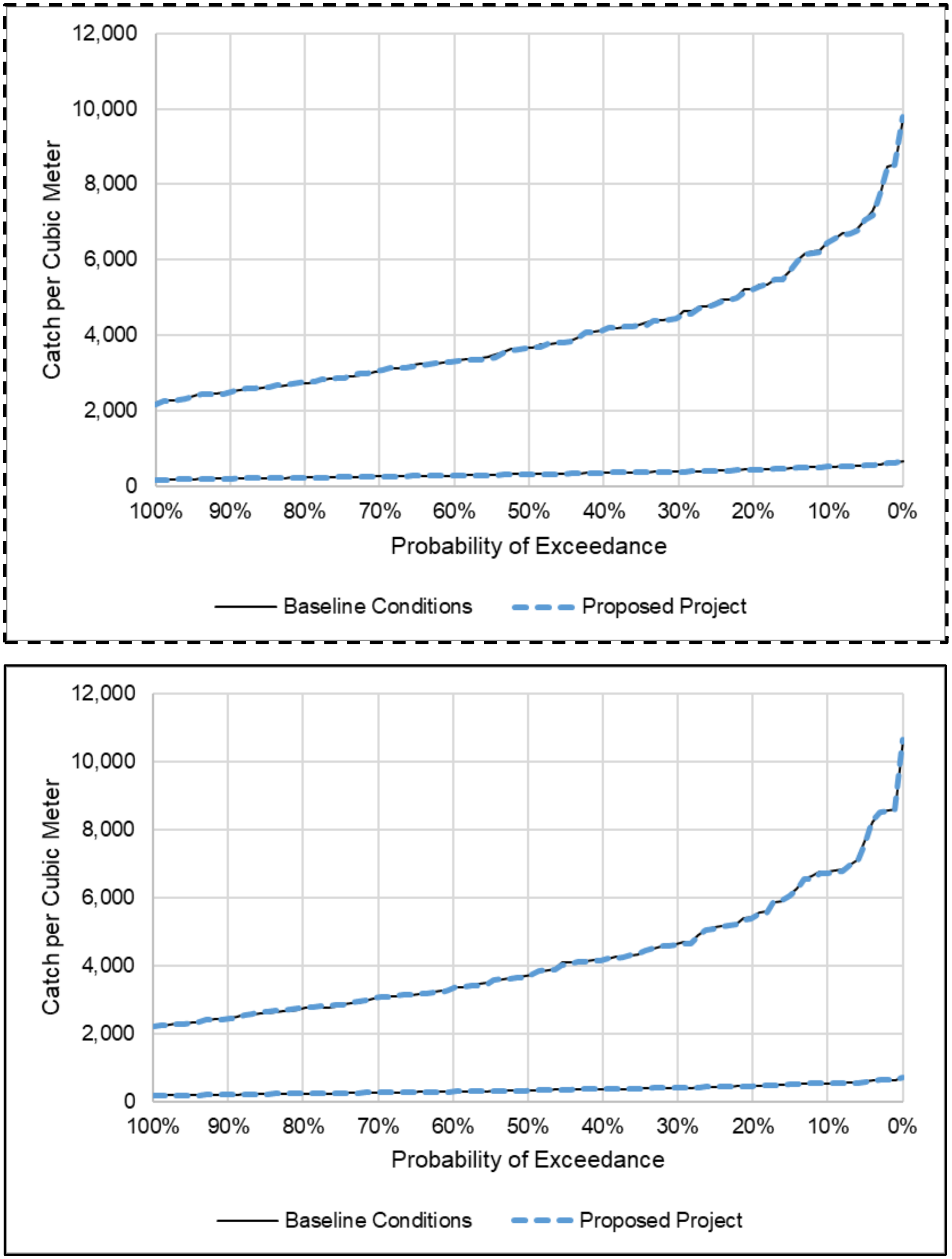
Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

Figure 6-21. Exceedance Plot of March–May Other Calanoid Copepod Adults Catch per Cubic Meter in the Low-Salinity Zone 95% Prediction Interval, for the 1922–2021 Modeled Period

Table 6-10. Mean Predicted March–May Other Calanoid Copepod Copepodites Catch per Cubic Meter in the Low-Salinity Zone under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~1,661.4~~ 1,735.5	~~1,651.4 (-0.6%)~~ 1,726.7 (-0.5%)
Above Normal	~~1,364.2~~ 1,346.2	~~1,359.4 (-0.4%)~~ 1,342.9 (-0.2%)
Below Normal	~~1,091.1~~ 1,113.1	~~1,088.1 (-0.3%)~~ 1,112.2 (-0.1%)
Dry	~~888.5~~ 884.3	~~895.3 (0.8%)~~ 895.6 (1.3%)
Critically Dry	~~723.8~~ 714.3	~~719.4 (-0.6%)~~ 711.6 (-0.4%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-22 for 95% prediction intervals)

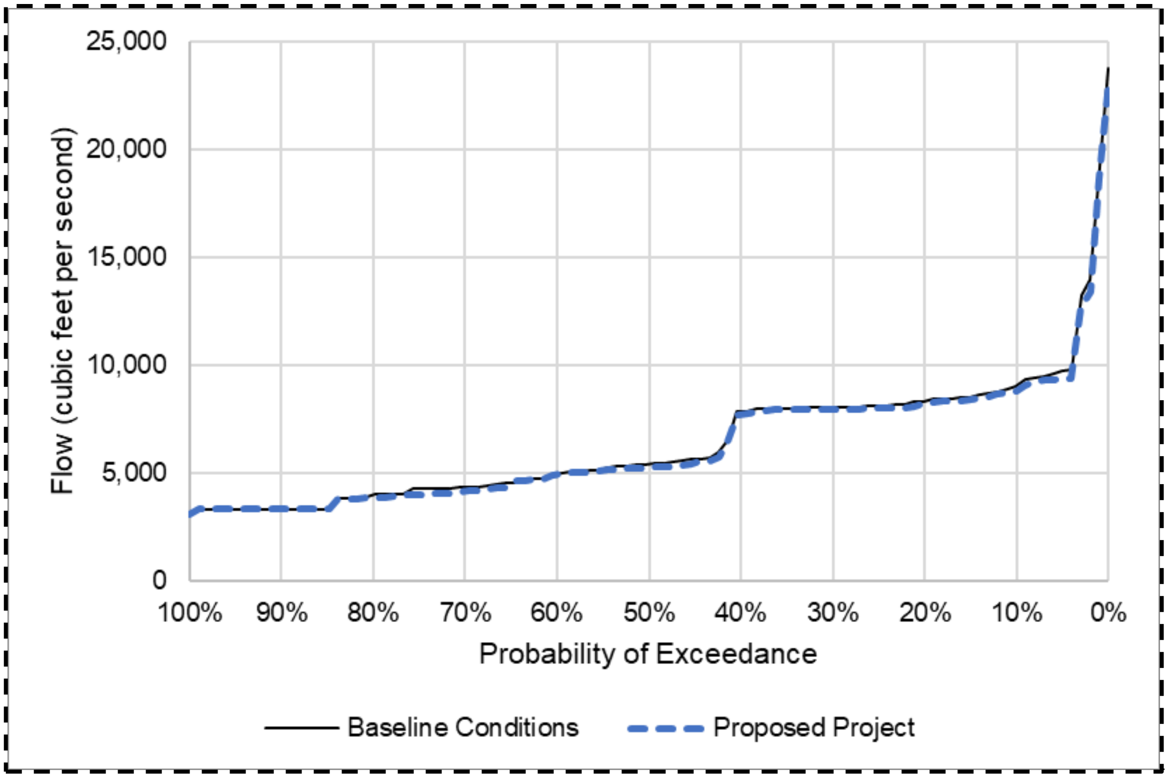


Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

Figure 6-22. Exceedance Plot of March–May Other Calanoid Copepod Copepodites Catch per Cubic Meter in the Low-Salinity Zone 95% Prediction Interval, for the 1922–2021 Modeled Period

Juveniles to Subadults (June–September)

The IEP MAST (2015:88–89) conceptual model incorporates food availability and quality as key components of the probability of juvenile and subadult Delta Smelt transition to subsequent life stages, through growth and survival of individuals. Empirical evidence for the importance of food during this life stage transition has been provided in some studies (Kimmerer 2008; Miller et al. 2012) but not others (Smith et al. 2021). Summer and fall (July–September) Delta outflow is positively correlated with the subsidy of the Delta Smelt zooplankton prey *Pseudodiaptomus forbesi* to the low-salinity zone from the freshwater Delta (Kimmerer et al. 2018; see also discussion under "Subadults to Adults [September–December]"). Delta outflow is generally similar between the Proposed Project and Baseline Conditions scenarios during July–September (Figures 6-23, 6-24, 6-25, 6-26), albeit slightly lower in August (Figure 6-25) as a result of differences in operational criteria between the scenarios, including SMSCG operations and implementation of summer Delta outflow. Delta outflow is also similar for June (Figure 6-27). No statistically significant regressions were found between Delta Smelt zooplankton prey and summer (June–August) Delta outflow (see Appendix 6B, Section 6B.9, "Zooplankton–Delta Outflow Analysis") to quantitatively inform the comparison of the Proposed Project and Baseline Conditions scenarios, suggesting any effects of Delta outflow on zooplankton prey for Delta Smelt during this time period would be similar between the Proposed Project and Baseline Conditions scenarios.



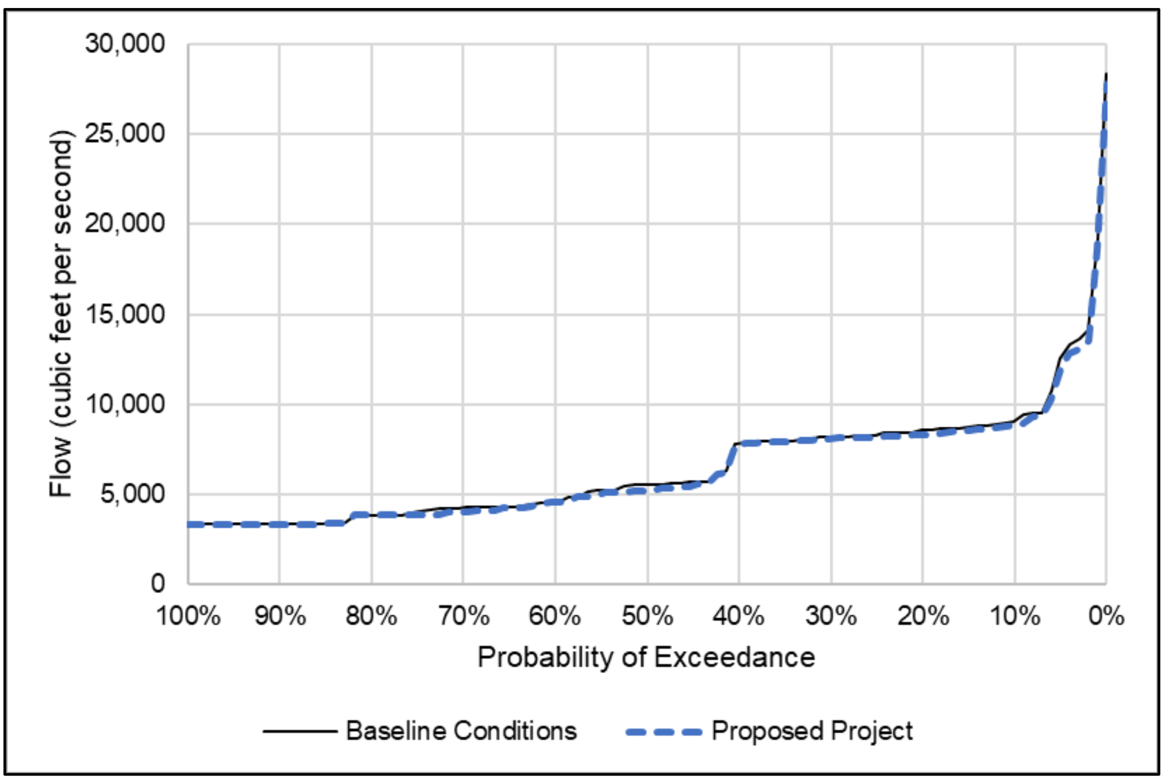


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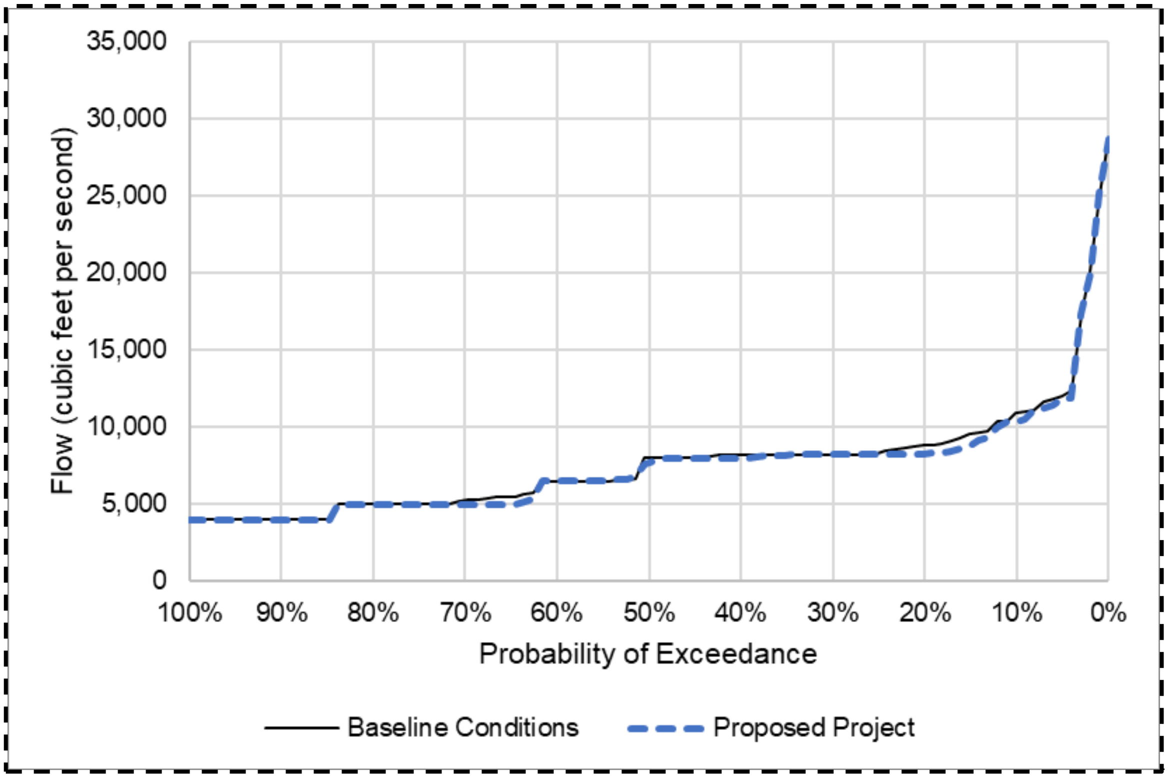
Figure 6-23. Mean Modeled Delta Outflow, July–September



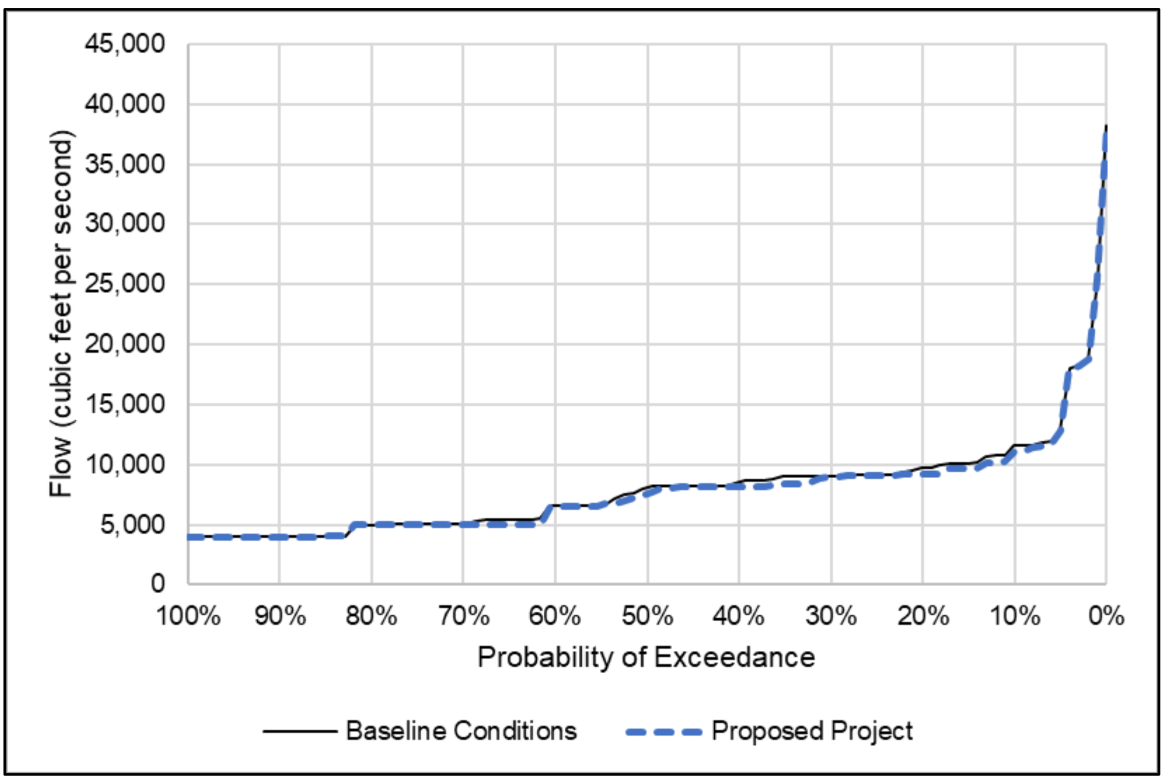


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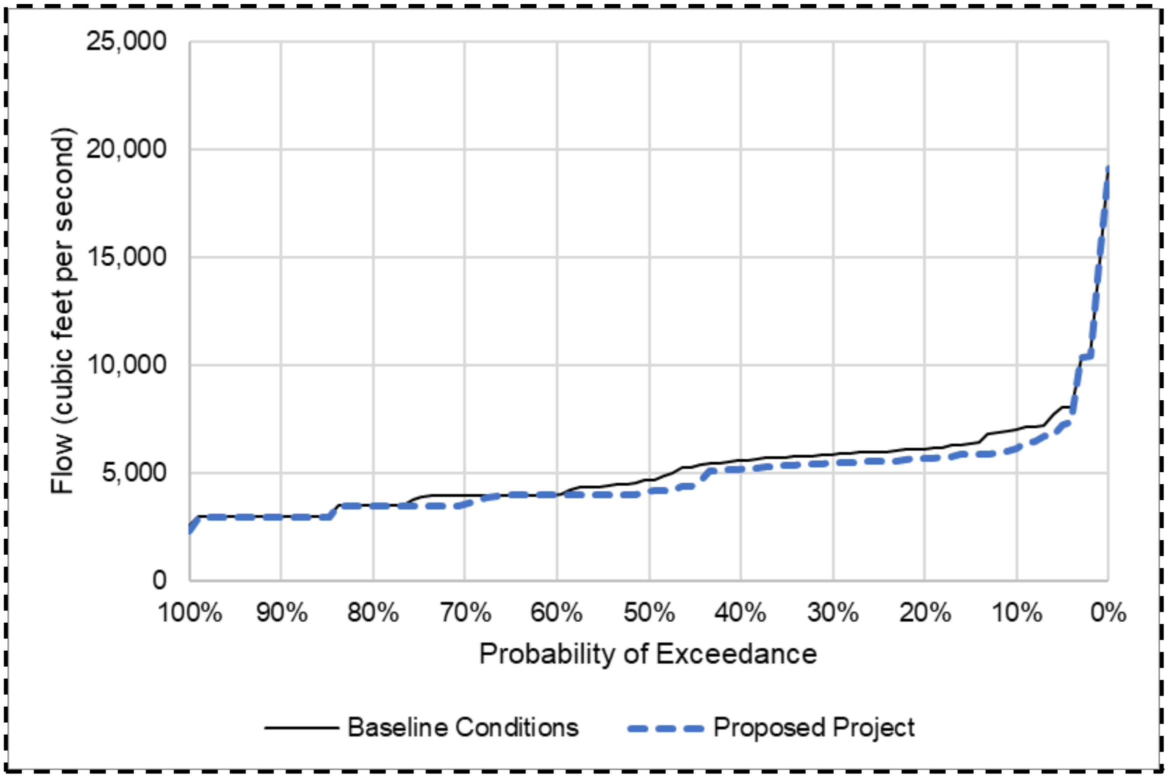
Figure 6-24. Mean Modeled Delta Outflow, July



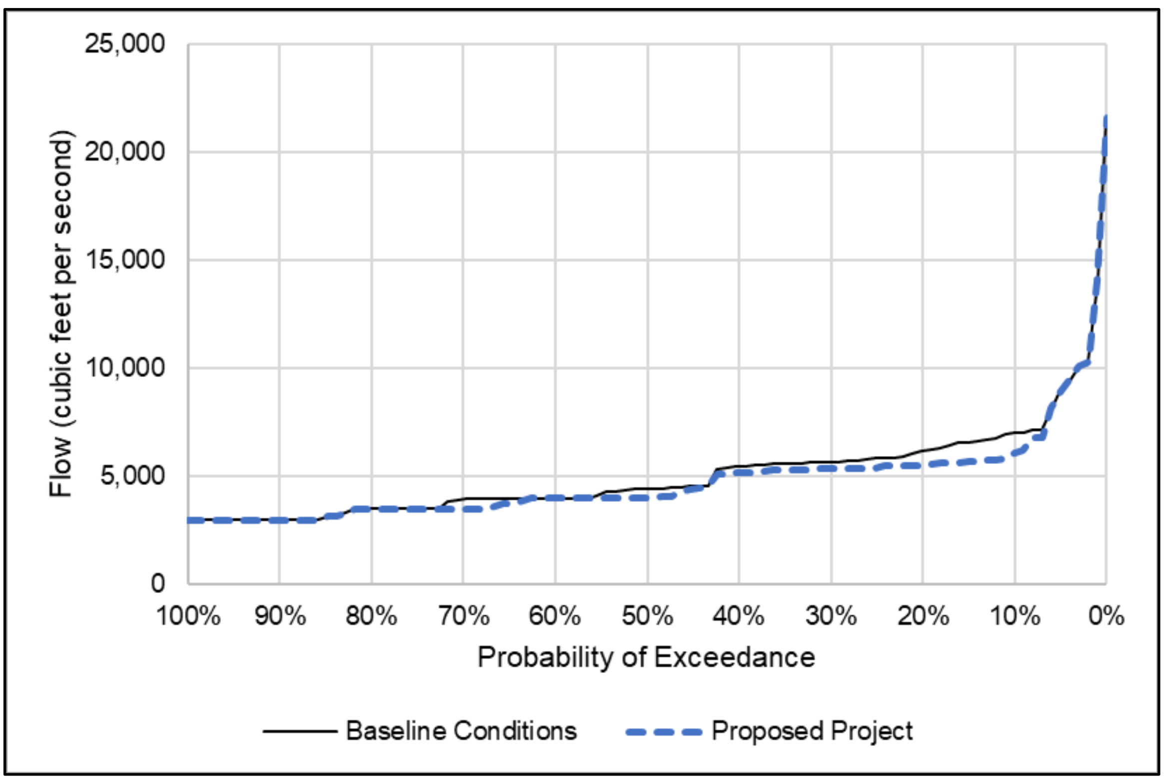


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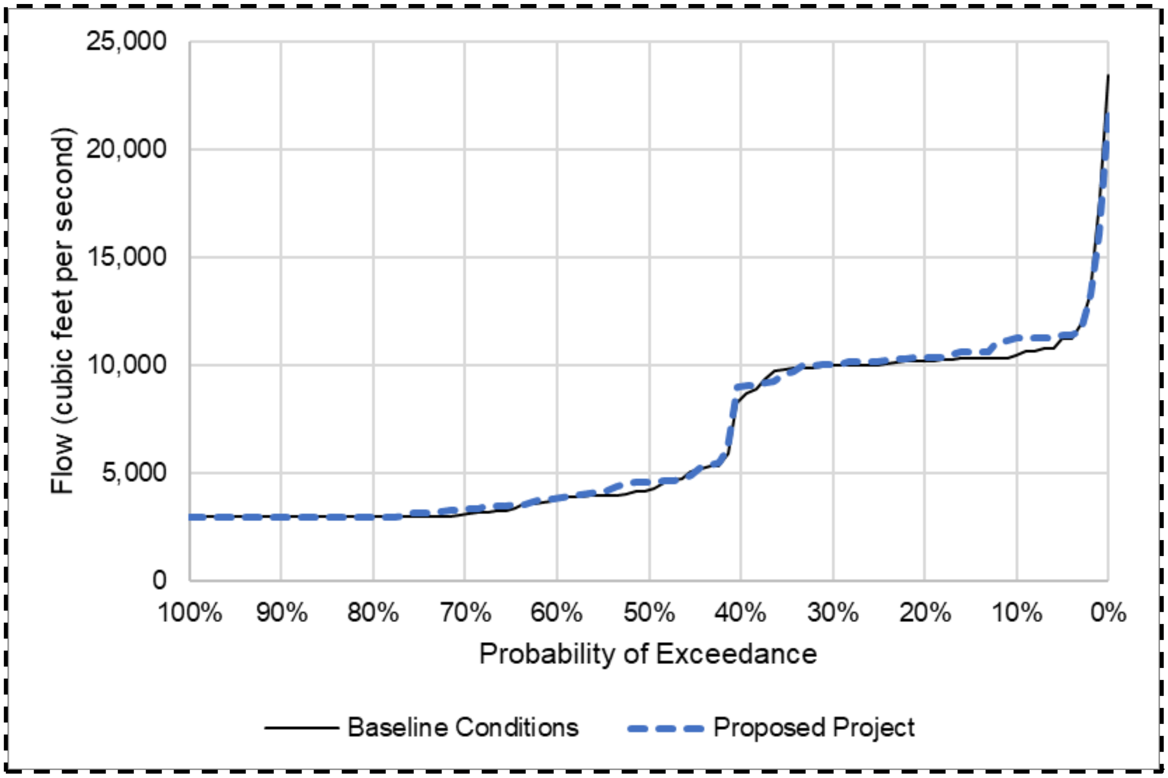
Figure 6-25. Mean Modeled Delta Outflow, August



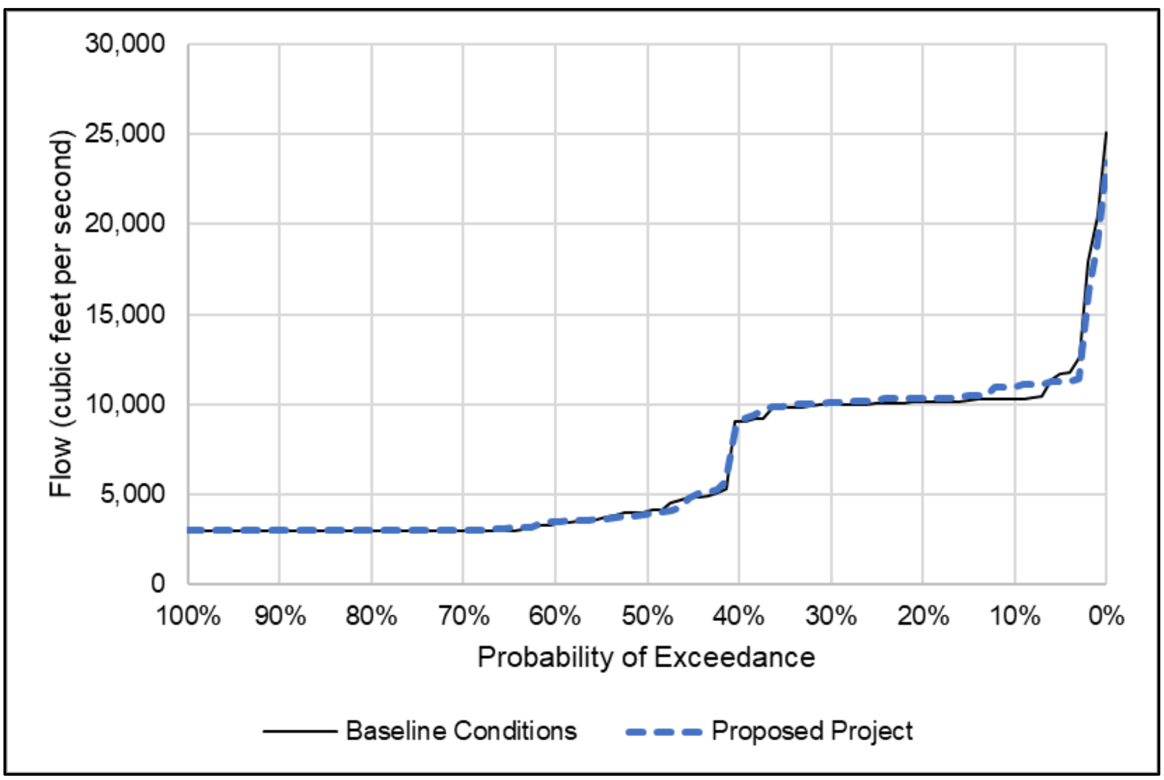


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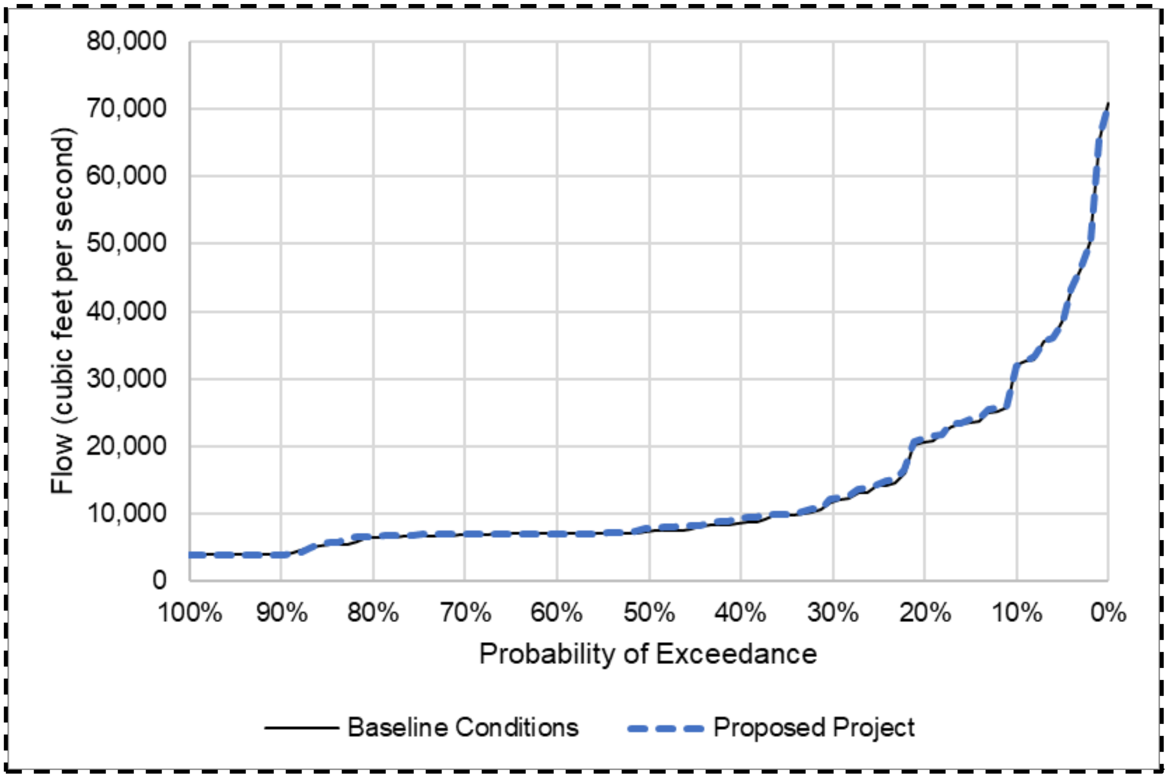
Figure 6-26. Mean Modeled Delta Outflow, September



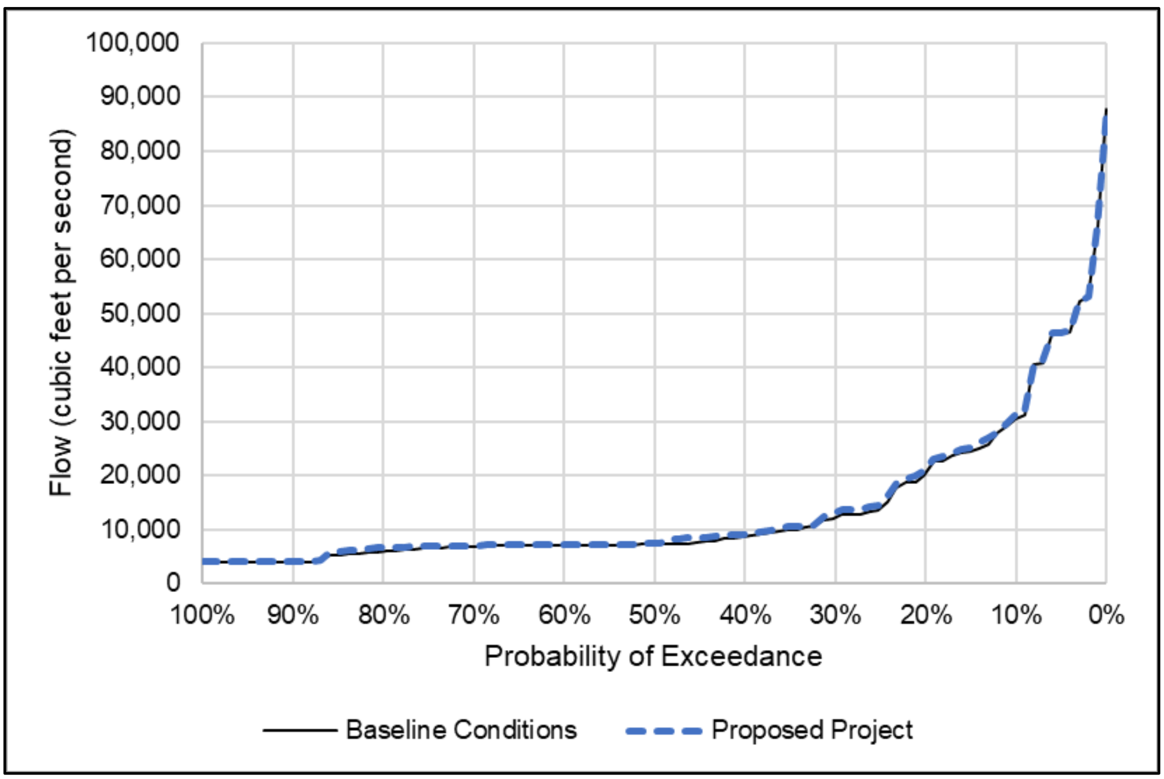


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Figure 6-27. Mean Modeled Delta Outflow, June

Subadults to Adults (September–December)

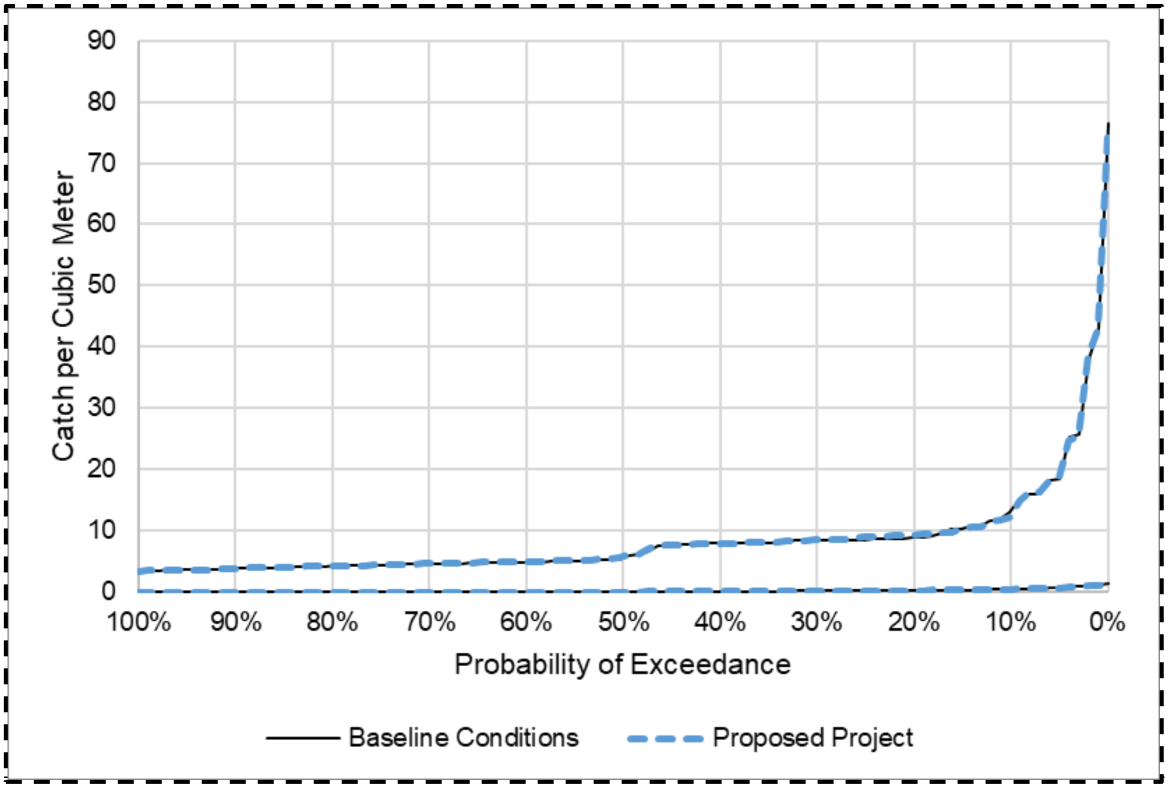
As described in Appendix 6A, detailed examination of a fall flow action in 2017 compared to 2011–2016 did not provide evidence for an increase in Delta Smelt prey with increased outflow in 2017 (Schultz et al. 2019; Interagency Ecological Program 2020). In contrast, Lee et al. (2023) found support for higher abundance of *P. forbesi* in Suisun Bay and Suisun Marsh during years of higher September–November Delta outflow (2017 and 2019) relative to years with lower Delta outflow (2018 and 2020). These empirical observations of greater *P. forbesi* density with greater Delta outflow are supported by recent modeling analyses, although it may be difficult to detect increased *P. forbesi* density in the low-salinity zone due to the volume of Delta outflow required (Hassrick et al. 2023). Other analyses have found largely nonlinear relationships between outflow and calanoid copepod biomass in the Delta and Suisun Marsh/Bay, with potential for negative effects of greater September/October outflow on Delta Smelt prey at several locations (Hamilton et al. 2020).

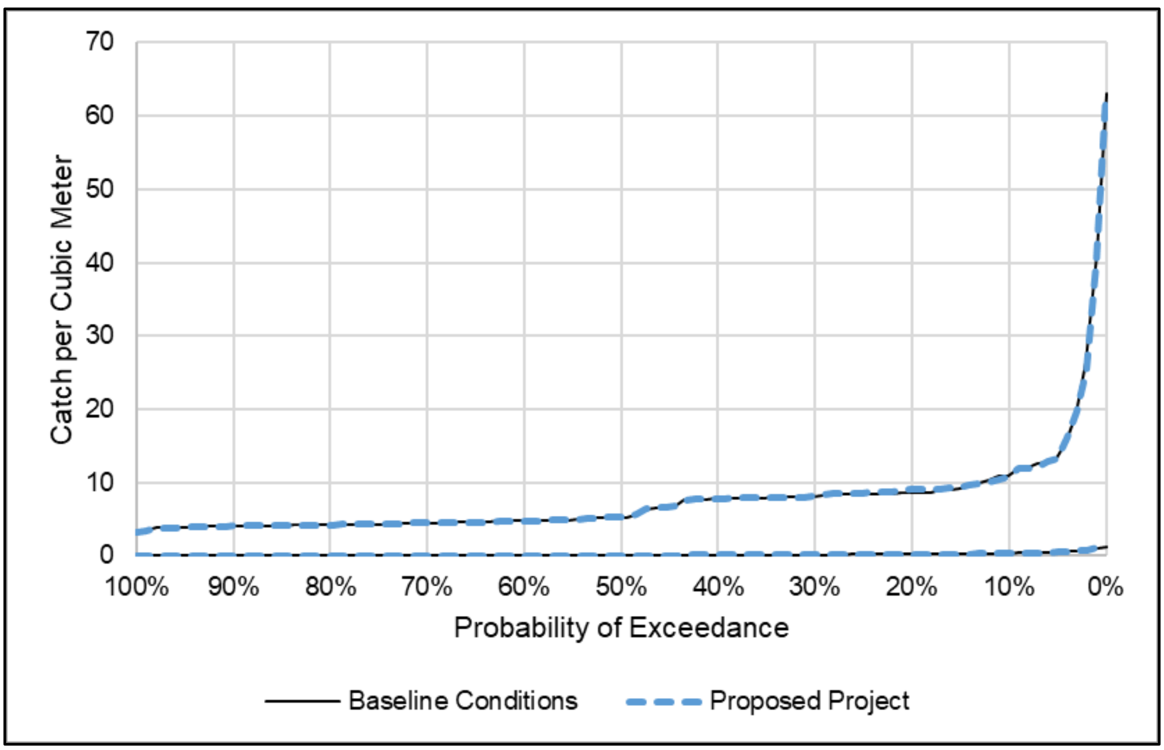
Examination of evidence for relationships between Delta Smelt zooplankton prey in the low-salinity zone and fall (September–November) Delta outflow indicated only two taxa (*E. affinis* adults and mysids) had statistically significant regression relationships (see Appendix 6B, Section 6B.9, "Zooplankton–Delta Outflow Analysis"). Application of these relationships to the CalSim 3–modeled Delta outflow scenarios indicates there would be little difference in zooplankton density in the low-salinity zone between the Proposed Project and Baseline Conditions (Tables 6-11, 6-12; Figures 6-28, 6-29). This reflects the similar Delta outflow between the scenarios (Figures 6-30, 6-31, 6-32, 6-33).

Table 6-11. Mean Predicted September–November *Eurytemora affinis* Adults Catch per Cubic Meter in the Low-Salinity Zone under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~3.3~~ <u>3.1</u>	~~3.2 (-0.5%)~~ <u>3.0 (-0.8%)</u>
Above Normal	~~2.9~~ <u>2.6</u>	~~3.0 (4.2%)~~ <u>2.7 (5.3%)</u>
Below Normal	~~1.4~~ <u>1.2</u>	~~1.4 (2.2%)~~ <u>1.2 (-0.4%)</u>
Dry	~~1.4~~ <u>1.1</u>	~~1.4 (1.1%)~~ <u>1.2 (0.9%)</u>
Critically Dry	~~0.6~~ <u>0.7</u>	~~0.6 (0.2%)~~ <u>0.7 (-0.1%)</u>

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-28 for 95% prediction intervals)





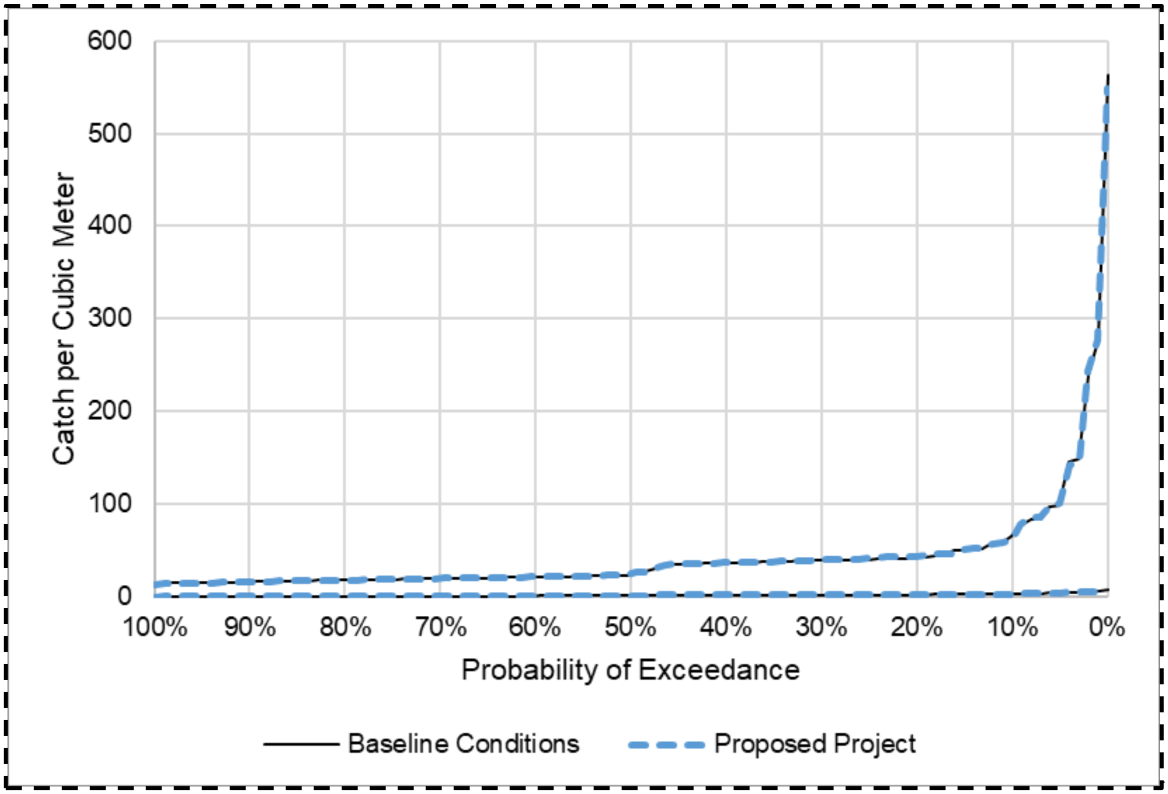
Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

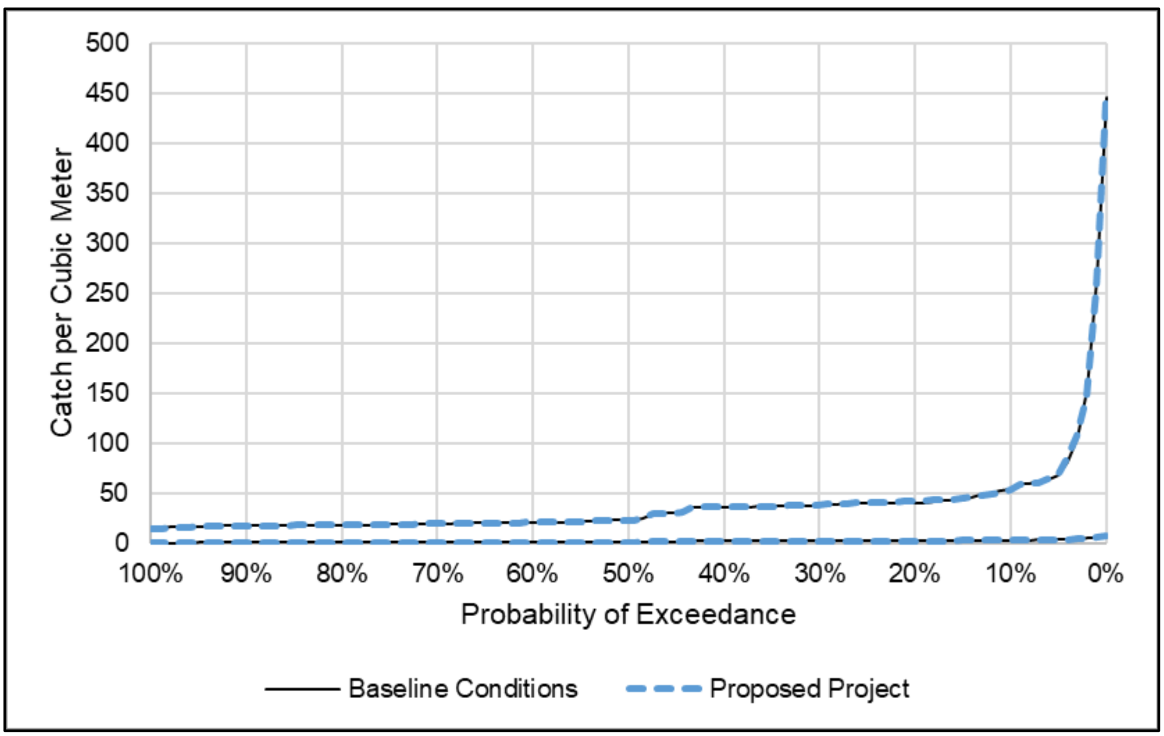
Figure 6-28. Exceedance Plot of September–November Eurytemora affinis Adults Catch per Cubic Meter in the Low-Salinity Zone 95% Prediction Interval, for the 1922–2021 Modeled Period

Table 6-12. Mean Predicted September–November Mysids Catch per Cubic Meter in the Low-Salinity Zone under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~15.2~~ 14.2	~~15.1 (-0.6%)~~ 14.1 (-0.9%)
Above Normal	~~13.2~~ 11.7	~~13.7 (4.1%)~~ 12.3 (5.2%)
Below Normal	~~6.7~~ 6.0	~~6.8 (1.9%)~~ 5.9 (-0.3%)
Dry	~~6.7~~ 5.6	~~6.8 (0.9%)~~ 5.7 (0.7%)
Critically Dry	~~3.5~~ 4.0	~~3.5 (0.1%)~~ 3.9 (-0.1%)

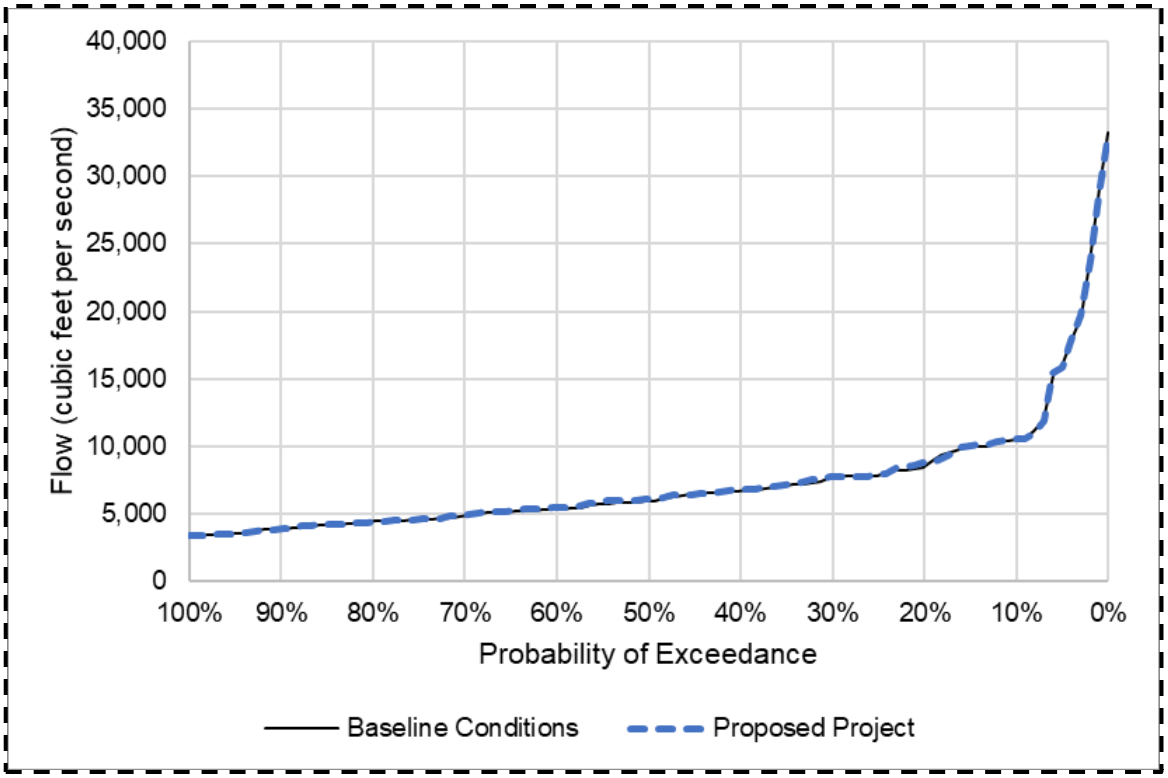
Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-29 for 95% prediction intervals)





Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

Figure 6-29. Exceedance Plot of September–November Mysids Catch per Cubic Meter in the Low-Salinity Zone 95% Prediction Interval, for the 1922–2021 Modeled Period



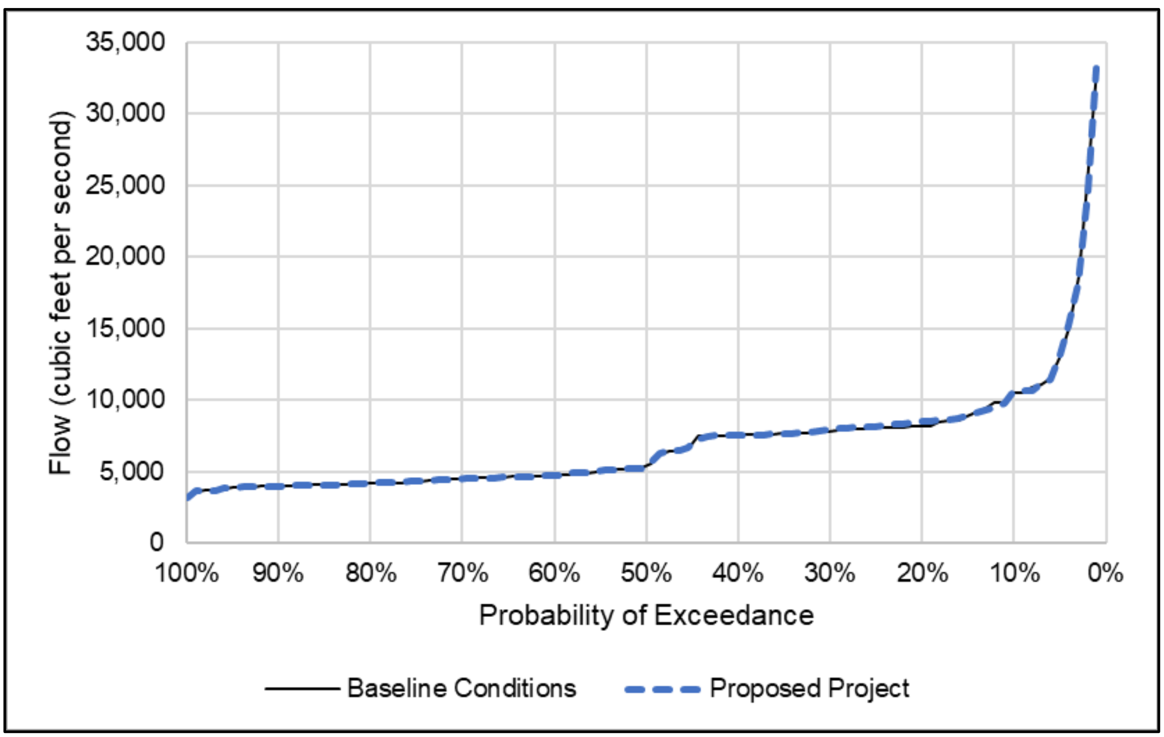


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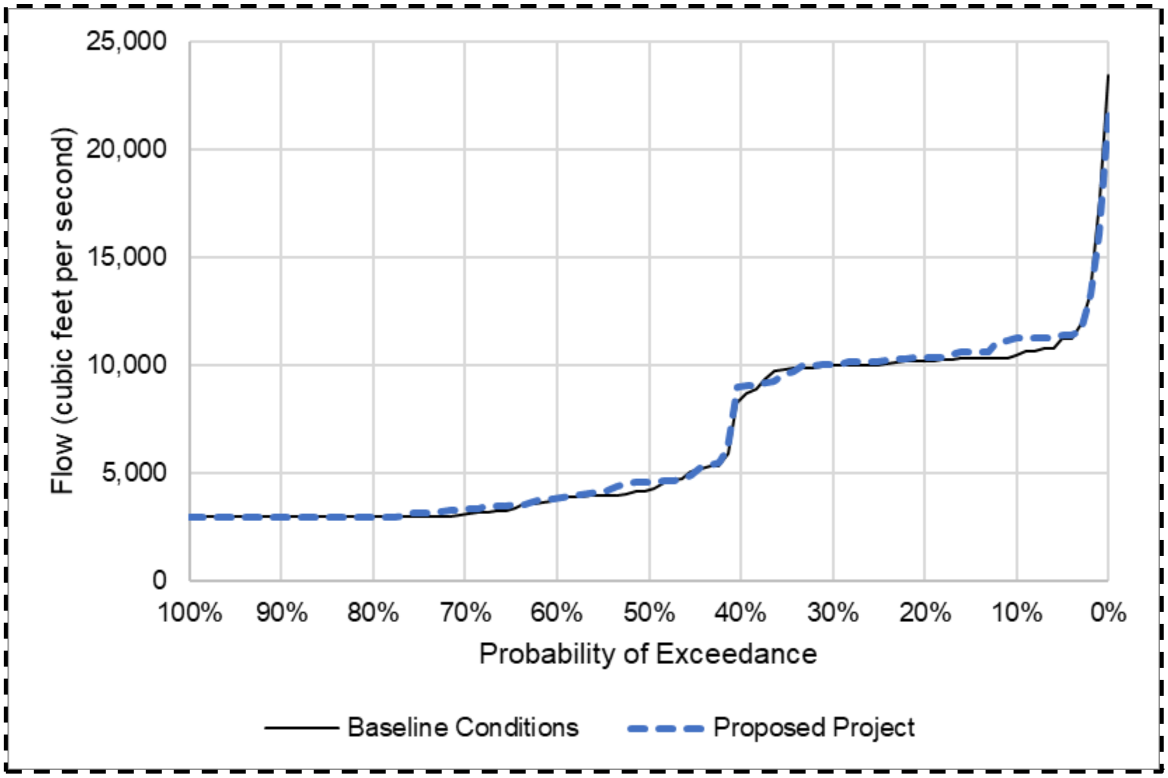
Figure 6-30. Mean Modeled Delta Outflow, September–November



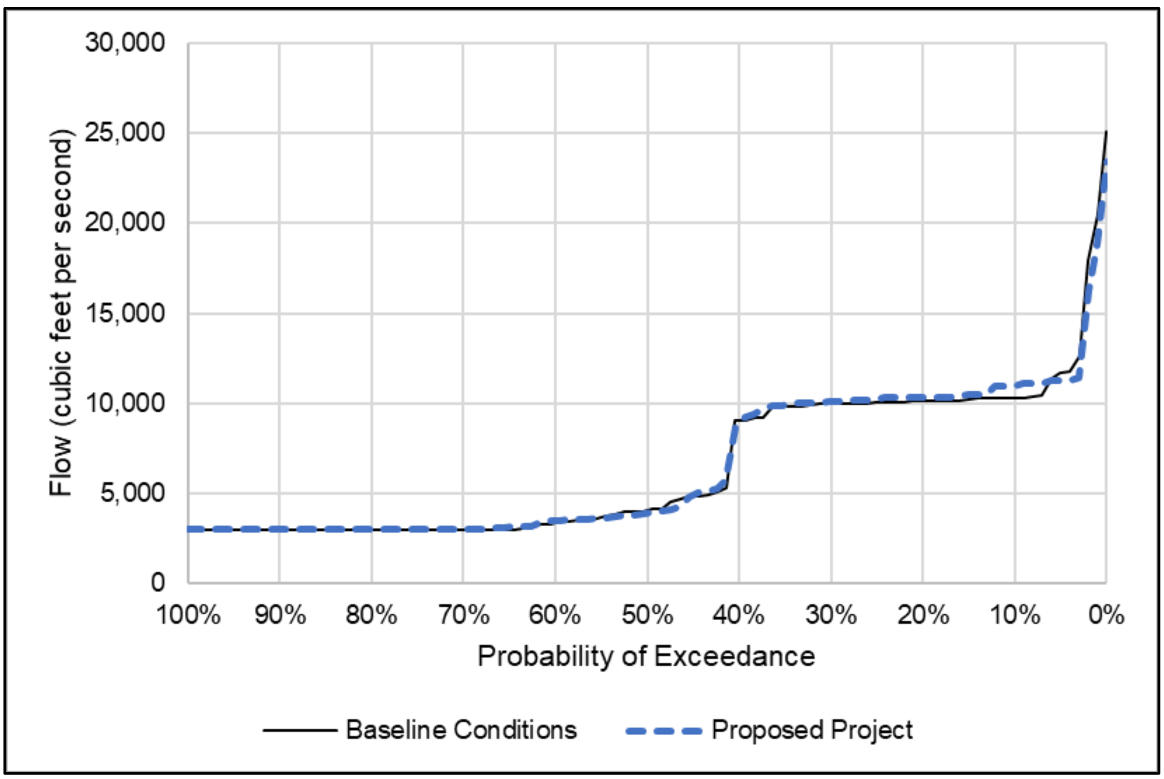


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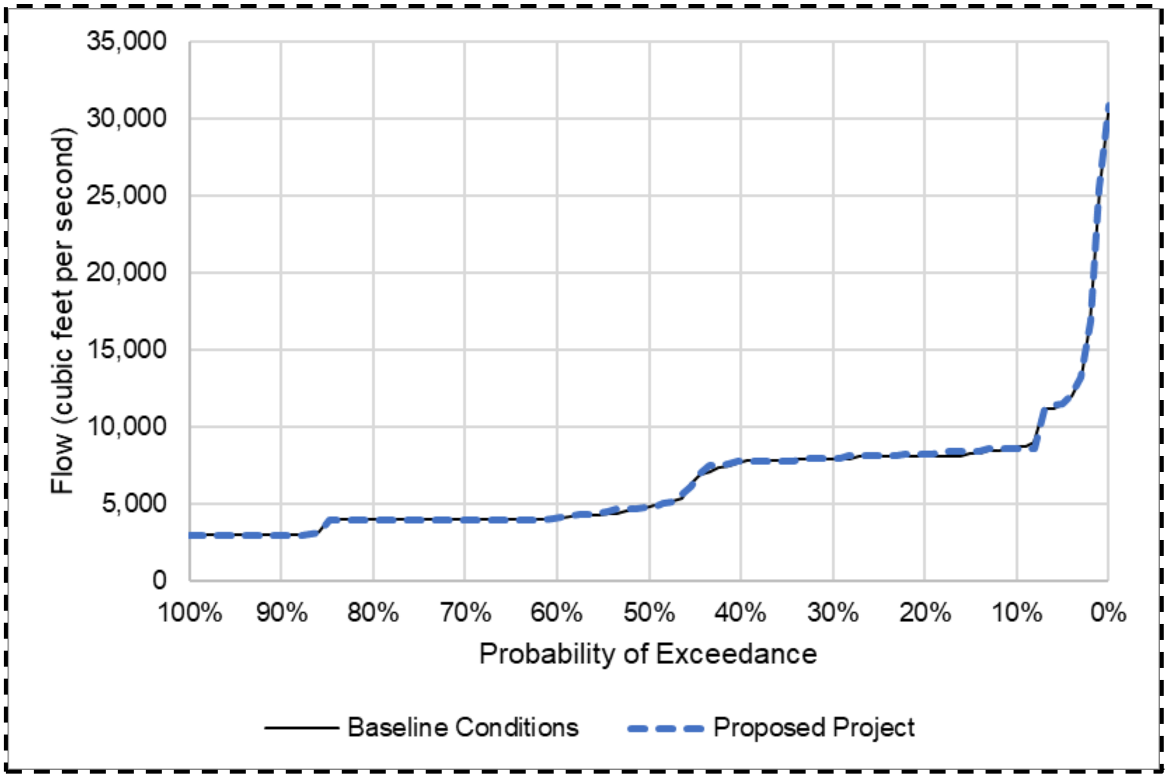
Figure 6-31. Mean Modeled Delta Outflow, September



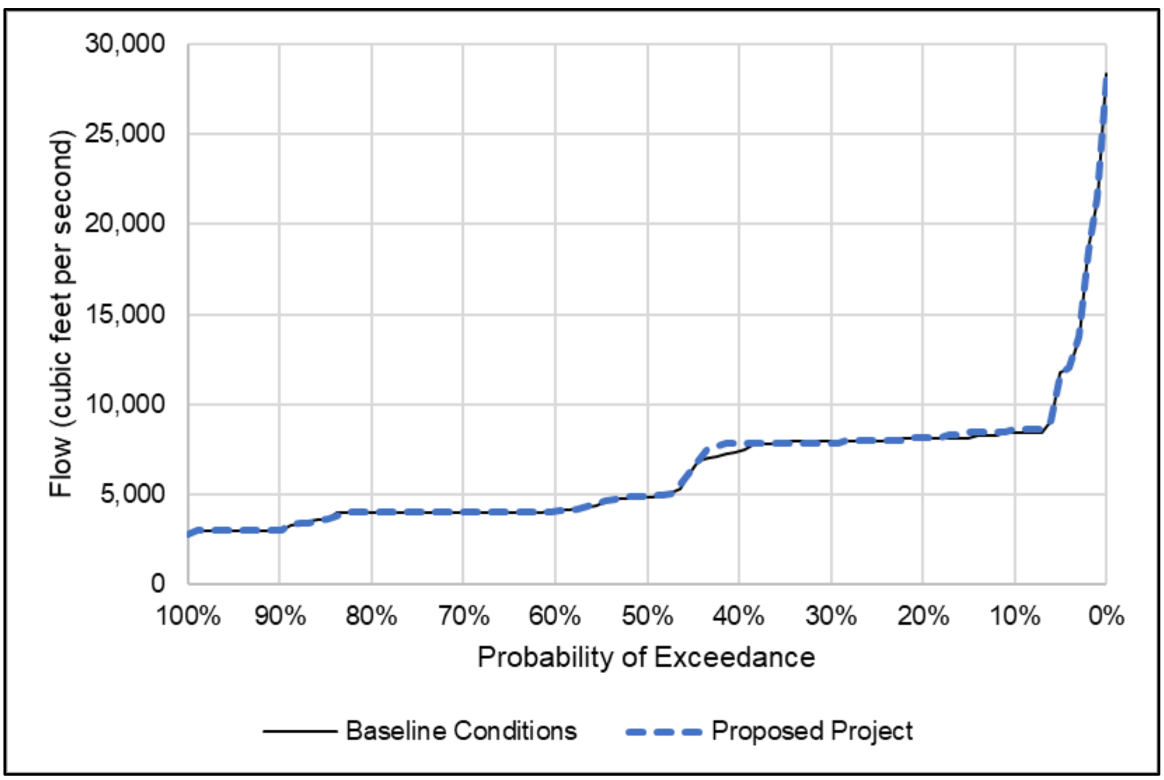


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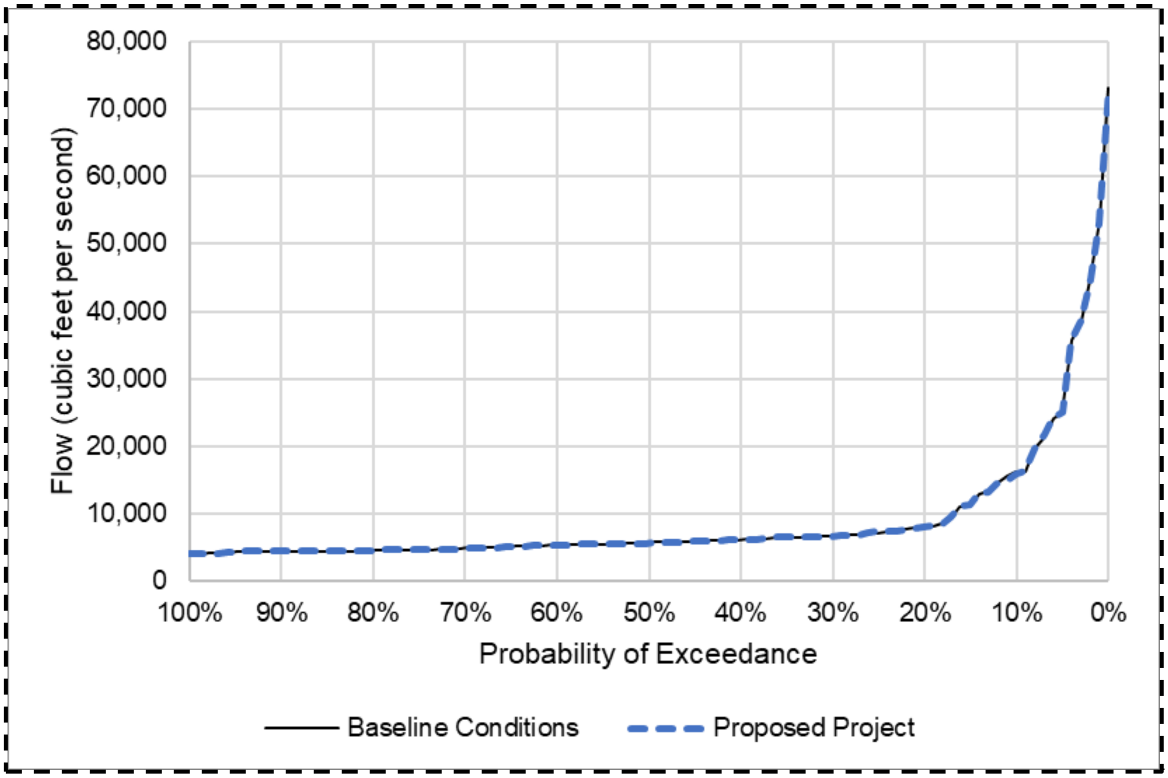
Figure 6-32. Mean Modeled Delta Outflow, October



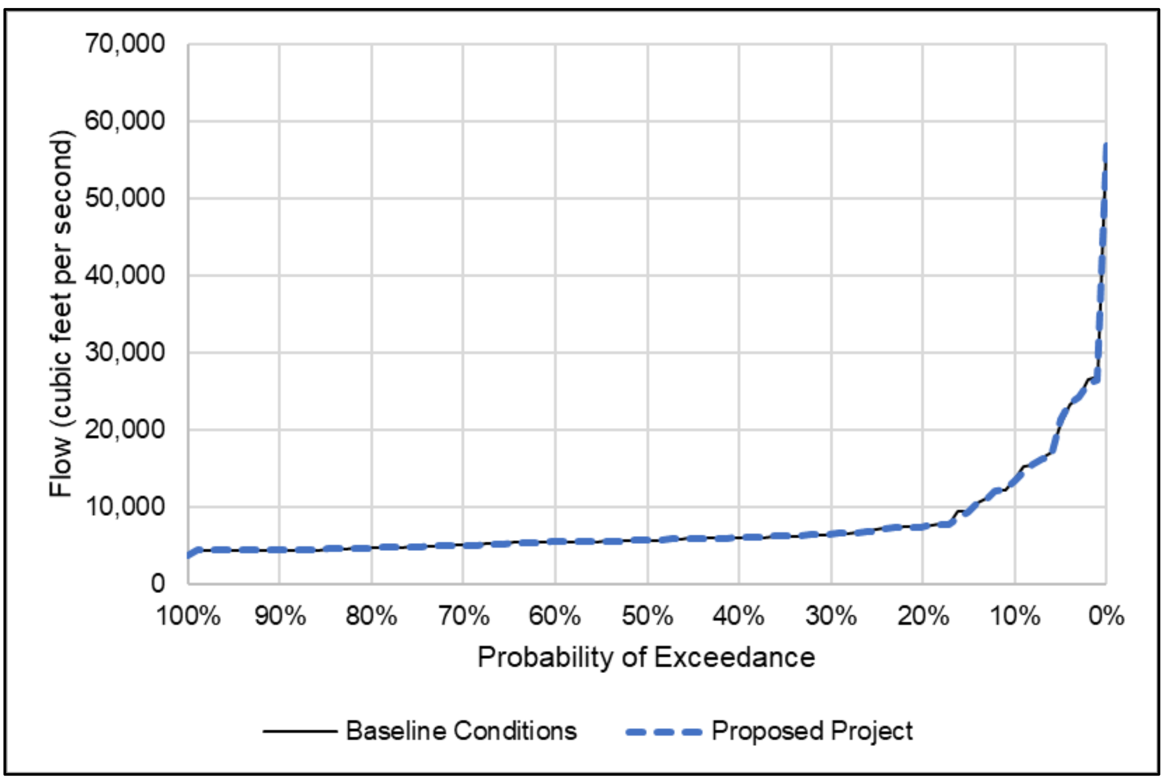


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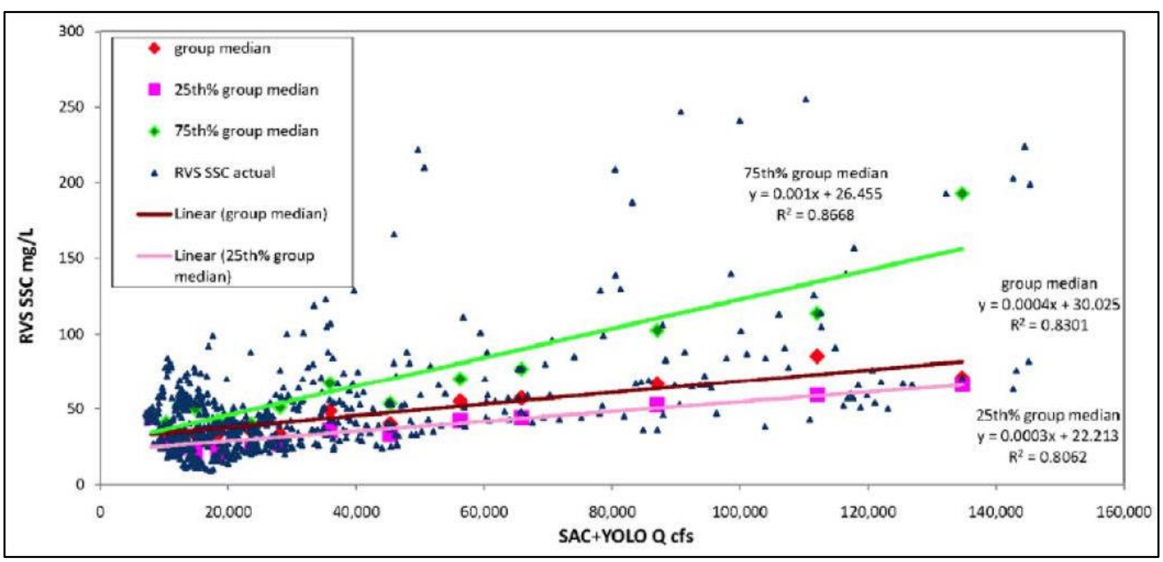
Figure 6-33. Mean Modeled Delta Outflow, November

Predation

Adults to Eggs and Larvae (December–March)

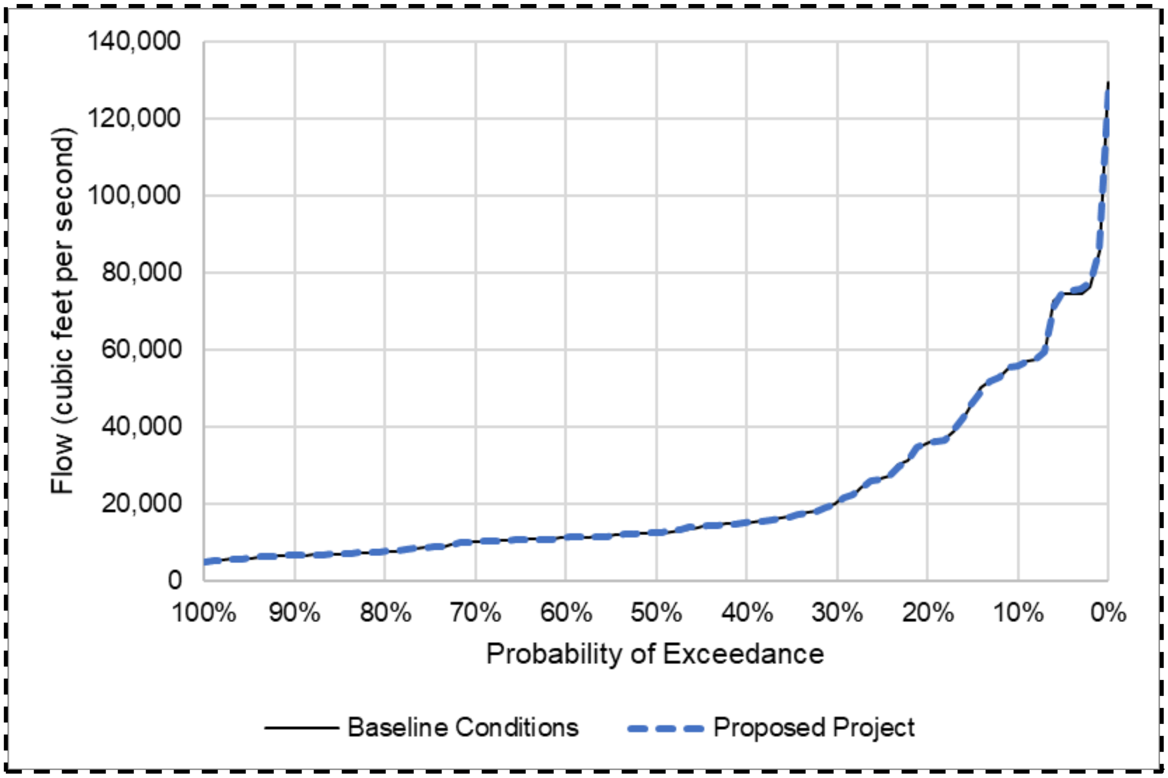
The IEP MAST (2015) conceptual model identifies predation risk as a habitat attribute affecting the probability of adult Delta Smelt to survive and produce eggs and larvae; predation risk is inversely related to turbidity, which depends on flow and erodible sediment supply (Bennett 2005; Moyle et al. 2016; Schreier et al. 2016). Large amounts of sediment enter the Delta from winter and spring storm runoff, with resuspension by tidal and wind action (Schoellhamer et al. 2014; Bever et al. 2018). Cloern et al. (2011:Figure S1) developed a rating curve of the Sacramento River at Rio Vista suspended sediment concentration as a function of Sacramento River at Freeport plus Yolo Bypass flows to the Delta (reproduced and shown in Figure 6-34). Based on this curve, differences between the Proposed Project and Baseline Conditions scenarios in suspended sediment concentration as a function of mean winter-spring Rio Vista flows would be expected to be limited, as the flows generally are similar between the two scenarios (Figures 6-35, 6-36, 6-37, 6-38, 6-39, 6-40).

Available estimates of sediment removal by the south Delta export facilities are low; roughly 2 percent of sediment entering the Delta at Freeport in the 1999–2002 period (Wright and Schoellhamer 2005). The potential effects of the Proposed Project on turbidity are expected to be low because there would be limited expected difference in suspended sediment entering the Delta under the Proposed Project scenario relative to the Baseline Conditions scenario (as suggested by the Rio Vista flows discussed above), and there would be a small percentage of sediment expected to be removed by the south Delta export facilities. South Delta export reductions during OMR flow management, in particular First Flush and Turbidity Bridge actions, would limit the potential for suspended sediment entrainment by the south Delta export facilities. The IEP MAST (2015) conceptual model hypothesizes high turbidity relates to low predation risk for Delta Smelt, as supported by mesocosm studies (Ferrari et al. 2014). There is uncertainty in this conclusion, given the complexity of sedimentation mechanisms in the Delta (Schoellhamer et al. 2012:Figure 7), though Schreier et al. (2016) found evidence of an effect of turbidity on predation of larval Delta Smelt by Mississippi Silversides.



Source: Cloern et al. 2011:Figure S1.

Figure 6-34. Sediment Rating Curve for the Sacramento River at Rio Vista, 1998–2002



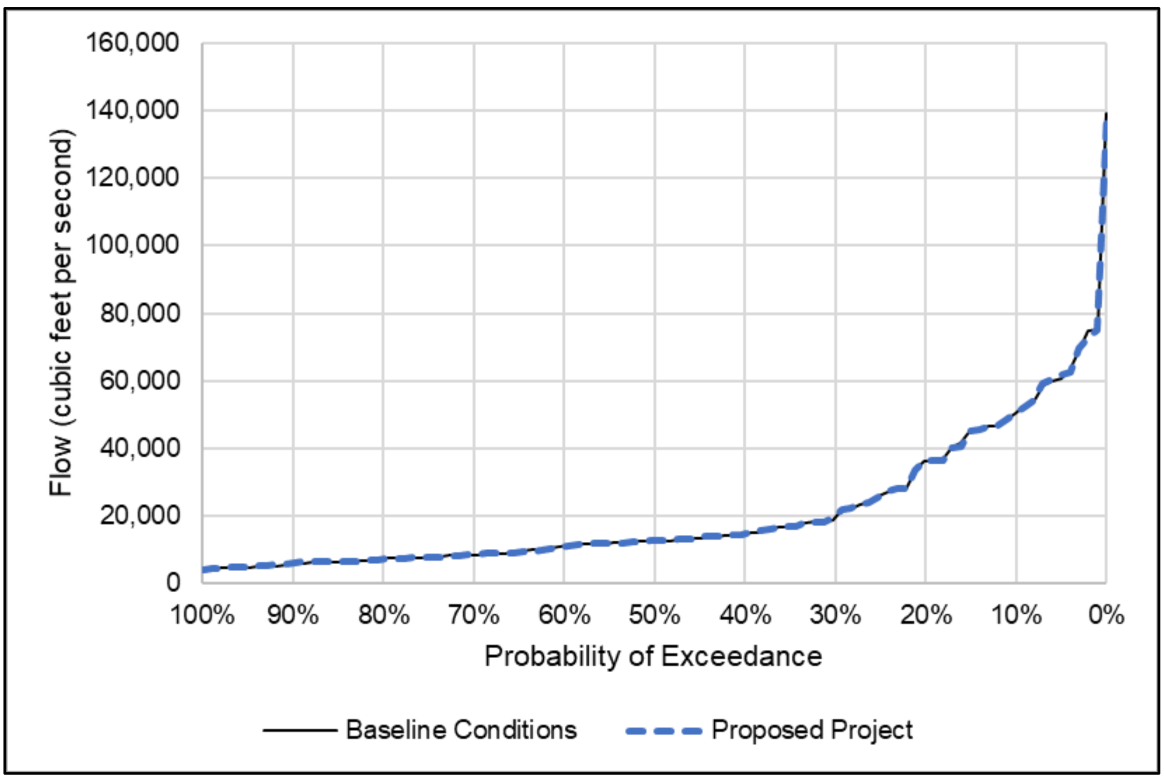


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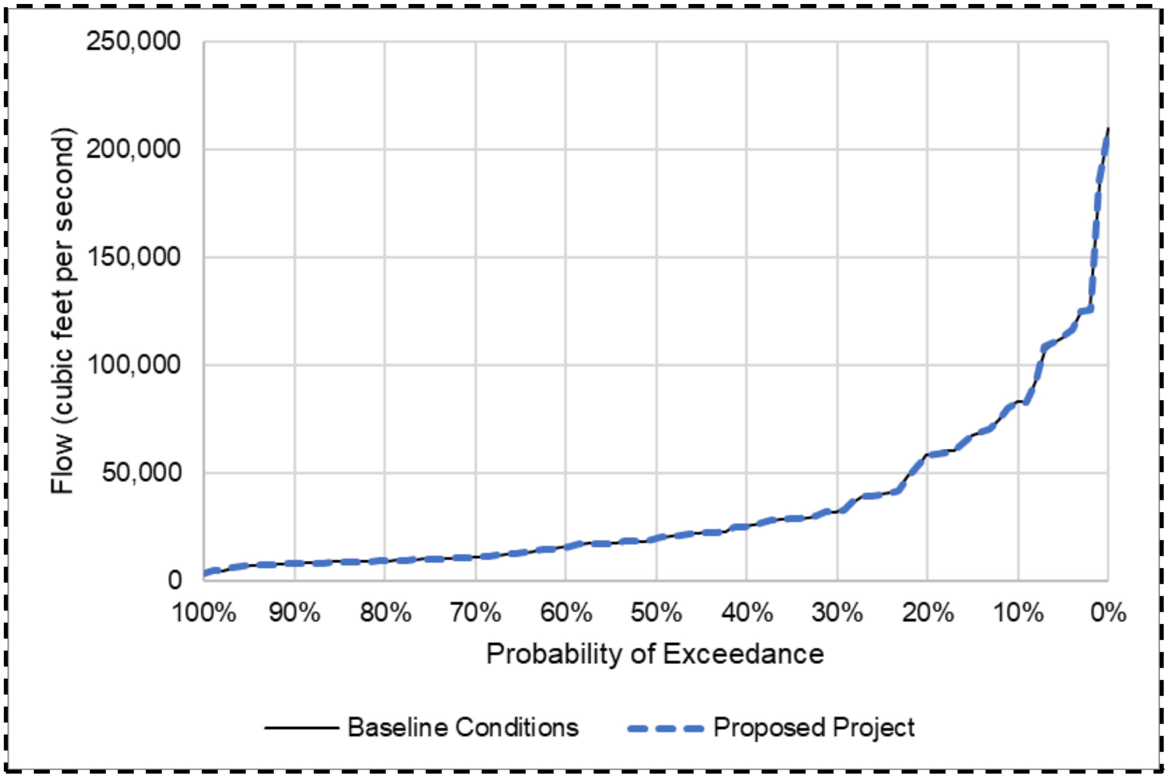
Figure 6-35. Mean Modeled Sacramento River Flow at Rio Vista, December



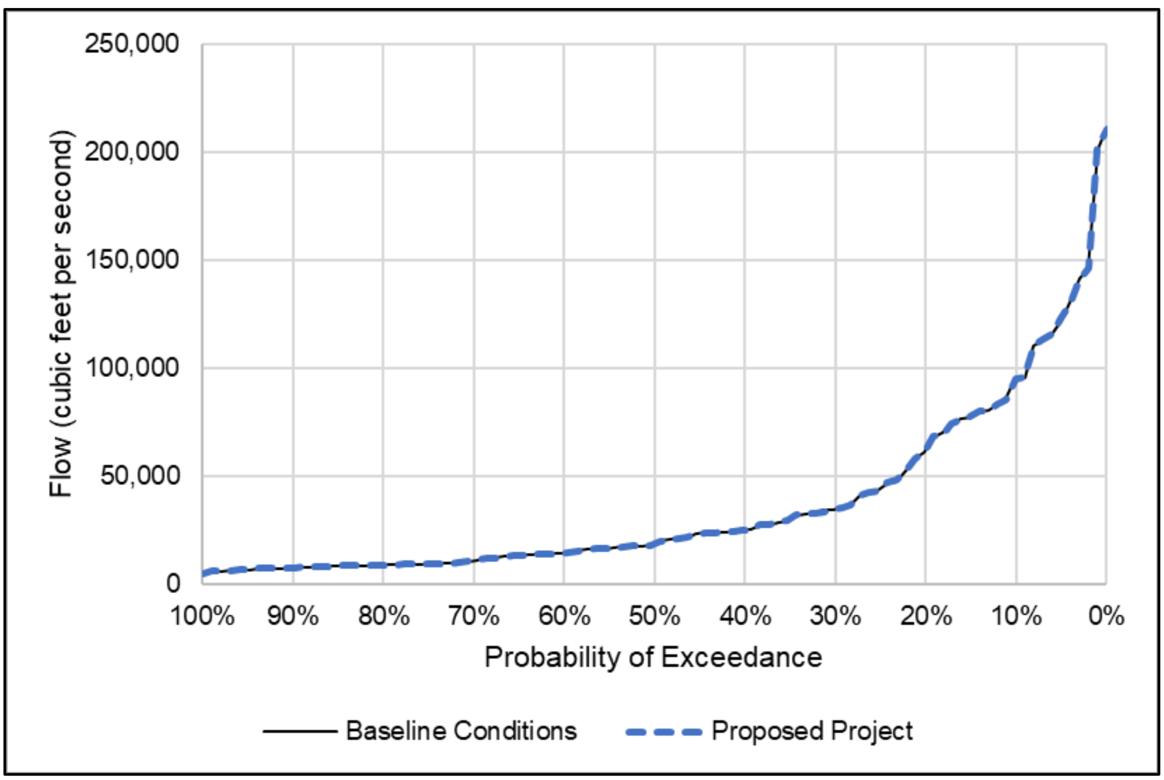


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Figure 6-36. Mean Modeled Sacramento River Flow at Rio Vista, January

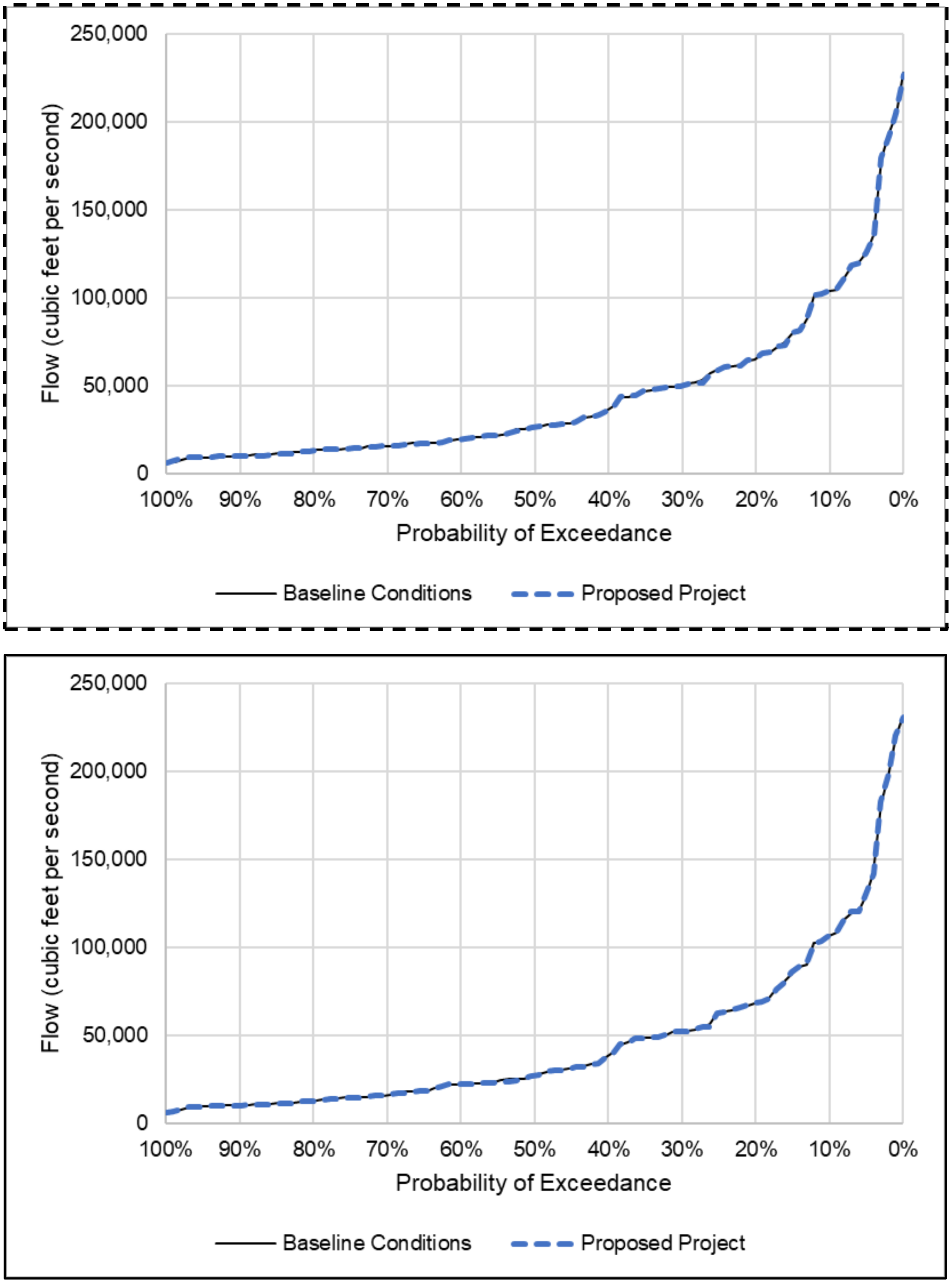

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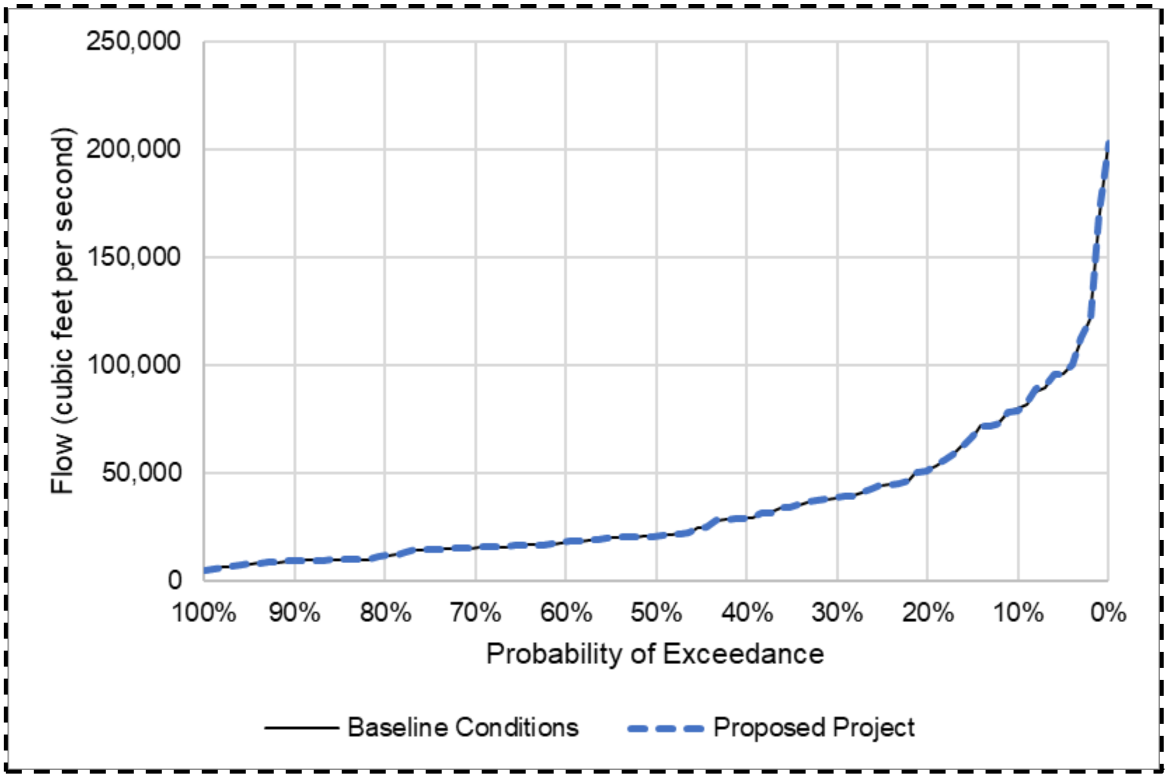
Figure 6-37. Mean Modeled Sacramento River Flow at Rio Vista, February



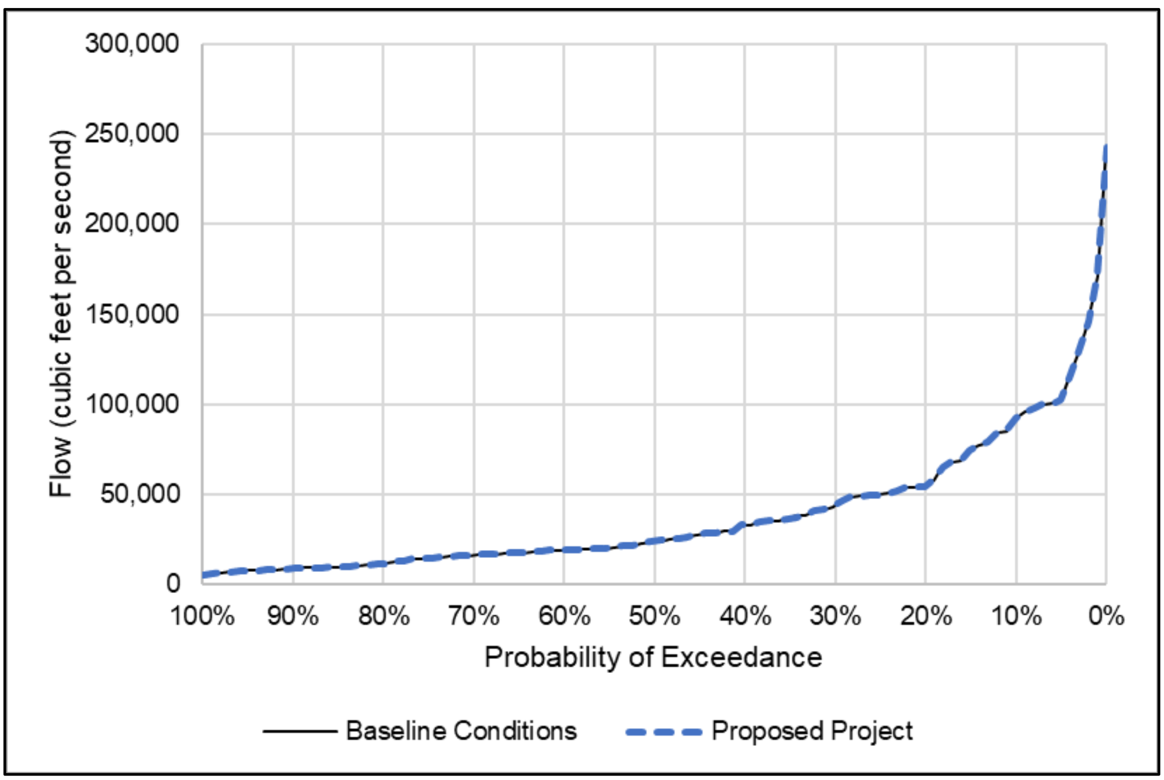


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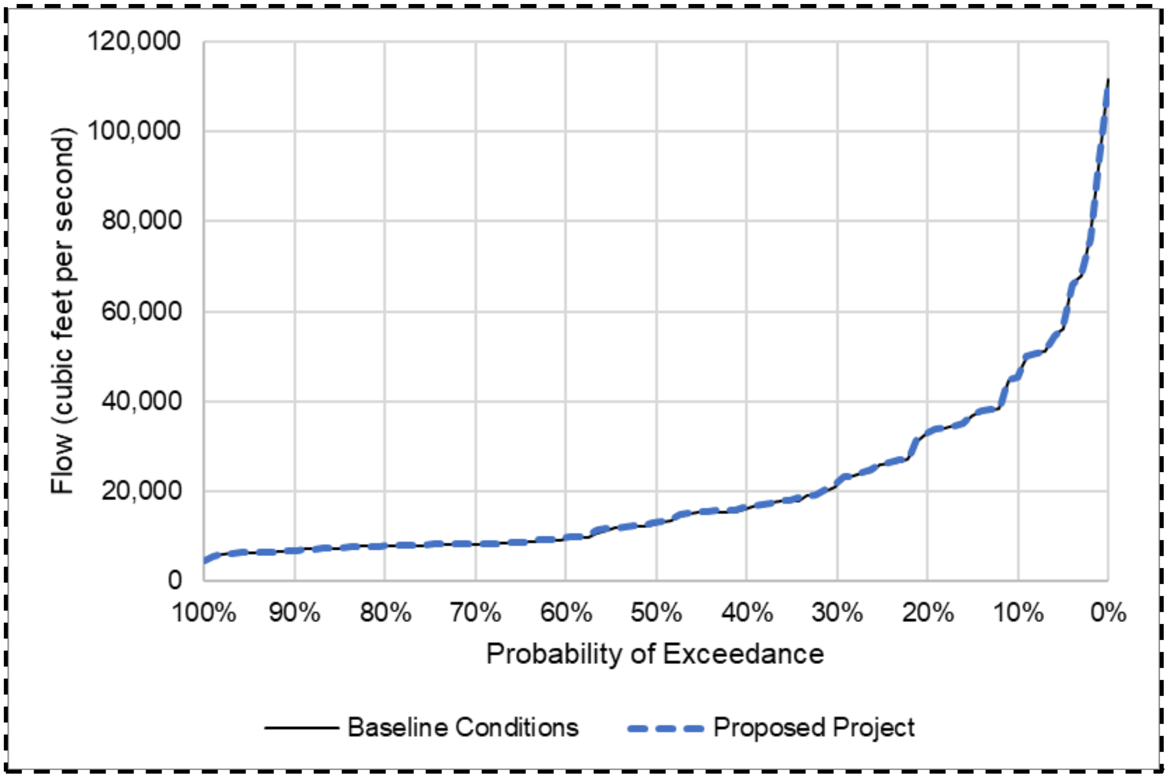
Figure 6-38. Mean Modeled Sacramento River Flow at Rio Vista, March



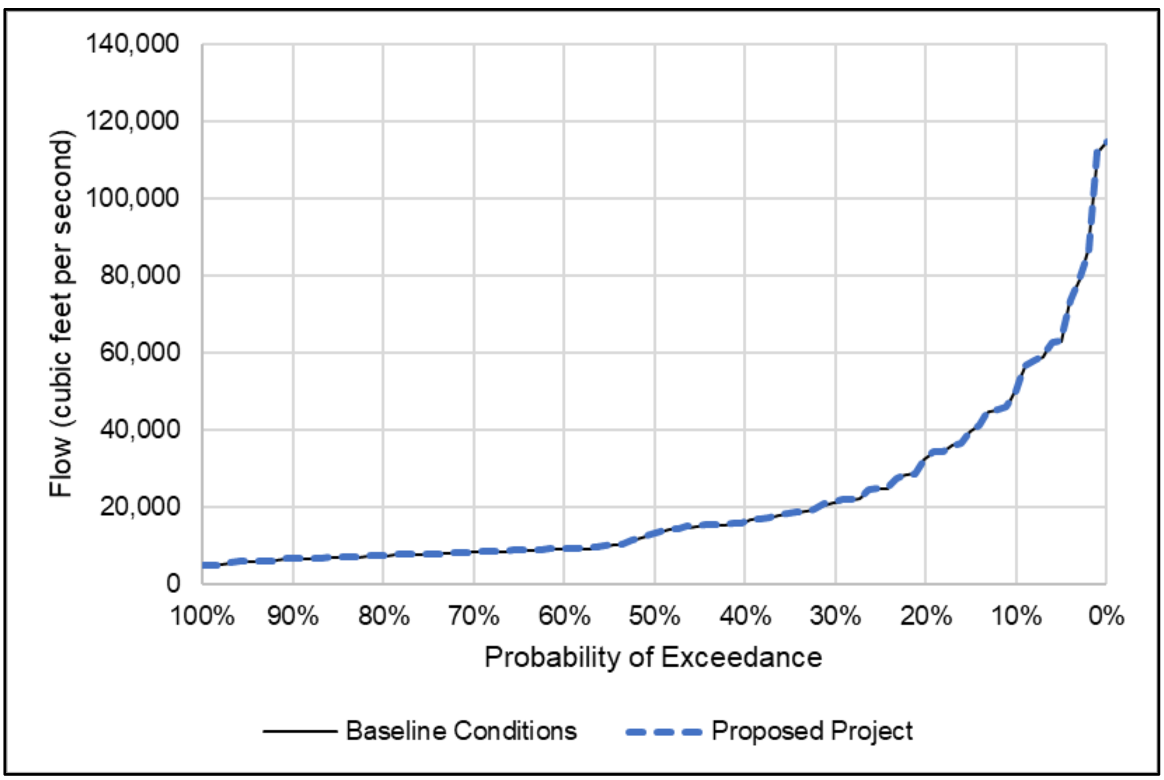


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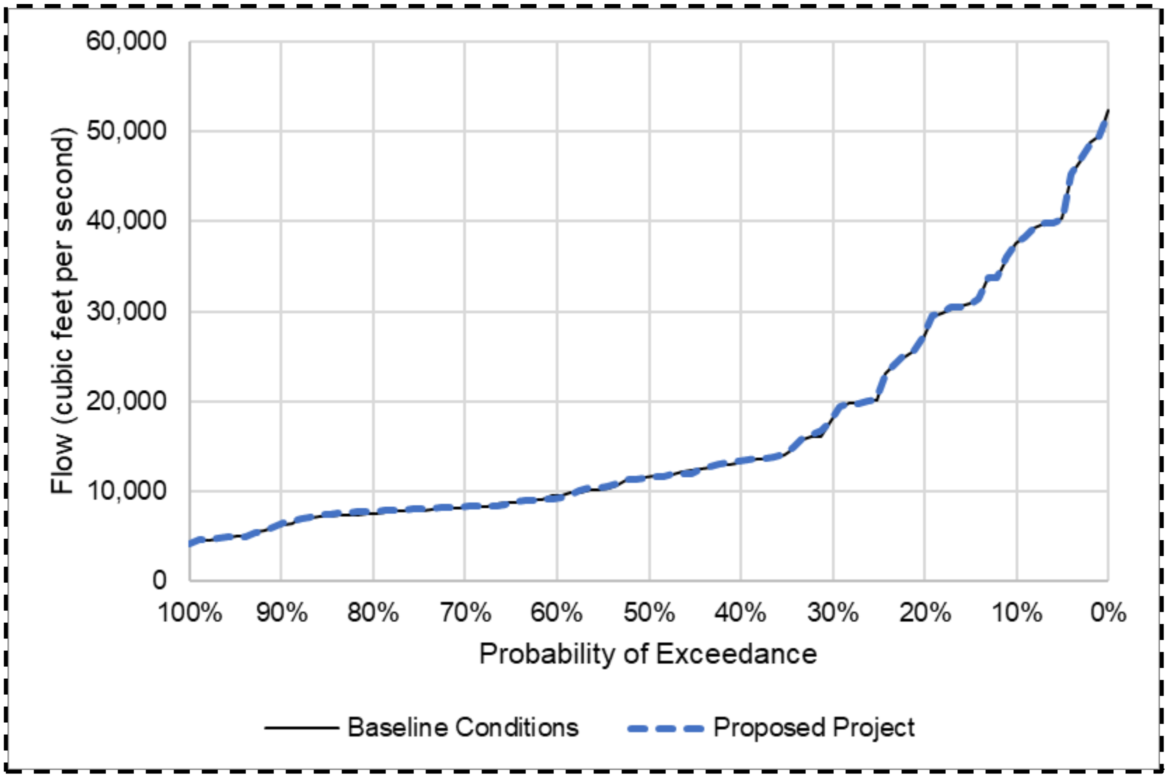
Figure 6-39. Mean Modeled Sacramento River Flow at Rio Vista, April



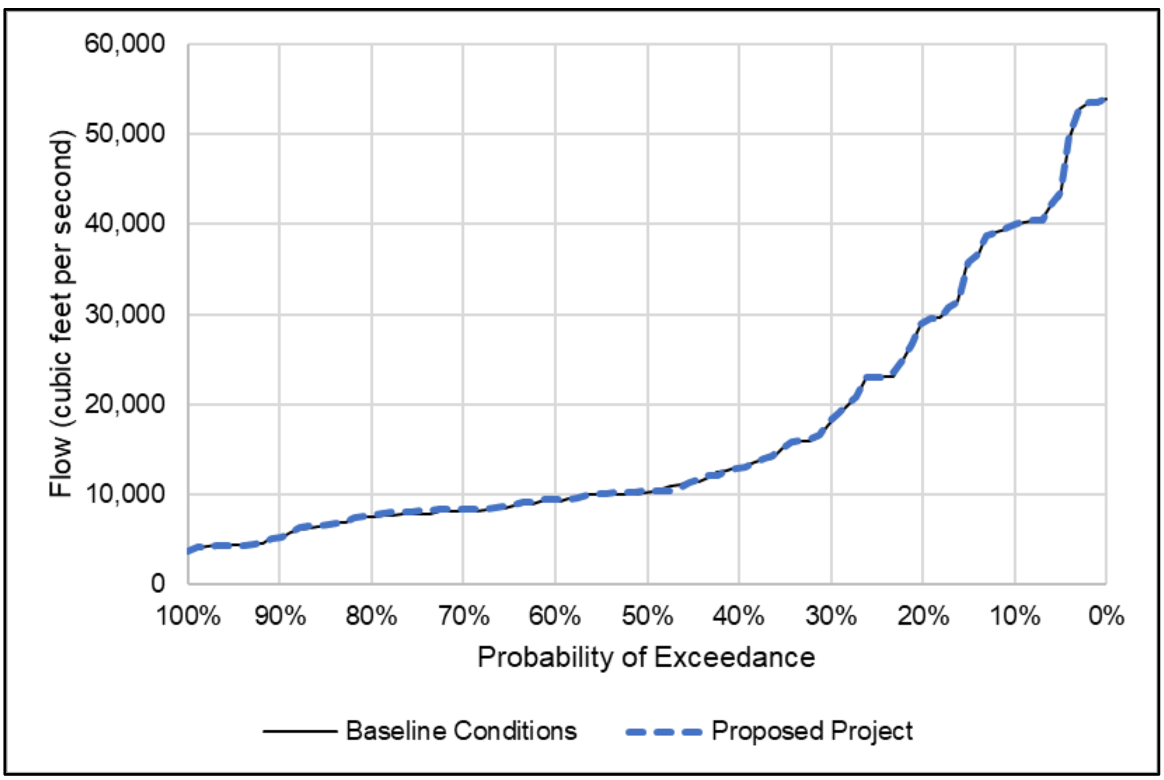


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Figure 6-40. Mean Modeled Sacramento River Flow at Rio Vista, May

Eggs and Larvae to Juveniles (March–June)

The IEP MAST conceptual model (2015) suggests the probability of egg/larval Delta Smelt surviving to juveniles is influenced by predation risk, which may involve different factors such as turbidity, water temperature, and predators (silversides). The relationship between these factors is not well understood based on empirical research, and recent life cycle modeling efforts have not found appreciable support for silversides as a driver on Delta Smelt population dynamics (Polansky et al. 2021; Smith et al. 2021). Potential effects of the Proposed Project on turbidity due to reduced upstream supply and removal by south Delta exports are concluded to be low, for the reasons previously described for adult Delta Smelt, although this is uncertain. Wild detection of Delta Smelt embryos and larvae is rare, which reduces the certainty of any conclusions, although silversides have been found with Delta Smelt DNA in their guts during the larval period (Schreier et al. 2016). Water temperature in the San Francisco Estuary is driven mainly by air temperature and even in the Delta the water temperature is only slightly affected by freshwater inflow so that flow-related effects of the Proposed Project on Delta water temperature are expected to be minor (Wagner et al. 2011).

Mahardja et al.'s (2016) multivariate model showed summer (June–September) Delta inflow and spring (March–May) south Delta exports had the strongest correlations with silverside cohort strength; both relationships were negative. These relationships do not imply causality, given that the mechanisms could not be identified (Mahardja et al. 2016:12). In addition, beach seines (used in the study) only sample upstream of the confluence, so if high flow moves silversides downstream, then the inverse correlation of flow and abundance is misleading. In other words, the observed pattern might simply be a result of a redistribution of silversides rather than increased production in wetter conditions. Recognizing this uncertainty, the Proposed Project scenario has greater South Delta exports in March–May (mainly in May) than the Baseline Conditions scenario (Figure 6-41), which would be expected to correlate with lower silverside cohort strength under the Proposed Project, whereas the Proposed Project has similar June–September Delta inflow as the Baseline Conditions scenario (Figure 6-42), which would be expected to correlate with similar silverside cohort strength under the Proposed Project. It is uncertain whether the magnitude of any change would be of consequence to silversides given that a causal relationship between cohort strength and inflow or exports has not been established (Mahardja et al. 2016); given that there is little statistical evidence for trends in silversides being correlated with Delta Smelt survival (Polansky et al. 2021; Smith et al. 2021), the effects of the Proposed Project would be expected to be limited.

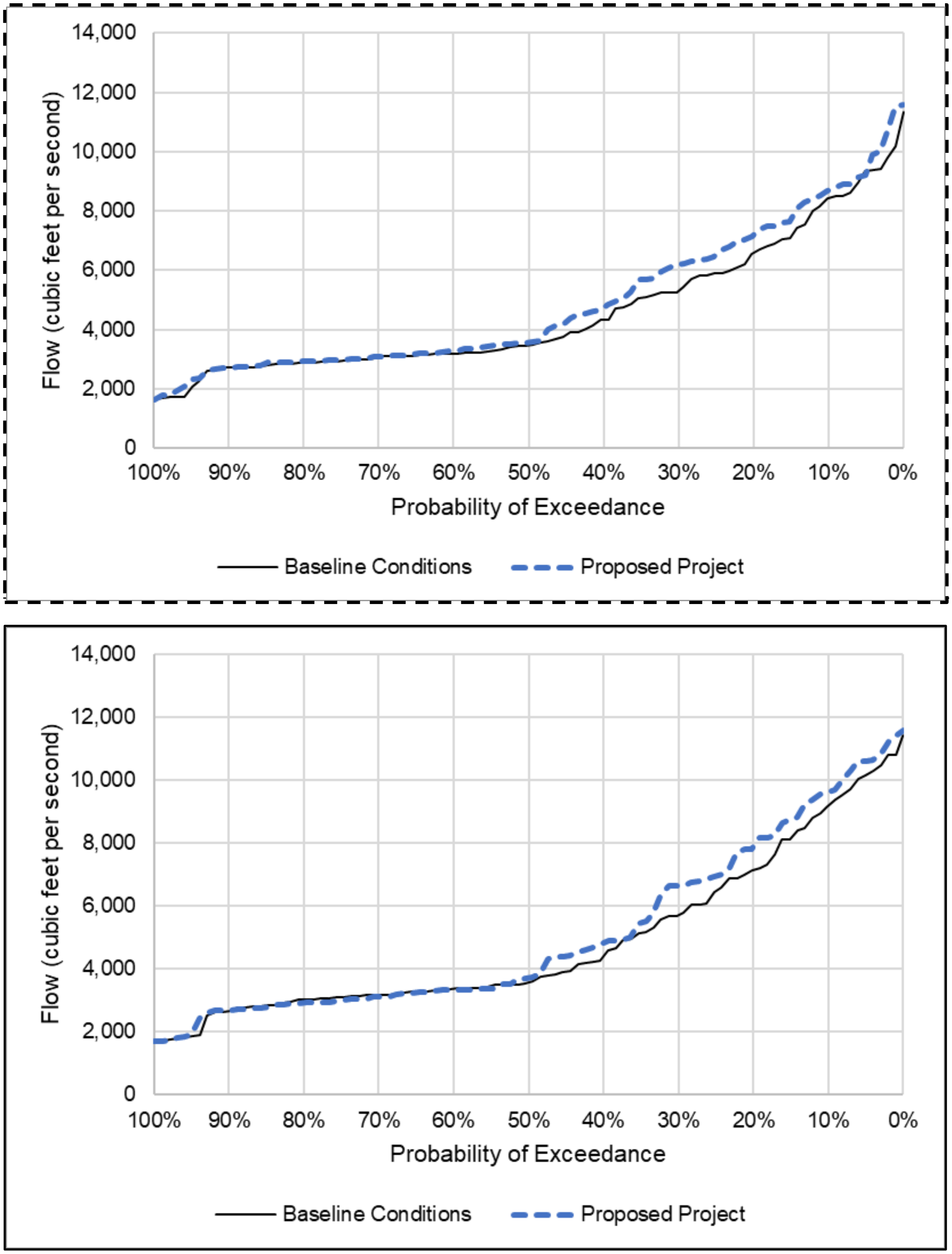

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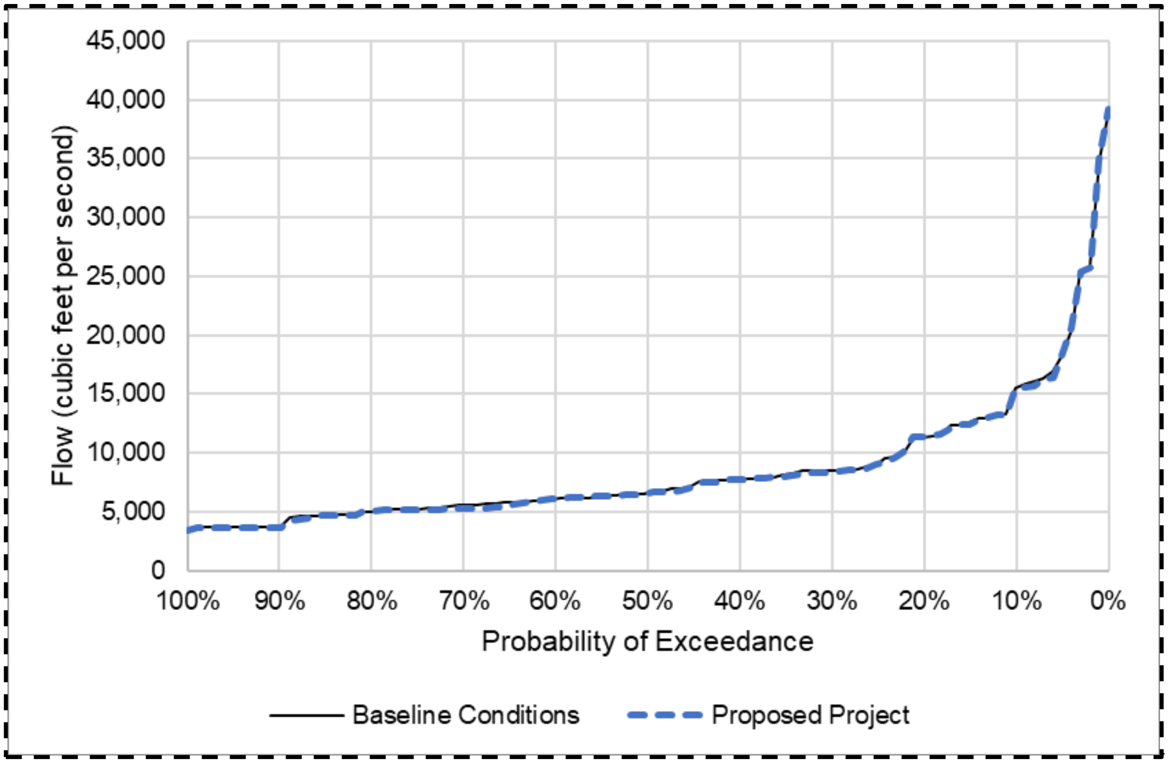
Figure 6-41. Mean Modeled South Delta Exports, March–May



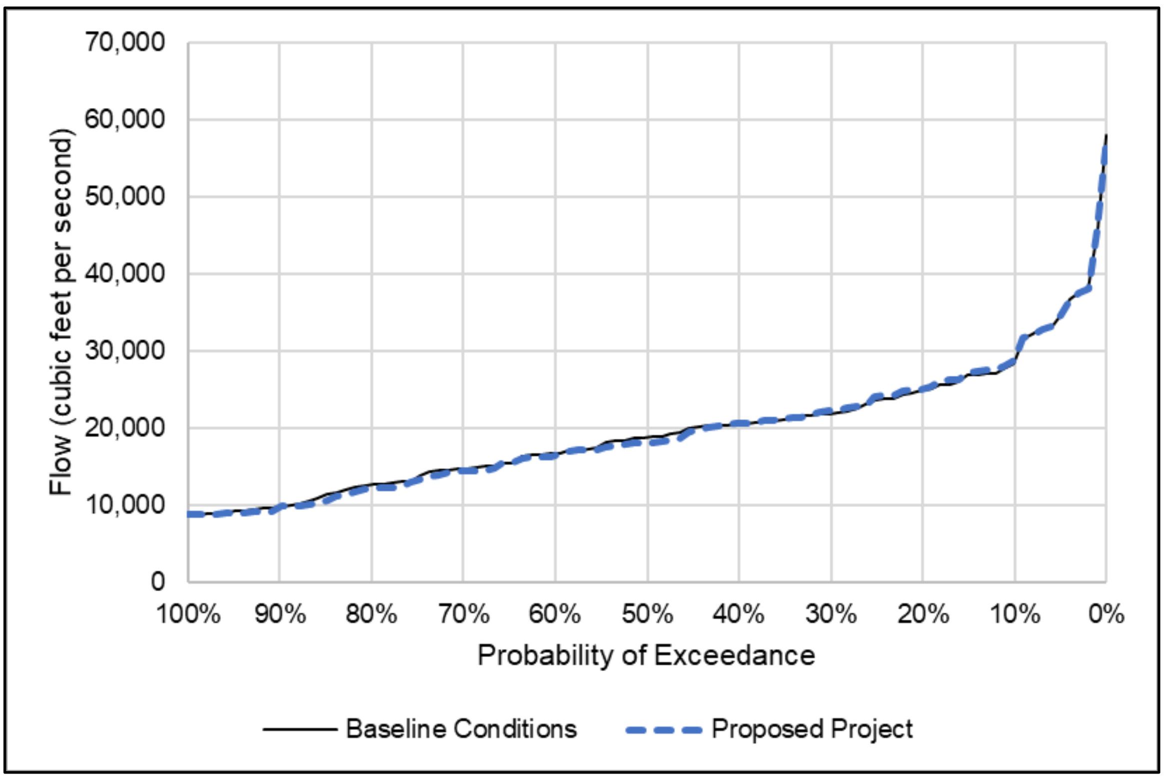


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Figure 6-42. Mean Modeled Delta Inflow, June–September

Juveniles to Subadults (June–September)

The IEP MAST (2015) conceptual model posits that predation risk for juvenile Delta Smelt is a function of predators, turbidity, and water temperature. Effects on water temperature from the Proposed Project relative to the Baseline Conditions scenario are expected to be negligible, as previously discussed for larval Delta Smelt. Turbidity during the low-flow summer and fall periods is partly a function of sediment delivery during the high-flow winter/spring periods, for it influences the amount of sediment available (see summary by Interagency Ecological Program 2015:50). Differences in winter/spring Rio Vista flow and sediment delivery, together with only small amounts of sediment lost to entrainment, suggest little difference between the Proposed Project and Baseline Conditions scenarios in terms of turbidity and therefore predation risk. Operation of the SMSCG during Delta Smelt Summer and Fall Habitat Actions (see Section 6.4.1.2, "Delta Smelt Summer and Fall Habitat Actions") is designed to increase access to Suisun Marsh, which usually has higher turbidity than the Sacramento River (Sommer et al. 2020). Predation may be reduced in years when the action is implemented for Delta Smelt accessing Suisun Marsh; application of the action is common to both the Proposed Project and Baseline Conditions scenarios.

Subadults to Adults (September–December)

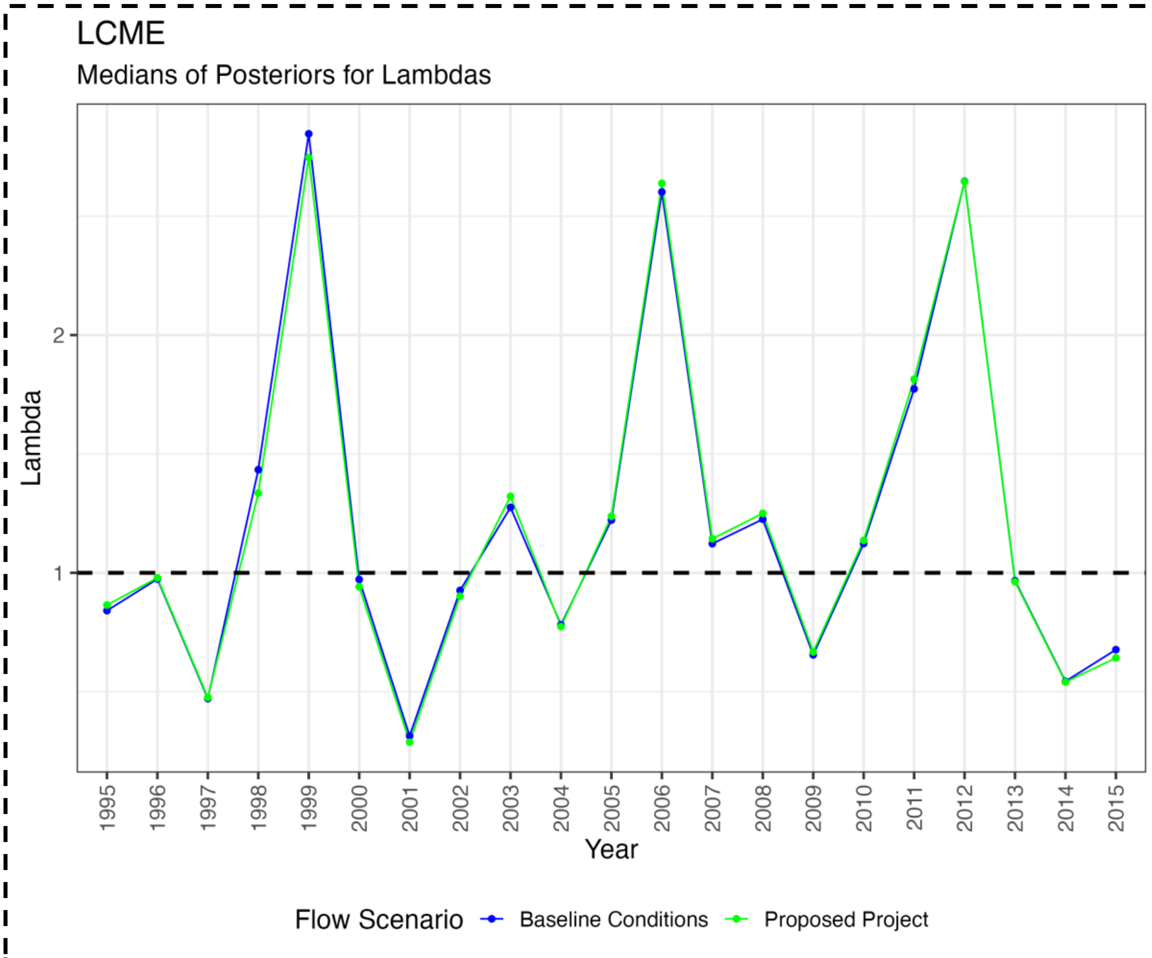
As noted for other Delta Smelt life stages, there would be little difference in sediment supply during the winter/spring between the Proposed Project and Baseline Conditions scenarios and therefore little potential to affect sediment for resuspension during the fall subadult period. The Proposed Project and the Baseline Conditions scenarios include the same criteria for fall X2 (i.e., maintaining a 30-day average X2 ≤ 80 kilometers) in Wet and Above Normal hydrologic water year types, resulting in similar X2 and position of the low-salinity zone (see discussion in Section 6.4.1.2). Greater X2 generally provides an indicator of overlap of areas with potentially greater water clarity (i.e., lower turbidity) (ICF International 2017:105–115) that are less likely to have wind-wave sediment resuspension (Interagency Ecological Program 2015:50) and therefore potentially greater predation risk based on the posited negative correlation between predation risk and turbidity. The similarity in X2 suggests that predation risk would not be expected to greatly differ between the Proposed Project and Baseline Conditions. The extent to which observed negative correlations between fall X2 and water clarity in the low-salinity zone are the result of antecedent conditions (i.e., sediment supply during high-flow months) is uncertain (ICF International 2017:106), with recent studies indicating wind may control turbidity to a considerable extent (Bever et al. 2018) and water operations would not affect wind-related suspension of sediment.

Water temperature would not be expected to be greatly affected by the Proposed Project relative to the Baseline Conditions scenario, as illustrated by the low to non-existent correlation between water temperature in the low-salinity zone and X2 (U.S. Bureau of Reclamation 2019:5-401, Figure 5.16-39). Any differences between the Proposed Project and Baseline Conditions scenarios would be expected to be within the tolerance of subadult Delta Smelt (Komoroske et al. 2014), which, combined with the similarity in outflow/X2 discussed above, would indicate little potential for differences in subadult Delta Smelt predation risk between the scenarios.

Delta Smelt Life Cycle Modeling

The Delta Smelt Life Cycle Model with Entrainment (LCME), as described by Smith et al. (2021), was applied to compare Delta Smelt population growth rate under the Proposed Project to the population growth rate under Baseline Conditions. As described further in Section 6B.10, "Delta Smelt Life Cycle Model with Entrainment (LCME)" in Appendix 6B, the LCME includes five OMR covariates representing entrainment risk's effect on probability of transition to the next life stage for five different life stages covering the period from early subadults in December–January to late postlarvae in June. The LCME also includes June–August Delta outflow, representing a general indicator of outflow-related habitat influencing the transition from postlarval to juvenile life stages.

The results of the LCME modeling showed median population growth rate during 1995–2015 ranged from ~~3~~ 8 percent higher to ~~9~~ 8 percent lower under the Proposed Project compared to Baseline Conditions (Figure 6-43, Table 6-13). The proportion of the Proposed Project population growth rate posterior distribution that was lower than Baseline Conditions was generally close to 0.500, ranging from ~~0.494~~ 0.488 in 1995 and 2003 to over 0.51 in several years (Table 6-13). The model authors suggested during coordination on use of the LCME that particular focus be placed on the years following implementation of the 2009 BiOp, during which OMR flow management and other factors changed. From 2009 onwards, the difference between scenarios ranged from ~~2~~ 3 percent more to ~~5~~ 1 percent lower under the Proposed Project, with ~~0.496~~ 0.494 to 0.503 of the posterior distribution being lower under the Proposed Project than Baseline Conditions (Figure 6-43, Table 6-13). The general similarity in the results reflected limited differences in OMR flow and Delta outflow between the Proposed Project and Baseline Conditions modeling scenarios, with larger relative differences in population growth rates reflecting ~~larger relative differences in the model inputs. For example, the largest difference, a 9 percent lower median population growth rate in 2001 under the Proposed Project, corresponded with an 8 percent lower June–August Delta outflow in that year (see Table 6B-44 in Appendix 6B). Such differences arise because of~~ differences in operational criteria between the scenarios, including SMSCG operations and implementation of summer Delta outflow. The limited difference in results between modeling scenarios is consistent with explorations by Smith et al. (2021), who showed population growth rate under OMR flow management to a limit of -5,000 cfs (i.e., generally representative of post-2008 conditions) was within 0.04 (8.5 percent relative difference) of the population growth rate under hypothetical OMR flow management to a limit of 0 cfs (i.e., elimination of negative OMR flows).


LCME
Medians of Posteriors for Lambdas
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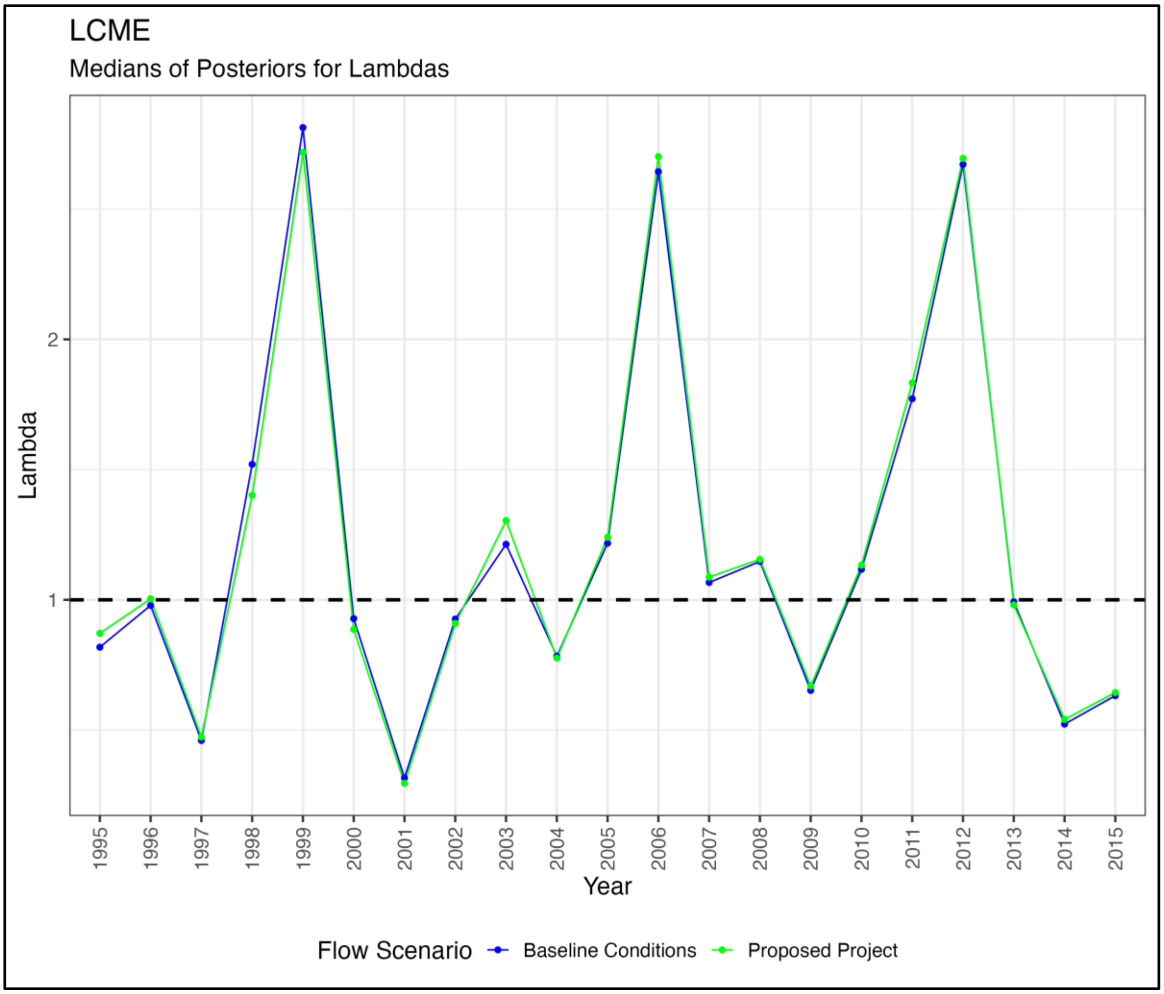
Flow Scenario
Baseline Conditions
Proposed Project



Note: BC = Baseline Conditions; PP = Proposed Project; median is 50th percentile of posterior distribution by year. Broken line indicates lambda = 1, i.e., the population replacement rate.

Figure 6-43. Median Population Growth Rate (Lambda) from Delta Smelt LCME Modeling

Table 6-13. Median, Percentage Difference (Proposed Action minus Baseline Conditions), and Proportion of Posterior Distribution with Proposed Action Less than Baseline Conditions in Population Growth Rate from Delta Smelt LCME Modeling

Cohort Year	Baseline Conditions	Proposed Project	Proportion of Posterior Distribution Less Under Proposed Project
1995	~~0.841~~ 0.818	~~0.865 (3%)~~ 0.872 (7%)	~~0.494~~ 0.488
1996	~~0.974~~ 0.979	~~0.979 (0%)~~ 1.004 (3%)	~~0.499~~ 0.494
1997	~~0.471~~ 0.460	~~0.476 (1%)~~ 0.473 (3%)	~~0.500~~ 0.497
1998	~~1.434~~ 1.520	~~1.335 (-7%)~~ 1.401 (-8%)	~~0.512~~ 0.513
1999	~~2.846~~ 2.813	~~2.747 (-4%)~~ 2.718 (-3%)	0.506
2000	~~0.972~~ 0.928	~~0.942 (-3%)~~ 0.887 (-4%)	~~0.510~~ 0.512
2001	~~0.314~~ 0.316	~~0.288 (-8%)~~ 0.296 (-6%)	~~0.515~~ 0.512
2002	0.926	~~0.902 (-3%)~~ 0.909 (-2%)	~~0.503~~ 0.502
2003	~~1.275~~ 1.213	~~1.322 (4%)~~ 1.304 (8%)	~~0.495~~ 0.488
2004	~~0.781~~ 0.784	~~0.774~~ 0.777 (-1%)	0.503
2005	~~1.222~~ 1.218	~~1.238 (1%)~~ 1.240 (2%)	~~0.496~~ 0.495
2006	~~2.602~~ 2.644	~~2.638 (1%)~~ 2.702 (2%)	~~0.495~~ 0.493
2007	~~1.123~~ 1.067	~~1.143~~ 1.088 (2%)	~~0.497~~ 0.496
2008	~~1.225~~ 1.147	~~1.250 (2%)~~ 1.156 (1%)	~~0.498~~ 0.500
2009	~~0.655~~ 0.652	~~0.668 (2%)~~ 0.669 (3%)	~~0.497~~ 0.496
2010	~~1.123~~ 1.117	~~1.136~~ 1.133 (1%)	~~0.496~~ 0.495
2011	~~1.773~~ 1.772	~~1.814 (2%)~~ 1.833 (3%)	~~0.496~~ 0.494
2012	~~2.647~~ 2.672	~~2.645 (0%)~~ 2.695 (1%)	~~0.501~~ 0.498
2013	~~0.967~~ 0.992	~~0.962 (0%)~~ 0.980 (-1%)	~~0.502~~ 0.503
2014	~~0.543~~ 0.523	~~0.541 (-1%)~~ 0.541 (3%)	~~0.501~~ 0.495
2015	~~0.677~~ 0.632	~~0.642 (-5%)~~ 0.644 (2%)	~~0.509~~ 0.497

6.4.1.2 Delta Smelt Summer and Fall Habitat Actions

Habitat actions that help support a broad species distribution can have long-term population benefits (Thorson et al. 2014). Directing more water into Suisun Marsh through reoperation of the SMSCG during summer/fall has the potential to benefit Delta Smelt by making salinity in the relatively prey-rich Marsh more suitable for Delta Smelt (Hammock et al. 2015; Sommer et al. 2020). Water operations (particularly reservoir releases and south Delta exports) affect Delta outflow in summer and fall. Recent state-space nonlinear modeling investigation by Polansky et al. (2021) found relatively strong statistical support for June–August Delta outflow being positively correlated to June–August survival (further shown by Smith et al. 2021), and September–November X2 being negatively correlated to the subsequent year's recruitment (adult to larval survival).[5]

Both the Proposed Project and Baseline Conditions scenarios include Delta Smelt summer-fall habitat actions and therefore both would provide low-salinity habitat through Fall X2 and operation of the SMSCG. The Proposed Project has the potential to have positive effects on Delta Smelt relative to Baseline Conditions in Above Normal years following Wet or Above Normal years by including the potential for DWR to operate the SMSCG during June–October (compared to June–August under Baseline Conditions). During Above Normal and Below Normal years not following Wet and Above Normal years, there may be limited negative effects of the Proposed Project relative to Baseline Conditions given that SMSCG operations could occur under Baseline Conditions but are not part of the Proposed Project. Overall, summer-fall habitat conditions would be expected to be generally similar for Baseline Conditions and the Proposed Project.[6] During fall (September–November), X2 is similar under the Proposed Project and Baseline Conditions scenarios (Figure 6-44). An additional indicator of Delta Smelt summer-fall habitat is provided by the frequency of occurrence of X2 at less than 85 kilometers, indicating low-salinity water (i.e., 0.5 to 6 ppt salinity; Delta Modeling Associates 2014:1) would be overlapping physically larger habitat areas in Honker Bay (U.S. Fish and Wildlife Service 2017:307–317). CalSim 3 modeling indicates that the frequency of occurrence of low-salinity water in Honker Bay under the Proposed Project generally would be similar to Baseline Conditions (Table 6-14).

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[5] As illustrated by plots of the predicted relationship with associated credible intervals from statistical modeling (Polansky et al. 2021:Figures 1 and C.1), there is appreciable statistical uncertainty in the relationships, which are based on annual mean values across water years. September–November X2 thus was not included in the modeling effort by Smith et al. (2021), which focused only on the relationships found by Polansky et al. (2021) to have the most evidence of having an effect in the hypothesized direction. Potential effects based on differences in June–August outflow as represented in the LCME are discussed in "Delta Smelt Life Cycle Modeling."

[6] As described in Section 2.3.6.3, "One Time Water Commitment for Delta Outflow," DWR has committed to deploying a one-time block of water in 2025 during the summer–fall period for Delta Smelt habitat under the new ITP ~~if CDFW opts not to use the block of water under the current ITP in 2024~~ . Relative to Baseline Conditions, 2025 Delta outflow under the Proposed Project could be greater or less, depending on hydrological conditions, although the differences between the scenarios would likely be limited to no more than several tens of thousands of acre-feet. This would be expected to result in limited differences to the Delta Smelt population in 2025: based on the results from the LCME model, for which the comparison of the Proposed Project to Baseline Conditions (see the "Delta Smelt Life Cycle Modeling" discussion above) illustrated that there is less than a 1 percent difference in population growth rate (lambda) per 10 taf of June–August Delta outflow difference, population growth rate under the Proposed Project would range from a low single-digit greater population growth rate to a low single-digit lower population growth rate than Baseline Conditions (assuming all of the additional outflow is applied during June–August).

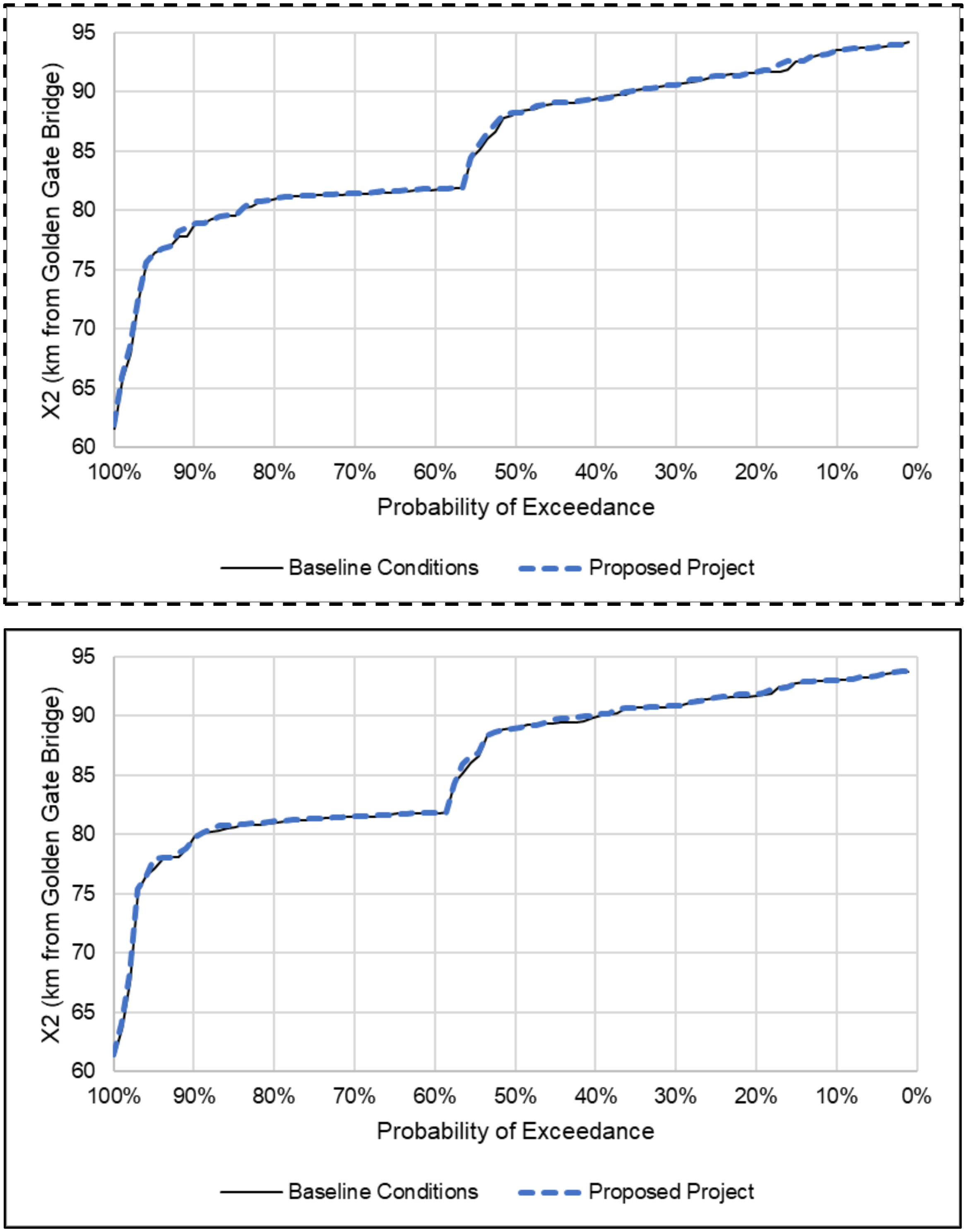

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Figure 6-44. Mean Modeled X2, September–November

Table 6-14. Percentage of Years with X2 Less than 85 km (Low-Salinity Zone within Honker Bay), June–December

Month	Baseline Conditions	Proposed Project
June	~~89.0%~~ 87.0%	~~89.0%~~ 87.0% (0.0%)
July	~~68.0%~~ 67.0%	~~69.0%~~ 68.0% (1.5%)
August	~~42.0%~~ 43.0%	~~46.0% (9.5%)~~ 47.0% (9.3%)
September	41.4%	41.4% (0.0%)
October	44.0%	~~44.0% (0.0%)~~ 43.0% (-2.3%)
November	~~39.0%~~ 37.0%	~~37.0% (-5.1%)~~ 38.0% (2.7%)
December	~~51.0%~~ 54.0%	~~51.0% (0.0%)~~ 53.0% (-1.9%)

Note: Percentage values in parentheses indicate differences of alternatives compared to existing conditions (these are percentage point differences as opposed to absolute percentage differences). Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Further evaluation of proposed SMSCG operation in terms of affecting the area of low-salinity water was conducted with SCHISM modeling (Appendix 6C, "SCHISM Model Results"). The scenarios examined were no action, 30 or 60 days of continuous tidal operation, and an alternating seven-day tidal, seven-day open schedule (Chapter 2). These scenarios were applied to 2010, 2016, and 2020 hydrology to represent different hydrologic, regulatory and antecedent salinity conditions. The 30-day operational patterns were only tested in 2020, the Dry year example. The area of water with low salinity (i.e., 0–6 ppt) was reported for five regions shown in Figure 6-45. Additional manipulations to flow (e.g., increases in Delta outflow to meet regulatory salinity criteria in the Delta) were undertaken as described in Appendix 6C. The SCHISM results showed that an alternating seven-day tidal operation, seven-day open SMSCG operation achieved nearly the same low-salinity acreage at a 50 percent lower rate of operational days and compensating flow than continuous operation (Figures 6-46, 6-47, 6-48). This may benefit Delta Smelt by lengthening the duration of low-salinity habitat creation, particularly in Dry years, under a fixed operational budget of 30 or 60 days. This has the potential to benefit Delta Smelt (Sommer et al. 2020).

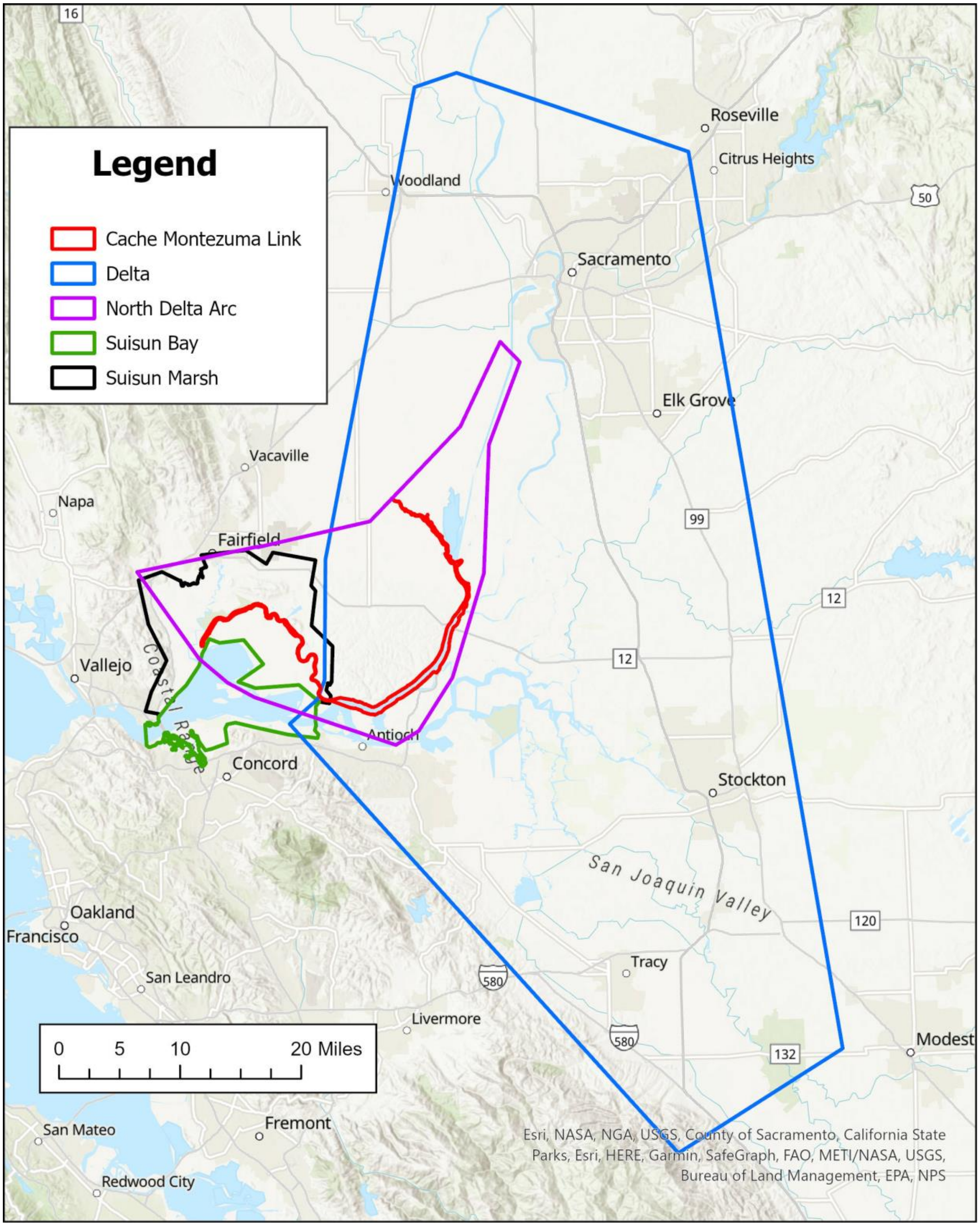
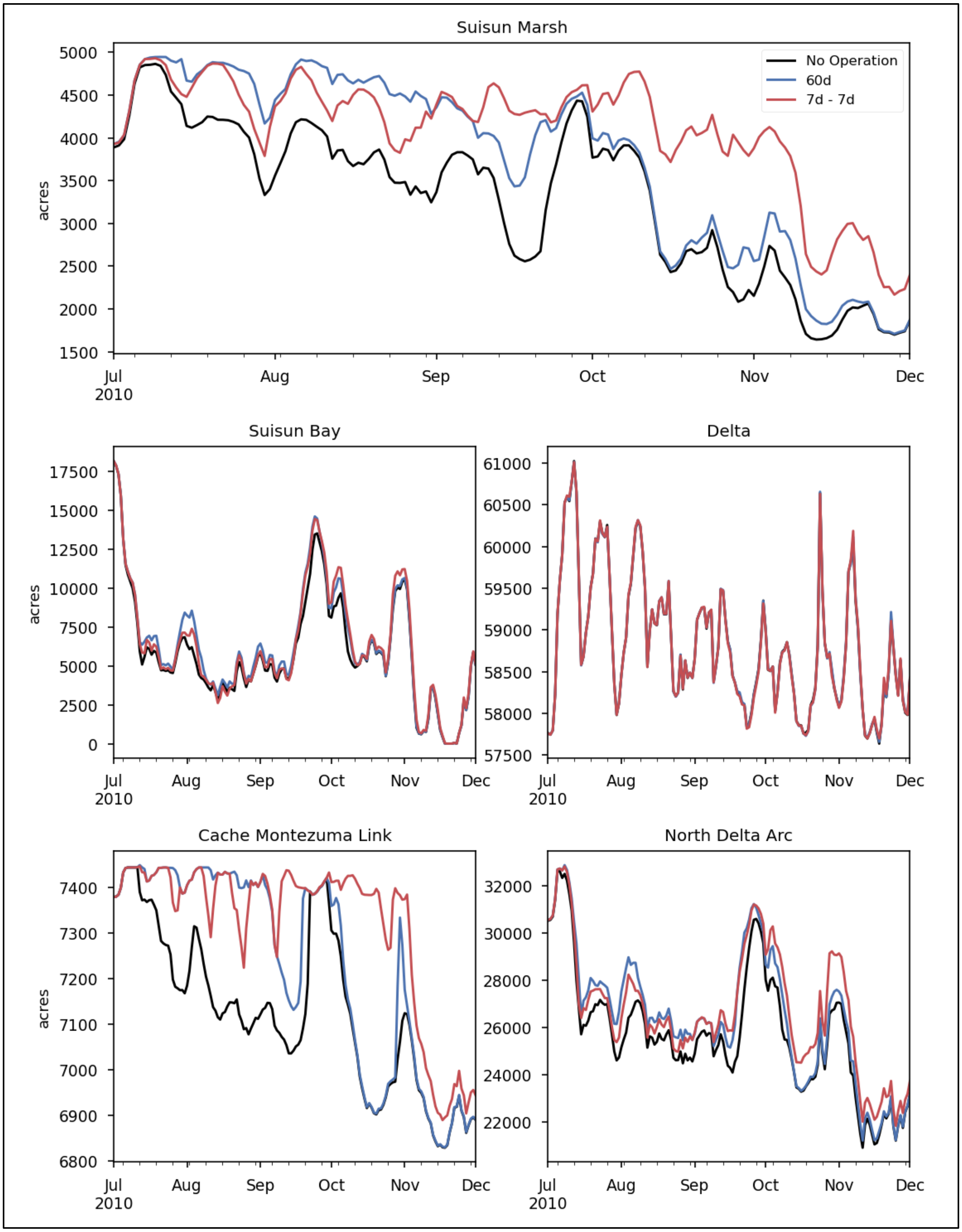
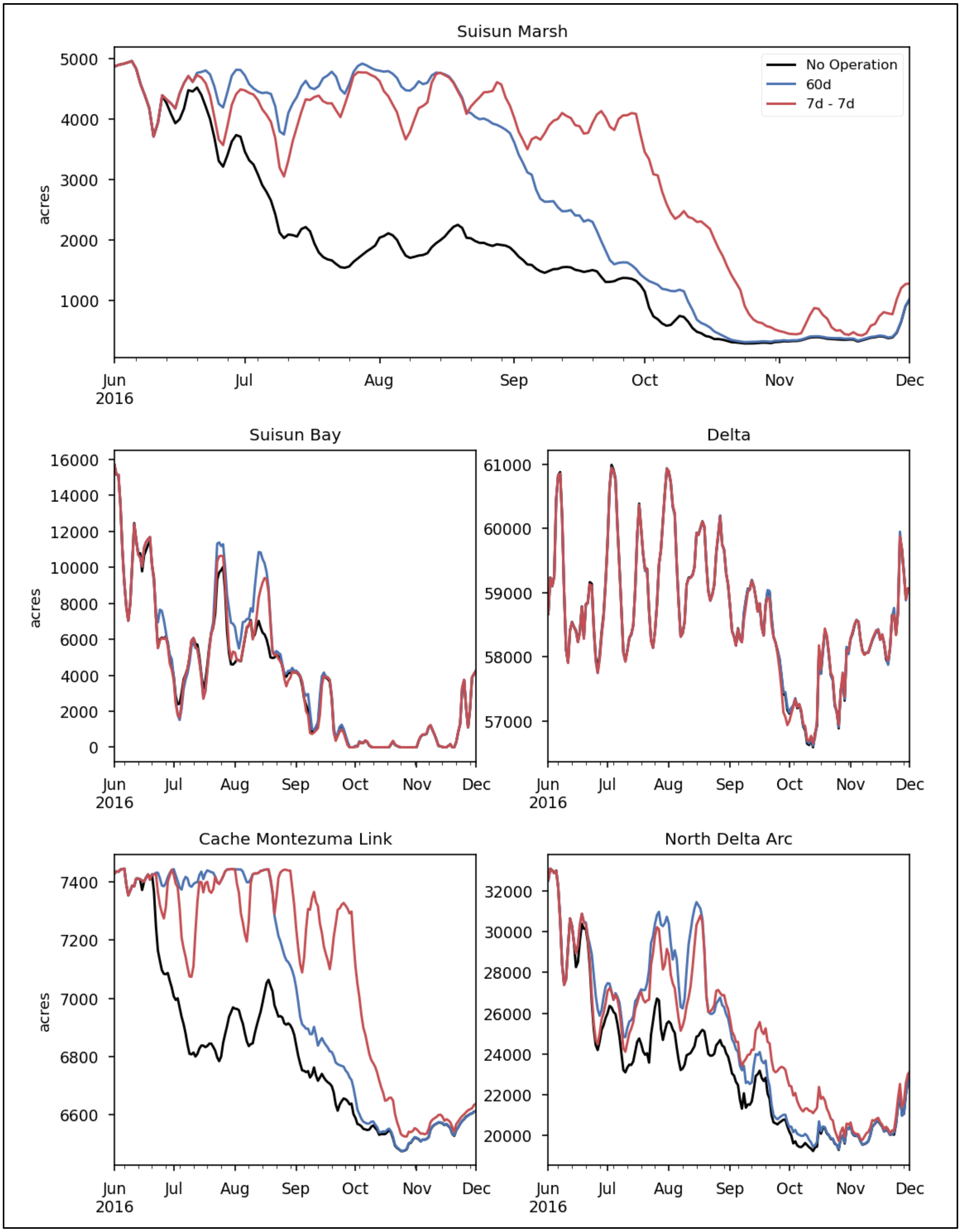


Figure 6-45. Geographic Regions Used in SCHISM Analysis



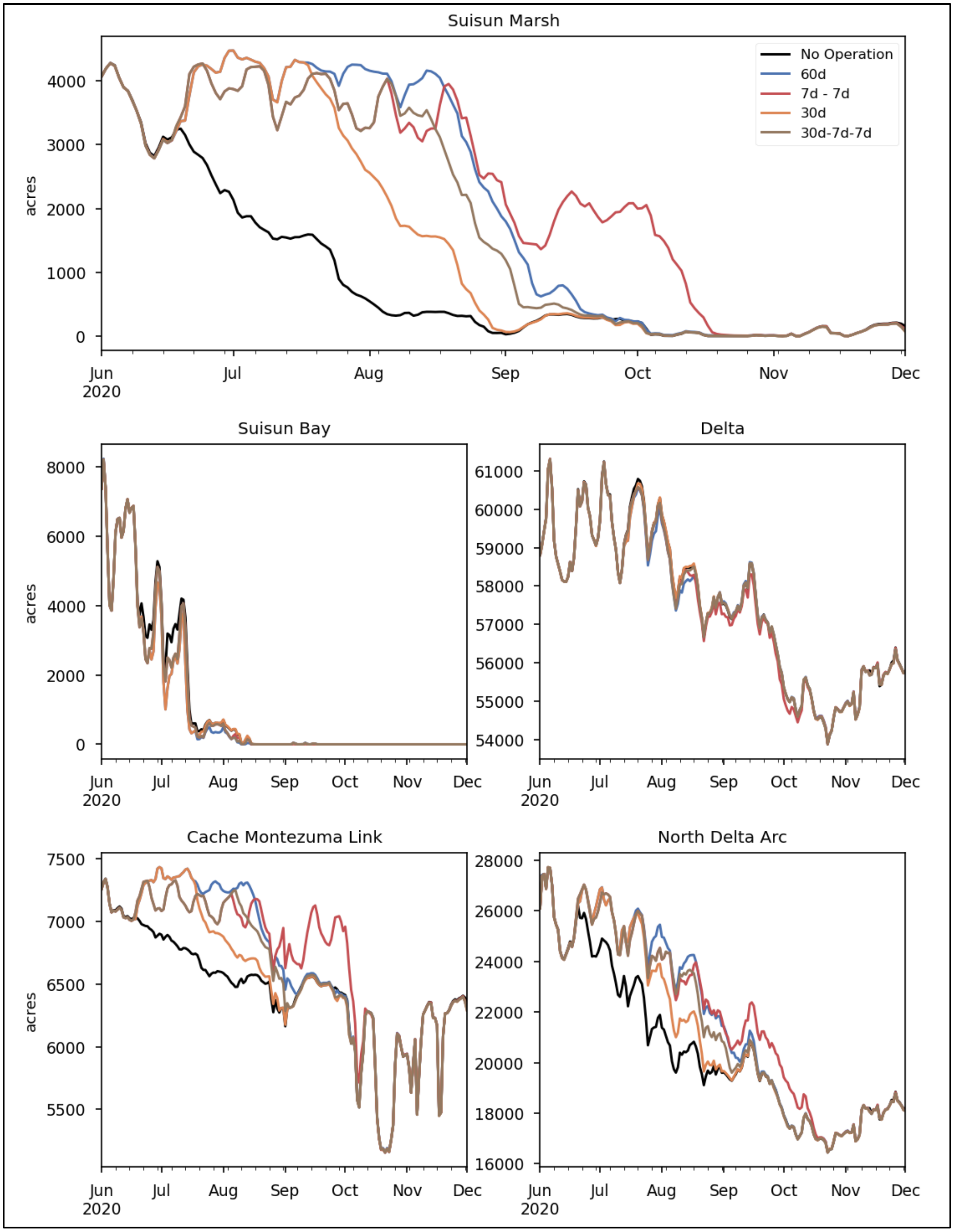
Note: No Operation = No Suisun Marsh Salinity Control Gates operation; 60d = 60 consecutive days of Suisun Marsh Salinity Control Gates tidal operations; 7d-7d = 60 days of Suisun Marsh Salinity Control Gates operation (7 days of tidal operations followed by 7 days of open gates).

Figure 6-46. Low-Salinity Area in 2010 from SCHISM Modeling



Note: No Operation = No Suisun Marsh Salinity Control Gates operation; 60d = 60 consecutive days of Suisun Marsh Salinity Control Gates tidal operations; 7d-7d = 60 days of Suisun Marsh Salinity Control Gates operation (7 days of tidal operations followed by 7 days of open gates).

Figure 6-47. Low-Salinity Area in 2016 from SCHISM Modeling



Note: No Operation = No Suisun Marsh Salinity Control Gates operation; 60d = 60 consecutive days of Suisun Marsh Salinity Control Gates tidal operations; 7d-7d = 60 days of Suisun Marsh Salinity Control Gates operation (7 days of tidal operations followed by 7 days of open gates); 30d = 30 consecutive days of Suisun Marsh Salinity Control Gates tidal operations; 30-7d-7d = 30 days of Suisun Marsh Salinity Control Gates operation (7 days of tidal operations followed by 7 days of open gates).

Figure 6-48. Low-Salinity Area in 2020 from SCHISM Modeling

6.4.1.3 John E. Skinner Delta Fish Protective Facility

Any activities associated with the Skinner Fish Facility (i.e., maintenance and repair, facility improvements, and salvage release site improvements,) would have minimal effects on Delta Smelt because minimization of entrainment risk through OMR management would also minimize the number of Delta Smelt exposed to the facility. Survival in CCF for entrained individuals is estimated to be low (Castillo et al. 2012; U.S. Fish and Wildlife Service 2019:136–138), which would also result in minimal effects from Skinner Fish Facility activities. To the extent Delta Smelt do occur at the facility, salvage disruptions during maintenance and repair could increase mortality of Delta Smelt, while facility and salvage release site improvements could decrease mortality, but such decreases or increases would affect minimal numbers of fish. Given low population abundance and high losses in the CCF, the salvage process does not return meaningful numbers of Delta Smelt back into the Delta (U.S. Fish and Wildlife Service 2019:139), so any facility-related effects would be minimal.

6.4.1.4 Delta Smelt Supplementation

Delta Smelt supplementation will increase the likelihood that the population of Delta Smelt will be sustained in the wild by releasing individuals from a robust, genetically diverse captive population, increasing the likelihood of Delta Smelt's ability to survive and reproduce in the wild to boost population numbers and maintain distribution throughout the species range and to be able to withstand the multiple factors that have led to its decline (U.S. Fish and Wildlife Service 2019:172).[7] Enhanced Delta Smelt Monitoring (EDSM) Survey data following experimental releases in WY 2022 and 2023 indicate most adult Delta Smelt collected are of cultured origin, so supplementation can greatly increase population abundance in the short term. For example, in WY 2023, nearly 44,000 marked Delta Smelt reared at the University of California (UC) Davis Fish Conservation and Culture Laboratory (FCCL) were released into the Sacramento River at Rio Vista and the Sacramento Deep Water Ship Channel during late November and mid- to late January (Columbia Basin Research, University of Washington 2023). EDSM sampling with Kodiak trawls found 23 of 26 Delta Smelt collected following the releases were marked. Catches of marked Delta Smelt in EDSM occurred between January 24 and March 21. Fish were collected near the release sites and in other locations such as Suisun Bay, Suisun Marsh, the confluence of the Sacramento and San Joaquin rivers, and the Cache Slough/Liberty Island area (Columbia Basin Research, University of Washington 2023). These results show that marked, culture-origin fish are able to survive and disperse in the Delta. Marked Delta Smelt were also detected in fish salvage operations at both the CVP and SWP from January 7 to March 2. Finger et al. (2018) found in the FCCL Delta Smelt population low differentiation between wild and cultured populations, so genetic diversity was largely maintained, although differential breeding success evidenced genetic adaptation to captivity; individuals with higher levels of hatchery ancestry tended to produce a greater number of offspring. Further research has found that there has been a small but significant increase in age at maturity among FCCL Delta Smelt broodstock by 2.2 weeks from 2010 to 2021; this loss of plasticity in age at maturity potentially could result in low fitness of reintroduced fish (LaCava et al. 2023). As described in Chapter 2, DWR and Reclamation will continue to collaborate with USFWS and CDFW on the development of a program to supplement the wild Delta Smelt population with propagated fish consistent with USFWS' Supplementation Strategy (California Department of Fish and Wildlife 2021). The Supplementation Strategy identifies a need for additional facilities and evaluation of new approaches to maintain these fish, support supplementation, improve transportation and release of

[7] Environmental compliance for Delta Smelt broodstock collection is not included in this EIR.

fish, maximize genetic diversity, and minimize domestication effects, with additional facilities being the subject of subsequent environmental compliance.

6.4.1.5 Water Transfers

The July to November water transfer window would be unlikely to affect Delta Smelt through entrainment at the SWP south Delta export facility, given that the species generally is not in the south Delta in late summer and fall. Upstream migrating adults could overlap the window if first flushes of precipitation of flow occur prior to December. This is unlikely, as the main period of potential entrainment is December–March (U.S. Fish and Wildlife Service 2019:142–150). Note this EIR does not provide environmental compliance for individual water transfer proposals.

6.4.1.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on Delta Smelt would be similar between the scenarios. Dispersing adult Delta Smelt may come into contact with agricultural barriers if they are moving upstream and into the south Delta, but this possibility is low because agricultural barriers are put into place relatively late (May), when Delta Smelt are no longer thought to be dispersing large distances (U.S. Fish and Wildlife Service 2019:214). Larval Delta Smelt distribution will be affected much more by OMR flows than by the operation of the temporary barriers, but based on historical distributions, it is unlikely this will affect individuals that were not already entrained into Old and Middle rivers (U.S. Fish and Wildlife Service 2019:214). OMR flow management inherently accounts for the hydraulic effect of the agricultural barriers, because OMR flow reflects the action of the barriers and south Delta exports on hydrodynamics in these channels. Individual Delta Smelt encountering the agricultural barriers may be precluded from moving within the channel and made more vulnerable to predators in the vicinity of the barriers and gates, although survival of such fish is likely low because of the prevailing hydrodynamics in the south Delta, which are hypothesized to result in loss by predation or entrainment (U.S. Fish and Wildlife Service 2019:214). Other potential effects, such as hydraulic reduction in the flux of the Delta Smelt prey *P. forbesi*, on the low-salinity zone (U.S. Fish and Wildlife Service 2008:226) would be expected to be similar for the Proposed Project and Baseline Conditions scenarios.

6.4.1.7 Barker Slough Pumping Plant

Low levels of entrainment would be expected under both the Proposed Project and Baseline Conditions scenarios, based on recent available entrainment monitoring data (Yip et al. 2017, 2019). As discussed in Section 6.4.1.1, "Delta SWP Facility Operations," the DSM2-PTM results indicated little difference in the potential for entrainment of Delta Smelt at BSPP between the Baseline Conditions and Proposed Project scenarios. Estimates of loss of Delta Smelt by entrainment at the NBA during 1995 to 2004 were made in response to the 1995 Operations Criteria and Plan BiOp monitoring requirements by multiplying pumping by the density of larvae at stations in the vicinity. Historical estimates of loss by entrainment ranged from 375 larval Delta Smelt in 1995 to 32,323 larval Delta Smelt in 2001 (U.S. Fish and Wildlife Service 2008:170).

These estimates are not closely related to overall indices of Delta Smelt abundance from the 20-mm and FMWT surveys, although it would be expected that entrainment in the future would be less than previously occurred because of the apparent low abundance of the Delta Smelt population that currently exists relative to the 1995–2004 period for which the NBA estimates were made (ICF International 2016:4-190). Recent entrainment monitoring suggests very low levels of entrainment (only one larval Delta Smelt was collected during sampling in January–June, 2015–2016; Yip et al. 2017, 2019).

Sediment removal by suction dredge at BSPP would have the potential to entrain Delta Smelt, although the numbers would be expected to be limited given low numbers of Delta Smelt expected to occur in the area and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on Delta Smelt given that the species does not occur in vegetation (Ferrari et al. 2014) and as previously noted, abundance would be expected to be low in the vicinity.

6.4.1.8 Clifton Court Forebay Weed Management

Low numbers of Delta Smelt would occur in CCF because of OMR management and low population abundance, similar to the Skinner Fish Facility. To the extent Delta Smelt do occur in CCF, control of aquatic weeds for the Proposed Project includes summer and fall applications of herbicides and therefore would not be expected to coincide with the occurrence of Delta Smelt in CCF. Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months. Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and so could coincide with occurrence of Delta Smelt. Delta Smelt would not be expected to be found near aquatic weeds (Ferrari et al. 2014) but could occur near the weeds if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual Delta Smelt from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) could be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency due to reduced smothering by weeds. However, only a limited number of individuals would be subject to these potential positive and negative impacts.

6.4.1.9 Suisun Marsh Operations

Other than the differences in SMSCG operations discussed in Section 6.4.1.2, Suisun Marsh operations would remain the same between the Baseline Conditions and Proposed Project scenarios. This could result in predation near facilities or entrainment at low levels into the RRDS and MIDS. Loss by entrainment of older Delta Smelt at the MIDS intake is expected to be minimal, as entrainment has not been observed in previous studies (2004–2006; Enos et al. 2007), and very little entrainment of larvae is expected based on PTM studies (Culberson et al. 2004). The screens on the RRDS intake minimize loss of Delta Smelt by entrainment of larvae or smaller juveniles (<30 mm). Entrainment could occur into the Goodyear Slough Outfall, but the system is open and Delta Smelt could exit at the intake or the outfall (U.S. Fish and Wildlife Service 2019:39).

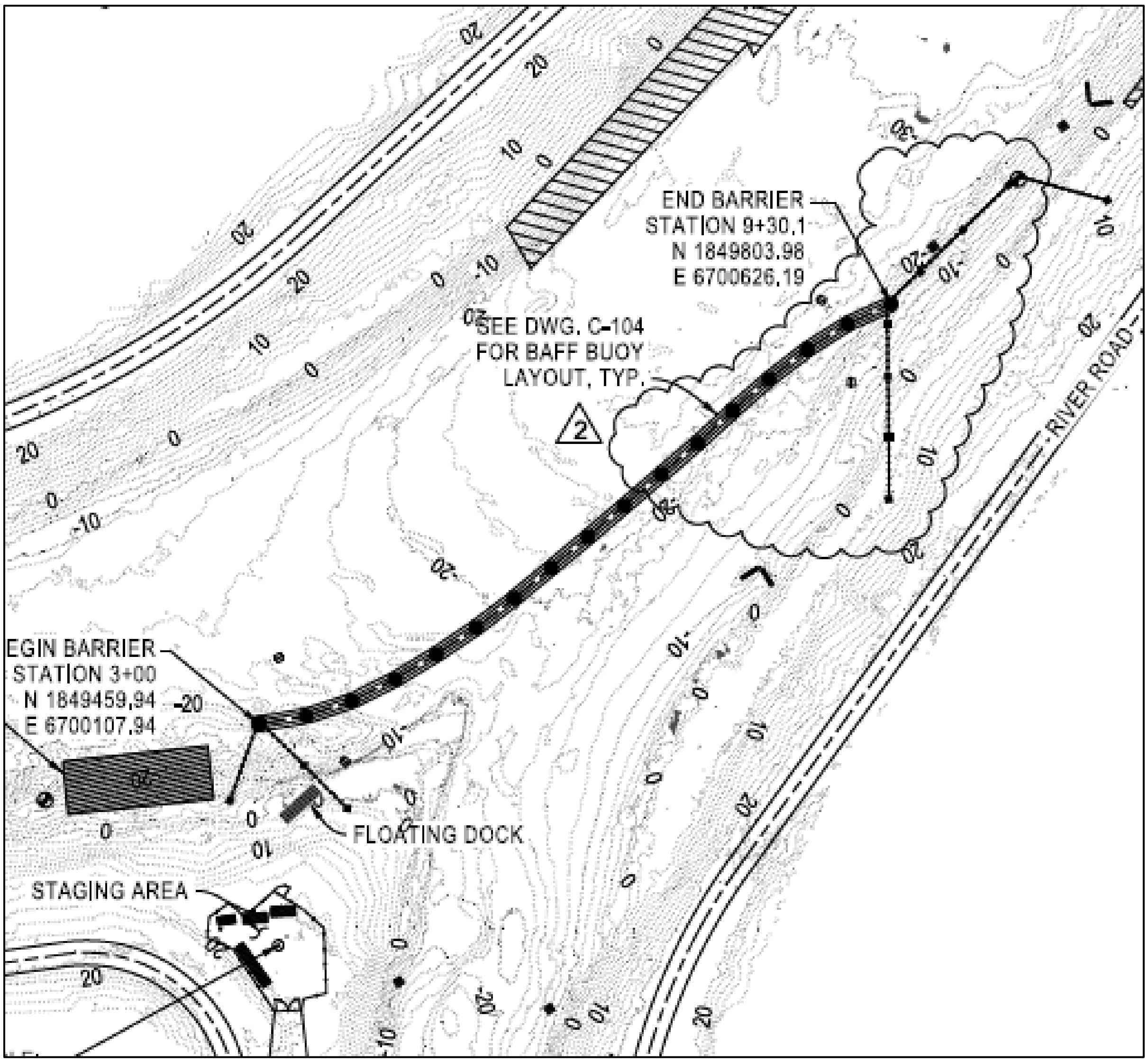
There are apparently no monitoring data from which to infer the level of loss of larval Delta Smelt; the entrainment risk appears limited based on DSM2-PTM modeling for the California Department of Fish and Game (2009a) Longfin Smelt ITP application not observing any particles entering RRDS.

6.4.1.10 Georgiana Slough Salmonid Migratory Barrier Operations

As described below for the analysis of through-Delta survival for winter-run Chinook Salmon (see Section 6.4.3.1, "Delta SWP Facility Operations", analyses pertaining to the Delta Passage Model, STARS model, and ECO-PTM model), for this analysis the GSSMB is assumed to be operated as follows:

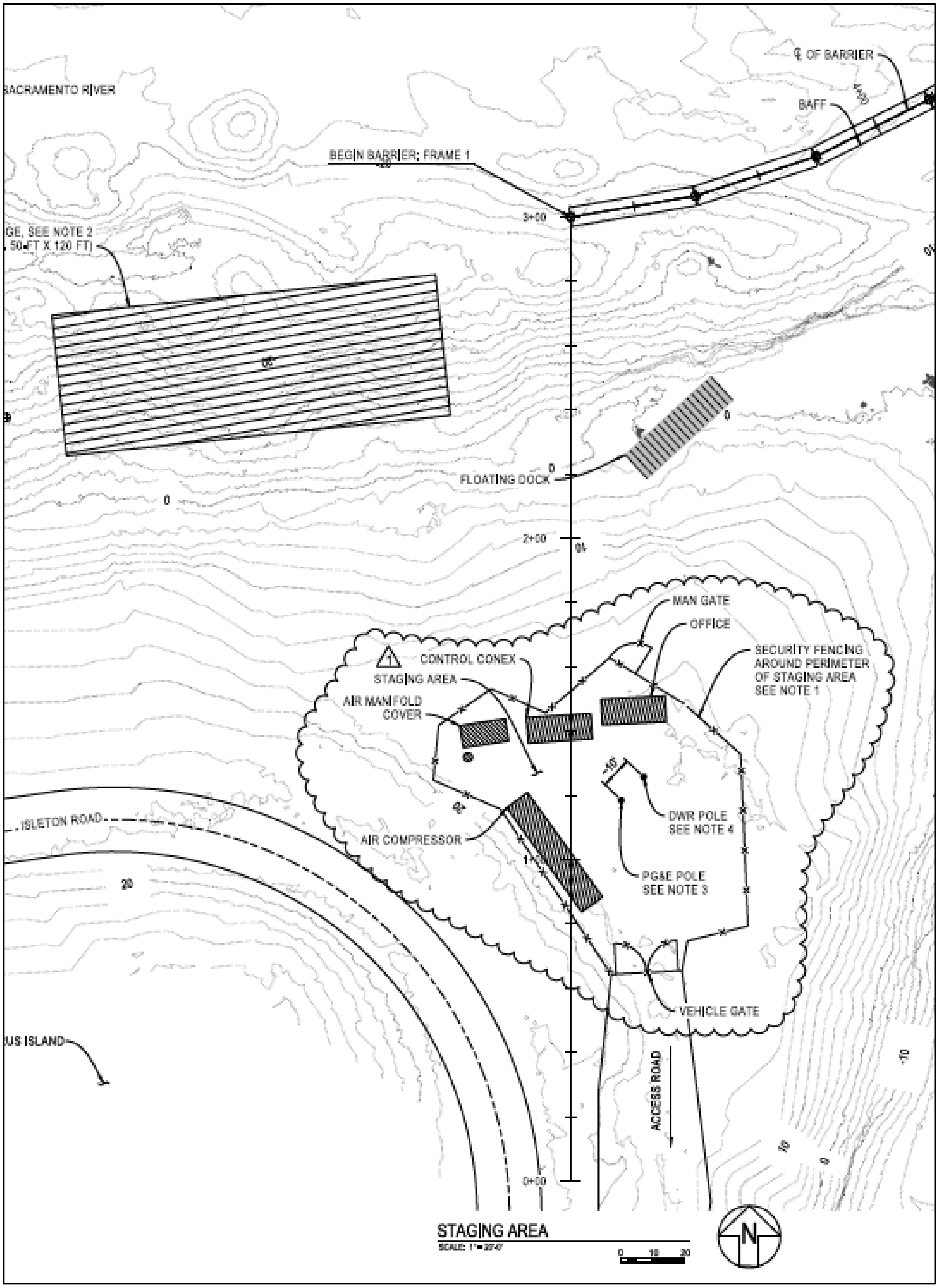
- November 16-December 31: BAFF assumed to be turned on when the ~~Delta Cross Channel~~ DCC is closed.
- January 1-April 30: BAFF assumed to be turned on all the time.
- Otherwise: BAFF assumed to be turned off.

Plan and profile views of the BAFF are provided in Figures 6-49, 6-50, and 6-51.



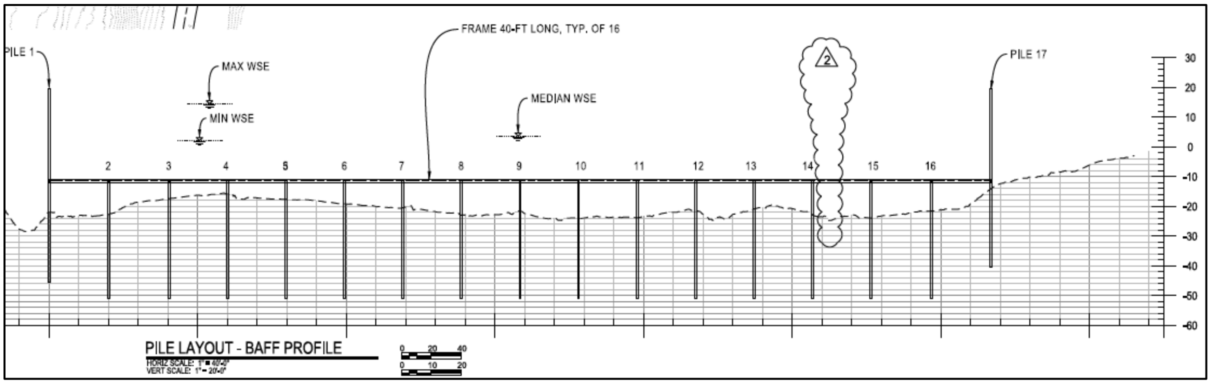
Source: California Department of Water Resources (2021).

Figure 6-49. Plan View of BioAcoustic Fish Fence Excerpted from Engineering Drawings.



Source: California Department of Water Resources (2021).

Figure 6-50. Close-up Plan View of Downstream End of BioAcoustic Fish Fence Excerpted from Engineering Drawings.



Source: California Department of Water Resources (2021).

Figure 6-51. Profile View of BioAcoustic Fish Fence Excerpted from Engineering Drawings.

Available summaries indicate that the proportion of the population occurring near the BAFF would be small as the species' main distribution is farther downstream (Merz et al. 2011; Murphy and Hamilton 2013).

As summarized in the Biological Assessment of Potential Effects on Listed Fishes Georgiana Slough Salmonid Migration Barrier Project (ICF ESA Joint Venture 2021:84), the BAFF is a non-physical barrier and therefore will not block or impede the flow of water at Georgiana Slough. Therefore, there will be effectively no hydrodynamic changes in the flow splits at the junction and thus, there should be no impacts to fish related to changes in the ambient flow patterns or distribution of water associated with the operation of the barrier beyond possibly very localized effects near to the structure. The physical presence of the piles and BAFF infrastructure may create small eddies immediately down current of (i.e., behind) the structures as water moves past it. For the BAFF, the actions of the bubbles will create a localized vertical current along the face of the bubble curtain as the less dense bubbles move upwards towards the surface, carrying a fraction of the water within the air-bubble mixture with it towards the surface. At the river surface, the air-water mixture is expected to flow downstream with the prevailing current in the river channel. There is the potential that small fish could be entrained with this vertical movement of water towards the surface and this movement could be disorienting so the entrained fish could be more vulnerable to predators. It is unlikely that there will be any demonstrable changes in measured water quality, local water elevations, or general water velocities in the larger area surrounding the technology location that might alter fish distribution due to the operation of the barrier. The available studies related to predation associated with the BAFF have focused on juvenile salmonids because the technology is intended for salmonids and because acoustic tagging is possible to assess BAFF efficiency and predation; there has been no study of smelt because of tagging constraints (Wilder et al. 2016) and the limited spatial overlap with the barrier (see above).

Predator distribution may be altered by the BAFF due to the fine scale environment surrounding the physical structure associated with the BAFF. The creation of structure may enhance the ability for predators to hold station in the mid-channel location as they orient to the hard structure in the water column (i.e., predator attraction to physical structure) and take advantage of the small velocity breaks associated with the physical structure. Tracks of acoustic-tagged predatory fishes have provided little evidence for association with the physical structure (e.g., for the Floating Fish Guidance Structure [FFGS study]; California Department of Water Resources 2016); however, DIDSON observations suggested higher density of predatory fishes near the FFGS than farther away.

As summarized by California Department of Water Resources (2015a), the 2011 BAFF study provided no evidence that the BAFF's physical infrastructure (i.e., piles and scaffolding) provided velocity refuge and ambush habitat for predatory fish because only one predation event on acoustically tagged juvenile Chinook Salmon occurred close (less than 15 feet) to the BAFF, with the remainder (48 classified predation events) being 15 feet or more away from the BAFF, and the majority of these being more than 260 feet away from the BAFF. Most (65 %) of the predation events occurred with the BAFF off, and combined with some evidence from acoustic-tagged predators, suggests that predatory fishes may have been startled by the BAFF when it was turned on (California Department of Water Resources 2012); evidence for predatory fishes moving away from the BAFF when turned on was also found in 2012 (California Department of Water Resources 2015a,b). As described by California Department of Water Resources (2015a,b), spatial patterns of 116 juvenile Chinook Salmon and 42 juvenile steelhead predation events analyzed for the 2012 BAFF deployment suggested that the BAFF's structural and deterrence features did not contribute to increased predation in the area close to the BAFF, although the comparison of BAFF on versus BAFF off does not provide an indication of baseline predation rates in the absence of a BAFF. The extent to which predatory fishes could become conditioned to the BAFF when operated continuously is uncertain. An assessment of the evidence for predatory fish becoming conditioned to the 2012 BAFF over time gave mixed results, with the general conclusion being that predatory fishes as a group showed increasing avoidance of the BAFF over time, whereas individual species (i.e., Striped Bass and Smallmouth Bass) displayed some evidence of potential conditioning over time (California Department of Water Resources 2015a,b).

Although intended for juvenile salmonids, the BAFF could deter Delta Smelt from migratory pathways. As discussed above, only a small proportion of the Delta Smelt population would be likely to be exposed to barrier effects. Upstream-migrating adult Delta Smelt could be delayed if encountering the BAFF, particularly as they are assumed to occupy the upper half of the water column (~4 meters, or 13 feet; Kimmerer 2008). Given that upstream migrating adult Delta Smelt primarily use selective tidal stream transport (tidal surfing) to migrate upstream (Bennett and Burau 2015), they would be more likely to occur on the mainstem Sacramento River than in Georgiana Slough, based on the near absence of reversing flood tide flows in Georgiana Slough compared to more frequent reversing flood tide flows in the Sacramento River just below Georgiana Slough (0-39%, depending on month and year; ICF ESA Joint Venture 2021:93). Therefore relatively few Delta Smelt would be expected to be migrating upstream in Georgiana Slough (unless actively swimming), which may limit the potential for migration delay because of the BAFF. By way of comparison, the frequency of flood tide reversing flows in the Sacramento River Deep Water Ship Channel is generally around 44-45% (ICF ESA Joint Venture 2021:93), reflecting the strong tidal currents in the Cache Slough region, which is known for having relatively high abundance of Delta Smelt (Sommer and Mejia 2013).

The fact that Delta Smelt historically occurred consistently (albeit in low numbers) in the more riverine reaches of the Sacramento River (e.g., upstream of the Sutter/Steamboat Slough junctions at Clarksburg and Garcia Bend; ICF ESA Joint Venture 2021: 94) suggests active swimming is necessary to reach these areas. The prevailing downstream river velocity is faster than the critical swimming speed of Delta Smelt (i.e., 27.6 cm/s, or 0.91 ft/s; Swanson et al. 1998) around 70-80% of the time (ICF ESA Joint Venture 2021: 94), which suggests that adult Delta Smelt actively swimming upstream may need to use the river margins or perhaps deeper areas where velocity is less than in the upper water column where velocity measurements are made. If using such a mechanism to swim up Georgiana Slough, this may result in a lower likelihood of encountering the BAFF during operations, although this is uncertain. Any Delta Smelt passing through the BAFF's bubble curtain would be likely to experience only momentary discomfort and no long-lasting effects. The BAFF would only affect a portion of the stream channel; as such, Delta Smelt would be able to avoid the structures by utilizing the remaining unaffected portions of the river channel. The BAFF does not form a complete barrier to upstream migration at the head of Georgiana Slough because in addition to the space beneath the BAFF (Figure 6-56), there is also approximately 50-60 feet of open water between the BAFF and the shore (Figures 6-49 and 6-50), allowing adults to go around the edges of the BAFF if not passing beneath it. Historical beach seine monitoring data show that the frequency of occurrence of adult Delta Smelt upstream of the BAFF at Clarksburg and Garcia Bend during pilot years of BAFF implementation in 2011 and 2012 was not lower than other years without BAFF implementation during 2004-2014 (ICF ESA Joint Venture 2021: 94). This indicates that any effects of BAFF operations were limited. (Note that the BAFF was not operated continuously during these years of pilot testing and testing focused on the March-May period, which may have been after the main upstream migration of adult Delta Smelt had already occurred.)

Overall, although it is possible that there may be negative effects to Delta Smelt from GSSMB operations, such effects would be limited.

6.4.1.11 Significance of Impacts on Delta Smelt

The Proposed Project includes various measures that would limit the potential for significant impacts on Delta Smelt, including but not limited to entrainment protection, spring Delta outflow, summer/fall Delta Smelt habitat actions, habitat restoration, Delta Smelt supplementation, and other measures such as Skinner Fish Facility improvements (see detailed descriptions in Chapter 2). Although there is the potential for impacts on Delta Smelt primarily by entrainment (with only spring entrainment in April/May potentially being greater under the Proposed Project than Baseline Conditions) and changes to summer Delta outflow, such effects would likely result in a relatively small percentage change to population numbers. Elements of the Proposed Project—in particular Delta Smelt supplementation—would more than offset potential negative effects because supplementation would result in a severalfold increase in population size, which is greater than estimated negative effects. Based on the analysis presented above (Section 6.4.1.1, "Delta SWP Facility Operations;" Section 6.4.1.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.1.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.1.4, "Delta Smelt Supplementation;" Section 6.4.1.5, "Water Transfers;" Section 6.4.1.6, "Agricultural Barriers;" Section 6.4.1.7, "Barker Slough Pumping Plant;" Section 6.4.1.8, "Clifton Court Forebay Weed Management;" Section 6.4.1.9, "Suisun Marsh Operations;" and Section 6.4.1.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3, "Threshold of Significance and Approach to Impact Assessment." Therefore, the impact of the Proposed Project on Delta Smelt would be less than significant. No mitigation is required.

6.4.2 Longfin Smelt

6.4.2.1 Delta SWP Facility Operations

Entrainment

Adult Entrainment

There is the potential for the Proposed Project to result in entrainment loss of adult Longfin Smelt, although entrainment loss of adults is very limited relative to other life stages because survey data indicate that adult Longfin Smelt mostly rear and spawn seaward of the Delta or in regions of the Delta less susceptible to subsequent entrainment as larvae (Grimaldo et al. 2017, 2020; Eakin 2021; Gross et al. 2022; Kimmerer and Gross 2022). Grimaldo et al. (2009a) found that adult Longfin Smelt salvage at the south Delta export facilities was significantly negatively related to mean December–February OMR flows, but not to X2 (or other variables that were examined). As described in Chapter 2, the Adult Longfin Smelt Entrainment Protection Action may be initiated if salvage exceeds a threshold determined by the San Francisco Bay Study Longfin Smelt index. This would limit the potential for entrainment loss of adult Longfin Smelt. In addition, the Proposed Project adult Longfin Smelt entrainment action overlaps with the larval and juvenile entrainment action. The adult action does not offramp when larval Longfin Smelt appear as it does for Baseline Conditions. As a result, the adult and larval/juvenile actions operate in concert to minimize entrainment potential. As previously noted for Delta Smelt, modeling indicates that there would be little difference between the Proposed Project and Baseline Conditions scenarios in OMR flows during this period (Figures 6-1, 6-2, 6-3). Historical estimates suggest that the percentage of the adult Longfin Smelt population lost to entrainment was very low (Table 6-15; note that the population estimates are based on the FMWT survey, which does not sample much of San Francisco Bay where Longfin Smelt are known to occur; MacWilliams et al. 2016).

Table 6-15. Entrainment Loss of Adult Longfin Smelt in Relation to December Population Abundance

		Population Abundance			Entrainment Loss as % of Population Abundance		
Water Year	Entrainment Loss	Mean	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Mean	Lower 95% Confidence Limit	Upper 95% Confidence Limit
1994	515	2,121,299	1,539,453	2,923,767	0.02%	0.02%	0.03%
1995	1,256	762,931	492,457	1,185,366	0.16%	0.11%	0.26%
1996	794	1,897,507	1,280,158	2,626,755	0.04%	0.03%	0.06%
1997	43	2,505,703	1,707,191	3,556,312	0.00%	0.00%	0.00%
1998	86	356,804	169,092	623,598	0.02%	0.01%	0.05%
1999	43	There were insufficient trawl samples for an estimate.					
2000	333	893,531	548,077	1,371,856	0.04%	0.02%	0.06%
2001	601	6,261,994	4,538,034	8,417,526	0.01%	0.01%	0.01%
2002	1,648	252,942	142,355	422,206	0.65%	0.39%	1.16%
2003	3,429	1,627,699	1,038,290	2,369,905	0.21%	0.14%	0.33%
2004	2,102	1,145,721	801,008	1,605,858	0.18%	0.13%	0.26%
2005	183	475,231	271,314	756,977	0.04%	0.02%	0.07%
2006	0	159,244	90,862	257,436	0.00%	0.00%	0.00%
2007	0	83,311	26,826	159,348	0.00%	0.00%	0.00%
2008	570	21,376	6,255	43,048	2.67%	1.32%	9.11%

Sources: Entrainment loss: Fujimura 2009.
Population abundance: California Department of Fish and Game 2009b: Appendix B, Attachment 2, Table 2.

Particle Tracking Modeling (Larval Entrainment)

There is potential for the Proposed Project to result in loss of larval Longfin Smelt through entrainment by water diversions in the Delta, including CCF and BSPP. Winter (January–March) is the main period of concern. As described in Chapter 2, Kimmerer and Gross (2022) examined available 2009–2020 survey data for all Longfin Smelt life stages and noted that vulnerability to south Delta entrainment is greatest in early larvae, but that larval losses were low in population terms (mean of 1.5 percent of the population). Gross et al. (2022) estimated that proportional entrainment of larvae was just under 2 percent of the population in WY 2013 and less than 0.1 percent of the population in WY 2017; application of the same methods gave estimates of just under 1 percent in 2021 and 1.3 percent in 2022 (Resource Management Associates 2023).

As described in Chapter 2, south Delta entrainment risk for larval Longfin Smelt would be managed with the Larval and Juvenile Longfin Smelt Protection Action as part of OMR flow management. A DSM2-PTM analysis was undertaken using the methods described in Appendix 6B, Section 6B.11, "Longfin Smelt Larval Entrainment (DSM2 Particle Tracking Model)[8]," which considers surface-oriented as well as neutrally buoyant particles. As noted in Chapter 2, it is thought that larval Longfin Smelt are initially surface-oriented. Staff observations from preliminary Longfin Smelt culture efforts at the UC Davis FCCL have suggested that larvae may not be buoyant in fresh water but are buoyant in brackish water (Acuña pers. comm. August 28, 2019), which may add some uncertainty to the results from PTM analysis. Analysis of surface-oriented and neutrally buoyant particles provides information on two plausible behaviors, recognizing that the estimates are only order-of-magnitude comparisons that are best used in a relative fashion to compare different operational scenarios.

Initial DSM2-PTM modeling was used in the development of the Proposed Project's Larval and Juvenile Longfin Smelt Protection Action (Chapter 2), to inform the design of OMR management triggers that would minimize the SWP entrainment risk for larval Longfin Smelt. These modeling results evaluated the entrainment of particles injected at long-term monitoring stations 809 and 812 in the lower San Joaquin River among several OMR management scenarios. Ultimately, the results of these evaluations indicated that the seven-day -3,500 cfs action included in the Proposed Project was protective.

Results from the DSM2-PTM modeling suggest that SWP entrainment risk for larval Longfin Smelt under the Proposed Project would be similar or potentially slightly lower than under Baseline Conditions (Tables 6-16, 6-17, 6-18, 6-19, 6-20, 6-21). Based on historical data, this would mean entrainment of a low (<2 percent) percentage of the population (Gross et al. 2022; Kimmerer and Gross 2022; Resource Management Associates 2023). Results for stations 809 and 812 are of interest given the inclusion of these stations in the Larval and Juvenile Longfin Smelt Protection Action. Consistent with the overall results, these stations generally also suggested similar or slightly lower entrainment risk under the Proposed Project as Baseline Conditions (e.g., Tables ~~6B-45 and 6B-46~~ 6B-72, 6B-75, 6B-93, and 6B-96 in Appendix 6B).

[8] See also Appendix 4A, Attachment 4, "DSM2 PTM Documentation".

Table 6-16. Mean Percentage of Neutrally Buoyant Particles Entrained Over 90 Days into Clifton Court Forebay and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
January	Wet	~~1.11~~ 1.05	~~1.09 (-1%)~~ 0.99 (-5%)
January	Above Normal	~~1.32~~ 1.43	~~1.27 (-3%)~~ 1.32 (-7%)
January	Below Normal	~~2.93~~ 2.95	~~2.72 (-7%)~~ 2.78 (-6%)
January	Dry	~~3.76~~ 3.97	~~3.50 (-7%)~~ 3.82 (-4%)
January	Critically Dry	~~4.47~~ 3.67	~~3.90 (-13%)~~ 3.44 (-6%)
February	Wet	~~0.61~~ 0.56	~~0.62 (2%)~~ 0.54 (-3%)
February	Above Normal	~~0.91~~ 1.06	~~0.87 (-5%)~~ 0.93 (-12%)
February	Below Normal	1.59	~~1.41 (-11%)~~ 1.34 (-16%)
February	Dry	~~2.05~~ 2.19	~~1.71 (-17%)~~ 1.79 (-18%)
February	Critically Dry	~~2.52~~ 2.61	~~2.43 (-4%)~~ 2.28 (-13%)
March	Wet	~~0.50~~ 0.41	~~0.54 (8%)~~ 0.44 (7%)
March	Above Normal	~~0.70~~ 0.76	~~0.59 (-15%)~~ 0.62 (-18%)
March	Below Normal	~~1.06~~ 1.04	~~0.83 (-22%)~~ 0.77 (-26%)
March	Dry	~~1.52~~ 1.70	~~1.36 (-11%)~~ 1.31 (-23%)
March	Critically Dry	~~1.45~~ 1.55	~~1.54 (6%)~~ 1.55 (0%)

Note: Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table 6-17. Mean Percentage of Neutrally Buoyant Particles Entrained Over 90 Days into Barker Slough Pumping Plant and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
January	Wet	~~0.38~~ 0.37	0.38 ~~(0%)~~ (1%)
January	Above Normal	~~0.28~~ 0.29	~~0.27 (-2%)~~ 0.29 (-1%)
January	Below Normal	~~0.41~~ 0.40	0.40 ~~(-2%)~~ (0%)
January	Dry	~~0.46~~ 0.40	~~0.46~~ 0.40 (1%)
January	Critically Dry	~~0.20~~ 0.23	~~0.21 (3%)~~ 0.23 (0%)
February	Wet	~~0.37~~ 0.35	~~0.37~~ 0.35 (0%)
February	Above Normal	0.27	0.27 ~~(-1%)~~ (2%)
February	Below Normal	~~0.35~~ 0.33	~~0.36 (2%)~~ 0.34 (3%)
February	Dry	~~0.28~~ 0.29	~~0.28 (-1%)~~ 0.29 (1%)
February	Critically Dry	~~0.14~~ 0.15	0.15 ~~(4%)~~ (0%)
March	Wet	~~0.19~~ 0.18	0.19 ~~(-2%)~~ (2%)
March	Above Normal	0.17	~~0.17 (1%)~~ 0.16 (-1%)
March	Below Normal	~~0.27~~ 0.25	~~0.26 (-2%)~~ 0.25 (0%)
March	Dry	~~0.22~~ 0.21	~~0.22 (0%)~~ 0.21 (1%)
March	Critically Dry	~~0.16~~ 0.18	~~0.16 (1%)~~ 0.17 (-5%)

Note: Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table 6-18. Mean Percentage of Neutrally Buoyant Particles Passing Chipps Island Over 90 Days and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
January	Wet	~~46.67~~ 47.05	~~46.75 (0%)~~ 47.39 (1%)
January	Above Normal	~~46.28~~ 46.61	~~46.39 (0%)~~ 46.02 (-1%)
January	Below Normal	~~40.44~~ 40.90	~~40.91~~ 41.21 (1%)
January	Dry	~~36.31~~ 37.51	~~37.25 (3%)~~ 37.35 (0%)
January	Critically Dry	~~34.54~~ 33.94	~~36.22 (5%)~~ 34.91 (3%)
February	Wet	~~47.98~~ 48.08	~~47.98~~ 48.10 (0%)
February	Above Normal	~~47.56~~ 47.24	~~47.62~~ 47.42 (0%)
February	Below Normal	~~44.72~~ 45.20	~~45.28~~ 45.60 (1%)
February	Dry	~~41.40~~ 41.48	~~42.11 (2%)~~ 42.00 (1%)
February	Critically Dry	~~38.41~~ 37.03	~~39.24 (2%)~~ 38.15 (3%)
March	Wet	~~47.67~~ 47.80	~~47.65~~ 47.76 (0%)
March	Above Normal	~~47.22~~ 47.13	~~47.37~~ 47.31 (0%)
March	Below Normal	~~46.10~~ 46.16	~~46.44~~ 46.54 (1%)
March	Dry	~~43.70~~ 43.59	~~44.33~~ 44.18 (1%)
March	Critically Dry	~~41.44~~ 39.76	~~40.99 (-1%)~~ 40.13 (1%)

Note: Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table 6-19. Mean Percentage of Surface-Oriented Particles Entrained Over 90 Days into Clifton Court Forebay and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
January	Wet	~~2.22~~ 1.13	~~2.23 (0%)~~ 1.07 (-5%)
January	Above Normal	~~1.37~~ 1.54	~~1.30 (-5%)~~ 1.43 (-7%)
January	Below Normal	~~2.50~~ 3.28	~~2.36~~ 3.10 (-6%)
January	Dry	~~2.89~~ 4.40	~~2.57 (-11%)~~ 4.27 (-3%)
January	Critically Dry	~~3.66~~ 4.15	~~3.31 (-10%)~~ 3.88 (-6%)
February	Wet	~~1.29~~ 0.59	~~1.21 (-7%)~~ 0.57 (-3%)
February	Above Normal	~~0.93~~ 1.15	~~0.90 (-4%)~~ 1.01 (-13%)
February	Below Normal	~~1.60~~ 1.77	~~1.54 (-4%)~~ 1.49 (-16%)
February	Dry	~~1.86~~ 2.45	~~1.37 (-26%)~~ 2.02 (-18%)
February	Critically Dry	~~1.81~~ 2.97	~~1.76 (-3%)~~ 2.59 (-13%)
March	Wet	~~0.89~~ 0.44	~~0.85 (-4%)~~ 0.48 (8%)
March	Above Normal	~~0.70~~ 0.84	~~0.64 (-9%)~~ 0.70 (-17%)
March	Below Normal	~~1.15~~ 1.17	~~1.03 (-10%)~~ 0.85 (-27%)
March	Dry	~~1.19~~ 1.96	~~1.04 (-13%)~~ 1.50 (-23%)
March	Critically Dry	~~1.24~~ 1.83	~~1.25~~ 1.84 (1%)

Note: Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table 6-20. Mean Percentage of Surface-Oriented Particles Entrained Over 90 Days into Barker Slough Pumping Plant and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
January	Wet	~~0.39~~ 0.37	~~0.39 (1%)~~ 0.37 (0%)
January	Above Normal	~~0.23~~ 0.29	~~0.23 (1%)~~ 0.29 (3%)
January	Below Normal	~~0.36~~ 0.40	~~0.36 (0%)~~ 0.39 (-1%)
January	Dry	~~0.45~~ 0.40	~~0.45 (0%)~~ 0.40 (1%)
January	Critically Dry	~~0.24~~ 0.23	~~0.25 (3%)~~ 0.23 (2%)
February	Wet	~~0.36~~ 0.34	~~0.35 (-1%)~~ 0.34 (1%)
February	Above Normal	~~0.31~~ 0.26	~~0.30 (-2%)~~ 0.26 (1%)
February	Below Normal	~~0.29~~ 0.32	~~0.30~~ 0.33 (2%)
February	Dry	~~0.32~~ 0.29	~~0.31 (-3%)~~ 0.29 (2%)
February	Critically Dry	~~0.20~~ 0.13	~~0.21~~ 0.14 (4%)
March	Wet	~~0.19~~ 0.18	~~0.19~~ 0.18 (-1%)
March	Above Normal	0.16	~~0.16 (1%)~~ 0.15 (-4%)
March	Below Normal	~~0.22~~ 0.24	~~0.22 (-4%)~~ 0.24 (-3%)
March	Dry	0.19	~~0.19 (-2%)~~ 0.20 (1%)
March	Critically Dry	~~0.21~~ 0.16	~~0.21 (0%)~~ 0.16 (1%)

Note: Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table 6-21. Mean Percentage of Surface-Oriented Particles Passing Chipps Island Over 90 Days and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
January	Wet	~~43.52~~ 47.66	~~43.59 (0%)~~ 48.00 (1%)
January	Above Normal	~~45.71~~ 47.06	~~45.90 (0%)~~ 46.46 (-1%)
January	Below Normal	~~41.70~~ 41.01	~~42.36 (2%)~~ 41.33 (1%)
January	Dry	~~40.34~~ 37.35	~~41.14 (2%)~~ 37.14 (-1%)
January	Critically Dry	~~36.64~~ 33.81	~~37.91~~ 34.76 (3%)
February	Wet	~~46.42~~ 48.91	~~46.51~~ 48.94 (0%)
February	Above Normal	~~47.94~~ 47.87	~~48.01~~ 48.09 (0%)
February	Below Normal	~~44.75~~ 45.57	~~45.06~~ 46.02 (1%)
February	Dry	~~42.96~~ 41.63	~~44.25 (3%)~~ 42.18 (1%)
February	Critically Dry	~~41.12~~ 37.00	~~41.67 (1%)~~ 38.20 (3%)
March	Wet	~~46.92~~ 48.75	~~47.00~~ 48.70 (0%)
March	Above Normal	~~47.39~~ 47.94	~~47.46~~ 48.11 (0%)
March	Below Normal	~~46.30~~ 46.67	~~46.21 (0%)~~ 47.08 (1%)
March	Dry	~~44.89~~ 43.84	~~45.94~~ 44.51 (2%)
March	Critically Dry	~~43.13~~ 39.91	~~43.33 (0%)~~ 40.28 (1%)

Note: Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

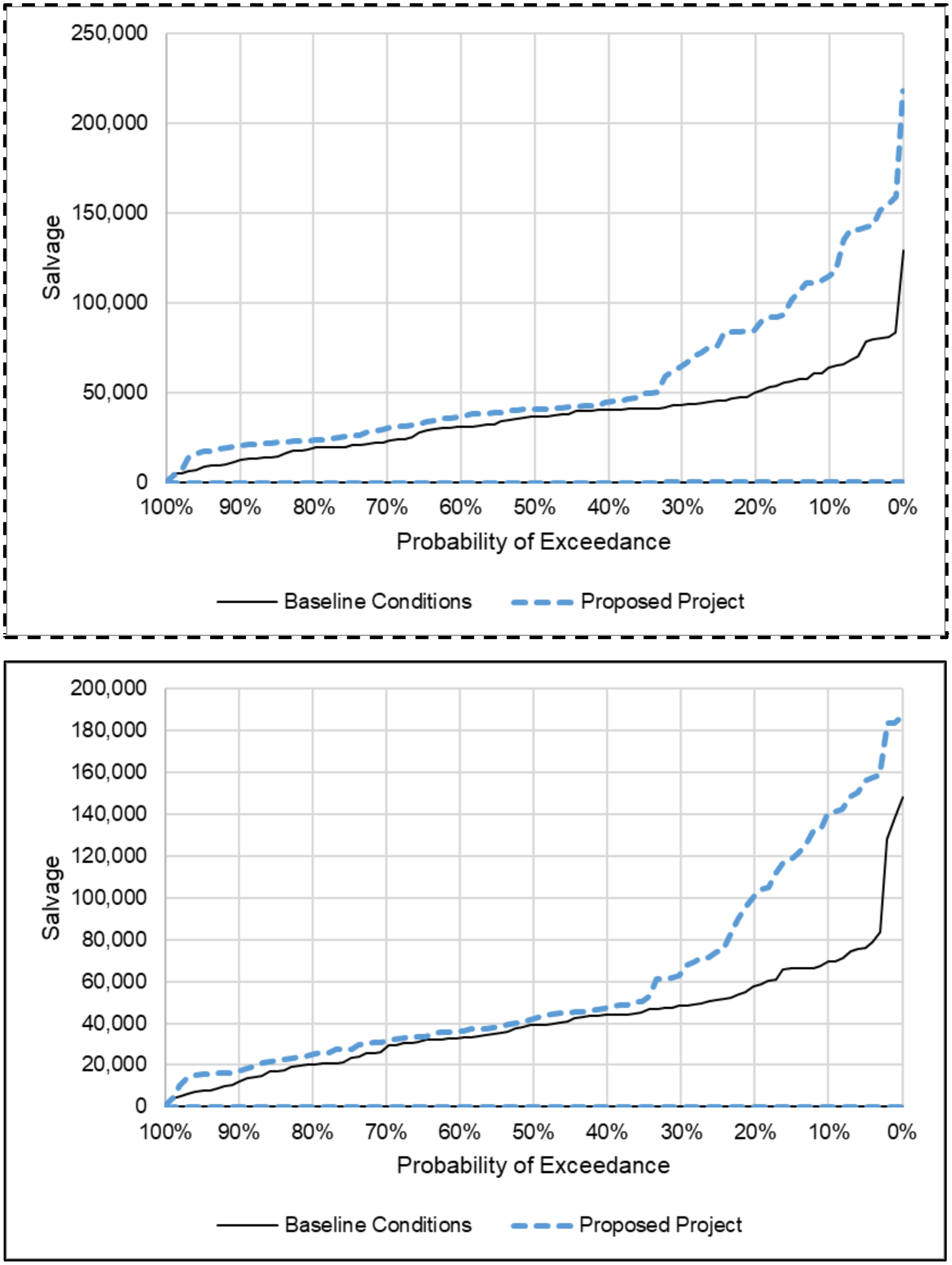
Juvenile Salvage—Old and Middle River Flow Analysis (based on Grimaldo et al. 2009a)

Juvenile Longfin Smelt may be taken by entrainment into CCF. As noted above, vulnerability to south Delta entrainment is less for juvenile Longfin Smelt than larvae (Kimmerer and Gross 2022). Grimaldo et al. (2009a) found that juvenile Longfin Smelt salvage principally occurred in April–May and was significantly negatively related to mean April–May OMR flow (and was not related to other factors such as X2). For this effects analysis, an evaluation of potential differences between Baseline Conditions and Proposed Project scenarios in terms of entrainment (salvage) was undertaken by recreating and applying the Grimaldo et al. (2009a) relationship between salvage and OMR flows (see Appendix 6B, Section 6B.12, "Longfin Smelt Salvage–Old and Middle River Flow Analysis Based on Grimaldo et al. (2009)").

Table 6-22. Mean Annual Longfin Smelt April–May Salvage, from the Regression Including Mean Old and Middle River Flows (Grimaldo et al. 2009a) and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped By Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~1,072.5~~ 1,226.9	~~1,853.4 (72.8%)~~ 1,986.6 (61.9%)
Above Normal	~~935.7~~ 985.4	~~1,625.9 (73.8%)~~ 1,661.7 (68.6%)
Below Normal	~~396.4~~ 447.2	~~582.1 (46.8%)~~ 622.3 (39.1%)
Dry	~~635.1~~ 681.5	~~688.6 (8.4%)~~ 704.4 (3.4%)
Critically Dry	~~695.1~~ 738.0	~~771.9 (11.0%)~~ 797.8 (8.1%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-52 for 95% prediction intervals)



Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

Figure 6-52. Exceedance Plot of Longfin Smelt April–May Salvage Prediction Interval, Based on the Analysis using the Salvage-Old and Middle River Flow Regression Developed by Grimaldo et al. (2009a)

The analysis based on the Grimaldo et al. (2009a) salvage-OMR flow regression suggested the potential for large relative increases in entrainment under the Proposed Project compared to the Baseline Conditions scenario, albeit with considerable uncertainty around the predictive estimates (Figure 6-52; Table 6-22). In absolute terms, entrainment loss of juvenile Longfin Smelt under the Proposed Project, even if greater than under the Baseline Conditions scenario, is likely to represent a low percentage of the overall juvenile Longfin Smelt population because management of entrainment is estimated to have resulted in a very small percentage of the juvenile population being entrained (Table 6-23). Vulnerability to south Delta entrainment is less for juvenile Longfin Smelt than larvae; ~~estimates of~~ larval population-level losses were estimated to average 1.5 percent during 2009–2020 (Kimmerer and Gross 2022), consistent with larval estimates of loss <0.1–2 percent using a different method for 2013, 2017, 2021, and 2022 (Gross et al. 2022; Resource Management Associates 2023). The Larval and Juvenile Longfin Smelt Protection Action described in Chapter 2 would minimize entrainment risk. Conditions preceding spring generally would be conducive to a lower proportion of juveniles potentially being in the south Delta and susceptible to entrainment following the larval stage under the Proposed Project than Baseline Conditions (Tables 6-24 and 6-25).[9]

[9] As described in Chapter 2, prior to Voluntary Agreement Implementation (as reflected in CalSim 3 modeling), Early Voluntary Agreement Implementation includes provision of more Delta outflow through either export curtailment consistent with CDFW's 2020 ITP Condition of Approval 8.17 or other actions, which also would be expected to minimize entrainment risk.

Table 6-23. Juvenile Longfin Smelt: Estimated Entrainment Loss Relative to Population Size, SWP South Delta Export Facility, 1995–2015

		Population Abundance			Entrainment Loss as % of Population Abundance		
Water Year	Entrainment Loss	Mean	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Mean	Lower 95% Confidence Limit	Upper 95% Confidence Limit
1995	690	28,533,241	646,582	83,446,706	0.00%	0.00%	0.11%
1996	1,888	55,551,678	2,952,507	160,930,326	0.00%	0.00%	0.06%
1997	14,941	53,124,330	27,786,879	81,514,564	0.03%	0.02%	0.05%
1998	12,870	67,816,816	430,480	201,955,221	0.02%	0.01%	2.99%
1999	13,662	105,680,968	23,624,089	227,525,445	0.01%	0.01%	0.06%
2000	28,136	155,878,920	29,659,827	397,513,090	0.02%	0.01%	0.09%
2001	44,701	14,788,919	6,268,759	27,156,527	0.30%	0.16%	0.71%
2002	1,106,614	34,788,791	16,739,707	57,544,906	3.18%	1.92%	6.61%
2003	10,252	12,690,736	2,456,744	31,824,070	0.08%	0.03%	0.42%
2004	4,101	11,953,747	3,049,485	25,527,635	0.03%	0.02%	0.13%
2005	3,593	20,103,627	3,154,146	53,010,040	0.02%	0.01%	0.11%
2006	0	95,376,388	835,562	280,036,933	0.00%	0.00%	0.00%
2007	1,218	3,401,228	1,296,730	6,933,677	0.04%	0.02%	0.09%
2008	22,036	23,211,998	9,640,306	41,680,217	0.09%	0.05%	0.23%
2009	447	14,105,134	4,450,357	28,046,192	0.00%	0.00%	0.01%
2010	81	11,153,903	3,420,542	21,828,717	0.00%	0.00%	0.00%
2011	0	26,490,436	3,961,703	60,752,372	0.00%	0.00%	0.00%
2012	57,693	9,952,855	3,415,564	18,849,797	0.58%	0.31%	1.69%
2013	13,297	81,399,104	22,474,351	193,721,641	0.02%	0.01%	0.06%
2014	650	5,885,151	2,546,574	10,333,427	0.01%	0.01%	0.03%
2015	2,071	1,105,156	128,317	2,788,331	0.19%	0.07%	1.61%

Source: Entrainment loss estimated from observed juvenile salvage with California Department of Fish and Game (2009a) loss multiplier (20.3) applied. Population abundance estimates from ICF International (2016).

Table 6-24. Mean Percentage of Neutrally Buoyant Particles Entering the South Delta (via Big Break, Dutch Slough, False River, Fishermans Cut, Mouth of Old River, Mouth of Middle River, Columbia Cut, or Turner Cut) and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
January	Wet	~~0.07~~ -0.09	~~-0.01 (-108%)~~ -0.17 (-104%)
January	Above Normal	~~0.57~~ 0.81	~~0.47 (-17%)~~ 0.60 (-25%)
January	Below Normal	~~3.24~~ 3.14	~~2.89 (-11%)~~ 2.86 (-9%)
January	Dry	~~5.29~~ 5.60	~~4.69 (-11%)~~ 5.35 (-4%)
January	Critically Dry	~~6.52~~ 5.27	~~5.56 (-15%)~~ 4.93 (-6%)
February	Wet	~~-0.97~~ -1.04	~~-0.96 (1%)~~ -1.06 (-2%)
February	Above Normal	~~-0.29~~ -0.04	~~-0.36 (-24%)~~ -0.24 (-529%)
February	Below Normal	~~1.06~~ 0.98	~~0.77 (-27%)~~ 0.58 (-41%)
February	Dry	~~2.27~~ 2.63	~~1.61~~ 1.88 (-29%)
February	Critically Dry	~~3.25~~ 3.69	~~2.99 (-8%)~~ 3.09 (-16%)
March	Wet	~~-1.17~~ -1.30	~~-1.13 (4%)~~ -1.26 (3%)
March	Above Normal	~~-0.76~~ -0.65	~~-0.90 (-18%)~~ -0.83 (-28%)
March	Below Normal	~~-0.03~~ -0.06	~~-0.35 (-1,306%)~~ -0.43 (-620%)
March	Dry	~~1.20~~ 1.50	~~0.90 (-26%)~~ 0.93 (-38%)
March	Critically Dry	~~1.33~~ 1.66	~~1.36 (3%)~~ 1.57 (-5%)

Table 6-25. Mean Percentage of Surface-Oriented Particles Entering the South Delta (via Big Break, Dutch Slough, False River, Fishermans Cut, Mouth of Old River, Mouth of Middle River, Columbia Cut, or Turner Cut) and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
January	Wet	~~2.10~~ 0.08	~~1.97 (-6%)~~ 0.00 (-104%)
January	Above Normal	~~0.69~~ 1.05	~~0.54 (-22%)~~ 0.85 (-19%)
January	Below Normal	~~2.73~~ 3.71	~~2.55 (-7%)~~ 3.39 (-9%)
January	Dry	~~3.59~~ 6.38	~~2.97 (-17%)~~ 6.16 (-4%)
January	Critically Dry	~~5.28~~ 6.12	~~4.65 (-12%)~~ 5.73 (-6%)
February	Wet	~~0.50~~ -0.99	~~0.32 (-37%)~~ -1.01 (-3%)
February	Above Normal	~~-0.27~~ 0.14	~~-0.34 (-26%)~~ -0.10 (-171%)
February	Below Normal	~~1.18~~ 1.31	~~1.12 (-5%)~~ 0.86 (-34%)
February	Dry	~~1.84~~ 3.14	~~0.95 (-49%)~~ 2.32 (-26%)
February	Critically Dry	~~1.87~~ 4.38	~~1.73 (-7%)~~ 3.72 (-15%)
March	Wet	~~-0.30~~ -1.25	~~-0.37 (-24%)~~ -1.21 (3%)
March	Above Normal	~~-0.75~~ -0.53	~~-0.83 (-10%)~~ -0.70 (-34%)
March	Below Normal	~~0.21~~ 0.15	~~0.00 (-99%)~~ -0.27 (-287%)
March	Dry	~~0.51~~ 1.97	~~0.27 (-48%)~~ 1.33 (-32%)
March	Critically Dry	~~0.98~~ 2.21	~~0.92 (-6%)~~ 2.13 (-4%)

Delta Outflow—Abundance Analysis

For Longfin Smelt, focus on estuarine flow has centered on the positive relationship found between winter and spring outflow and juvenile abundance during the fall (Rosenfield and Baxter 2007; Kimmerer et al. 2009). Specifically, as Delta outflow increases or X2 shifts downstream during the winter and spring, the abundance index of Longfin Smelt in the following FMWT survey increases (Kimmerer 2002b; Kimmerer et al. 2009). The potential mechanisms underlying this relationship have been hypothesized but their relative importance is poorly understood; however, significant outflow- or X2-abundance relationships suggests that higher outflow (lower X2) or wetter hydrology produce conditions that enhance recruitment to juvenile life stages. Hypotheses about underlying mechanisms to this X2-abundance relationship include transport of larval Longfin Smelt out of the Delta to downstream rearing habitats (Moyle 2002:32; Rosenfield and Baxter 2007); increased extent of rearing habitat as X2 moves seaward (Kimmerer et al. 2009); retention of larvae in suitable rearing habitats (Kimmerer et al. 2009); increased food abundance under higher flows (Kimmerer 2002b); tributary flows leading to greater spawning/recruitment in wetter years (Lewis et al. 2020; Grimaldo et al. 2020); and processes occurring after the larval life stage (Kimmerer and Gross 2022). Analyses relying on surveys such as the FMWT index do not fully encompass the range of Longfin Smelt and do not reflect potential changes in catchability over time because of factors such as increased water clarity and gear avoidance (Latour 2016; Peterson and Barajas 2018) that are the subject of ongoing investigations.

With respect to habitat size for early life stages, new information indicates that the distribution of spawning and early life stages may be broader than previously thought, including areas with salinity ranging from 2 to 12 ppt (Grimaldo et al. 2017). It has also been recognized that abundance of adults (spawners) is an important factor driving Longfin Smelt population dynamics (Baxter et al. 2010), with two studies examining this link in detail (Maunder et al. 2015; Nobriga and Rosenfield 2016). A state-space modeling study by Maunder et al. (2015) found that multiple factors (i.e., flow, ammonium concentration, and water temperature) and density dependence were correlated to the survival of Longfin Smelt (represented by Bay Study abundance indices during 1980–2009). The flow factors included in their best models (i.e., Sacramento River October–July unimpaired runoff and Napa River runoff), however, cannot be affected by Delta water operations because of their geographic position in the watersheds. Nobriga and Rosenfield (2016) found that December–May Delta outflow had a positive association with recruits per spawner and that juvenile recruitment from age 0 to age 2 was density-dependent (lower survival with greater numbers of juveniles), but cautioned that the density dependence in the model may be too strong; both recruits per spawner and juvenile recruitment were based on Bay Study sampling.

To assess potential effects of the Proposed Project, a population dynamics model estimating FMWT index as a function of December–May and March–May Delta outflow (accounting for changes in this relationship because of the *Potamocorbula* clam invasion and the POD) and parental stock size (the FMWT index two years earlier) was developed. Similar models were also developed using San Francisco Bay Study Midwater Trawl and Otter Trawl, with age-0 abundance indices predicted by age-2 abundance indices and the covariates described previously for the analysis based on the FMWT index. These models were used to compare the Proposed Project to Baseline Conditions, using Delta outflow outputs from CalSim 3; additional detail on the methods is provided in Appendix 6B, Section 6B.13, "Longfin Smelt Delta Outflow–Abundance Index Analysis (Bayesian Method)."

The results of the Delta outflow–abundance index analysis showed that differences in predicted FMWT, Bay Midwater Trawl, and Bay Otter Trawl abundance indices between Baseline Conditions and the Proposed Project were very small relative to the variability in the predicted values, which spans several orders of magnitude (Figures 6-53, 6-54, and 6-55). Differences in mean estimates of FMWT abundance index by water year type ranged from ~~0.2~~ 0.4 percent more to ~~0.6~~ 1.4 percent less under the Proposed Project compared to Baseline Conditions (Table 6-26). Differences in mean estimates of Bay Midwater Trawl and Bay Otter Trawl abundance indices ranged from ~~0.1~~ 1.1 percent more to ~~0.9~~ 0.3 percent less under the Proposed Project compared to Baseline Conditions (Tables 6-27 and 6-28). The modeling results showed that the variability in FMWT, Bay Midwater Trawl, and Bay Otter Trawl index predictions within each scenario was considerably greater than the differences between the scenarios. The mean probability of the FMWT, Bay Midwater Trawl, and Bay Otter Trawl indices being less under the Proposed Project than Baseline Conditions was not greatly different than 0.500, where 0.500 indicates an equal probability of the indices being smaller or larger than Baseline Conditions (Tables 6-29, 6-30, and 6-31). The variability in abundance index predictions reflects the uncertainty in parameter estimates, which in turn results in uncertainty in the extent to which operations-related differences in Delta outflow could affect Longfin Smelt. Specifically, variability in Delta outflow associated with overall hydrologic conditions (i.e., different water year types) is substantially larger than the relatively minor differences in Delta outflow associated with changes in water operations resulting from the Proposed Project.

In addition to the population dynamics analysis, a second analysis used a linear regression approach to examine the relationship of Longfin Smelt FMWT index to December–May and March–May Delta outflow. These regressions did not give statistically significant results[10] and so were not used to compare the modeled CalSim 3 scenarios for Proposed Project and Baseline Conditions. The lack of a statistically significant relationship for these linear regressions, in addition to the results from the population dynamics analysis based on the FMWT, Bay Midwater Trawl, and Bay Otter Trawl, suggest that overall the Delta outflow-abundance-related effect would be similar for the Proposed Project and Baseline Conditions. Somewhat greater Delta outflow under the Proposed Project relative to Baseline Conditions in drier years (e.g., ~~January/~~ February of Critically Dry years; ~~May~~ March/April of Dry years) could benefit Longfin Smelt when low flows and other associated drier-year conditions such as higher temperature otherwise may negatively affect Longfin Smelt (Drought MAST 2022) (Table 6-32).

[10] The linear regression analyses used FMWT index data for 2003 through 2022: 1) $\log_e$(Fall midwater trawl index) = -3.837 + 0.831*$\log_e$(December–May Delta outflow, cfs), $r^2 = 0.18$, P = 0.06; 2) $\log_e$(Fall midwater trawl index) = -1.800 + 0.630*$\log_e$(March–May Delta outflow, cfs), $r^2 = 0.14$, P = 0.11.

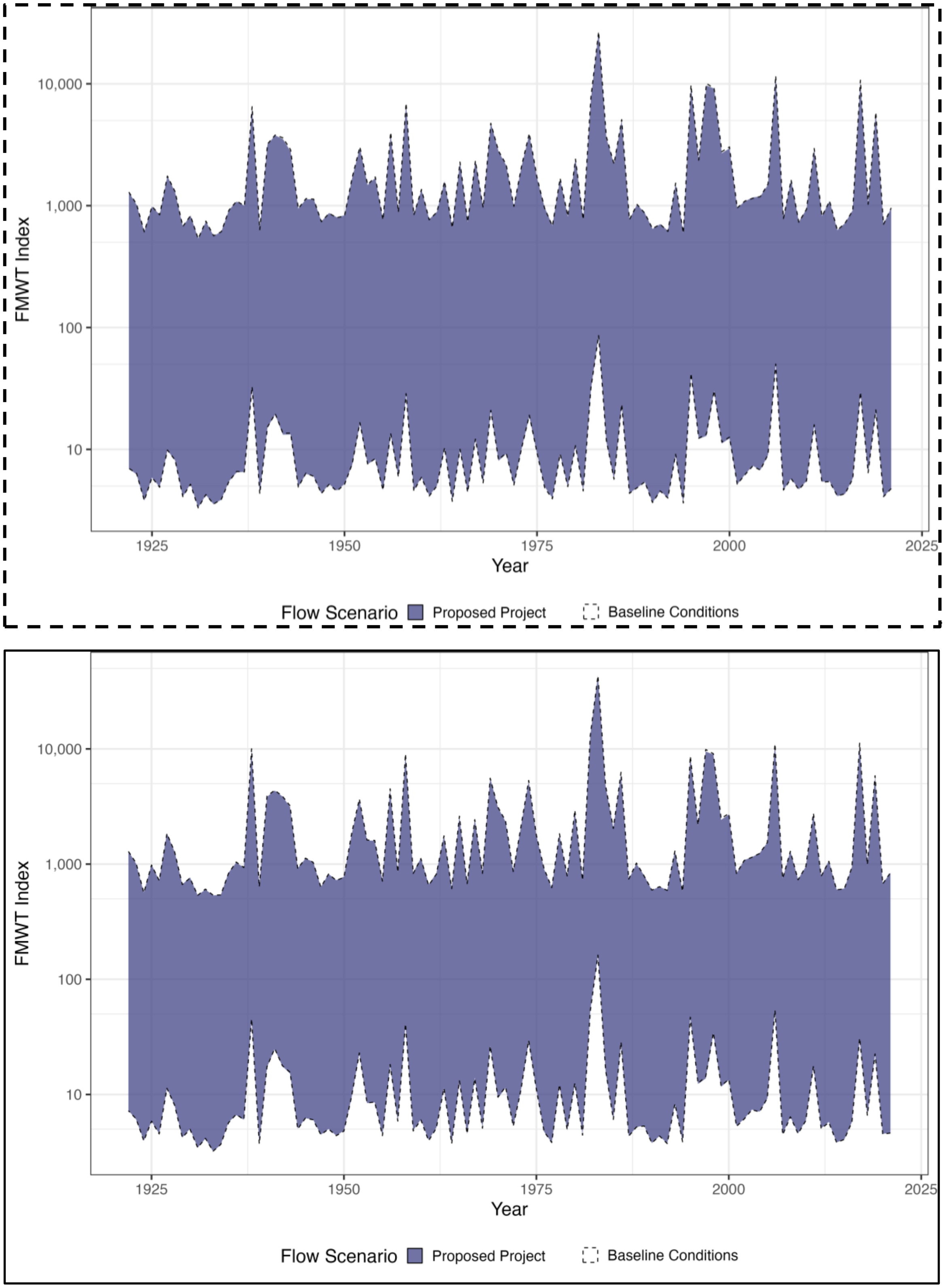
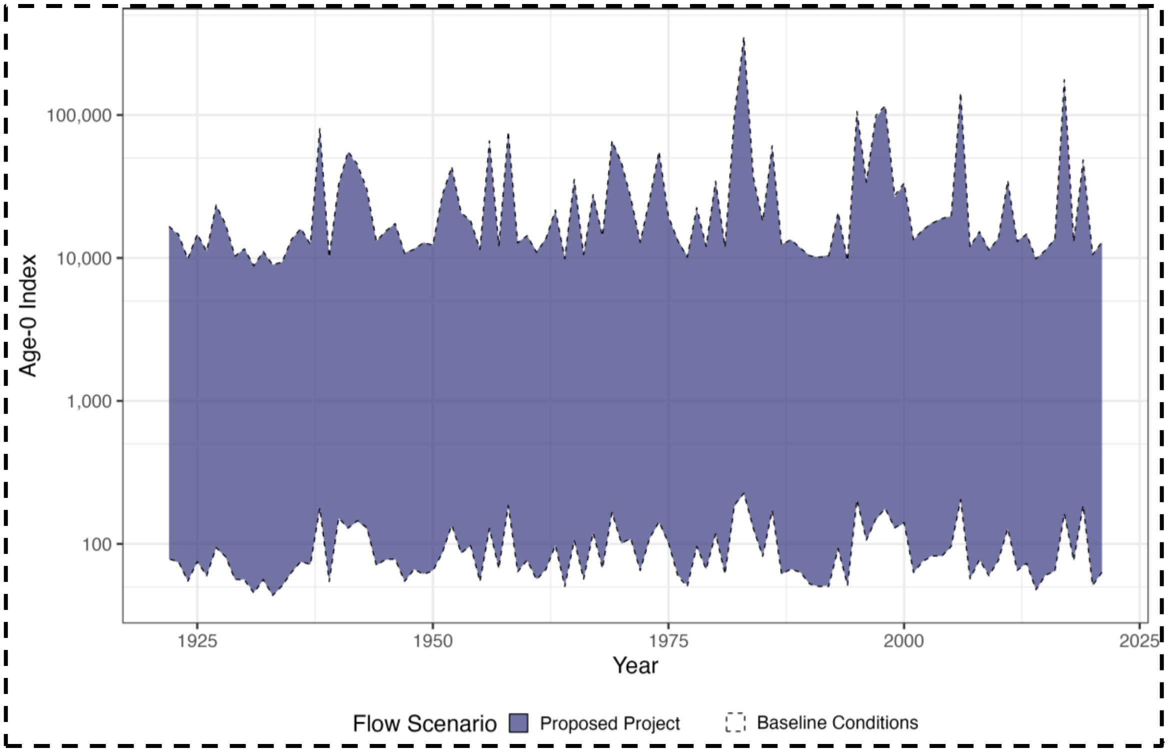


Figure 6-53. Time Series Plot of 95% Posterior Distribution of the Longfin Smelt Fall Midwater Trawl Index from Application of the Delta Outflow-Abundance Index Method



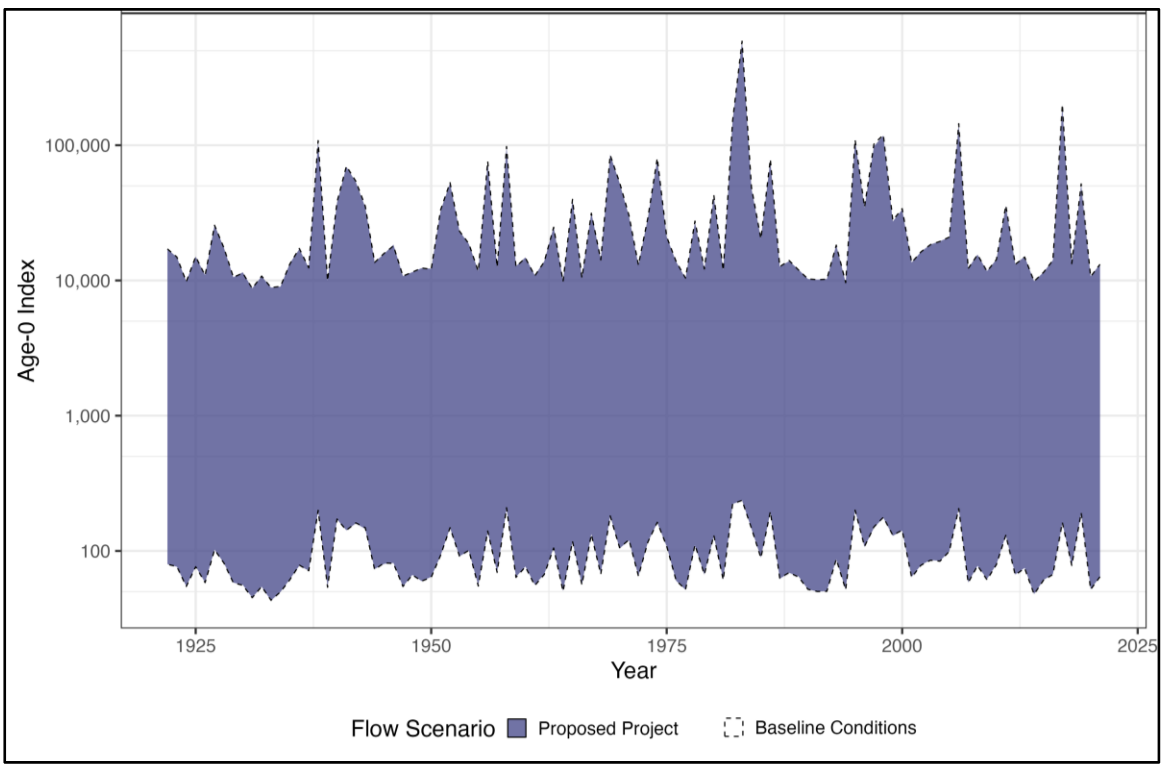
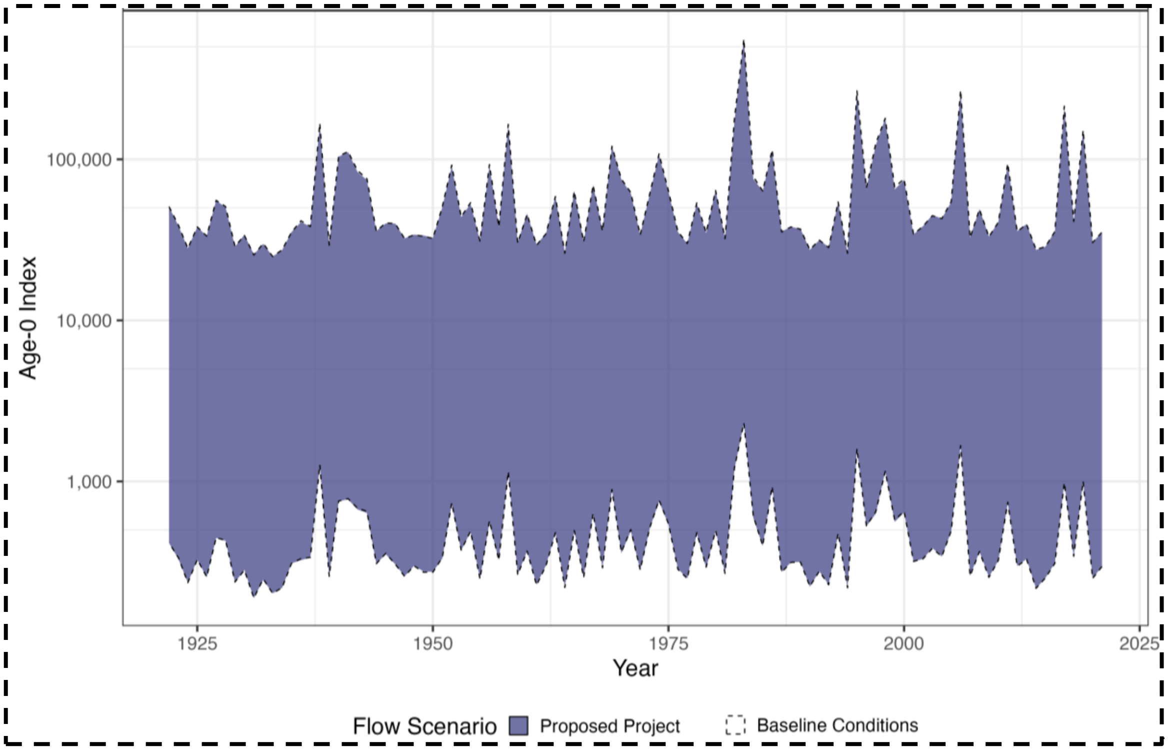


Figure 6-54. Time Series Plot of 95% Posterior Distribution of the Longfin Smelt Bay Midwater Trawl Age-0 Index from Application of the Delta Outflow-Abundance Index Method



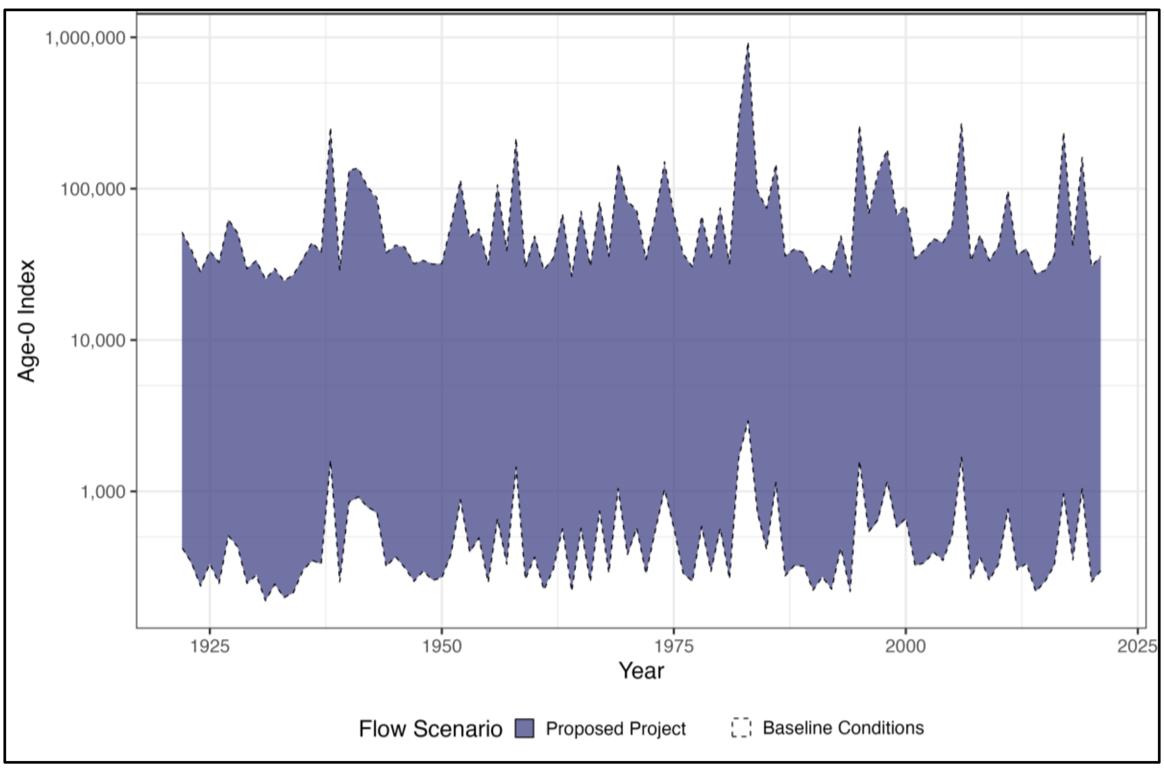


Figure 6-55. Time Series Plot of 95% Posterior Distribution of the Longfin Smelt Bay Otter Trawl Age-0 Index from Application of the Delta Outflow-Abundance Index Method

Table 6-26. Mean Predicted Longfin Smelt Fall Midwater Trawl Index under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~330.6~~ 393.0	~~327.5(-0.9%)~~ 387.4 (-1.4%)
Above Normal	~~120.5~~ 116.8	~~119.7~~ 116.0 (-0.7%)
Below Normal	~~72.6~~ 74.1	~~72.4(-0.3%)~~ 73.9 (-0.2%)
Dry	~~59.8~~ 61.2	~~60.0(0.3%)~~ 61.5 (0.4%)
Critically Dry	52.6	52.6 ~~(0.0%)~~ (-0.1%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-53 for 95% posterior distribution)

Table 6-27. Mean Predicted Longfin Smelt Bay Midwater Trawl Age-0 Index under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~12,386.7~~ 14,236.1	~~12,332.2(-0.4%)~~ 14,262.9 (0.2%)
Above Normal	~~5,149.9~~ 5,010.8	~~5,144.5(-0.1%)~~ 5,031.5 (0.4%)
Below Normal	~~3,271~~ 3,329.7	~~3,275.7(0.1%)~~ 3,353.6 (0.7%)
Dry	~~2,713.2~~ 2,774.7	~~2,731.3(0.7%)~~ 2,805.9 (1.1%)
Critically Dry	~~2,417.4~~ 2,419.6	~~2,427.1(0.4%)~~ 2,433.3 (0.6%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure ~~6-59~~ 6-54 for 95% posterior distribution)

Table 6-28. Mean Predicted Longfin Smelt Bay Otter Trawl Age-0 Index under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~13,216.6~~ 15,093.7	~~13,174.3~~ 15,054.9 (-0.3%)
Above Normal	~~5,726.2~~ 5,590.4	~~5,740.9~~ 5,608.4 (0.3%)
Below Normal	~~3,799.1~~ 3,872.1	~~3,815.5(0.4%)~~ 3,897.3 (0.7%)
Dry	~~3,234.6~~ 3,290.1	~~3,264.3(0.9%)~~ 3,326.6 (1.1%)
Critically Dry	~~2,912.1~~ 2,913.1	~~2,933.4(0.7%)~~ 2,929.9 (0.6%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure ~~6-60~~ 6-55 for 95% posterior distribution)

Table 6-29. Mean Probability of Lower Longfin Smelt Fall Midwater Trawl Index under the Proposed Project Modeling Scenario than under the Baseline Conditions Modeling Scenario, Grouped by Water Year Type

Water Year Type	Probability
Wet	~~0.506~~ 0.512
Above Normal	~~0.504~~ 0.506
Below Normal	~~0.502~~ 0.500
Dry	~~0.497~~ 0.494
Critically Dry	0.500

Note: Probability of 0.500 indicates equal probability of Fall Midwater Trawl index under the Proposed Project being smaller or larger than under Baseline Conditions.

Table 6-30. Mean Probability of Lower Longfin Smelt Bay Midwater Trawl Age-0 Index under the Proposed Project Modeling Scenario than under the Baseline Conditions Modeling Scenario, Grouped by Water Year Type

Water Year Type	Probability
Wet	~~0.509~~ 0.501
Above Normal	~~0.504~~ 0.499
Below Normal	~~0.501~~ 0.496
Dry	~~0.495~~ 0.492
Critically Dry	~~0.499~~ 0.495

Note: Probability of 0.500 indicates equal probability of Bay Midwater Trawl index under the Proposed Project being smaller or larger than under Baseline Conditions.

Table 6-31. Mean Probability of Lower Longfin Smelt Bay Otter Trawl Age-0 Index under the Proposed Project Modeling Scenario than under the Baseline Conditions Modeling Scenario, Grouped by Water Year Type

Water Year Type	Probability
Wet	~~0.501~~ 0.497
Above Normal	~~0.502~~ 0.493
Below Normal	~~0.500~~ 0.490
Dry	~~0.492~~ 0.486
Critically Dry	~~0.494~~ 0.492

Note: Probability of 0.500 indicates equal probability of Bay Otter Trawl index under the Proposed Project being smaller or larger than under Baseline Conditions.

Table 6-32. Mean Modeled December–May Delta Outflow under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
December	Wet	~~47,570~~ 39,990	~~47,540~~ 39,962 (0%)
December	Above Normal	~~14,592~~ 16,470	~~14,362 (-2%)~~ 16,260 (-1%)
December	Below Normal	~~12,212~~ 12,969	~~12,328~~ 13,080 (1%)
December	Dry	~~10,766~~ 12,536	~~10,754~~ 12,590 (0%)
December	Critically Dry	~~8,749~~ 8,318	~~8,961 (2%)~~ 8,252 (-1%)
January	Wet	~~80,707~~ 89,212	~~80,929~~ 89,342 (0%)
January	Above Normal	~~50,616~~ 51,796	~~50,788~~ 51,953 (0%)
January	Below Normal	~~21,347~~ 22,072	~~21,584 (1%)~~ 22,178 (0%)
January	Dry	~~13,893~~ 13,473	~~13,921~~ 13,507 (0%)
January	Critically Dry	~~11,077~~ 11,023	~~11,546 (4%)~~ 11,076 (0%)
February	Wet	~~101,897~~ 105,597	~~101,816~~ 105,756 (0%)
February	Above Normal	~~59,027~~ 54,040	~~59,320 (0%)~~ 54,372 (1%)
February	Below Normal	~~32,990~~ 35,101	~~33,011 (0%)~~ 35,447 (1%)
February	Dry	~~21,516~~ 22,336	~~22,023~~ 22,774 (2%)
February	Critically Dry	~~13,876~~ 13,594	~~14,298~~ 14,008 (3%)
March	Wet	~~81,961~~ 93,358	~~81,830~~ 93,064 (0%)
March	Above Normal	~~56,105~~ 53,952	~~56,567~~ 54,604 (1%)
March	Below Normal	~~28,290~~ 31,308	~~29,062~~ 32,251 (3%)
March	Dry	~~19,063~~ 19,338	~~19,678 (3%)~~ 20,047 (4%)
March	Critically Dry	~~11,855~~ 11,564	~~11,830 (0%)~~ 11,627 (1%)
April	Wet	~~55,323~~ 58,766	~~55,086 (0%)~~ 58,305 (-1%)
April	Above Normal	~~30,579~~ 29,011	~~30,186~~ 28,644 (-1%)
April	Below Normal	~~22,358~~ 22,225	~~22,253~~ 22,235 (0%)
April	Dry	~~14,038~~ 13,514	~~14,183 (1%)~~ 13,937 (3%)
April	Critically Dry	~~9,724~~ 9,606	~~9,580~~ 9,486 (-1%)
May	Wet	~~39,956~~ 41,598	~~38,551 (-4%)~~ 40,691 (-2%)
May	Above Normal	~~23,772~~ 24,476	~~22,840~~ 23,562 (-4%)
May	Below Normal	~~18,687~~ 18,703	~~17,603~~ 17,570 (-6%)
May	Dry	~~11,606~~ 11,380	~~11,540 (-1%)~~ 11,367 (0%)
May	Critically Dry	~~7,144~~ 6,725	~~6,941~~ 6,552 (-3%)

Other Effects

Other Delta SWP facility operations habitat-related effects previously discussed for Delta Smelt and noted to generally be similar between Baseline Conditions and the Proposed Project (i.e., food availability and predation) would have less potential for effect than for Delta Smelt given Longfin Smelt's occurrence further downstream than Delta Smelt.

6.4.2.2 Delta Smelt Summer and Fall Habitat Actions

Longfin Smelt would not be likely to be affected by Delta Smelt summer and fall habitat actions because the species would tend to be downstream of the potential location of effect of the actions.

6.4.2.3 John E. Skinner Delta Fish Protective Facility

As discussed for Delta Smelt, any activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—would have minimal effects on Longfin Smelt because management of entrainment risk (e.g., through OMR management) would result in low numbers of Longfin Smelt being exposed to the facility. If similar to Delta Smelt, survival in CCF for Longfin Smelt entrained would be low (Castillo et al. 2012; U.S. Fish and Wildlife Service 2019:136–138). To the extent that Longfin Smelt do occur at the facility, salvage disruptions during maintenance and repair could increase mortality of Longfin Smelt, whereas facility and salvage release site improvements could decrease mortality, but such decreases or increases would be of minimal numbers of fish. Overall, given that the Longfin Smelt life stage most susceptible to entrainment is larvae (Kimmerer and Gross 2022), and that population-level entrainment of larvae and juveniles is low (see discussion in "Entrainment"), facility-related effects would be minimal.

6.4.2.4 Delta Smelt Supplementation

Supplementation of Delta Smelt would be unlikely to have appreciable negative effects on Longfin Smelt given that the rate of hybridization between the species was low during periods when Delta Smelt abundance indices were considerably higher (Fisch et al. 2014).[11] Although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential competitors with Longfin Smelt for prey resources.

6.4.2.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and would be expected to have limited potential for entrainment loss of Longfin Smelt given that upstream migrating adults have very little entrainment during these months (Grimaldo et al. 2009a). Note this EIR does not provide environmental compliance for individual water transfer proposals.

6.4.2.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on Longfin Smelt would be similar between the scenarios. As described for Delta Smelt, potential effects from operations of the agricultural barriers include near-field effects such as predation, as well as broader hydraulic effects on south Delta channels (although effects on OMR flows are accounted for in OMR flow management). The potential for any negative effects is limited given the spatiotemporal period of operations (beginning in May, ending in November), and would not differ between the Proposed Project and Baseline Conditions.

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[11] Environmental compliance for Delta Smelt broodstock collection is not included in this EIR.

6.4.2.7 Barker Slough Pumping Plant

As discussed in Section 6.4.2.1, "Delta SWP Facility Operations," DSM2-PTM modeling indicates that entrainment risk for larval Longfin Smelt at BSPP would be similar under the Proposed Project and Baseline Conditions. As described in Chapter 2, BSPP pumping would be adjusted based on water year type in order to limit potential for Longfin Smelt entrainment. No Longfin Smelt were collected during entrainment monitoring in 2015–2016 (Yip et al. 2019), indicating the number of Longfin Smelt lost to entrainment would likely be low. Sediment removal by suction dredge at BSPP would have the potential to entrain Longfin Smelt, although the numbers would be expected to be limited given low numbers of Longfin Smelt expected to occur in the area and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens also would be expected to have little effect on Longfin Smelt given that the species is more associated with open water and as previously noted, abundance would be expected to be low in the vicinity.

6.4.2.8 Clifton Court Forebay Weed Management

As described previously in the discussion regarding the Skinner Fish Facility, low numbers of Longfin Smelt would occur in CCF because of OMR management and low population abundance. To the extent that Longfin Smelt do occur in CCF, control of aquatic weeds for the Proposed Project includes summer and fall application of herbicides and therefore would not be expected to coincide with the occurrence of Longfin Smelt in CCF. Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months. Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and therefore could coincide with occurrence of Longfin Smelt, with occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual Longfin Smelt from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds. However, such positive or negative effects would only be on limited numbers of individuals.

6.4.2.9 Suisun Marsh Operations

No operational changes at the Suisun Marsh facilities would occur, other than differences in SMSCG described previously for Delta Smelt in Section 6.4.1.2. Minimal loss by entrainment of older Longfin Smelt is expected at the MIDS based on little observed entrainment during previous studies (2004–2006; Enos et al. 2007), and very little entrainment of larvae is expected based on PTM studies (Culberson et al. 2004). The screens on the RRDS intake minimize loss of Longfin Smelt to entrainment of larvae or smaller juveniles (<30 mm). As described for Delta Smelt, there are apparently no monitoring data from which to infer the level of loss of larvae; the entrainment risk appears limited given that that DSM2-PTM modeling for the California Department of Fish and Game (2009a) Longfin Smelt ITP application did not observe any particles entering RRDS.

6.4.2.10 Georgiana Slough Salmonid Migratory Barrier Operations

Effects to Longfin Smelt from GSSMB operations may be generally similar to those discussed above for Delta Smelt in Section 6.4.1.10, "Georgiana Slough Migratory Barrier Operations", although Longfin Smelt are distributed farther downstream than Delta Smelt (Merz et al. 2013) and therefore an even smaller proportion of the population would potentially occur near the BAFF. Overall, although it is possible that there may be negative effects to Longfin Smelt from GSSMB operations, such effects would be limited.

6.4.2.11 Significance of Impacts on Longfin Smelt

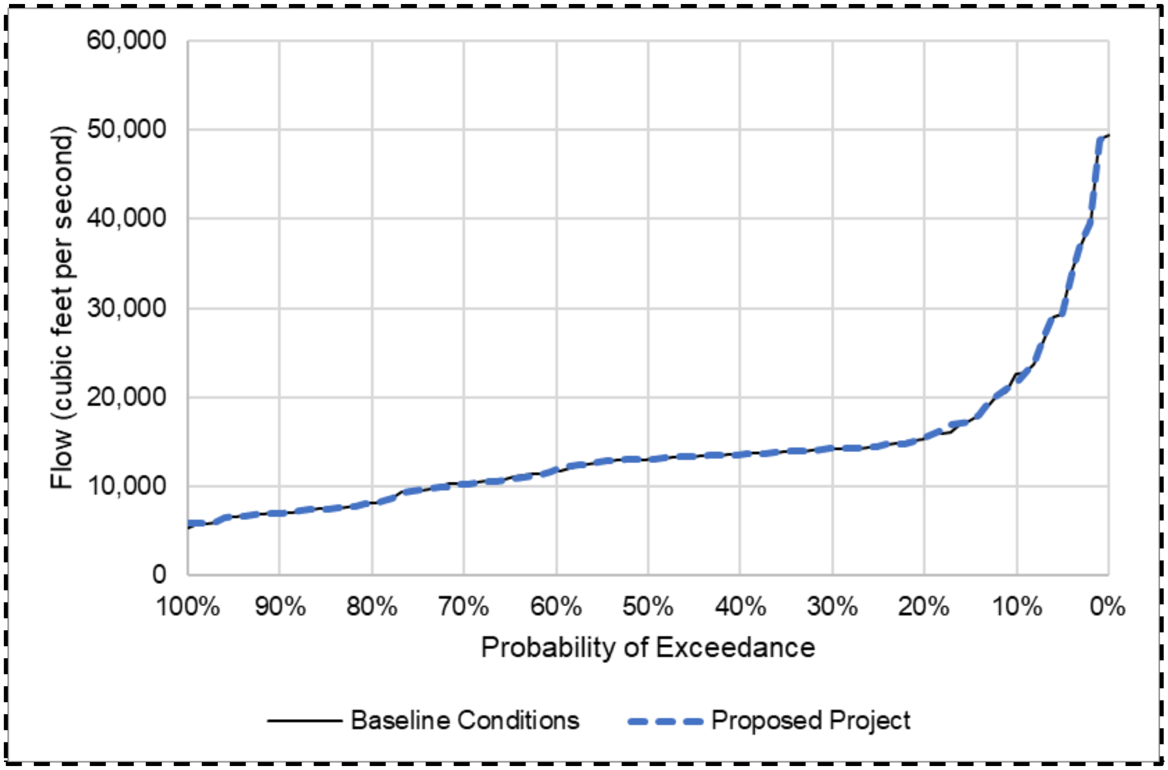
The Proposed Project includes various measures that would limit the potential for significant impacts on Longfin Smelt, including but not limited to entrainment protection, spring Delta outflow, and other measures such as Skinner Fish Facility improvements (see detailed descriptions in Chapter 2). As noted in the analysis presented above, relative to Baseline Conditions, there is the potential for greater entrainment loss of juvenile Longfin Smelt in April/May, but entrainment loss of any life stage would be low in population-level terms. Overall entrainment loss of Longfin Smelt would be limited because of entrainment protections: larval Longfin Smelt entrainment under the Proposed Project would be similar or less than under Baseline Conditions, with conditions preceding spring generally being conducive to a lower proportion of juveniles potentially being in the south Delta and susceptible to entrainment following the larval stage; although OMR flows would be lower (more negative) under the Proposed Project than Baseline Conditions in April/May, OMR flows would be within the protective ranges described in Chapter 2, ranges within which entrainment risk for smelt early life stages is limited (e.g., Smith et al. 2021). As discussed above, recent studies have estimated that south Delta entrainment results in loss of only a small proportion (less than 2 percent) of the life stage most susceptible to south Delta entrainment (i.e., larvae). Based on the analysis presented above (Section 6.4.2.1, "Delta SWP Facility Operations;" Section 6.4.2.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.2.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.2.4, "Delta Smelt Supplementation;" Section 6.4.2.5, "Water Transfers;" Section 6.4.2.6, "Agricultural Barriers;" Section 6.4.2.7, "Barker Slough Pumping Plant;" Section 6.4.2.8, "Clifton Court Forebay Weed Management;" Section 6.4.2.9, "Suisun Marsh Operations;" and Section 6.4.2.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on Longfin Smelt would be less than significant. No mitigation is required.

6.4.3 Winter-Run Chinook Salmon

6.4.3.1 Delta SWP Facility Operations

Immigrating Adults

CalSim modeling suggests that there would be little difference between Baseline Conditions and Proposed Project scenarios in flow entering the Delta in the Sacramento River at Freeport during the main winter/spring period of upstream migration of adult winter-run Chinook Salmon (Figures 6-56, 6-57, 6-58, 6-59, 6-60, 6-61, 6-62, and 6-63). Evidence from the Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon were very low (<1 percent) during the period from 1979 through 2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low. This, coupled with the similarity in flow entering the Delta between Baseline Conditions and the Proposed Project scenarios, suggests that there would be little potential for differences in rates of straying of adult winter-run Chinook Salmon between the Baseline Conditions and Proposed Project scenarios.



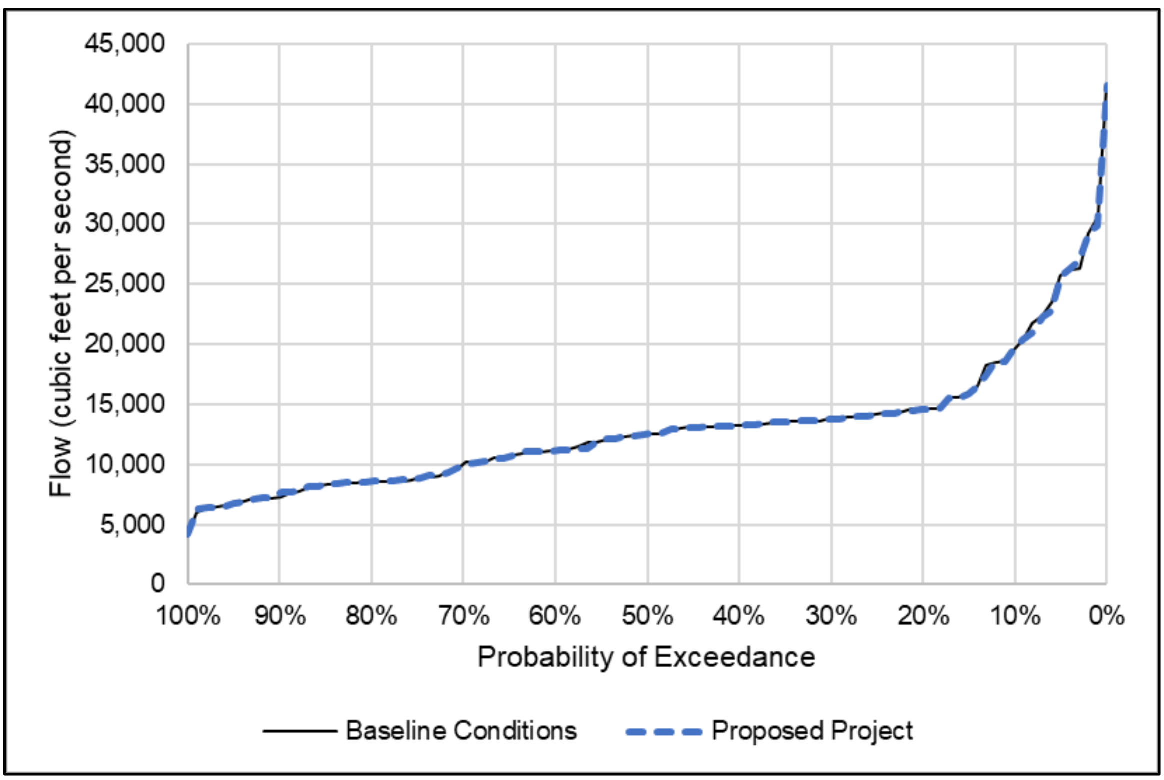


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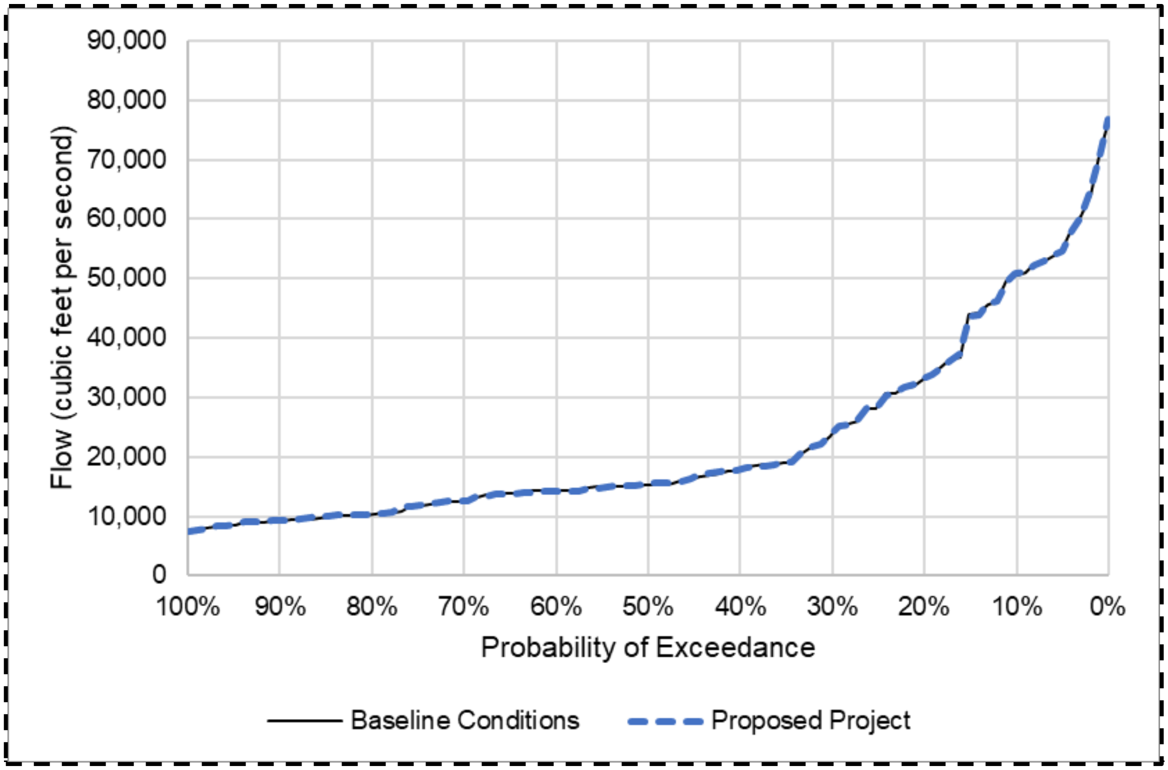
Figure 6-56. Mean Modeled Sacramento River Flow at Freeport, November



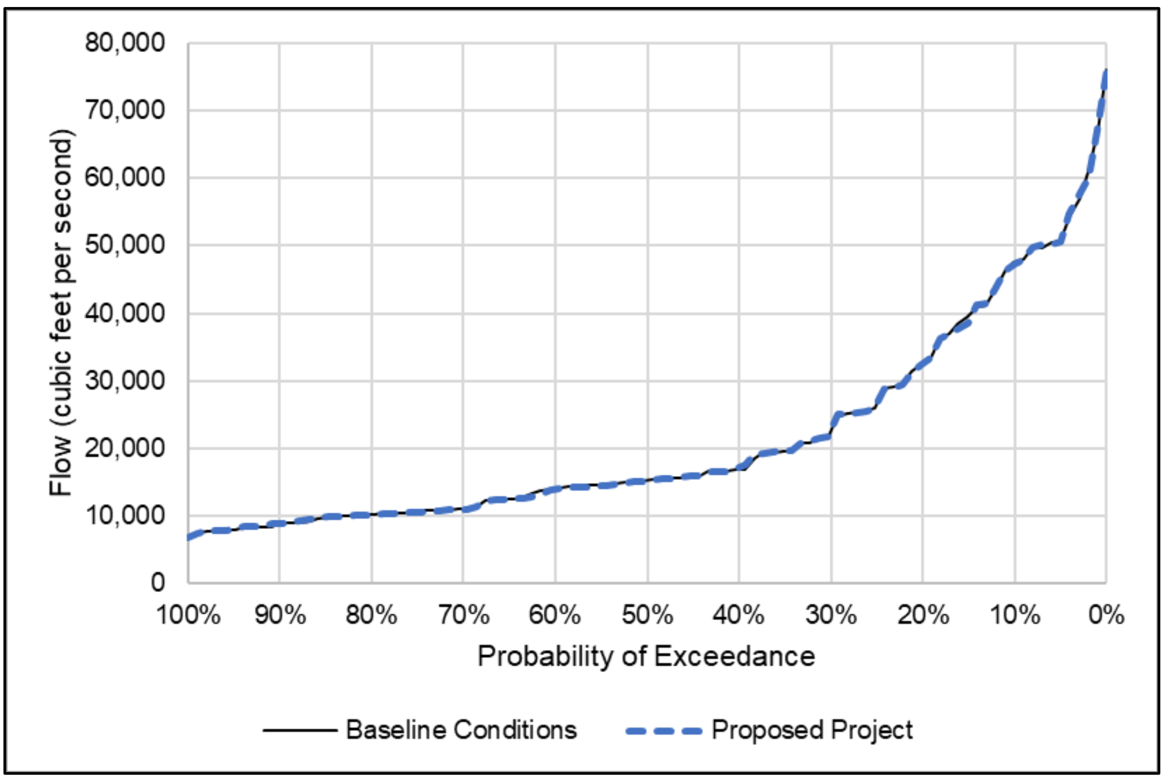


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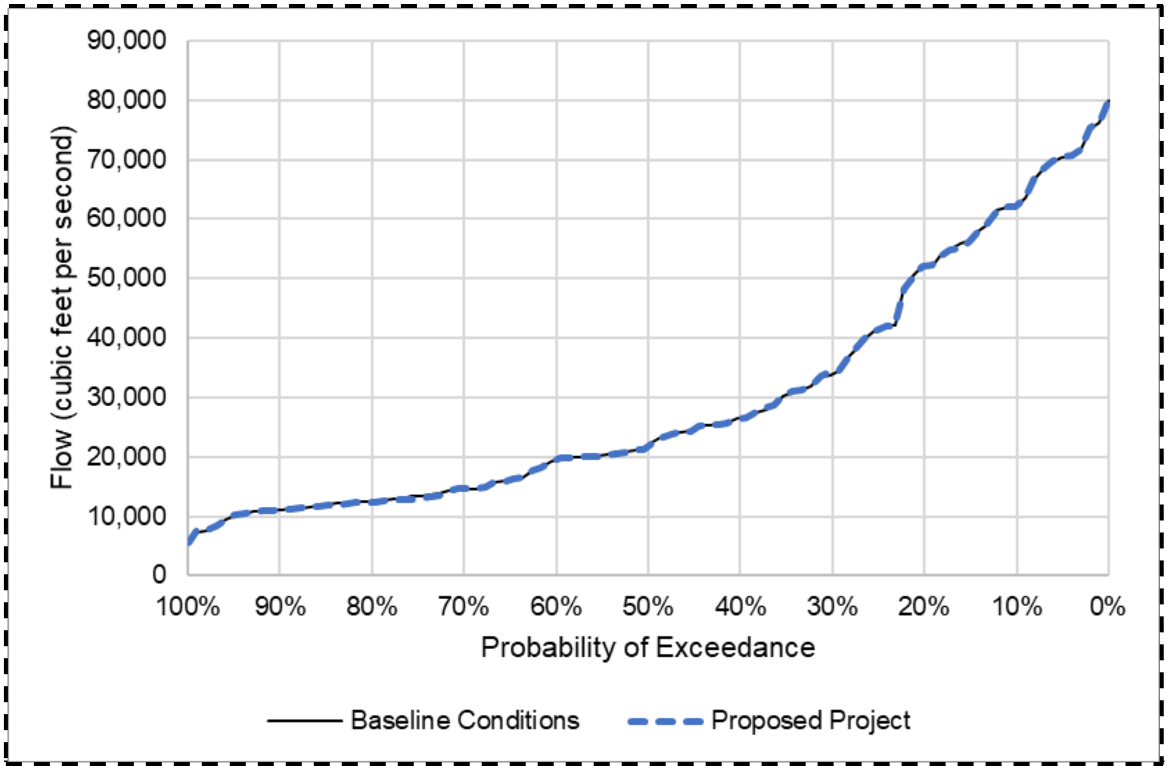
Figure 6-57. Mean Modeled Sacramento River Flow at Freeport, December



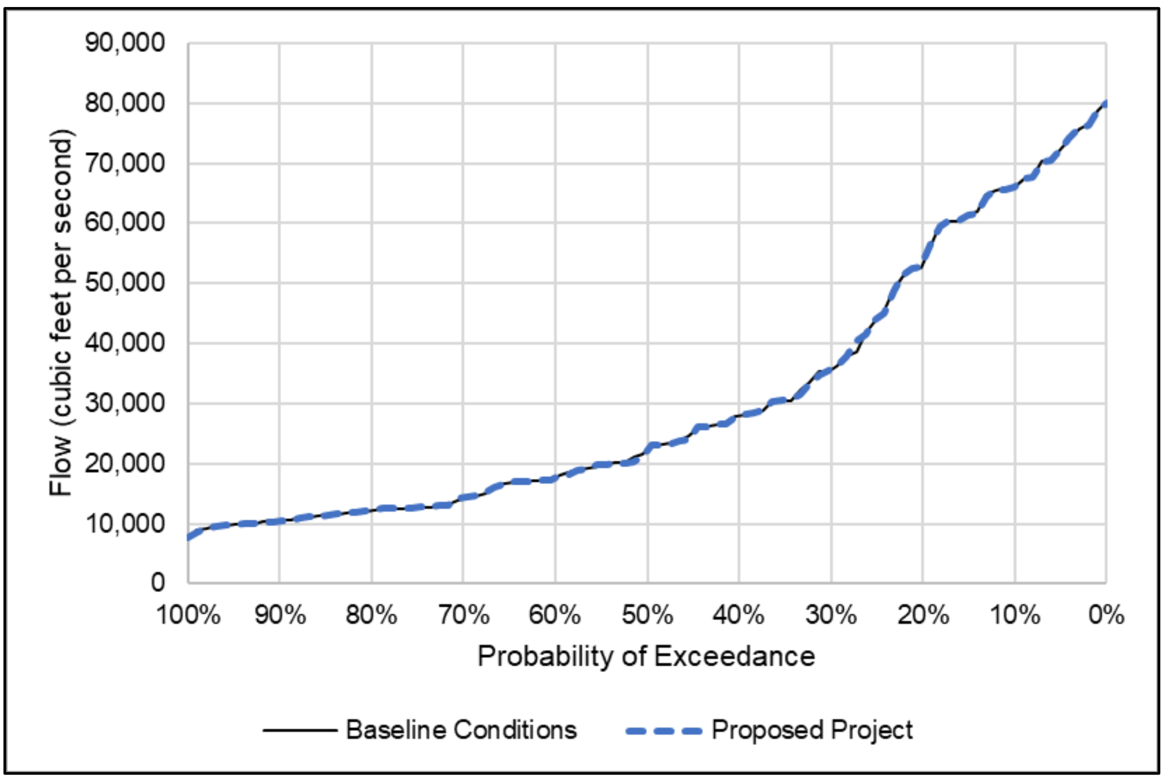


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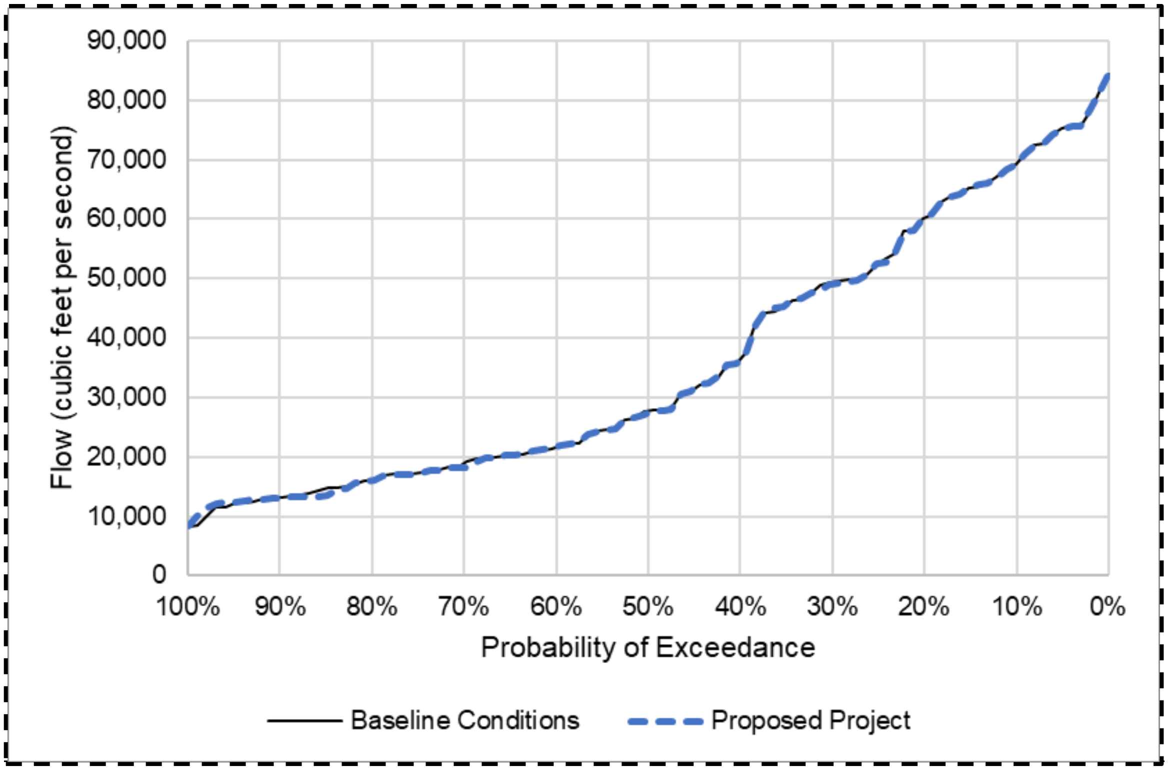
Figure 6-58. Mean Modeled Sacramento River Flow at Freeport, January



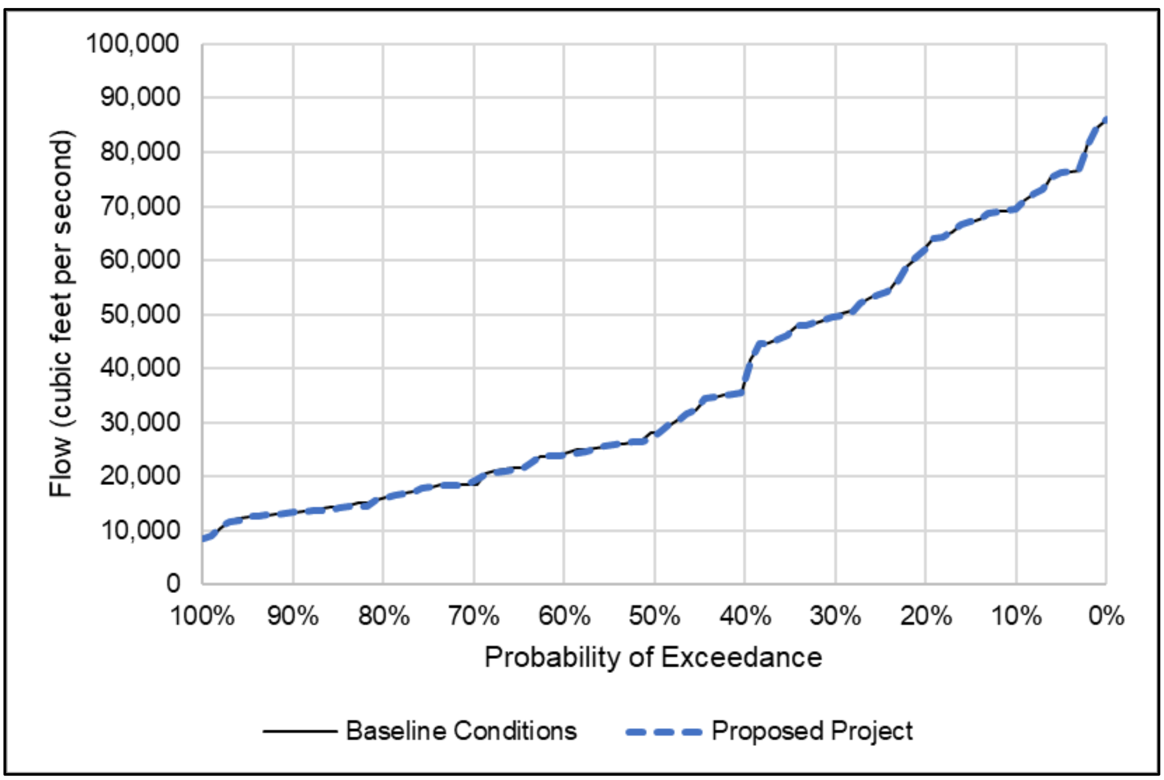


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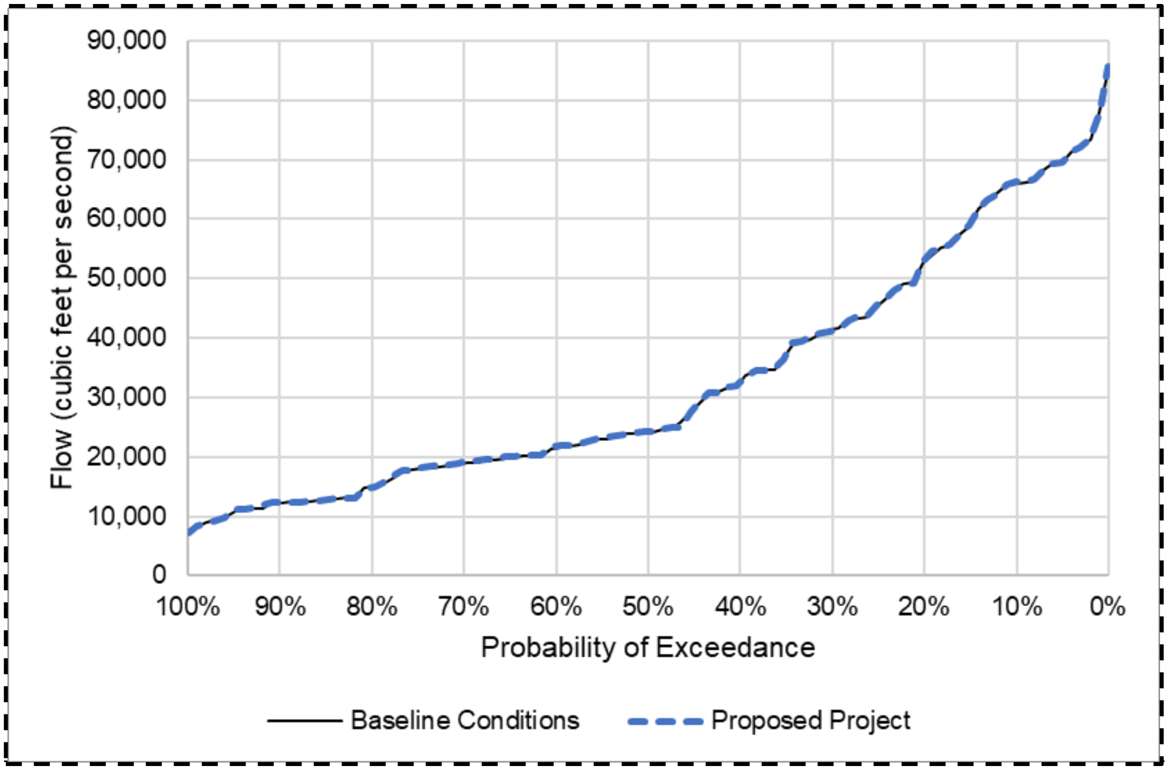
Figure 6-59. Mean Modeled Sacramento River Flow at Freeport, February



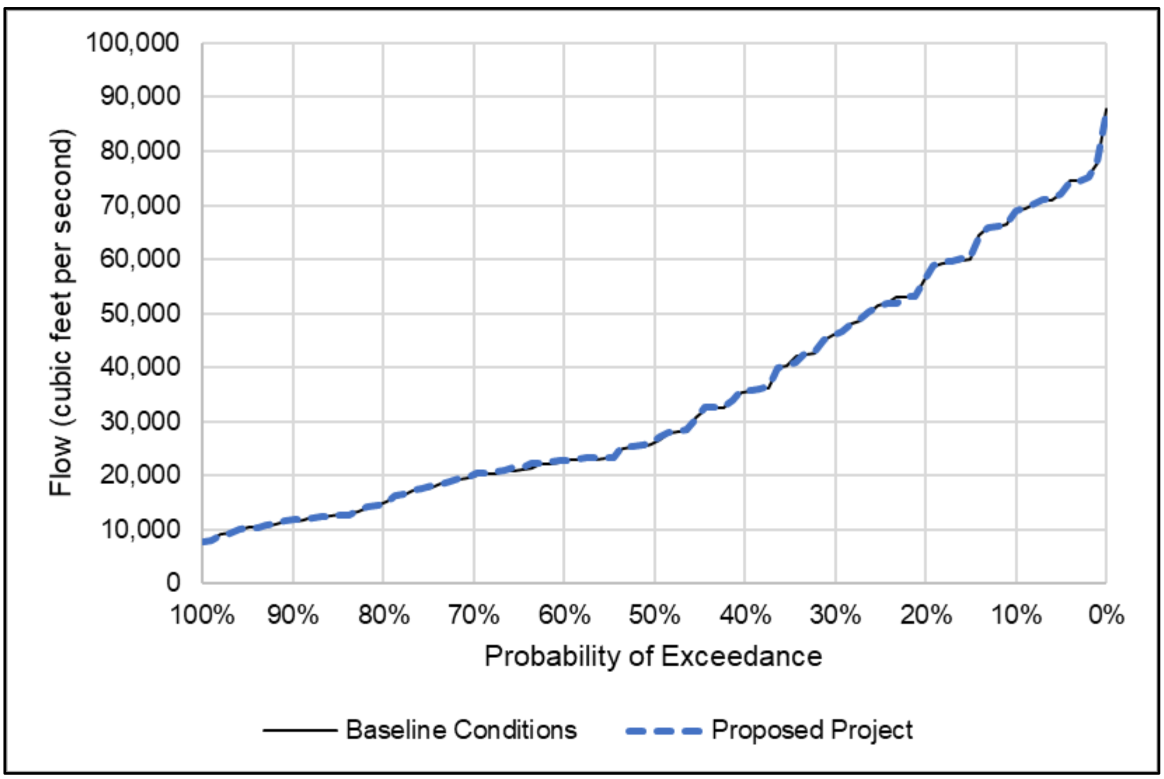


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Figure 6-60. Mean Modeled Sacramento River Flow at Freeport, March

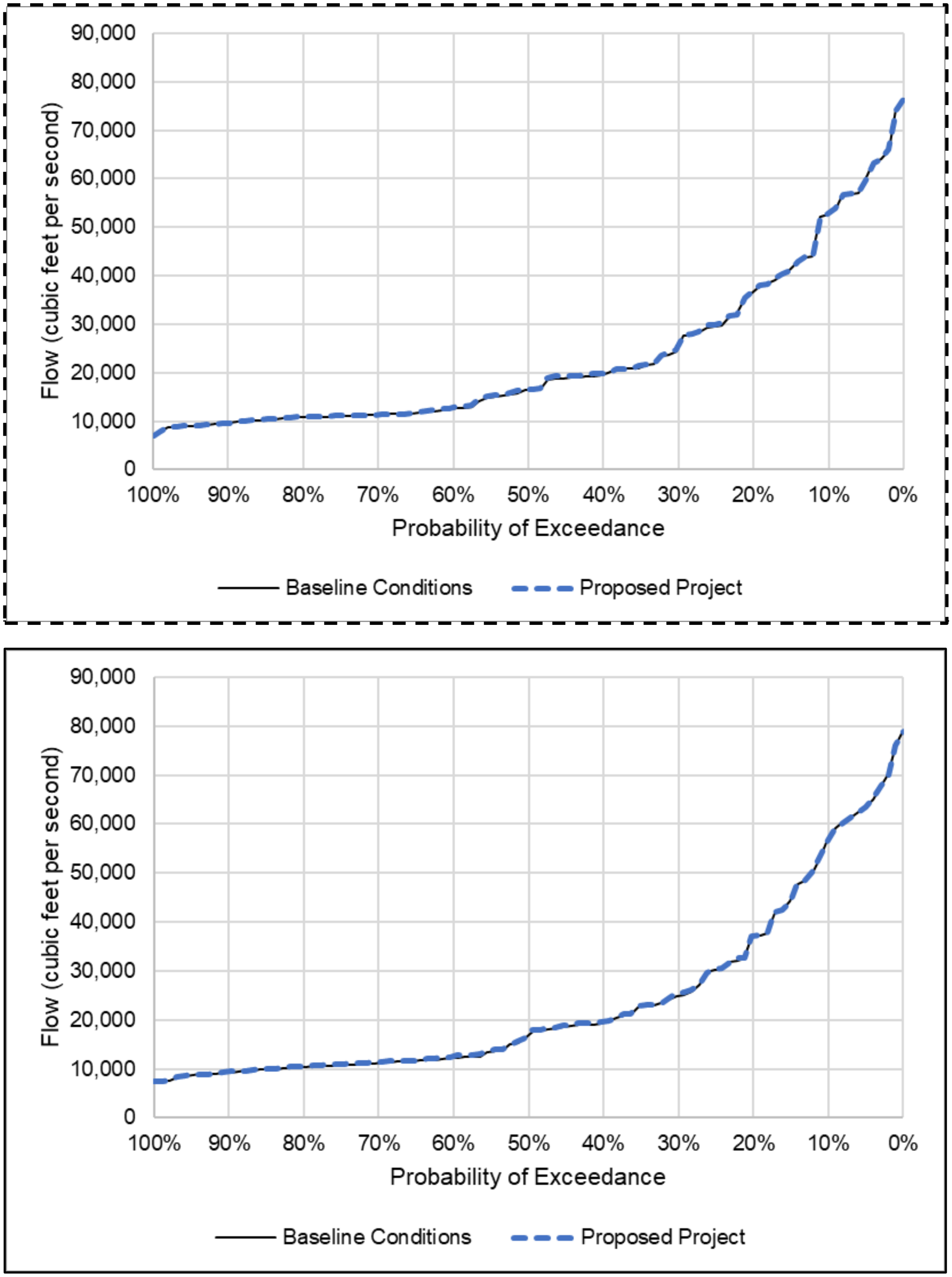

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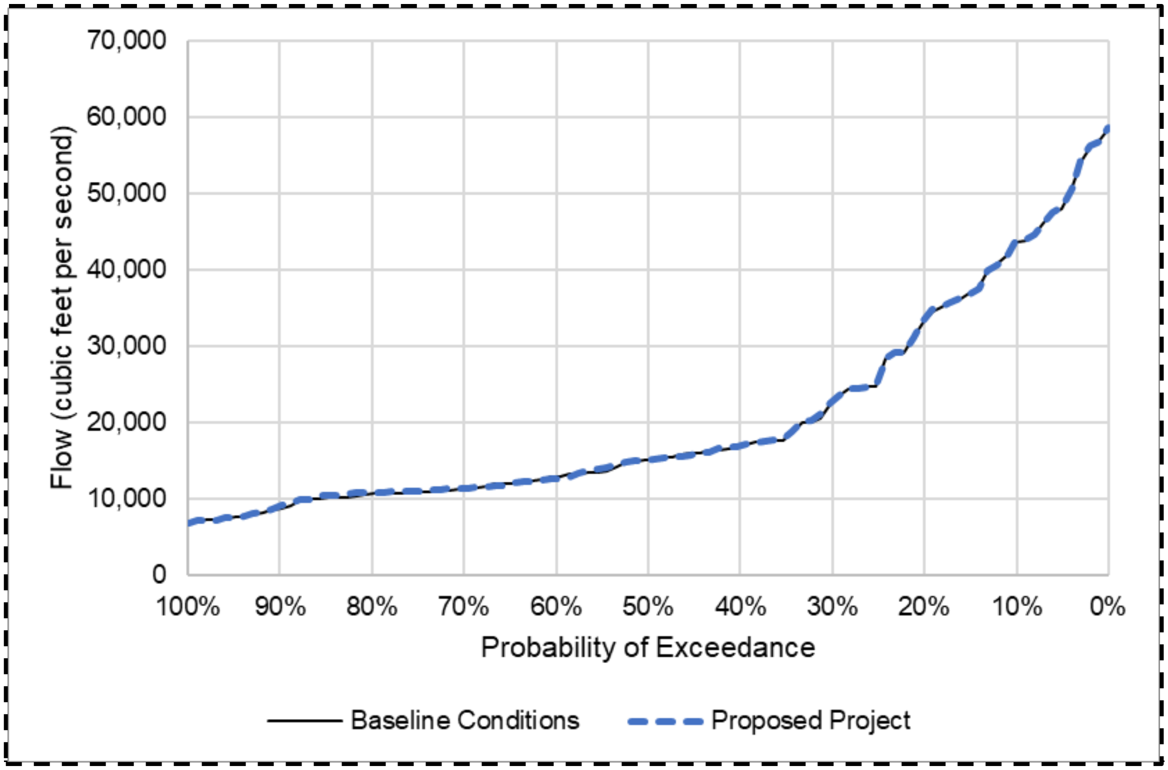
Figure 6-61. Mean Modeled Sacramento River Flow at Freeport, April



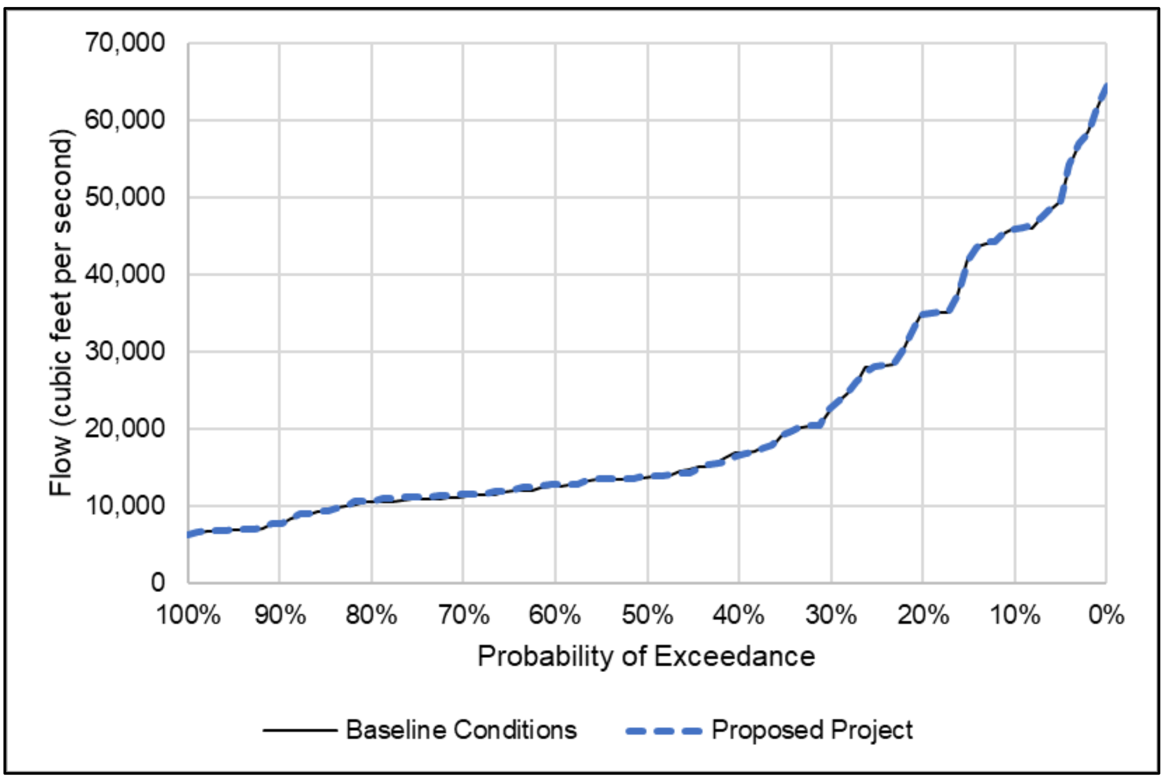


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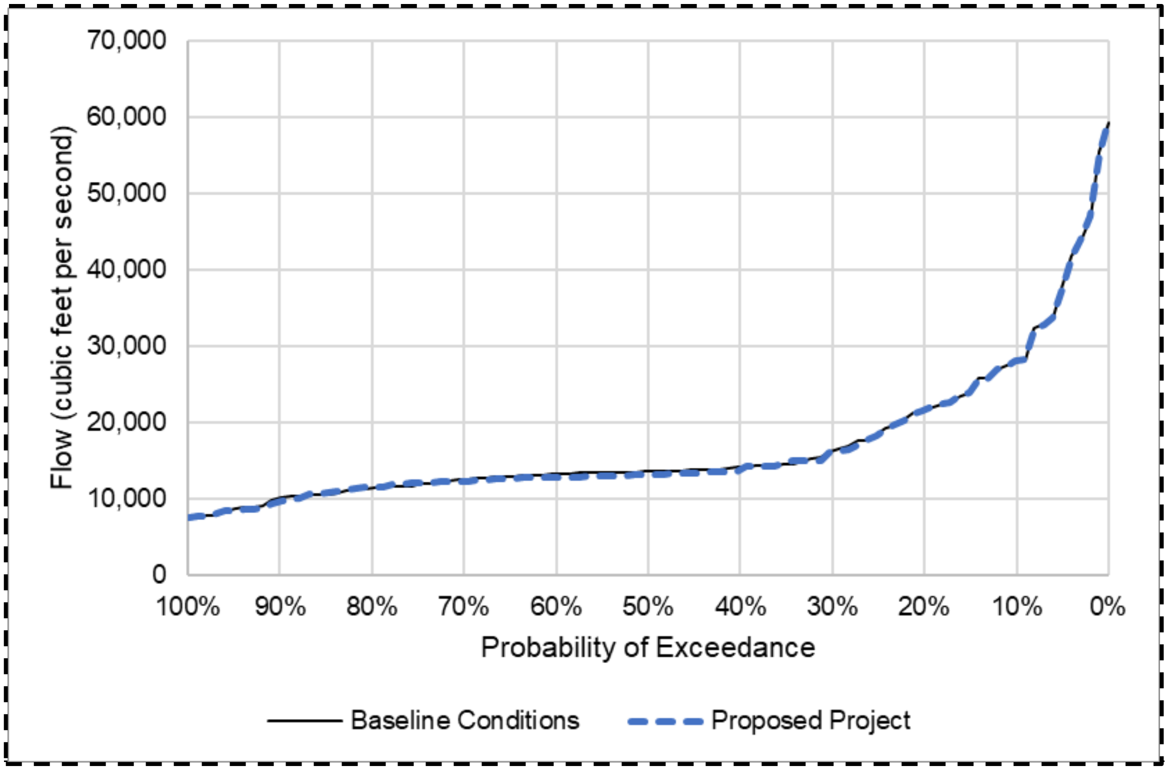
Figure 6-62. Mean Modeled Sacramento River Flow at Freeport, May



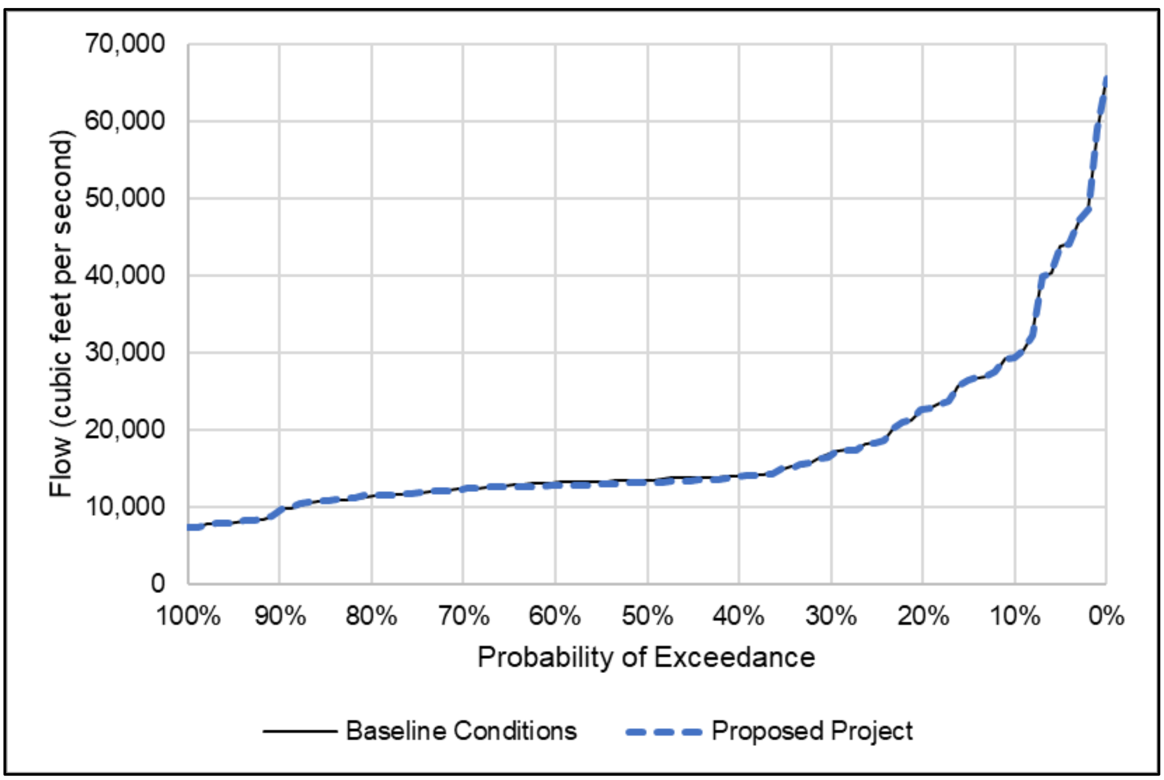


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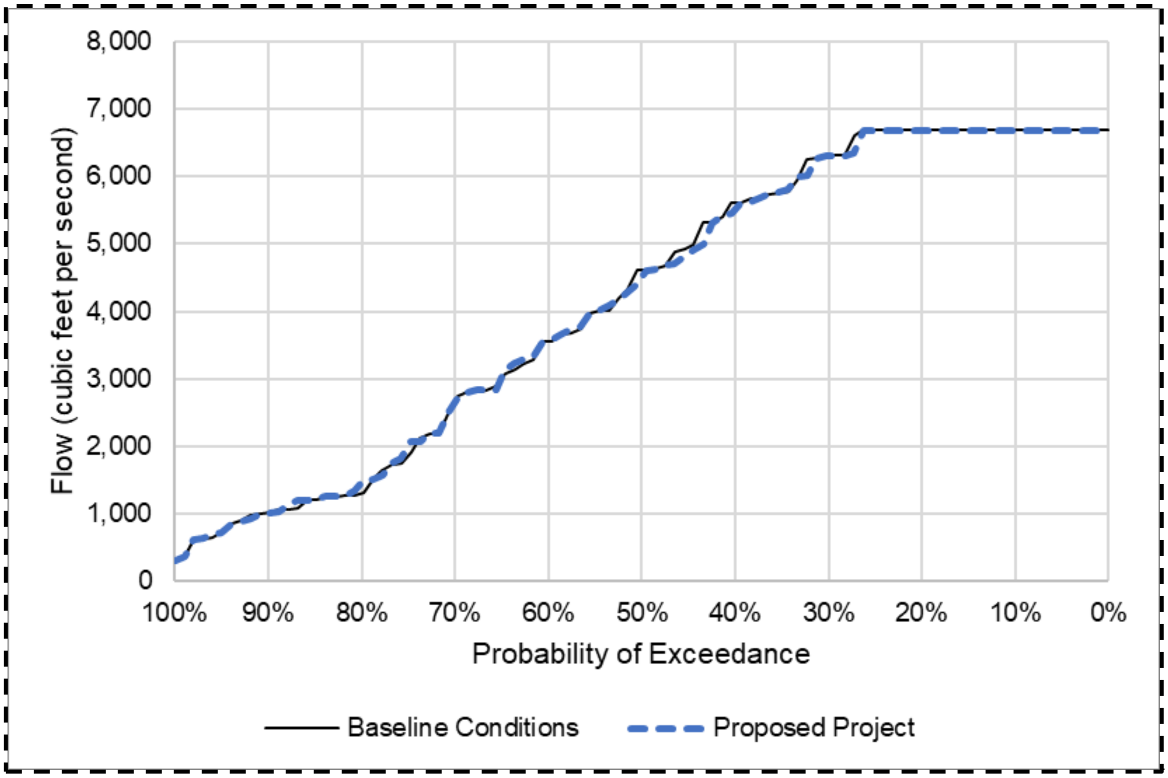
Figure 6-63. Mean Modeled Sacramento River Flow at Freeport, June

In addition to juvenile winter-run Chinook Salmon discussed in "Outmigrating Juveniles," adult winter-run Chinook Salmon are also subject to entrainment at the south Delta export facilities (California Department of Fish and Wildlife 2020b, Attachment 8:60–63). For example, it is estimated that 466 adult Chinook Salmon[12] were salvaged during 1993–2018 (i.e., an annual mean of ~18 fish), all during the months of September through May, with highest salvage in November, December, and March, which overlaps with adult winter-run Chinook Salmon occurrence in the Delta (California Department of Fish and Wildlife 2020b, Attachment 8:60–63; Table 2-3 in Chapter 2 shows January–March as the main period of occurrence in a broader November–June period of possible occurrence). SWP South Delta exports generally would be similar under the Proposed Project and Baseline Conditions during this time period, with somewhat lower exports under the Proposed Project in March and greater exports under the Proposed Project in April and May (Figures 6-64, 6-65, 6-66, 6-67, 6-68, 6-69, 6-70, 6-71). This indicates entrainment risk for adult winter-run Chinook Salmon under the Proposed Project generally would be similar to Baseline Conditions, with potentially marginally less risk in March (during the period of highest occurrence; Table 2-3 in Chapter 2) and greater risk in April/May. However, given the low numbers of adult Chinook Salmon salvaged historically, any positive or negative differences in entrainment loss between the Proposed Project and Baseline Conditions would be limited in terms of the numbers of fish involved (i.e., likely single digits).

[12] Salvaged Chinook Salmon are classified as adults when more than 300-mm fork length.



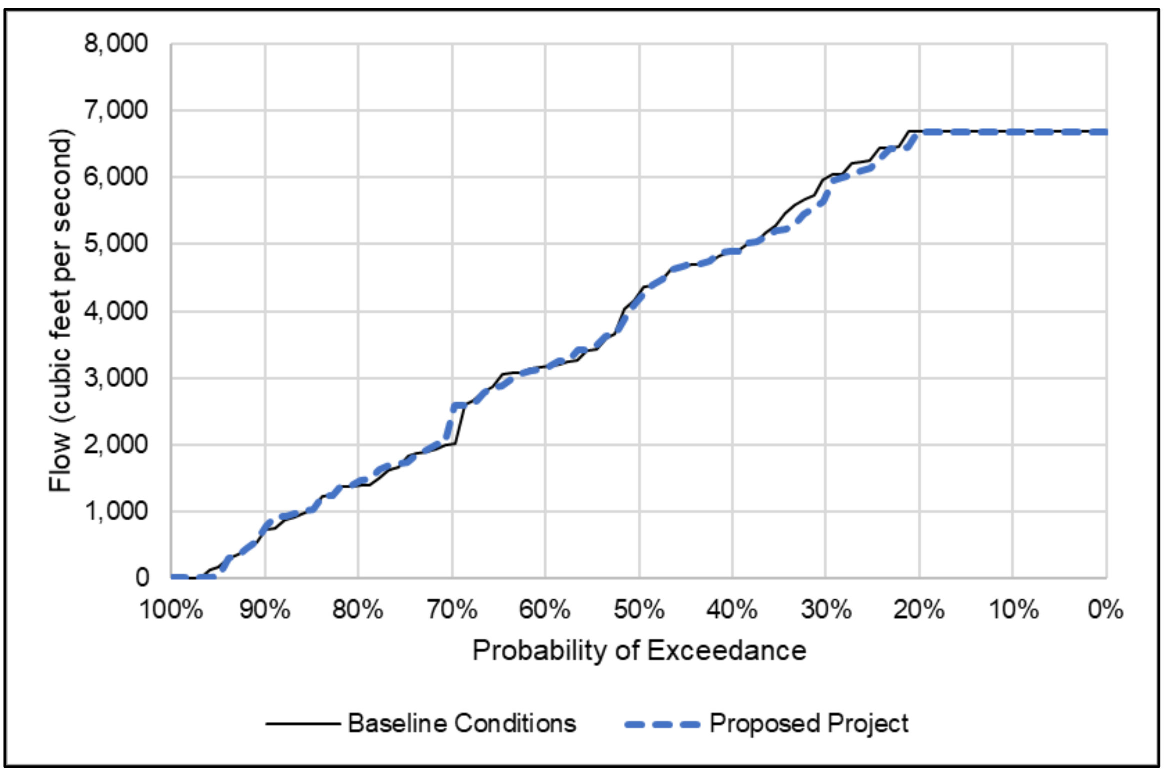


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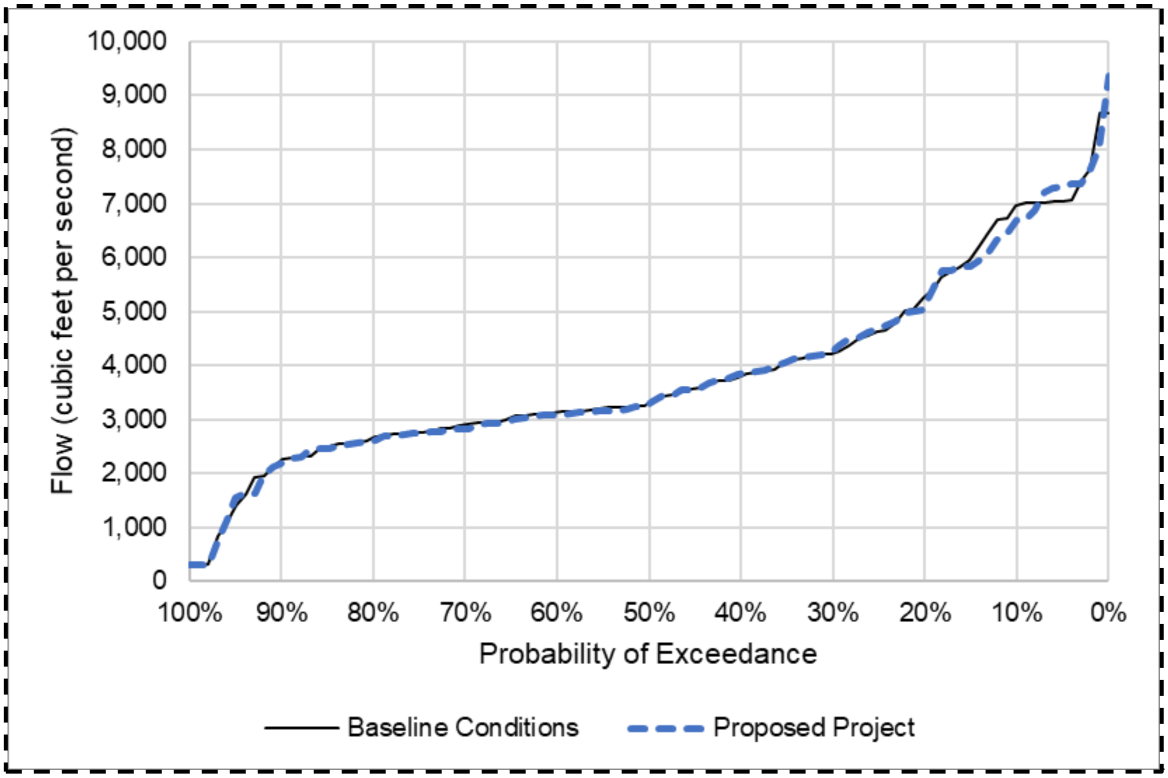
Figure 6-64. Mean Modeled SWP South Delta Exports, November



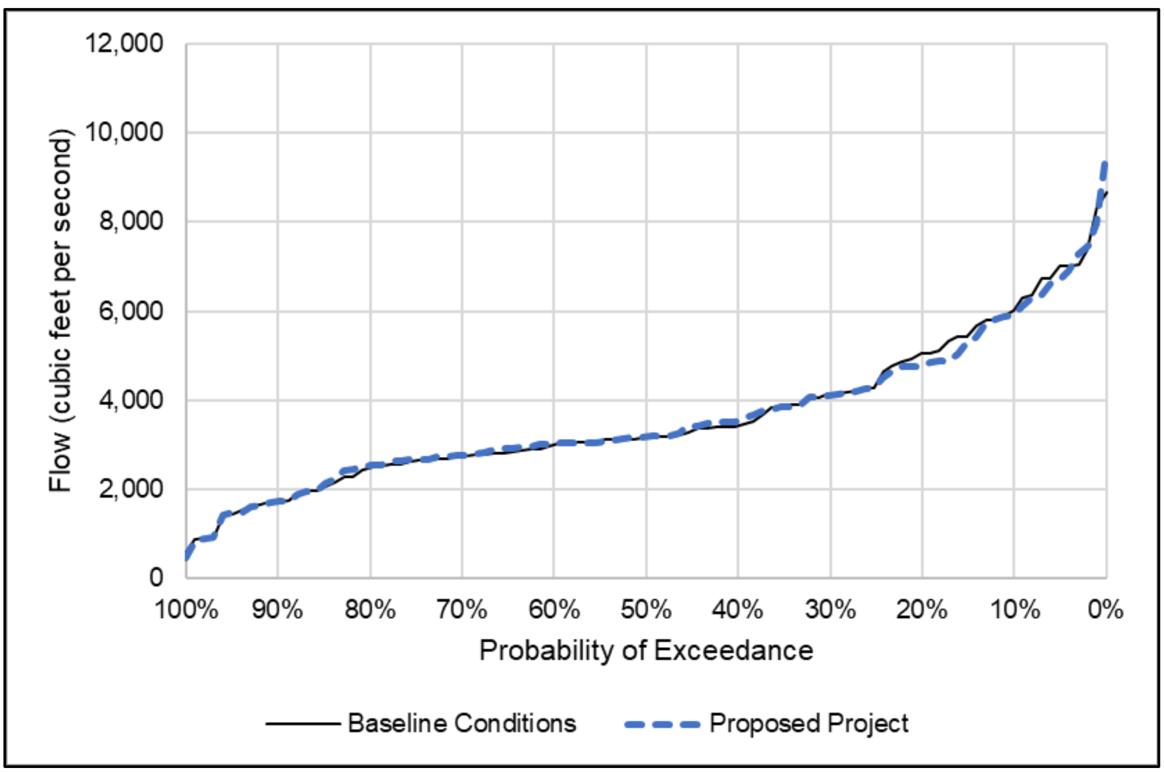


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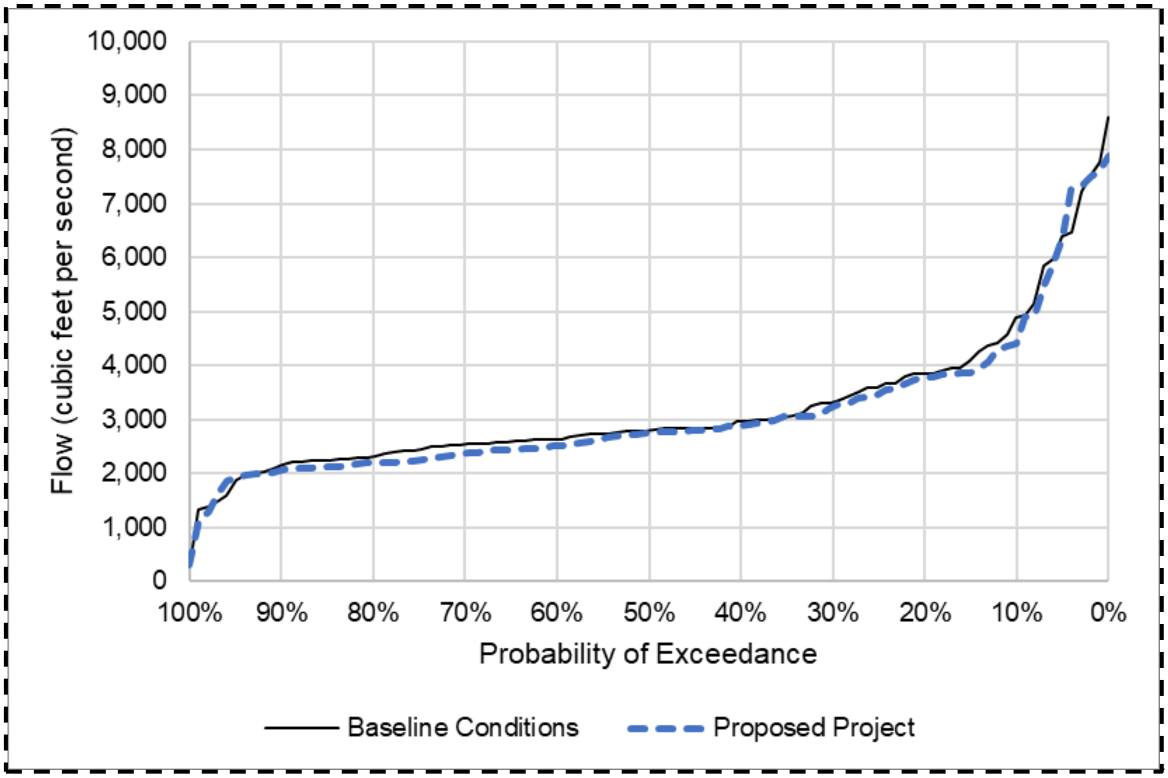
Figure 6-65. Mean Modeled SWP South Delta Exports, December



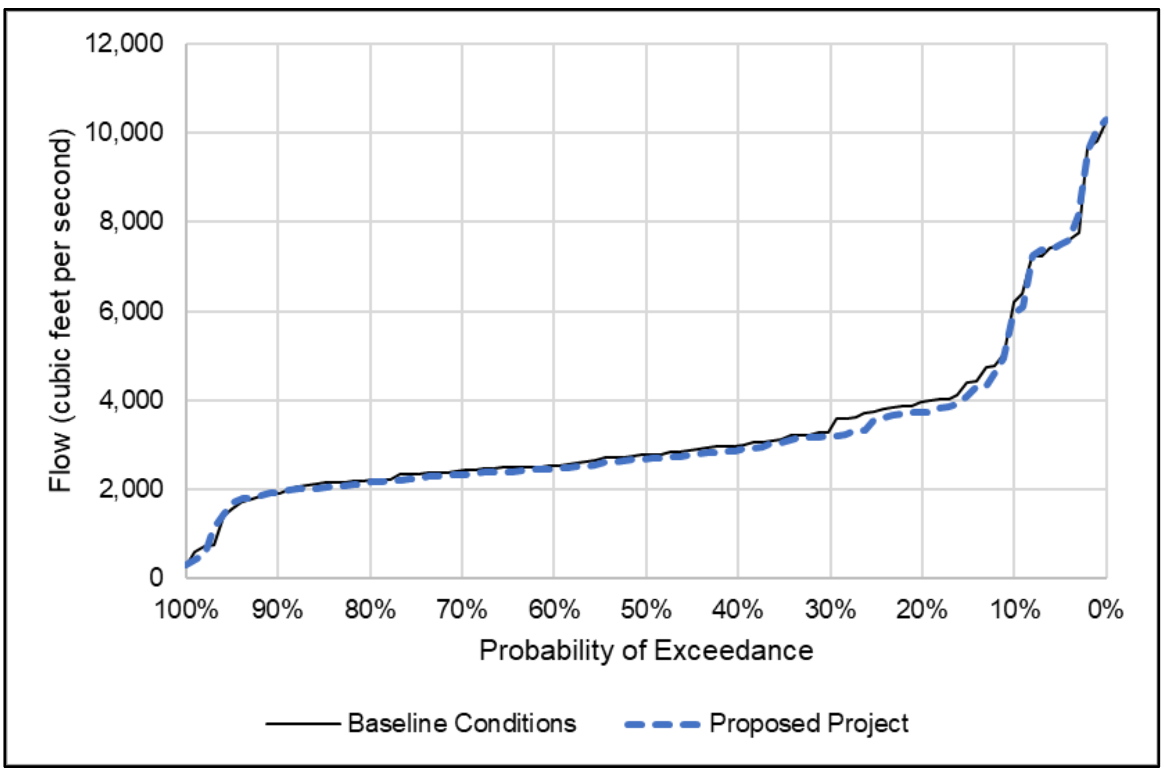


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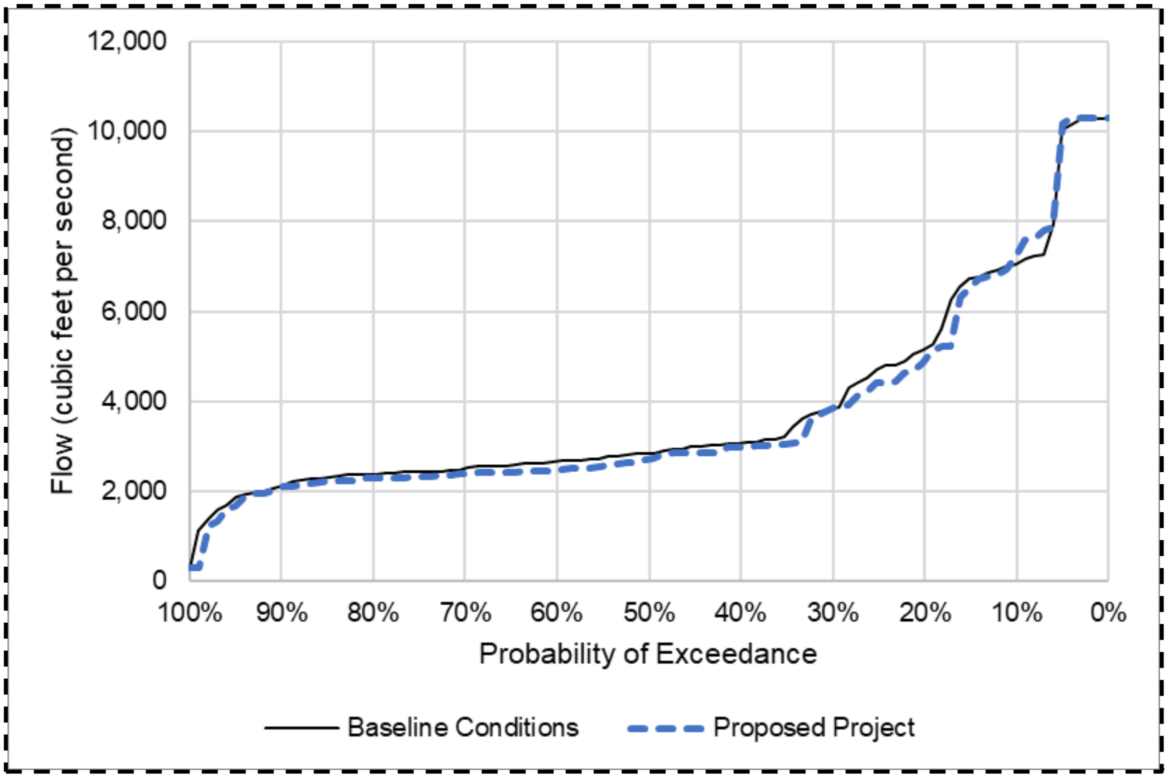
Figure 6-66. Mean Modeled SWP South Delta Exports, January



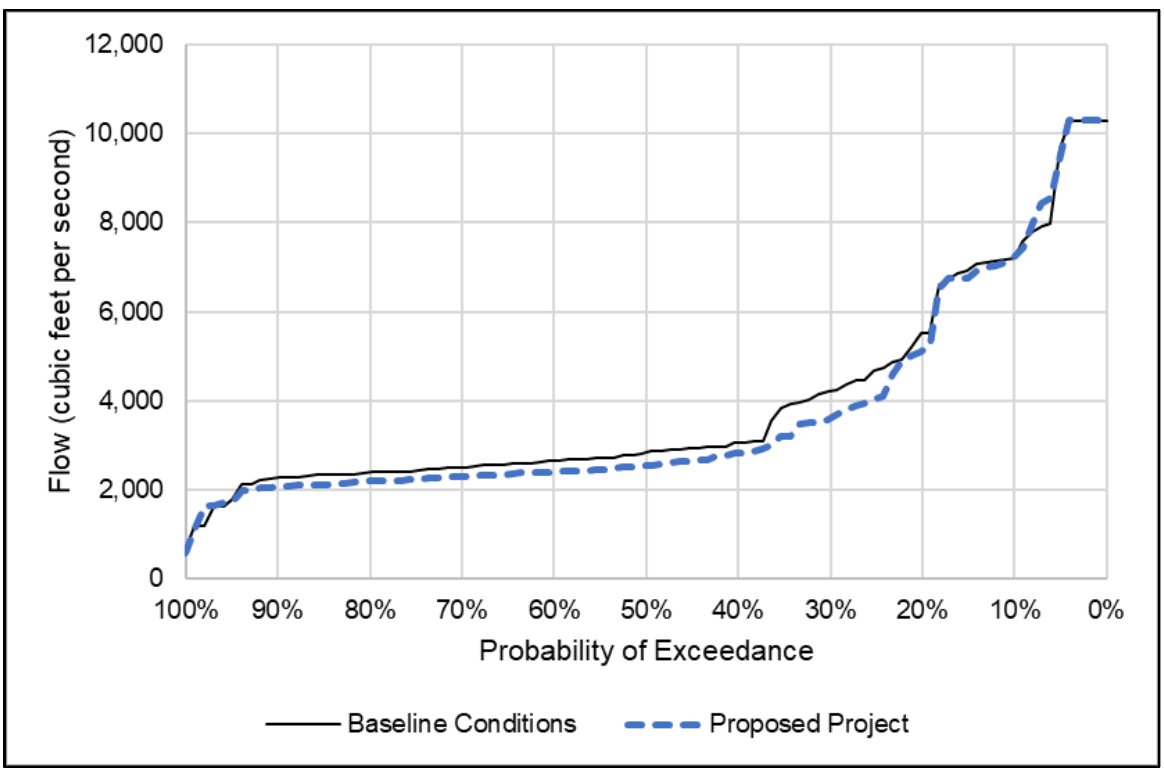


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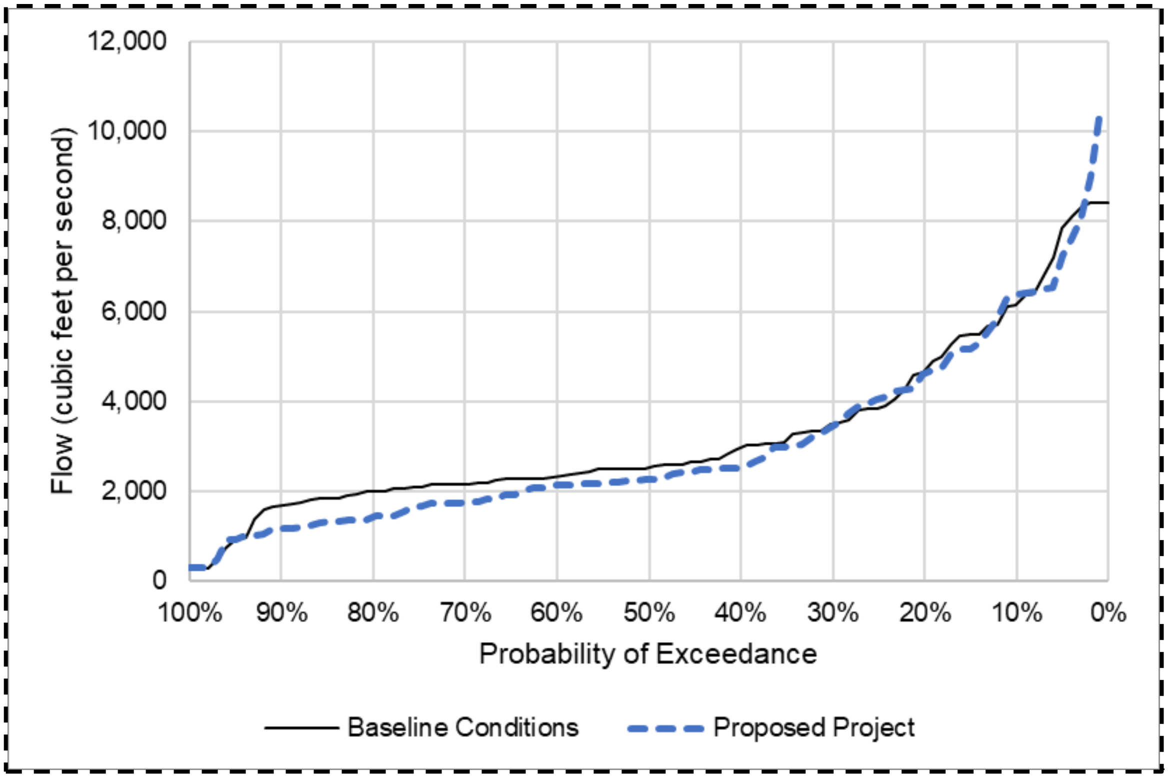
Figure 6-67. Mean Modeled SWP South Delta Exports, February



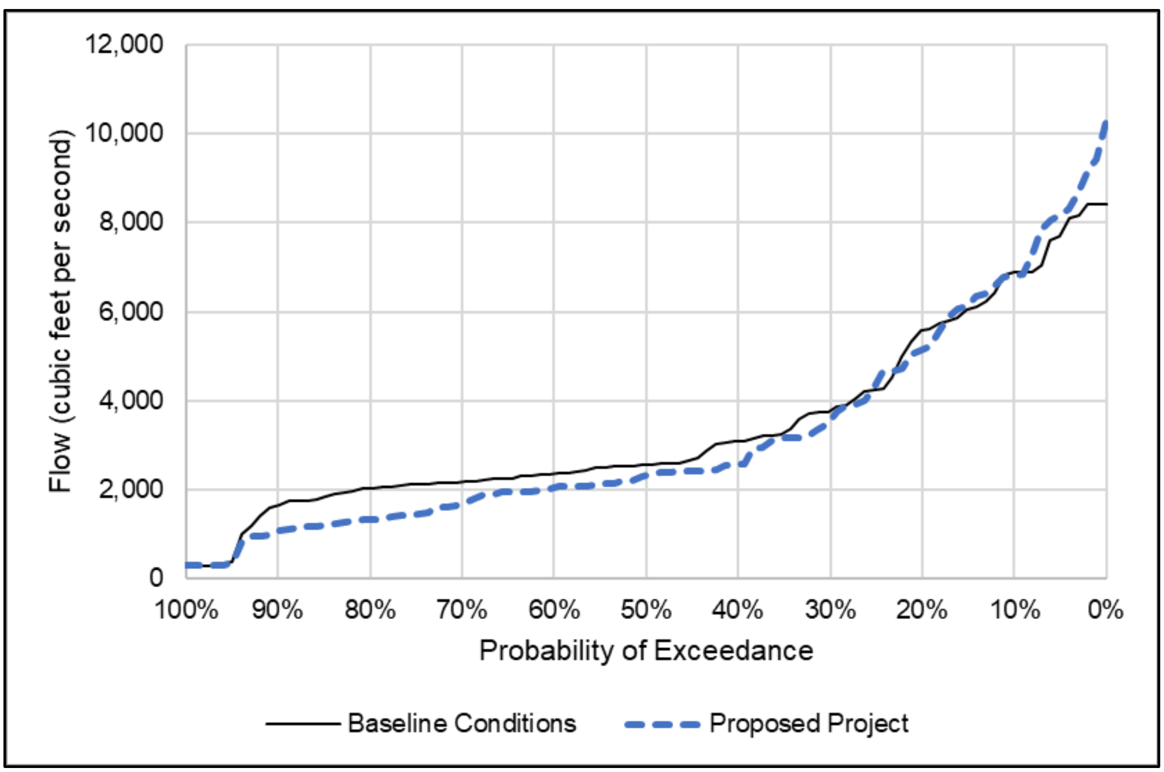


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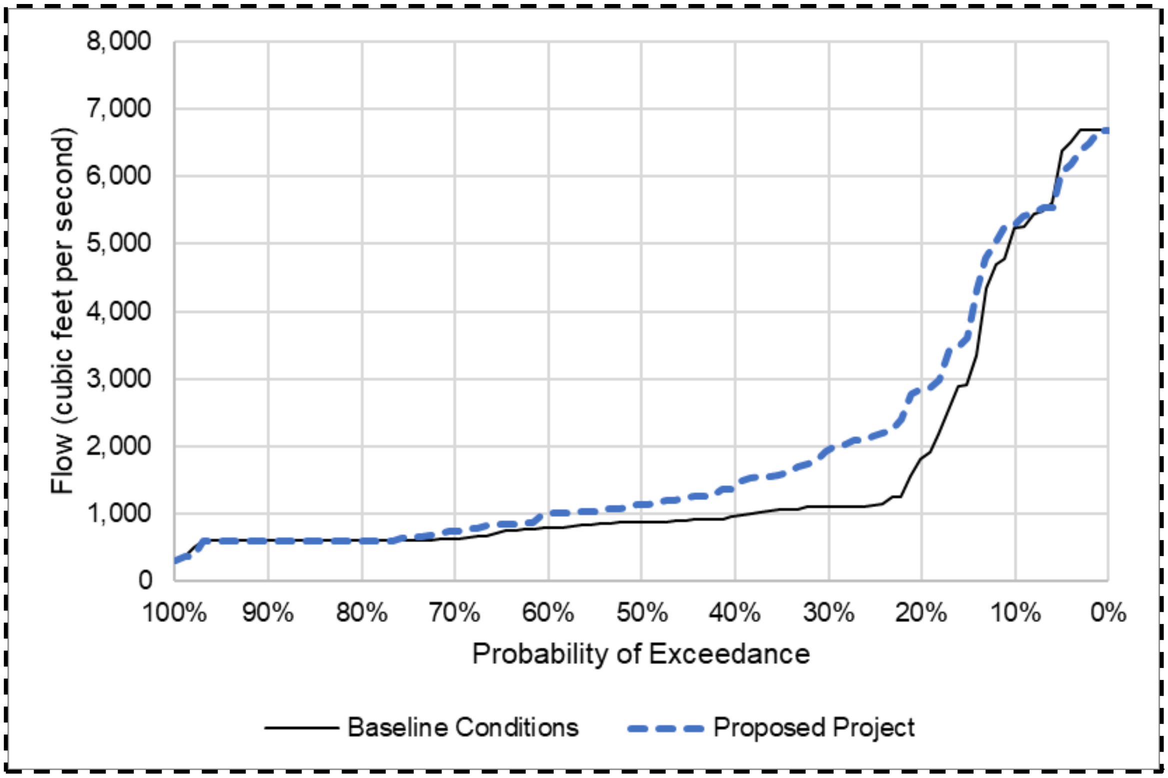
Figure 6-68. Mean Modeled SWP South Delta Exports, March



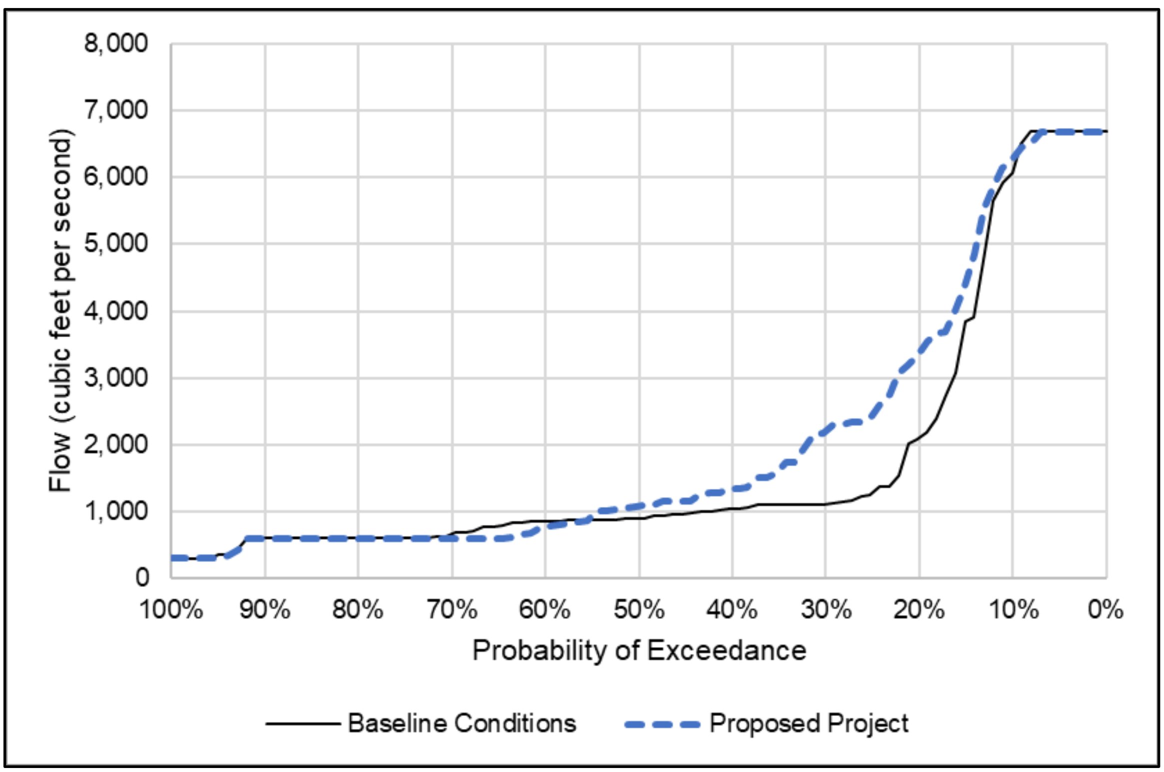


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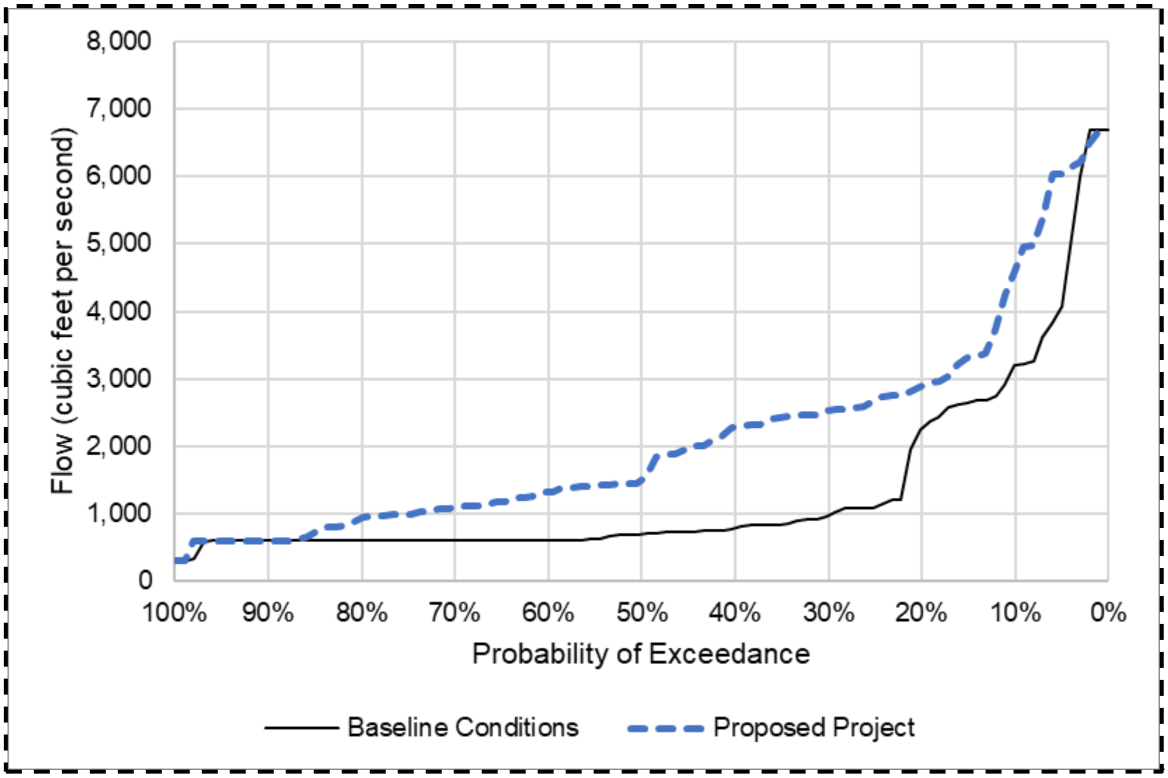
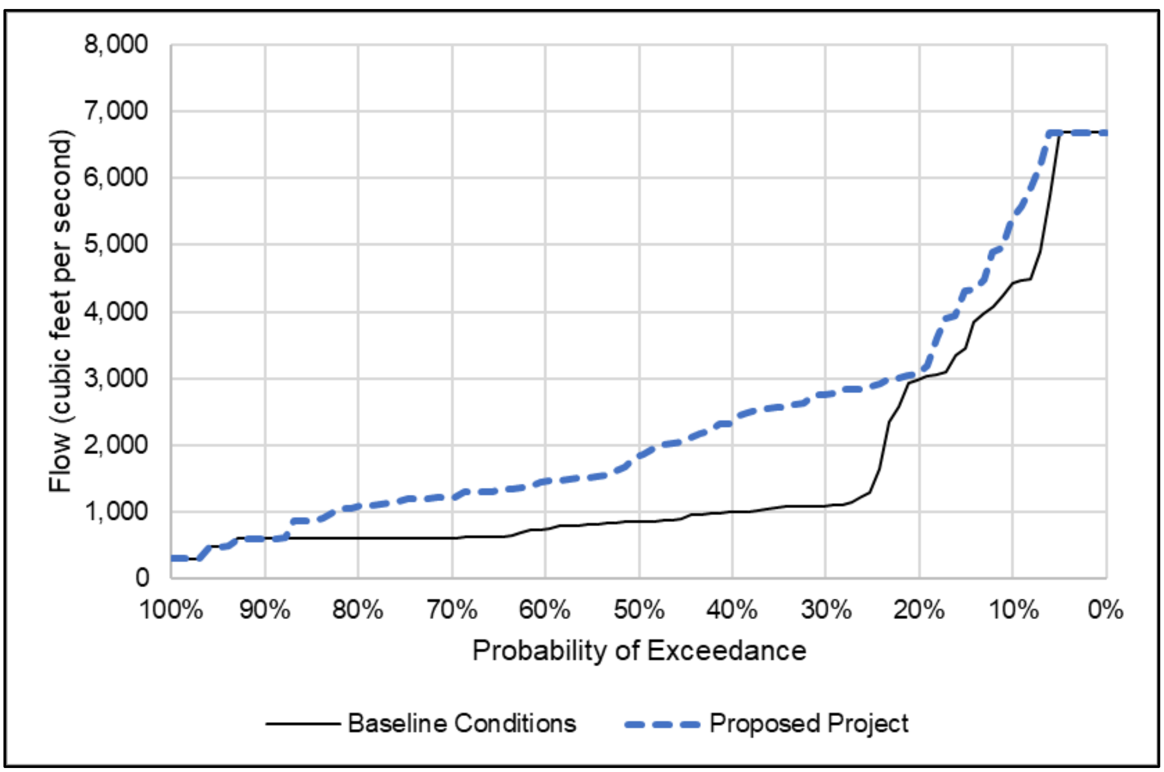
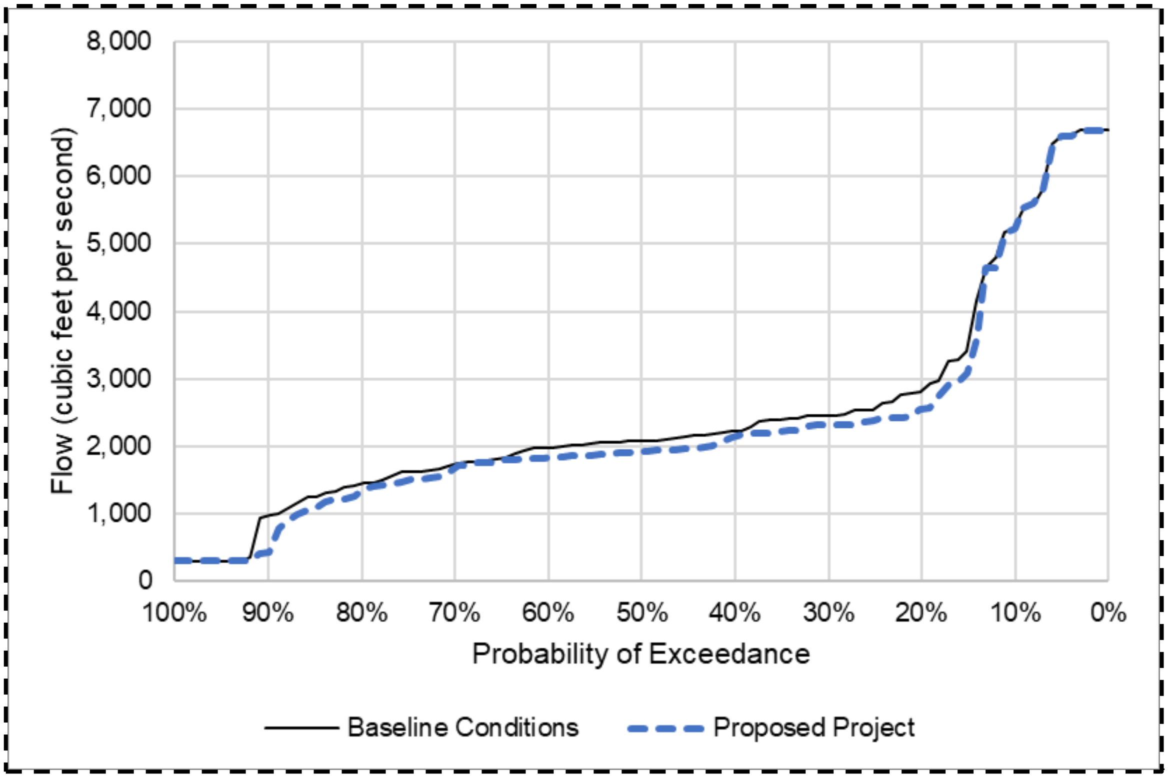
Figure 6-69. Mean Modeled SWP South Delta Exports, April





Source: ~~<DRAFT_TrendReport_MultiCalSim_rev11_NoMacro_S1_S7_S7v2_S9b_S9bv2.xlsm>~~ <DRAFT_TrendReport_MultiCalSim_rev12_FEIR_1_9bv2_12av2_7.23.xlsx>.

Figure 6-70. Mean Modeled SWP South Delta Exports, May



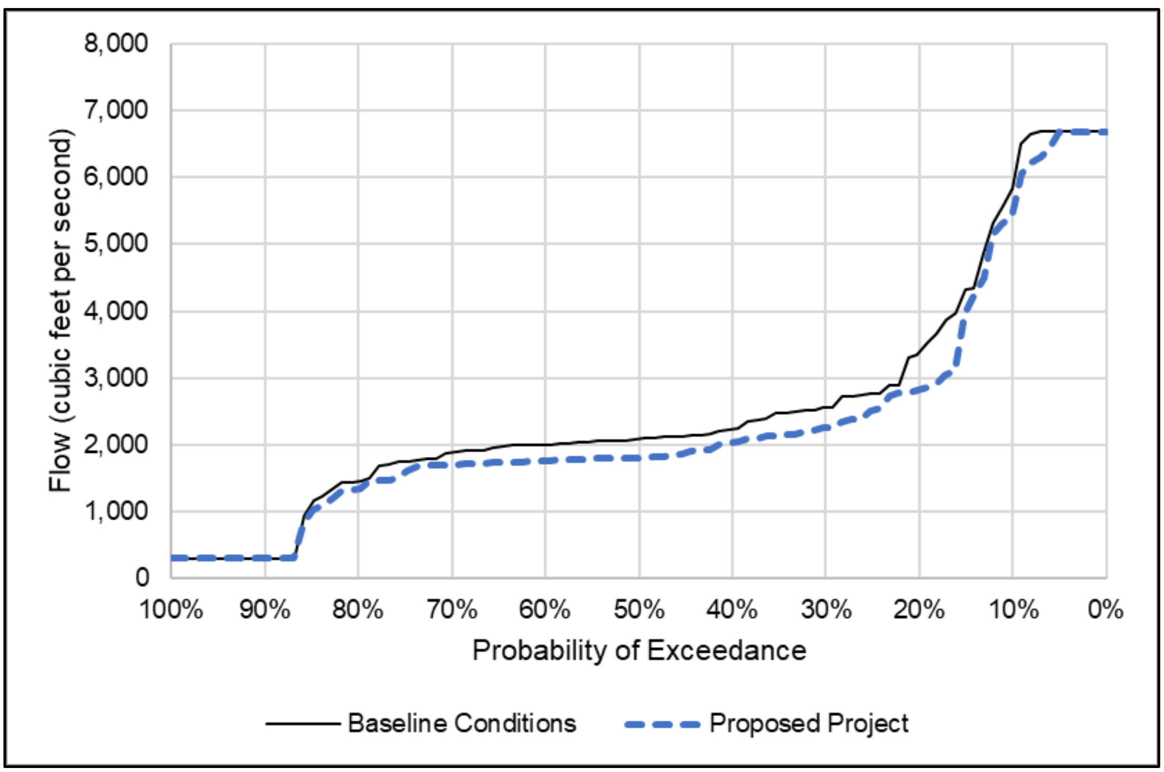


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Figure 6-71. Mean Modeled SWP South Delta Exports, June

Outmigrating Juveniles

Entrainment

Salvage-Density Method

To provide perspective on potential differences in entrainment loss of winter-run Chinook Salmon juveniles between the Baseline Conditions and Proposed Project scenarios, the salvage-density method was used (see Appendix 6B, Section 6B.1, "Salvage-Density Method"). This analysis was based on loss of genetically identified and coded wire tagged juvenile winter-run Chinook Salmon.[13] The estimates of entrainment loss obtained from the salvage-density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim 3-modeled differences in SWP exports between Baseline Conditions and Proposed Project scenarios; the results are basically a description of differences in export flows weighted by historical monthly loss density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained, but these data are more so a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected.[14] Although the emphasis is consideration of the relative difference between scenarios, it is important to appreciate that the modeling is limited in its representation of real-time adjustments to operations in order to minimize effects on listed fishes, so differences between scenarios are likely to be less than suggested by the method.

The salvage-density method suggested that entrainment loss of juvenile winter-run Chinook Salmon at the SWP south Delta export facility would be similar between Baseline Conditions and Proposed Project scenarios (~~Table 6-33~~ Tables 6-33 and 6-34). Most winter-run Chinook Salmon entrainment largely occurs prior to the April–May period when the largest difference in south Delta exports is projected to occur between Baseline Conditions and Proposed Project scenarios. Entrainment management through criteria described in Chapter 2, including Winter-Run Chinook Salmon Early Season Migration, Winter-Run Chinook Salmon Annual Loss Threshold, and Winter-Run Chinook Salmon Weekly Distribution Loss Threshold, would be expected to maintain low levels of entrainment observed in recent years, i.e., considerably less than ESA-authorized take (~1 percent of genetic winter-run juveniles entering the Delta), as has occurred with the NMFS (2019) BiOp and CDFW (2020b) ITP (Islam et al. 2020, 2021, 2022).

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[13] The effects analysis for the 2019 ITP Application and 2020 EIR used length-at-date loss density estimates, for which water year type monthly means during 2010–2022 averaged 84 percent more than the corresponding genetic loss density estimates. This illustrates that the absolute effect is considerably less than was permitted under the 2020 ITP.

[14] The loss density estimates reflect the regulatory accepted multipliers for estimating loss as a function of observed salvage; it is acknowledged herein that loss is likely to vary from the regulatory multipliers, for example as illustrated by historical and recent studies of prescreen loss in CCF (Gingras 1997; Miranda 2019), but it is assumed that loss density provides a reasonable depiction of seasonal patterns in entrainment from which to weight modeled exports for comparison of the Baseline Conditions and Proposed Project scenarios.

Table 6-33. Mean Number of Genetically Identified Winter-run Chinook Salmon Juveniles Lost (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~806~~ 838	~~824 (2%)~~ 869 (4%)
Above Normal	N/A	(-9%)
Below Normal	~~571~~ 596	~~473 (-17%)~~ 484 (-19%)
Dry	~~103~~ 108	~~92 (-10%)~~ 85 (-22%)
Critically Dry	~~10~~ 9	~~11 (13%)~~ 10 (9%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2010–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-1 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table 6-34. Mean Number of Coded Wire Tagged Winter-run Chinook Salmon Juveniles Lost (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Metho d

Water Year Type	Baseline Conditions	Proposed Project
Wet	0	0 (0%)
Above Normal	N/A	(0%)
Below Normal	21	18 (-16%)
Dry	4	3 (-22%)
Critically Dry	2	2 (-12%)

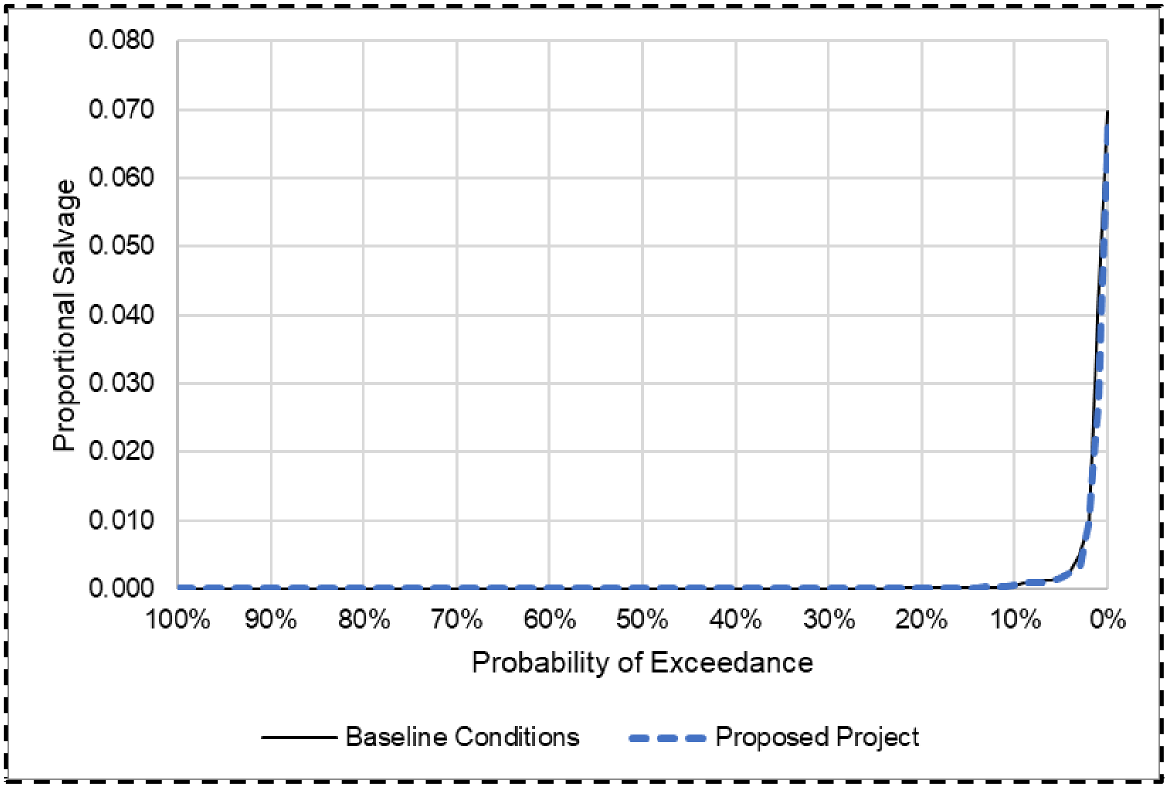
Note: N/A indicates there were no Above Normal years in the historical record for the 2010–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-1a in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Salvage Analysis (Based on Zeug and Cavallo 2014)

The salvage-density method is essentially a means of examining changes in south Delta exports weighted by historical salvage density to account for species timing between months; the method does not account for potential nonlinear relationships between salvage (entrainment) and south Delta exports, nor does it account for other factors that may influence salvage, such as Delta channel flows that could influence the survival or migration routes that juvenile salmonids may take. Zeug and Cavallo (2014) demonstrated that these other factors could be linked statistically to salvage of marked hatchery-reared juvenile Chinook Salmon. The methods employed by Zeug and Cavallo (2014) were used to assess potential differences in juvenile winter-run Chinook Salmon entrainment risk between Baseline Conditions and the Proposed Project (see detailed methods description in Appendix 6B, Section 6B.2, "Juvenile Winter-Run Chinook Salmon Salvage Based on Zeug and Cavallo (2014)"). The results of this method were consistent with the salvage-density method in suggesting that salvage of juvenile winter-run Chinook Salmon generally would be similar under the Proposed Project relative to Baseline Conditions (Table ~~6-34~~ 6-35 and Figure 6-72; additional summary plots broken down by month are provided in Appendix 6B, Section 6B.2.2, "Results").

Table ~~6-34~~ 6-35. Mean Annual Proportion of Juvenile Winter-run Chinook Salmon Entering the Delta Salvaged at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), from the Salvage Analysis Based on Zeug and Cavallo (2014)

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~0.00447~~ 0.00554	~~0.00392 (-12.3%)~~ 0.00550 (-0.7%)
Above Normal	~~0.00010~~ 0.00014	~~0.00010 (2.2%)~~ 0.00013 (-6.5%)
Below Normal	0.00008	0.00008 ~~(0.7%)~~ (-1.2%)
Dry	0.00004	0.00004 ~~(5.7%)~~ (-1.9%)
Critically Dry	0.00006	0.00006 ~~(1.4%)~~ (-0.2%)



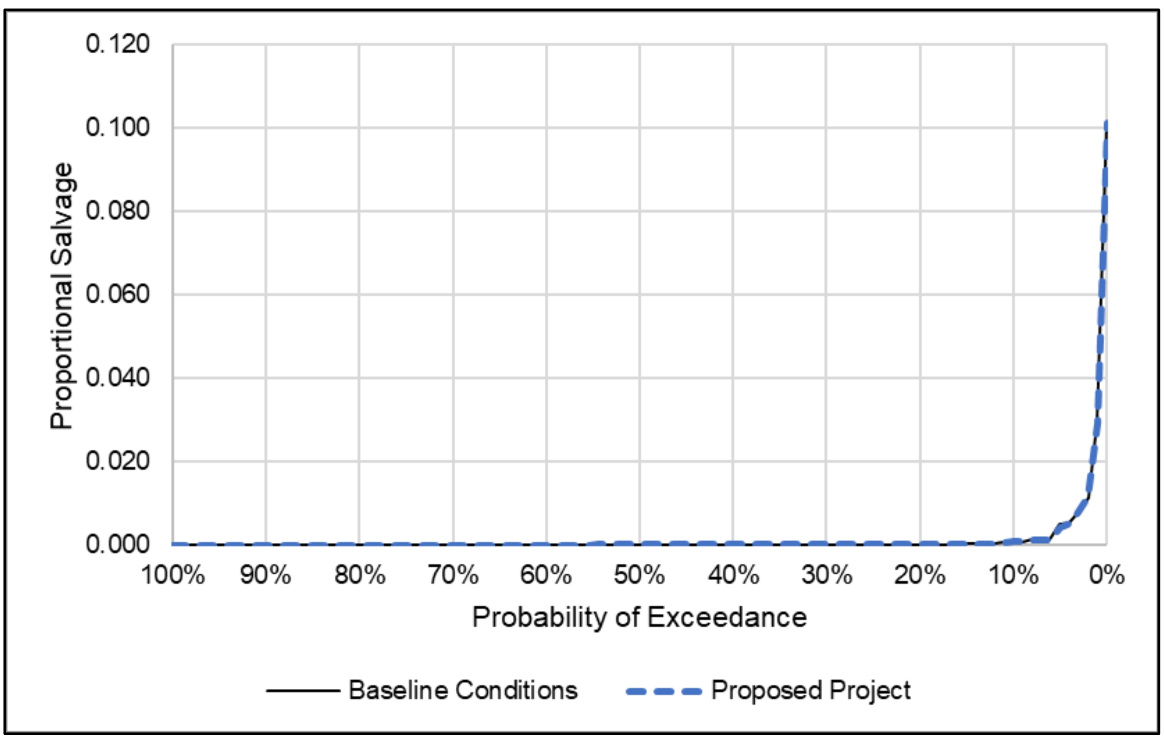


Figure 6-72. Exceedance Plot of Annual Proportion of Juvenile Winter-run Chinook Salmon Entering the Delta Salvaged at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios from the Salvage Analysis Based on Zeug and Cavallo (2014)

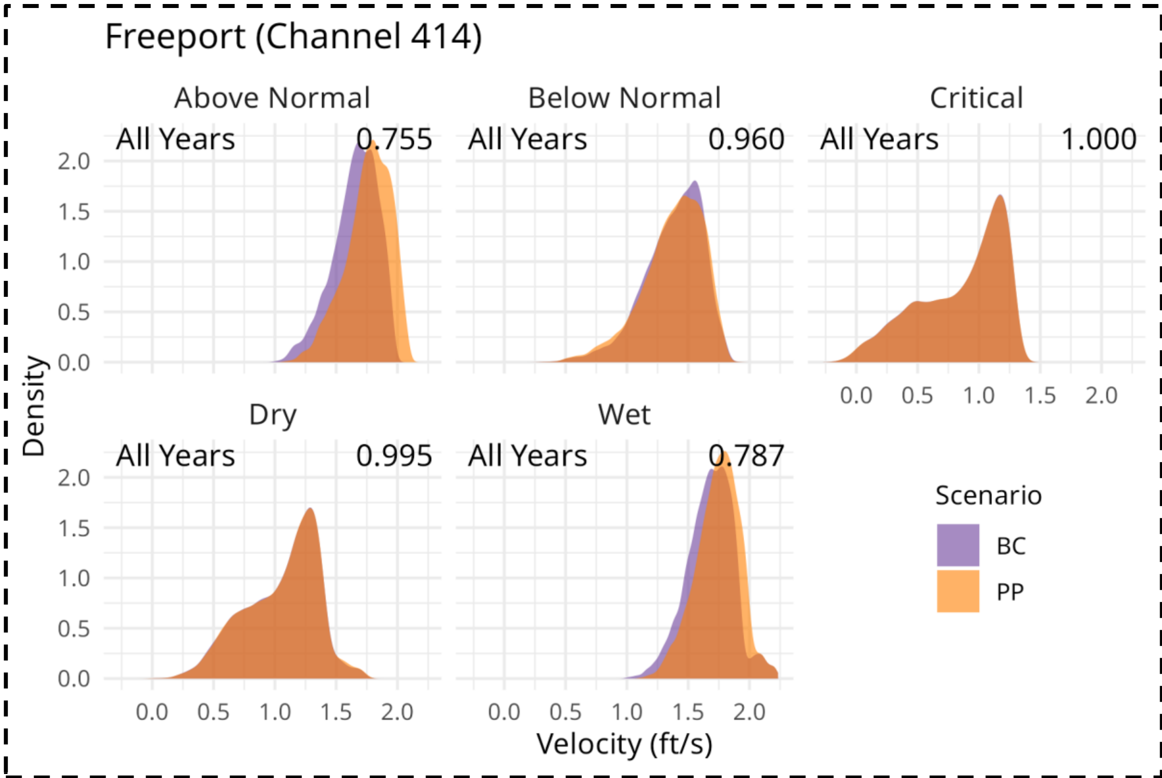
Delta Hydrodynamic Assessment and Junction Routing Analysis

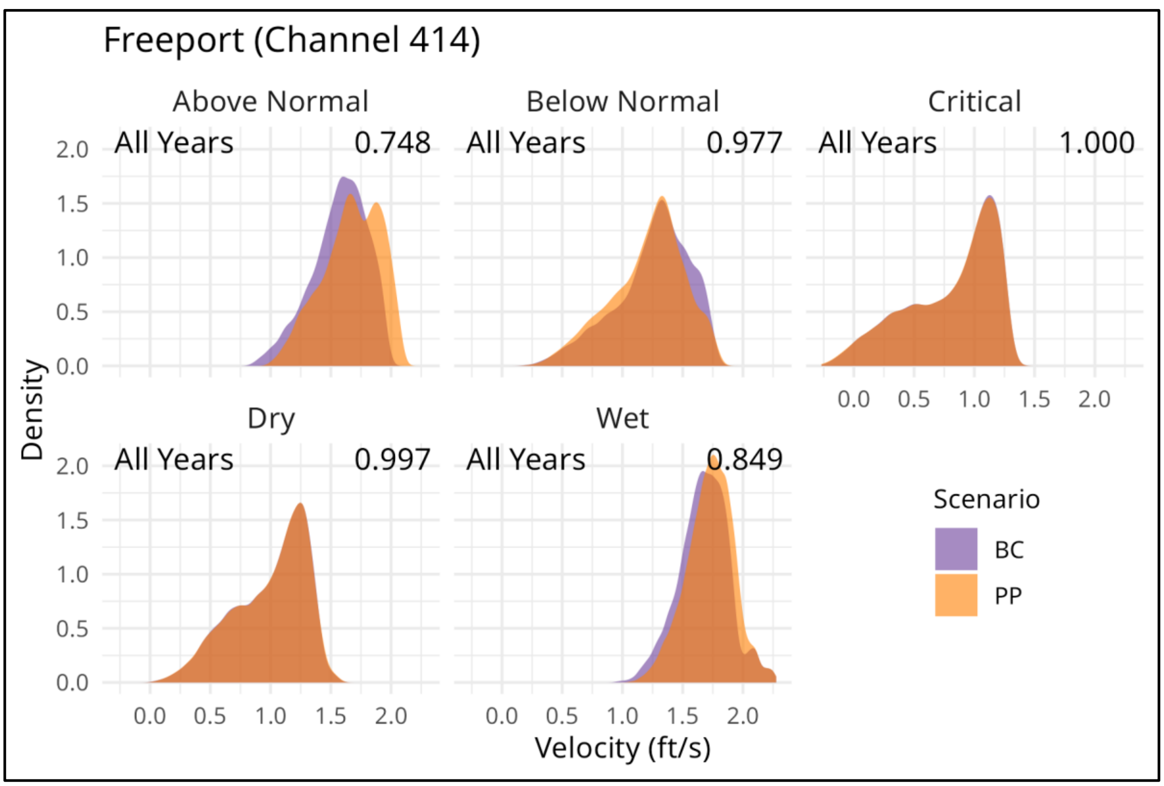
Velocity

Sacramento River flow entering the Delta is correlated with through-Delta survival of juvenile Chinook Salmon (Hance et al. 2022), reflecting the influence of flow on juvenile Chinook Salmon travel time and potential exposure to predatory fish. Less Sacramento River inflow increases the potential for flow to be diverted into the interior Delta at Georgiana Slough/DCC, where juvenile Chinook Salmon survival is lower than on the mainstem Sacramento River or other north Delta migratory pathways (Perry et al. 2018; Hance et al. 2022). Channel velocity and flow direction therefore affects overall through-Delta survival (Salmonid Scoping Team 2017:5). As described in Appendix 6B, Section 6B.3, "Hydrodynamic Effects Based on DSM2-HYDRO Data," an assessment of potential hydrodynamic changes was undertaken using DSM2-HYDRO velocity outputs.

For outmigrating juvenile winter-run Chinook Salmon, which all originate in the Sacramento River basin, velocity and flow direction in the north Delta are of particular importance. The DSM2-HYDRO outputs indicated very similar velocity between the Proposed Project and Baseline Conditions during the broader September–June period and in the main months of winter-run Chinook Salmon occurrence (i.e., December–April per Tables 6A-2, 6A-4a, and 6A-4b in Appendix 6A[15]) in the Sacramento River at Freeport and Walnut Grove (Figures 6-73 through 6-92). Additional results for other locations are provided in Appendix 6B, as well as plots showing the minimum overlap between scenarios by month for the north and south Delta. Overall, these plots illustrate the general similarity in velocity throughout the Delta, with the most apparent differences occurring in some months near the south Delta export facilities.

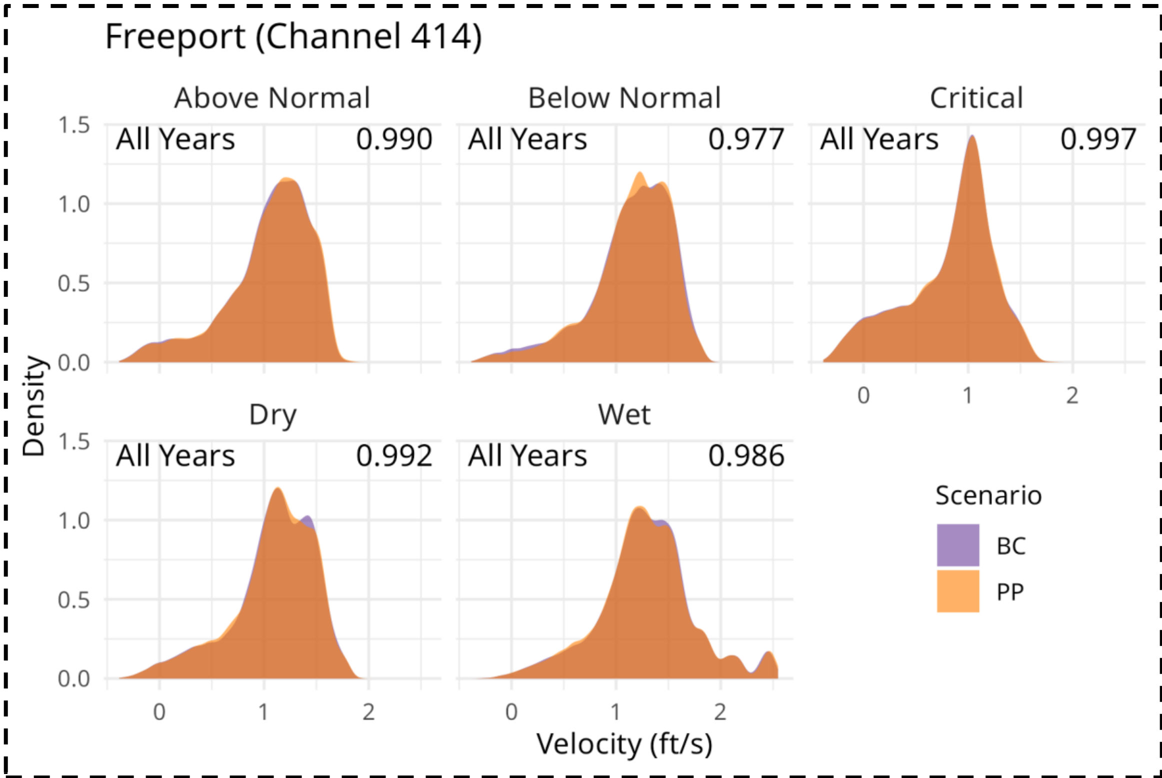
[15] Note that the specific relative patterns in Tables 6A-2, 6A-4a, and 6A-4b reflect length-at-date winter-run Chinook Salmon designation. 2010–2022 loss data for genetically identified winter-run Chinook Salmon at the SWP that were used for the salvage-density analysis discussed previously indicated highest loss in March, then February, then December/January; low loss in April; very little loss in May; and no loss prior to December or in June.

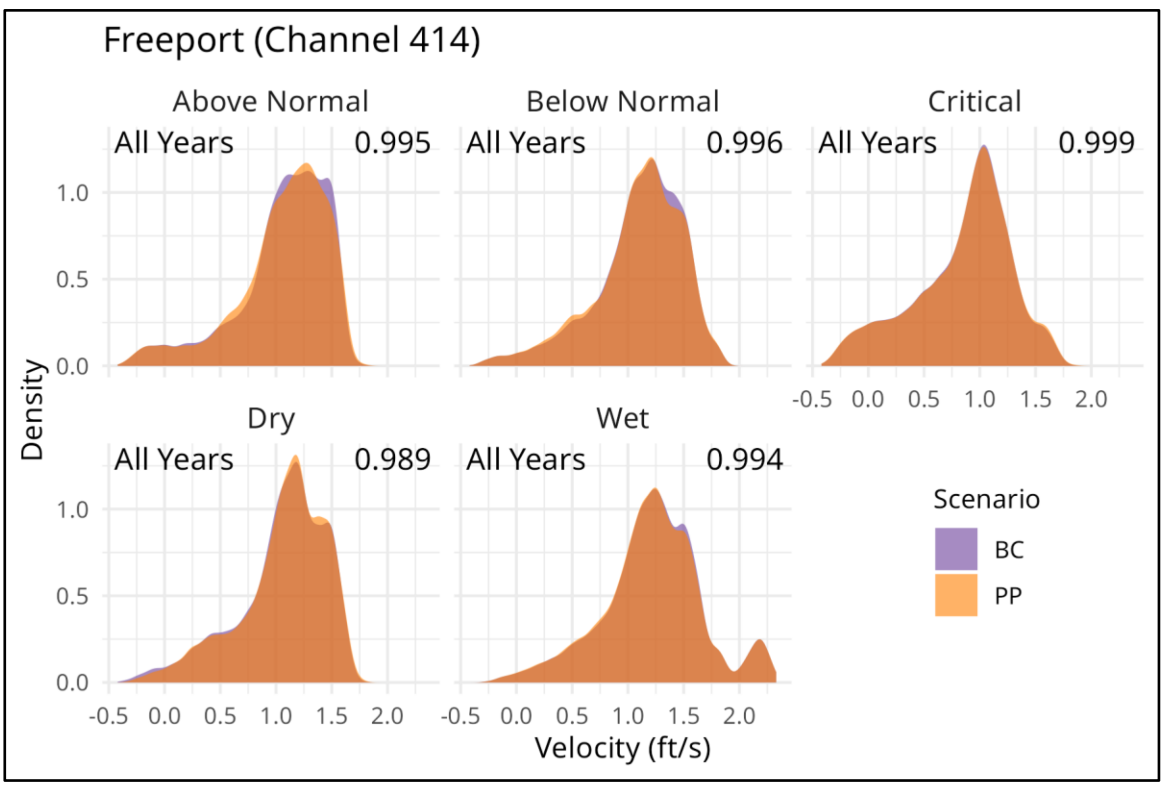




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

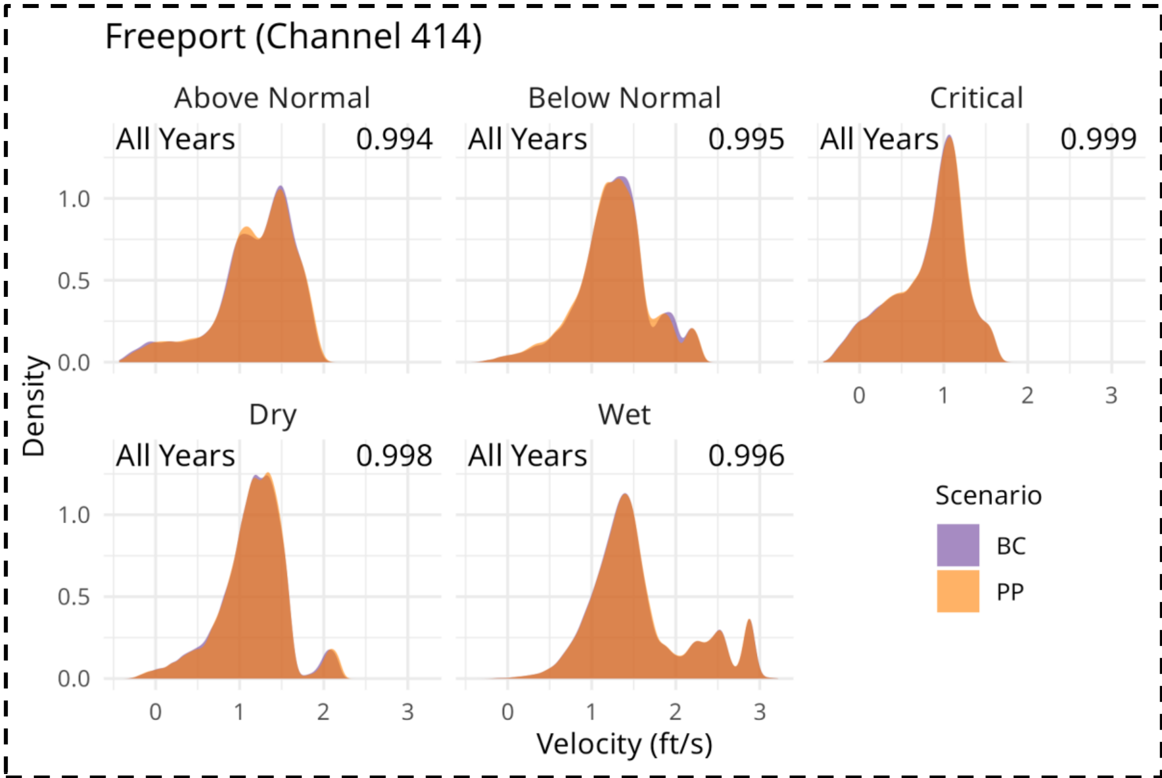
Figure 6-73. Velocity Density Distribution for Sacramento River at Freeport, September

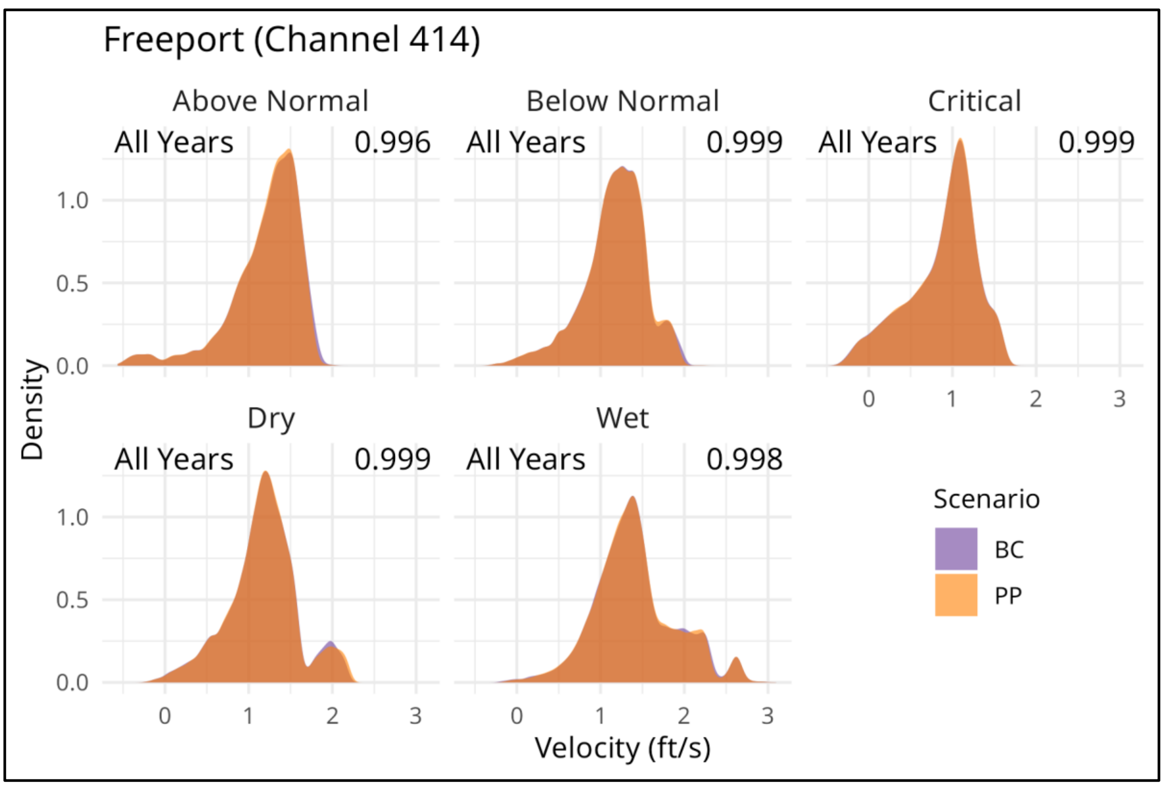




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

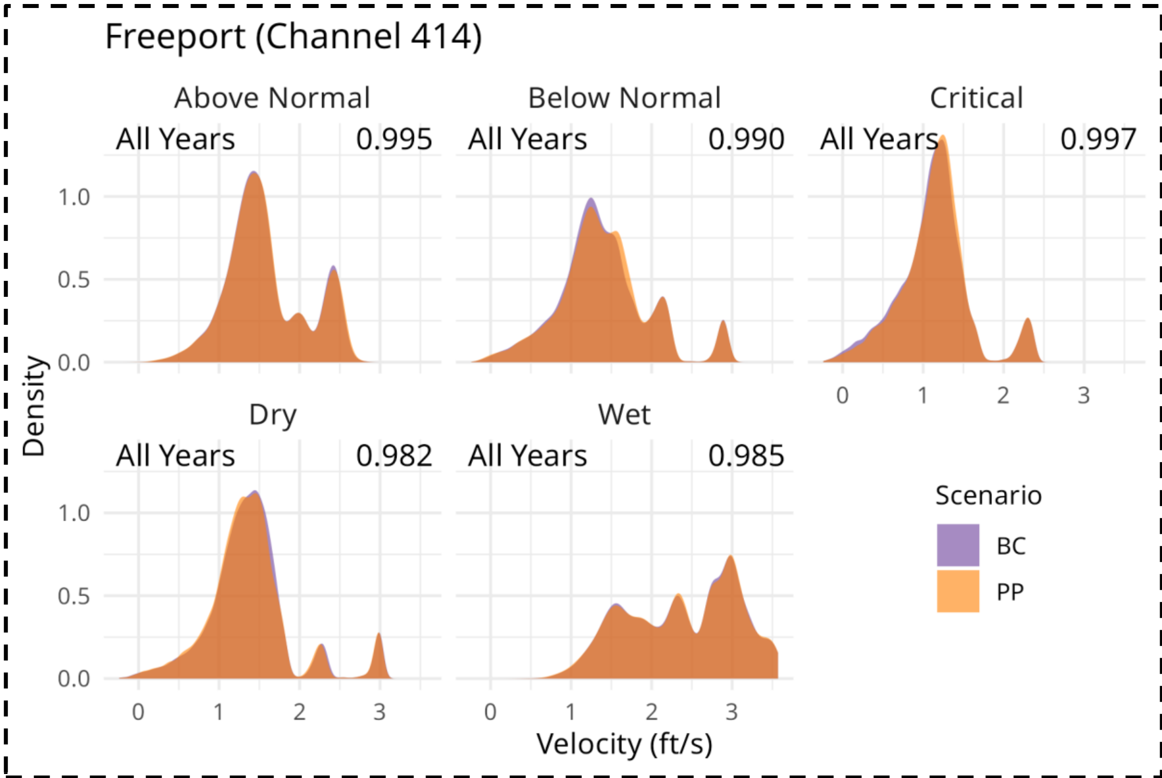
Figure 6-74. Velocity Density Distribution for Sacramento River at Freeport, October

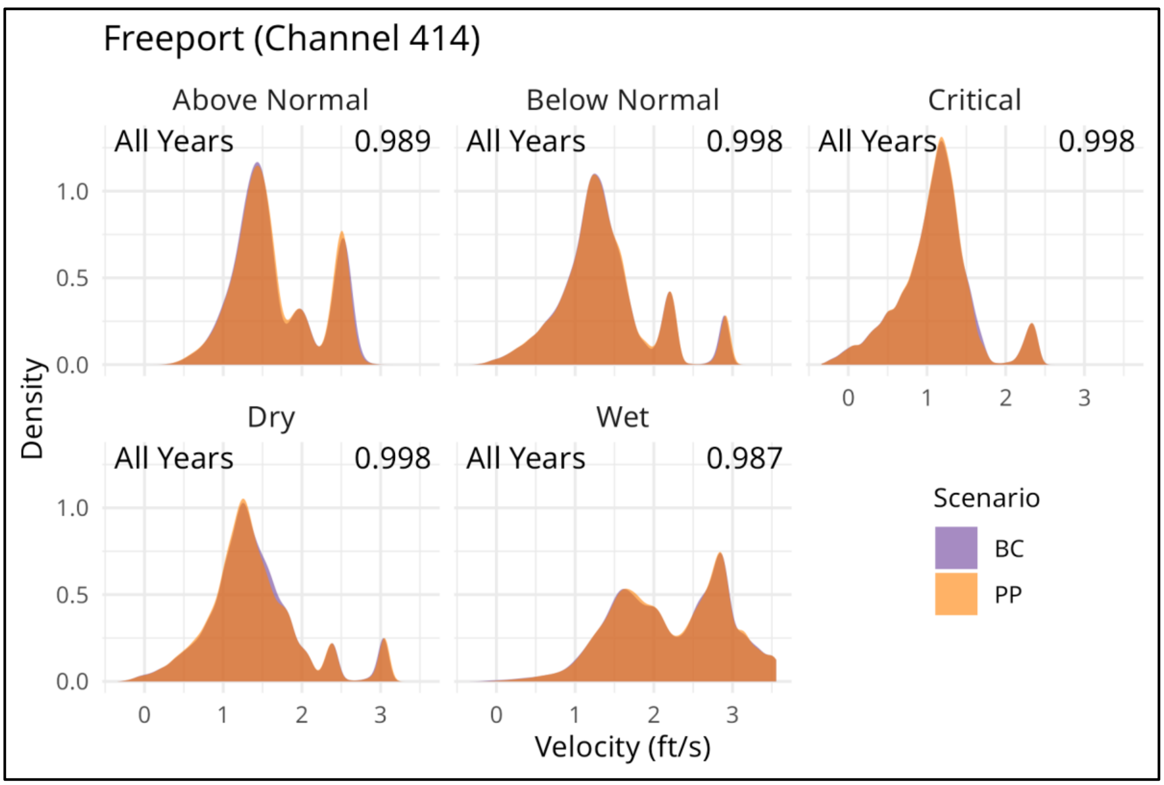




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

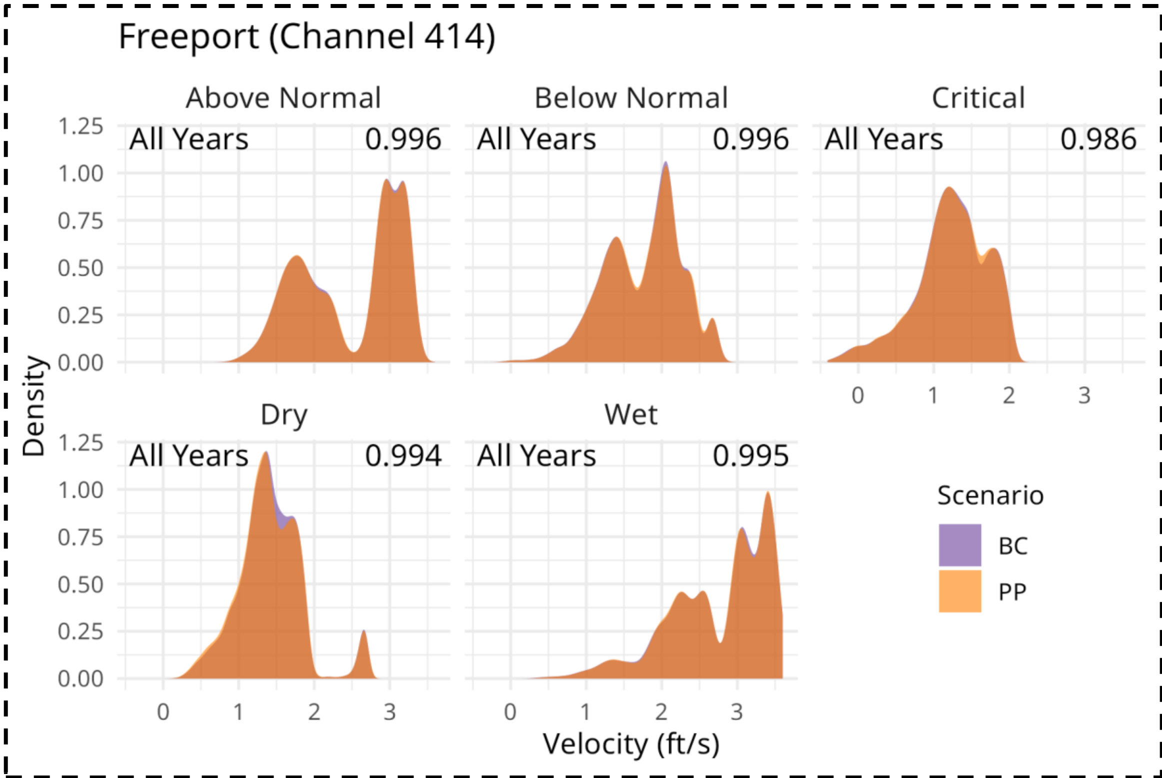
Figure 6-75. Velocity Density Distribution for Sacramento River at Freeport, November

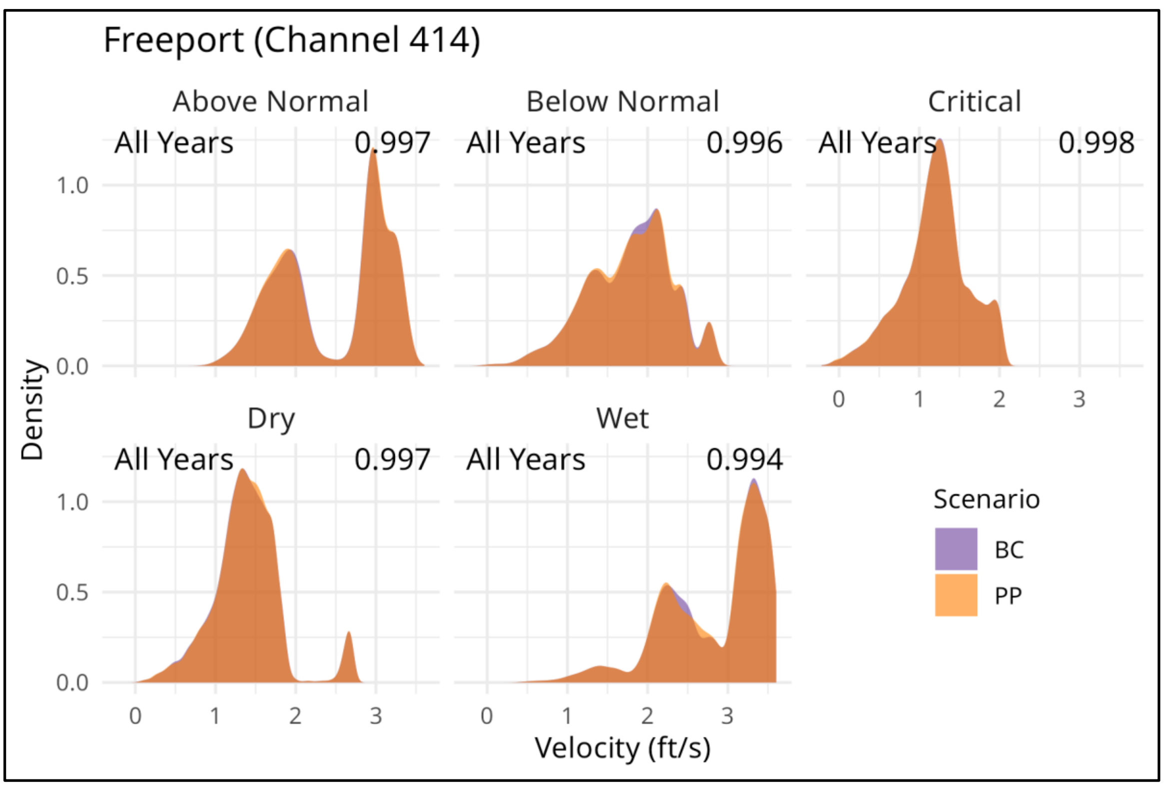




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

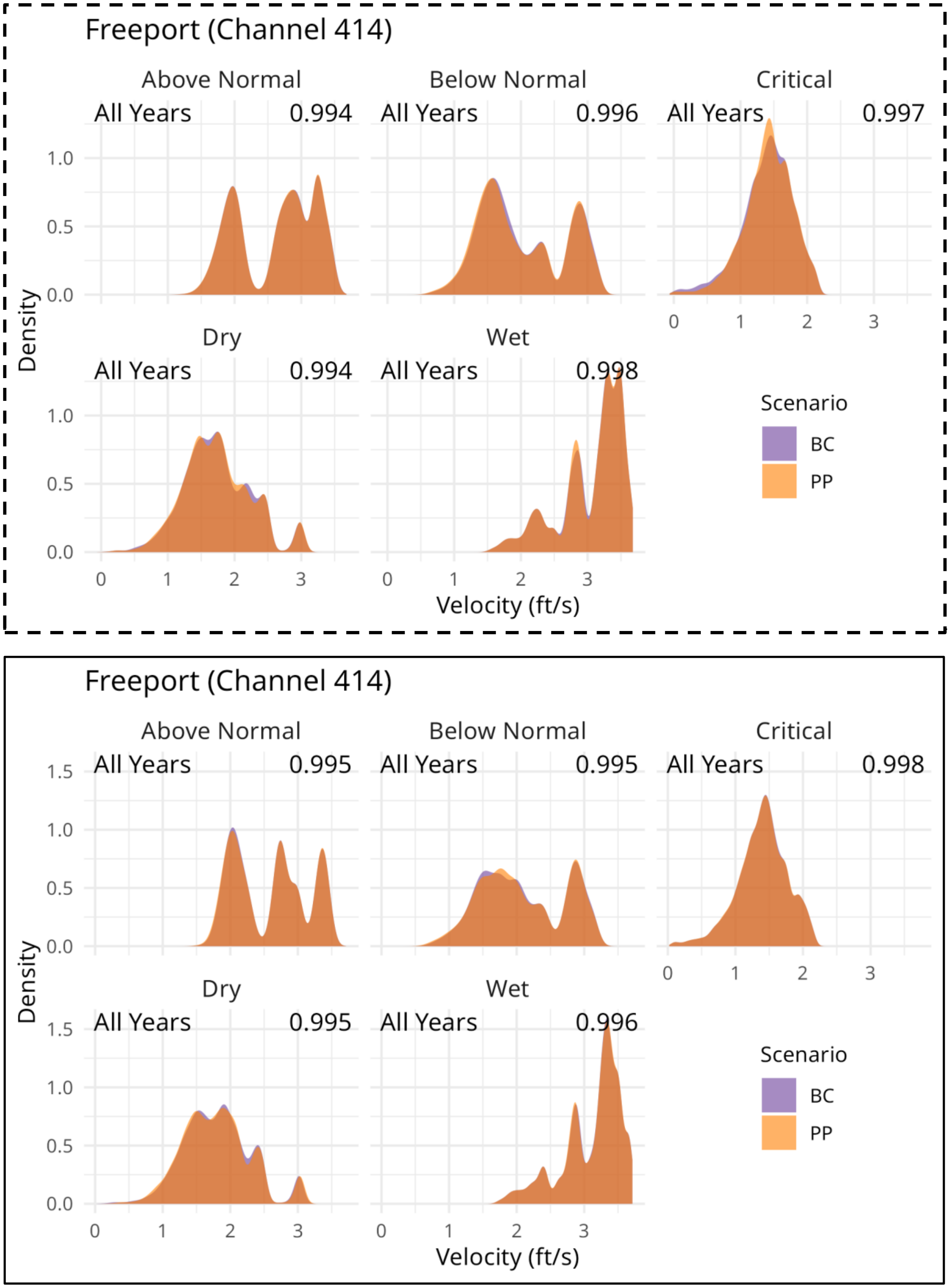
Figure 6-76. Velocity Density Distribution for Sacramento River at Freeport, December





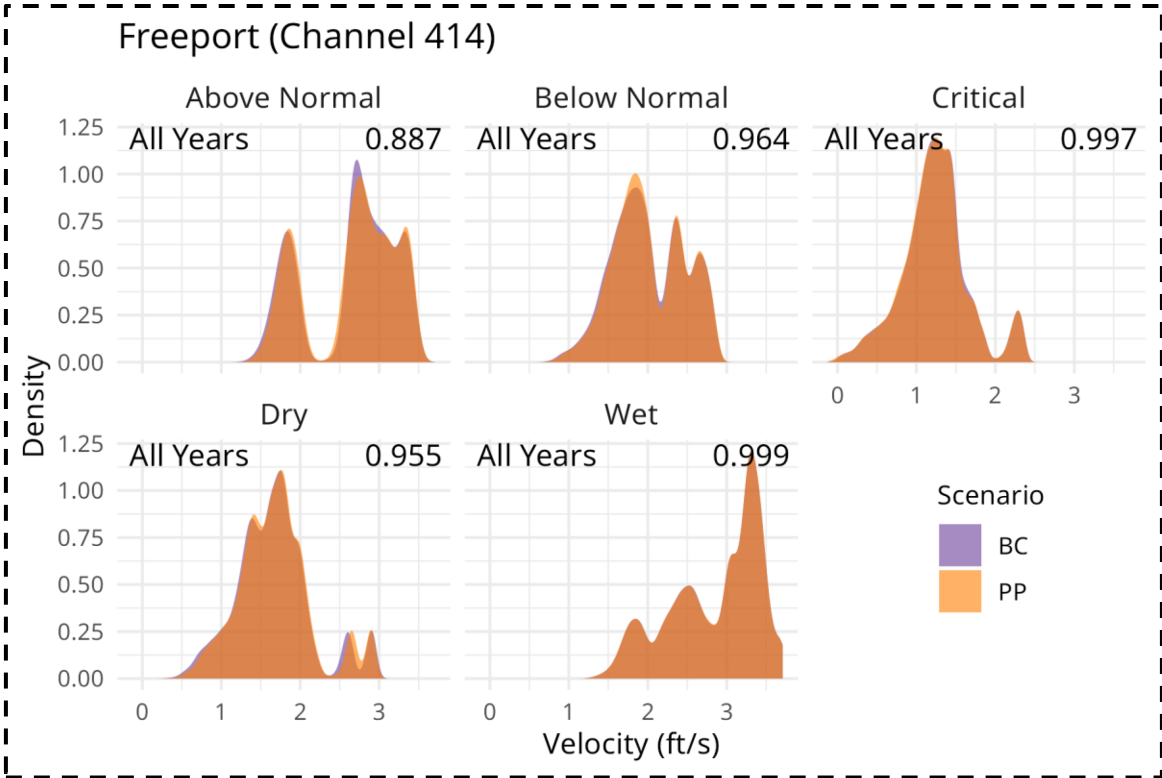
Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

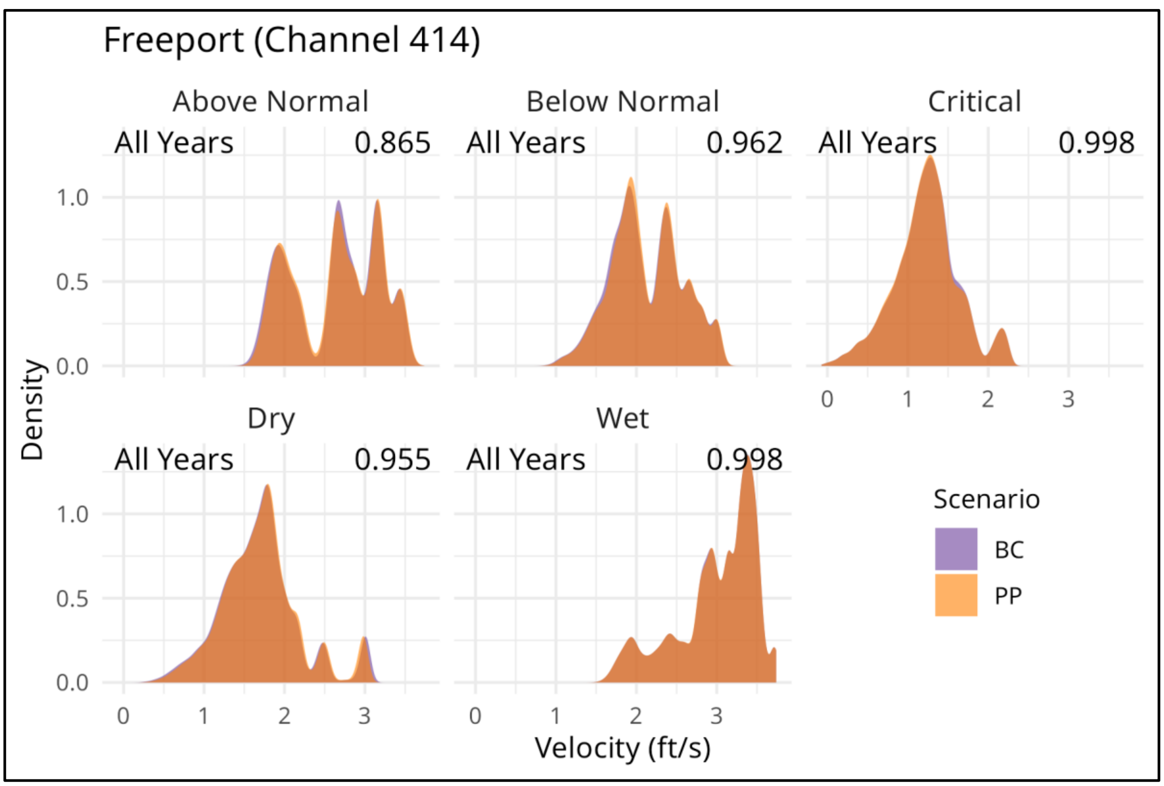
Figure 6-77. Velocity Density Distribution for Sacramento River at Freeport, January



Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

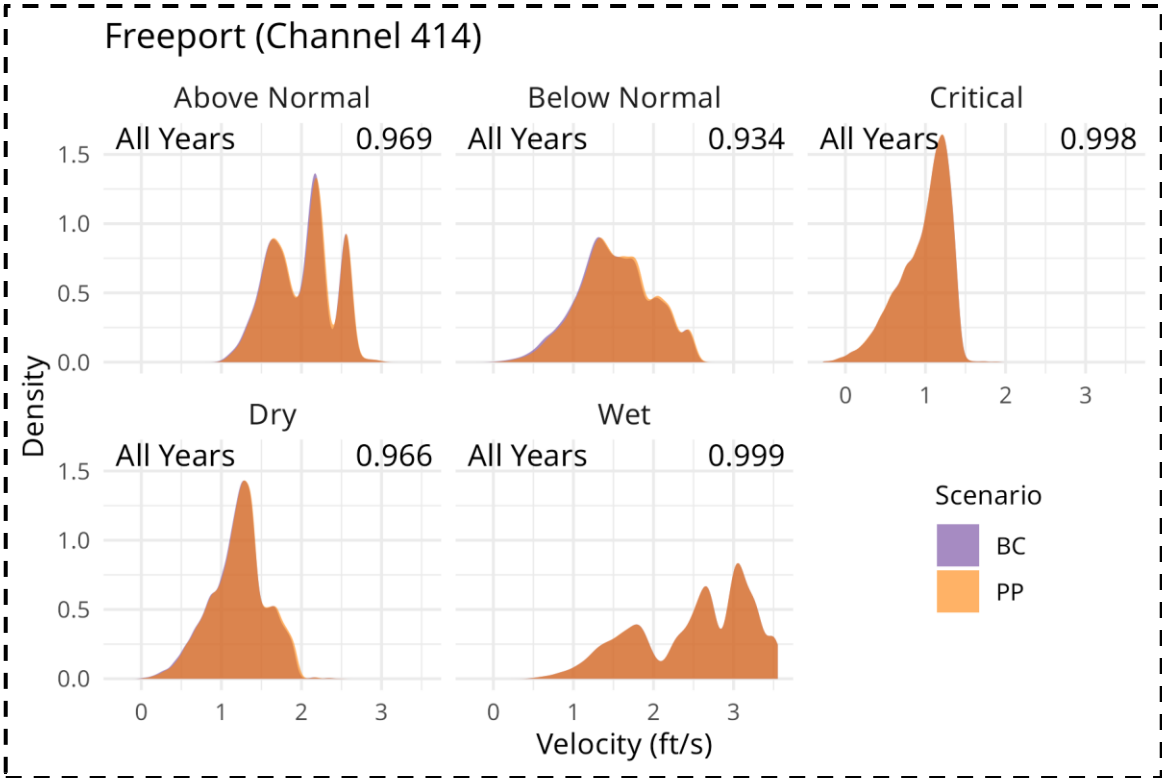
Figure 6-78. Velocity Density Distribution for Sacramento River at Freeport, February

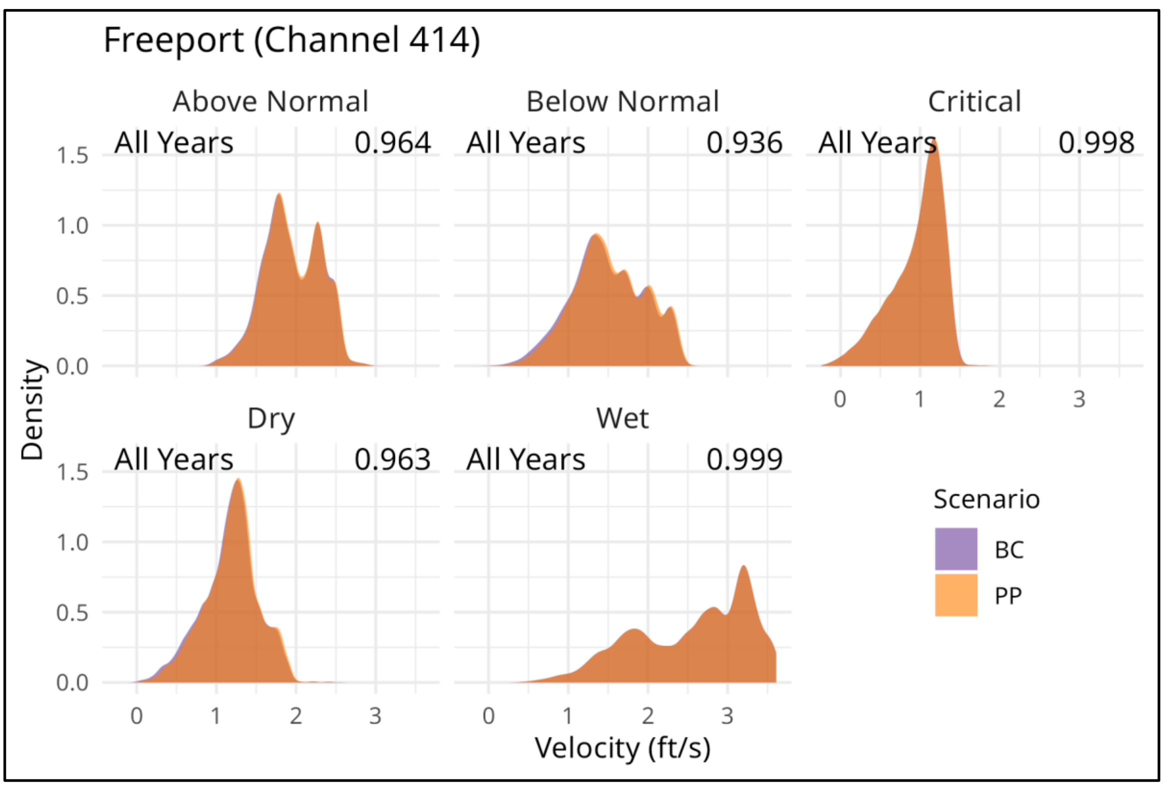




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

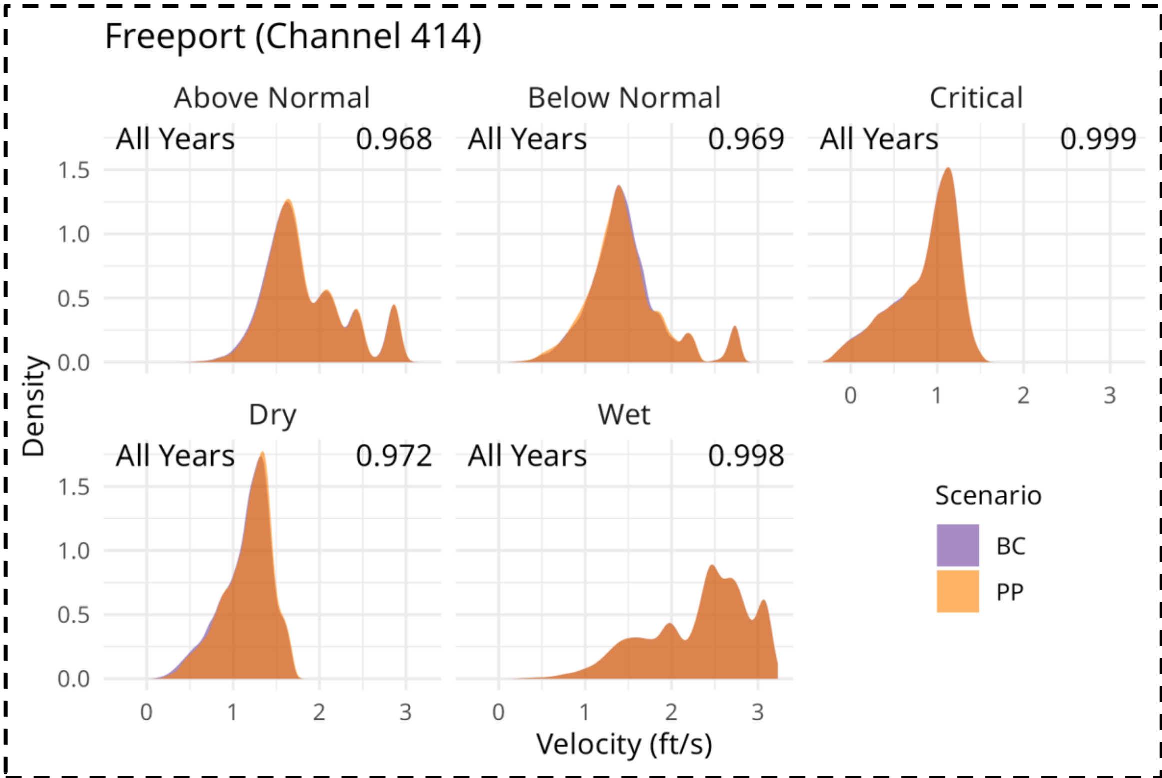
Figure 6-79. Velocity Density Distribution for Sacramento River at Freeport, March

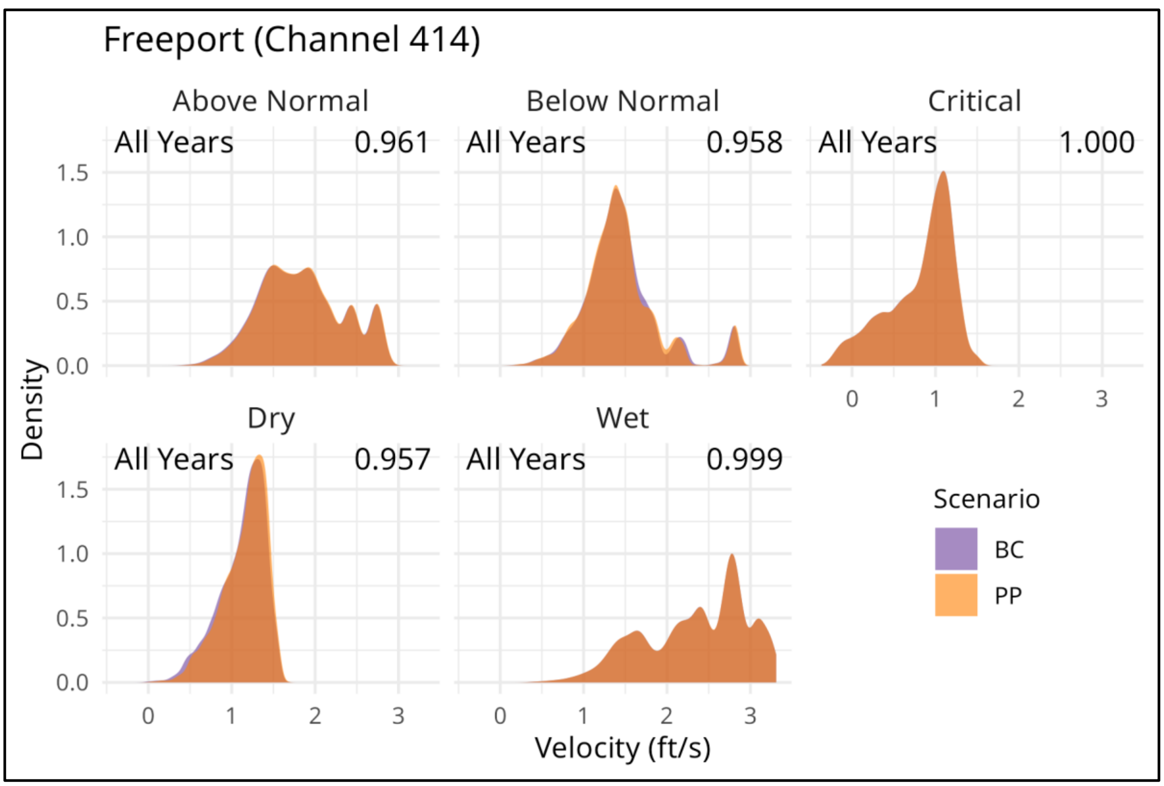




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

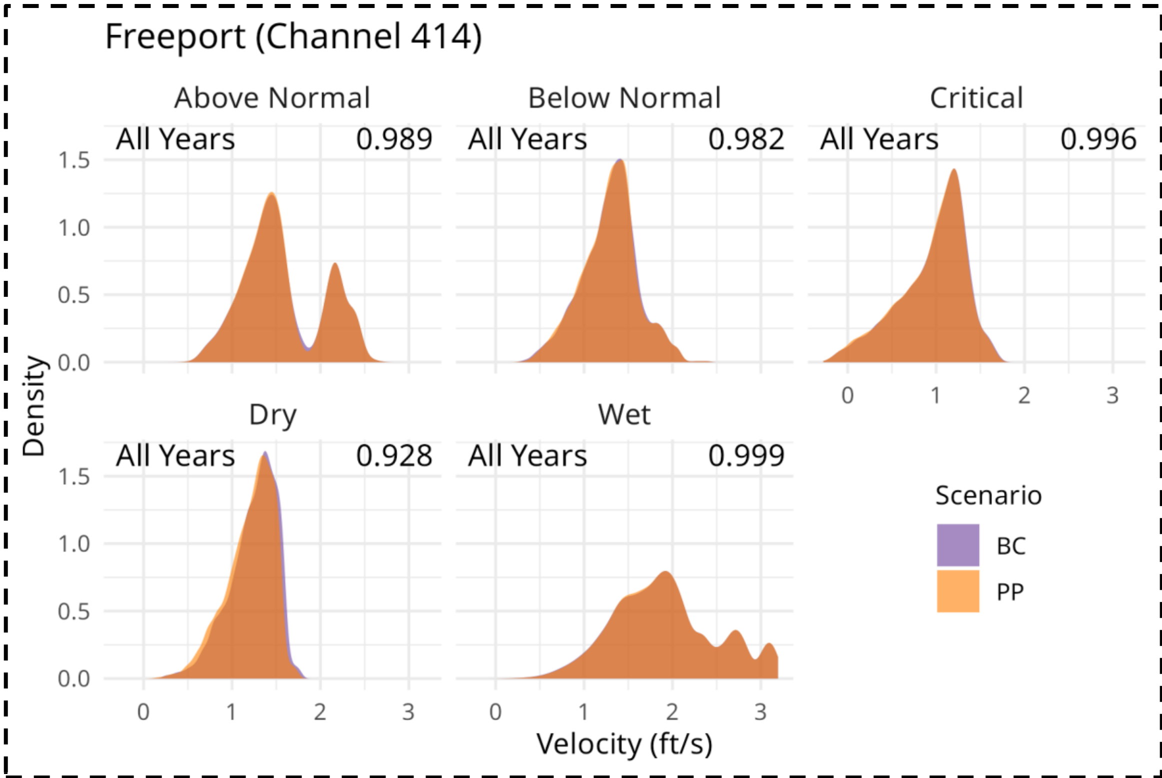
Figure 6-80. Velocity Density Distribution for Sacramento River at Freeport, April

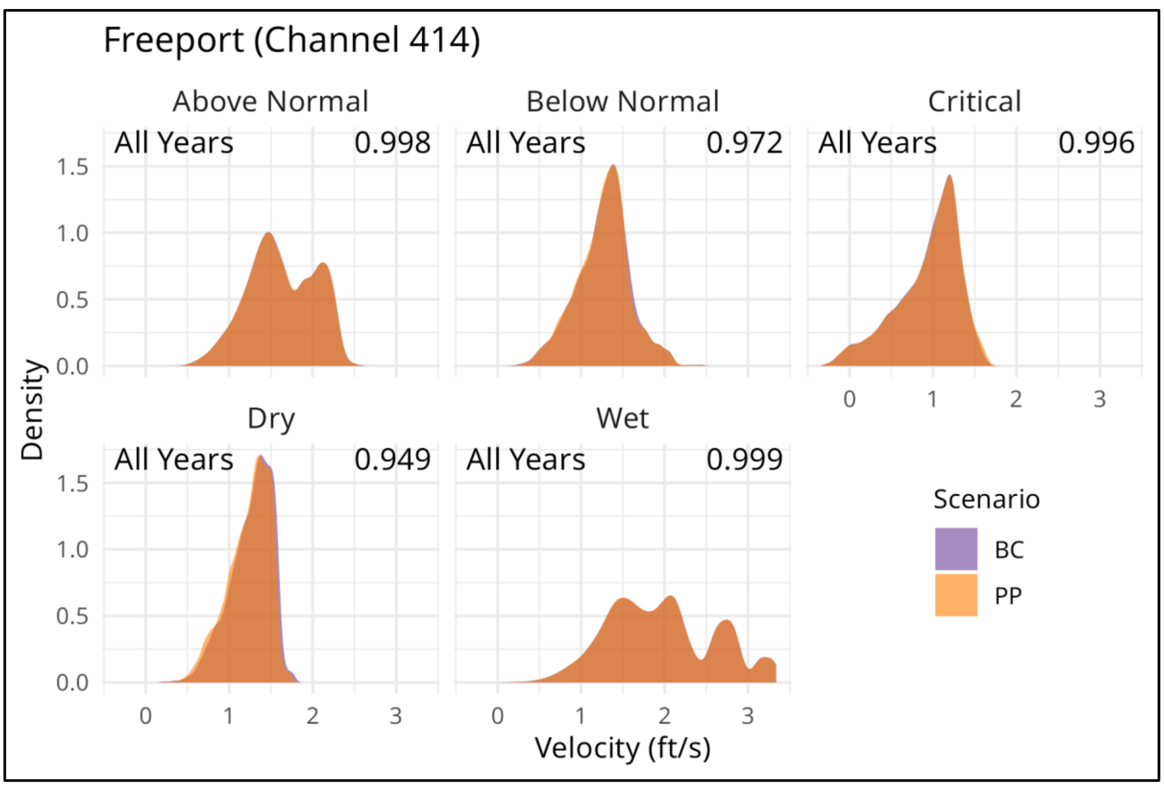




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

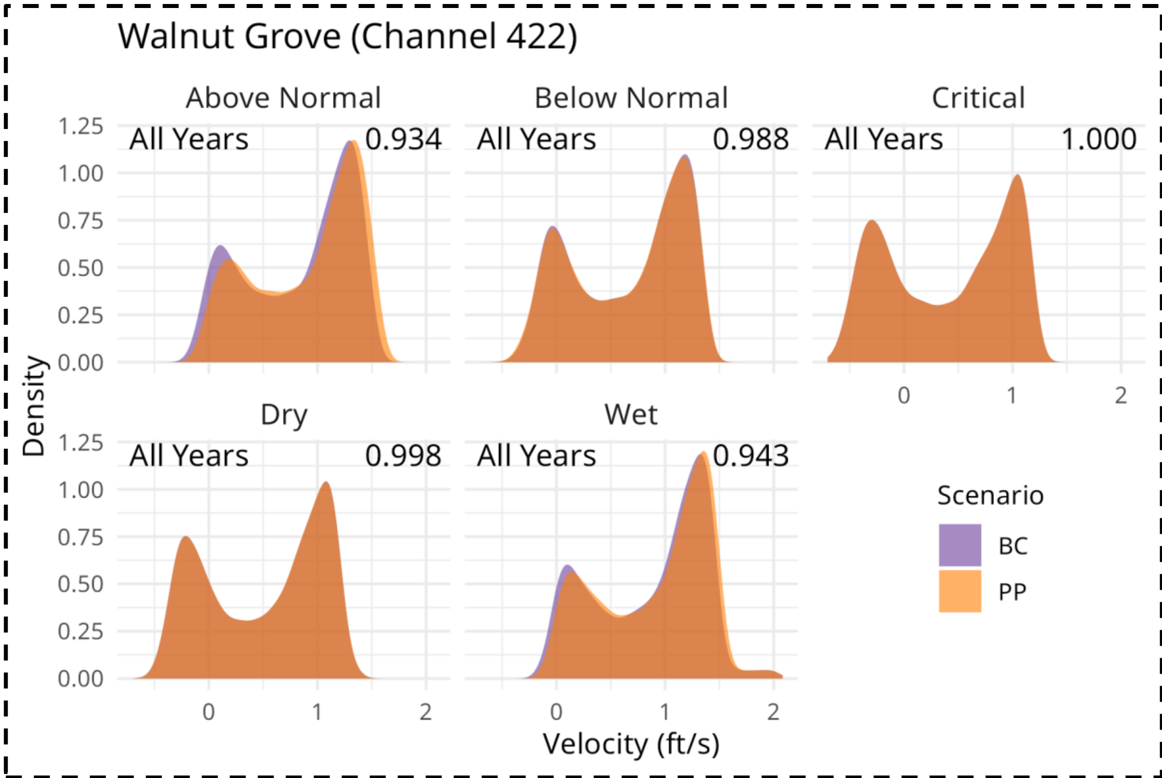
Figure 6-81. Velocity Density Distribution for Sacramento River at Freeport, May

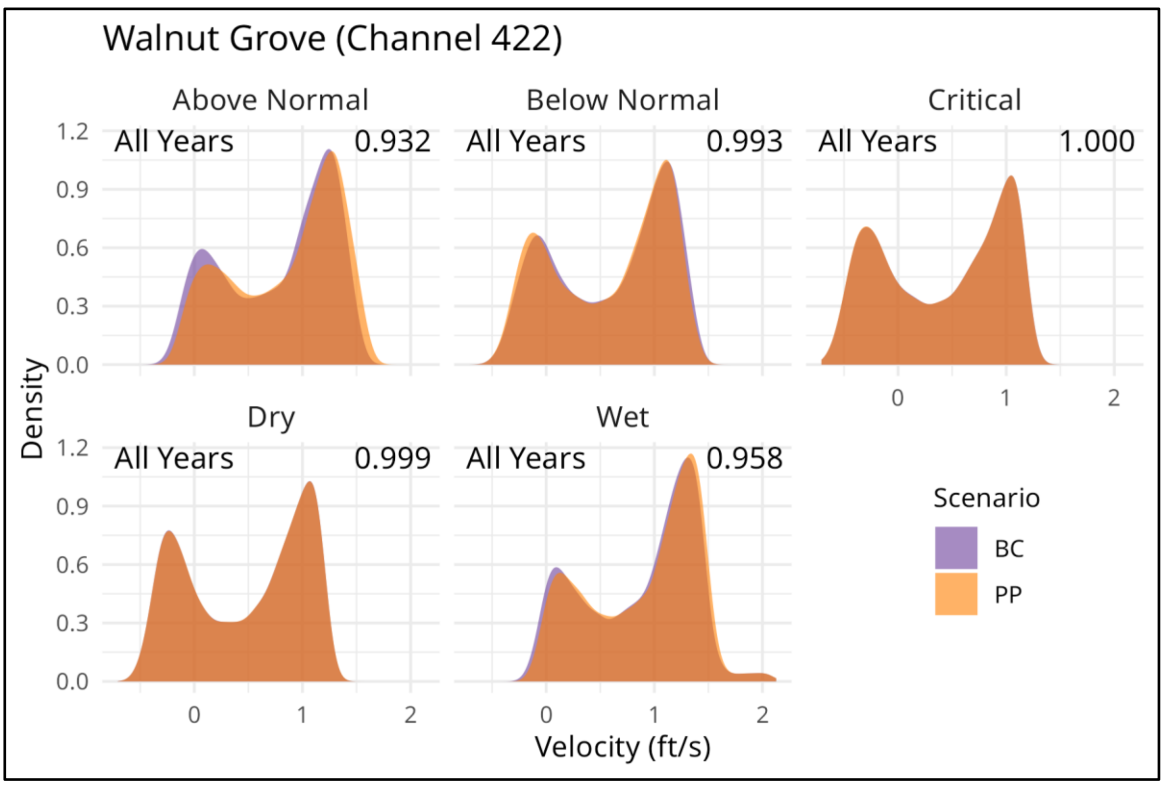




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

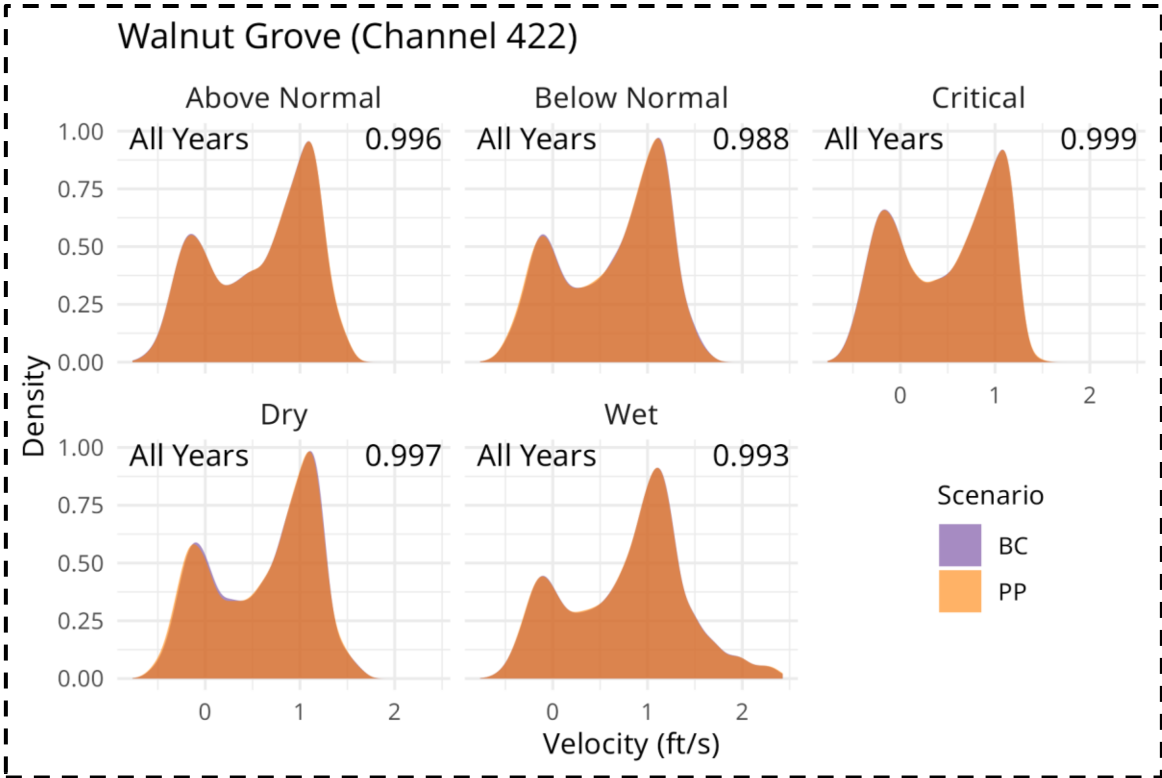
Figure 6-82. Velocity Density Distribution for Sacramento River at Freeport, June

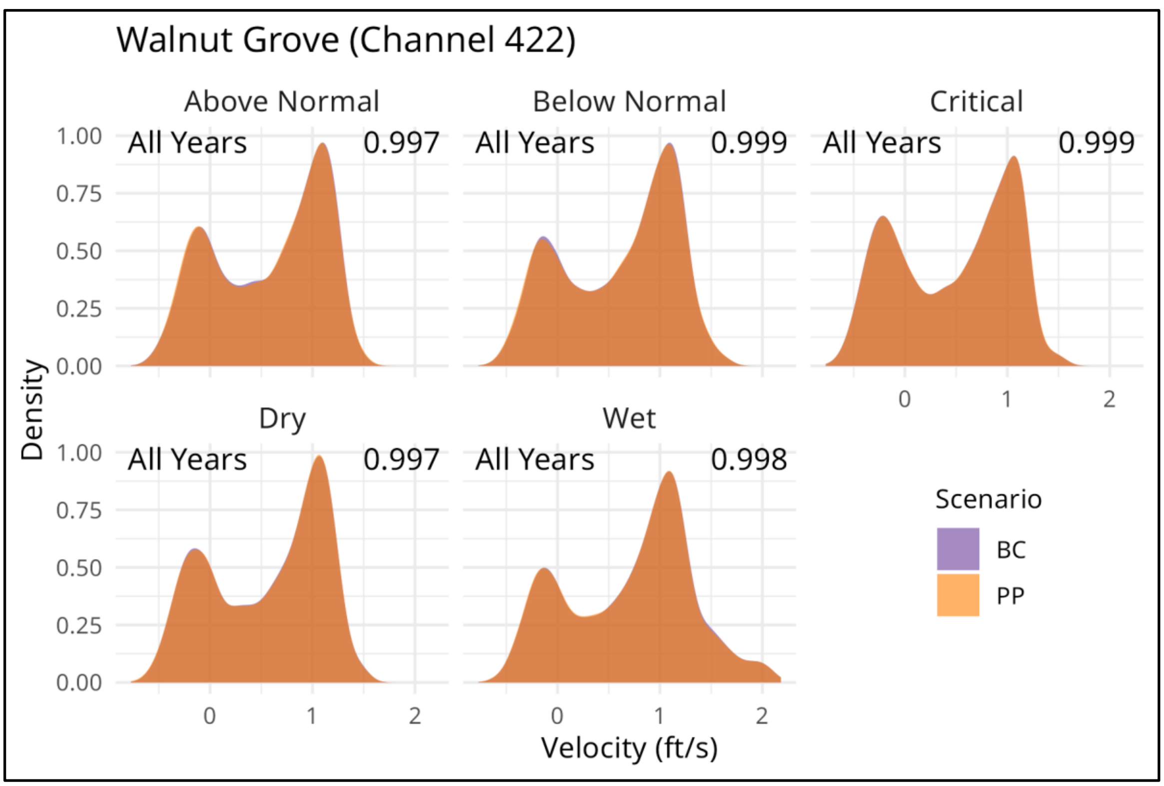




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

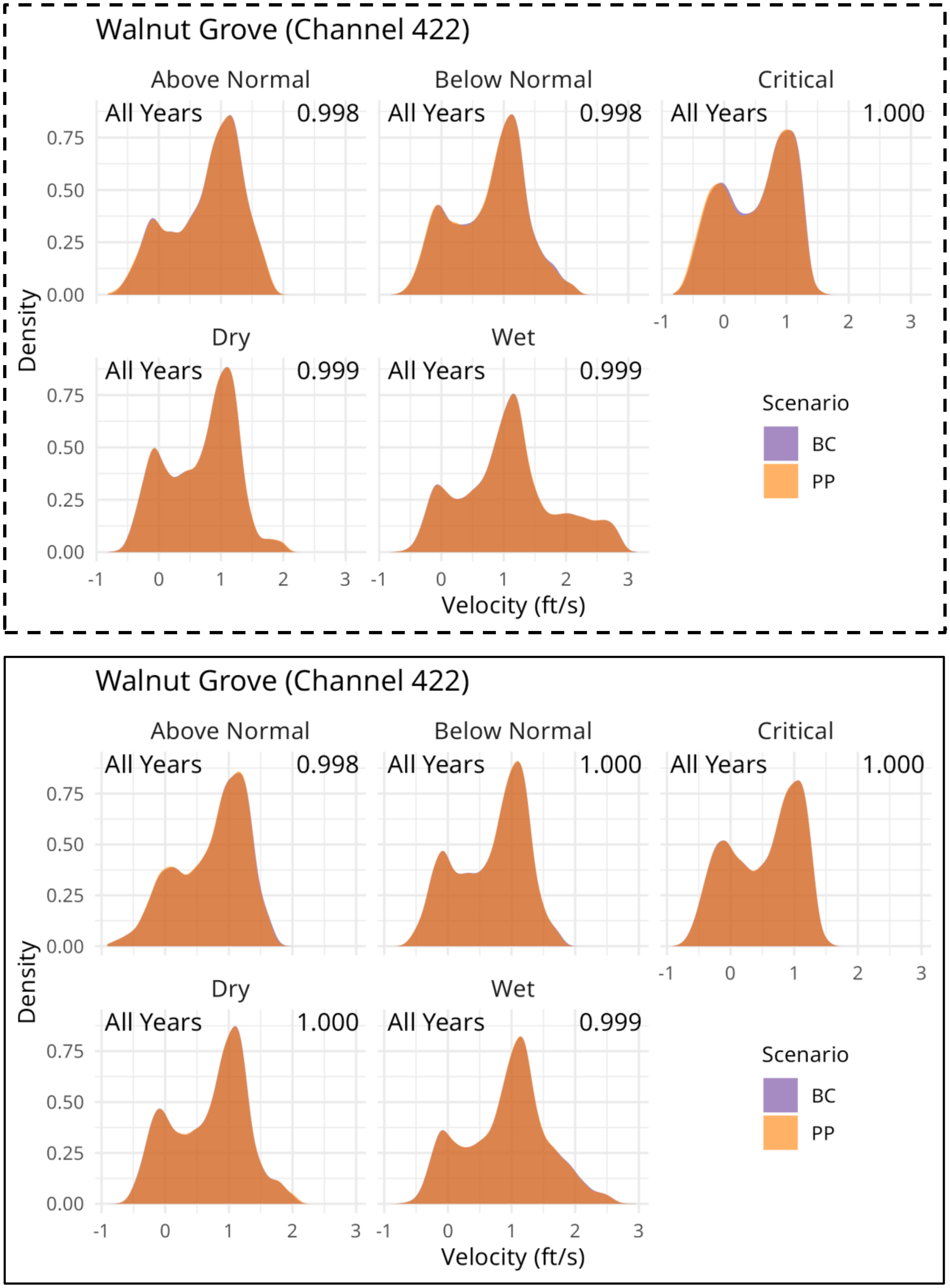
Figure 6-83. Velocity Density Distribution for Sacramento River at Walnut Grove, September





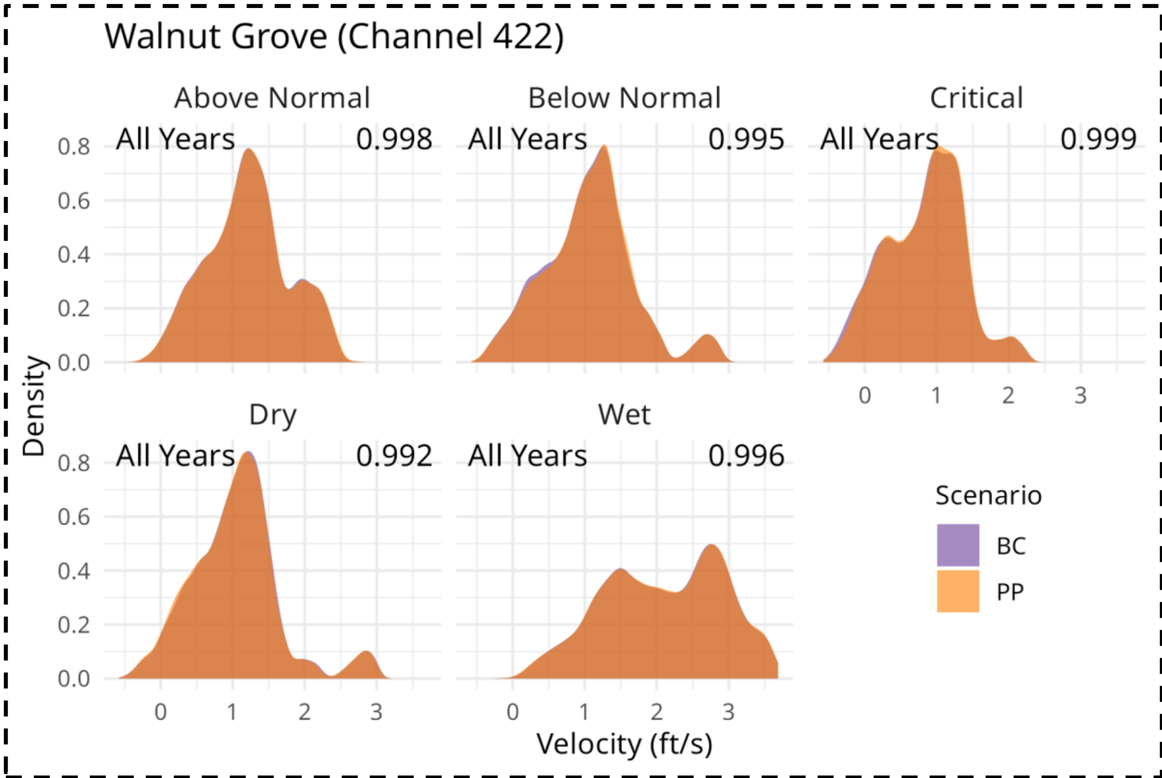
Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

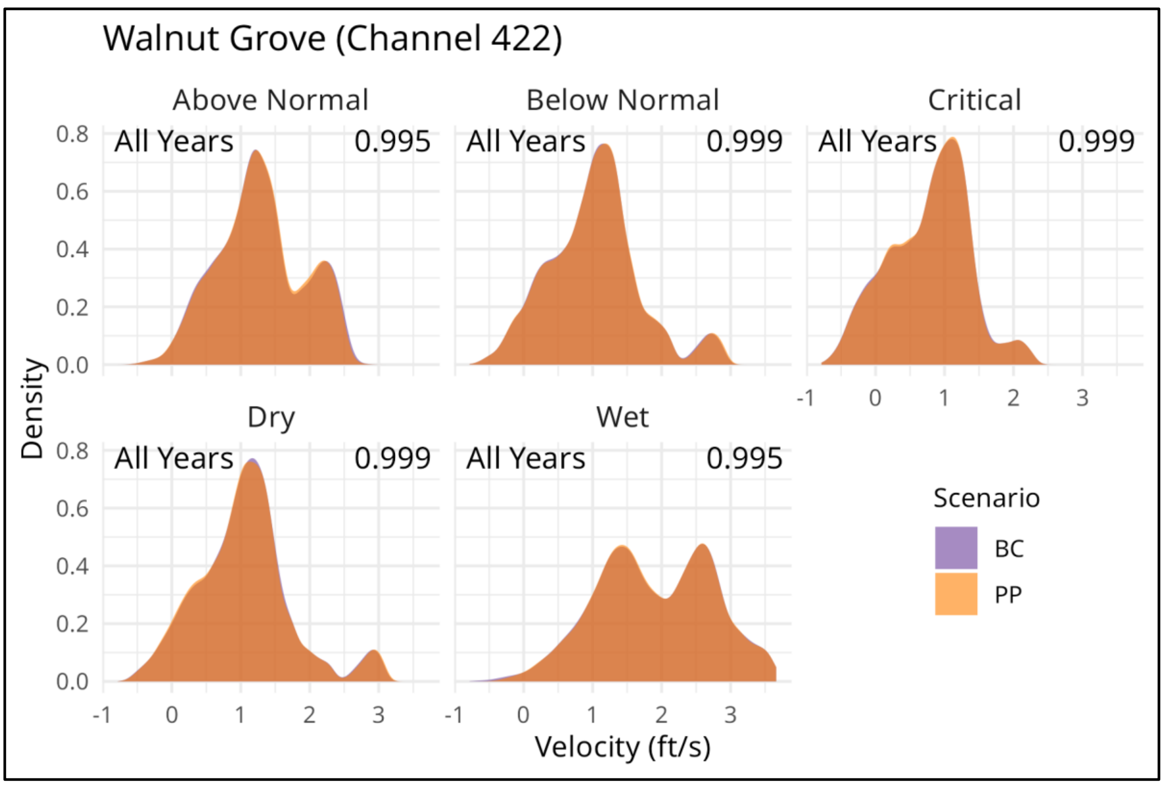
Figure 6-84. Velocity Density Distribution for Sacramento River at Walnut Grove, October



Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

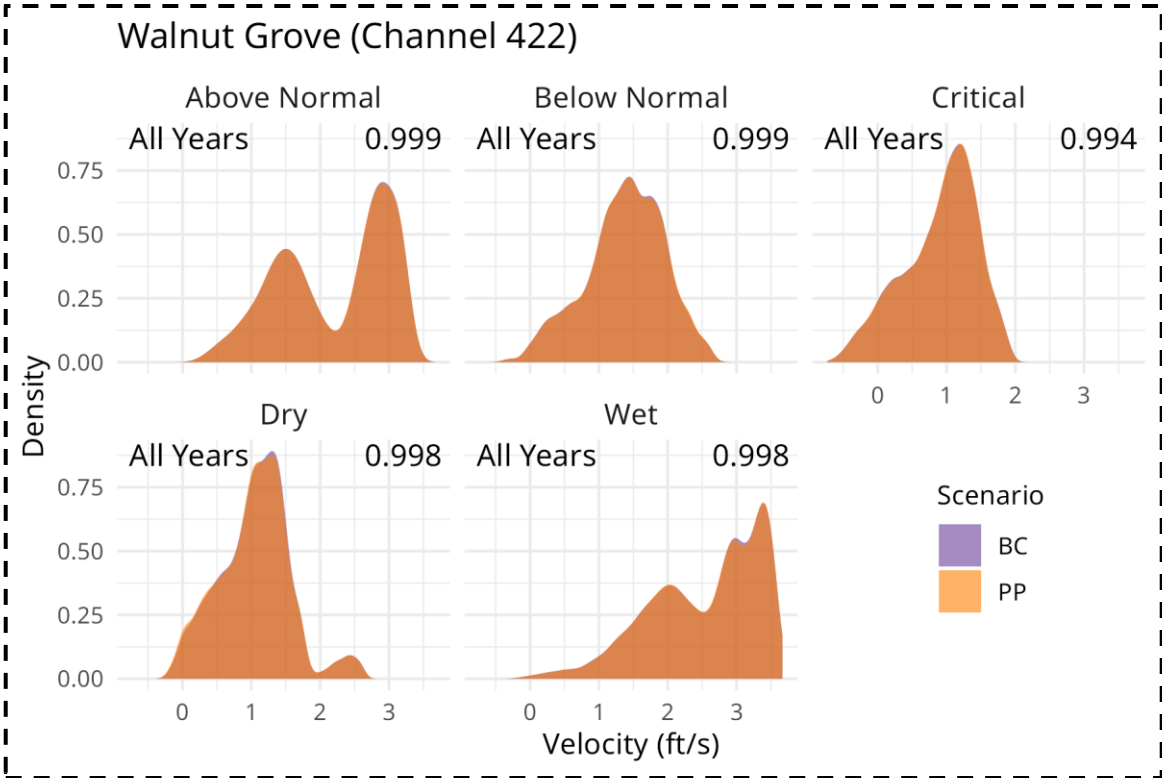
Figure 6-85. Velocity Density Distribution for Sacramento River at Walnut Grove, November

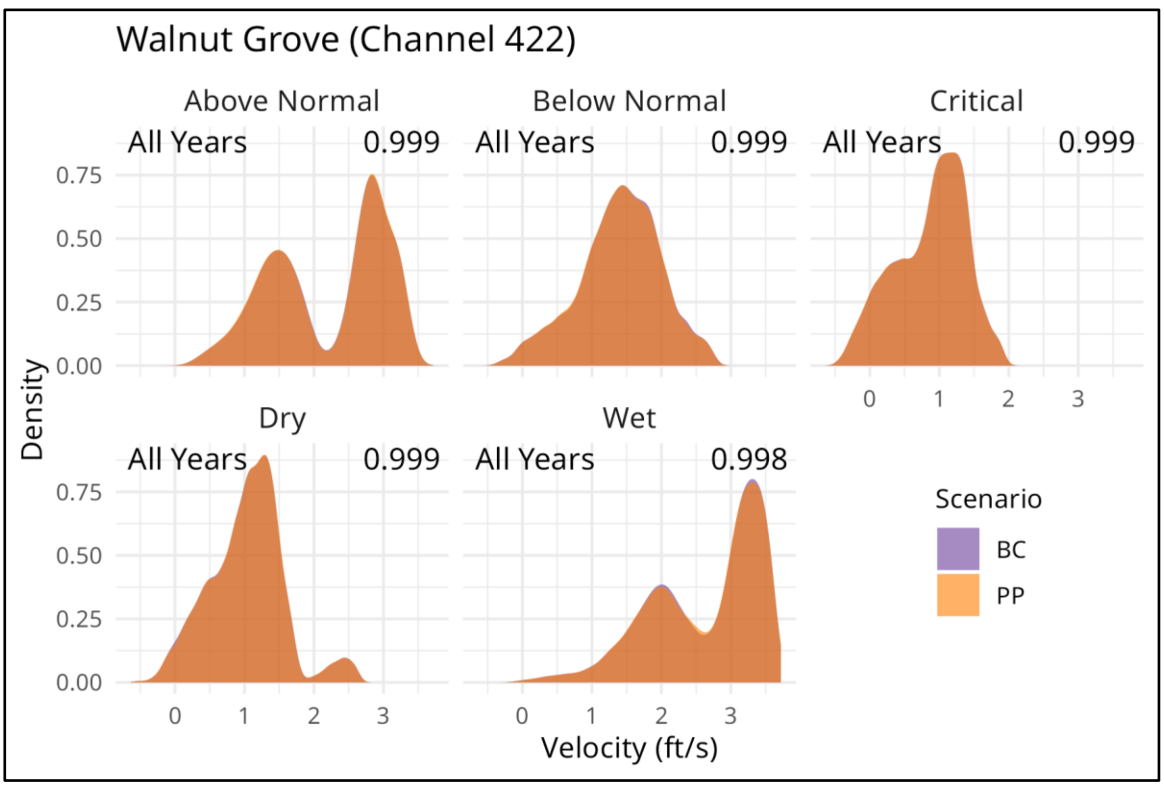




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

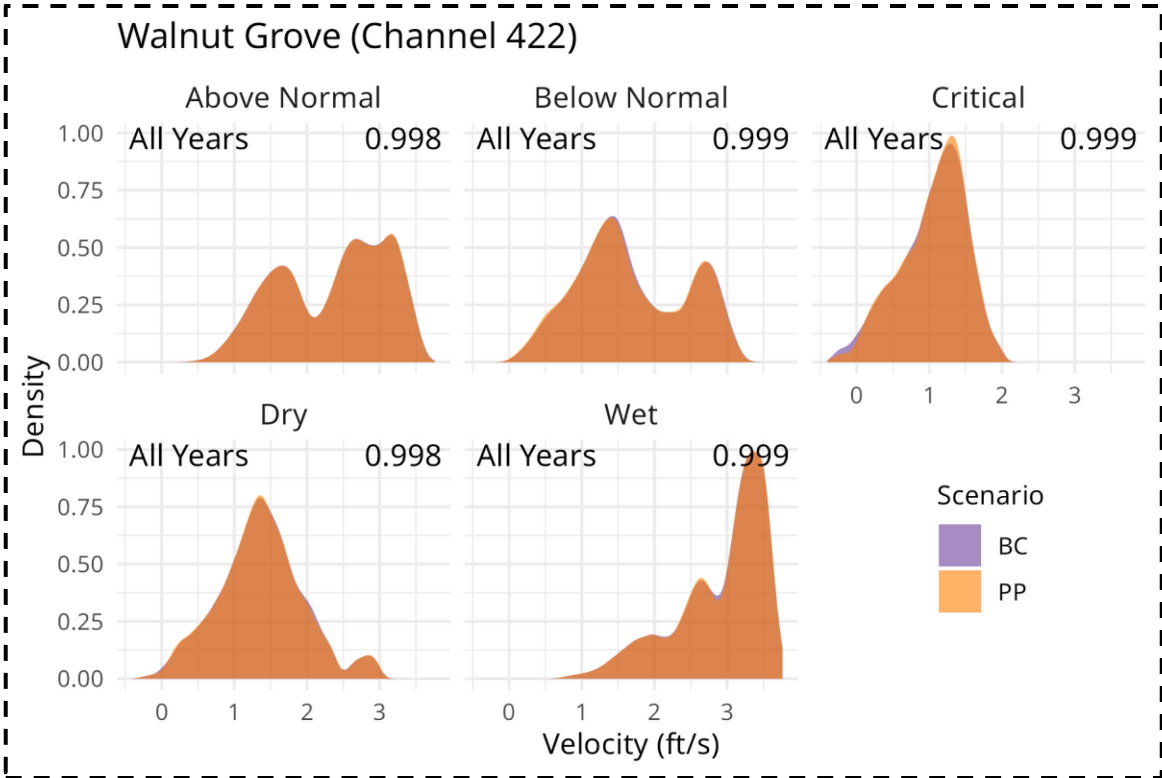
Figure 6-86. Velocity Density Distribution for Sacramento River at Walnut Grove, December

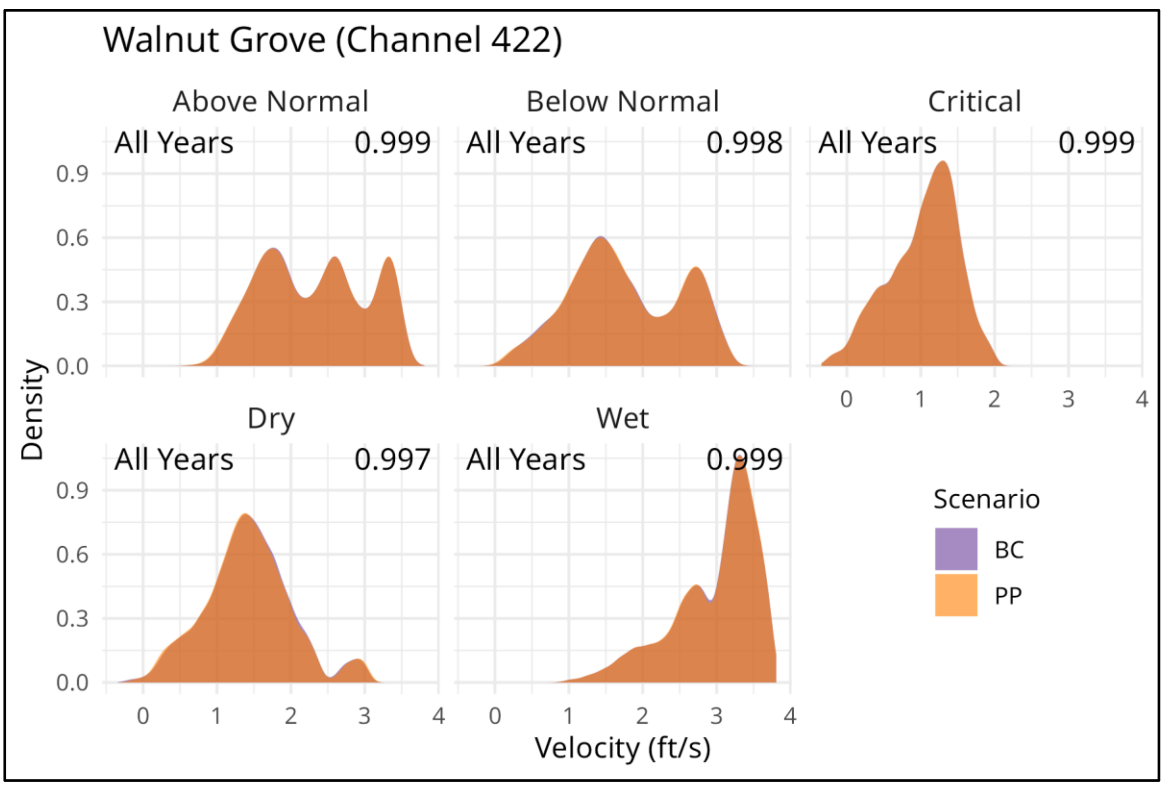




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

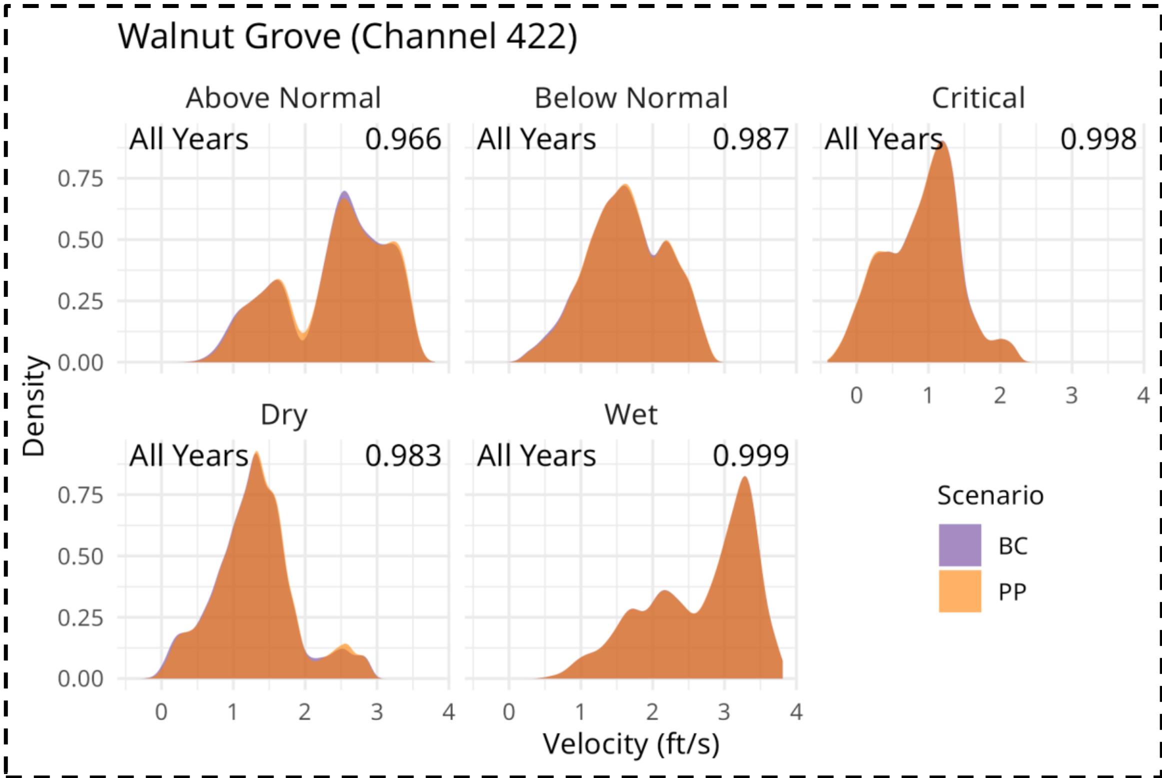
Figure 6-87. Velocity Density Distribution for Sacramento River at Walnut Grove, January

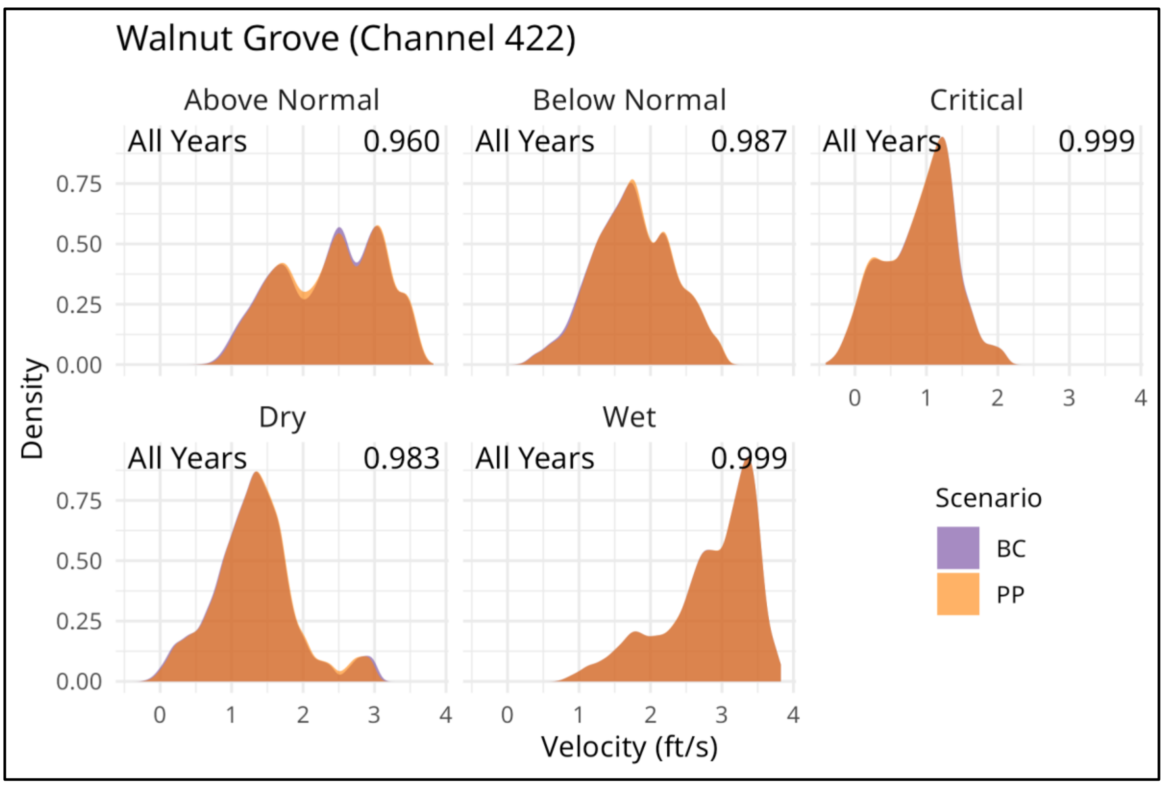




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

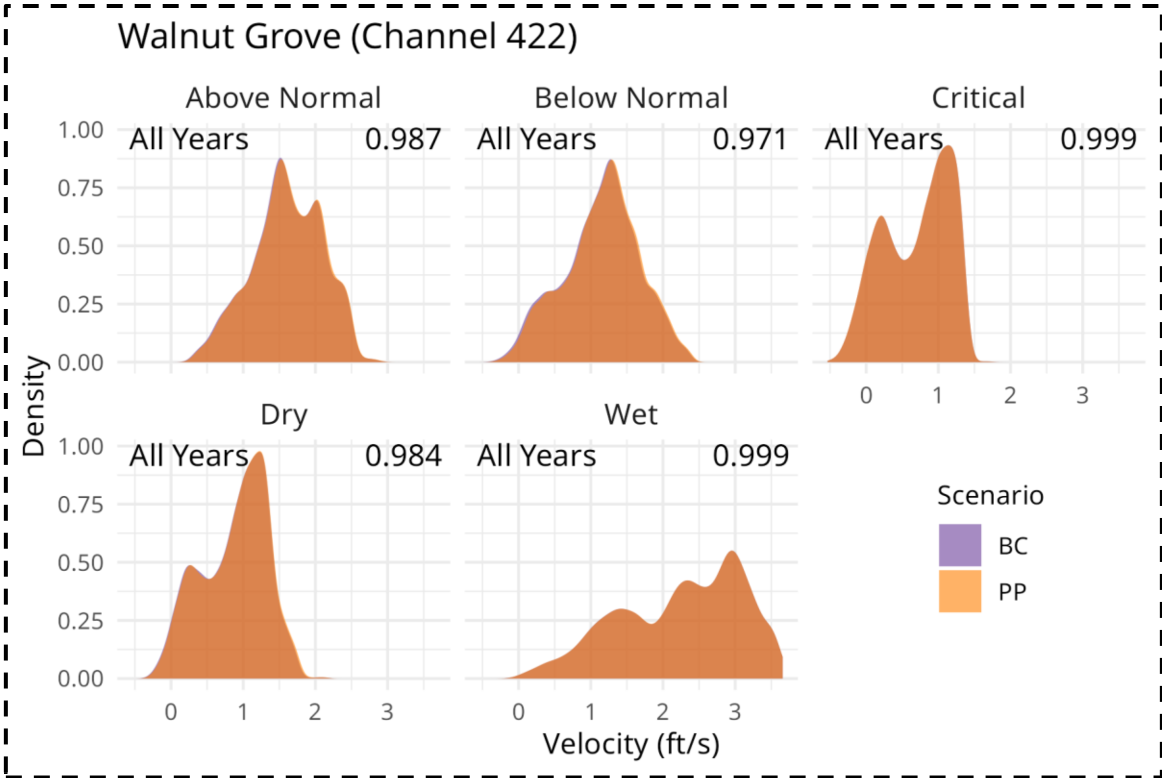
Figure 6-88. Velocity Density Distribution for Sacramento River at Walnut Grove, February

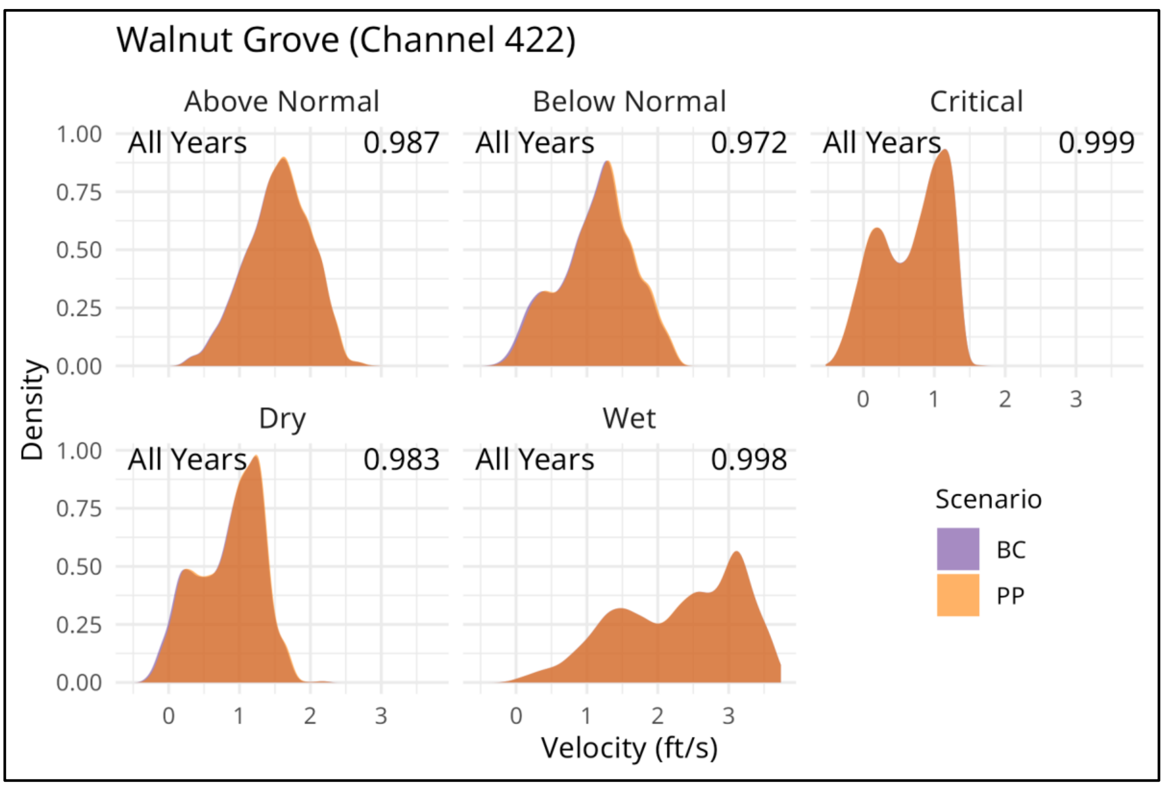




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

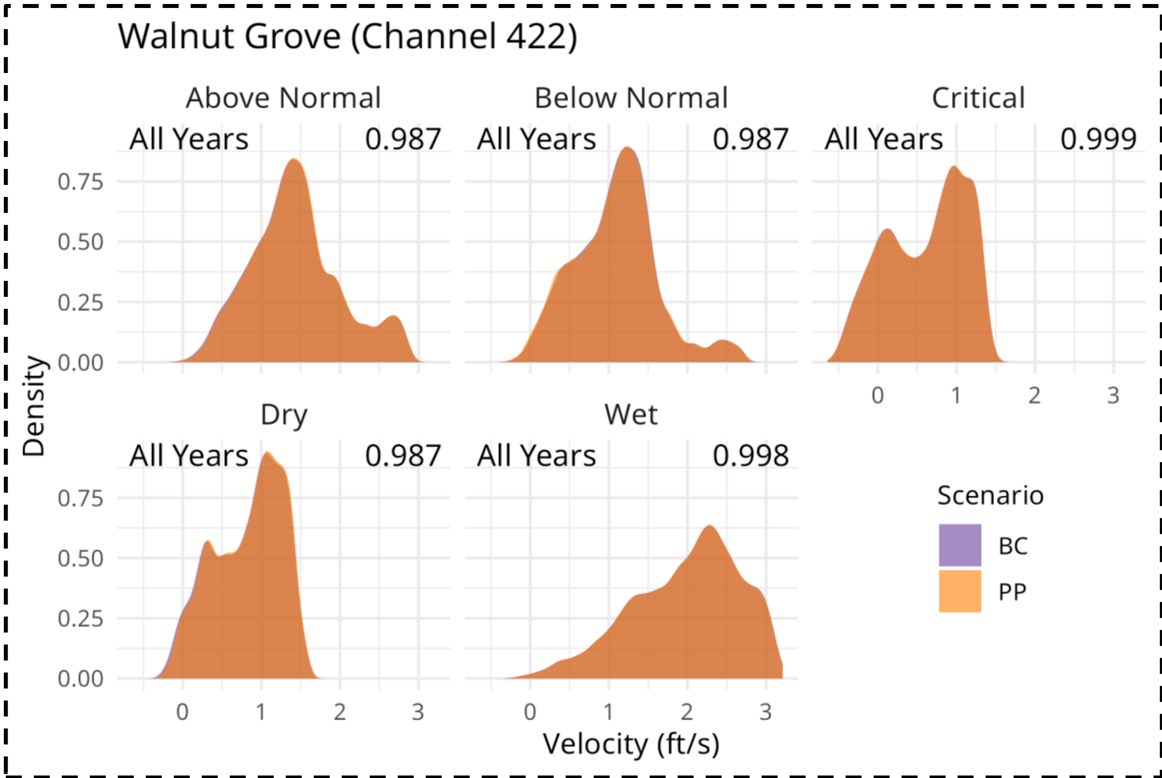
Figure 6-89. Velocity Density Distribution for Sacramento River at Walnut Grove, March

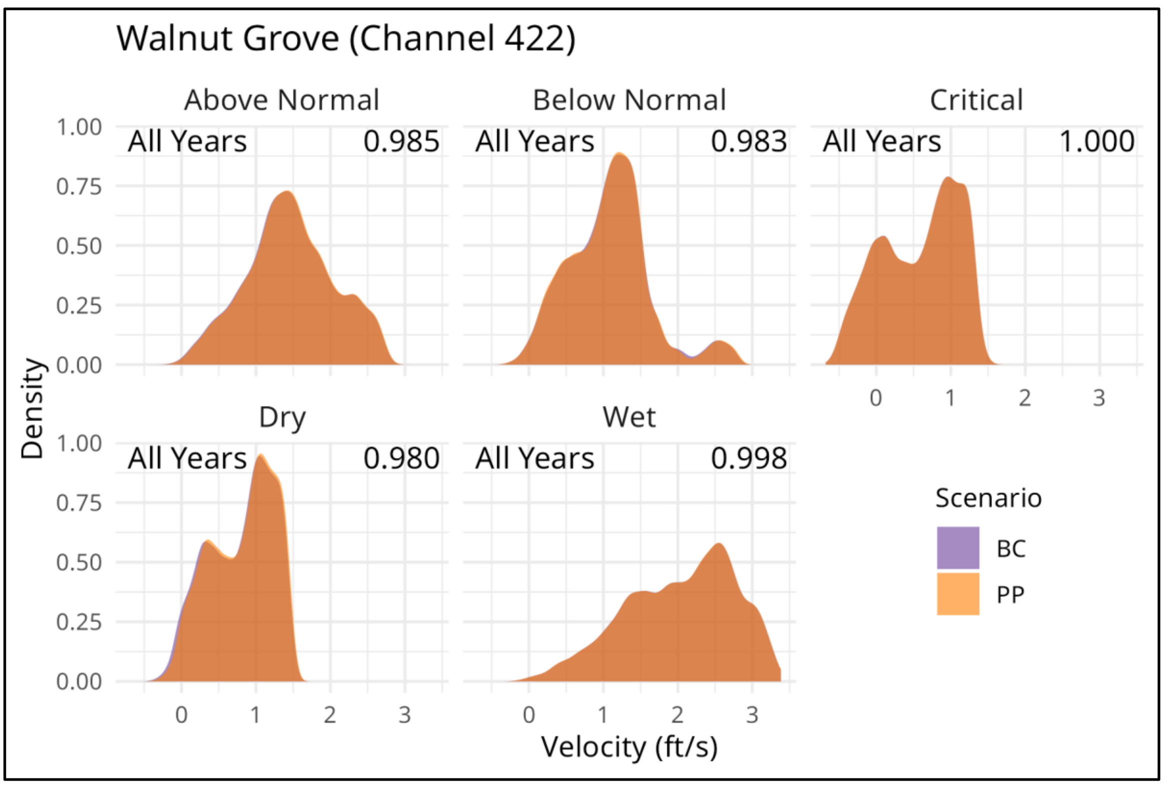




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

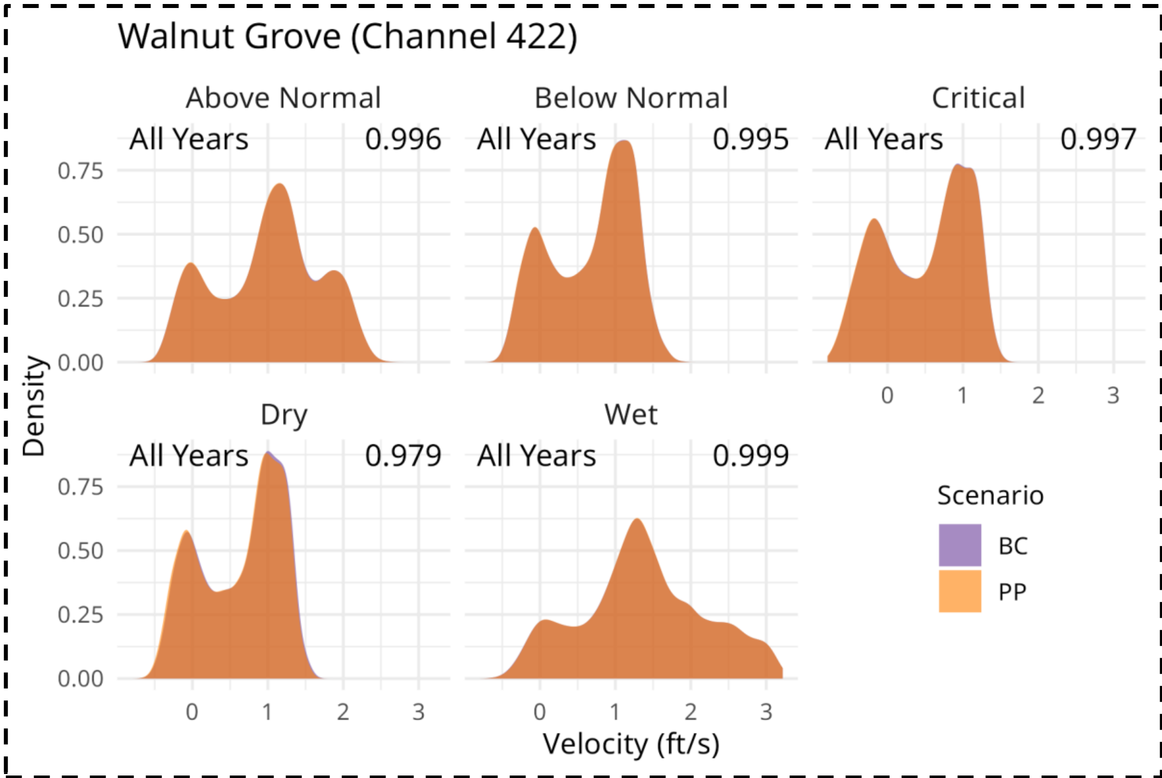
Figure 6-90. Velocity Density Distribution for Sacramento River at Walnut Grove, April

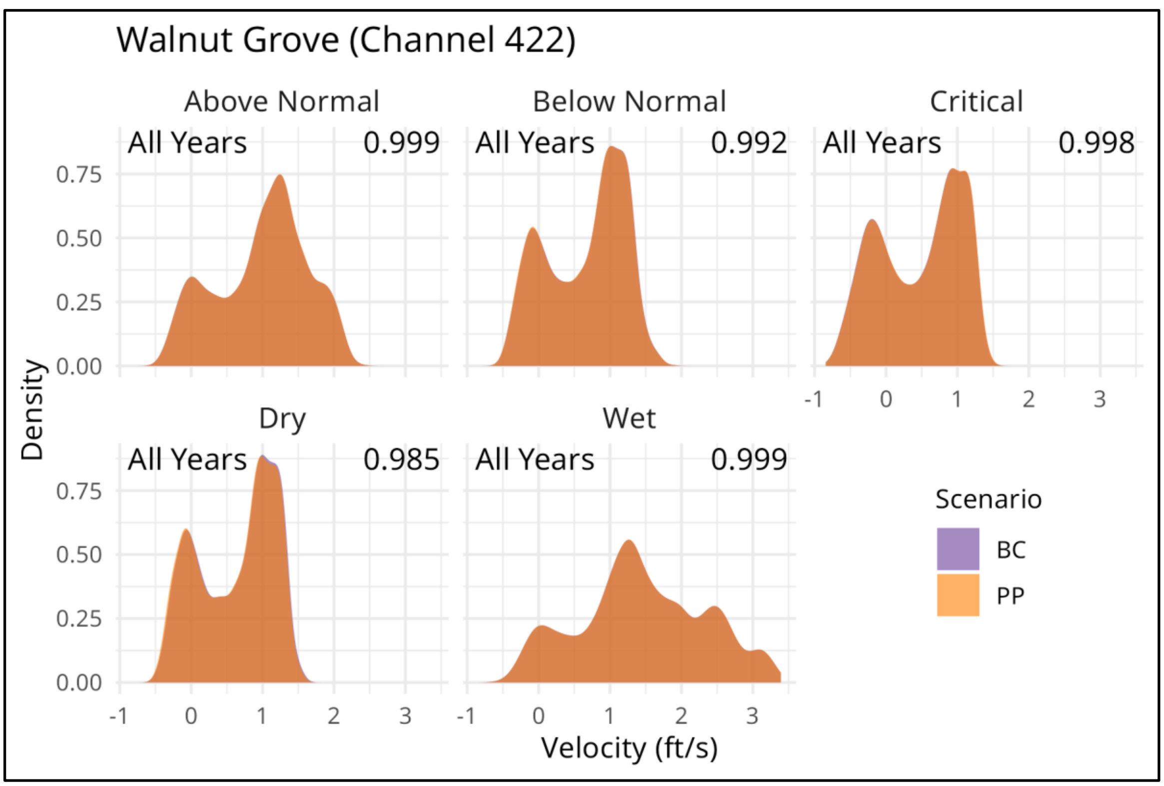




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

Figure 6-91. Velocity Density Distribution for Sacramento River at Walnut Grove, May





Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

Figure 6-92. Velocity Density Distribution for Sacramento River at Walnut Grove, June

Junction Routing

As noted under "Velocity," survival of outmigrating juvenile Chinook Salmon is generally lower in the interior Delta than remaining in the north Delta/mainstem Sacramento River. Flow entering a river junction is positively correlated with the probability of juvenile Chinook Salmon entering the river junction (Cavallo et al. 2015). The DSM2-HYDRO outputs showed that the mean flow entering key migratory junctions in the Delta generally would be similar between the Proposed Project and Baseline Conditions (Table ~~6-35~~ 6-36 and Figures 6B-269 through 6B-280 in Appendix 6B).[16]

Table ~~6-35~~ 6-36. Mean Daily Proportion of Flow Entering Delta Junctions by Month and Water Year Type

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Columbia Cut	Sep	Wet	~~0.136~~ 0.135	~~0.138 (1.6%)~~ 0.137 (1.5%)
Columbia Cut	Sep	Above Normal	~~0.130~~ 0.127	~~0.131 (1.3%)~~ 0.129 (1.1%)
Columbia Cut	Sep	Below Normal	~~0.135~~ 0.131	~~0.134 (-0.3%)~~ 0.130 (-0.7%)
Columbia Cut	Sep	Dry	~~0.124~~ 0.122	~~0.124 (-0.3%)~~ 0.122 (-0.2%)
Columbia Cut	Sep	Critically Dry	~~0.118~~ 0.116	~~0.118 (0.0%)~~ 0.116 (-0.1%)
Columbia Cut	Oct	Wet	~~0.130~~ 0.129	~~0.129 (-0.3%)~~ 0.128 (-0.2%)
Columbia Cut	Oct	Above Normal	~~0.121~~ 0.122	0.121 ~~(0.0%)~~ (-0.5%)
Columbia Cut	Oct	Below Normal	~~0.128~~ 0.127	~~0.128 (0.2%)~~ 0.127 (-0.4%)
Columbia Cut	Oct	Dry	0.125	0.125 ~~(-0.1%)~~ (0.5%)
Columbia Cut	Oct	Critically Dry	~~0.116~~ 0.118	~~0.116 (0.1%)~~ 0.118 (0.0%)
Columbia Cut	Nov	Wet	~~0.135~~ 0.133	~~0.136 (0.1%)~~ 0.133 (-0.1%)
Columbia Cut	Nov	Above Normal	0.128	0.128 ~~(0.1%)~~ (0.0%)
Columbia Cut	Nov	Below Normal	~~0.131~~ 0.130	~~0.131 (-0.1%)~~ 0.130 (0.0%)
Columbia Cut	Nov	Dry	~~0.129~~ 0.128	~~0.129~~ 0.128 (0.1%)
Columbia Cut	Nov	Critically Dry	~~0.117~~ 0.118	~~0.117 (0.1%)~~ 0.118 (-0.1%)
Columbia Cut	Dec	Wet	~~0.134~~ 0.131	~~0.134~~ 0.131 (0.1%)
Columbia Cut	Dec	Above Normal	~~0.126~~ 0.127	0.127 ~~(0.5%)~~ (0.3%)
Columbia Cut	Dec	Below Normal	~~0.126~~ 0.123	~~0.126 (0.1%)~~ 0.123 (0.0%)
Columbia Cut	Dec	Dry	~~0.125~~ 0.122	~~0.124 (-0.4%)~~ 0.122 (-0.3%)
Columbia Cut	Dec	Critically Dry	0.119	0.119 (0.1%)
Columbia Cut	Jan	Wet	~~0.133~~ 0.134	~~0.132 (-0.5%)~~ 0.133 (-0.2%)
Columbia Cut	Jan	Above Normal	~~0.129~~ 0.127	~~0.129 (-0.3%)~~ 0.127 (-0.4%)
Columbia Cut	Jan	Below Normal	0.123	~~0.123~~ 0.122 (-0.3%)
Columbia Cut	Jan	Dry	~~0.121~~ 0.120	0.120 ~~(-0.4%)~~ (0.0%)
Columbia Cut	Jan	Critically Dry	~~0.120~~ 0.117	~~0.119 (-0.8%)~~ 0.117 (-0.1%)

[16] Greater flow entering the DCC during October ~~/November~~ of ~~some water year types~~ Dry years reflects modeling assumptions for DCC Gates assumption reflecting simulation of the NMFS 2019 BiOp action for which the gates are assumed closed when daily flows at Wilkins Slough exceeds 7,500 cfs. This is calculated in the model as a partial month when monthly flows range between 6,000 cfs and 10,000 cfs. When flows are in this range, a simple linear regression is used to determine the number of days the DCC is closed based on monthly flow at Wilkins Slough. Application of this regression can result in relatively small changes in flow giving differences in the number of days the DCC is closed between scenarios. Note that the DCC is not an SWP facility and so is not part of the Proposed Project.

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Columbia Cut	Feb	Wet	~~0.137~~ 0.136	~~0.137 (0.1%)~~ 0.136 (-0.1%)
Columbia Cut	Feb	Above Normal	0.133	0.132 (-0.7%)
Columbia Cut	Feb	Below Normal	0.129	0.128 ~~(-0.5%)~~ (-0.8%)
Columbia Cut	Feb	Dry	0.122	~~0.121~~ 0.120 (-1.1%)
Columbia Cut	Feb	Critically Dry	~~0.121~~ 0.120	~~0.121 (-0.4%)~~ 0.119 (-0.9%)
Columbia Cut	Mar	Wet	0.132	~~0.132 (0.2%)~~ 0.133 (0.6%)
Columbia Cut	Mar	Above Normal	0.129	0.128 (-0.7%)
Columbia Cut	Mar	Below Normal	~~0.125~~ 0.126	0.124 ~~(-1.1%)~~ (-1.2%)
Columbia Cut	Mar	Dry	0.120	~~0.120 (-0.6%)~~ 0.119 (-1.0%)
Columbia Cut	Mar	Critically Dry	~~0.117~~ 0.116	~~0.117 (-0.1%)~~ 0.116 (-0.2%)
Columbia Cut	Apr	Wet	0.130	~~0.130 (0.4%)~~ 0.132 (0.9%)
Columbia Cut	Apr	Above Normal	0.122	0.123 ~~(1.2%)~~ (1.0%)
Columbia Cut	Apr	Below Normal	0.115	~~0.116 (1.1%)~~ 0.117 (1.0%)
Columbia Cut	Apr	Dry	0.113	0.113 ~~(0.1%)~~ (-0.3%)
Columbia Cut	Apr	Critically Dry	0.111	0.111 ~~(0.3%)~~ (0.2%)
Columbia Cut	May	Wet	~~0.129~~ 0.131	0.133 ~~(2.6%)~~ (1.7%)
Columbia Cut	May	Above Normal	~~0.122~~ 0.123	~~0.125 (2.3%)~~ 0.126 (2.2%)
Columbia Cut	May	Below Normal	~~0.113~~ 0.115	~~0.116 (2.3%)~~ 0.118 (2.6%)
Columbia Cut	May	Dry	~~0.111~~ 0.112	~~0.112 (0.7%)~~ 0.113 (0.8%)
Columbia Cut	May	Critically Dry	~~0.108~~ 0.109	~~0.109 (0.6%)~~ 0.110 (0.5%)
Columbia Cut	Jun	Wet	0.133	~~0.132 (-0.5%)~~ 0.131 (-1.1%)
Columbia Cut	Jun	Above Normal	~~0.128~~ 0.127	~~0.127 (-1.0%)~~ 0.125 (-1.5%)
Columbia Cut	Jun	Below Normal	~~0.126~~ 0.125	0.124 ~~(-0.8%)~~ (-1.2%)
Columbia Cut	Jun	Dry	0.122	~~0.121~~ 0.120 (-1.1%)
Columbia Cut	Jun	Critically Dry	~~0.114~~ 0.113	~~0.114 (-0.3%)~~ 0.113 (0.2%)
Delta Cross Channel	Sep	Wet	~~0.401~~ 0.402	~~0.397 (-0.9%)~~ 0.399 (-0.6%)
Delta Cross Channel	Sep	Above Normal	~~0.419~~ 0.422	~~0.411 (-1.9%)~~ 0.416 (-1.5%)
Delta Cross Channel	Sep	Below Normal	~~0.444~~ 0.442	~~0.444~~ 0.441 (-0.1%)
Delta Cross Channel	Sep	Dry	~~0.445~~ 0.440	~~0.445 (0.0%)~~ 0.439 (-0.1%)
Delta Cross Channel	Sep	Critically Dry	~~0.412~~ 0.339	~~0.413~~ 0.339 (0.0%)
Delta Cross Channel	Oct	Wet	~~0.262~~ 0.295	~~0.262 (-0.4%)~~ 0.296 (0.5%)
Delta Cross Channel	Oct	Above Normal	~~0.281~~ 0.292	~~0.282 (0.4%)~~ 0.294 (0.6%)
Delta Cross Channel	Oct	Below Normal	~~0.298~~ 0.308	~~0.318 (7.0%)~~ 0.304 (-1.3%)
Delta Cross Channel	Oct	Dry	~~0.276~~ 0.342	~~0.290 (5.3%)~~ 0.362 (5.9%)
Delta Cross Channel	Oct	Critically Dry	~~0.202~~ 0.254	~~0.200 (-0.8%)~~ 0.255 (0.1%)
Delta Cross Channel	Nov	Wet	~~0.195~~ 0.201	~~0.195 (0.0%)~~ 0.201 (-0.2%)
Delta Cross Channel	Nov	Above Normal	~~0.125~~ 0.205	~~0.141 (12.7%)~~ 0.207 (0.9%)
Delta Cross Channel	Nov	Below Normal	~~0.230~~ 0.261	~~0.230 (0.2%)~~ 0.260 (-0.3%)
Delta Cross Channel	Nov	Dry	~~0.244~~ 0.245	~~0.245 (0.5%)~~ 0.244 (-0.5%)
Delta Cross Channel	Nov	Critically Dry	~~0.134~~ 0.200	~~0.166 (24.2%)~~ 0.202 (0.6%)
Delta Cross Channel	Dec	Wet	~~0.000~~ 0.004	0.000 ~~(0.0%)~~ (-100.0%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Delta Cross Channel	Dec	Above Normal	~~0.000~~ 0.015	~~0.000~~ 0.015 (0.0%)
Delta Cross Channel	Dec	Below Normal	~~0.000~~ 0.024	~~0.000~~ 0.024 (0.0%)
Delta Cross Channel	Dec	Dry	~~0.000~~ 0.024	~~0.000 (0.0%)~~ 0.024 (-1.8%)
Delta Cross Channel	Dec	Critically Dry	~~0.000~~ 0.067	~~0.000 (0.0%)~~ 0.063 (-6.6%)
Delta Cross Channel	Jan	Wet	0.000	0.000 (0.0%)
Delta Cross Channel	Jan	Above Normal	0.000	0.000 (0.0%)
Delta Cross Channel	Jan	Below Normal	~~0.000~~ 0.007	~~0.000~~ 0.007 (0.0%)
Delta Cross Channel	Jan	Dry	~~0.000~~ 0.006	~~0.000~~ 0.006 (0.0%)
Delta Cross Channel	Jan	Critically Dry	~~0.000~~ 0.011	~~0.000 (0.0%)~~ 0.011 (0.3%)
Delta Cross Channel	Feb	Wet	0.000	0.000 (0.0%)
Delta Cross Channel	Feb	Above Normal	0.000	0.000 (0.0%)
Delta Cross Channel	Feb	Below Normal	0.000	0.000 (0.0%)
Delta Cross Channel	Feb	Dry	0.000	0.000 (0.0%)
Delta Cross Channel	Feb	Critically Dry	0.000	0.000 (0.0%)
Delta Cross Channel	Mar	Wet	0.000	0.000 (0.0%)
Delta Cross Channel	Mar	Above Normal	0.000	0.000 (0.0%)
Delta Cross Channel	Mar	Below Normal	0.000	0.000 (0.0%)
Delta Cross Channel	Mar	Dry	0.000	0.000 (0.0%)
Delta Cross Channel	Mar	Critically Dry	0.000	0.000 (0.0%)
Delta Cross Channel	Apr	Wet	0.000	0.000 (0.0%)
Delta Cross Channel	Apr	Above Normal	0.000	0.000 (0.0%)
Delta Cross Channel	Apr	Below Normal	0.000	0.000 (0.0%)
Delta Cross Channel	Apr	Dry	0.000	0.000 (0.0%)
Delta Cross Channel	Apr	Critically Dry	0.000	0.000 (0.0%)
Delta Cross Channel	May	Wet	0.000	0.000 (0.0%)
Delta Cross Channel	May	Above Normal	0.000	0.000 (0.0%)
Delta Cross Channel	May	Below Normal	0.000	0.000 (0.0%)
Delta Cross Channel	May	Dry	0.000	0.000 (0.0%)
Delta Cross Channel	May	Critically Dry	0.000	0.000 (0.0%)
Delta Cross Channel	Jun	Wet	~~0.202~~ 0.186	~~0.202 (-0.2%)~~ 0.186 (0.2%)
Delta Cross Channel	Jun	Above Normal	~~0.268~~ 0.293	~~0.267 (-0.2%)~~ 0.292 (-0.3%)
Delta Cross Channel	Jun	Below Normal	~~0.369~~ 0.382	~~0.368 (-0.2%)~~ 0.382 (0.0%)
Delta Cross Channel	Jun	Dry	~~0.380~~ 0.397	~~0.378 (-0.4%)~~ 0.396 (-0.1%)
Delta Cross Channel	Jun	Critically Dry	~~0.353~~ 0.366	~~0.352 (-0.2%)~~ 0.366 (0.1%)
Fishermans Cut	Sep	Wet	0.014	0.014 ~~(-0.2%)~~ (-0.3%)
Fishermans Cut	Sep	Above Normal	0.014	0.014 ~~(-4.4%)~~ (0.8%)
Fishermans Cut	Sep	Below Normal	0.014	~~0.014 (0.7%)~~ 0.013 (-1.9%)
Fishermans Cut	Sep	Dry	~~0.014~~ 0.013	0.013 ~~(-0.7%)~~ (0.2%)
Fishermans Cut	Sep	Critically Dry	0.013	0.013 ~~(0.4%)~~ (0.0%)
Fishermans Cut	Oct	Wet	0.014	~~0.014 (-0.7%)~~ 0.013 (-1.1%)
Fishermans Cut	Oct	Above Normal	0.013	0.013 ~~(0.0%)~~ (-0.1%)
Fishermans Cut	Oct	Below Normal	0.013	0.013 ~~(1.5%)~~ (1.1%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Fishermans Cut	Oct	Dry	0.013	0.013 ~~(-0.4%)~~ (0.2%)
Fishermans Cut	Oct	Critically Dry	0.013	0.013 ~~(0.6%)~~ (1.3%)
Fishermans Cut	Nov	Wet	0.014	0.014 (0.8%)
Fishermans Cut	Nov	Above Normal	0.013	0.013 ~~(0.0%)~~ (-0.9%)
Fishermans Cut	Nov	Below Normal	0.013	0.013 ~~(0.4%)~~ (-0.1%)
Fishermans Cut	Nov	Dry	0.013	0.013 ~~(-0.4%)~~ (-0.7%)
Fishermans Cut	Nov	Critically Dry	~~0.013~~ 0.012	~~0.013 (0.2%)~~ 0.012 (0.1%)
Fishermans Cut	Dec	Wet	0.016	~~0.017 (0.9%)~~ 0.016 (0.1%)
Fishermans Cut	Dec	Above Normal	~~0.014~~ 0.015	~~0.014~~ 0.015 (-0.9%)
Fishermans Cut	Dec	Below Normal	0.014	~~0.013 (-1.5%)~~ 0.014 (1.4%)
Fishermans Cut	Dec	Dry	0.014	~~0.014 (0.0%)~~ 0.013 (-0.8%)
Fishermans Cut	Dec	Critically Dry	0.013	0.013 ~~(0.1%)~~ (-0.7%)
Fishermans Cut	Jan	Wet	0.020	~~0.020~~ 0.021 (0.6%)
Fishermans Cut	Jan	Above Normal	~~0.016~~ 0.017	~~0.016 (0.1%)~~ 0.017 (0.9%)
Fishermans Cut	Jan	Below Normal	0.014	0.014 ~~(0.0%)~~ (-0.9%)
Fishermans Cut	Jan	Dry	0.013	~~0.013~~ 0.014 (1.1%)
Fishermans Cut	Jan	Critically Dry	0.013	~~0.014 (1.1%)~~ 0.013 (0.8%)
Fishermans Cut	Feb	Wet	0.023	0.023 ~~(-0.8%)~~ (0.3%)
Fishermans Cut	Feb	Above Normal	~~0.018~~ 0.017	0.017 ~~(-1.3%)~~ (-3.9%)
Fishermans Cut	Feb	Below Normal	0.015	~~0.015 (0.7%)~~ 0.016 (1.4%)
Fishermans Cut	Feb	Dry	0.014	0.014 ~~(-0.6%)~~ (-1.5%)
Fishermans Cut	Feb	Critically Dry	0.014	~~0.014 (1.6%)~~ 0.013 (-2.6%)
Fishermans Cut	Mar	Wet	~~0.020~~ 0.021	~~0.019 (-1.5%)~~ 0.021 (-0.5%)
Fishermans Cut	Mar	Above Normal	~~0.017~~ 0.016	~~0.018 (2.6%)~~ 0.017 (4.0%)
Fishermans Cut	Mar	Below Normal	0.015	0.015 ~~(-1.2%)~~ (0.1%)
Fishermans Cut	Mar	Dry	0.014	0.014 ~~(0.4%)~~ (1.4%)
Fishermans Cut	Mar	Critically Dry	0.013	0.013 ~~(0.3%)~~ (-0.6%)
Fishermans Cut	Apr	Wet	~~0.016~~ 0.017	~~0.016 (1.0%)~~ 0.017 (0.8%)
Fishermans Cut	Apr	Above Normal	0.015	~~0.014 (-1.0%)~~ 0.015 (0.1%)
Fishermans Cut	Apr	Below Normal	0.014	0.014 ~~(-0.2%)~~ (1.8%)
Fishermans Cut	Apr	Dry	0.013	0.013 ~~(0.5%)~~ (1.3%)
Fishermans Cut	Apr	Critically Dry	0.013	0.013 ~~(-0.4%)~~ (-2.2%)
Fishermans Cut	May	Wet	~~0.016~~ 0.015	~~0.015 (-2.8%)~~ 0.016 (0.7%)
Fishermans Cut	May	Above Normal	0.014	0.014 ~~(-3.0%)~~ (-0.3%)
Fishermans Cut	May	Below Normal	0.013	0.013 ~~(-2.1%)~~ (1.4%)
Fishermans Cut	May	Dry	0.013	0.013 ~~(0.8%)~~ (-0.6%)
Fishermans Cut	May	Critically Dry	0.013	0.013 ~~(0.0%)~~ (-0.1%)
Fishermans Cut	Jun	Wet	~~0.014~~ 0.015	~~0.014 (-0.2%)~~ 0.015 (0.0%)
Fishermans Cut	Jun	Above Normal	0.014	0.014 ~~(0.4%)~~ (3.0%)
Fishermans Cut	Jun	Below Normal	0.013	0.013 ~~(0.9%)~~ (0.1%)
Fishermans Cut	Jun	Dry	0.013	0.013 ~~(-0.7%)~~ (0.8%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Fishermans Cut	Jun	Critically Dry	0.013	0.013 ~~(-0.5%)~~ (1.1%)
False River	Sep	Wet	0.185	~~0.186~~ 0.185 (0.5%)
False River	Sep	Above Normal	0.182	~~0.183 (0.3%)~~ 0.182 (0.2%)
False River	Sep	Below Normal	~~0.186~~ 0.185	~~0.186 (0.0%)~~ 0.185 (-0.1%)
False River	Sep	Dry	~~0.184~~ 0.183	0.183 (0.0%)
False River	Sep	Critically Dry	0.183	0.183 (0.0%)
False River	Oct	Wet	~~0.184~~ 0.183	~~0.184~~ 0.183 (0.0%)
False River	Oct	Above Normal	0.182	0.182 ~~(0.0%)~~ (-0.1%)
False River	Oct	Below Normal	0.183	0.183 ~~(0.0%)~~ (-0.1%)
False River	Oct	Dry	~~0.183~~ 0.182	~~0.183 (0.0%)~~ 0.182 (0.1%)
False River	Oct	Critically Dry	0.182	0.182 (0.0%)
False River	Nov	Wet	0.185	0.185 (0.0%)
False River	Nov	Above Normal	0.184	0.184 ~~(-0.1%)~~ (0.0%)
False River	Nov	Below Normal	0.185	0.185 (0.0%)
False River	Nov	Dry	0.184	0.184 (0.0%)
False River	Nov	Critically Dry	0.183	0.183 (0.0%)
False River	Dec	Wet	0.184	0.184 (0.0%)
False River	Dec	Above Normal	0.186	0.186 ~~(0.2%)~~ (0.1%)
False River	Dec	Below Normal	0.185	~~0.186~~ 0.185 (0.0%)
False River	Dec	Dry	~~0.186~~ 0.185	~~0.186~~ 0.185 (-0.1%)
False River	Dec	Critically Dry	0.184	0.184 (0.0%)
False River	Jan	Wet	~~0.179~~ 0.178	~~0.179~~ 0.178 (-0.1%)
False River	Jan	Above Normal	0.183	0.183 (-0.1%)
False River	Jan	Below Normal	0.183	0.183 (-0.1%)
False River	Jan	Dry	~~0.183~~ 0.184	0.183 ~~(-0.1%)~~ (0.0%)
False River	Jan	Critically Dry	0.183	0.183 ~~(-0.2%)~~ (0.0%)
False River	Feb	Wet	~~0.178~~ 0.177	~~0.178~~ 0.177 (0.0%)
False River	Feb	Above Normal	~~0.181~~ 0.182	~~0.181~~ 0.182 (-0.2%)
False River	Feb	Below Normal	0.182	0.182 ~~(-0.1%)~~ (-0.2%)
False River	Feb	Dry	~~0.182~~ 0.183	0.182 (-0.3%)
False River	Feb	Critically Dry	0.182	0.182 ~~(-0.1%)~~ (-0.2%)
False River	Mar	Wet	~~0.176~~ 0.175	~~0.176~~ 0.175 (0.1%)
False River	Mar	Above Normal	~~0.181~~ 0.180	0.180 (-0.2%)
False River	Mar	Below Normal	0.181	0.181 (-0.3%)
False River	Mar	Dry	0.182	0.182 ~~(-0.1%)~~ (-0.2%)
False River	Mar	Critically Dry	0.181	~~0.180 (0.0%)~~ 0.181 (-0.1%)
False River	Apr	Wet	~~0.177~~ 0.176	0.177 ~~(0.1%)~~ (0.2%)
False River	Apr	Above Normal	~~0.178~~ 0.179	0.179 ~~(0.3%)~~ (0.2%)
False River	Apr	Below Normal	0.177	0.178 (0.1%)
False River	Apr	Dry	~~0.180~~ 0.181	~~0.180~~ 0.181 (0.0%)
False River	Apr	Critically Dry	0.180	0.180 ~~(0.1%)~~ (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
False River	May	Wet	0.179	0.180 ~~(0.6%)~~ (0.4%)
False River	May	Above Normal	0.180	0.181 ~~(0.5%)~~ (0.4%)
False River	May	Below Normal	0.180	0.180 (0.4%)
False River	May	Dry	0.180	0.181 (0.1%)
False River	May	Critically Dry	0.181	0.181 (0.1%)
False River	Jun	Wet	0.181	0.181 ~~(-0.1%)~~ (-0.2%)
False River	Jun	Above Normal	0.183	0.183 ~~(-0.2%)~~ (-0.3%)
False River	Jun	Below Normal	0.183	0.183 (-0.2%)
False River	Jun	Dry	0.184	~~0.184~~ 0.183 (-0.2%)
False River	Jun	Critically Dry	0.182	0.182 ~~(0.0%)~~ (0.1%)
Georgiana Slough	Sep	Wet	~~0.447~~ 0.446	0.444 ~~(-0.8%)~~ (-0.4%)
Georgiana Slough	Sep	Above Normal	~~0.453~~ 0.450	~~0.443 (-2.1%)~~ 0.444 (-1.2%)
Georgiana Slough	Sep	Below Normal	~~0.449~~ 0.426	~~0.447 (-0.3%)~~ 0.420 (-1.4%)
Georgiana Slough	Sep	Dry	~~0.391~~ 0.377	~~0.392 (0.1%)~~ 0.377 (0.0%)
Georgiana Slough	Sep	Critically Dry	~~0.333~~ 0.336	~~0.333 (0.0%)~~ 0.335 (-0.3%)
Georgiana Slough	Oct	Wet	~~0.392~~ 0.386	~~0.391~~ 0.385 (-0.1%)
Georgiana Slough	Oct	Above Normal	~~0.389~~ 0.399	~~0.390 (0.3%)~~ 0.396 (-0.6%)
Georgiana Slough	Oct	Below Normal	~~0.399~~ 0.394	~~0.398 (-0.4%)~~ 0.391 (-0.8%)
Georgiana Slough	Oct	Dry	~~0.404~~ 0.384	~~0.399 (-1.3%)~~ 0.383 (-0.1%)
Georgiana Slough	Oct	Critically Dry	~~0.372~~ 0.352	~~0.374 (0.4%)~~ 0.352 (0.1%)
Georgiana Slough	Nov	Wet	~~0.390~~ 0.395	~~0.390 (0.0%)~~ 0.395 (0.2%)
Georgiana Slough	Nov	Above Normal	~~0.393~~ 0.405	~~0.390 (-0.6%)~~ 0.406 (0.3%)
Georgiana Slough	Nov	Below Normal	~~0.406~~ 0.406	~~0.405 (-0.3%)~~ 0.406 (0.0%)
Georgiana Slough	Nov	Dry	~~0.413~~ 0.403	~~0.413 (0.1%)~~ 0.403 (0.2%)
Georgiana Slough	Nov	Critically Dry	~~0.386~~ 0.379	~~0.377 (-2.2%)~~ 0.379 (0.1%)
Georgiana Slough	Dec	Wet	~~0.317~~ 0.326	~~0.317 (0.1%)~~ 0.327 (0.4%)
Georgiana Slough	Dec	Above Normal	~~0.385~~ 0.379	~~0.385 (-0.1%)~~ 0.378 (-0.2%)
Georgiana Slough	Dec	Below Normal	0.399	~~0.396 (-0.8%)~~ 0.398 (-0.2%)
Georgiana Slough	Dec	Dry	~~0.405~~ 0.394	~~0.407~~ 0.396 (0.5%)
Georgiana Slough	Dec	Critically Dry	~~0.423~~ 0.403	~~0.424 (0.3%)~~ 0.404 (0.4%)
Georgiana Slough	Jan	Wet	~~0.298~~ 0.296	~~0.298 (-0.1%)~~ 0.296 (0.0%)
Georgiana Slough	Jan	Above Normal	~~0.308~~ 0.309	~~0.308~~ 0.309 (0.0%)
Georgiana Slough	Jan	Below Normal	~~0.355~~ 0.351	~~0.354 (-0.1%)~~ 0.352 (0.1%)
Georgiana Slough	Jan	Dry	~~0.401~~ 0.402	0.402 ~~(0.3%)~~ (-0.1%)
Georgiana Slough	Jan	Critically Dry	~~0.397~~ 0.416	~~0.397 (-0.2%)~~ 0.416 (0.0%)
Georgiana Slough	Feb	Wet	~~0.286~~ 0.285	~~0.286~~ 0.285 (0.0%)
Georgiana Slough	Feb	Above Normal	~~0.294~~ 0.292	~~0.294~~ 0.292 (0.0%)
Georgiana Slough	Feb	Below Normal	~~0.336~~ 0.329	~~0.338 (0.5%)~~ 0.329 (-0.1%)
Georgiana Slough	Feb	Dry	~~0.356~~ 0.349	~~0.356 (0.0%)~~ 0.350 (0.4%)
Georgiana Slough	Feb	Critically Dry	~~0.392~~ 0.396	~~0.392 (0.1%)~~ 0.395 (-0.1%)
Georgiana Slough	Mar	Wet	~~0.289~~ 0.286	~~0.289~~ 0.286 (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Georgiana Slough	Mar	Above Normal	~~0.293~~ 0.291	~~0.292 (-0.3%)~~ 0.290 (-0.2%)
Georgiana Slough	Mar	Below Normal	~~0.320~~ 0.310	~~0.319 (-0.6%)~~ 0.309 (-0.5%)
Georgiana Slough	Mar	Dry	~~0.362~~ 0.359	~~0.360~~ 0.357 (-0.7%)
Georgiana Slough	Mar	Critically Dry	~~0.420~~ 0.421	~~0.420 (0.1%)~~ 0.421 (0.2%)
Georgiana Slough	Apr	Wet	~~0.305~~ 0.302	~~0.305~~ 0.303 (0.2%)
Georgiana Slough	Apr	Above Normal	~~0.314~~ 0.315	~~0.313~~ 0.314 (-0.3%)
Georgiana Slough	Apr	Below Normal	~~0.373~~ 0.376	~~0.371~~ 0.374 (-0.6%)
Georgiana Slough	Apr	Dry	~~0.422~~ 0.425	~~0.420~~ 0.424 (-0.4%)
Georgiana Slough	Apr	Critically Dry	~~0.447~~ 0.443	~~0.447~~ 0.444 (0.1%)
Georgiana Slough	May	Wet	~~0.308~~ 0.309	0.309 ~~(0.3%)~~ (0.2%)
Georgiana Slough	May	Above Normal	~~0.342~~ 0.343	0.342 ~~(-0.2%)~~ (-0.1%)
Georgiana Slough	May	Below Normal	~~0.389~~ 0.392	~~0.391 (0.7%)~~ 0.394 (0.5%)
Georgiana Slough	May	Dry	~~0.435~~ 0.440	~~0.434 (-0.1%)~~ 0.439 (-0.2%)
Georgiana Slough	May	Critically Dry	~~0.423~~ 0.410	~~0.424 (0.2%)~~ 0.410 (0.1%)
Georgiana Slough	Jun	Wet	~~0.361~~ 0.356	~~0.361 (0.0%)~~ 0.355 (-0.2%)
Georgiana Slough	Jun	Above Normal	~~0.390~~ 0.394	~~0.389 (-0.1%)~~ 0.393 (-0.3%)
Georgiana Slough	Jun	Below Normal	~~0.415~~ 0.413	~~0.414 (-0.2%)~~ 0.411 (-0.4%)
Georgiana Slough	Jun	Dry	~~0.418~~ 0.423	~~0.414 (-1.1%)~~ 0.419 (-0.9%)
Georgiana Slough	Jun	Critically Dry	~~0.358~~ 0.350	~~0.356 (-0.7%)~~ 0.351 (0.4%)
Head of Old River	Sep	Wet	~~0.562~~ 0.552	~~0.567~~ 0.557 (1.0%)
Head of Old River	Sep	Above Normal	~~0.553~~ 0.508	~~0.559 (1.1%)~~ 0.514 (1.2%)
Head of Old River	Sep	Below Normal	~~0.558~~ 0.513	~~0.555 (-0.4%)~~ 0.509 (-0.9%)
Head of Old River	Sep	Dry	~~0.490~~ 0.440	~~0.486 (-0.9%)~~ 0.439 (-0.4%)
Head of Old River	Sep	Critically Dry	~~0.393~~ 0.353	~~0.392 (-0.3%)~~ 0.352 (-0.4%)
Head of Old River	Oct	Wet	~~0.546~~ 0.542	~~0.545 (-0.3%)~~ 0.541 (-0.2%)
Head of Old River	Oct	Above Normal	~~0.529~~ 0.526	~~0.529 (-0.1%)~~ 0.524 (-0.4%)
Head of Old River	Oct	Below Normal	~~0.534~~ 0.525	~~0.535 (0.2%)~~ 0.524 (-0.1%)
Head of Old River	Oct	Dry	~~0.532~~ 0.526	~~0.532 (-0.1%)~~ 0.528 (0.3%)
Head of Old River	Oct	Critically Dry	~~0.502~~ 0.507	~~0.503 (0.1%)~~ 0.507 (0.0%)
Head of Old River	Nov	Wet	~~0.568~~ 0.562	~~0.569 (0.1%)~~ 0.561 (-0.2%)
Head of Old River	Nov	Above Normal	~~0.551~~ 0.544	~~0.551~~ 0.544 (0.0%)
Head of Old River	Nov	Below Normal	~~0.552~~ 0.545	~~0.551 (-0.1%)~~ 0.545 (0.1%)
Head of Old River	Nov	Dry	~~0.545~~ 0.536	~~0.545~~ 0.537 (0.1%)
Head of Old River	Nov	Critically Dry	0.492	0.492 ~~(0.2%)~~ (-0.1%)
Head of Old River	Dec	Wet	~~0.650~~ 0.649	~~0.650 (0.0%)~~ 0.649 (0.1%)
Head of Old River	Dec	Above Normal	~~0.680~~ 0.682	~~0.682 (0.4%)~~ 0.683 (0.2%)
Head of Old River	Dec	Below Normal	~~0.680~~ 0.662	~~0.681 (0.1%)~~ 0.662 (0.0%)
Head of Old River	Dec	Dry	~~0.683~~ 0.655	~~0.680 (-0.4%)~~ 0.653 (-0.3%)
Head of Old River	Dec	Critically Dry	~~0.624~~ 0.612	~~0.623 (0.0%)~~ 0.613 (0.2%)
Head of Old River	Jan	Wet	~~0.608~~ 0.603	~~0.607 (-0.1%)~~ 0.601 (-0.2%)
Head of Old River	Jan	Above Normal	~~0.640~~ 0.647	~~0.639 (-0.2%)~~ 0.645 (-0.3%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Head of Old River	Jan	Below Normal	~~0.660~~ 0.656	~~0.658 (-0.3%)~~ 0.654 (-0.4%)
Head of Old River	Jan	Dry	~~0.669~~ 0.655	~~0.667 (-0.2%)~~ 0.656 (0.0%)
Head of Old River	Jan	Critically Dry	~~0.660~~ 0.615	~~0.654 (-0.9%)~~ 0.614 (-0.2%)
Head of Old River	Feb	Wet	~~0.577~~ 0.576	~~0.577 (0.0%)~~ 0.575 (-0.1%)
Head of Old River	Feb	Above Normal	~~0.615~~ 0.621	~~0.615 (-0.1%)~~ 0.617 (-0.5%)
Head of Old River	Feb	Below Normal	~~0.626~~ 0.627	~~0.624 (-0.3%)~~ 0.623 (-0.6%)
Head of Old River	Feb	Dry	~~0.666~~ 0.667	0.660 ~~(-0.9%)~~ (-1.0%)
Head of Old River	Feb	Critically Dry	~~0.663~~ 0.656	~~0.660 (-0.4%)~~ 0.650 (-0.9%)
Head of Old River	Mar	Wet	~~0.566~~ 0.565	~~0.566~~ 0.565 (0.0%)
Head of Old River	Mar	Above Normal	~~0.593~~ 0.602	~~0.590 (-0.4%)~~ 0.599 (-0.5%)
Head of Old River	Mar	Below Normal	0.621	~~0.616 (-0.8%)~~ 0.615 (-1.0%)
Head of Old River	Mar	Dry	0.664	~~0.660 (-0.6%)~~ 0.657 (-1.1%)
Head of Old River	Mar	Critically Dry	~~0.647~~ 0.635	~~0.647 (0.0%)~~ 0.633 (-0.3%)
Head of Old River	Apr	Wet	0.553	~~0.554~~ 0.553 (0.1%)
Head of Old River	Apr	Above Normal	~~0.562~~ 0.567	~~0.564 (0.3%)~~ 0.568 (0.1%)
Head of Old River	Apr	Below Normal	~~0.574~~ 0.575	0.575 ~~(0.2%)~~ (0.0%)
Head of Old River	Apr	Dry	~~0.614~~ 0.617	0.614 ~~(0.0%)~~ (-0.4%)
Head of Old River	Apr	Critically Dry	~~0.619~~ 0.621	~~0.621~~ 0.623 (0.3%)
Head of Old River	May	Wet	~~0.561~~ 0.557	~~0.566 (0.9%)~~ 0.560 (0.6%)
Head of Old River	May	Above Normal	~~0.575~~ 0.574	~~0.582 (1.3%)~~ 0.581 (1.2%)
Head of Old River	May	Below Normal	~~0.587~~ 0.582	~~0.595 (1.3%)~~ 0.588 (1.1%)
Head of Old River	May	Dry	~~0.619~~ 0.615	~~0.623 (0.7%)~~ 0.619 (0.6%)
Head of Old River	May	Critically Dry	~~0.600~~ 0.620	~~0.605 (0.8%)~~ 0.623 (0.4%)
Head of Old River	Jun	Wet	~~0.534~~ 0.535	0.533 ~~(-0.2%)~~ (-0.4%)
Head of Old River	Jun	Above Normal	~~0.528~~ 0.526	~~0.525 (-0.5%)~~ 0.521 (-1.0%)
Head of Old River	Jun	Below Normal	~~0.524~~ 0.511	~~0.521 (-0.7%)~~ 0.505 (-1.1%)
Head of Old River	Jun	Dry	~~0.501~~ 0.477	~~0.495 (-1.2%)~~ 0.469 (-1.6%)
Head of Old River	Jun	Critically Dry	~~0.430~~ 0.381	~~0.427 (-0.6%)~~ 0.382 (0.3%)
Jersey Point	Sep	Wet	0.071	0.071 (-0.1%)
Jersey Point	Sep	Above Normal	0.071	~~0.072~~ 0.071 (0.2%)
Jersey Point	Sep	Below Normal	0.071	0.071 (0.0%)
Jersey Point	Sep	Dry	0.071	0.071 (0.0%)
Jersey Point	Sep	Critically Dry	0.071	0.071 (0.0%)
Jersey Point	Oct	Wet	0.070	0.070 (0.0%)
Jersey Point	Oct	Above Normal	0.070	0.070 (-0.1%)
Jersey Point	Oct	Below Normal	0.070	0.070 (0.0%)
Jersey Point	Oct	Dry	0.070	~~0.070~~ 0.071 (0.0%)
Jersey Point	Oct	Critically Dry	0.070	0.070 (0.0%)
Jersey Point	Nov	Wet	0.071	0.071 (0.0%)
Jersey Point	Nov	Above Normal	0.071	0.071 (0.0%)
Jersey Point	Nov	Below Normal	0.071	0.071 (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Jersey Point	Nov	Dry	0.071	0.071 (0.0%)
Jersey Point	Nov	Critically Dry	0.070	0.070 (0.0%)
Jersey Point	Dec	Wet	~~0.072~~ 0.071	~~0.072~~ 0.071 (0.0%)
Jersey Point	Dec	Above Normal	0.071	0.071 (0.0%)
Jersey Point	Dec	Below Normal	0.071	0.071 (0.0%)
Jersey Point	Dec	Dry	0.071	0.071 (0.0%)
Jersey Point	Dec	Critically Dry	0.071	0.071 (0.0%)
Jersey Point	Jan	Wet	0.072	0.072 (0.0%)
Jersey Point	Jan	Above Normal	~~0.072~~ 0.071	~~0.072~~ 0.071 (0.0%)
Jersey Point	Jan	Below Normal	0.072	0.072 (0.0%)
Jersey Point	Jan	Dry	0.071	0.071 (0.0%)
Jersey Point	Jan	Critically Dry	0.071	0.071 (0.0%)
Jersey Point	Feb	Wet	~~0.071~~ 0.072	~~0.071~~ 0.072 (0.0%)
Jersey Point	Feb	Above Normal	0.072	0.072 (0.0%)
Jersey Point	Feb	Below Normal	0.071	0.071 (0.0%)
Jersey Point	Feb	Dry	0.071	0.071 (0.0%)
Jersey Point	Feb	Critically Dry	0.071	0.071 ~~(-0.1%)~~ (0.0%)
Jersey Point	Mar	Wet	0.072	0.072 (0.0%)
Jersey Point	Mar	Above Normal	0.072	0.072 (0.0%)
Jersey Point	Mar	Below Normal	0.071	0.071 (-0.1%)
Jersey Point	Mar	Dry	0.071	0.071 (0.0%)
Jersey Point	Mar	Critically Dry	0.071	0.071 (0.0%)
Jersey Point	Apr	Wet	0.071	0.071 (0.0%)
Jersey Point	Apr	Above Normal	0.071	0.071 (0.3%)
Jersey Point	Apr	Below Normal	0.071	0.071 (0.1%)
Jersey Point	Apr	Dry	0.070	0.070 (0.0%)
Jersey Point	Apr	Critically Dry	0.071	0.071 (0.0%)
Jersey Point	May	Wet	0.072	0.072 (0.1%)
Jersey Point	May	Above Normal	0.071	0.071 (0.3%)
Jersey Point	May	Below Normal	0.071	0.071 (0.2%)
Jersey Point	May	Dry	0.071	0.071 ~~(0.1%)~~ (0.0%)
Jersey Point	May	Critically Dry	0.071	0.071 ~~(0.1%)~~ (0.0%)
Jersey Point	Jun	Wet	0.071	0.071 (0.0%)
Jersey Point	Jun	Above Normal	0.071	0.071 (0.0%)
Jersey Point	Jun	Below Normal	0.071	0.071 (0.0%)
Jersey Point	Jun	Dry	0.071	0.071 ~~(0.0%)~~ (-0.1%)
Jersey Point	Jun	Critically Dry	0.071	0.071 (0.0%)
Mouth of Middle River	Sep	Wet	~~0.203~~ 0.202	~~0.208 (2.4%)~~ 0.207 (2.1%)
Mouth of Middle River	Sep	Above Normal	~~0.198~~ 0.193	~~0.201 (1.9%)~~ 0.196 (1.5%)
Mouth of Middle River	Sep	Below Normal	~~0.205~~ 0.198	~~0.204 (-0.5%)~~ 0.197 (-0.9%)
Mouth of Middle River	Sep	Dry	~~0.188~~ 0.186	~~0.188 (-0.2%)~~ 0.186 (-0.1%)
Mouth of Middle River	Sep	Critically Dry	~~0.177~~ 0.174	~~0.177 (0.0%)~~ 0.174 (-0.1%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Mouth of Middle River	Oct	Wet	~~0.194~~ 0.192	~~0.193 (-0.5%)~~ 0.192 (-0.2%)
Mouth of Middle River	Oct	Above Normal	~~0.184~~ 0.185	~~0.184 (-0.1%)~~ 0.183 (-0.9%)
Mouth of Middle River	Oct	Below Normal	~~0.190~~ 0.189	~~0.190 (0.4%)~~ 0.188 (-0.3%)
Mouth of Middle River	Oct	Dry	~~0.187~~ 0.186	~~0.187 (-0.2%)~~ 0.188 (0.7%)
Mouth of Middle River	Oct	Critically Dry	~~0.177~~ 0.180	~~0.178 (0.1%)~~ 0.180 (0.0%)
Mouth of Middle River	Nov	Wet	~~0.203~~ 0.201	~~0.204 (0.2%)~~ 0.201 (0.0%)
Mouth of Middle River	Nov	Above Normal	~~0.194~~ 0.195	~~0.193 (-0.2%)~~ 0.195 (0.0%)
Mouth of Middle River	Nov	Below Normal	~~0.198~~ 0.197	~~0.198 (-0.1%)~~ 0.197 (0.1%)
Mouth of Middle River	Nov	Dry	~~0.195~~ 0.194	~~0.195 (0.1%)~~ 0.194 (0.0%)
Mouth of Middle River	Nov	Critically Dry	~~0.176~~ 0.178	~~0.177 (0.3%)~~ 0.178 (-0.2%)
Mouth of Middle River	Dec	Wet	~~0.194~~ 0.191	~~0.195~~ 0.191 (0.0%)
Mouth of Middle River	Dec	Above Normal	~~0.188~~ 0.190	~~0.189 (0.6%)~~ 0.190 (0.1%)
Mouth of Middle River	Dec	Below Normal	~~0.189~~ 0.184	~~0.189 (0.2%)~~ 0.184 (0.0%)
Mouth of Middle River	Dec	Dry	~~0.187~~ 0.182	~~0.187 (-0.4%)~~ 0.181 (-0.3%)
Mouth of Middle River	Dec	Critically Dry	~~0.176~~ 0.177	~~0.176 (0.1%)~~ 0.177 (0.0%)
Mouth of Middle River	Jan	Wet	0.190	0.189 ~~(-0.3%)~~ (-0.2%)
Mouth of Middle River	Jan	Above Normal	~~0.186~~ 0.184	~~0.186~~ 0.184 (-0.2%)
Mouth of Middle River	Jan	Below Normal	~~0.181~~ 0.180	~~0.180 (-0.4%)~~ 0.179 (-0.6%)
Mouth of Middle River	Jan	Dry	~~0.179~~ 0.178	0.178 ~~(-0.4%)~~ (0.0%)
Mouth of Middle River	Jan	Critically Dry	~~0.177~~ 0.174	0.174 ~~(-1.2%)~~ (-0.2%)
Mouth of Middle River	Feb	Wet	~~0.192~~ 0.191	~~0.192 (0.0%)~~ 0.190 (-0.2%)
Mouth of Middle River	Feb	Above Normal	0.187	~~0.185~~ 0.186 (-0.8%)
Mouth of Middle River	Feb	Below Normal	0.185	~~0.184 (-0.4%)~~ 0.183 (-0.9%)
Mouth of Middle River	Feb	Dry	0.180	~~0.178 (-1.3%)~~ 0.177 (-1.2%)
Mouth of Middle River	Feb	Critically Dry	~~0.178~~ 0.177	~~0.177 (-0.2%)~~ 0.175 (-1.0%)
Mouth of Middle River	Mar	Wet	~~0.186~~ 0.187	~~0.186 (0.2%)~~ 0.188 (0.4%)
Mouth of Middle River	Mar	Above Normal	~~0.184~~ 0.185	0.183 (-0.7%)
Mouth of Middle River	Mar	Below Normal	~~0.182~~ 0.183	~~0.180 (-0.9%)~~ 0.181 (-1.1%)
Mouth of Middle River	Mar	Dry	0.177	~~0.176 (-0.4%)~~ 0.175 (-0.9%)
Mouth of Middle River	Mar	Critically Dry	~~0.173~~ 0.172	0.172 ~~(-0.2%)~~ (-0.1%)
Mouth of Middle River	Apr	Wet	~~0.183~~ 0.184	~~0.184 (0.6%)~~ 0.186 (0.9%)
Mouth of Middle River	Apr	Above Normal	0.176	~~0.177 (0.7%)~~ 0.178 (1.0%)
Mouth of Middle River	Apr	Below Normal	0.168	~~0.169 (0.8%)~~ 0.170 (0.9%)
Mouth of Middle River	Apr	Dry	0.166	0.166 ~~(0.1%)~~ (-0.1%)
Mouth of Middle River	Apr	Critically Dry	0.167	0.167 (0.1%)
Mouth of Middle River	May	Wet	~~0.185~~ 0.187	0.190 ~~(2.6%)~~ (1.5%)
Mouth of Middle River	May	Above Normal	0.178	~~0.180 (1.6%)~~ 0.182 (1.9%)
Mouth of Middle River	May	Below Normal	~~0.167~~ 0.169	~~0.170 (1.4%)~~ 0.172 (1.9%)
Mouth of Middle River	May	Dry	~~0.165~~ 0.166	~~0.165 (0.2%)~~ 0.166 (0.4%)
Mouth of Middle River	May	Critically Dry	~~0.165~~ 0.166	~~0.165 (0.2%)~~ 0.166 (0.1%)
Mouth of Middle River	Jun	Wet	0.193	~~0.192 (-0.6%)~~ 0.191 (-1.3%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Mouth of Middle River	Jun	Above Normal	0.190	~~0.188 (-1.1%)~~ 0.187 (-1.8%)
Mouth of Middle River	Jun	Below Normal	0.187	~~0.186 (-0.8%)~~ 0.184 (-1.3%)
Mouth of Middle River	Jun	Dry	0.184	0.182 ~~(-1.2%)~~ (-0.9%)
Mouth of Middle River	Jun	Critically Dry	0.174	0.174 ~~(-0.2%)~~ (0.1%)
Mouth of Old River	Sep	Wet	~~0.184~~ 0.182	~~0.191 (3.7%)~~ 0.188 (3.3%)
Mouth of Old River	Sep	Above Normal	~~0.174~~ 0.170	~~0.180 (3.6%)~~ 0.175 (3.0%)
Mouth of Old River	Sep	Below Normal	~~0.180~~ 0.171	~~0.179 (-0.4%)~~ 0.168 (-1.6%)
Mouth of Old River	Sep	Dry	~~0.155~~ 0.151	~~0.155 (-0.2%)~~ 0.151 (-0.1%)
Mouth of Old River	Sep	Critically Dry	~~0.143~~ 0.139	~~0.143 (0.0%)~~ 0.139 (-0.1%)
Mouth of Old River	Oct	Wet	~~0.162~~ 0.160	~~0.162 (-0.4%)~~ 0.160 (-0.2%)
Mouth of Old River	Oct	Above Normal	0.149	~~0.149 (0.0%)~~ 0.148 (-0.6%)
Mouth of Old River	Oct	Below Normal	~~0.158~~ 0.157	~~0.159 (0.5%)~~ 0.155 (-0.7%)
Mouth of Old River	Oct	Dry	0.154	~~0.154 (0.0%)~~ 0.155 (0.8%)
Mouth of Old River	Oct	Critically Dry	~~0.139~~ 0.142	~~0.140 (0.1%)~~ 0.142 (0.0%)
Mouth of Old River	Nov	Wet	~~0.177~~ 0.170	~~0.177 (0.2%)~~ 0.169 (-0.2%)
Mouth of Old River	Nov	Above Normal	~~0.159~~ 0.162	~~0.159 (0.1%)~~ 0.162 (-0.1%)
Mouth of Old River	Nov	Below Normal	~~0.167~~ 0.164	~~0.167 (-0.2%)~~ 0.164 (0.0%)
Mouth of Old River	Nov	Dry	~~0.161~~ 0.160	~~0.161 (0.2%)~~ 0.160 (0.0%)
Mouth of Old River	Nov	Critically Dry	~~0.138~~ 0.141	~~0.139 (0.5%)~~ 0.141 (-0.2%)
Mouth of Old River	Dec	Wet	~~0.188~~ 0.178	~~0.188 (0.1%)~~ 0.178 (0.0%)
Mouth of Old River	Dec	Above Normal	~~0.156~~ 0.159	~~0.157 (0.8%)~~ 0.160 (0.4%)
Mouth of Old River	Dec	Below Normal	~~0.154~~ 0.149	~~0.155 (0.4%)~~ 0.149 (0.1%)
Mouth of Old River	Dec	Dry	~~0.152~~ 0.148	~~0.151 (-0.6%)~~ 0.147 (-0.5%)
Mouth of Old River	Dec	Critically Dry	0.141	~~0.142 (0.2%)~~ 0.141 (0.0%)
Mouth of Old River	Jan	Wet	~~0.208~~ 0.216	~~0.207 (-0.5%)~~ 0.215 (-0.3%)
Mouth of Old River	Jan	Above Normal	~~0.179~~ 0.177	~~0.178 (-0.4%)~~ 0.176 (-0.5%)
Mouth of Old River	Jan	Below Normal	0.151	0.150 ~~(-0.4%)~~ (-0.5%)
Mouth of Old River	Jan	Dry	~~0.144~~ 0.143	0.143 ~~(-0.6%)~~ (0.0%)
Mouth of Old River	Jan	Critically Dry	~~0.142~~ 0.138	~~0.140 (-1.2%)~~ 0.138 (-0.2%)
Mouth of Old River	Feb	Wet	~~0.229~~ 0.232	~~0.229 (0.1%)~~ 0.231 (-0.2%)
Mouth of Old River	Feb	Above Normal	~~0.188~~ 0.184	~~0.186~~ 0.182 (-1.0%)
Mouth of Old River	Feb	Below Normal	~~0.166~~ 0.168	~~0.165 (-0.8%)~~ 0.166 (-1.2%)
Mouth of Old River	Feb	Dry	~~0.151~~ 0.152	0.149 ~~(-1.4%)~~ (-1.6%)
Mouth of Old River	Feb	Critically Dry	~~0.146~~ 0.145	~~0.145 (-0.5%)~~ 0.143 (-1.2%)
Mouth of Old River	Mar	Wet	~~0.202~~ 0.212	~~0.203 (0.3%)~~ 0.213 (0.7%)
Mouth of Old River	Mar	Above Normal	0.179	0.178 (-0.8%)
Mouth of Old River	Mar	Below Normal	~~0.158~~ 0.161	~~0.155 (-1.4%)~~ 0.158 (-1.6%)
Mouth of Old River	Mar	Dry	0.147	0.146 ~~(-0.6%)~~ (-1.1%)
Mouth of Old River	Mar	Critically Dry	~~0.139~~ 0.138	~~0.139 (-0.2%)~~ 0.138 (-0.3%)
Mouth of Old River	Apr	Wet	~~0.182~~ 0.185	~~0.182 (0.4%)~~ 0.187 (0.9%)
Mouth of Old River	Apr	Above Normal	~~0.151~~ 0.150	~~0.153 (1.3%)~~ 0.151 (1.1%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Mouth of Old River	Apr	Below Normal	0.138	~~0.139 (1.3%)~~ 0.140 (1.2%)
Mouth of Old River	Apr	Dry	0.132	0.132 ~~(0.2%)~~ (-0.1%)
Mouth of Old River	Apr	Critically Dry	0.129	0.129 (0.2%)
Mouth of Old River	May	Wet	~~0.173~~ 0.176	~~0.178 (3.1%)~~ 0.180 (2.0%)
Mouth of Old River	May	Above Normal	~~0.149~~ 0.152	~~0.153 (2.3%)~~ 0.155 (2.2%)
Mouth of Old River	May	Below Normal	~~0.136~~ 0.138	~~0.138 (2.0%)~~ 0.141 (2.3%)
Mouth of Old River	May	Dry	~~0.129~~ 0.131	~~0.130 (0.6%)~~ 0.132 (0.8%)
Mouth of Old River	May	Critically Dry	0.125	0.126 ~~(0.5%)~~ (0.3%)
Mouth of Old River	Jun	Wet	~~0.174~~ 0.175	0.173 ~~(-0.5%)~~ (-1.3%)
Mouth of Old River	Jun	Above Normal	~~0.160~~ 0.162	0.159 ~~(-1.2%)~~ (-1.7%)
Mouth of Old River	Jun	Below Normal	~~0.157~~ 0.156	~~0.155 (-0.9%)~~ 0.154 (-1.3%)
Mouth of Old River	Jun	Dry	0.152	0.150 ~~(-1.5%)~~ (-1.4%)
Mouth of Old River	Jun	Critically Dry	~~0.139~~ 0.138	~~0.139 (-0.3%)~~ 0.138 (0.3%)
Sutter Slough	Sep	Wet	0.195	0.195 (0.2%)
Sutter Slough	Sep	Above Normal	~~0.194~~ 0.191	~~0.194 (0.4%)~~ 0.193 (0.9%)
Sutter Slough	Sep	Below Normal	~~0.181~~ 0.170	~~0.181 (-0.3%)~~ 0.167 (-1.9%)
Sutter Slough	Sep	Dry	~~0.154~~ 0.149	~~0.154 (0.2%)~~ 0.149 (0.1%)
Sutter Slough	Sep	Critically Dry	~~0.145~~ 0.147	~~0.145 (-0.1%)~~ 0.147 (-0.2%)
Sutter Slough	Oct	Wet	~~0.185~~ 0.177	~~0.184~~ 0.177 (-0.2%)
Sutter Slough	Oct	Above Normal	0.171	~~0.171 (-0.2%)~~ 0.169 (-0.9%)
Sutter Slough	Oct	Below Normal	~~0.177~~ 0.173	~~0.175 (-0.7%)~~ 0.173 (-0.3%)
Sutter Slough	Oct	Dry	~~0.176~~ 0.167	~~0.174 (-1.4%)~~ 0.167 (0.0%)
Sutter Slough	Oct	Critically Dry	~~0.160~~ 0.155	~~0.160 (0.3%)~~ 0.156 (0.1%)
Sutter Slough	Nov	Wet	~~0.197~~ 0.193	~~0.197 (0.1%)~~ 0.194 (0.2%)
Sutter Slough	Nov	Above Normal	~~0.188~~ 0.190	~~0.189 (0.3%)~~ 0.190 (-0.2%)
Sutter Slough	Nov	Below Normal	~~0.189~~ 0.184	~~0.188 (-0.4%)~~ 0.184 (0.0%)
Sutter Slough	Nov	Dry	~~0.185~~ 0.184	~~0.185 (0.0%)~~ 0.184 (0.2%)
Sutter Slough	Nov	Critically Dry	~~0.174~~ 0.172	~~0.172 (-1.4%)~~ 0.173 (0.2%)
Sutter Slough	Dec	Wet	~~0.219~~ 0.217	~~0.219 (0.0%)~~ 0.218 (0.4%)
Sutter Slough	Dec	Above Normal	~~0.219~~ 0.217	~~0.219 (-0.2%)~~ 0.217 (-0.1%)
Sutter Slough	Dec	Below Normal	~~0.215~~ 0.214	~~0.215 (-0.1%)~~ 0.214 (0.0%)
Sutter Slough	Dec	Dry	~~0.216~~ 0.212	~~0.216 (-0.1%)~~ 0.213 (0.2%)
Sutter Slough	Dec	Critically Dry	~~0.213~~ 0.200	~~0.215 (1.2%)~~ 0.201 (0.4%)
Sutter Slough	Jan	Wet	0.220	0.220 (0.0%)
Sutter Slough	Jan	Above Normal	0.218	0.218 (0.0%)
Sutter Slough	Jan	Below Normal	~~0.218~~ 0.217	~~0.218~~ 0.217 (0.0%)
Sutter Slough	Jan	Dry	~~0.222~~ 0.219	~~0.222 (0.1%)~~ 0.219 (-0.1%)
Sutter Slough	Jan	Critically Dry	~~0.210~~ 0.216	~~0.210 (0.1%)~~ 0.216 (-0.1%)
Sutter Slough	Feb	Wet	0.221	0.221 (0.0%)
Sutter Slough	Feb	Above Normal	0.218	0.218 (0.0%)
Sutter Slough	Feb	Below Normal	0.218	0.218 ~~(0.1%)~~ (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Sutter Slough	Feb	Dry	~~0.218~~ 0.217	~~0.218 (0.0%)~~ 0.217 (0.2%)
Sutter Slough	Feb	Critically Dry	~~0.216~~ 0.218	0.218 ~~(0.6%)~~ (0.0%)
Sutter Slough	Mar	Wet	~~0.220~~ 0.221	~~0.220~~ 0.221 (0.0%)
Sutter Slough	Mar	Above Normal	0.219	0.219 (0.0%)
Sutter Slough	Mar	Below Normal	0.217	0.217 (0.0%)
Sutter Slough	Mar	Dry	0.219	0.219 ~~(-0.1%)~~ (0.0%)
Sutter Slough	Mar	Critically Dry	0.221	0.221 ~~(0.0%)~~ (0.1%)
Sutter Slough	Apr	Wet	~~0.220~~ 0.221	~~0.220~~ 0.221 (0.0%)
Sutter Slough	Apr	Above Normal	0.217	0.217 (0.0%)
Sutter Slough	Apr	Below Normal	~~0.222~~ 0.223	0.222 ~~(0.0%)~~ (-0.1%)
Sutter Slough	Apr	Dry	0.225	0.225 ~~(0.0%)~~ (0.3%)
Sutter Slough	Apr	Critically Dry	~~0.222~~ 0.219	~~0.222 (-0.1%)~~ 0.219 (0.0%)
Sutter Slough	May	Wet	0.220	0.220 (0.0%)
Sutter Slough	May	Above Normal	~~0.219~~ 0.220	~~0.219~~ 0.220 (-0.1%)
Sutter Slough	May	Below Normal	0.224	0.224 ~~(0.1%)~~ (0.0%)
Sutter Slough	May	Dry	0.228	0.228 ~~(0.2%)~~ (-0.1%)
Sutter Slough	May	Critically Dry	~~0.203~~ 0.194	~~0.203 (0.2%)~~ 0.194 (0.0%)
Sutter Slough	Jun	Wet	~~0.203~~ 0.204	~~0.203 (0.1%)~~ 0.204 (0.0%)
Sutter Slough	Jun	Above Normal	0.194	0.194 (0.1%)
Sutter Slough	Jun	Below Normal	~~0.180~~ 0.178	~~0.181 (0.0%)~~ 0.177 (-0.1%)
Sutter Slough	Jun	Dry	0.178	0.176 ~~(-1.1%)~~ (-1.0%)
Sutter Slough	Jun	Critically Dry	~~0.162~~ 0.158	~~0.162 (-0.2%)~~ 0.159 (0.3%)
Steamboat Slough	Sep	Wet	~~0.190~~ 0.189	~~0.193 (2.1%)~~ 0.192 (1.7%)
Steamboat Slough	Sep	Above Normal	~~0.185~~ 0.180	~~0.192 (3.6%)~~ 0.186 (3.2%)
Steamboat Slough	Sep	Below Normal	0.166	~~0.167 (0.2%)~~ 0.165 (-0.6%)
Steamboat Slough	Sep	Dry	~~0.164~~ 0.167	~~0.164 (0.0%)~~ 0.167 (0.1%)
Steamboat Slough	Sep	Critically Dry	~~0.184~~ 0.186	~~0.183 (-0.1%)~~ 0.186 (0.0%)
Steamboat Slough	Oct	Wet	~~0.190~~ 0.186	~~0.190~~ 0.186 (-0.1%)
Steamboat Slough	Oct	Above Normal	~~0.180~~ 0.176	~~0.180 (0.1%)~~ 0.176 (-0.1%)
Steamboat Slough	Oct	Below Normal	~~0.181~~ 0.180	~~0.180 (-0.5%)~~ 0.181 (0.6%)
Steamboat Slough	Oct	Dry	~~0.179~~ 0.178	~~0.179 (0.0%)~~ 0.178 (-0.2%)
Steamboat Slough	Oct	Critically Dry	~~0.183~~ 0.185	~~0.183 (0.1%)~~ 0.185 (0.0%)
Steamboat Slough	Nov	Wet	~~0.199~~ 0.194	~~0.199 (0.1%)~~ 0.194 (0.0%)
Steamboat Slough	Nov	Above Normal	~~0.194~~ 0.186	~~0.194 (0.1%)~~ 0.185 (-0.4%)
Steamboat Slough	Nov	Below Normal	~~0.186~~ 0.181	~~0.186~~ 0.181 (0.0%)
Steamboat Slough	Nov	Dry	~~0.179~~ 0.182	~~0.179~~ 0.182 (-0.1%)
Steamboat Slough	Nov	Critically Dry	~~0.184~~ 0.182	~~0.184 (-0.1%)~~ 0.182 (0.1%)
Steamboat Slough	Dec	Wet	~~0.250~~ 0.244	~~0.250 (0.0%)~~ 0.244 (0.1%)
Steamboat Slough	Dec	Above Normal	~~0.218~~ 0.220	~~0.218 (0.1%)~~ 0.220 (0.2%)
Steamboat Slough	Dec	Below Normal	~~0.209~~ 0.207	~~0.210 (0.6%)~~ 0.207 (0.1%)
Steamboat Slough	Dec	Dry	~~0.209~~ 0.208	0.208 ~~(-0.5%)~~ (-0.3%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Steamboat Slough	Dec	Critically Dry	~~0.196~~ 0.194	~~0.197 (0.2%)~~ 0.194 (0.0%)
Steamboat Slough	Jan	Wet	~~0.262~~ 0.265	~~0.262~~ 0.265 (0.0%)
Steamboat Slough	Jan	Above Normal	0.255	0.255 (0.0%)
Steamboat Slough	Jan	Below Normal	~~0.228~~ 0.229	0.228 ~~(0.1%)~~ (-0.1%)
Steamboat Slough	Jan	Dry	~~0.210~~ 0.209	0.209 ~~(-0.4%)~~ (0.1%)
Steamboat Slough	Jan	Critically Dry	~~0.205~~ 0.200	~~0.205 (0.1%)~~ 0.200 (0.0%)
Steamboat Slough	Feb	Wet	~~0.272~~ 0.274	~~0.272~~ 0.274 (0.0%)
Steamboat Slough	Feb	Above Normal	~~0.261~~ 0.260	~~0.261~~ 0.260 (0.0%)
Steamboat Slough	Feb	Below Normal	~~0.239~~ 0.242	~~0.239 (-0.3%)~~ 0.242 (-0.1%)
Steamboat Slough	Feb	Dry	~~0.228~~ 0.230	~~0.227 (-0.1%)~~ 0.230 (-0.3%)
Steamboat Slough	Feb	Critically Dry	~~0.213~~ 0.212	~~0.214 (0.2%)~~ 0.212 (0.0%)
Steamboat Slough	Mar	Wet	~~0.266~~ 0.270	~~0.266~~ 0.270 (0.0%)
Steamboat Slough	Mar	Above Normal	~~0.260~~ 0.259	0.260 (0.1%)
Steamboat Slough	Mar	Below Normal	~~0.240~~ 0.244	~~0.241~~ 0.245 (0.2%)
Steamboat Slough	Mar	Dry	~~0.225~~ 0.226	0.226 ~~(0.4%)~~ (0.3%)
Steamboat Slough	Mar	Critically Dry	0.201	0.201 ~~(-0.1%)~~ (-0.2%)
Steamboat Slough	Apr	Wet	~~0.254~~ 0.255	~~0.254~~ 0.255 (0.0%)
Steamboat Slough	Apr	Above Normal	~~0.241~~ 0.239	~~0.241 (0.2%)~~ 0.240 (0.1%)
Steamboat Slough	Apr	Below Normal	~~0.217~~ 0.216	~~0.218 (0.6%)~~ 0.217 (0.7%)
Steamboat Slough	Apr	Dry	~~0.199~~ 0.197	~~0.199 (0.3%)~~ 0.198 (0.4%)
Steamboat Slough	Apr	Critically Dry	~~0.186~~ 0.187	~~0.186~~ 0.187 (-0.1%)
Steamboat Slough	May	Wet	~~0.248~~ 0.249	~~0.248~~ 0.249 (-0.1%)
Steamboat Slough	May	Above Normal	~~0.233~~ 0.232	~~0.233~~ 0.232 (0.2%)
Steamboat Slough	May	Below Normal	~~0.214~~ 0.213	~~0.213 (-0.5%)~~ 0.212 (-0.2%)
Steamboat Slough	May	Dry	~~0.194~~ 0.192	~~0.195 (0.4%)~~ 0.193 (0.8%)
Steamboat Slough	May	Critically Dry	0.187	~~0.186 (-0.1%)~~ 0.187 (0.0%)
Steamboat Slough	Jun	Wet	~~0.216~~ 0.218	~~0.216~~ 0.219 (0.1%)
Steamboat Slough	Jun	Above Normal	~~0.193~~ 0.194	~~0.193 (0.0%)~~ 0.195 (0.2%)
Steamboat Slough	Jun	Below Normal	~~0.174~~ 0.172	~~0.173~~ 0.172 (-0.1%)
Steamboat Slough	Jun	Dry	~~0.169~~ 0.167	~~0.168~~ 0.166 (-0.4%)
Steamboat Slough	Jun	Critically Dry	~~0.178~~ 0.177	~~0.178 (0.0%)~~ 0.177 (-0.1%)
Turner Cut	Sep	Wet	~~0.175~~ 0.173	~~0.178 (1.9%)~~ 0.177 (1.8%)
Turner Cut	Sep	Above Normal	~~0.163~~ 0.160	~~0.165 (1.4%)~~ 0.162 (1.2%)
Turner Cut	Sep	Below Normal	~~0.170~~ 0.164	~~0.169 (-0.3%)~~ 0.163 (-0.7%)
Turner Cut	Sep	Dry	~~0.157~~ 0.154	~~0.157 (-0.3%)~~ 0.154 (-0.2%)
Turner Cut	Sep	Critically Dry	~~0.150~~ 0.148	~~0.150 (0.0%)~~ 0.147 (-0.1%)
Turner Cut	Oct	Wet	0.170	~~0.170~~ 0.169 (-0.2%)
Turner Cut	Oct	Above Normal	0.158	0.158 ~~(0.0%)~~ (-0.4%)
Turner Cut	Oct	Below Normal	0.167	0.167 ~~(0.2%)~~ (-0.4%)
Turner Cut	Oct	Dry	~~0.163~~ 0.162	~~0.162 (-0.1%)~~ 0.163 (0.4%)
Turner Cut	Oct	Critically Dry	~~0.151~~ 0.153	~~0.151 (0.1%)~~ 0.153 (0.0%)

Junction	Month	Water Year Type	Baseline Conditions	Proposed Project
Turner Cut	Nov	Wet	~~0.182~~ 0.178	~~0.182 (0.1%)~~ 0.178 (-0.1%)
Turner Cut	Nov	Above Normal	~~0.169~~ 0.168	0.168 ~~(-0.1%)~~ (0.0%)
Turner Cut	Nov	Below Normal	~~0.176~~ 0.174	~~0.176 (-0.1%)~~ 0.174 (0.0%)
Turner Cut	Nov	Dry	~~0.170~~ 0.168	~~0.170 (0.1%)~~ 0.168 (0.0%)
Turner Cut	Nov	Critically Dry	~~0.153~~ 0.154	~~0.153 (0.0%)~~ 0.154 (-0.2%)
Turner Cut	Dec	Wet	~~0.173~~ 0.168	~~0.174~~ 0.168 (0.1%)
Turner Cut	Dec	Above Normal	0.159	0.159 ~~(0.6%)~~ (0.3%)
Turner Cut	Dec	Below Normal	~~0.159~~ 0.154	~~0.159 (0.2%)~~ 0.154 (0.0%)
Turner Cut	Dec	Dry	~~0.156~~ 0.152	~~0.156 (-0.4%)~~ 0.152 (-0.3%)
Turner Cut	Dec	Critically Dry	~~0.149~~ 0.148	0.149 ~~(0.0%)~~ (0.1%)
Turner Cut	Jan	Wet	0.174	0.174 ~~(-0.4%)~~ (-0.2%)
Turner Cut	Jan	Above Normal	~~0.164~~ 0.159	~~0.164 (-0.2%)~~ 0.159 (-0.4%)
Turner Cut	Jan	Below Normal	~~0.156~~ 0.154	~~0.155~~ 0.154 (-0.3%)
Turner Cut	Jan	Dry	~~0.151~~ 0.150	~~0.151 (-0.3%)~~ 0.150 (0.0%)
Turner Cut	Jan	Critically Dry	~~0.151~~ 0.147	~~0.150 (-0.7%)~~ 0.147 (-0.1%)
Turner Cut	Feb	Wet	~~0.181~~ 0.179	~~0.181 (0.1%)~~ 0.179 (-0.1%)
Turner Cut	Feb	Above Normal	~~0.175~~ 0.173	~~0.173~~ 0.172 (-0.7%)
Turner Cut	Feb	Below Normal	~~0.168~~ 0.167	~~0.168 (-0.4%)~~ 0.166 (-0.7%)
Turner Cut	Feb	Dry	~~0.153~~ 0.151	~~0.151~~ 0.150 (-1.0%)
Turner Cut	Feb	Critically Dry	~~0.152~~ 0.150	~~0.151 (-0.4%)~~ 0.148 (-0.8%)
Turner Cut	Mar	Wet	0.182	0.183 ~~(0.2%)~~ (0.6%)
Turner Cut	Mar	Above Normal	~~0.172~~ 0.171	~~0.171 (-0.4%)~~ 0.170 (-0.5%)
Turner Cut	Mar	Below Normal	~~0.164~~ 0.165	~~0.163 (-0.8%)~~ 0.164 (-1.0%)
Turner Cut	Mar	Dry	~~0.151~~ 0.149	~~0.150 (-0.5%)~~ 0.148 (-0.8%)
Turner Cut	Mar	Critically Dry	~~0.147~~ 0.145	~~0.147 (-0.1%)~~ 0.145 (-0.2%)
Turner Cut	Apr	Wet	~~0.187~~ 0.188	~~0.187 (0.3%)~~ 0.189 (0.7%)
Turner Cut	Apr	Above Normal	~~0.172~~ 0.171	~~0.173~~ 0.172 (0.7%)
Turner Cut	Apr	Below Normal	~~0.158~~ 0.160	~~0.160~~ 0.161 (0.7%)
Turner Cut	Apr	Dry	0.146	0.146 ~~(0.1%)~~ (-0.2%)
Turner Cut	Apr	Critically Dry	0.143	0.143 (0.1%)
Turner Cut	May	Wet	~~0.183~~ 0.186	~~0.186 (2.0%)~~ 0.189 (1.2%)
Turner Cut	May	Above Normal	~~0.167~~ 0.169	~~0.169 (1.5%)~~ 0.171 (1.3%)
Turner Cut	May	Below Normal	~~0.153~~ 0.158	~~0.156 (1.6%)~~ 0.160 (1.8%)
Turner Cut	May	Dry	~~0.143~~ 0.146	~~0.144 (0.4%)~~ 0.147 (0.5%)
Turner Cut	May	Critically Dry	~~0.139~~ 0.142	~~0.140~~ 0.142 (0.3%)
Turner Cut	Jun	Wet	0.189	~~0.189 (-0.4%)~~ 0.188 (-0.9%)
Turner Cut	Jun	Above Normal	~~0.172~~ 0.169	~~0.170 (-0.9%)~~ 0.167 (-1.3%)
Turner Cut	Jun	Below Normal	~~0.165~~ 0.163	~~0.163 (-0.8%)~~ 0.162 (-1.1%)
Turner Cut	Jun	Dry	~~0.157~~ 0.155	~~0.156 (-1.0%)~~ 0.154 (-0.9%)
Turner Cut	Jun	Critically Dry	~~0.147~~ 0.145	~~0.147 (-0.2%)~~ 0.146 (0.2%)

Delta Passage Model

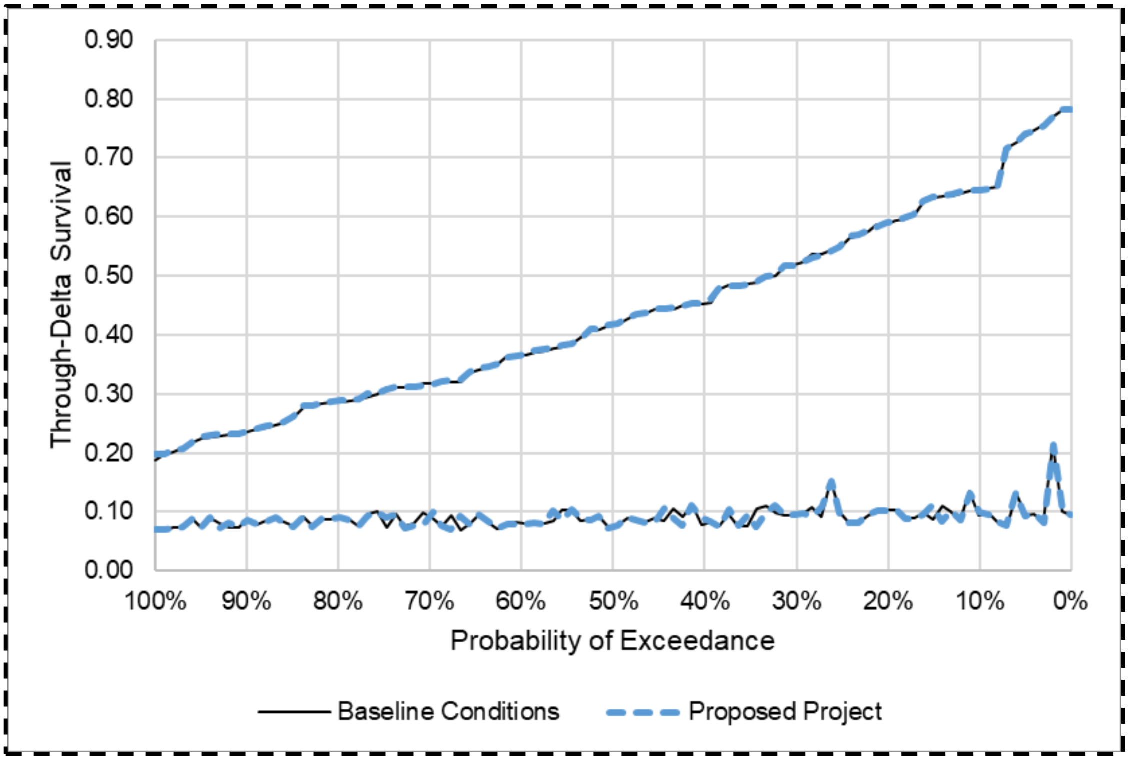
The Delta Passage Model (DPM) integrates operational effects of the Baseline Conditions and Proposed Project scenarios that could influence through-Delta survival of migrating juvenile Chinook Salmon smolts including winter-run Chinook Salmon. Functions included in the DPM include reach-specific flow-survival and flow travel-time relationships, flow-routing relationships, and an export-survival relationship. The DPM methods are described in detail in Appendix 6B, Section 6B.4, "Delta Passage Model." Dynamic operation of the Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) was assumed, consistent with the final Georgiana Slough Salmonid Migratory Barrier Operations Plan (California Department of Water Resources 2022), i.e., BAFF assumed to be turned on when the DCC is closed during November 16–December 31, BAFF assumed to be turned on all the time during January 1–April 30, and BAFF otherwise assumed to be turned off, for both the Proposed Project and Baseline Conditions scenarios. Therefore, two sets of analyses were undertaken, that the BAFF was reducing flow-predicted entry into Georgiana Slough by either 50 percent or 67 percent during the days it was operating.

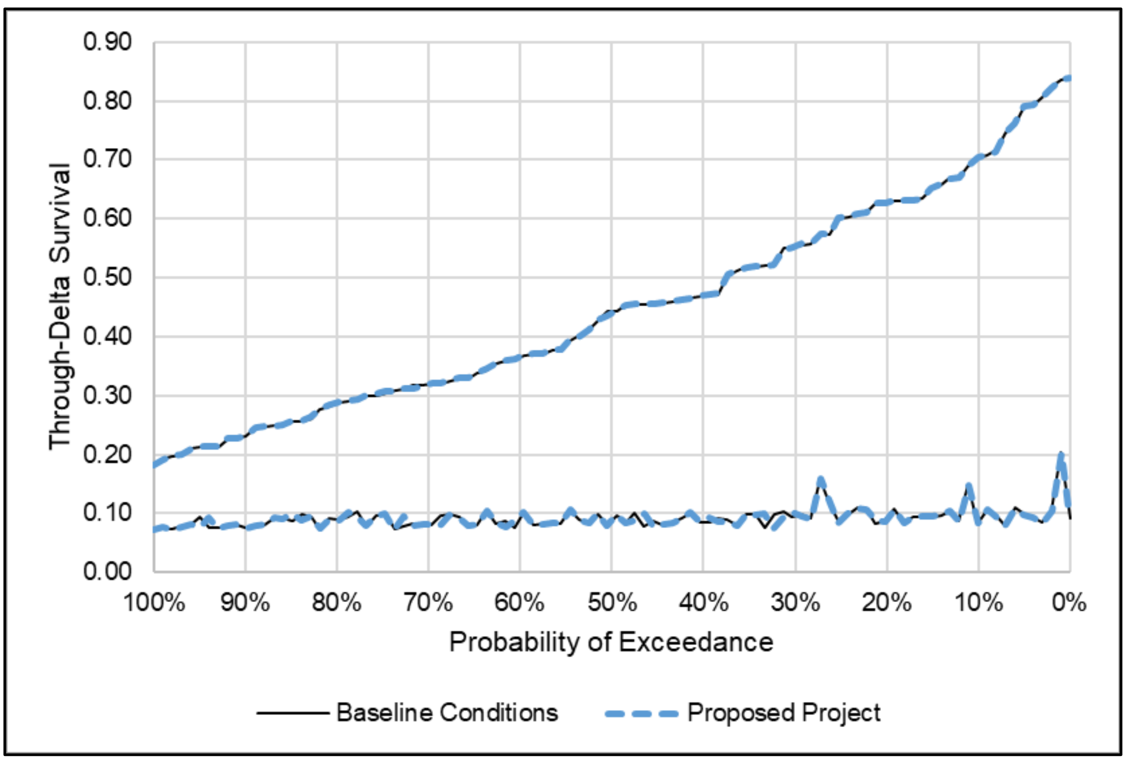
The results of the DPM suggested that through-Delta survival of winter-run Chinook Salmon smolts would be similar under the Proposed Project and Baseline Conditions, with relative differences in mean survival by water year type all less than 1 percent (Table ~~6-36~~ 6-37) and largely overlapping predictions across all years (Figures 6-93 and 6-94).

Table ~~6-36~~ 6-37. Delta Passage Model: Mean Winter-Run Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	**Baseline Conditions**	**Proposed Project**	**Baseline Conditions**	**Proposed Project**
Wet	~~0.33~~ 0.34	~~0.32~~ 0.34 (-0.1%)	~~0.33~~ 0.35	~~0.32~~ 0.35 (-0.1%)
Above Normal	~~0.26~~ 0.27	~~0.26~~ 0.27 (0.0%)	~~0.26~~ 0.27	~~0.26~~ 0.27 (0.0%)
Below Normal	~~0.20~~ 0.21	~~0.20 (0.0%)~~ 0.21 (0.1%)	~~0.20~~ 0.21	~~0.20 (0.0%)~~ 0.21 (0.1%)
Dry	~~0.17~~ 0.18	~~0.17~~ 0.18 (0.3%)	~~0.17~~ 0.18	~~0.17~~ 0.18 (0.3%)
Critically Dry	~~0.14~~ 0.15	0.15 ~~(0.4%)~~ (0.0%)	~~0.14~~ 0.15	0.15 ~~(0.4%)~~ (-0.1%)

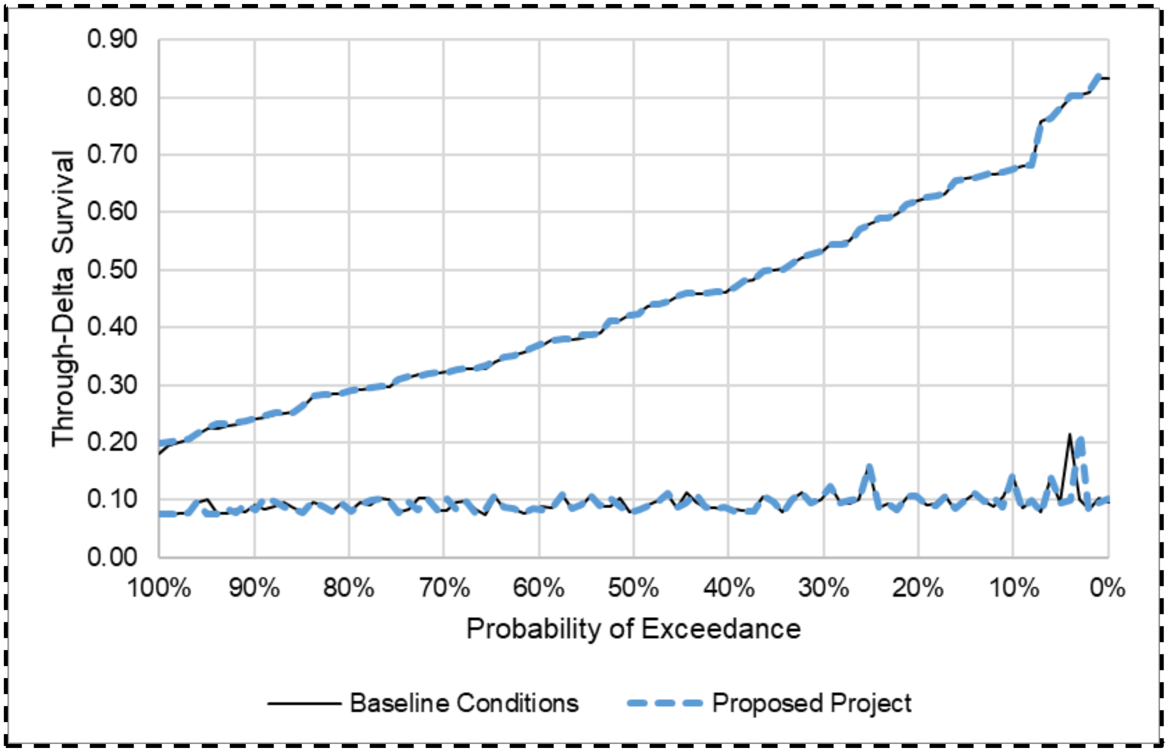
Note: Table only includes mean responses and does not consider model uncertainty. 95% predictions are shown in Figures 6-93 and 6-94.

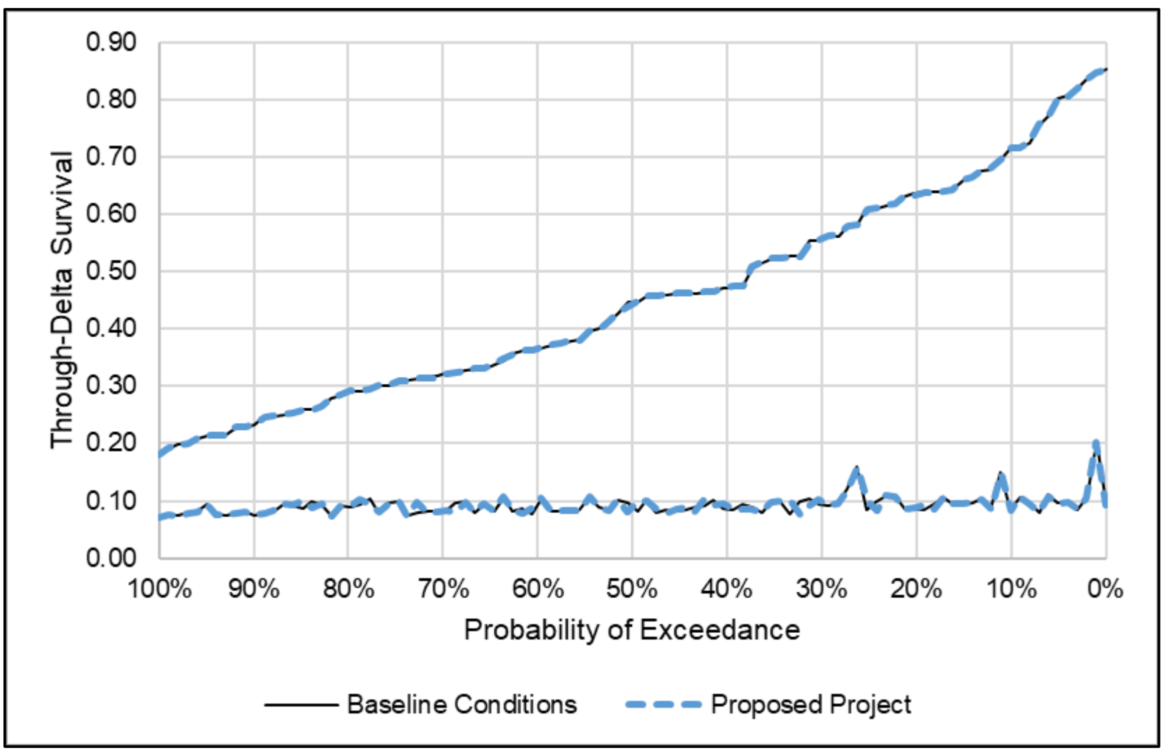




Note: Data are sorted by 97.5th percentile of predictions, with 2.5th and 97.5th percentiles shown, representing middle 95% of predictions.

Figure 6-93. Delta Passage Model: Exceedance Plot of Winter-Run Chinook Salmon Through-Delta Survival 95% Predictions, for the 1922–2021 Modeled Period, Assuming BioAcoustic Fish Fence Reducing Entry into Georgiana Slough by 50%.





Note: Data are sorted by 97.5th percentile of predictions, with 2.5th and 97.5th percentiles shown, representing middle 95% of predictions.

Figure 6-94. Delta Passage Model: Exceedance Plot of Winter-Run Chinook Salmon Through-Delta Survival 95% Predictions, for the 1922–2021 Modeled Period, Assuming BioAcoustic Fish Fence Reducing Entry into Georgiana Slough by 67%.

Survival, Travel Time, and Routing Analysis (Based on Perry et al. 2018)

As with the DPM, the Survival, Travel Time, and Routing Analysis (STARS) was used to assess potential differences in through-Delta survival of migrating Chinook Salmon smolts from the Sacramento River Basin. This analysis covered a broader juvenile Chinook Salmon migration period from September to June, although the period of highest occurrence for winter-run Chinook Salmon is December–April per Tables 6A-2, 6A-4a, and 6A-4b in Appendix 6A, *Environmental Setting Background Information*. STARS methods are described in Appendix 6B, Section 6B.5, "Survival, Travel Time, and Routing Analysis (STARS, Based on Perry et al. 2018)."

The results of the STARS analysis were consistent with the DPM in suggesting little difference between the Proposed Project and Baseline Conditions in through-Delta migration survival of Chinook Salmon smolts. During September–June, relative differences in mean through-Delta survival by water year type varied from -2.8 -1.9 percent less under the Proposed Project (November September of Critically Dry Below Normal years with 67 percent BAFF assumption) to 4.0 percent more under the Proposed Project (September of Above Normal years with 50 percent BAFF assumption) (Tables 6-37 through 6-46 6-38 through 6-47). Higher estimates under the Proposed Project in September of wetter years at least in part reflect differences in SMSCG operations between the scenarios: during periods in which water quality criteria are controlling operations, the assumed switch from continuous operation under Baseline Conditions to seven-day tidal/seven-day open under the Proposed Project tends to reduce required outflow in July and August and tends to increase required outflow in September and October; although this difference was assumed in the modeling, it is not part of the Project Description (see Chapter 2, Section 2.3.6.2, "Suisun Marsh Salinity Control Gates") and has limited effects on flows (see Appendix 4A, Attachment 9, "Suisun Marsh Salinity Control Gate Operation Sensitivity Analysis") and therefore biological responses, as illustrated here. The largest differences are in Above Normal years because these years require a larger inflow to meet Fall X2 requirements. Differences during the period of highest winter-run occurrence (December–April) were less than 1 percent. The mean probability of survival being less under the Proposed Project was close to 0.500 and generally corresponded with the mean survival difference, ranging from 0.453 0.454 (September in Above Normal years) to 0.529 0.521 (November September in Critically Dry Below Normal years) (Tables 6-47 through 6-56 6-48 through 6-57). Plots of daily posterior probability intervals are provided in Appendix 6B, Figures 6B-291 through 6B-390, illustrating considerable overlap between the Proposed Project and Baseline Conditions scenarios.

The STARS analysis also provided outputs for routing into north Delta junctions (Sutter and Steamboat Sloughs; DCC; Georgiana Slough). This illustrated that there were limited differences in routing probability between the Baseline Conditions and Proposed Project (see Tables 6B-33a through 6B-33bh in Appendix 6B), consistent with the results of the STARS survival analysis and the junction routing analysis (Table 6-35 6-36).

Table ~~6-37~~ 6-38. STARS: Mean September Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	0.37	~~0.38 (2.2%)~~ 0.38 (1.9%)
Above Normal	~~0.36~~ 0.35	~~0.37~~ 0.36 (4.0%)
Below Normal	~~0.32~~ 0.31	~~0.32 (-0.2%)~~ 0.30 (-1.9%)
Dry	~~0.28~~ 0.27	~~0.28~~ 0.27 (0.1%)
Critically Dry	~~0.26~~ 0.27	~~0.26 (0.0%)~~ 0.27 (-0.1%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-38~~ 6-39. STARS: Mean October Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~0.36~~ 0.34	~~0.36 (-0.2%)~~ 0.34 (-0.5%)
Above Normal	0.32	0.32 ~~(0.3%)~~ (-0.3%)
Below Normal	~~0.33~~ 0.32	0.32 ~~(-1.4%)~~ (-0.2%)
Dry	~~0.32~~ 0.30	~~0.32 (-1.2%)~~ 0.30 (-1.1%)
Critically Dry	~~0.30~~ 0.29	~~0.31 (0.3%)~~ 0.29 (0.1%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-39~~ 6-40. STARS: Mean November Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project
Wet	~~0.43~~ 0.41	~~0.43 (0.2%)~~ 0.41 (0.0%)	~~0.43~~ 0.41	~~0.43 (0.1%)~~ 0.41 (0.0%)
Above Normal	~~0.40~~ 0.38	~~0.39 (-1.0%)~~ 0.38 (-0.4%)	~~0.41~~ 0.38	~~0.40 (-0.9%)~~ 0.38 (-0.4%)
Below Normal	~~0.38~~ 0.36	~~0.38 (-0.5%)~~ 0.36 (-0.1%)	~~0.39~~ 0.36	~~0.38 (-0.4%)~~ 0.36 (0.1%)
Dry	0.36	0.36 (0.2%)	~~0.36~~ 0.37	~~0.36~~ 0.37 (0.2%)
Critically Dry	~~0.34~~ 0.33	0.33 ~~(-2.7%)~~ (-0.1%)	~~0.35~~ 0.34	0.34 ~~(-2.8%)~~ (-0.1%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-40~~ 6-41. STARS: Mean December Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	**Baseline Conditions**	**Proposed Project**	**Baseline Conditions**	**Proposed Project**
Wet	~~0.60~~ 0.58	~~0.60 (0.0%)~~ 0.58 (0.4%)	~~0.61~~ 0.59	~~0.61 (0.0%)~~ 0.59 (0.4%)
Above Normal	0.51	0.51 ~~(0.1%)~~ (0.2%)	~~0.52~~ 0.53	0.53 ~~(0.1%)~~ (0.2%)
Below Normal	~~0.48~~ 0.47	~~0.49 (0.5%)~~ 0.47 (0.2%)	~~0.50~~ 0.48	~~0.50 (0.4%)~~ 0.48 (0.1%)
Dry	~~0.48~~ 0.47	~~0.48 (-0.4%)~~ 0.47 (-0.3%)	~~0.50~~ 0.49	~~0.50 (-0.4%)~~ 0.49 (-0.1%)
Critically Dry	~~0.45~~ 0.42	~~0.45 (0.7%)~~ 0.42 (0.4%)	~~0.46~~ 0.43	~~0.47 (0.6%)~~ 0.43 (0.3%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-41~~ 6-42. STARS: Mean January Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	**Baseline Conditions**	**Proposed Project**	**Baseline Conditions**	**Proposed Project**
Wet	~~0.63~~ 0.64	~~0.63 (0.1%)~~ 0.64 (0.0%)	~~0.64~~ 0.65	~~0.64~~ 0.65 (0.0%)
Above Normal	0.61	0.61 (0.0%)	0.62	0.62 ~~(0.0%)~~ (-0.1%)
Below Normal	~~0.53~~ 0.54	~~0.53 (0.1%)~~ 0.54 (-0.1%)	0.55	0.55 ~~(0.1%)~~ (-0.1%)
Dry	~~0.49~~ 0.48	~~0.49 (-0.3%)~~ 0.48 (0.0%)	0.50	0.50 ~~(-0.3%)~~ (0.1%)
Critically Dry	0.46	0.46 (0.0%)	~~0.48~~ 0.47	~~0.48 (0.1%)~~ 0.47 (-0.1%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-42~~ 6-43. STARS: Mean February Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	**Baseline Conditions**	**Proposed Project**	**Baseline Conditions**	**Proposed Project**
Wet	0.66	0.66 (0.0%)	0.67	0.67 (0.0%)
Above Normal	0.62	~~0.63 (0.1%)~~ 0.62 (-0.1%)	0.64	0.64 ~~(0.0%)~~ (-0.1%)
Below Normal	~~0.56~~ 0.57	~~0.56 (-0.3%)~~ 0.57 (-0.1%)	0.58	~~0.57 (-0.2%)~~ 0.58 (0.0%)
Dry	~~0.53~~ 0.54	~~0.53 (-0.1%)~~ 0.54 (-0.2%)	~~0.54~~ 0.55	~~0.54 (-0.1%)~~ 0.55 (-0.3%)
Critically Dry	0.49	0.49 ~~(0.4%)~~ (0.0%)	0.50	0.50 ~~(0.5%)~~ (0.0%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-43~~ 6-44. STARS: Mean March Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	**Baseline Conditions**	**Proposed Project**	**Baseline Conditions**	**Proposed Project**
Wet	~~0.64~~ 0.65	~~0.64~~ 0.65 (0.0%)	~~0.65~~ 0.66	~~0.65~~ 0.66 (0.0%)
Above Normal	0.63	0.63 (0.1%)	0.64	0.64 ~~(0.1%)~~ (0.2%)
Below Normal	~~0.57~~ 0.58	~~0.57~~ 0.58 (0.2%)	~~0.58~~ 0.59	~~0.58 (0.2%)~~ 0.59 (0.3%)
Dry	0.52	0.52 ~~(0.5%)~~ (0.4%)	~~0.53~~ 0.54	0.54 (0.4%)
Critically Dry	0.46	0.46 (-0.1%)	0.48	0.48 ~~(-0.2%)~~ (-0.1%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-44~~ 6-45. STARS: Mean April Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project
Wet	0.61	0.61 (0.0%)	0.62	0.62 (0.0%)
Above Normal	0.56	~~0.57~~ 0.56 (0.2%)	~~0.58~~ 0.57	~~0.58~~ 0.57 (0.2%)
Below Normal	0.50	0.50 ~~(0.7%)~~ (0.8%)	0.51	0.52 ~~(0.7%)~~ (0.8%)
Dry	~~0.46~~ 0.45	0.46 ~~(0.5%)~~ (0.7%)	0.47	~~0.48 (0.4%)~~ 0.47 (0.7%)
Critically Dry	~~0.43~~ 0.42	~~0.43~~ 0.42 (0.0%)	0.44	0.44 (-0.1%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-45~~ 6-46. STARS: Mean May Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

Water Year Type	Baseline Conditions	Proposed Project
Wet	0.56	0.56 (0.0%)
Above Normal	0.50	~~0.50~~ 0.51 (0.3%)
Below Normal	0.45	0.45 ~~(-0.3%)~~ (-0.1%)
Dry	0.40	~~0.41 (0.7%)~~ 0.40 (1.0%)
Critically Dry	0.36	0.36 ~~(0.3%)~~ (0.0%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-46~~ 6-47. STARS: Mean June Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~0.45~~ 0.46	~~0.45 (0.1%)~~ 0.46 (0.0%)
Above Normal	0.39	0.39 ~~(-0.1%)~~ (0.0%)
Below Normal	~~0.33~~ 0.32	~~0.33 (-0.1%)~~ 0.32 (-0.4%)
Dry	0.32	0.32 ~~(-1.5%)~~ (-1.2%)
Critically Dry	0.28	0.28 ~~(-0.4%)~~ (0.3%)

Note: Table only includes mean responses and does not consider model uncertainty. 95% posterior probability intervals by year are shown in Appendix 6B.

Table ~~6-47~~ 6-48. STARS: Mean September Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type

Water Year Type	Probability
Wet	~~0.472~~ 0.477
Above Normal	~~0.453~~ 0.454
Below Normal	~~0.502~~ 0.521
Dry	0.499
Critically Dry	~~0.500~~ 0.501

Table ~~6-48~~ 6-49. STARS: Mean October Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type

Water Year Type	Probability
Wet	~~0.502~~ 0.505
Above Normal	~~0.496~~ 0.504
Below Normal	~~0.517~~ 0.503
Dry	~~0.513~~ 0.510
Critically Dry	~~0.496~~ 0.499

Table ~~6-49~~ 6-50. STARS: Mean November Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry Assumption	
Water Year Type	50%	67%
Wet	~~0.497~~ 0.500	~~0.498~~ 0.500
Above Normal	~~0.513~~ 0.505	~~0.513~~ 0.504
Below Normal	~~0.507~~ 0.501	~~0.506~~ 0.500
Dry	~~0.497~~ 0.498	0.498
Critically Dry	~~0.528~~ 0.501	~~0.529~~ 0.500

Table ~~6-50~~ 6-51. STARS: Mean December Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry Assumption	
Water Year Type	50%	67%
Wet	~~0.500~~ 0.494	~~0.500~~ 0.494
Above Normal	0.497	0.498
Below Normal	~~0.492~~ 0.497	~~0.493~~ 0.499
Dry	~~0.506~~ 0.504	~~0.506~~ 0.502
Critically Dry	~~0.491~~ 0.496	~~0.490~~ 0.496

Table ~~6-51~~ 6-52 . STARS: Mean January Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry Assumption	
Water Year Type	**50%**	**67%**
Wet	~~0.499~~ 0.500	0.500
Above Normal	~~0.500~~ 0.501	~~0.500~~ 0.502
Below Normal	~~0.499~~ 0.502	~~0.499~~ 0.502
Dry	~~0.504~~ 0.499	~~0.505~~ 0.498
Critically Dry	~~0.499~~ 0.500	~~0.499~~ 0.500

Table ~~6-52~~ 6-53 . STARS: Mean February Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry Assumption	
Water Year Type	**50%**	**67%**
Wet	0.500	~~0.499~~ 0.500
Above Normal	~~0.498~~ 0.501	~~0.499~~ 0.502
Below Normal	~~0.505~~ 0.501	~~0.505~~ 0.500
Dry	~~0.502~~ 0.505	~~0.502~~ 0.506
Critically Dry	~~0.493~~ 0.500	~~0.494~~ 0.501

Table ~~6-53~~ 6-54 . STARS: Mean March Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry Assumption	
Water Year Type	**50%**	**67%**
Wet	0.500	0.500
Above Normal	~~0.497~~ 0.498	~~0.497~~ 0.496
Below Normal	~~0.496~~ 0.495	0.496
Dry	~~0.491~~ 0.492	0.493
Critically Dry	0.502	~~0.504~~ 0.502

Table ~~6-54~~ 6-55 . STARS: Mean April Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry Assumption	
Water Year Type	50%	67%
Wet	0.500	0.500
Above Normal	0.496	0.496
Below Normal	0.487	0.487
Dry	~~0.492~~ 0.490	~~0.493~~ 0.489
Critically Dry	~~0.500~~ 0.499	0.502

Table ~~6-55~~ 6-56 . STARS: Mean May Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

Water Year Type	Probability
Wet	0.500
Above Normal	0.495
Below Normal	~~0.505~~ 0.501
Dry	~~0.490~~ 0.486
Critically Dry	~~0.496~~ 0.499

Table ~~6-56~~ 6-57 . STARS: Mean June Probability of Chinook Salmon Smolt Survival Through the Delta under the Proposed Project Being Less Than Baseline Conditions, Grouped by Water Year Type

Water Year Type	Probability
Wet	~~0.499~~ 0.500
Above Normal	~~0.502~~ 0.500
Below Normal	~~0.501~~ 0.504
Dry	~~0.518~~ 0.515
Critically Dry	~~0.504~~ 0.497

Ecological Particle Tracking Modeling (ECO-PTM)

As with the other through-Delta survival models (DPM and STARS), ECO-PTM was used to assess potential differences in through-Delta survival of migrating Chinook Salmon smolts from the Sacramento River Basin. As with the STARS model, this analysis covered a broader juvenile Chinook Salmon migration period from September to June, although the period of highest occurrence for winter-run Chinook Salmon is December–April per Tables 6A-2, 6A-4a, and 6A-4b in Appendix 6A.[17] ECO-PTM methods are described in Appendix 6B, Section 6B.6, "ECO-PTM".[18]

At the time of preparation of this ~~DEIR~~ EIR, the model code for ECO-PTM was not able to include dynamic operation of the Georgiana Slough Salmonid Migratory Barrier BAFF in the same manner as was done for the DPM and STARS (i.e., BAFF assumed to be turned on when the DCC is closed during November 16–December 31, BAFF assumed to be turned on all the time during January 1–April 30, and BAFF otherwise assumed to be turned off, for both the Proposed Project and Baseline Conditions scenarios). Therefore, three sets of analyses were performed, assuming either that the BAFF was not operating or that the BAFF was operating in all months and reducing flow-predicted entry into Georgiana Slough by 50 percent or 67 percent; results are only reported for the 50 percent and 67 percent analyses in the months when the BAFF would be operating (i.e., November–April).

The results of the ECO-PTM indicated differences in mean through-Delta survival of Chinook Salmon smolts between the Proposed Project and Baseline Conditions ranging from ~~just over~~ 2 percent less under the Proposed Project (Dry years in June) to ~~~1.5~~ 3.4 percent greater under the Proposed Project (~~Below~~ Above Normal years in ~~April~~ September), with most differences being less than 1 percent (Tables ~~6-57 through 6-66~~ 6-58 through 6-67). During the main period of juvenile winter-run Chinook Salmon occurrence (December–April), the differences in mean through-Delta survival between scenarios were all less than 1 percent except ~~the aforementioned~~ in April of Below Normal years (2.1 percent greater under the Proposed Project assuming 67 percent reduction in flow-predicted entry into Georgiana Slough). Overall, consistent with the DPM and STARS model results, the ECO-PTM results suggest there would be little difference in through-Delta survival between the Proposed Project and Baseline Conditions for Chinook Salmon smolts. ECO-PTM contrasts with the other models in that greater SWP south Delta export pumping results in negative effects on the particles representing Chinook Salmon smolts (e.g., by changing interior Delta hydraulics, leading to increased travel time and mortality). The limited differences in through-Delta survival between the Proposed Project and Baseline Conditions scenarios indicate limited differences between the scenarios in interior Delta hydraulics from south Delta SWP pumping.

[17] Note that the specific relative patterns shown Tables 6A-2, 6A-4a, and 6A-4b reflect length-at-date winter-run Chinook Salmon designation. 2010–2022 loss data for genetically identified winter-run Chinook Salmon at the SWP that were used for the salvage-density analysis discussed previously indicated highest loss in March, then February, then December/January; low loss in April; very little loss in May; and no loss prior to December or in June.

[18] See also Appendix 4A, Attachment 5, "DSM2 ECO-PTM Documentation".

Table ~~6-57~~ 6-58. ECO-PTM: Mean September Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~0.40~~ 0.41	0.41 ~~(2.3%)~~ (1.9%)
Above Normal	~~0.41~~ 0.40	0.42 (3.4%)
Below Normal	~~0.37~~ 0.35	~~0.37 (-0.3%)~~ 0.35 (-1.7%)
Dry	~~0.33~~ 0.32	~~0.33 (0.2%)~~ 0.32 (0.0%)
Critically Dry	0.32	0.32 ~~(0.2%)~~ (-0.5%)

Table only includes mean responses and does not consider model uncertainty.

Table ~~6-58~~ 6-59. ECO-PTM: Mean October Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~0.37~~ 0.36	~~0.37 (-0.3%)~~ 0.36 (-0.6%)
Above Normal	0.34	0.34 ~~(-0.4%)~~ (0.2%)
Below Normal	~~0.36~~ 0.35	~~0.36 (-0.3%)~~ 0.35 (-0.4%)
Dry	~~0.35~~ 0.34	~~0.35 (-0.5%)~~ 0.34 (-0.2%)
Critically Dry	0.34	0.34 ~~(-0.4%)~~ (0.0%)

Table only includes mean responses and does not consider model uncertainty.

Table ~~6-59~~ 6-60. ECO-PTM: Mean November Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Not Operating		BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project
Wet	~~0.41~~ 0.39	~~0.41 (0.3%)~~ 0.39 (-0.2%)	~~0.43~~ 0.41	~~0.43~~ 0.41 - (0.1%)	~~0.44~~ 0.42	~~0.44 (0.3%)~~ 0.41 (0.0%)
Above Normal	~~0.38~~ 0.37	~~0.38 (-0.1%)~~ 0.37 (-0.5%)	~~0.40~~ 0.39	0.39 ~~(-0.6%)~~ (-0.5%)	~~0.40~~ 0.39	~~0.40 (0.0%)~~ 0.39 (-0.2%)
Below Normal	~~0.38~~ 0.36	~~0.38 (-0.5%)~~ 0.36 (-0.4%)	~~0.40~~ 0.38	~~0.40 (-0.3%)~~ 0.38 (-0.2%)	~~0.41~~ 0.39	~~0.40 (-0.6%)~~ 0.39 (0.0%)
Dry	0.37	0.37 ~~(0.4%)~~ (0.2%)	~~0.38~~ 0.39	0.39 ~~(0.6%)~~ (0.1%)	0.39	0.39 ~~(0.4%)~~ (0.1%)
Critically Dry	~~0.35~~ 0.34	~~0.35 (-1.0%)~~ 0.34 (0.3%)	~~0.37~~ 0.36	0.36 ~~(-1.0%)~~ (0.2%)	~~0.37~~ 0.36	~~0.37 (-0.9%)~~ 0.36 (0.1%)

Table only includes mean responses and does not consider model uncertainty.

Table ~~6-60~~ 6-61. ECO-PTM: Mean December Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Not Operating		BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project
Wet	~~0.53~~ 0.51	~~0.53 (0.1%)~~ 0.51 (0.2%)	~~0.55~~ 0.53	~~0.55~~ 0.53 (0.1%)	~~0.56~~ 0.54	~~0.56 (-0.1%)~~ 0.54 (0.2%)
Above Normal	~~0.43~~ 0.44	~~0.43 (-0.1%)~~ 0.44 (0.1%)	~~0.45~~ 0.46	~~0.45~~ 0.46 - (0.0%)	~~0.46~~ 0.47	~~0.46~~ 0.47 (-0.1%)
Below Normal	0.41	~~0.42 (0.9%)~~ 0.41 (0.1%)	0.43	~~0.44 (0.5%)~~ 0.43 (0.1%)	0.44	0.44 ~~(0.6%)~~ (0.1%)
Dry	0.41	0.41 ~~(-0.5%)~~ (-0.4%)	~~0.44~~ 0.43	0.43 ~~(-0.6%)~~ (-0.3%)	0.44	0.44 (-0.4%)
Critically Dry	~~0.39~~ 0.38	~~0.39 (0.8%)~~ 0.38 (0.1%)	~~0.41~~ 0.40	~~0.41 (0.5%)~~ 0.40 (-0.1%)	~~0.42~~ 0.40	~~0.42 (0.7%)~~ 0.40 (0.2%)

Table only includes mean responses and does not consider model uncertainty.

Table ~~6-61~~ 6-62. ECO-PTM: Mean January Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Not Operating		BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project
Wet	~~0.57~~ 0.58	~~0.57 (0.2%)~~ 0.58 (0.0%)	~~0.59~~ 0.60	~~0.59 (0.1%)~~ 0.60 (0.0%)	~~0.59~~ 0.60	~~0.59 (0.0%)~~ 0.60 (0.1%)
Above Normal	~~0.54~~ 0.53	~~0.54~~ 0.53 (0.0%)	0.55	0.55 (0.0%)	0.56	0.56 (-0.2%)
Below Normal	0.45	0.45 ~~(0.0%)~~ (-0.2%)	0.47	0.47 ~~(0.1%)~~ (-0.2%)	0.48	0.48 ~~(0.0%)~~ (-0.2%)
Dry	~~0.41~~ 0.40	0.40 ~~(-0.4%)~~ (-0.2%)	0.43	~~0.43 (-0.5%)~~ 0.42 (-0.3%)	~~0.44~~ 0.43	0.43 ~~(-0.4%)~~ (0.1%)
Critically Dry	~~0.39~~ 0.38	0.38 ~~(-0.5%)~~ (-0.2%)	~~0.41~~ 0.40	0.40 ~~(-0.6%)~~ (-0.3%)	0.41	0.41 ~~(-0.8%)~~ (0.1%)

Table only includes mean responses and does not consider model uncertainty.

Table ~~6-62~~ 6-63 . ECO-PTM: Mean February Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Not Operating		BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	**Baseline Conditions**	**Proposed Project**	**Baseline Conditions**	**Proposed Project**	**Baseline Conditions**	**Proposed Project**
Wet	~~0.60~~ 0.61	~~0.60 (0.0%)~~ 0.61 (0.1%)	0.62	0.62 (0.0%)	~~0.62~~ 0.63	~~0.62 (0.0%)~~ 0.63 (0.1%)
Above Normal	0.55	0.55 ~~(0.1%)~~ (-0.5%)	0.57	0.57 ~~(-0.1%)~~ (0.0%)	~~0.58~~ 0.57	0.57 ~~(-0.1%)~~ (-0.2%)
Below Normal	0.48	~~0.47 (-0.4%)~~ 0.48 (-0.2%)	~~0.50~~ 0.51	~~0.49 (-0.5%)~~ 0.50 (-0.3%)	~~0.50~~ 0.51	~~0.50 (-0.5%)~~ 0.51 (-0.1%)
Dry	~~0.45~~ 0.46	~~0.45 (-0.3%)~~ 0.46 (-0.5%)	~~0.47~~ 0.48	~~0.47 (0.0%)~~ 0.48 (-0.3%)	~~0.48~~ 0.49	~~0.48 (0.0%)~~ 0.49 (-0.5%)
Critically Dry	0.41	0.41 ~~(0.8%)~~ (-0.1%)	~~0.44~~ 0.43	~~0.44 (0.5%)~~ 0.43 (0.0%)	0.44	~~0.45 (0.7%)~~ 0.44 (0.0%)

Table only includes mean responses and does not consider model uncertainty.

Table ~~6-63~~ 6-64 . ECO-PTM: Mean March Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Not Operating		BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	**Baseline Conditions**	**Proposed Project**	**Baseline Conditions**	**Proposed Project**	**Baseline Conditions**	**Proposed Project**
Wet	~~0.58~~ 0.59	~~0.57 (-0.1%)~~ 0.59 (0.1%)	~~0.59~~ 0.61	~~0.59~~ 0.61 (0.0%)	~~0.60~~ 0.61	~~0.60~~ 0.61 (0.0%)
Above Normal	0.55	0.55 ~~(0.4%)~~ (0.3%)	0.57	0.57 ~~(0.1%)~~ (0.4%)	0.57	0.57 ~~(0.2%)~~ (0.1%)
Below Normal	~~0.47~~ 0.49	~~0.47 (0.3%)~~ 0.49 (0.5%)	~~0.49~~ 0.51	~~0.50 (0.5%)~~ 0.51 (0.4%)	~~0.50~~ 0.52	~~0.50 (0.3%)~~ 0.52 (0.4%)
Dry	0.43	~~0.43 (0.6%)~~ 0.44 (0.5%)	~~0.45~~ 0.46	~~0.46 (0.7%)~~ 0.46 (0.5%)	~~0.46~~ 0.47	0.47 ~~(0.6%)~~ (0.3%)
Critically Dry	0.38	0.38 ~~(-0.3%)~~ (-0.1%)	0.41	0.40 ~~(-0.5%)~~ (-0.3%)	0.41	0.41 ~~(-0.2%)~~ (-0.1%)

Table only includes mean responses and does not consider model uncertainty.

Table ~~6-64~~ 6-65. ECO-PTM: Mean April Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence Operation Assumption

	BAFF Not Operating		BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project
Wet	0.53	0.53 ~~(0.1%)~~ (-0.1%)	~~0.54~~ 0.55	~~0.54 (0.1%)~~ 0.55 (-0.1%)	0.55	~~0.55~~ 0.56 - (0.1%)
Above Normal	~~0.47~~ 0.46	~~0.47 (0.4%)~~ 0.46 (0.5%)	~~0.49~~ 0.48	~~0.49~~ 0.48 (0.6%)	0.49	~~0.50 (0.8%)~~ 0.49 (0.6%)
Below Normal	~~0.40~~ 0.39	0.40 ~~(1.4%)~~ (1.7%)	~~0.42~~ 0.41	0.42 ~~(1.7%)~~ (1.6%)	~~0.43~~ 0.42	0.43 ~~(1.4%)~~ (2.1%)
Dry	~~0.36~~ 0.35	0.36 ~~(0.3%)~~ (1.3%)	~~0.38~~ 0.37	0.38 ~~(0.6%)~~ (1.0%)	~~0.39~~ 0.38	0.39 ~~(0.7%)~~ (1.3%)
Critically Dry	~~0.34~~ 0.35	~~0.34~~ 0.35 (0.0%)	~~0.36~~ 0.37	~~0.36 (-0.1%)~~ 0.37 (0.0%)	0.37	0.37 ~~(0.0%)~~ (-0.3%)

Table only includes mean responses and does not consider model uncertainty.

Table ~~6-65~~ 6-66. ECO-PTM: Mean May Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	0.50	0.50 ~~(-0.1%)~~ (-0.2%)
Above Normal	0.43	0.43 ~~(0.2%)~~ (-0.2%)
Below Normal	0.38	~~0.38 (-1.0%)~~ 0.37 (-0.2%)
Dry	0.32	0.33 ~~(1.0%)~~ (1.9%)
Critically Dry	~~0.29~~ 0.28	~~0.29 (0.8%)~~ 0.28 (0.5%)

Table only includes mean responses and does not consider model uncertainty.

Table ~~6-66~~ 6-67. ECO-PTM: Mean June Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~0.41~~ 0.42	~~0.41 (0.0%)~~ 0.42 (0.1%)
Above Normal	0.35	0.35 (0.4%)
Below Normal	0.29	0.29 ~~(-0.2%)~~ (0.0%)
Dry	0.29	~~0.28 (-2.3%)~~ 0.29 (-2.0%)
Critically Dry	~~0.26~~ 0.25	~~0.26~~ 0.25 (0.1%)

Table only includes mean responses and does not consider model uncertainty.

Rearing Habitat

Although this overall section primarily focuses on effects on outmigrating juvenile winter-run Chinook Salmon, some juveniles may rear within the Delta. The limited differences in flow and hydrodynamic conditions described above for outmigrating juveniles indicate that there would be little, if any, effect on rearing winter-run Chinook Salmon juveniles as a result of the Proposed Project relative to Baseline Conditions.

6.4.3.2 Delta Smelt Summer and Fall Habitat Actions

There would not be expected to be any effect on winter-run Chinook Salmon from the Delta Smelt summer and fall habitat actions, which would occur during summer/fall, a period when winter-run Chinook Salmon would not be expected to occur in the Delta.

6.4.3.3 John E. Skinner Delta Fish Protective Facility

Any activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—would have limited effects on winter-run Chinook Salmon because the location of the Skinner Fish Facility in the south Delta and management of entrainment risk (e.g., through OMR management) would result in low numbers of winter-run Chinook Salmon being exposed to the facility (Zeug and Cavallo 2014; Islam et al. 2020, 2021, 2022). To the extent that winter-run Chinook Salmon do occur at the facility, salvage disruptions during maintenance and repair could increase mortality, whereas facility and salvage release site improvements could decrease mortality, but such decreases or increases would be of relatively few fish in population-level terms.

6.4.3.4 Delta Smelt Supplementation

There is some dietary overlap between juvenile Chinook Salmon and Delta Smelt (Kjelson et al. 1982; Slater and Baxter 2014). However, supplementation of Delta Smelt would be unlikely to have appreciable negative effects on winter-run Chinook Salmon because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential competitors with winter-run Chinook Salmon juveniles for prey resources.[19]

6.4.3.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and would be expected to have limited overlap with winter-run Chinook Salmon occurrence in the Delta, given that most individuals appear to migrate into the Delta with early winter flow pulses (del Rosario et al. 2013), but some could occur within the window (see Tables 6A-2, 6A-4a, and 6A-4b in Appendix 6A). The potential for greater south Delta entrainment would exist for juvenile winter-run Chinook Salmon occurring during the water transfer window, but this would be expected to be limited given that no genetically confirmed winter-run have been found in salvage during WYs 2010–2022 before December (based on data used for the salvage-density method). The Winter-Run Chinook Salmon Early Season Migration OMR flow management action would also explicitly limit the potential for entrainment beginning November 1 (see Chapter 2). Entrainment loss occurring during the water transfer period would also count toward cumulative yearly loss thresholds for protection of the yearly cohort. Note this EIR does not provide environmental compliance for individual water transfer proposals.

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[19] Coverage for take resulting from Delta Smelt broodstock collection would be sought under separation authorization.

6.4.3.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on winter-run Chinook Salmon would be similar between the scenarios. The potential for negative effects on winter-run Chinook Salmon from the agricultural barriers during their May–November operational period is limited because the spatiotemporal overlap with the barriers would be minimal. Should juvenile winter-run Chinook Salmon occur near the barriers, they could be subject to greater predation by predatory fish occurring near the barriers. Far-field hydraulic effects of the barriers on south Delta channels could occur but would be limited by OMR flow management beginning November 1 if early season winter-run Chinook Salmon entrainment loss exceeded thresholds described in Chapter 2 for Winter-Run Chinook Salmon Early Season Migration.

6.4.3.7 Barker Slough Pumping Plant

Operations of the BSPP would be expected to have minimal effects on winter-run Chinook Salmon because of infrequent presence of winter-run Chinook Salmon in the nearby monitoring surveys (National Marine Fisheries Service 2019:440–443). BSPP fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screens. BSPP diversion restrictions described in Chapter 2 for protection of larval Longfin Smelt (January 1–March 31 of Dry and Critically Dry water years) and larval Delta Smelt (March 1–June 30 of Dry and Critically Dry water years) would also reduce the already low potential for negative effects on winter-run Chinook Salmon.

Sediment removal by suction dredge at BSPP would have the potential to entrain juvenile winter-run Chinook Salmon, although the numbers would be expected to be limited given low numbers of juvenile winter-run Chinook Salmon expected to occur in the area and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on winter-run Chinook Salmon given that the species does not associate with vegetation (Grimaldo et al. 2012) and as previously noted, abundance would be expected to be low in the vicinity.

6.4.3.8 Clifton Court Forebay Weed Management

As described previously in the discussion regarding the Skinner Fish Facility, relatively low numbers of winter-run Chinook Salmon would occur in CCF because of factors such as OMR management and the location of the facility in the south Delta. The Proposed Project includes summer and fall applications of herbicides and therefore would be expected to have limited potential for temporal overlap given species timing in the Delta (Tables 6A-2, 6A-3, 6A-4a, and 6A-4b in Appendix 6A). Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months. Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and therefore may be more likely to temporally coincide with occurrence of winter-run Chinook Salmon, with occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual winter-run Chinook Salmon from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds. However, such positive or negative effects would only be on limited numbers of winter-run Chinook Salmon individuals.

6.4.3.9 Suisun Marsh Operations

Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement provides water quality benefits to winter-run Chinook Salmon habitat. This beneficial operation coincides with downstream migration of juvenile winter-run Chinook Salmon and upstream migration of adult winter-run Chinook Salmon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. The proportion of the total run utilizing this route is unknown. Operation of the SMSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators because the gates would not be continuously operated and boat lock passage is available when the gates are closed (National Marine Fisheries Service 2019:463). There could be delay to adult winter-run Chinook Salmon for a few hours to several days if SMSCG closure coincides with adult presence in the Delta, although such effects would be limited because winter-run Chinook Salmon are typically several weeks or months away from spawning when passing through the Delta (National Marine Fisheries Service 2019:462). Any negative effects would be consistent between the Proposed Project and Baseline Conditions scenarios. Winter-run Chinook Salmon would not be expected to occur in the Delta during additional operations of the SMSCG for the Delta Smelt summer and fall habitat actions.

6.4.3.10 Georgiana Slough Salmonid Migratory Barrier Operations

The operations assumptions for the GSSMB BAFF are discussed for Delta Smelt in Section 6.4.1.10, "Georgiana Slough Migratory Barrier Operations." These assumptions were applied in Section 6.4.3.1, "Delta SWP Facility Operations", analyses pertaining to the Delta Passage Model, STARS model, and ECO-PTM model. The results of the ECO-PTM analysis illustrate the potential positive effects of BAFF operations on through-Delta survival, relative to no BAFF operation; for example, in March, BAFF operations increase through-Delta survival (for winter-run entering the Delta via the Sacramento River) by 0.02–0.03 (i.e., 2–3 percentage points in absolute terms) relative to no BAFF operations (Table ~~6-63~~ 6-64). BAFF operations would not differ between Baseline Conditions and the Proposed Project, so effects would be similar.

The number of winter-run Chinook Salmon juveniles potentially occurring near the BAFF depends on the proportion of the population taking this migratory pathway through the Delta. Alternative pathways include via the Yolo Bypass/Fremont Weir or through Sutter/Steamboat sloughs. Using historical data for length-at-date fish occurrence at Knights Landing and the proportion of flow entering Yolo Bypass at Fremont Weir, Acierto et al. (2014) estimated that a mean of around 6% of winter-run Chinook Salmon juveniles would enter Yolo Bypass in wet and above normal years, with virtually no fish entering in dry and critically dry years. With a Fremont Weir notch, Acierto et al. (2014) estimated that the percentage of juveniles entering the Yolo Bypass would increase to around 16% in wet and above normal years and to around 8% in dry and critically dry years. Hance et al. (2022) showed that the percentage of acoustically tagged winter-run Chinook Salmon juveniles entering Sutter Slough is fairly consistent (~12-13%) across a range of Sacramento River flows, whereas the percentage entering Steamboat Slough decreases with increasing flow from around 20% at low flow to around 10% at high flow. Based on these estimates, the majority of juveniles would occur at the Sacramento River-Georgiana Slough junction and could potentially be exposed to the BAFF, but a sizable minority would be likely to take other migration pathways that would not place them near the BAFF.

A summary of available information regarding predation and predatory fish related to BAFF operations is provided in the discussion for Delta Smelt in Section 6.4.1.10, "Georgiana Slough Migratory Barrier Operations." At the scale of through-Delta survival, the operation of the 2011 BAFF did not appear to influence survival of juvenile Chinook Salmon downstream of the study area (California Department of Water Resources 2015b). Survival for the BAFF On and BAFF Off conditions were not significantly different for either route, which suggests that operation of the BAFF did not have a negative effect on survival of fish downstream of the barrier. This finding is not surprising because operation of the BAFF would need to have a large localized effect on survival to considerably influence route-specific survival (California Department of Water Resources 2015b:3-195). Implementation of the GSSMB beginning in 2024 will also include through-Delta survival assessment of potential BAFF effects.

Operation of the BAFF would coincide with much of the upstream migration period of adult winter-run Chinook Salmon. For example, per the National Marine Fisheries Service (2022:43) Biological Opinion for the Georgiana Slough Salmonid Migratory Barrier Project, the temporal overlap for January-April continuous operations would be 80% for winter-run Chinook Salmon. There are few data to inform what percentage of adult winter-run and spring-run could migrate up Georgiana Slough and encounter the BAFF when moving upstream to the Sacramento River watershed. Although it is expected that most adult salmonids from the Sacramento River basin would probably be migrating up the mainstem of the Sacramento River, some may be migrating up through Georgiana Slough after entering the San Joaquin River system. Stein and Cuetara (2004) found that of 66 adult fall-run Chinook salmon acoustically tagged and released in Suisun Marsh, 47 of these fish left the Delta in the Sacramento River at Hood; only four fish were detected in Georgiana Slough near its junction with the Sacramento River.

When the BAFF is turned on, adult Chinook Salmon in the Sacramento River could avoid the barrier after first contact by swimming away from it towards the opposite bank (northern bank), and thus avoid or reduce their exposure to the barrier's bubbles, light, and sound properties. Fish moving upstream in Georgiana Slough would encounter the functioning BAFF from the downstream side and would have to swim through, around, or under the bubble curtain, wait for the bubble curtain to be turned off, or return down Georgiana Slough and find a different pathway to enter the Sacramento River mainstem channel. The vertical distribution of upstream migrating adult Chinook Salmon in the Central Valley is not well known, but data from other locations suggest that fish move more frequently at depths that are shallower than the depth of the BAFF (Gray and Haynes 1977; Quinn 2005), which would generally cover the upper half of the water column. In contrast, observations by local biologists and models of depths at which upstream migration energy costs are reduced (Hughes 2004) suggest that fish use waters very close to the bottom during their upstream migration and therefore would pass upstream below the depth of the BAFF framework, which has at least 2 feet, but up to12 feet of clearance beneath it (Figure 6-51). Other factors such as water temperatures, local velocity profiles, and light penetration could affect the distribution of adults in the water column (Quinn 2005). The BAFF does not form a complete barrier to upstream migration at the head of Georgiana Slough because in addition to the space beneath the BAFF (Figure 6-51), there is also approximately 50-60 feet of open water between the BAFF and the shore (Figures 6-49 and 6-50), allowing adults to go around the edges of the BAFF if not passing beneath it.

It is unlikely that the BAFF would delay upstream migrating winter-run Chinook Salmon to any great extent. This conclusion is inferred from tracking studies of adult fall-run Chinook Salmon conducted as part of earlier Georgiana Slough acoustic deterrent studies (Hanson et al. 1997). Hanson et al. (1997) found that there was no significant delay in upstream passage time and only a 9 percent localized decrease in passage time when considering both upstream and downstream passage. They concluded that such a delay would not be considered significant in the context of reaching spawning grounds in good condition. Hanson et al. (1997) studied an acoustic deterrent that had a more wide-ranging (up to 0.25 mile) spread of sound into the water column at the Georgiana Slough junction, whereas the BAFF acoustic effects are limited to an area very close to the barrier because of the bubble curtain technology containing the sound signal. Therefore effects of the BAFF would be expected to be less wide-ranging than the effects observed by Hanson et al. (1997).

Overall, although it is possible that there may be negative effects to winter-run Chinook Salmon from GSSMB operations, such effects would be limited, and the potential for positive effects related to keeping juveniles out of the interior Delta appears greater than the potential for negative effects.

6.4.3.11 Significance of Impacts on Winter-Run Chinook Salmon

The Proposed Project includes various measures that would limit the potential for significant impacts on winter-run Chinook Salmon, including but not limited to entrainment protection, spring Delta outflow, and other measures such as Skinner Fish Facility improvements (see detailed descriptions in Chapter 2). Although there is the potential for negative effects on winter-run Chinook Salmon primarily by entrainment, impacts would be less than those occurring under Baseline Conditions, which as described above have been well below ESA-authorized take levels (south Delta entrainment loss of 1 percent of the juvenile population entering the Delta). Based on the analysis presented above (Section 6.4.3.1, "Delta SWP Facility Operations;" Section 6.4.3.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.3.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.3.4, "Delta Smelt Supplementation;" Section 6.4.3.5, "Water Transfers;" Section 6.4.3.6, "Agricultural Barriers;" Section 6.4.3.7, "Barker Slough Pumping Plant;" Section 6.4.3.8, "Clifton Court Forebay Weed Management;" Section 6.4.3.9, "Suisun Marsh Operations;" and Section 6.4.3.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on winter-run Chinook Salmon would be less than significant. No mitigation is required.

6.4.4 Spring-Run Chinook Salmon

6.4.4.1 Delta SWP Facility Operations

Immigrating Adults

As described for winter-run Chinook Salmon, CalSim modeling suggests that there would be little difference between Baseline Conditions and Proposed Project scenarios in flow entering the Delta in the Sacramento River at Freeport during the January–June period of upstream migration of adult spring-run Chinook Salmon (Figures 6-58, 6-59, 6-60, 6-61, 6-62, 6-63; Table 6A-6 in Appendix 6A). The similarity in flow entering the Delta between Baseline Conditions and the Proposed Project scenarios and the low rates of straying across a wide range of hydrological conditions (Marston et al. 2012) suggests that there would be little potential for differences in rates of straying of adult spring-run Chinook Salmon between the Baseline Conditions and Proposed Project scenarios.

In addition to juvenile spring-run Chinook Salmon discussed in "Outmigrating Juveniles," adult spring-run Chinook Salmon are also subject to entrainment at the south Delta export facilities (California Department of Fish and Wildlife 2020b, Attachment 8:60–63). As discussed for winter-run Chinook Salmon, small numbers of adult Chinook Salmon have been entrained during the period of adult spring-run Chinook Salmon occurrence in the Delta, which overlaps with adult winter-run Chinook Salmon occurrence in the Delta (California Department of Fish and Wildlife 2020b, Attachment 8:60–63). SWP south Delta exports generally would be similar under the Proposed Project and Baseline Conditions during this time period, with somewhat lower exports under the Proposed Project in March and greater exports under the Proposed Project in April and May (Figures 6-64, 6-65, 6-66, 6-67, 6-68, 6-69, 6-70, 6-71). This indicates entrainment risk for adult spring-run Chinook Salmon under the Proposed Project generally would be similar to Baseline Conditions, with potentially marginally less risk in March and greater risk in April/May during the period of high or medium occurrence (Table 6A-6 in Appendix 6A). However, given the low numbers of adult Chinook Salmon salvaged historically, any positive or negative differences in entrainment loss between the Proposed Project and Baseline Conditions would be limited in terms of the numbers of fish involved (i.e., likely single digits).

Outmigrating Juveniles

Entrainment

Salvage-Density Method

As discussed for winter-run Chinook Salmon, the salvage-density method (see Appendix 6B, Section 6B.1) was used to provide perspective on potential differences in entrainment loss of spring-run Chinook Salmon juveniles between the Baseline Conditions and Proposed Project scenarios. This analysis was based on loss of genetically identified juvenile winter-run Chinook Salmon.[20] As described for winter-run Chinook Salmon, the estimates of entrainment loss obtained from the salvage-density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim 3-modeled differences in SWP exports between Baseline Conditions and Proposed Project scenarios; the results are basically a description of differences in export flows weighted by historical monthly loss density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained, but these data are more a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected. Although the emphasis is consideration of the relative difference between scenarios, the modeling is limited in its representation of real-time adjustments to operations in order to minimize effects on listed fishes, so differences between scenarios are likely to be less than suggested by the method.

The salvage-density method indicated that SWP exports during the main period of juvenile spring-run Chinook Salmon loss at the SWP south Delta export facility would be appreciably greater under the Proposed Project relative to Baseline Conditions, resulting in higher numbers of fish under the Proposed Project relative to Baseline Conditions (~~Table 6-67~~ Tables 6-68 and 6-69). This reflects greater SWP exports under the Proposed Project during April and in particular May relative to

[20] The effects analysis for the 2019 ITP Application and 2020 EIR used length-at-date loss density estimates, for which water year type monthly means during 2017–2022 averaged 99 percent more than the corresponding genetic loss density estimates. This illustrates that the absolute effect is considerably less than was permitted under the 2020 ITP.

Baseline Conditions and indicates the potential for greater entrainment of juvenile spring-run Chinook Salmon under the Proposed Project relative to Baseline Conditions. As described in Chapter 2, entrainment risk to spring-run Chinook Salmon juveniles would be limited by cumulative loss thresholds from November 1 through the end of the OMR flow management period of each water year for Feather River Fish Hatchery spring-run and fall-run Chinook Salmon and Coleman National Fish Hatchery fall-run Chinook Salmon as surrogates for young-of-the-year spring-run; and Coleman National Fish Hatchery late-fall-run Chinook Salmon as surrogates for yearling spring-run. Entrainment risk for spring-run Chinook Salmon juveniles may also be limited by ancillary OMR flow management measures that would be undertaken for other species (e.g., loss thresholds for winter-run Chinook Salmon and proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections). As described in Chapter 2, DWR's continued support of the Spring-Run Chinook Salmon Juvenile Production Estimate framework will be the basis for consideration of updated entrainment minimization measures.

Table 6-67 6-68. Mean Number of Genetically Identified Spring-run Chinook Salmon Juveniles Lost (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	67 80	92 (38%) 98 (23%)
Above Normal	N/A	(48%) (57%)
Below Normal	53 57	67 (26%) (18%)
Dry	23 24	25 (7%) 20 (-17%)
Critically Dry	10	13 (29%) 12 (22%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2017–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-2 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

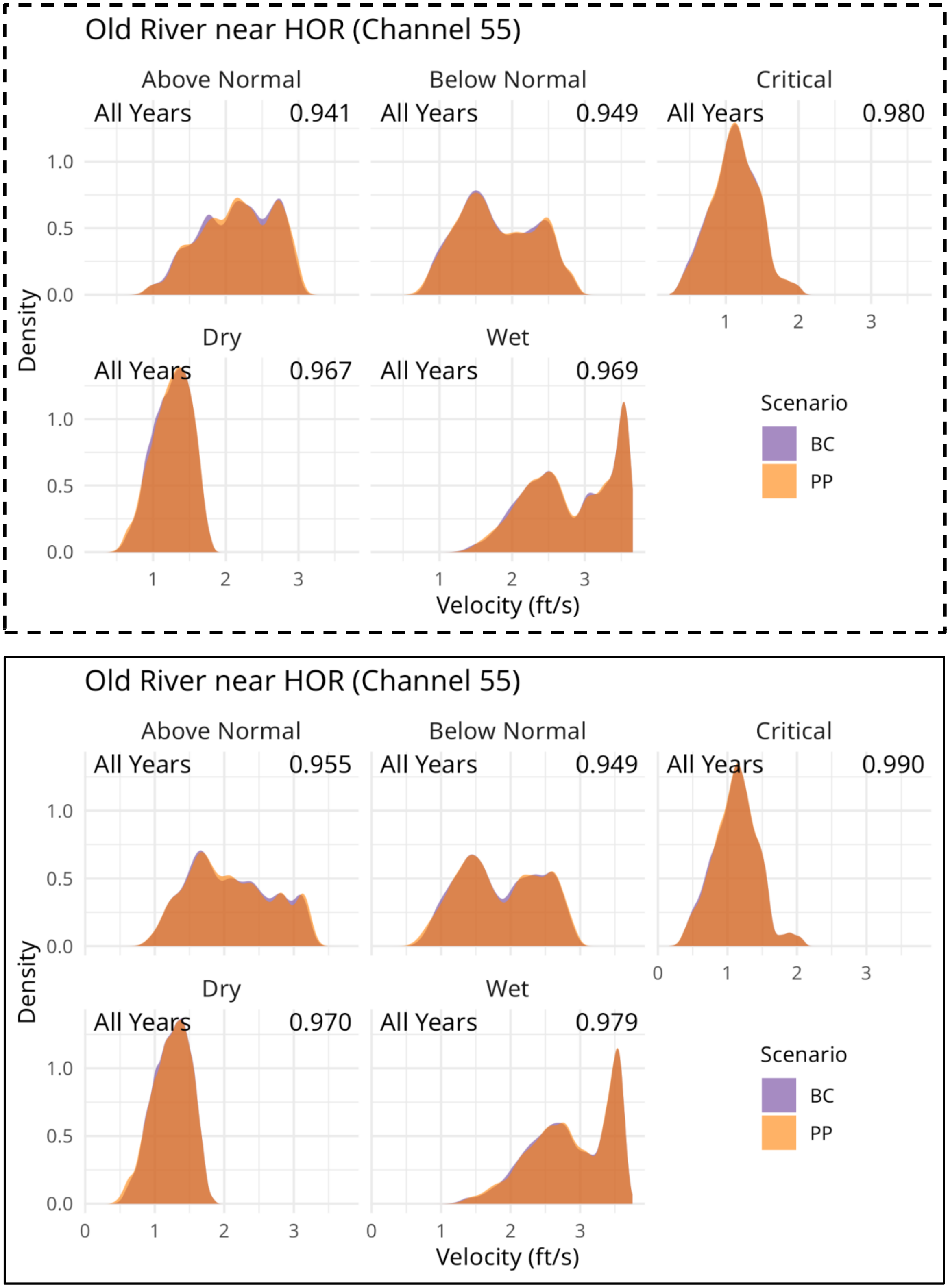
Table 6-69. Mean Number of Coded Wire Tagged Spring-run Chinook Salmon Juveniles Lost (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	0	0 (0%)
Above Normal	N/A	(0%)
Below Normal	1	1 (48%)
Dry	1	1 (-17%)
Critically Dry	0	0 (0%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2017–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-2a in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

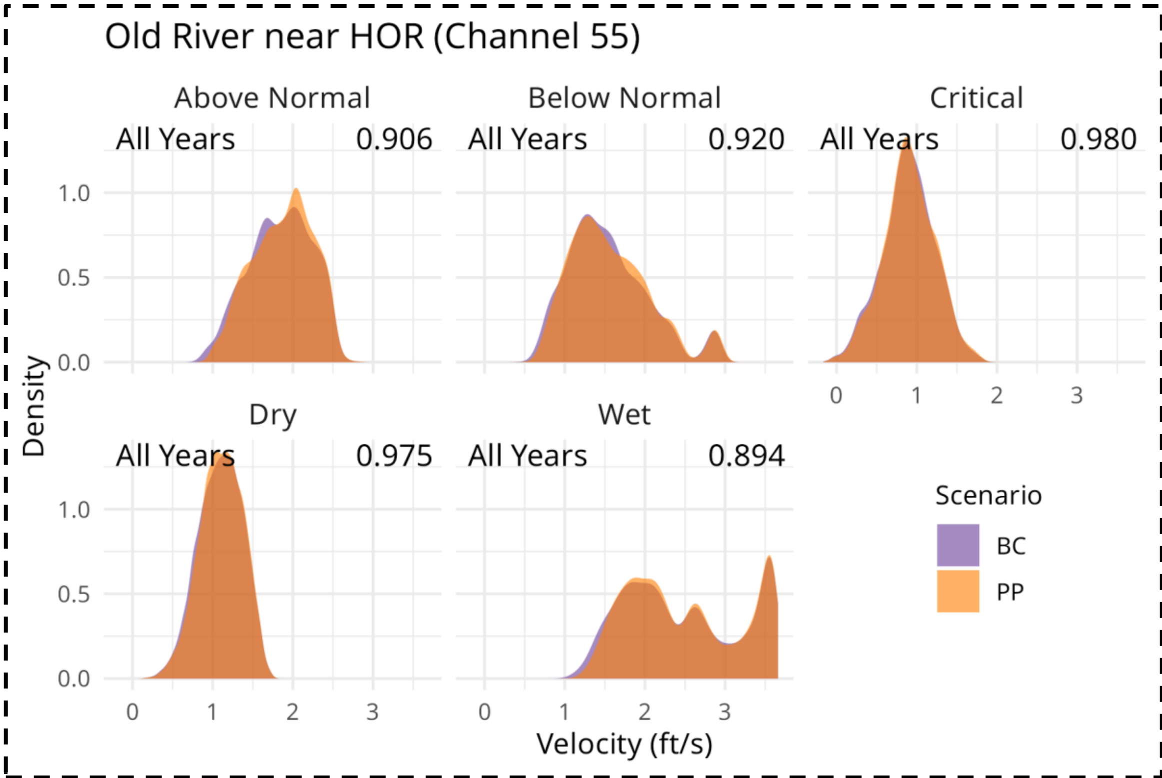
Delta Hydrodynamic Assessment and Junction Routing Analysis

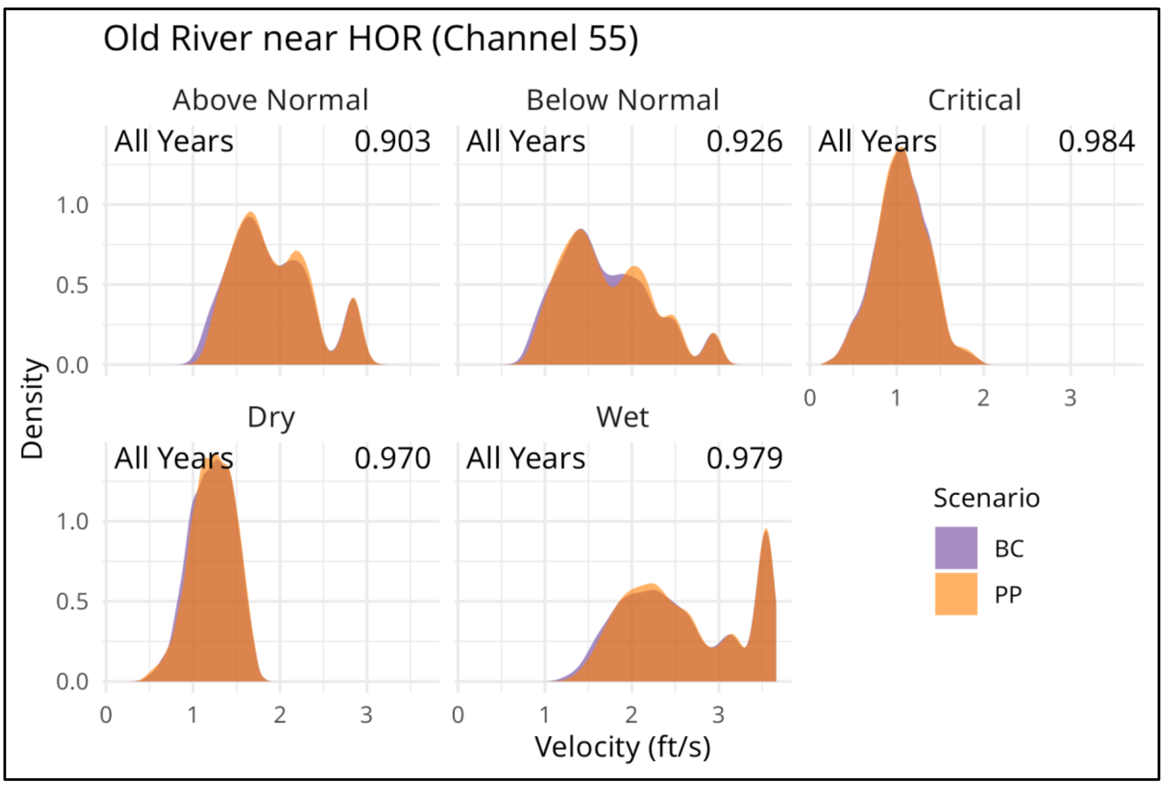
As previously described for winter-run Chinook Salmon, channel velocity and junction routing generally would be similar under the Proposed Project and Baseline Conditions, indicating that there would be little difference between scenarios in potential for effects on juvenile spring-run Chinook Salmon migrating through the Delta. The main migration period for spring-run Chinook Salmon juveniles overlaps the April/May period that tends to have greater SWP south Delta exports under the Proposed Project than Baseline Conditions and a small proportion of juvenile spring-run Chinook Salmon emigrate from the San Joaquin River Basin, both factors that could contribute to differences in the potential for negative effects under the Proposed Project relative to Baseline Conditions. However, the DSM2 hydrodynamic modeling indicated limited differences between scenarios. For example, in April and May at the Head of Old River, the mean proportion of flow entering Old River under the Proposed Project was no more than ~~1.3~~ 1.2 percent greater than Baseline Conditions (Table ~~6-35~~ 6-36) and velocity in Old River near Head of Old River was very similar (Figures 6-95 and 6-96); only very close to the south Delta export facilities were differences in velocity more apparent (Figures 6-97 and 6-98). Additional velocity and junction flow results are presented in Appendix 6B.



Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

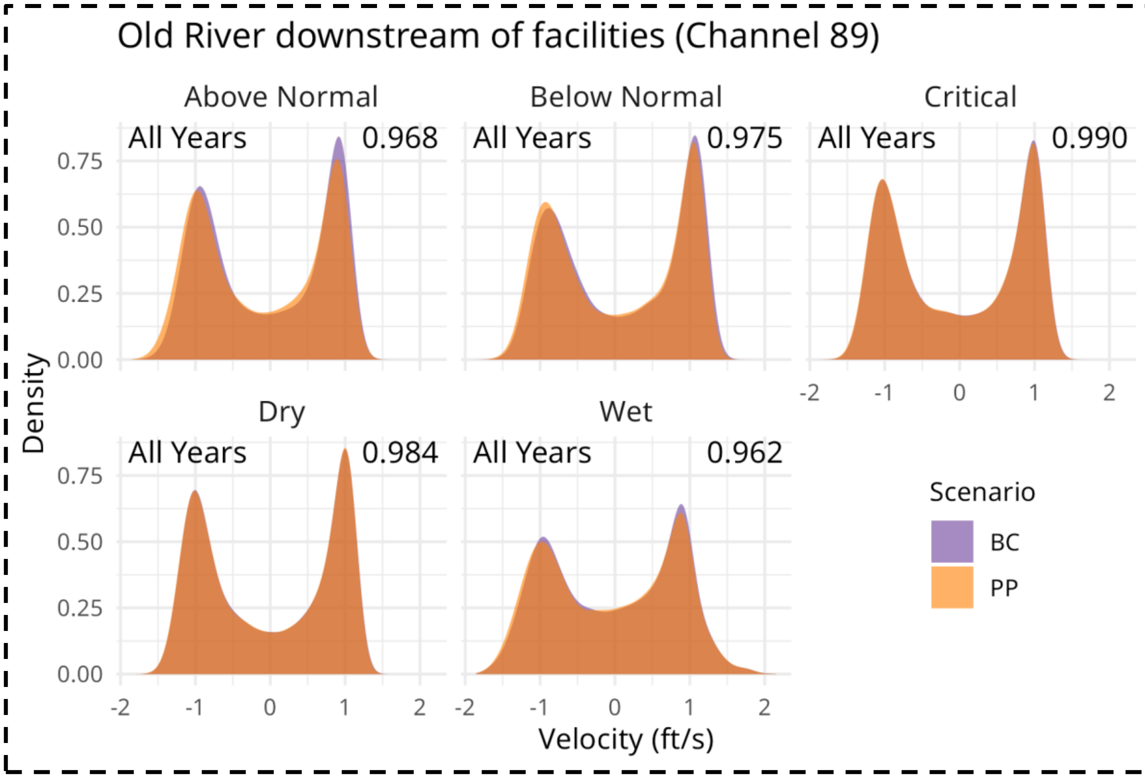
Figure 6-95. Velocity Density Distribution for Old River near Head of Old River, April

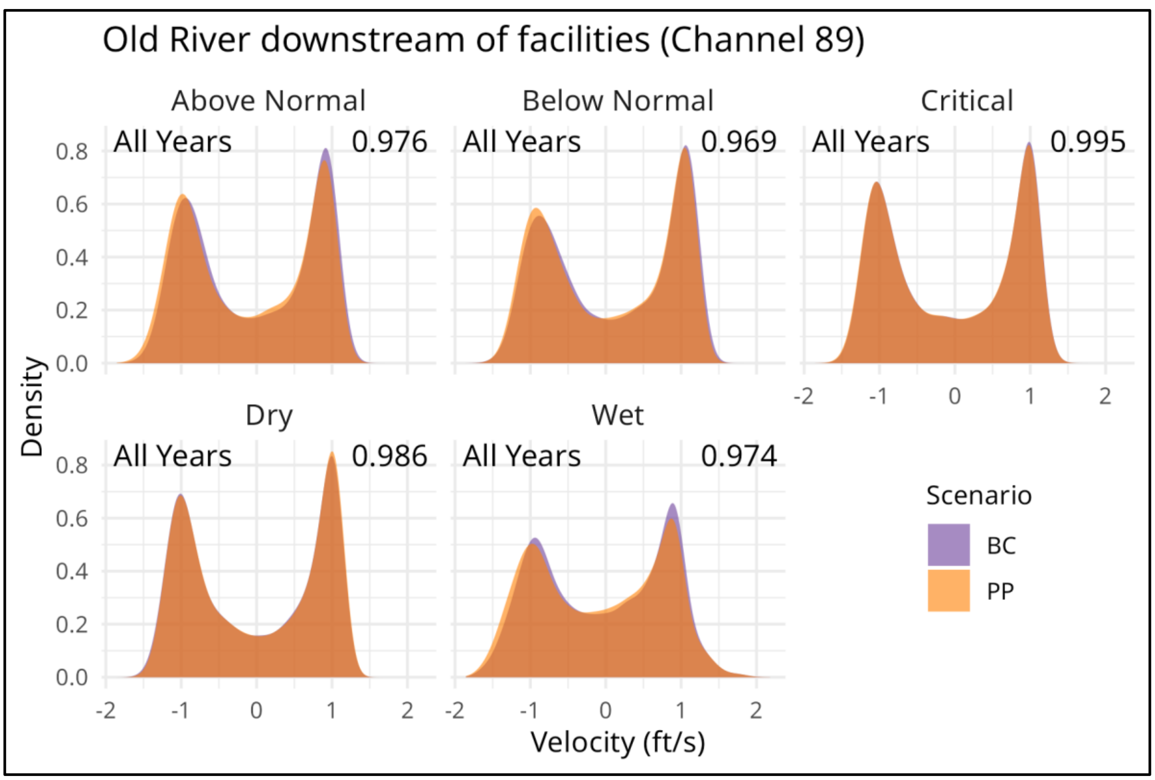




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

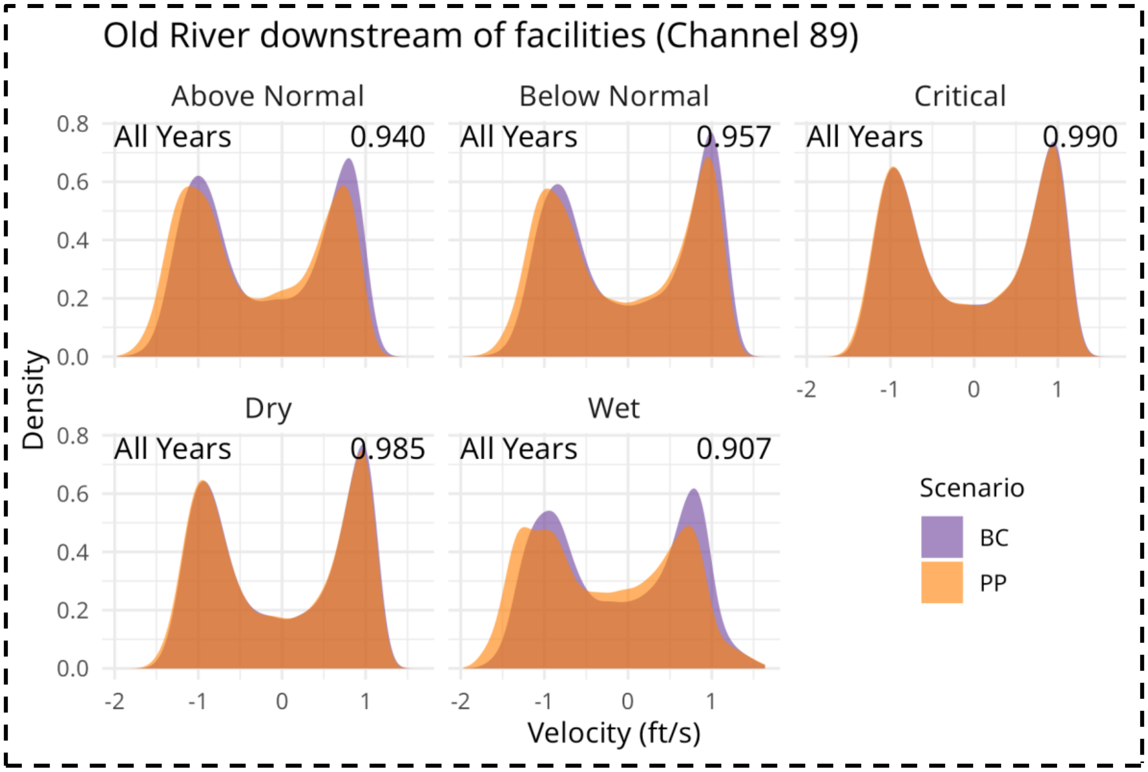
Figure 6-96. Velocity Density Distribution for Old River near Head of Old River, May

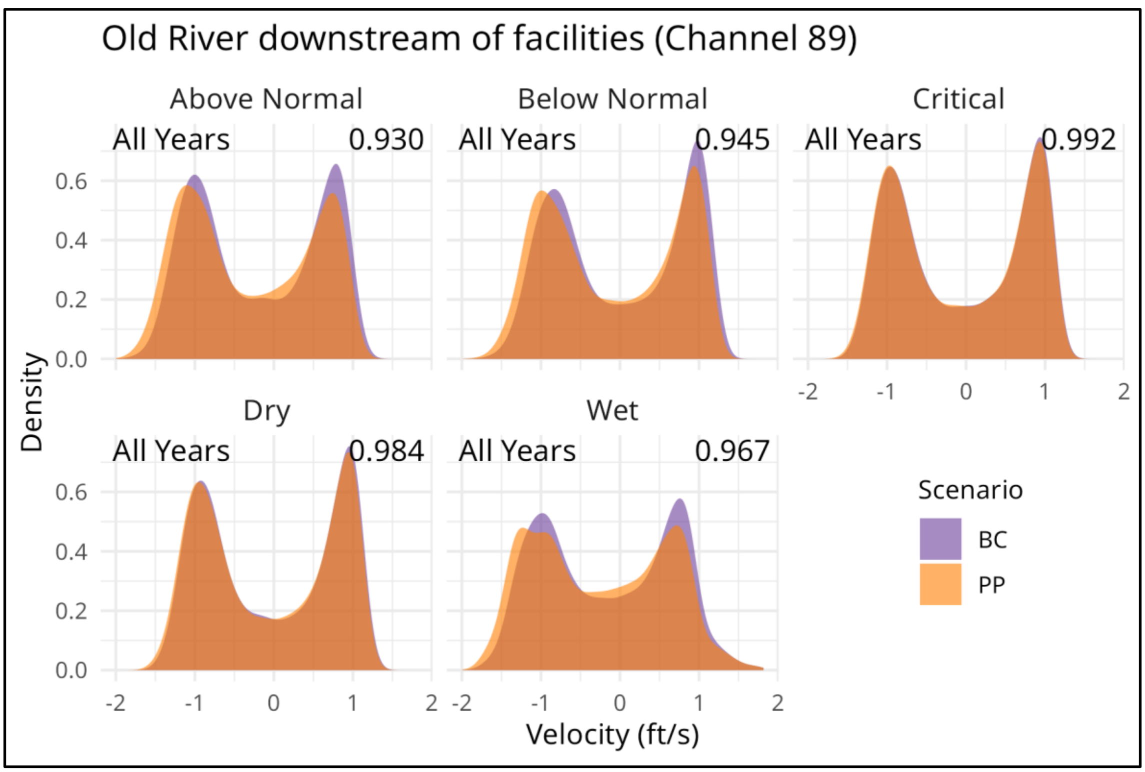




Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

Figure 6-97. Velocity Density Distribution for Old River Downstream of the South Delta Export Facilities, April





Note: The number on each plot represents the median overlap of density distribution between Baseline Conditions (BC) and Proposed Project (PP) for a given water year type.

Figure 6-98. Velocity Density Distribution for Old River Downstream of the South Delta Export Facilities, May.

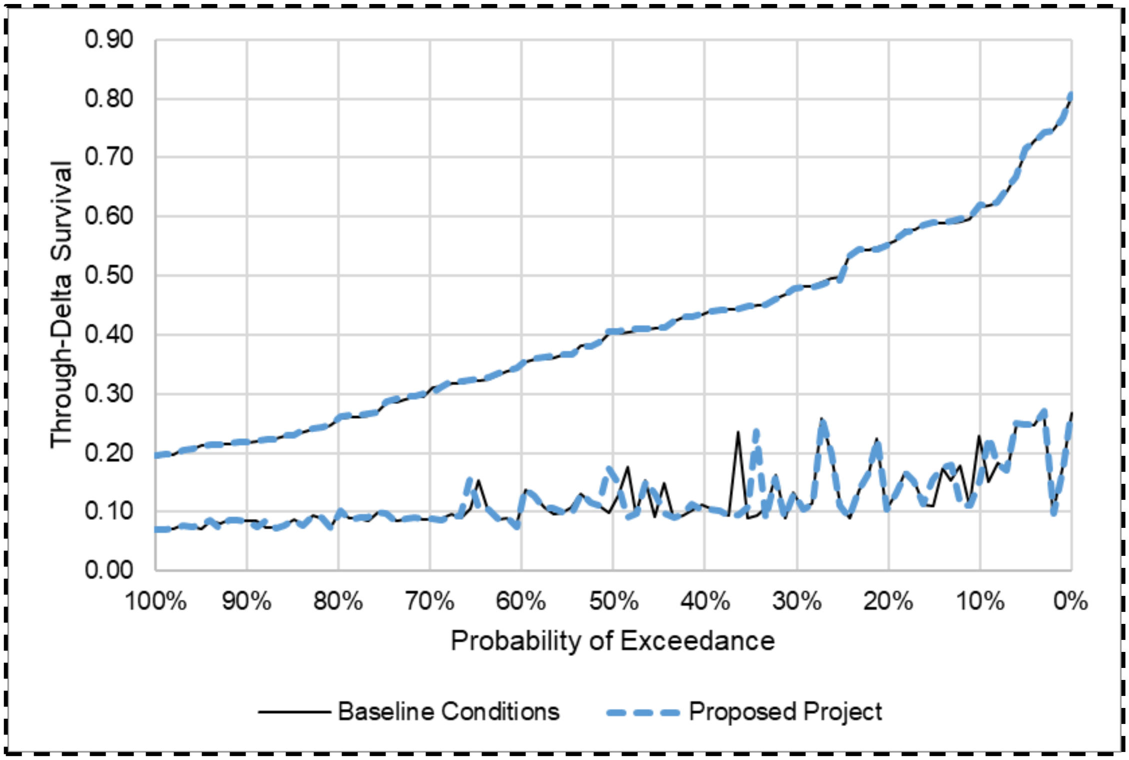
Delta Passage Model

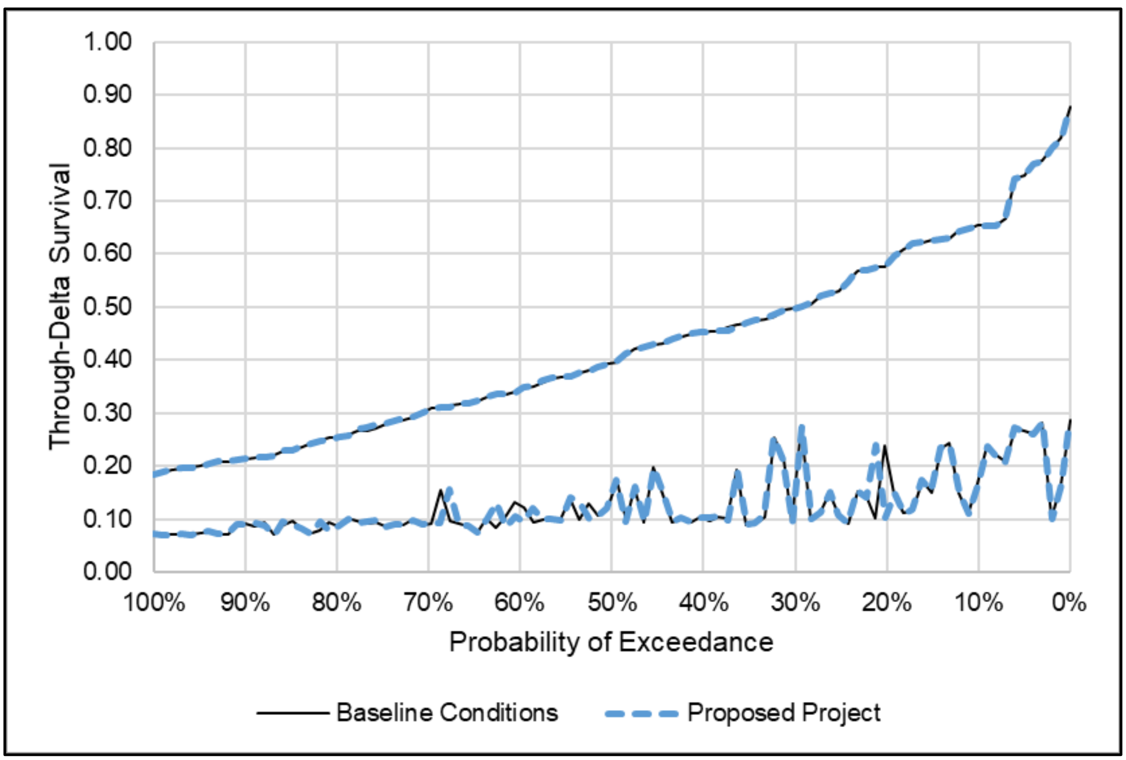
Background on the DPM is provided in the analysis for winter-run Chinook Salmon, with detailed methods provided in Appendix 6B, Section 6B.4. The results of the DPM suggested that through-Delta survival of spring-run Chinook Salmon smolts would be similar under the Proposed Project and Baseline Conditions, with relative differences in mean survival by water year type all less than 1 percent (Table ~~6-68~~ 6-70) and largely overlapping predictions across all years (Figures 6-99 and 6-100).

Table ~~6-68~~ 6-70 . Delta Passage Model: Mean Spring-Run Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project
Wet	~~0.34~~ 0.37	~~0.34 (-0.3%)~~ 0.37 (-0.2%)	~~0.34~~ 0.37	~~0.34 (-0.3%)~~ 0.37 (-0.2%)
Above Normal	0.28	~~0.28 (0.0%)~~ 0.29 (0.2%)	~~0.28~~ 0.29	~~0.28 (0.0%)~~ 0.29 (0.2%)
Below Normal	~~0.21~~ 0.22	~~0.22 (0.1%)~~ 0.23 (0.3%)	~~0.21~~ 0.23	~~0.22 (0.1%)~~ 0.23 (0.3%)
Dry	0.18	0.18 (0.8%)	0.18	0.18 (0.8%)
Critically Dry	0.14	0.14 ~~(0.0%)~~ (-0.1%)	~~0.14~~ 0.15	~~0.14 (0.0%)~~ 0.15 (-0.1%)

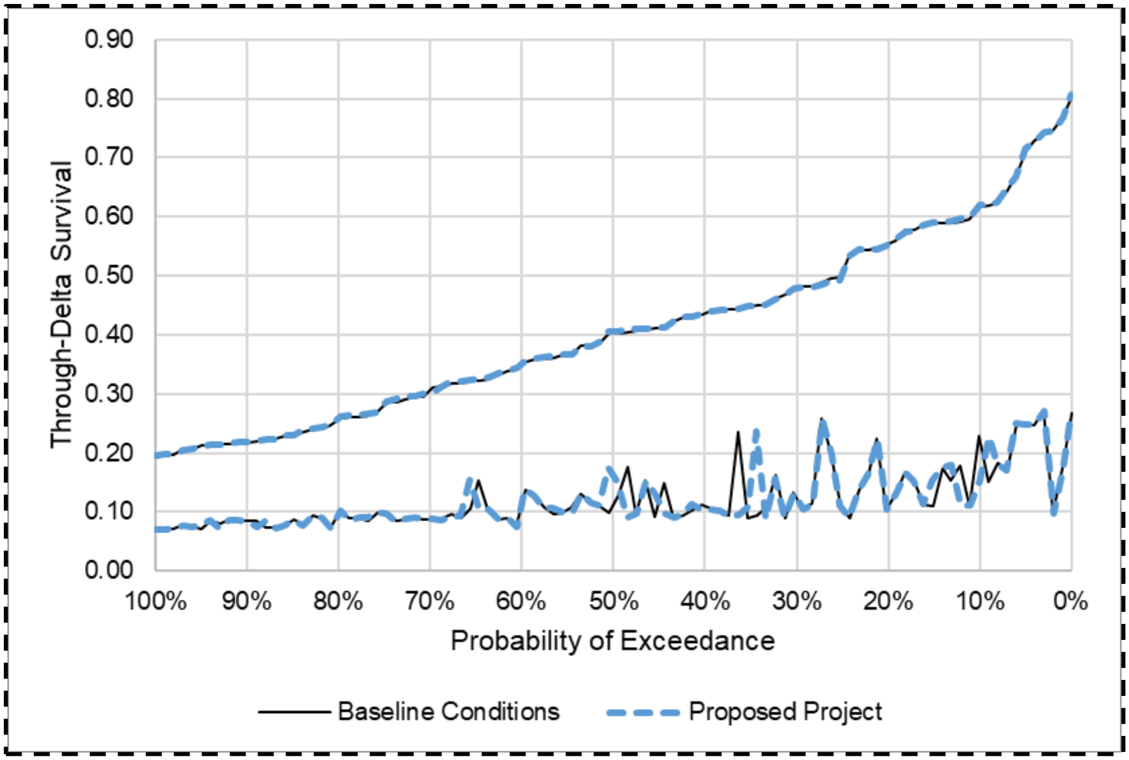
Note: Table only includes mean responses and does not consider model uncertainty. 95% predictions are shown in Figures 6-99 and 6-100.

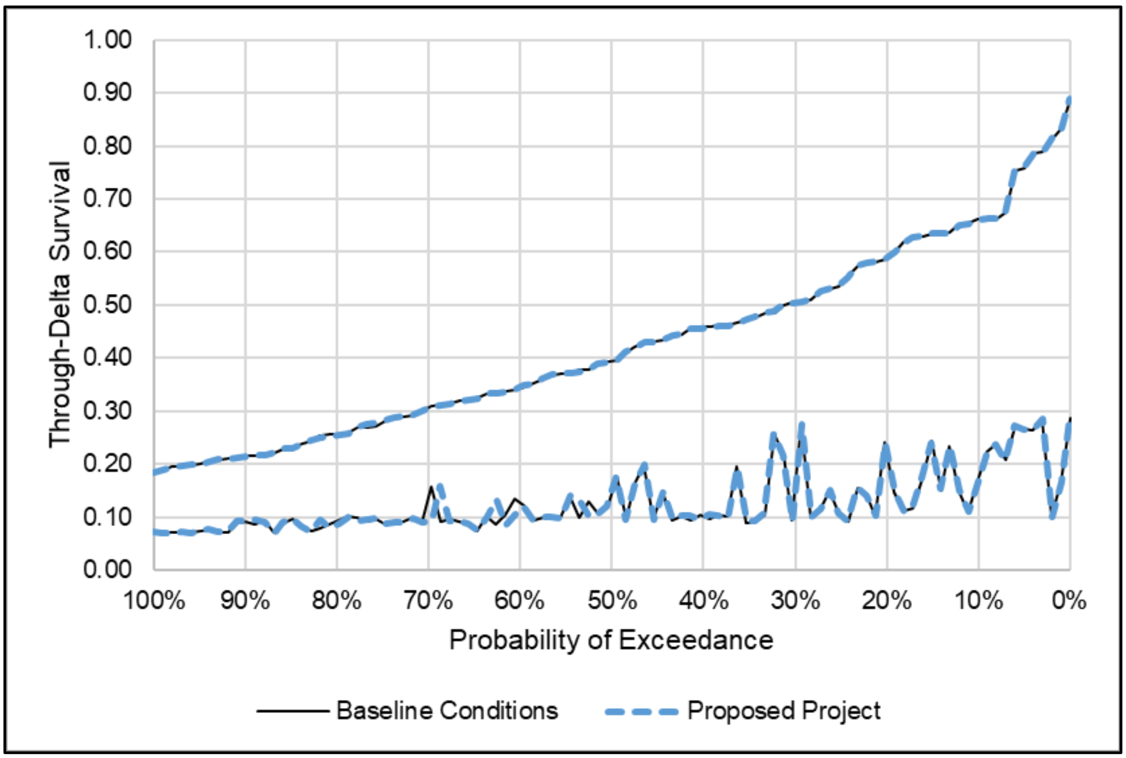




Note: Data are sorted by 97.5th percentile of predictions, with 2.5th and 97.5th percentiles shown, representing middle 95% of predictions.

Figure 6-99. Delta Passage Model: Exceedance Plot of Spring-Run Chinook Salmon Through-Delta Survival 95% Predictions, for the 1922–2021 Modeled Period, Assuming BioAcoustic Fish Fence Reducing Entry into Georgiana Slough by 50%





Note: Data are sorted by 97.5th percentile of predictions, with 2.5th and 97.5th percentiles shown, representing middle 95% of predictions.

Figure 6-100. Delta Passage Model: Exceedance Plot of Spring-Run Chinook Salmon Through-Delta Survival 95% Predictions, for the 1922–2021 Modeled Period, Assuming BioAcoustic Fish Fence Reducing Entry into Georgiana Slough by 67%

Survival, Travel Time, and Routing Analysis (based on Perry et al. 2018)

Background information on the STARS analysis is provided in the discussion of STARS for winter-run Chinook Salmon. For spring-run Chinook Salmon, the months of downstream young-of-the-year migration are December–May/June with yearling emigration in fall/winter (Tables 6A-6, 6A-7a, and 6A-7b in Appendix 6A). As described for winter-run Chinook Salmon, the differences in mean through-Delta survival between the Proposed Project and Baseline Conditions during this time period (~October–May/June) are limited (Tables 6-38 through 6-45 6-39 through 6-46), the mean probability of survival being less under the Proposed Project is close to 0.500 (Tables 6-48 through 6-55 6-49 through 6-56), and there is considerable overlap in the 95 percent posterior predictive intervals between scenarios (Appendix 6B, Figures 6B-66 through 6B-165).

Ecological Particle Tracking Modeling (ECO-PTM)

Background information on the ECO-PTM analysis is provided in the discussion of the ECO-PTM for winter-run Chinook Salmon. As noted for the STARS analysis, for spring-run Chinook Salmon, the months of downstream young-of-the-year migration are December–May/June (Tables 6A-6, 6A-7a, and 6A-7b in Appendix 6A), with yearling emigration in fall/winter (Table 6A-6 in Appendix 6A). During these time periods, the results of the ECO-PTM indicated differences in mean through-Delta survival of Chinook Salmon smolts between the Proposed Project and Baseline Conditions ranging from ~2 percent less under the Proposed Project (Dry years in April and June) to ~5 just over 2 percent greater under the Proposed Project (Dry Below Normal years in May April with 67% Georgiana Slough BAFF assumption), with most differences being less than 1 percent (Tables 6-57 through 6-65 6-58 through 6-66). The greater through-Delta survival in April/ May under the Proposed Project during Dry years in May reflects a potential positive effect of greater Delta inflow, which may benefit spring-run Chinook Salmon during drier years when conditions are less favorable for Chinook Salmon (Drought MAST 2022).

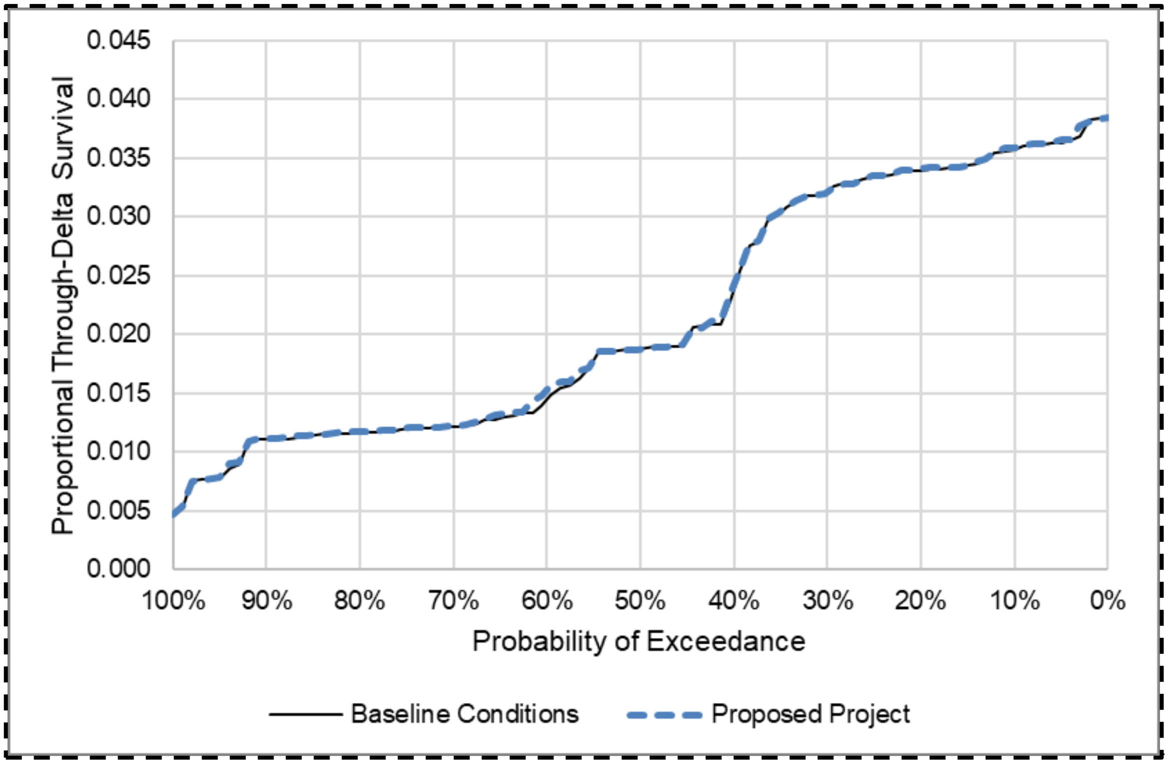
San Joaquin River-Origin Spring-run Chinook Salmon Structured Decision Model

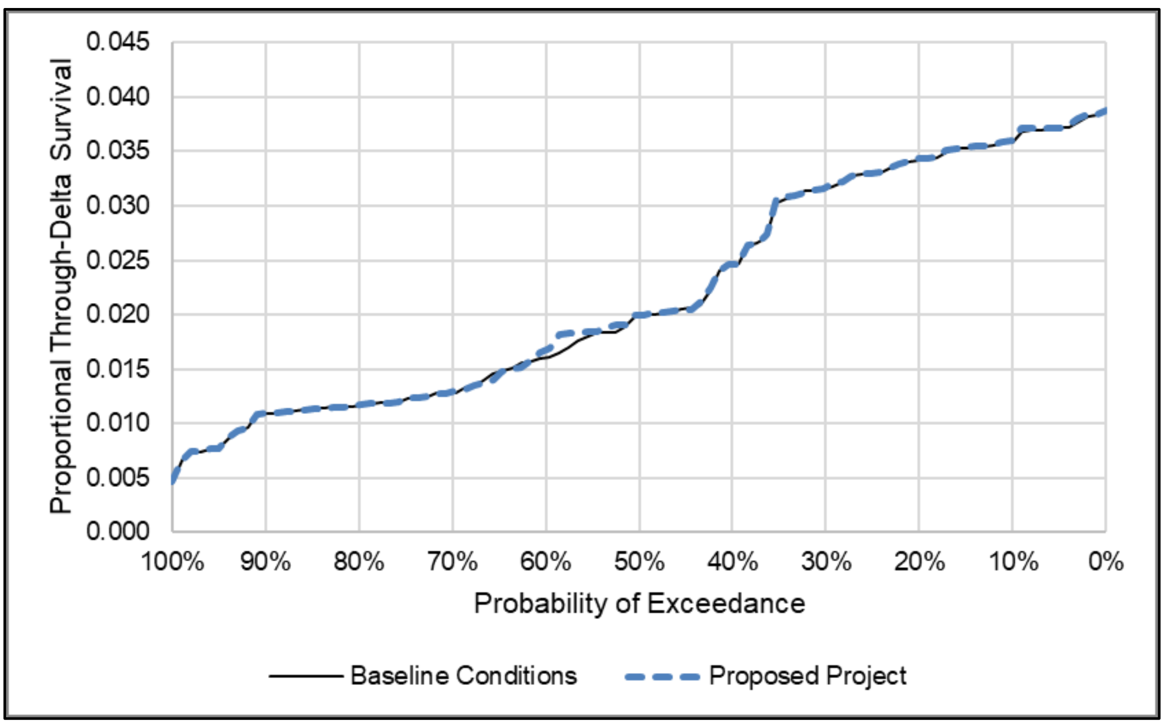
Spring-run Chinook Salmon have been reintroduced to the San Joaquin River Basin, and there is evidence for through-Delta flow-survival effects on juvenile Chinook Salmon following entry from the San Joaquin River Basin (e.g., Buchanan and Skalski 2020), so through-Delta survival impacts on juveniles were analyzed with the Structured Decision Model San Joaquin River routing application (see Appendix 6B, Section 6B.7, "San Joaquin River Juvenile Chinook Salmon Through-Delta Survival (Structured Decision Model Routing Application)"). The results of this analysis gave small differences in through-Delta survival between the scenarios (Table 6-69 6-71 ; Figure 6-101), suggesting there would be little difference in effects on spring-run Chinook Salmon from the San Joaquin River Basin as a result of Proposed Project operations relative to Baseline Conditions.

Table 6-69 6-71 . Mean Predicted San Joaquin River Spring-Run Chinook Salmon Annual Proportional Through-Delta Survival under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	0.033	0.033 (0.2%) (0.3%)
Above Normal	0.032	0.032 (0.3%) (0.1%)
Below Normal	0.016 0.017	0.016 (2.2%) 0.017 (-0.1%)
Dry	0.015 0.014	0.015 (0.4%) 0.014 (2.1%)
Critically Dry	0.010 0.012	0.010 (0.7%) 0.012 (0.5%)

Note: Table only includes mean responses and does not consider model uncertainty





Note: Figure only includes mean responses and does not consider model uncertainty

Figure 6-101. Exceedance Plot of San Joaquin River Spring-Run Chinook Salmon Annual Proportional Through-Delta Survival under the Proposed Project and Baseline Conditions Modeling Scenarios, for the 1922–2021 Modeled Period

Rearing Habitat

Although this overall section primarily focuses on effects on outmigrating juvenile spring-run Chinook Salmon, some juveniles may rear within the Delta. The limited differences in flow and hydrodynamic conditions described above for outmigrating juveniles indicate that there would be little, if any, effect on rearing spring-run Chinook Salmon juveniles as a result of the Proposed Project relative to Baseline Conditions.

6.4.4.2 Delta Smelt Summer and Fall Habitat Actions

There would not be expected to be any effect on spring-run Chinook Salmon from the Delta Smelt summer and fall habitat actions, which would occur during summer/fall, a period when spring-run Chinook Salmon generally would not be expected to occur in the Delta.

6.4.4.3 John E. Skinner Delta Fish Protective Facility

Any activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—would have limited effects on spring-run Chinook Salmon because, as discussed for winter-run Chinook Salmon, the location of the facility in the south Delta and management of entrainment risk (e.g., through OMR management) would result in low numbers of spring-run Chinook Salmon being exposed to the facility. To the extent that spring-run Chinook Salmon do occur at the facility, salvage disruptions during maintenance and repair could increase mortality, whereas facility and salvage release site improvements could decrease mortality, but such decreases or increases would be of relatively few fish in population-level terms.

6.4.4.4 Delta Smelt Supplementation

There is some dietary overlap between juvenile Chinook Salmon and Delta Smelt, as discussed for winter-run Chinook Salmon, but supplementation of Delta Smelt would be unlikely to have appreciable negative effects on spring-run Chinook Salmon because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential competitors with spring-run Chinook Salmon juveniles for prey resources.[21]

6.4.4.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and would be expected to have limited overlap with spring-run Chinook Salmon occurrence in the Delta but some could occur within the window (see Tables 6A-6, 6A-7a, and 6A-7b in Appendix 6A). The potential for greater south Delta entrainment would exist for juvenile spring-run Chinook Salmon occurring during the water transfer window, but this would be expected to be limited relative to entrainment later in winter/spring. Note this EIR does not provide environmental compliance for individual water transfer proposals.

[21] Coverage for take resulting from Delta Smelt broodstock collection would be sought under separation authorization.

6.4.4.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on spring-run Chinook Salmon would be similar between the scenarios. The proportion of juvenile spring-run Chinook Salmon exposed to the agricultural barriers depends on their annual timing of installation and removal. Due to their location, primarily migrants originating from the San Joaquin River would be exposed to the temporary barriers. The peak relative abundance of juvenile spring-run Chinook Salmon in the Delta is April (Tables 6A-6, 6A-7a, and 6A-7b in Appendix 6A). Operation of the barriers beginning in May would have the potential to expose a medium proportion of juvenile spring-run Chinook Salmon migrating through the Delta from the San Joaquin River Basin. Acoustically tagged juvenile Chinook Salmon from the San Joaquin River have demonstrated a high probability of selecting the Old River route (Buchanan et al. 2018), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile Chinook Salmon migrating past the barriers has been observed compared to when the barrier is not present (California Department of Water Resources 2018). When flap gates are tied up, Chinook Salmon passage past the agricultural barriers was improved (California Department of Water Resources 2018). As described in Appendix 2A, Attachment 3, one culvert at each of the three barriers will be left open and not operated tidally until June 1, thereby allowing passage of juvenile salmonids including spring-run Chinook Salmon.

6.4.4.7 Barker Slough Pumping Plant

Operations of the BSPP would be expected to have minimal effects on spring-run Chinook Salmon because of infrequent presence of spring-run Chinook Salmon in the nearby monitoring surveys (National Marine Fisheries Service 2019:440–443). BSPP fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screens. BSPP diversion restrictions described in Chapter 2 for protection of larval Longfin Smelt (January 1–March 31 of Dry and Critically Dry water years) and larval Delta Smelt (March 1–June 30 of Dry and Critically Dry water years) would also reduce the already low potential for negative effects on spring-run Chinook Salmon.

Sediment removal by suction dredge at BSPP would have the potential to entrain juvenile spring-run Chinook Salmon, although the numbers would be expected to be limited given low numbers of juvenile spring-run Chinook Salmon expected to occur in the area and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on spring-run Chinook Salmon given that Chinook Salmon do not associate with vegetation (Grimaldo et al. 2012) and abundance would be expected to be low in the vicinity.

6.4.4.8 Clifton Court Forebay Weed Management

As described previously in the discussion regarding the Skinner Fish Facility, relatively low numbers of spring-run Chinook Salmon would occur in CCF because of factors such as OMR management and the location of the facility in the south Delta. The Proposed Project includes summer and fall applications of herbicides and therefore would be expected to have limited potential for temporal overlap given species timing in the Delta (Tables 6A-5, 6A-6, 6A-7a, and 6A-7b in Appendix 6A). Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months. Mechanical removal of aquatic weeds in CCF would occur on an as needed basis and therefore may be more likely to temporally coincide with occurrence of spring-run Chinook Salmon, with occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual spring-run Chinook Salmon from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds. However, such positive or negative effects would only be on limited numbers of spring-run Chinook Salmon individuals.

6.4.4.9 Suisun Marsh Operations

Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement provides water quality benefits to spring-run Chinook Salmon habitat. This beneficial operation coincides with downstream migration of juvenile spring-run Chinook Salmon and upstream migration of adult spring-run Chinook Salmon. Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. The proportion of the total run utilizing this route is unknown. Operation of the SMSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators because the gates would not be continuously operated and boat lock passage is available when the gates are closed (National Marine Fisheries Service 2019:463). There could be delay to adult spring-run Chinook Salmon for a few hours to several days if SMSCG closure coincides with adult presence in the Delta. Spring-run Chinook Salmon are typically migrating through the estuary several months before spawning and an extended delay may affect their ability to access their natal spawning streams given general utilization of high stream flow conditions during the spring snowmelt to assist upstream migration (National Marine Fisheries Service 2019:462). Rapid upstream movement may be needed to take advantage of a short duration high stream flow event, particularly in Dry years when high flow events may be uncommon, so that if the destination of a pre-spawning adult spring-run Chinook Salmon is among the smaller tributaries of the Central Valley, delay could restrict access to areas with relatively short temporal accessibility (National Marine Fisheries Service 2019:462). Any negative effects would be consistent between the Proposed Project and Baseline Conditions scenarios. Spring-run Chinook Salmon would not be expected to occur in the Delta during additional operations of the SMSCG for the Delta Smelt summer and fall habitat actions.

6.4.4.10 Georgiana Slough Salmonid Migratory Barrier Operations

Effects to spring-run Chinook Salmon from GSSMB operations may be generally similar to those discussed above for winter-run Chinook Salmon in Section 6.4.3.10, "Georgiana Slough Migratory Barrier Operations", although there are timing differences in when juveniles and adults could encounter the BAFF. Thus, for example, only around 2.5% of adults could encounter the BAFF based on timing suggested by the National Marine Fisheries Service (2022:43) Biological Opinion for the Georgiana Slough Salmonid Migratory Barrier Project, and outmigration of some juveniles has greater potential to occur after operations of the BAFF end in April (Tables 6A-6, 6A-7a,b in Appendix 6A). Overall, although it is possible that there may be negative effects to spring-run Chinook Salmon from GSSMB operations, such effects would be limited, and the potential for positive effects related to keeping juveniles out of the interior Delta appears greater than the potential for negative effects.

6.4.4.11 Significance of Impacts on Spring-Run Chinook Salmon

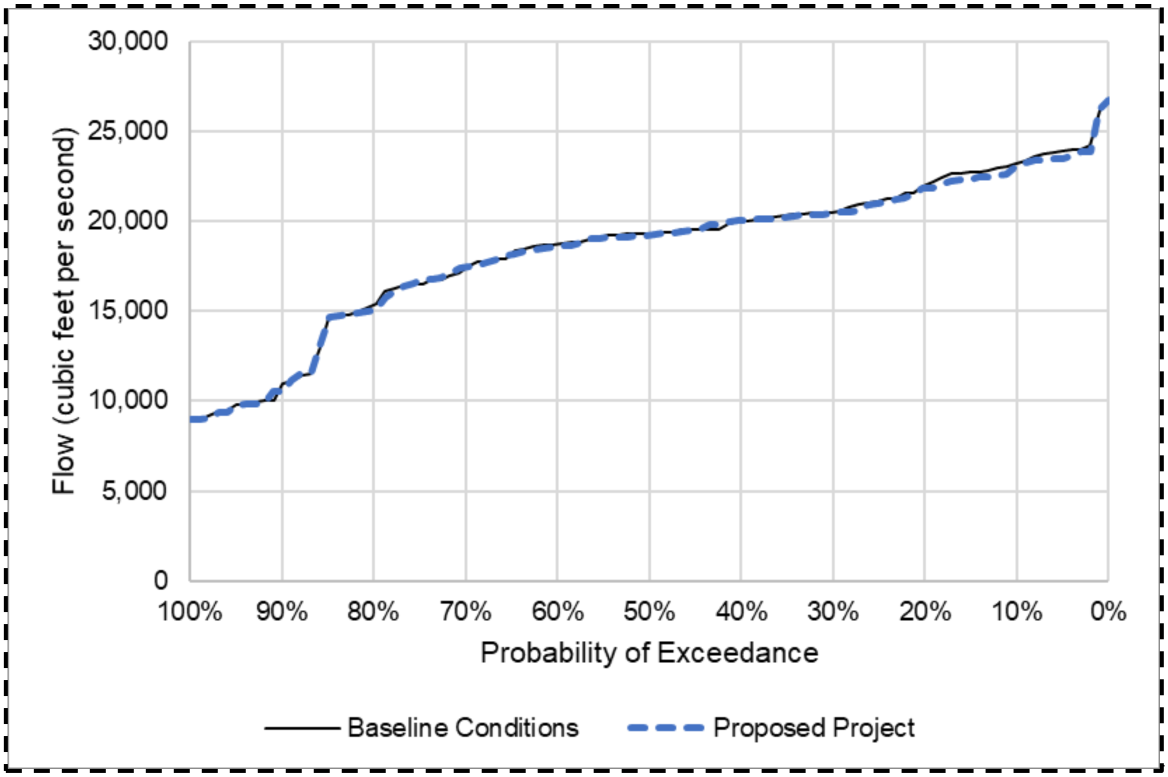
The Proposed Project includes various measures that would limit the potential for significant impacts on spring-run Chinook Salmon, including but not limited to entrainment protection, spring Delta outflow, and other measures such as Skinner Fish Facility improvements (see detailed descriptions in Chapter 2). There is greater potential for negative effects on spring-run Chinook Salmon under the Proposed Project relative to Baseline Conditions as a result of spring (April/May) entrainment, although the analysis above showed that the number of genetically identified individuals is likely low and also indicated that this would have little effect on through-Delta survival, which would be similar under the Proposed Project and Baseline Conditions. There may be positive effects from greater Delta inflow (spring Delta outflow) in Dry years in May under the Proposed Project. Based on the analysis presented above (Section 6.4.4.1, "Delta SWP Facility Operations;" Section 6.4.4.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.4.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.4.4, "Delta Smelt Supplementation;" Section 6.4.4.5, "Water Transfers;" Section 6.4.4.6, "Agricultural Barriers;" Section 6.4.4.7, "Barker Slough Pumping Plant;" Section 6.4.4.8, "Clifton Court Forebay Weed Management;" Section 6.4.4.9, "Suisun Marsh Operations;" and Section 6.4.4.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on spring-run Chinook Salmon would be less than significant. No mitigation is required.

6.4.5 Fall-Run and Late-Fall-Run Chinook Salmon

6.4.5.1 Delta SWP Facility Operations

Immigrating Adults

CalSim modeling suggests that there generally would be little difference between Baseline Conditions and Proposed Project scenarios in flow entering the Delta in the Sacramento River at Freeport during the main periods of upstream migration of adult fall-run and late-fall-run Chinook Salmon (Figures 6-102, 6-103, 6-104, and 6-105; for November–June, see Figures 6-56, 6-57, 6-58, 6-59, 6-60, 6-61, 6-62, and 6-63 in Section 6.4.3, "Winter-Run Chinook Salmon"). October Freeport flow would be somewhat greater under the Proposed Project than Baseline Conditions (Figure 6-105). Evidence from the Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon released upstream of the Delta were very low (<1 percent) during the period from 1979 through 2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low. This, coupled with the similarity in flow entering the Delta between Baseline Conditions and the Proposed Project scenarios, suggests that there would be little potential for differences in rates of straying of adult fall-run and late-fall-run Chinook Salmon from the Sacramento River Basin between the Baseline Conditions and Proposed Project scenarios.



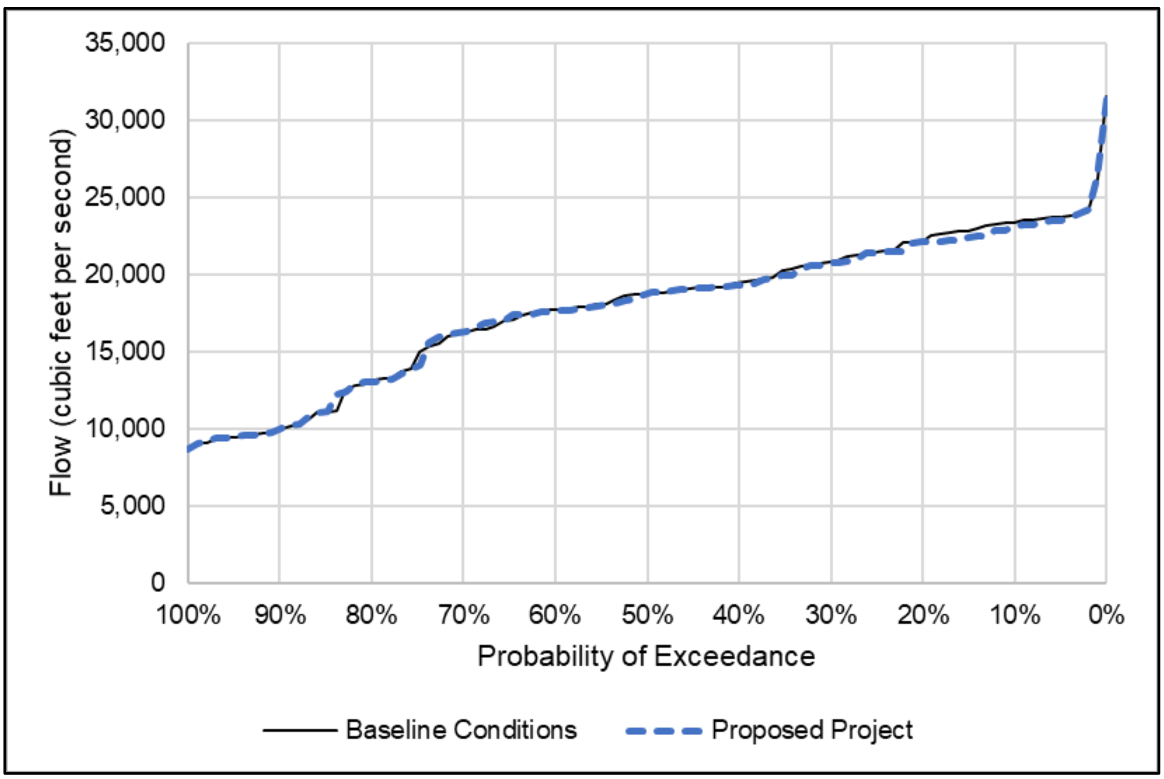


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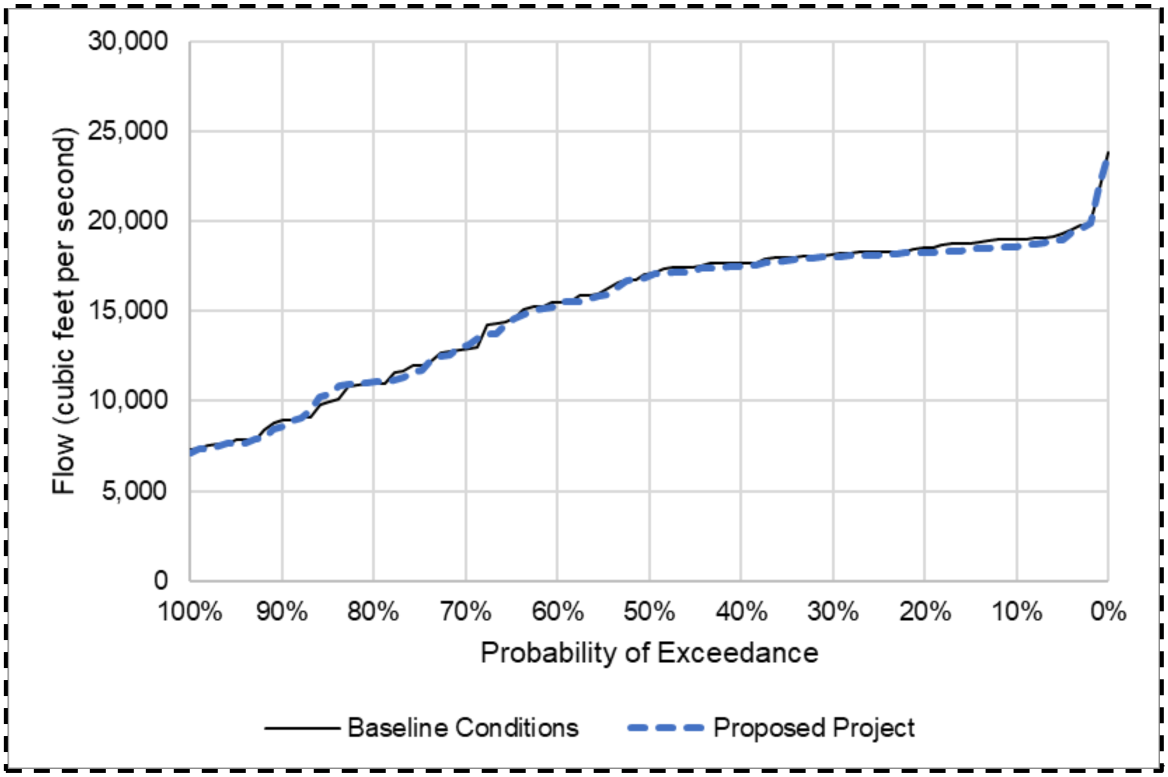
Figure 6-102. Mean Modeled Sacramento River Flow at Freeport, July



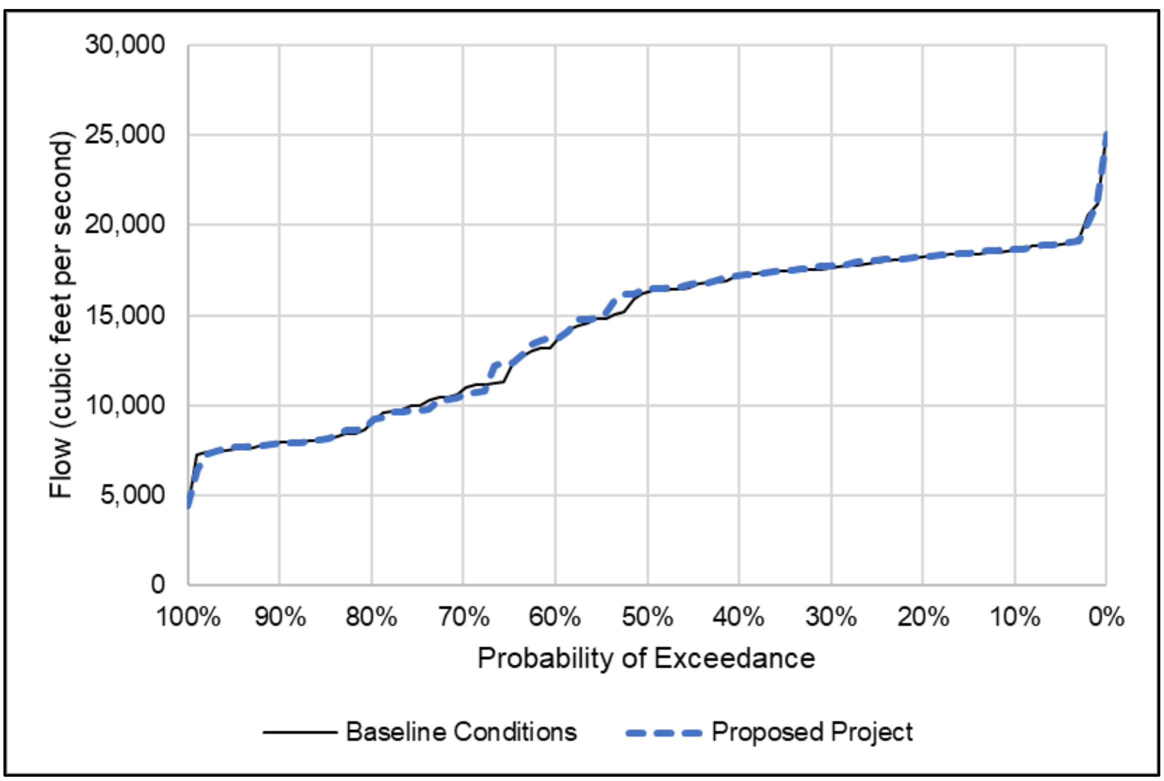


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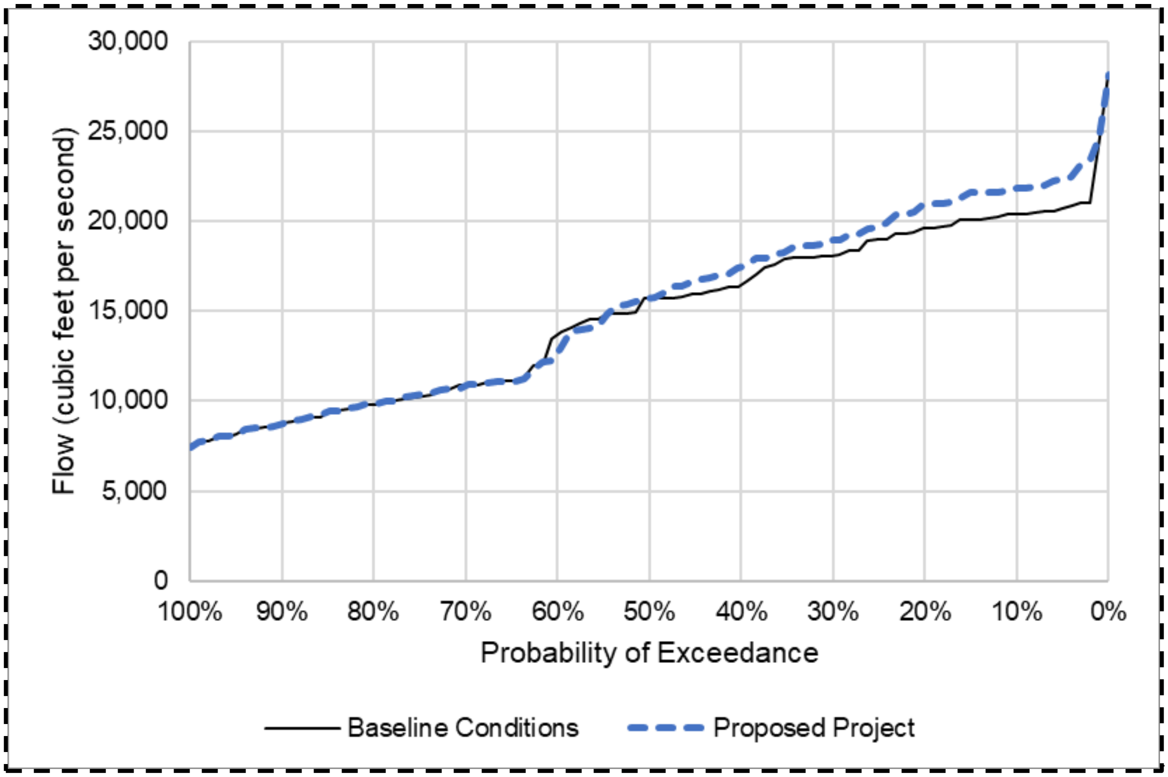
Figure 6-103. Mean Modeled Sacramento River Flow at Freeport, August



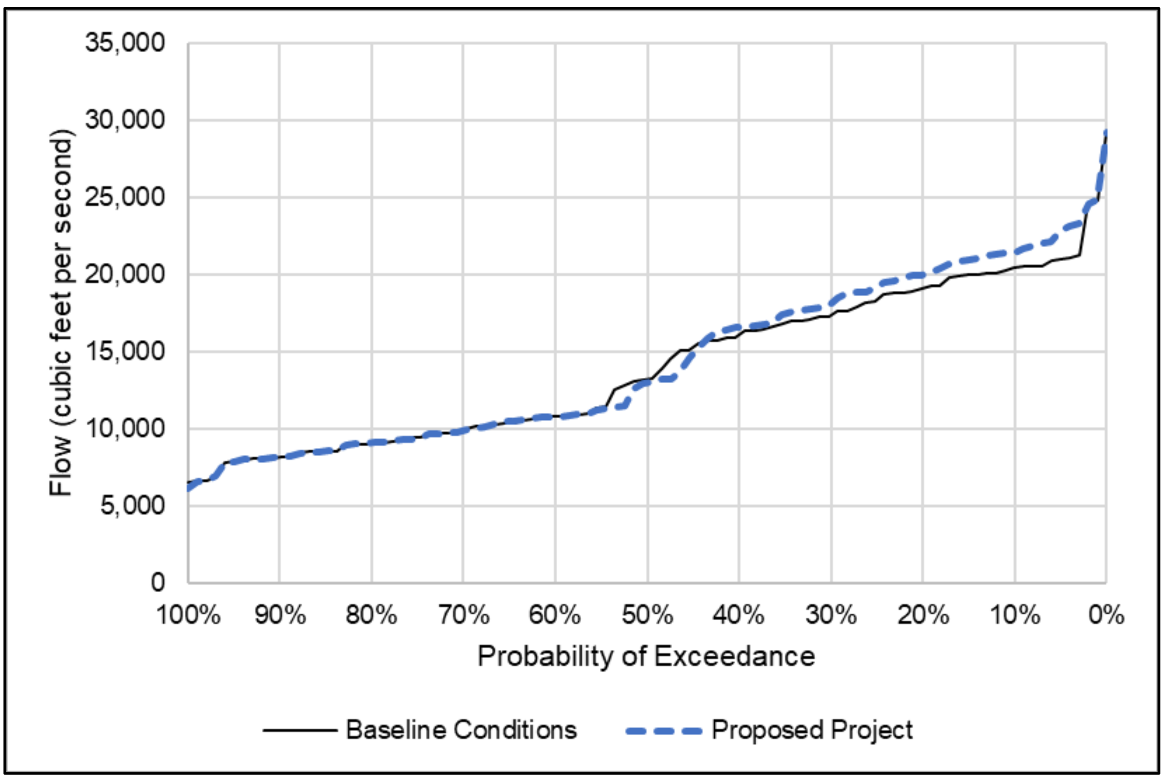


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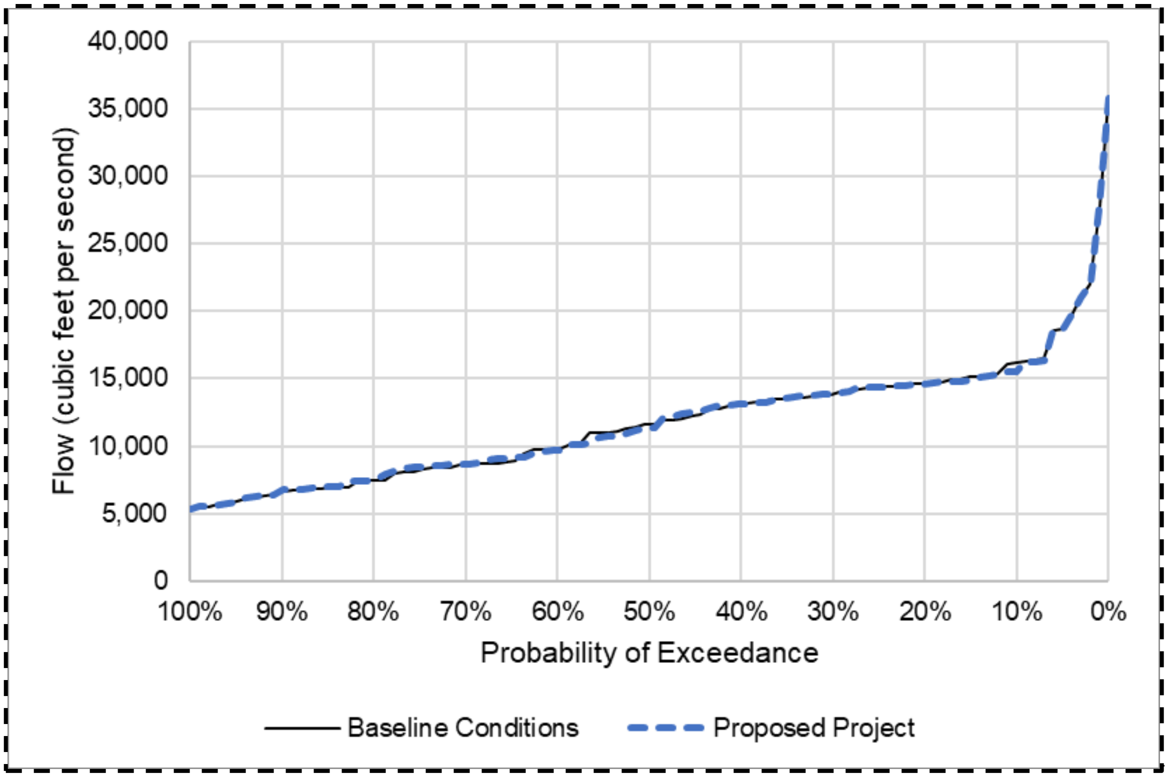
Figure 6-104. Mean Modeled Sacramento River Flow at Freeport, September



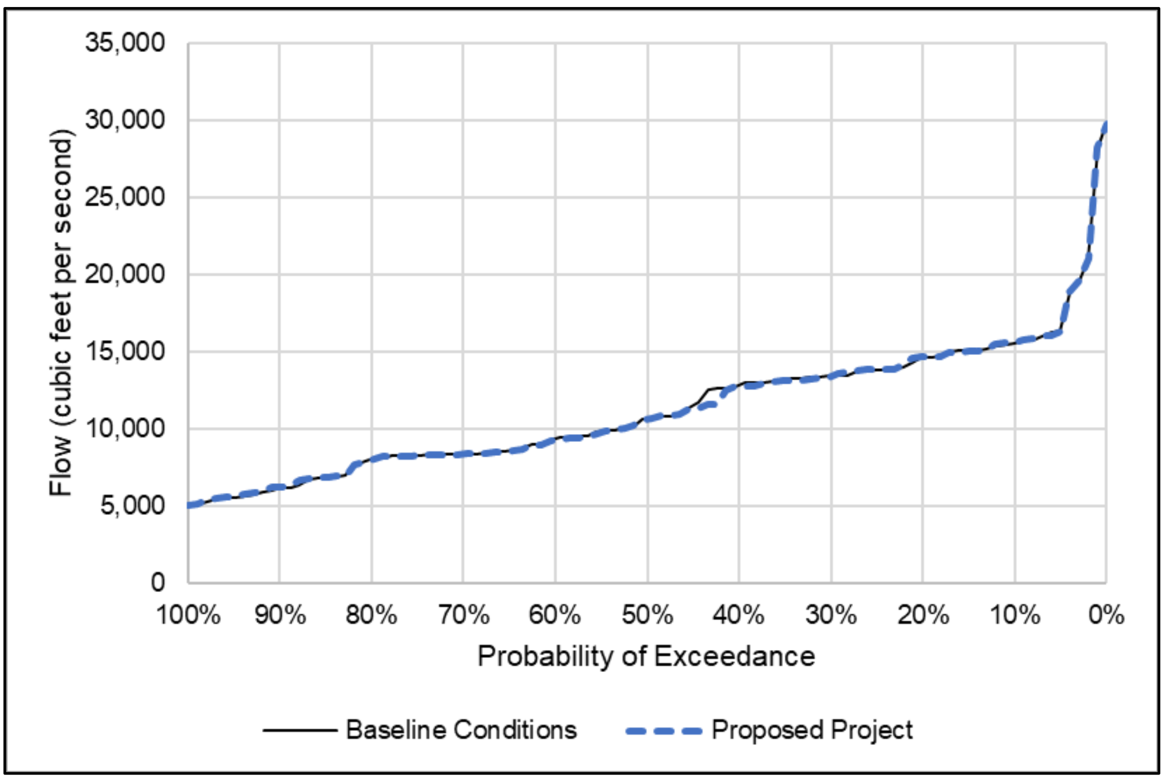


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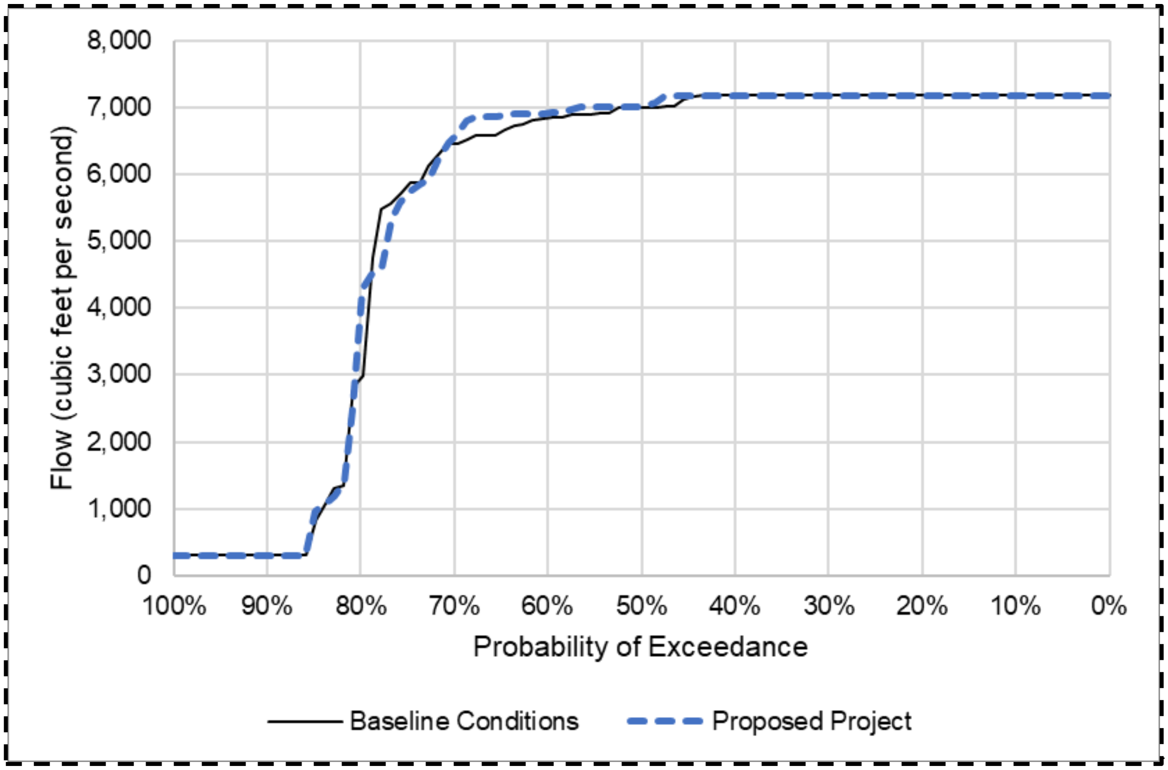
Figure 6-105. Mean Modeled Sacramento River Flow at Freeport, October

In addition to juvenile fall-run and late-fall-run Chinook Salmon discussed in "Outmigrating Juveniles," adult Chinook Salmon are also subject to entrainment at the south Delta export facilities (California Department of Fish and Wildlife 2020b, Attachment 8:60–63). For example, it is estimated that 466 adult Chinook Salmon[22] were salvaged during 1993–2018 (i.e., an annual mean of ~18 fish), all during the months of September through May, with highest salvage in November, December, and March, which overlaps with adult fall-run and late-fall-run Chinook Salmon occurrence in the Delta (see Tables 6A-7 and 6A-8 in Appendix 6A). SWP south Delta exports under the Proposed Project generally would be similar to Baseline Conditions, except for greater exports under the Proposed Project in September, April, and May (Figures 6-106, 6-107, 6-108, and 6-109; for November–June, see Figures 6-64, 6-65, 6-66, 6-67, 6-68, 6-69, 6-70, and 6-71 in Section 6.4.3). Although this may indicate greater entrainment risk for adult fall-run and late-fall-run Chinook Salmon under the Proposed Project, any differences in entrainment between the Proposed Project and Baseline Conditions would be limited in terms of the numbers of fish involved and the population-level effect, given the low numbers of fish salvaged historically relative to population sizes numbering in the tens or hundreds of thousands (see Figures 6A-12, 6A-13, 6A-14, and 6A-15 in Appendix 6A).

[22] Salvaged Chinook Salmon are classified as adults when more than 300-mm fork length.



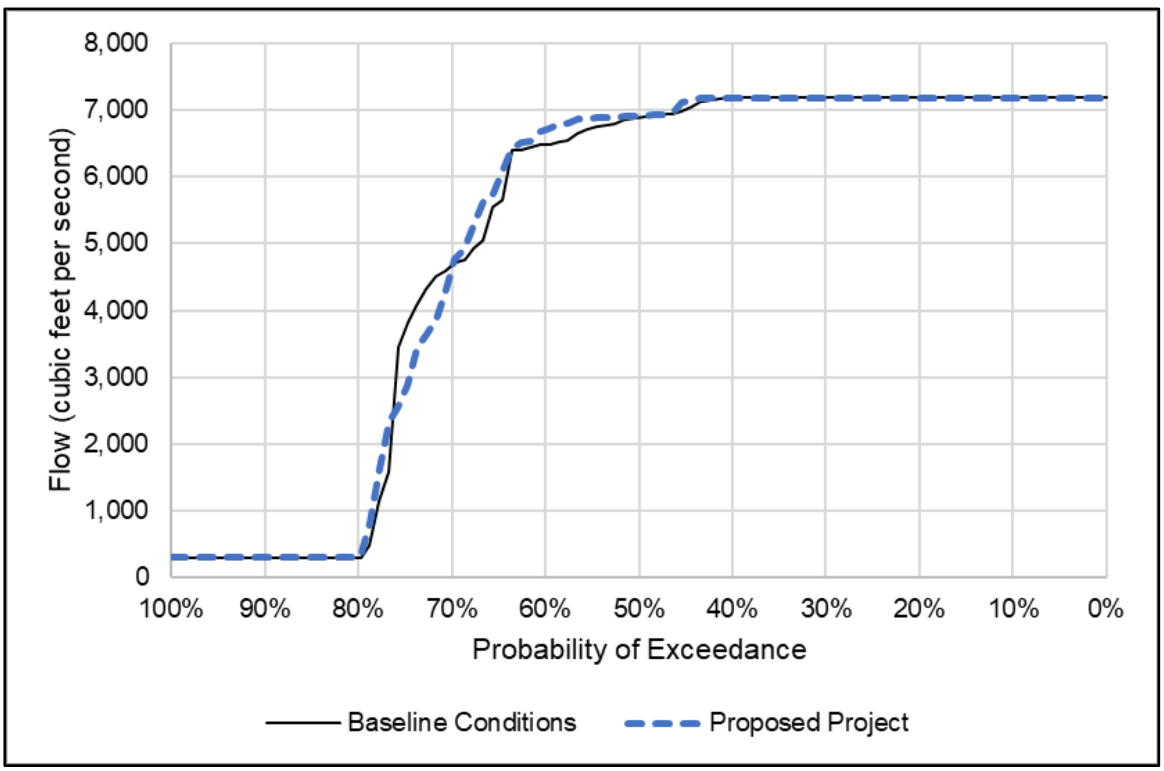


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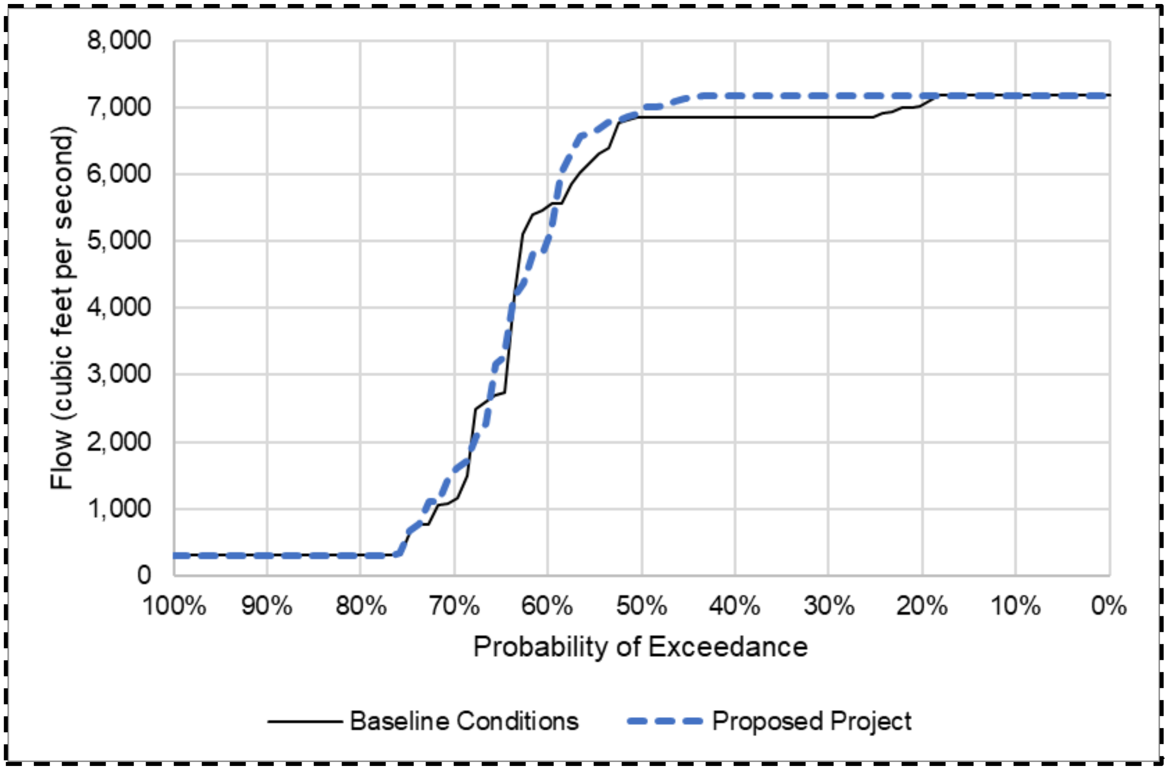
Figure 6-106. Mean Modeled SWP South Delta Exports, July



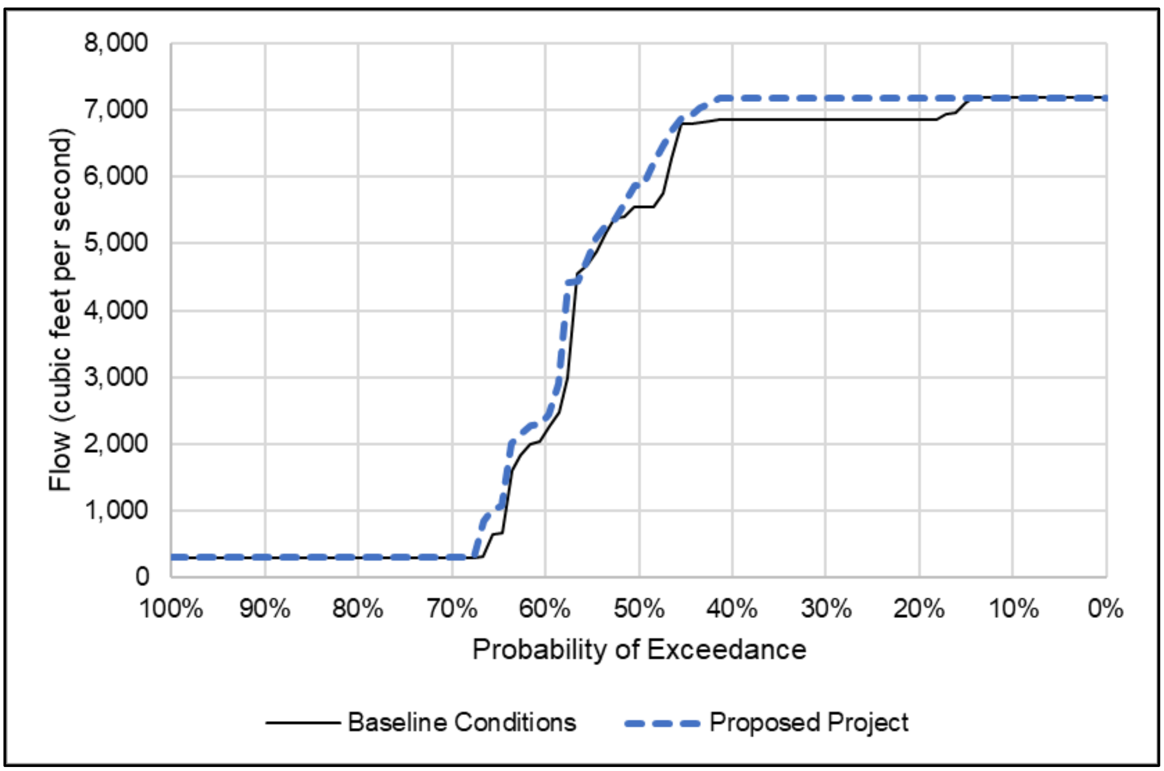


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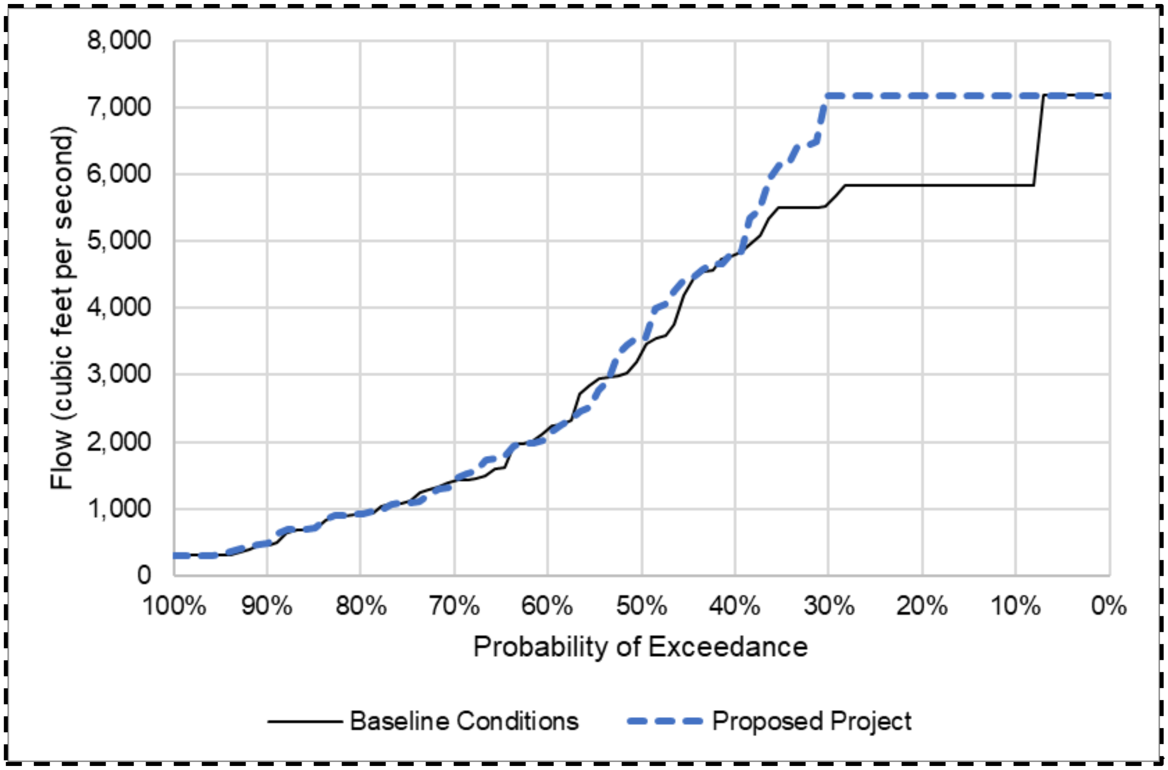
Figure 6-107. Mean Modeled SWP South Delta Exports, August



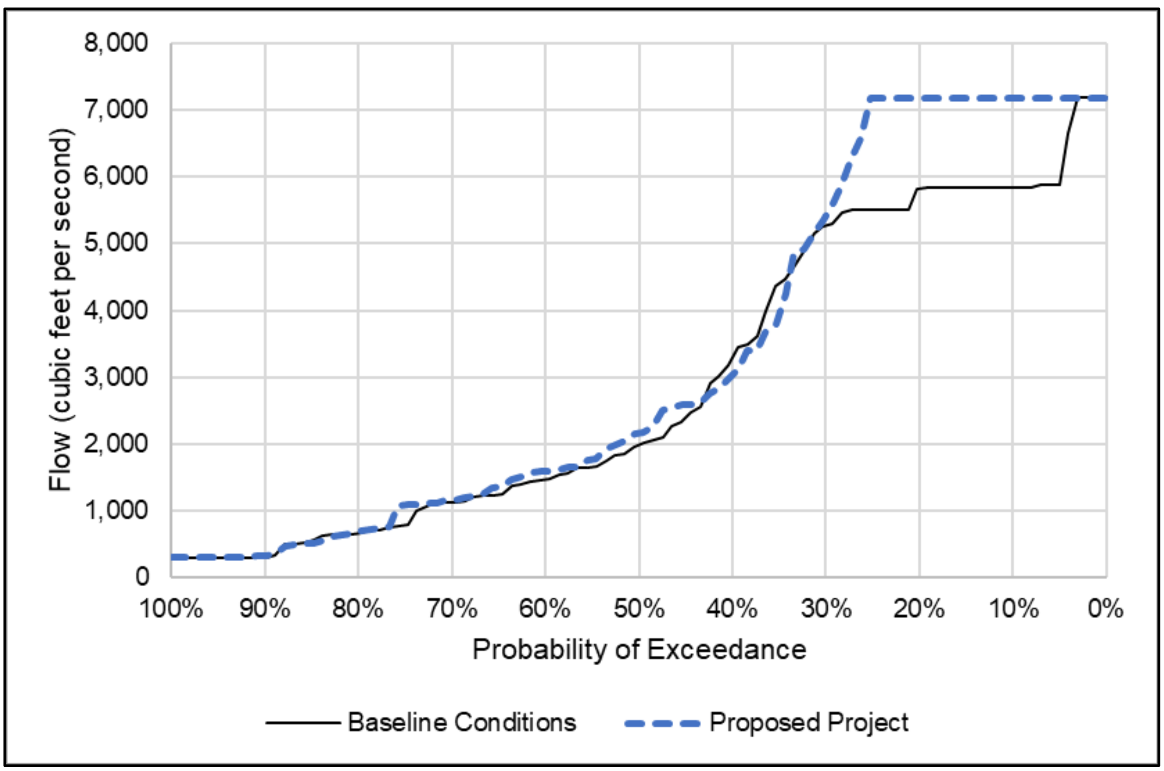


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Figure 6-108. Mean Modeled SWP South Delta Exports, September

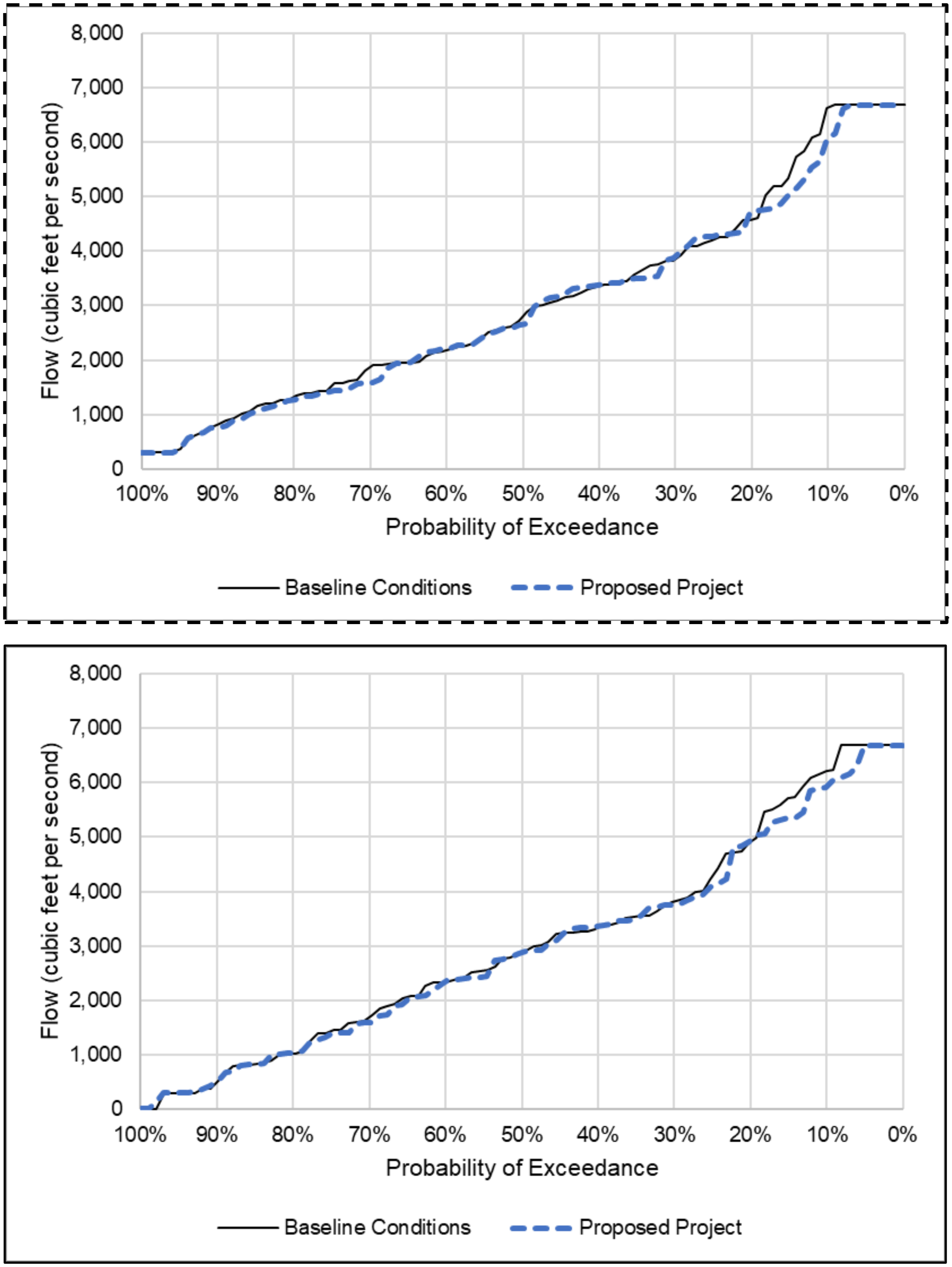

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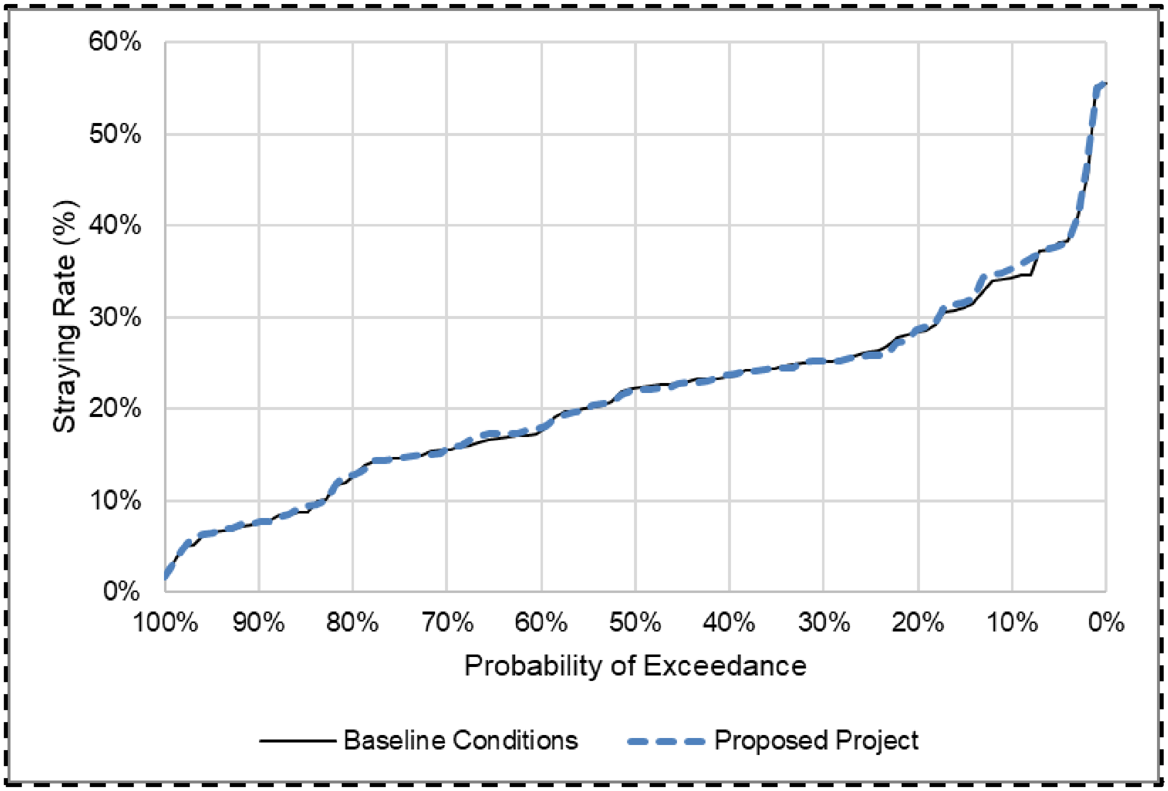
Figure 6-109. Mean Modeled SWP South Delta Exports, October

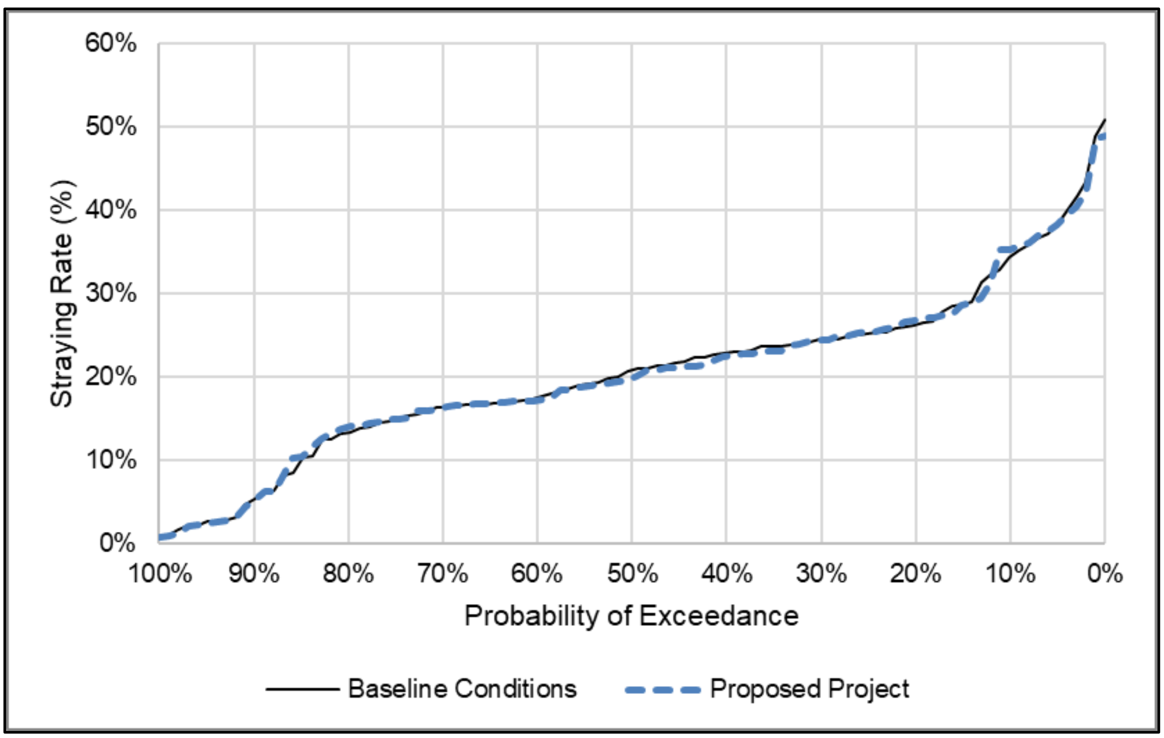
The straying rate of adult fall-run Chinook Salmon to the San Joaquin River Basin could be affected by south Delta water operations (Marston et al. 2012). As described further in Appendix 6B, Section 6B.14, "San Joaquin River Adult Fall-Run Chinook Salmon Straying Analysis Based on Marston et al. (2012)," statistical equations developed by Marston et al. (2012) were used to estimate straying rate as a function of October/November San Joaquin River flows and south Delta exports. This analysis suggested that the potential for straying would be similar under the Proposed Project and Baseline Conditions (Table ~~6-70~~ 6-72; Figure 6-110), albeit with appreciable uncertainty because it is unclear whether San Joaquin River pulse flows, south Delta exports, or both are the main driver of straying (Marston et al. 2012).

Table ~~6-70~~ 6-72. Mean Predicted San Joaquin River Basin Fall-Run Chinook Salmon Adult Straying to the Sacramento River Basin under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~26%~~ 24%	~~26% (0.0%)~~ 24% (-1.0%)
Above Normal	~~20%~~ 21%	20% ~~(0.0%)~~ (-3.2%)
Below Normal	~~21%~~ 20%	~~21% (1.0%)~~ 19% (-2.3%)
Dry	22%	22% ~~(1.2%)~~ (3.3%)
Critically Dry	13%	13% ~~(0.3%)~~ (-1.1%)

Note: Table only includes mean responses and does not consider model uncertainty





Note: Figure only includes mean responses and does not consider model uncertainty

Figure 6-110. Exceedance Plot of San Joaquin River Basin Fall-Run Chinook Salmon Adult Straying to the Sacramento River Basin under the Proposed Project and Baseline Conditions Modeling Scenarios, for the 1922–2021 Modeled Period

Potential effects related to straying of adult Mokelumne River fall-run Chinook Salmon to the Sacramento River when the DCC is open during October and November (Setka 2018) were also evaluated. The DCC, as with all CVP facilities, would continue to be operated consistent with applicable laws and contractual obligations. The modeling results for the number of days that the DCC is open showed that the Proposed Project had similar or marginally higher mean number of days of DCC open compared to Baseline Conditions (Table ~~6-71~~ 6-73; Figures 6-111 and 6-112), suggesting similar or marginally higher straying potential under the Proposed Project. However, the modeling results do not account for DCC closure in association with Mokelumne River pulse flows, as required under the Reinitiation of Consultation proposed action (U.S. Bureau of Reclamation 2019:3-37), with implementation as illustrated in October 2021 (Salmon Monitoring Team 2021). Overall, the Proposed Project would not have a significant effect on adult Mokelumne River fall-run Chinook Salmon straying.[23]

Table ~~6-71~~ 6-73. Mean Number of Days of Delta Cross Channel Opening in October and November under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Month	Water Year Type	Baseline Conditions	Proposed Project
October	Wet	~~19~~ 21	~~19 (0%)~~ 22 (1%)
October	Above Normal	21	21 ~~(0%)~~ (1%)
October	Below Normal	~~22~~ 23	~~23 (7%)~~ 22 (0%)
October	Dry	~~20~~ 25	~~21~~ 27 (6%)
October	Critically Dry	~~15~~ 19	~~15 (-1%)~~ 19 (0%)
November	Wet	14	14 (0%)
November	Above Normal	~~9~~ 15	~~10 (17%)~~ 15 (1%)
November	Below Normal	~~16~~ 18	~~16~~ 18 (0%)
November	Dry	17	17 ~~(0%)~~ (-1%)
November	Critically Dry	~~10~~ 15	~~13 (25%)~~ 15 (0%)

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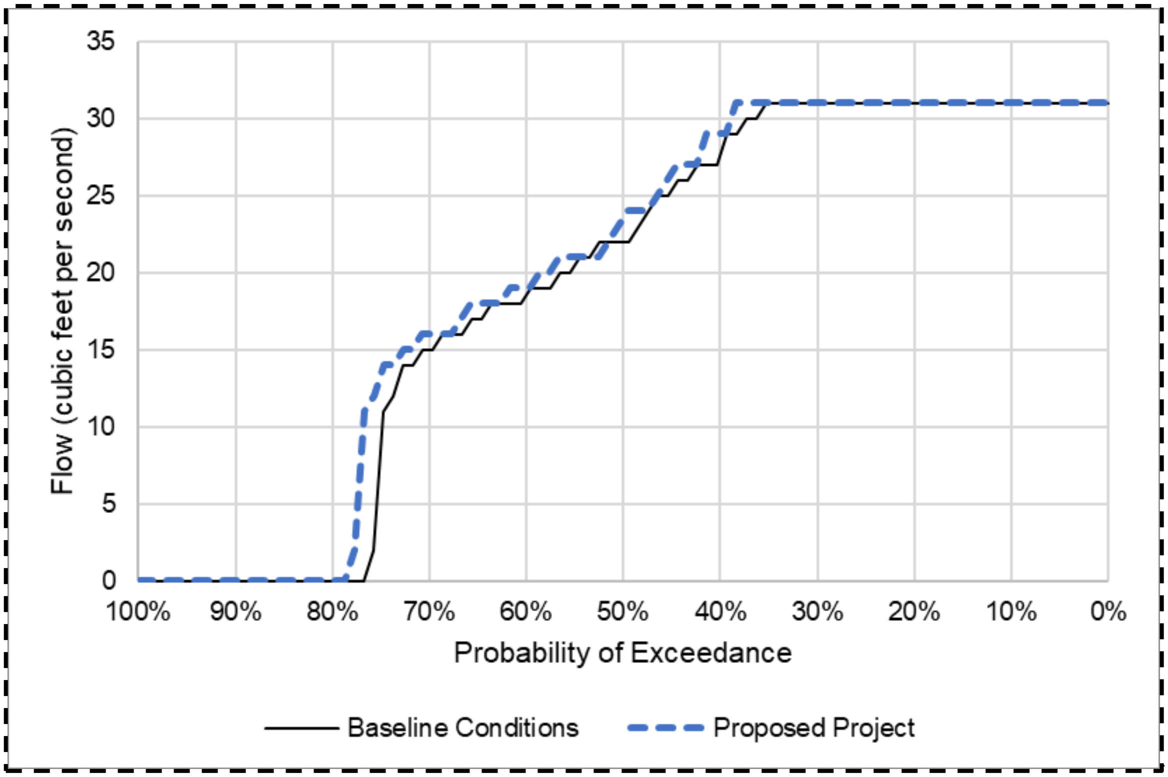
[23] As discussed further related to cumulative effects, as part of the ongoing consultation on CVP/SWP long-term operations, from October 1 through November 30, Reclamation proposes to close the DCC gates in addition to the requirements in D-1641 to enhance adult fall-run Chinook Salmon passage into the Mokelumne River.



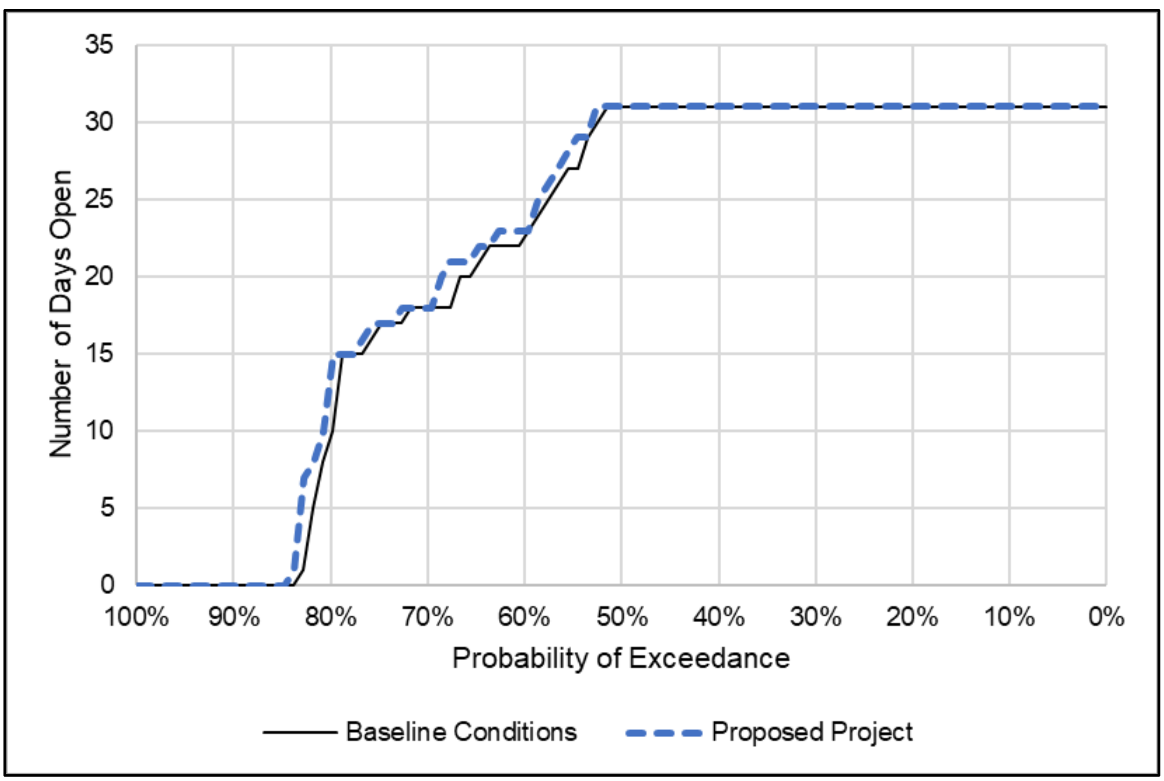


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Figure 6-111. Number of Days of Delta Cross Channel Opening, October

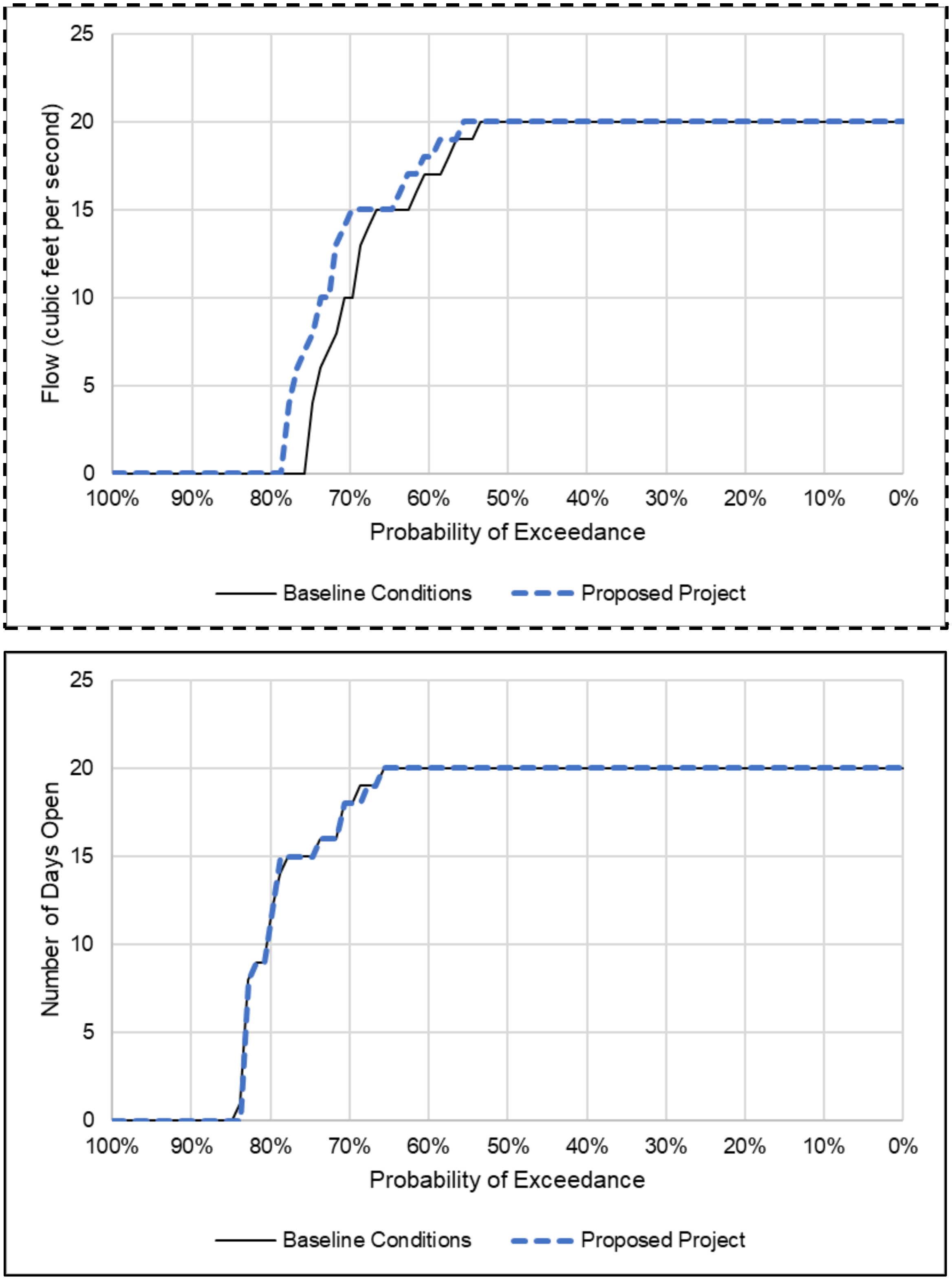

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Figure 6-112. Number of Days of Delta Cross Channel Opening, November

Outmigrating Juveniles

Entrainment

As discussed for winter-run Chinook Salmon, the salvage-density method (see Appendix 6B, Section 6B.1) was used to provide perspective on potential differences in entrainment loss of fall-run and late-fall-run Chinook Salmon juveniles between the Baseline Conditions and Proposed Project scenarios. As described for winter-run Chinook Salmon, the estimates of entrainment loss obtained from the salvage-density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim 3-modeled differences in SWP exports between Baseline Conditions and Proposed Project scenarios; the results are basically a description of differences in export flows weighted by historical monthly loss density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained, but these data are more a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected.

The salvage-density method indicated that SWP exports during the main period of juvenile fall-run Chinook Salmon loss at the SWP south Delta export facility would be appreciably greater under the Proposed Project relative to Baseline Conditions, resulting in higher numbers of fish under the Proposed Project relative to Baseline Conditions (Table ~~6-72~~ 6-74). This reflects greater SWP exports under the Proposed Project during April and in particular May relative to Baseline Conditions and indicates the potential for greater entrainment of juvenile fall-run Chinook Salmon under the Proposed Project relative to Baseline Conditions. Entrainment risk for fall-run Chinook Salmon juveniles would be limited by ancillary OMR flow management measures that would be undertaken for listed species (e.g., loss thresholds for winter-run and spring-run Chinook Salmon, and proposed larval and juvenile Delta Smelt and Longfin Smelt entrainment protections). The salvage-density method suggested that entrainment risk for late-fall-run Chinook Salmon juveniles would be similar between the Proposed Project and Baseline Conditions (Table ~~6-73~~ 6-75).

Table ~~6-72~~ 6-74. Mean Number of Fall-Run Chinook Salmon Juveniles Lost (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~22,328~~ 25,108	~~26,594 (19%)~~ 27,662 (10%)
Above Normal	N/A	~~(20%)~~ (23%)
Below Normal	~~3,673~~ 4,393	~~6,869 (87%)~~ 7,842 (79%)
Dry	~~4,054~~ 4,300	~~4,923 (21%)~~ 4,774 (11%)
Critically Dry	~~541~~ 553	~~709 (31%)~~ 680 (23%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-3 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table ~~6-73~~ 6-75 . Mean Number of Late-Fall-Run Chinook Salmon Juveniles Lost (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~1,411~~ 1,451	~~1,396~~ 1,442 (-1%)
Above Normal	N/A	(-1%)
Below Normal	~~412~~ 409	~~399 (-3%)~~ 385 (-6%)
Dry	~~782~~ 714	~~741 (-5%)~~ 685 (-4%)
Critically Dry	~~477~~ 455	~~462 (-3%)~~ 445 (-2%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-4 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

The above discussion of entrainment risk to fall-run Chinook Salmon juveniles based on the salvage-density method is general and not specific to consideration of the populations' main basin of origin (Sacramento, San Joaquin, or Mokelumne). Further discussion of factors relevant to entrainment risk and resulting outcomes in terms of through-Delta survival for the various populations are provided below in the discussion of Delta hydrodynamics/junction routing and through-Delta survival analyses based on the DPM, STARS model, ECO-PTM, and San Joaquin River-Origin Fall-run Chinook Salmon Structured Decision Model. For Mokelumne River Basin juvenile fall-run, the main effect of concern is related to entrainment risk caused by March–June south Delta exports (Workman 2018:14). California Department of Water Resources (2020b:4-229–4-230) estimated that historical (1992–2006) population-level losses to south Delta entrainment were small, indicating that April/May increases in SWP south Delta exports under the Proposed Project (see, for example, Figures 4.2.3-4-13 and 4.2.3-4-14 in Appendix 4B, Attachment 2) would not be expected to substantially affect Mokelumne River fall-run Chinook Salmon. This is supported by further discussion of hydrodynamic indicators provided below.

Delta Hydrodynamic Assessment and Junction Routing Analysis

As previously described for spring- and winter-run Chinook Salmon, channel velocity and junction routing generally would be similar under the Proposed Project and Baseline Conditions, indicating that there would be little difference between scenarios in potential for effects on juvenile fall-run and late-fall-run Chinook Salmon migrating through the Delta. The main migration period for fall-run Chinook Salmon juveniles overlaps the April/May period (see Appendix 6A, Tables 6A-8a, 6A-8b, and 6A-8e) that tends to have greater SWP south Delta exports under the Proposed Project than Baseline Conditions and a proportion of juvenile fall-run Chinook Salmon emigrate from the San Joaquin River Basin, both factors that could contribute to differences in the potential for through-Delta survival effects under the Proposed Project relative to Baseline Conditions. However, as discussed for spring-run Chinook Salmon, the DSM2 hydrodynamic modeling indicated limited differences between scenarios. For example, in April and May at the Head of Old River, the mean proportion of flow entering Old River under the Proposed Project was no more than 1.3 percent greater than Baseline Conditions (Table ~~6-35~~ 6-36) and velocity in Old River near Head of Old River was very similar (Figures 6-95 and 6-96); only very close to the south Delta export facilities were differences in velocity more apparent (Figures 6-97 and 6-98).

For Mokelumne River fall-run Chinook Salmon, hydrodynamic conditions and junction flow between where the forks of the Mokelumne River meet the San Joaquin River and the confluence of the Sacramento River and San Joaquin River are of particular relevance. DSM2-HYDRO results indicate very little difference in April and May channel velocity between the Proposed Project and Baseline Conditions in the San Joaquin River near the Mokelumne River and in the San Joaquin River near Jersey Point (see Figures 6B-201, 6B-202, 6B-225, and 6B-226 in Appendix 6B). There would also be little difference in mean junction flow entering the south Delta from the San Joaquin River during April and May at the mouth of Middle River (0.1–2.6 percent greater under the Proposed Project), mouth of Old River (0.2–3.1 percent greater under the Proposed Project), Fishermans Cut (-3.0 percent less to 1.0 percent greater under the Proposed Project), False River (0–0.6 percent greater under the Proposed Project), and Jersey Point (0–0.3 percent greater under the Proposed Project) (Table 6-35 6-36). Overall, these results indicate minimal differences in through-Delta survival indicators between the Proposed Project and Baseline Conditions for Mokelumne River fall-run Chinook Salmon juveniles.

Additional velocity and junction flow results are presented in Appendix 6B.

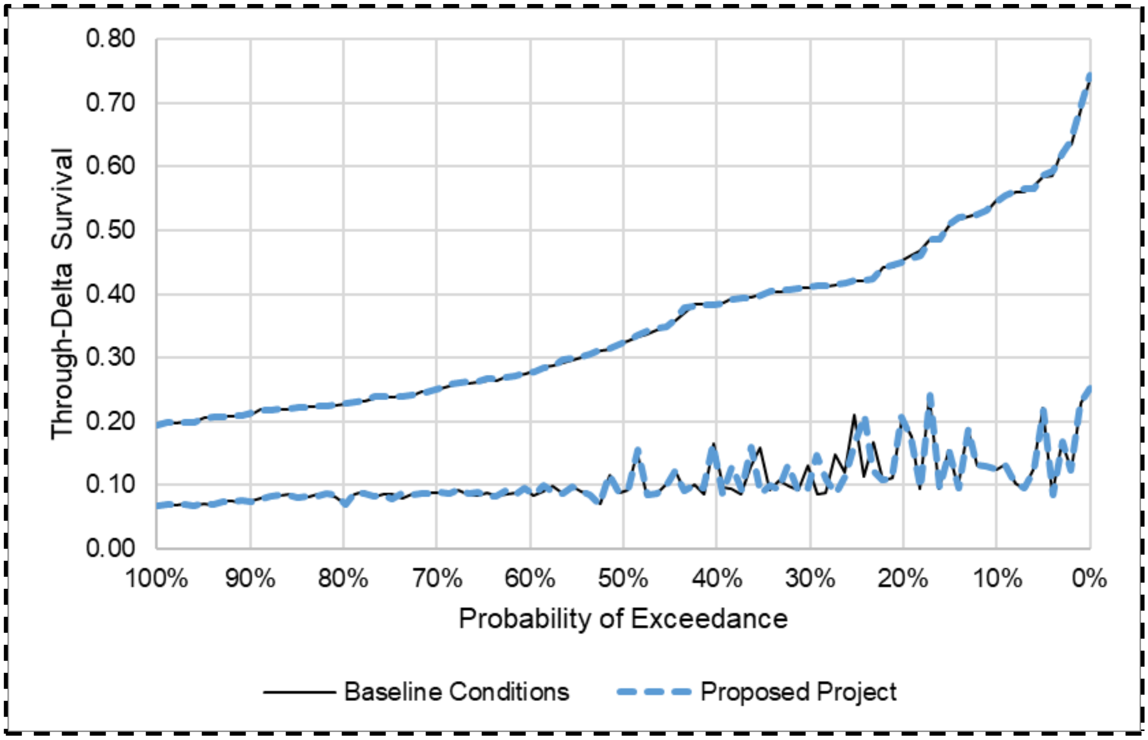
Delta Passage Model

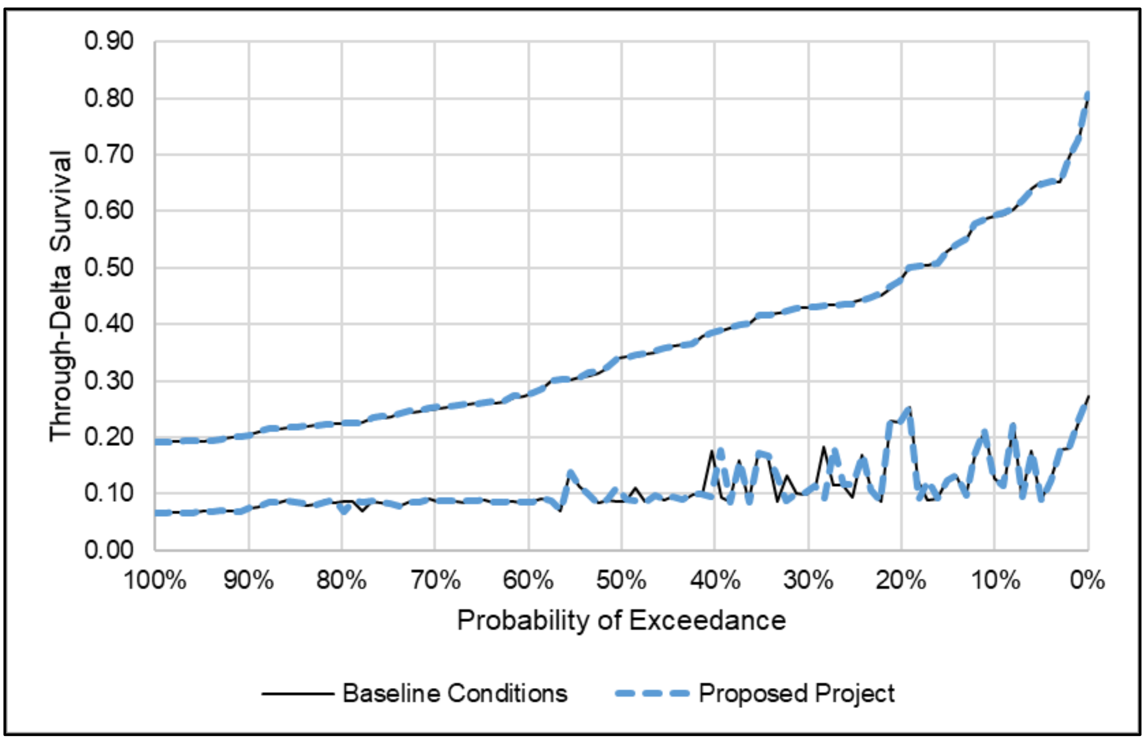
Background on the DPM is provided in the analysis for winter-run Chinook Salmon, with detailed methods provided in Appendix 6B, Section 6B.4. The results of the DPM suggested that through-Delta survival of fall-run and late-fall-run Chinook Salmon smolts from the Sacramento River Basin would be similar under the Proposed Project and Baseline Conditions, with relative differences in mean survival by water year type all less than 1 percent and largely overlapping predictions across all years (Table 6-74 6-76, Figure 6-113, Figure 6-114, Table 6-75 6-77, Figure 6-115, Figure 6-116).

Table 6-74 6-76. Delta Passage Model: Mean Fall-Run Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project
Wet	0.28 0.30	0.28 (-0.3%) 0.30 (-0.2%)	0.28 0.30	0.28 (-0.3%) 0.30 (-0.1%)
Above Normal	0.23	0.23 (-0.1%) 0.24 (0.2%)	0.23 0.24	0.23 (-0.1%) 0.24 (0.2%)
Below Normal	0.18 0.19	0.18 (-0.1%) 0.19 (0.1%)	0.18 0.19	0.18 (-0.1%) 0.19 (0.1%)
Dry	0.16	0.16 (0.3%) (0.7%)	0.16	0.16 (0.3%) (0.6%)
Critically Dry	0.13	0.13 (-0.2%) (-0.1%)	0.13	0.13 (-0.2%) (-0.1%)

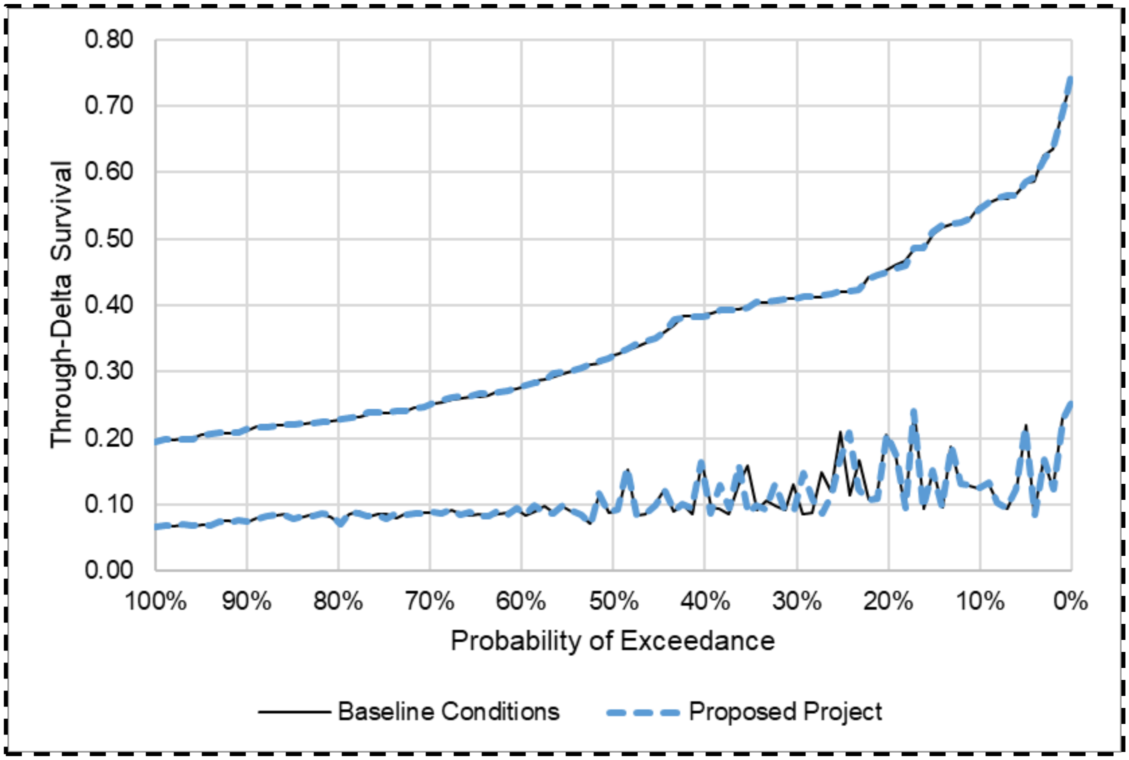
Note: Table only includes mean responses and does not consider model uncertainty. 95% predictions are shown in Figures 6-113 and 6-114.

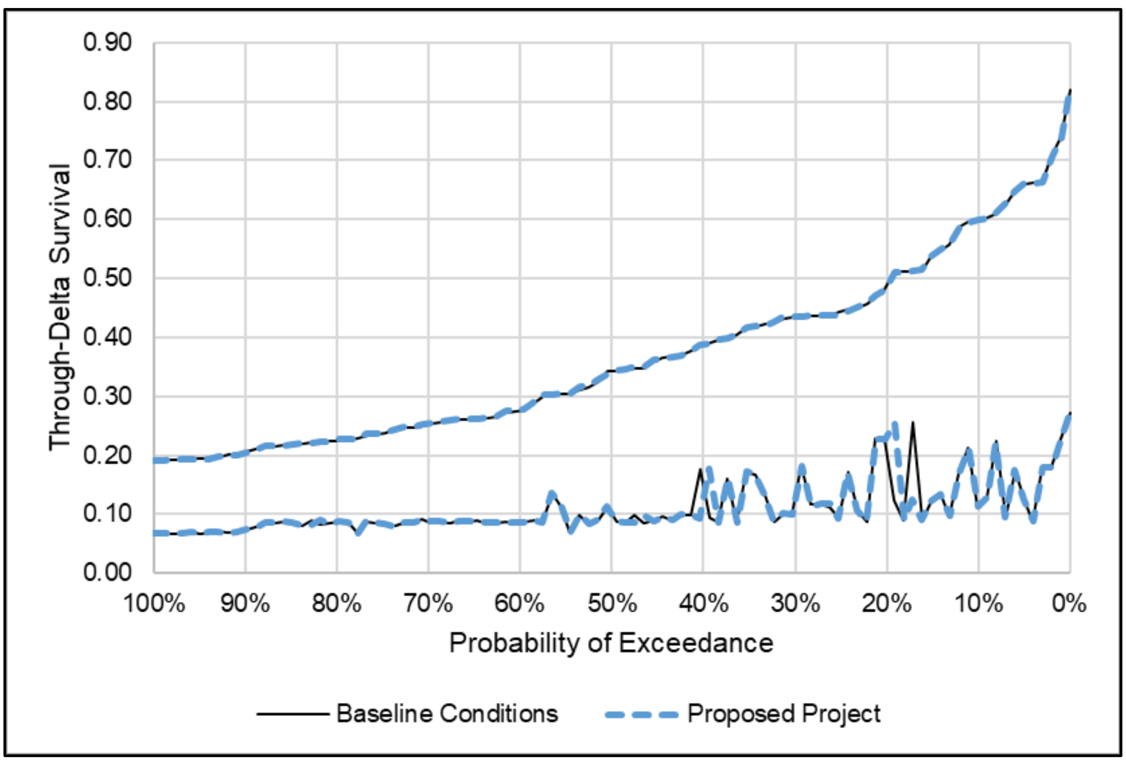




Note: Data are sorted by 97.5th percentile of predictions, with 2.5th and 97.5th percentiles shown, representing middle 95% of predictions.

Figure 6-113. Delta Passage Model: Exceedance Plot of Fall-Run Chinook Salmon Smolt Through-Delta Survival 95% Predictions, for the 1922–2021 Modeled Period, Assuming BioAcoustic Fish Fence Reducing Entry into Georgiana Slough by 50%





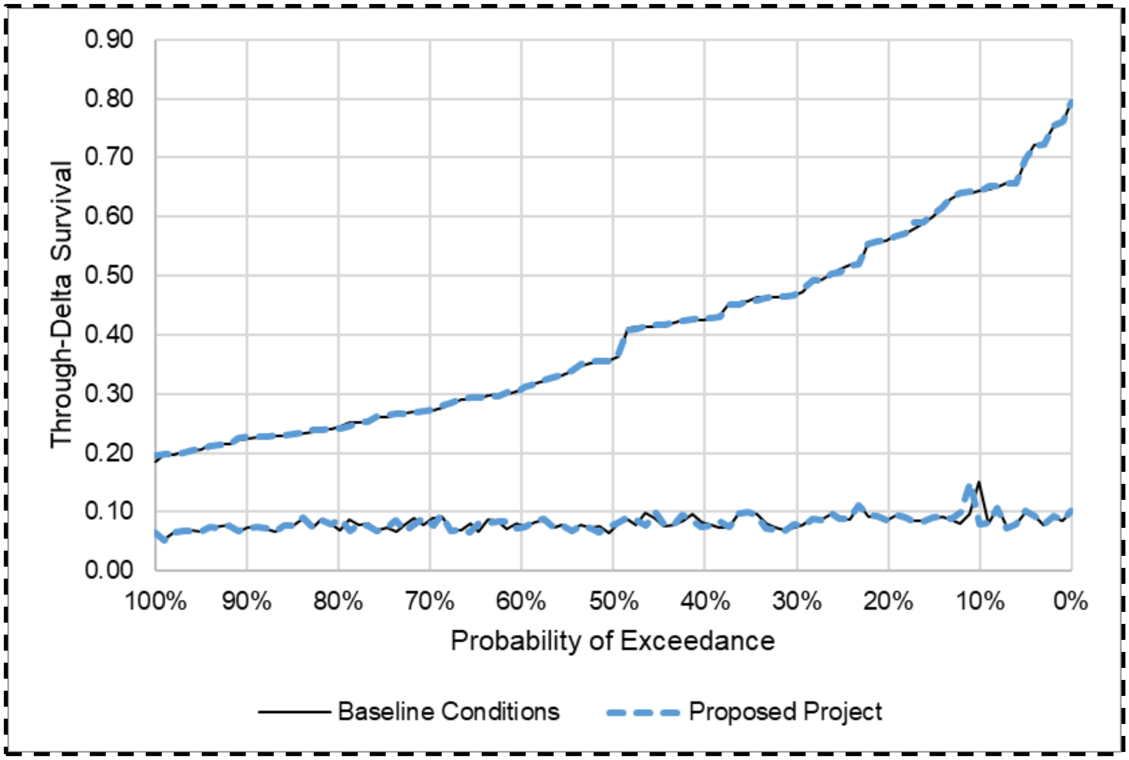
Note: Data are sorted by 97.5th percentile of predictions, with 2.5th and 97.5th percentiles shown, representing middle 95% of predictions.

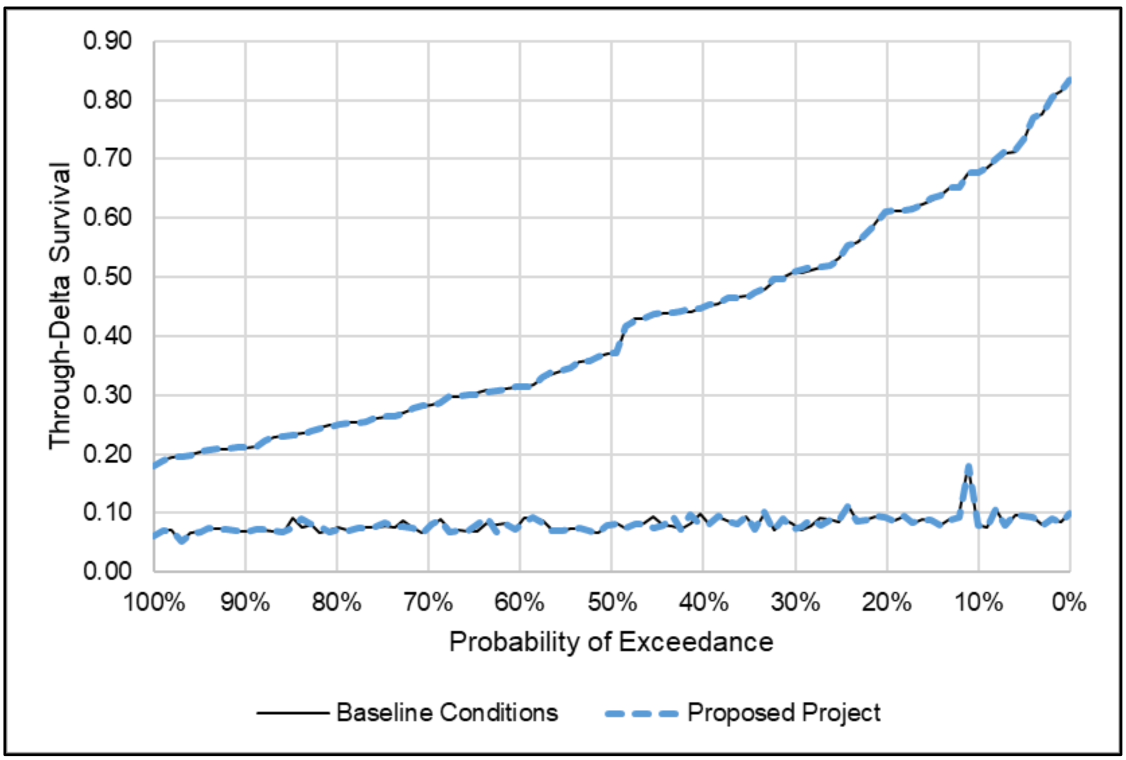
Figure 6-114. Delta Passage Model: Exceedance Plot of Fall-Run Chinook Salmon Smolt Through-Delta Survival 95% Predictions, for the 1922–2021 Modeled Period, Assuming BioAcoustic Fish Fence Reducing Entry into Georgiana Slough by 67%

Table ~~6-75~~ 6-77 . Delta Passage Model: Mean Late Fall-Run Chinook Salmon Smolt Survival Through the Delta under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type and Georgiana Slough Salmonid Migratory Barrier BioAcoustic Fish Fence (BAFF) Operation Assumption

	BAFF Reducing Georgiana Slough Entry by 50%		BAFF Reducing Georgiana Slough Entry by 67%	
Water Year Type	Baseline Conditions	Proposed Project	Baseline Conditions	Proposed Project
Wet	0.26	0.26 ~~(0.2%)~~ (0.1%)	~~0.26~~ 0.27	~~0.26 (0.2%)~~ 0.27 (0.1%)
Above Normal	~~0.21~~ 0.22	~~0.21 (0.5%)~~ 0.22 (0.4%)	~~0.21~~ 0.22	~~0.21 (0.5%)~~ 0.22 (0.4%)
Below Normal	~~0.17~~ 0.18	~~0.17 (0.0%)~~ 0.18 (-0.1%)	~~0.17~~ 0.18	~~0.17 (0.0%)~~ 0.18 (-0.1%)
Dry	~~0.15~~ 0.16	~~0.15 (-0.2%)~~ 0.16 (-0.1%)	~~0.15~~ 0.16	~~0.15 (-0.2%)~~ 0.16 (-0.1%)
Critically Dry	0.14	0.14 ~~(0.5%)~~ (0.0%)	0.14	0.14 ~~(0.5%)~~ (0.0%)

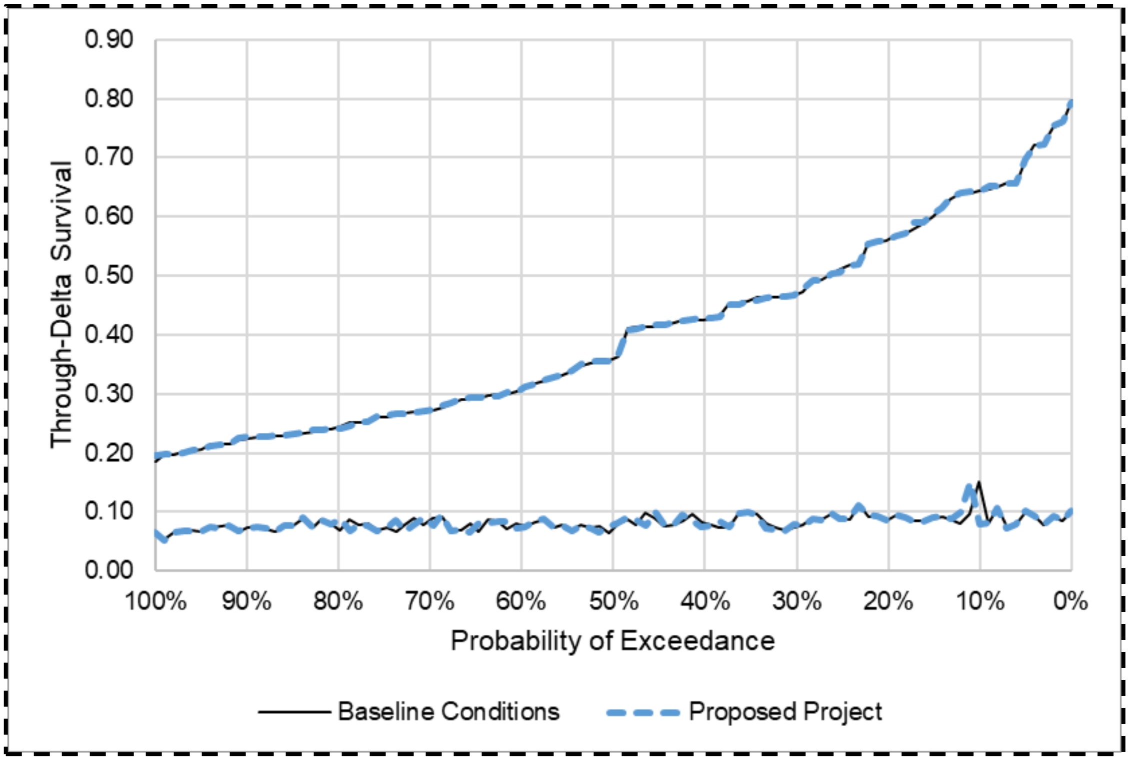
Note: Table only includes mean responses and does not consider model uncertainty. 95% predictions are shown in Figures 6-115 and 6-116.

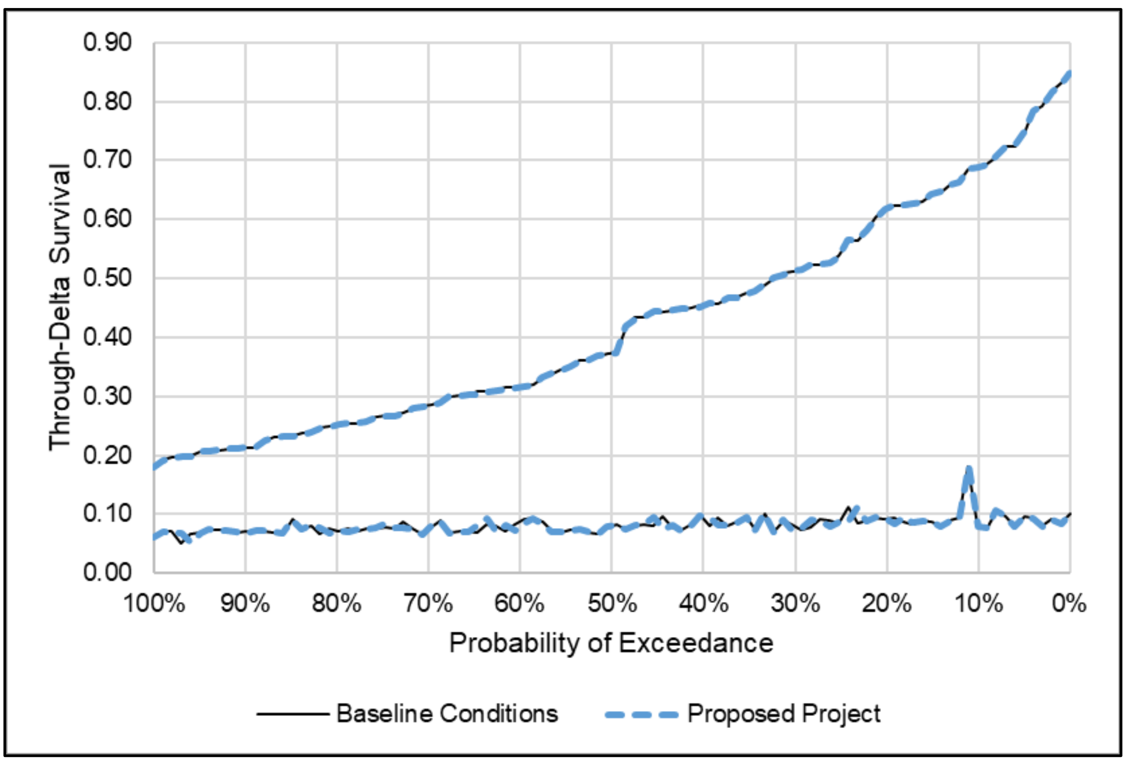




Note: Data are sorted by 97.5th percentile of predictions, with 2.5th and 97.5th percentiles shown, representing middle 95% of predictions.

Figure 6-115. Delta Passage Model: Exceedance Plot of Late Fall-Run Chinook Salmon Smolt Through-Delta Survival 95% Predictions, for the 1922–2021 Modeled Period, Assuming BioAcoustic Fish Fence Reducing Entry into Georgiana Slough by 50%





Note: Data are sorted by 97.5th percentile of predictions, with 2.5th and 97.5th percentiles shown, representing middle 95% of predictions.

Figure 6-116. Delta Passage Model: Exceedance Plot of Late Fall-Run Chinook Salmon Smolt Through-Delta Survival 95% Predictions, for the 1922–2021 Modeled Period, Assuming BioAcoustic Fish Fence Reducing Entry into Georgiana Slough by 67%

Survival, Travel Time, and Routing Analysis (Based on Perry et al. 2018)

Background information on the STARS analysis is provided in the discussion of STARS for winter-run Chinook Salmon. For juvenile fall-run Chinook Salmon, survey data indicate that the main months of migration are December–May/June (Tables 6A-8a and 6A-8b in Appendix 6A). As described for winter-run Chinook Salmon, the differences in mean through-Delta survival between the Proposed Project and Baseline Conditions during this time period December–May/June) are limited (Tables ~~6-38 through 6-45~~ 6-39 through 6-46), the mean probability of survival being less under the Proposed Project is close to 0.500 (Tables ~~6-48 through 6-55~~ 6-49 through 6-56), and there is considerable overlap in the 95 percent posterior predictive intervals between scenarios (Appendix 6B, Figures 6B-291 through 6B-390). The same conclusions apply to juvenile late-fall-run Chinook Salmon, for which the main migration period is December/January based on survey data (Appendix 6A, Tables 6A-8c and 6A-8d).

Ecological Particle Tracking Modeling (ECO-PTM)

Background information on the ECO-PTM analysis is provided in the discussion of the ECO-PTM for winter-run Chinook Salmon. As noted for the STARS analysis, survey data indicate that the main months of migration for fall-run Chinook Salmon are December–May/June (Tables 6A-8a and 6A-8b in Appendix 6A). During these time periods, the results of the ECO-PTM indicated differences in mean through-Delta survival of Chinook Salmon smolts between the Proposed Project and Baseline Conditions ranging from ~2 percent less under the Proposed Project (Dry years in June) to ~~~1.5~~ just over 2 percent greater under the Proposed Project (Below Normal years in April with 67 percent Georgiana Slough BAFF assumption), with most differences being less than 1 percent (Tables ~~6-57 through 6-65~~ 6-58 through 6-66). Differences between scenarios were less than 1 percent during the main December/January migration period of late fall-run Chinook Salmon (Tables 6A-8c and 6A-8d in Appendix 6A).

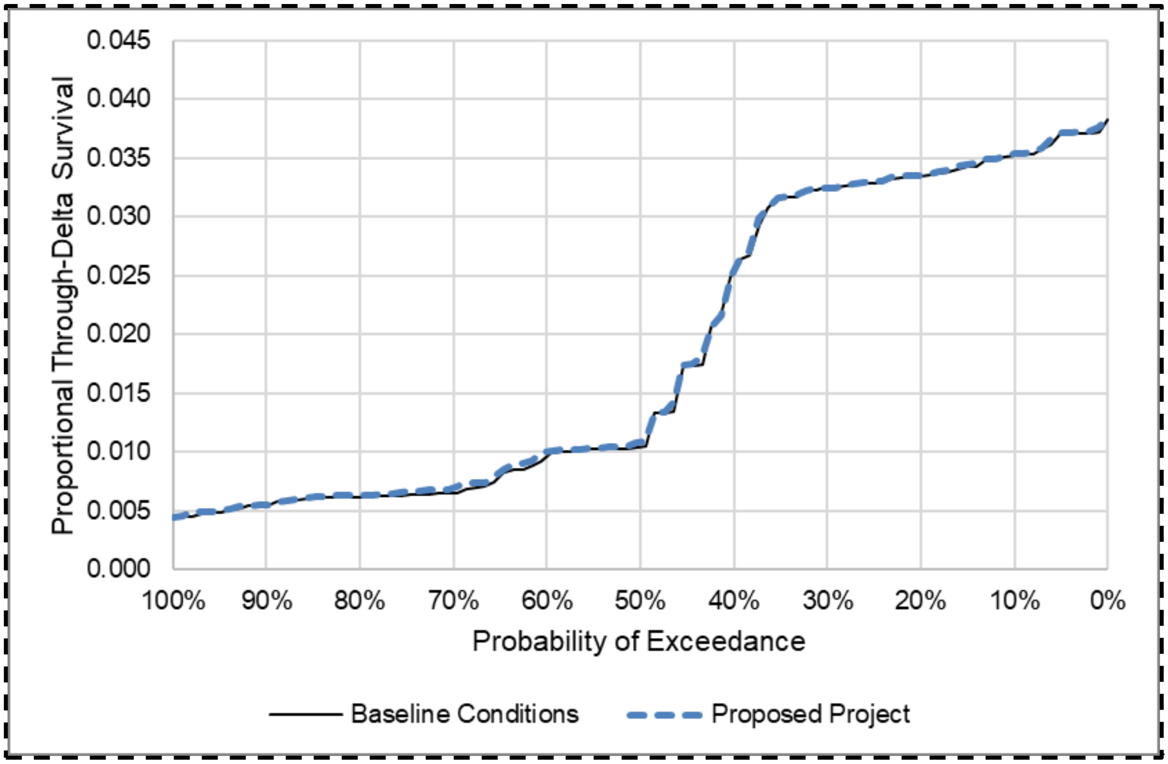
San Joaquin River-Origin Fall-run Chinook Salmon Structured Decision Model

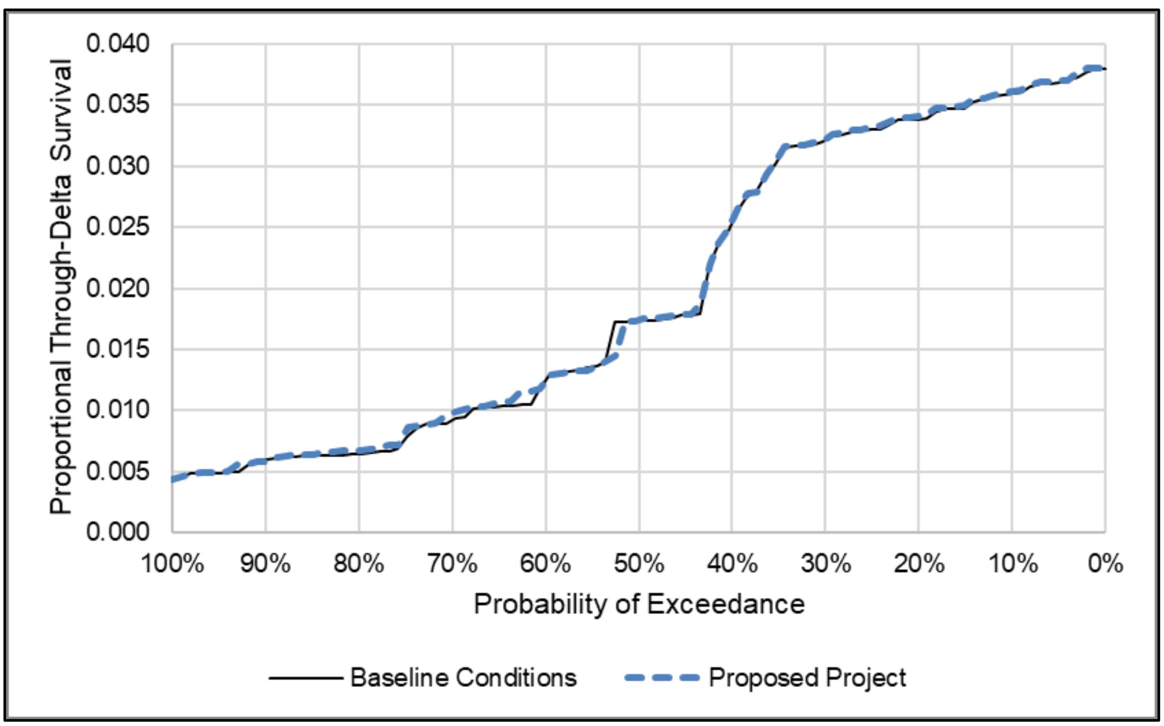
As described for spring-run Chinook Salmon, there is evidence for through-Delta flow-survival effects on juvenile Chinook Salmon following entry from the San Joaquin River basin (e.g., Buchanan and Skalski 2020), so through-Delta survival impacts on juveniles were analyzed with the Structured Decision Model San Joaquin River routing application (see Appendix 6B, Section 6B.7). The results of this analysis gave small differences in through-Delta survival between the scenarios (Table ~~6-76~~ 6-78; Figure 6-117), suggesting there would be little difference in effects on fall-run Chinook Salmon from the San Joaquin River basin as a result of Proposed Project operations relative to Baseline Conditions.

Table ~~6-76~~ 6-78. Mean Predicted San Joaquin River Fall-Run Chinook Salmon Juvenile Annual Proportional Through-Delta Survival under the Proposed Project and Baseline Conditions Modeling Scenarios, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	0.033	0.033 (0.4%)
Above Normal	0.033	0.033 (0.4%)
Below Normal	~~0.011~~ 0.014	~~0.011 (4.0%)~~ 0.014 (1.8%)
Dry	~~0.008~~ 0.010	~~0.009 (1.3%)~~ 0.010 (1.1%)
Critically Dry	~~0.006~~ 0.008	~~0.006 (2.2%)~~ 0.008 (1.3%)

Note: Table only includes mean responses and does not consider model uncertainty





Note: Figure only includes mean responses and does not consider model uncertainty

Figure 6-117. Exceedance Plot of San Joaquin River Fall-Run Chinook Salmon Juvenile Annual Proportional Through-Delta Survival under the Proposed Project and Baseline Conditions Modeling Scenarios, for the 1922–2021 Modeled Period

Rearing Habitat

Although this overall section primarily focuses on effects on outmigrating juvenile fall-run and late-fall-run Chinook Salmon, some juveniles may rear within the Delta. The limited differences in flow and hydrodynamic conditions described above for outmigrating juveniles indicate that there would be little, if any, effect on rearing fall-run and late-fall-run Chinook Salmon juveniles as a result of the Proposed Project relative to Baseline Conditions.

6.4.5.2 Delta Smelt Summer and Fall Habitat Actions

There would not be expected to be any effect on fall-run and late-fall-run Chinook Salmon juveniles from the Delta Smelt summer and fall habitat actions, which would occur during summer/fall, a period when these life stages generally would not be expected to occur in the Delta (Tables 6A-8a, 6A-8b, 6A-8c, and 6A-8d in Appendix 6A). In contrast, there likely would be considerable temporal overlap with adult fall-run Chinook Salmon and potentially some temporal overlap with late-fall-run Chinook Salmon (Tables 6A-7 and 6A-8 in Appendix 6A). Generally similar SMSCG operations under the Proposed Project and Baseline Conditions suggest generally similar potential for delay to adult upstream migration with the Proposed Project as under Baseline Conditions. However, boat lock passage would be available past the gates when closed, and any delay occurring would be unlikely to affect fall-run or late-fall-run Chinook Salmon adults because spawning tends to occur lower in the watershed in areas that are not potentially restricted in accessibility because of reduced flows (see Appendix 6A, Section 6A.1.5, “Fall-Run/Late-Fall-Run Chinook Salmon—Central Valley ESU”).

6.4.5.3 John E. Skinner Delta Fish Protective Facility

Any activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—would have limited effects on fall-/late-fall-run Chinook Salmon because, as discussed further for winter-run Chinook Salmon, the location of the facility in the south Delta and management of entrainment risk (e.g., through OMR management) for listed salmonids and smelts would result in low numbers of fall-run and late-fall-run Chinook Salmon being exposed to the facility. To the extent that fall-run and late-fall-run Chinook Salmon do occur at the facility, salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss, but such decreases or increases would be of relatively few fish in population-level terms.

6.4.5.4 Delta Smelt Supplementation

There is some dietary overlap between juvenile Chinook Salmon and Delta Smelt, as discussed for winter-run Chinook Salmon, but supplementation of Delta Smelt would be unlikely to have appreciable negative effects on fall- and late-fall-run Chinook Salmon because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential competitors with fall- and late-fall-run Chinook Salmon juveniles for prey resources.

6.4.5.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and would be expected to have limited overlap with juvenile fall- and late-fall-run Chinook Salmon occurrence in the Delta (see Tables 6A-8a, 6A-8b, 6A-8c, 6A-8d, and 6A-8e in Appendix 6A), but adults would occur within the transfer window, particularly fall-run (see Tables 6A-7 and 6A-8 in Appendix 6A). The potential for greater south Delta entrainment would exist for adult fall- and late-fall-run Chinook Salmon occurring during the water transfer window, but numbers of fish would be limited based on relatively few adult Chinook Salmon having been observed to have been entrained during these months (see discussion of entrainment in "Immigrating Adults"). Note this EIR does not provide environmental compliance for individual water transfer proposals.

6.4.5.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on fall-/late-fall-run Chinook Salmon would be similar between the scenarios. The proportion of juvenile fall-/late-fall-run Chinook Salmon exposed to the agricultural barriers depends on their annual timing of installation and removal. Due to their location, primarily fall-run migrants originating from the San Joaquin River would be exposed to the temporary barriers. The peak relative abundance of juvenile fall-run Chinook Salmon in the Delta emigrating from the San Joaquin River basin is April–June (Table 6A-8e in Appendix 6A). Operation of the barriers beginning in May would have the potential to expose an appreciable proportion of juvenile fall-run Chinook Salmon migrating through the Delta from the San Joaquin River Basin. Acoustically tagged juvenile Chinook Salmon from the San Joaquin River have demonstrated a high probability of selecting the Old River route (Buchanan et al. 2018), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile Chinook Salmon migrating past the barriers has been observed compared to when the barrier is not present (California Department of Water Resources 2018). When flap gates are tied up, Chinook Salmon passage past the agricultural barriers was improved (California Department of Water Resources 2018). As described in Appendix 2A, Attachment 3, one culvert at each of the three barriers will be left open and not operated tidally until June 1, thereby allowing passage of juvenile salmonids including fall-run Chinook Salmon. Notching of the Old River Tracy and Middle River barriers occurs in August or September in order to facilitate upstream passage of adult fall-run Chinook Salmon returning to the San Joaquin River Basin, reducing the potential for negative effects from migration delay.

6.4.5.7 Barker Slough Pumping Plant

Operations of the BSPP would be expected to have minimal effects on fall-run and late-fall-run Chinook Salmon because few individuals would be expected to occur at the location of the BSPP in a terminal slough far from the main migration pathways and because BSPP fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screens. BSPP diversion restrictions described in Chapter 2 for protection of larval Longfin Smelt (January 1–March 31 of Dry and Critically Dry water years) and larval Delta Smelt (March 1–June 30 of Dry and Critically Dry water years) would also reduce the already low potential for effects on fall-run and late-fall-run Chinook Salmon.

Sediment removal by suction dredge at BSPP would have the potential to entrain juvenile fall-run and late-fall-run Chinook Salmon, although the numbers would be expected to be limited given low numbers of juveniles expected to occur in the area and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on fall- and late-fall-run Chinook Salmon given that Chinook Salmon do not associate with vegetation (Grimaldo et al. 2012) and abundance would be expected to be low in the vicinity.

6.4.5.8 Clifton Court Forebay Weed Management

As described previously in the discussion regarding the Skinner Fish Facility, relatively low numbers of fall-/late-fall-run Chinook Salmon would occur in CCF because of factors such as OMR management and the location of the facility in the south Delta. Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months. Summer and fall treatments have limited potential for temporal overlap with juveniles and late-fall-run adults, but could overlap fall-run adults given species timing in the Delta (Tables 6A-7, 6A-8, 6A-8a, 6A-8b, 6A-8c, and 6A-8d in Appendix 6A); however, as discussed in the "Immigrating Adults" analysis in Section 6.4.5.1, "Delta SWP Facility Operations," few fall-run adults would be likely to be exposed. Mechanical removal of aquatic weeds in CCF would occur on an as needed basis and therefore could temporally coincide with occurrence of fall-/late-fall-run Chinook Salmon, with occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual fall-/late-fall-run Chinook Salmon from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds. However, such positive or negative effects would only be on limited numbers of fall-/late-fall-run Chinook Salmon individuals.

6.4.5.9 Suisun Marsh Operations

Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement coincides with downstream and upstream migration of juvenile and adult fall-/late-fall-run Chinook Salmon. Operational criteria are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt summer and fall habitat actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.5.2, "Delta Smelt Summer and Fall Habitat Actions.") Montezuma Slough provides an alternative route to the primary migration fall-/late-fall-run Chinook Salmon corridor through Suisun Bay, but the proportion of the total run utilizing this route is unknown. Operation of the SMSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators because the gates would not be continuously operated and , as a result of prior studies of adult Chinook Salmon passage (Vincik 2013), boat lock passage is available when the gates are closed (National Marine Fisheries Service 2019:463). Any effect such as short-term migration delay of a few hours to several days would be consistent between the Proposed Project and Baseline Conditions scenarios. Any effects of the other Suisun Marsh facilities (MIDS, RRDS, and the Goodyear Slough Outfall) would be expected to be minor and would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.5.10 Georgiana Slough Salmonid Migratory Barrier Operations

Effects to fall- and late fall-run Chinook Salmon from GSSMB operations may be generally similar to those discussed above for winter-run Chinook Salmon in Section 6.4.3.10, "Georgiana Slough Migratory Barrier Operations", although there are timing differences in when juveniles and adults could encounter the BAFF. Thus, for example, much of fall-run upstream migration may have been completed before continuous operations of the BAFF begin in January (Table 6A-8 in Appendix 6A). Outmigration of many fall-run juveniles has greater potential to occur after operations of the BAFF end in April (Tables 6A-10a,b in Appendix 6A). Temporal overlap of late fall-run adults and juveniles with BAFF operations is likely greater than for fall-run (Tables 6A-9, 6A-10c, and 6A-10d in Appendix 6). Overall, although it is possible that there may be negative effects to fall- and late fall-run Chinook Salmon from GSSMB operations, such effects would be limited, and the potential for positive effects related to keeping juveniles out of the interior Delta appears greater than the potential for negative effects.

6.4.5.11 Significance of Impacts on Fall- and Late-Fall-Run Chinook Salmon

The Proposed Project includes various measures that would limit the potential for significant impacts on fall- and late-fall-run Chinook Salmon, including but not limited to entrainment protection for listed fish that provides ancillary protection, spring Delta outflow, and other measures such as Skinner Fish Facility improvements (see detailed descriptions in Chapter 2). There is greater potential for negative effects on fall-run Chinook Salmon under the Proposed Project relative to Baseline Conditions as a result of spring (April/May) entrainment, although the various analyses indicated that this would have little effect on through-Delta survival, which generally would be similar under the Proposed Project and Baseline Conditions. Based on the analysis presented above (Section 6.4.5.1, "Delta SWP Facility Operations;" Section 6.4.5.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.5.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.5.4, "Delta Smelt Supplementation;" Section 6.4.5.5, "Water Transfers;" Section 6.4.5.6, "Agricultural Barriers;" Section 6.4.5.7, "Barker Slough Pumping Plant;" Section 6.4.5.8, "Clifton Court Forebay Weed Management;" Section 6.4.5.9, "Suisun Marsh Operations;" and Section 6.4.5.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on fall-/late-fall-run Chinook Salmon would be less than significant. No mitigation is required.

6.4.6 Central Valley Steelhead

6.4.6.1 Delta SWP Facility Operations

Immigrating Adults

Adult steelhead may occur in Delta during much of the year, with medium to high relative abundance from August to May (Table 6A-10 in Appendix 6A). As discussed for winter-, spring-, and fall-/late-fall-run Chinook Salmon, flow entering the Delta differs little between the Proposed Project and Baseline Conditions. This indicates that flow-related effects from the Proposed Project would be similar to Baseline Conditions.

Outmigrating Juveniles

Entrainment

The salvage-density method (see Appendix 6B, Section 6B.1) was used to provide perspective on potential differences in entrainment loss of steelhead between the Baseline Conditions and Proposed Project scenarios. The estimates of entrainment loss obtained from the salvage-density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim 3-modeled differences in SWP exports between Baseline Conditions and Proposed Project scenarios; the results are basically a description of differences in export flows weighted by historical monthly loss density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained, but these data are more a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected.

The salvage-density method indicated that SWP exports under the Proposed Project during the main period of juvenile steelhead loss at the SWP South Delta export facility would be similar or slightly higher than under Baseline Conditions (Table ~~6-77~~ 6-79). Therefore, entrainment risk would be expected to be similar or slightly higher under the Proposed Project relative to Baseline Conditions. However, steelhead would receive ancillary protection from OMR management measures for other listed species as described in Chapter 2, limiting the potential for losses, which would be expected to continue to be well within ESA-authorized take limits as has occurred in recent years (Islam et al. 2020, 2021, 2022).

Table ~~6-77~~ 6-79. Mean Number of Steelhead Juveniles Lost (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

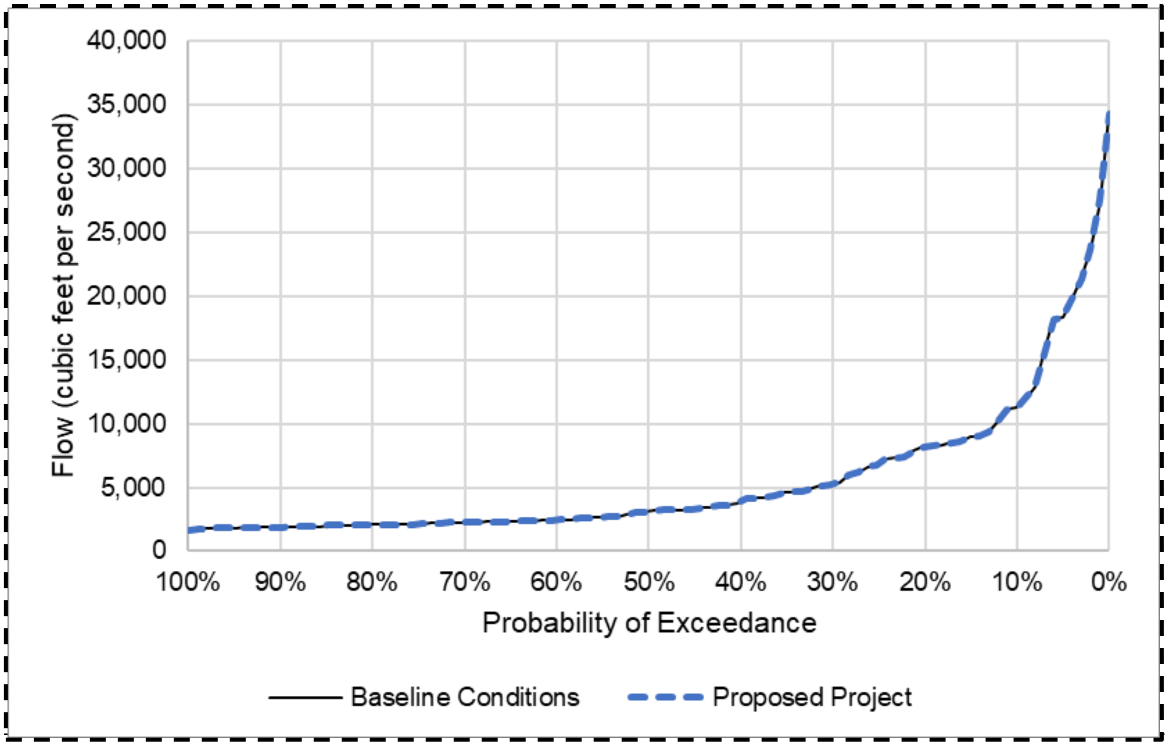
Water Year Type	Baseline Conditions	Proposed Project
Wet	~~5,482~~ 5,818	~~5,801 (6%)~~ 6,126 (5%)
Above Normal	N/A	~~(6%)~~ (5%)
Below Normal	~~3,911~~ 4,124	~~3,872 (-1%)~~ 3,972 (-4%)
Dry	~~2,087~~ 2,174	~~2,035 (-2%)~~ 1,900 (-13%)
Critically Dry	~~822~~ 773	~~873 (6%)~~ 790 (2%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-5 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Through-Delta Survival

The main juvenile steelhead migration period in the Delta is February–May (Table 6A-10 in Appendix 6A). Through-Delta flow-survival relationships analogous to those for juvenile Chinook Salmon (e.g., Perry et al. 2018; see also discussion for winter-run Chinook Salmon) have not been established for migrating juvenile steelhead from the Sacramento River Basin, although the species does show analogous route-specific survival differences (Singer et al. 2013) and there are flow-survival relationships for steelhead from the San Joaquin River Basin emigrating through the Delta (Buchanan et al. 2021). Assuming that flow may affect survival in a somewhat similar manner to juvenile Chinook Salmon, the modeling for Chinook Salmon undertaken with DPM, STARS, and ECO-PTM suggests there would be little difference in through-Delta survival between the Proposed Project and Baseline Conditions. This reflects the overall similarity in hydrodynamic conditions discussed previously for Chinook Salmon with respect to DSM2-HYDRO outputs.

Studies of acoustically tagged juvenile steelhead emigrating from the San Joaquin River found San Joaquin River flow at Vernalis, presence of a rock barrier at Head of Old River, fish size, and year to be significant predictors of through-Delta survival, whereas south Delta exports were not supported as significant predictors of survival (Buchanan et al. 2021). The Head of Old River rock barrier is no longer installed, so the essentially identical Vernalis flows (Figures 6-118, 6-119, 6-120, 6-121) indicate that there would be little to no difference in juvenile steelhead through-Delta survival from the San Joaquin River basin between the Proposed Project and Baseline Conditions.



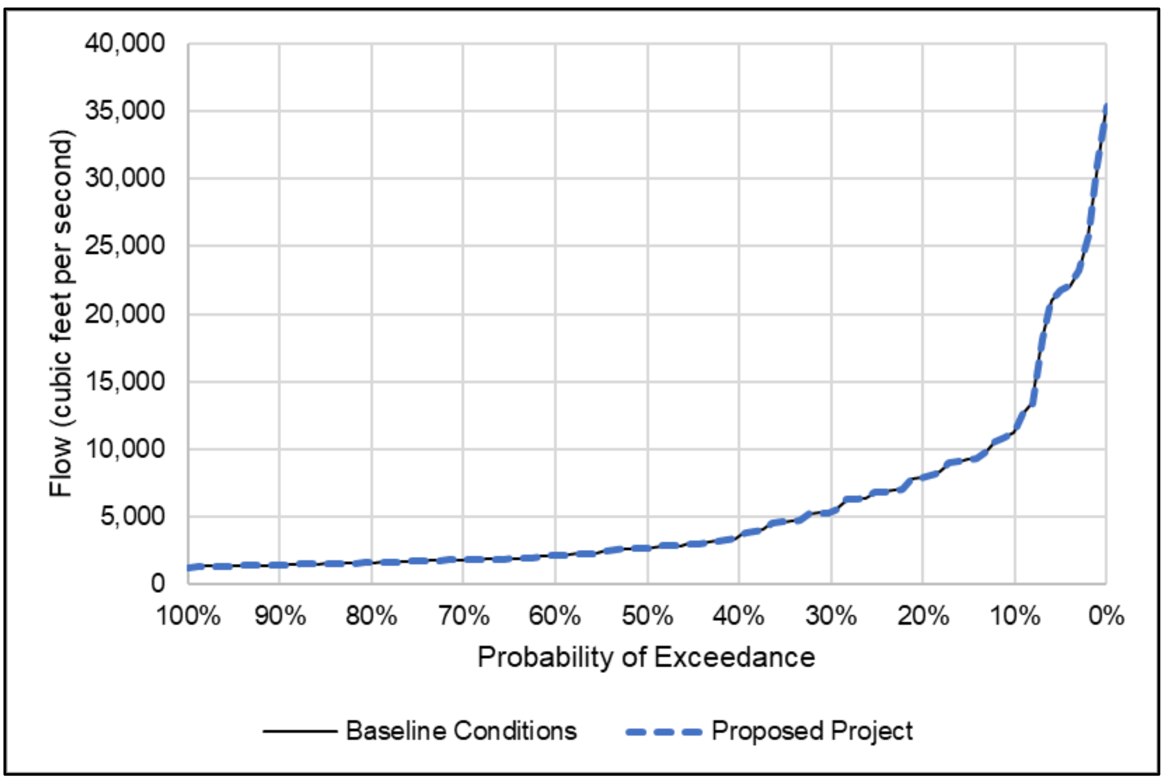


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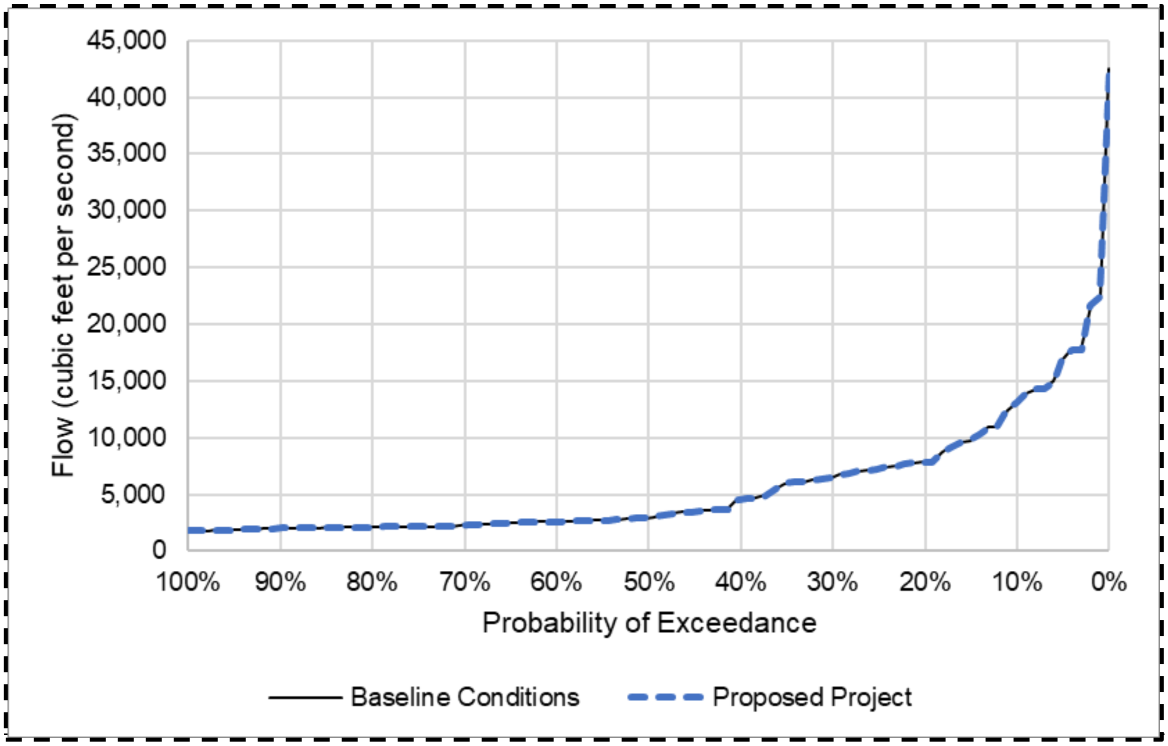
Figure 6-118. Mean Modeled San Joaquin River Flow at Vernalis, February



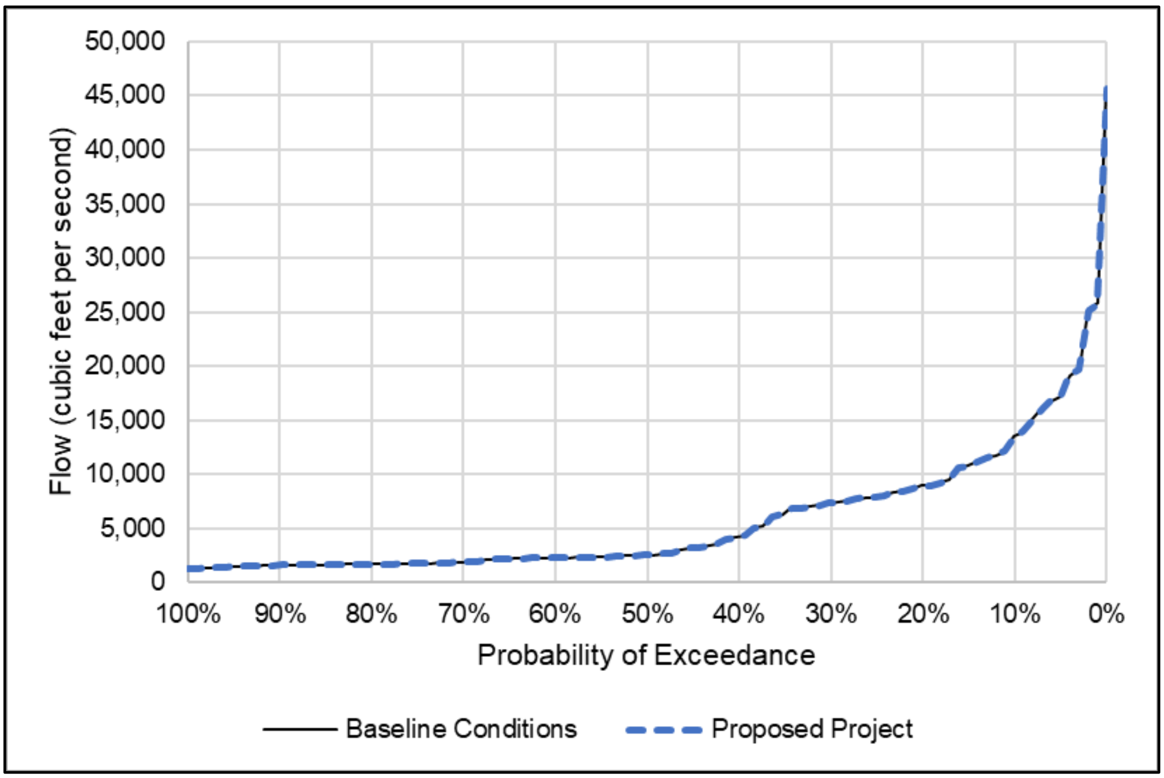


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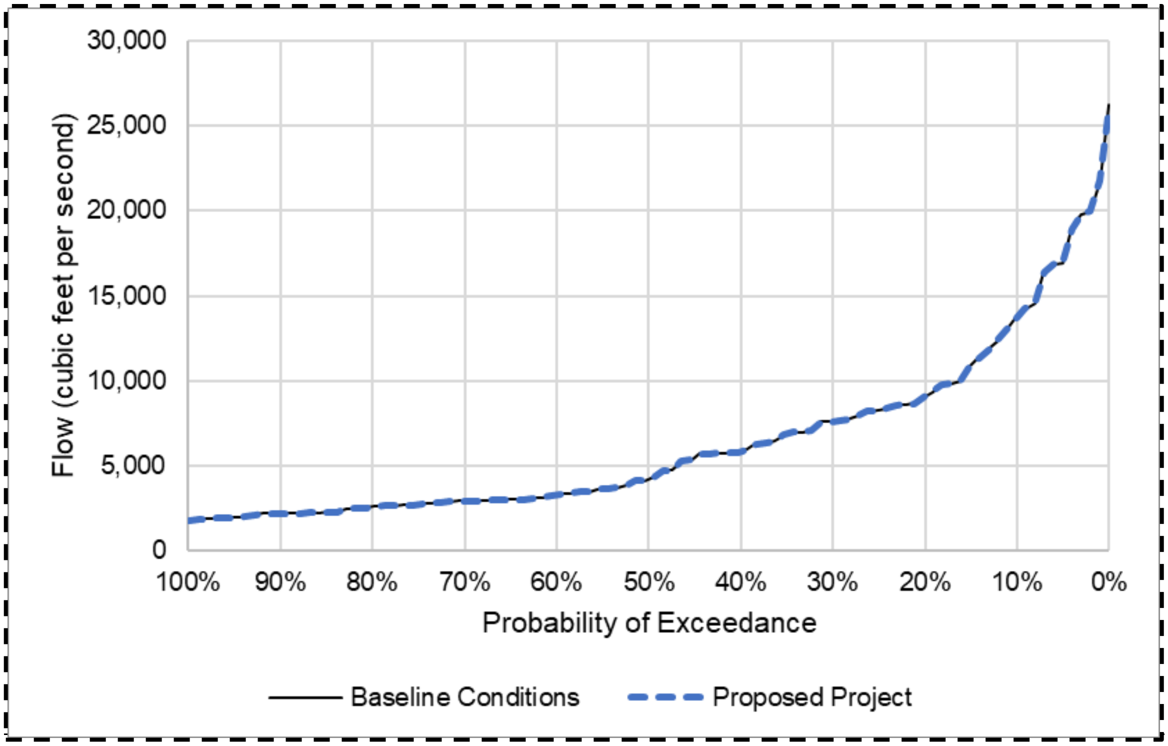
Figure 6-119. Mean Modeled San Joaquin River Flow at Vernalis, March



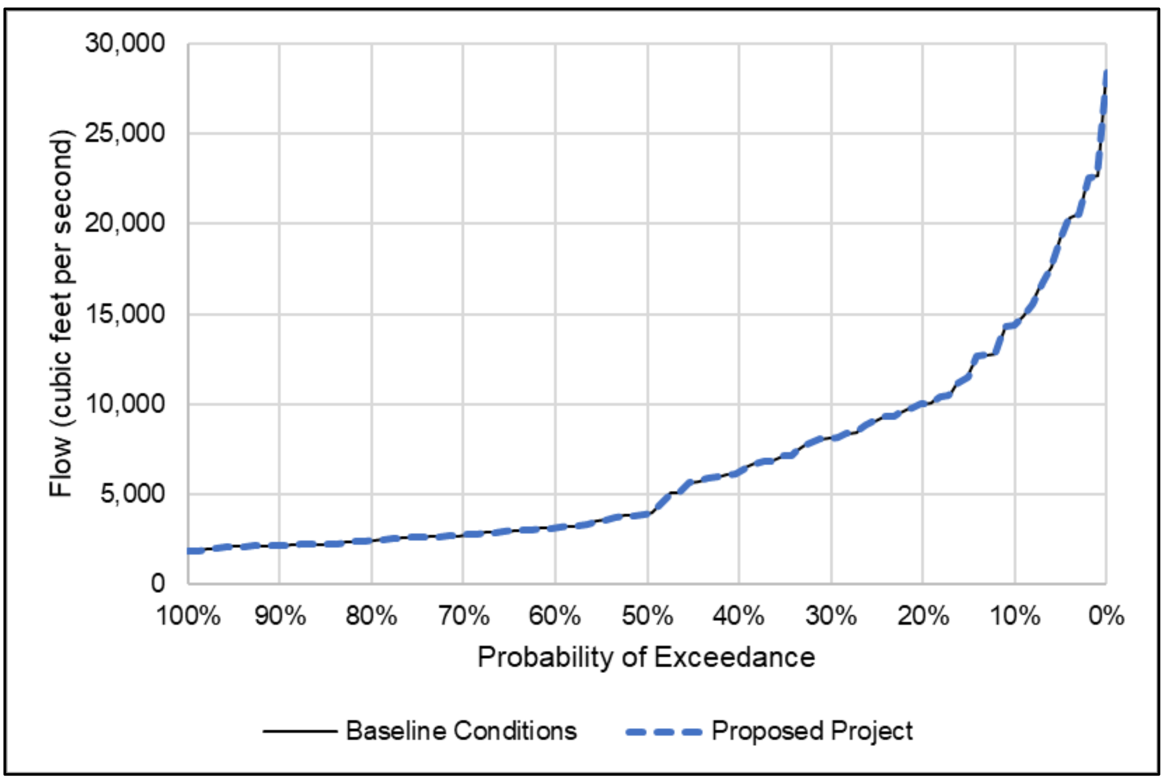


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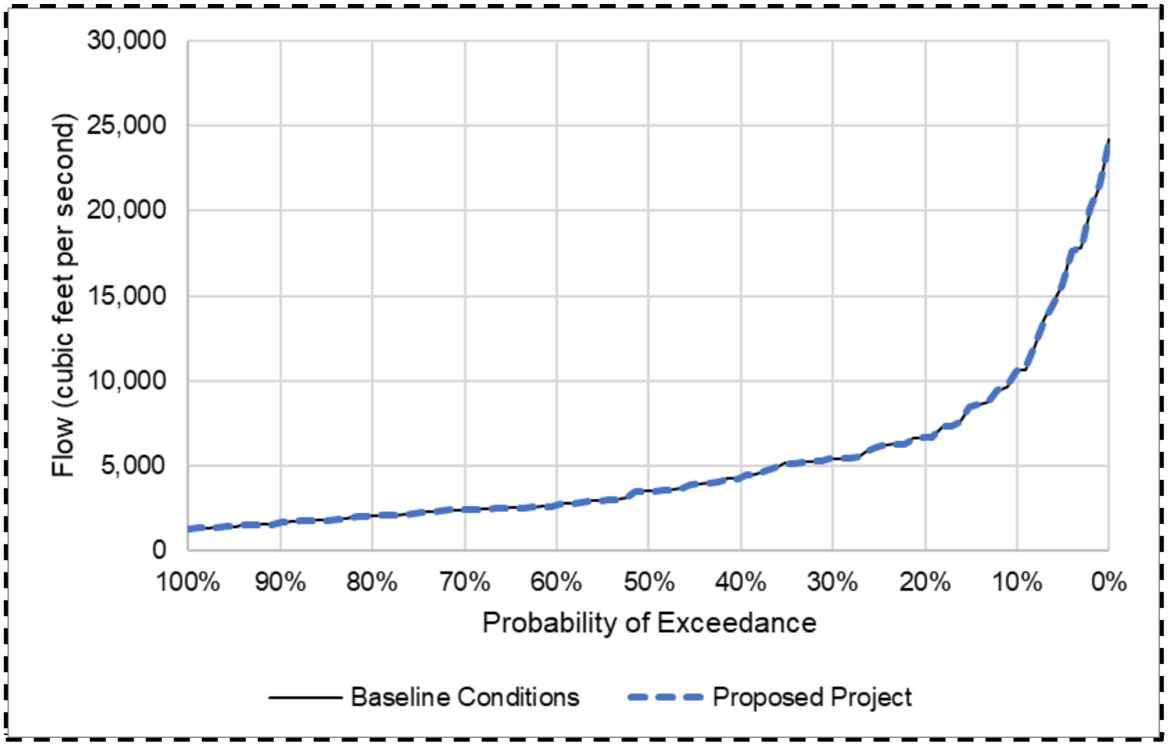
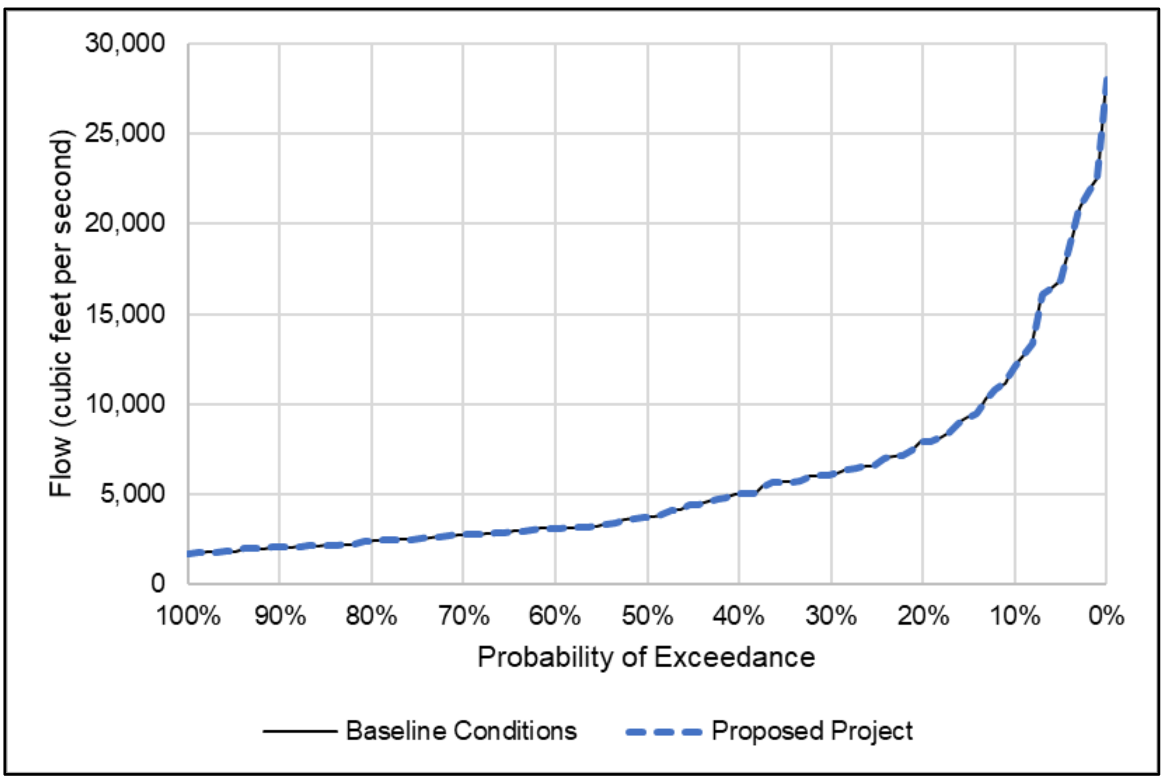
Figure 6-120. Mean Modeled San Joaquin River Flow at Vernalis, April





Source: ~~DRAFT_TrendReport_MultiCalSim_rev11_NoMacro_S1_S7_S7v2_S9b_S9bv2.xlsm~~
DRAFT_TrendReport_MultiCalSim_rev12_FEIR_1_9bv2_12av2_7.23.xlsx

Figure 6-121. Mean Modeled San Joaquin River Flow at Vernalis, May

6.4.6.2 Delta Smelt Summer and Fall Habitat Actions

There is likely to be considerable temporal overlap of Delta Smelt Summer and Fall Habitat Actions with adult steelhead upstream migration (Table 6A-10 in Appendix 6A), although it is unknown what proportion of individuals may encounter the SMSCG in Montezuma Slough. Boat lock passage would be available past the gates when closed under both the Proposed Project and Baseline Conditions. Any short delays occurring would be unlikely to greatly affect the ability of steelhead to migrate to upstream spawning habitat that may be temporally constricted in accessibility.

6.4.6.3 John E. Skinner Delta Fish Protective Facility

Any activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—would have limited effects on steelhead because, as discussed further for winter-run Chinook Salmon, the location of the facility in the south Delta and management of entrainment risk (e.g., through OMR management) for listed salmonids and smelts would result in relatively low numbers of steelhead being exposed to the facility. To the extent that steelhead do occur at the facility, salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss, but such decreases or increases would be of relatively few fish in population-level terms.

6.4.6.4 Delta Smelt Supplementation

There is some dietary overlap between juvenile steelhead and Delta Smelt (Merz 2002; Slater and Baxter 2014), but supplementation of Delta Smelt would be unlikely to have appreciable negative effects on steelhead because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential competitors with steelhead for prey resources.

6.4.6.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and would be expected to have limited overlap with juvenile steelhead occurrence in the Delta, and considerable overlap with adult occurrence in the Delta (see Tables 6A-9 and 6A-10 in Appendix 6A). The potential for greater south Delta entrainment would exist for adults occurring during the water transfer window, but numbers of fish would be limited based on relatively few adult steelhead having been observed to have been entrained during these months (see discussion of entrainment in “Immigrating Adults”). This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.6.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on steelhead would be similar between the scenarios. The proportion of juvenile steelhead exposed to the agricultural barriers depends on their annual timing of installation and removal. The peak relative abundance of juvenile Steelhead emigrating from the San Joaquin River basin is April–May (Table 6A-8 in Appendix 6A). Operation of the barriers beginning in May would have the potential to expose an appreciable proportion of juvenile steelhead migrating through the Delta from the San Joaquin River Basin. Acoustically tagged juvenile steelhead from the San Joaquin River have demonstrated a high probability of selecting the Old River route (Buchanan et al. 2021), which would expose them to the agricultural barriers. When the agricultural barriers are operating with tidal flap gates down, a significant decline in passage and reach survival of acoustically tagged juvenile steelhead migrating past the barriers has been observed compared to when the barrier is not present (California Department of Water Resources 2018). When flap gates are tied up, Chinook Salmon passage past the agricultural barriers was improved (California Department of Water Resources 2018). As described in Appendix 2A, Attachment 3, one culvert at each of the three barriers will be left open and not operated tidally until June 1, thereby allowing passage of juvenile salmonids including steelhead. Notching of the Old River Tracy and Middle River barriers occurs in August or September in order to facilitate upstream passage of adult fall-run Chinook Salmon returning to the San Joaquin River Basin, which would reduce the potential for negative effects from migration delay for the portion of steelhead adults migrating upstream to the San Joaquin River basin at this time (Table 6A-8 in Appendix 6A).

6.4.6.7 Barker Slough Pumping Plant

Operations of the BSPP would be expected to have minimal effects on steelhead because few individuals would be expected to occur at the location of the BSPP in a terminal slough far from the main migration pathways and because BSPP fish screens are designed to protect juvenile salmonids per NMFS criteria and should prevent entrainment while greatly minimizing any impingement of fish against the screens. BSPP diversion restrictions described in Chapter 2 for protection of larval Longfin Smelt (January 1–March 31 of Dry and Critically Dry water years) and larval Delta Smelt (March 1–June 30 of Dry and Critically Dry water years) would also reduce the already low potential for effects on steelhead.

Sediment removal by suction dredge at BSPP would have the potential to entrain juvenile steelhead, although the numbers would be expected to be limited given low numbers of juveniles expected to occur in the area and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on steelhead given that abundance would be expected to be low in the vicinity and any steelhead present nearby could swim away from the disturbance.

6.4.6.8 Clifton Court Forebay Weed Management

As described previously in the discussion regarding the Skinner Fish Facility, relatively low numbers of steelhead would occur in CCF because of factors such as OMR management and the location of the facility in the south Delta. Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months, overlapping the occurrence of steelhead adults in the Delta (Tables 6A-9 and 6A-10 in Appendix 6A); however, as discussed in “Immigrating Adults” in Section 6.4.6.1, “Delta SWP Facility Operations,” few steelhead adults would be likely to be exposed. Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and could temporally coincide with occurrence of steelhead, with occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual steelhead from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds. However, such positive or negative effects would only be on limited numbers of steelhead individuals.

6.4.6.9 Suisun Marsh Operations

Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement coincides with upstream and downstream migration of juvenile ~~fall-/late-fall-run Chinook Salmon~~ steelhead and upstream migration of adult ~~spring-run Chinook Salmon~~ steelhead. Operational criteria are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt Summer and Fall Habitat Actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.6.2, "Delta Smelt Summer and Fall Habitat Actions.") Montezuma Slough provides an alternative route to the primary steelhead migration corridor through Suisun Bay, but the proportion of the total run utilizing this route is unknown. Operation of the SMSCG is unlikely to impede migration of juvenile salmonids or produce conditions that support unusually high numbers of predators because the gates would not be continuously operated and boat lock passage is available when the gates are closed (National Marine Fisheries Service 2019:463). Any effect such as short-term migration delay of a few hours to several days would be consistent between the Proposed Project and Baseline Conditions scenarios. Any effects of the other Suisun Marsh facilities (MIDS, RRDS, and the Goodyear Slough Outfall) would be expected to be minor for the reasons discussed for Delta Smelt (e.g., very little observed entrainment at MIDS; Enos et al. 2007) and would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.6.10 Georgiana Slough Salmonid Migratory Barrier Operations

Effects to Central Valley steelhead from GSSMB operations may be generally similar to those discussed above for winter-run Chinook Salmon in Section 6.4.3.10, "Georgiana Slough Migratory Barrier Operations". Relative to winter-run Chinook Salmon, steelhead temporal overlap with BAFF operations is likely to be lower for adults and comparable for juveniles (Tables 6A-11 and 6A-12 in Appendix 6A). The 2012 BAFF study found that the BAFF was effective in deterring juvenile steelhead entry into Georgiana Slough at a similar or greater rate than for juvenile Chinook Salmon (California Department of Water Resources 2015b). Overall, although it is possible that there may be negative effects to Central Valley steelhead from GSSMB operations, such effects would be limited, and the potential for positive effects related to keeping juveniles out of the interior Delta appears greater than the potential for negative effects.

6.4.6.11 Significance of Impacts on Central Valley Steelhead

The Proposed Project includes various measures that would limit the potential for significant impacts on Central Valley steelhead, including but not limited to entrainment protection for listed fish that provides ancillary protection, spring Delta outflow, and other measures such as Skinner Fish Facility improvements (see detailed descriptions in Chapter 2). South Delta exports during the period of typical entrainment risk are not greatly different between the Proposed Project and Baseline Conditions, and the various through-Delta survival analyses for juvenile Chinook Salmon suggest that there would also be little difference between the scenarios for Central Valley steelhead. Based on the analysis presented above (Section 6.4.6.1, "Delta SWP Facility Operations;" Section 6.4.6.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.6.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.6.4, "Delta Smelt Supplementation;" Section 6.4.6.5, "Water Transfers;" Section 6.4.6.6, "Agricultural Barriers;" Section 6.4.6.7, "Barker Slough Pumping Plant;" Section 6.4.6.8, "Clifton Court Forebay Weed Management;" Section 6.4.6.9, "Suisun Marsh Operations;" and Section 6.4.6.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the

Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on Central Valley steelhead would be less than significant. No mitigation is required.

6.4.7 North American Green Sturgeon

6.4.7.1 Delta SWP Facility Operations

South Delta entrainment risk is the main operations-related consideration concerning the Proposed Project for Green Sturgeon. Very few Green Sturgeon have been salvaged in recent years: total salvage at SWP and CVP salvage facilities combined was only greater than zero in five years between 2008 and 2022, with annual total salvage in the past decade of 12 fish during WYs 2016, 2017, and 2020 (Islam et al. 2022), which represents salvage of a single fish in each of these three years expanded to four fish when accounting for the 25 percent of pumped water that is sampled for fish. As a result, salvage as assessed with the salvage-density method (see Appendix 6B, Section 6B.1) would be expected to be very low under the Proposed Project and Baseline Conditions, with little difference anticipated between the scenarios based on modeled exports (Table ~~6-78~~ 6-80). Therefore, entrainment risk would be similar for the Proposed Project and Baseline Conditions.

Table ~~6-78~~ 6-80. Mean Number of Green Sturgeon Juveniles Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	1	1 ~~(2%)~~ (5%)
Above Normal	N/A	(-13%)
Below Normal	1	1 ~~(-4%)~~ (-5%)
Dry	0	0 (0%)
Critically Dry	0	0 (0%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-6 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

In contrast to White Sturgeon (discussed in Section 6.4.8, "White Sturgeon"), there are currently no quantitative relationships established between Green Sturgeon and Delta flows. There appears to be a positive relationship between annual outflow and abundance in rotary screw traps at Red Bluff Diversion Dam of Green Sturgeon larvae and juveniles (Heublein et al. 2017a). Based on seven years of netting in the Delta (2015–2021), CDFW found that catch per unit effort of yearling juvenile Green Sturgeon was about ten times as high in years following Wet water years as in years following Dry and Critically Dry water years (Beccio pers. comm. August 12, 2021). These factors are generally suggestive of a positive relationship with flow, but it is uncertain the extent to which such effects may reflect water operations. Any effects of the Proposed Project on Green Sturgeon relative to Baseline Conditions would be expected to be limited given the limited differences in Delta flow conditions between the scenarios (see flow summaries presented in Appendix 4B, Attachment 2, "Flow Results (CalSim 3)").

6.4.7.2 Delta Smelt Summer and Fall Habitat Actions

There would be considerable temporal overlap of Delta Smelt Summer and Fall Habitat Actions with Green Sturgeon juvenile and adult occurrence in the Delta (Tables 6A-11 and 6A-12 in Appendix 6A), although it is unknown what proportion of individuals may encounter the SMSCG in Montezuma Slough. Boat lock passage would be available past the gates when closed under both the Proposed Project and Baseline Conditions. Any short delays occurring would be unlikely to greatly affect the ability of Green Sturgeon to move within their overall range, and the spring adult upstream migration period (Colborne et al. 2022) would not coincide with the Delta Smelt Summer and Fall Habitat Actions.

6.4.7.3 John E. Skinner Delta Fish Protective Facility

Any activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—would have limited effects on Green Sturgeon because there would be few Green Sturgeon being exposed to the facility, as discussed above in Section 6.4.7.1, "Delta SWP Facility Operations." To the extent that Green Sturgeon do occur at the facility, salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss (although predation-related losses are likely to be lower than smaller-bodied species such as juvenile salmonids), but such decreases or increases would be of relatively few fish in population-level terms.

6.4.7.4 Delta Smelt Supplementation

There is some limited dietary overlap between Green Sturgeon and Delta Smelt as both have been noted as eating amphipods (Appendix 6A, Section 6A.1.7, "Green Sturgeon—Southern DPS"; Slater et al. 2019). However, supplementation of Delta Smelt would be unlikely to have appreciable negative effects on Green Sturgeon because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential competitors with Green Sturgeon for prey resources.

6.4.7.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and overlaps adult and juvenile Green Sturgeon occurrence in the Delta (see Tables 6A-9 and 6A-10 in Appendix 6A). The potential for greater south Delta entrainment would exist for Green Sturgeon occurring during the water transfer window, but numbers of fish would be limited based on salvage data from the past decade (Section 6.4.7.1, "Delta SWP Facility Operations"). This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.7.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on Green Sturgeon would be similar between the scenarios. The proportion of the Green Sturgeon population exposed to the agricultural barriers is likely low because of the barrier location in the south Delta, as suggested by relatively few Green Sturgeon salvaged at the south Delta export facilities in recent years (see Section 6.4.7.1 and Appendix 6A). Operation of the barriers beginning in May would at most overlap only a small portion of the potential adult upstream migration period through the Delta and therefore would not be a substantial impediment. Juvenile Green Sturgeon in the Delta could encounter the barriers and have movement blocked but as noted above, such effects would be expected to occur on only a small proportion of the population.

6.4.7.7 Barker Slough Pumping Plant

Operations of the BSPP would be expected to have minimal effects on Green Sturgeon because BSPP fish screens are designed to protect juvenile salmonids per NMFS criteria. These criteria include low approach velocity that is below recommended water flow velocity to protect present Green Sturgeon life stages (Verhille et al. 2014). BSPP diversion restrictions described in Chapter 2 for protection of larval Longfin Smelt (January 1–March 31 of Dry and Critically Dry water years) and larval Delta Smelt (March 1–June 30 of Dry and Critically Dry water years) would also reduce the already low potential for effects on Green Sturgeon.

Sediment removal by suction dredge at BSPP would have the potential to entrain juvenile Green Sturgeon, although the numbers would be expected to be limited given low numbers of juveniles expected to occur in the area and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on Green Sturgeon given that abundance would be expected to be low in the vicinity and any Green Sturgeon present nearby could swim away from the disturbance.

6.4.7.8 Clifton Court Forebay Weed Management

As described previously in the discussion regarding the Skinner Fish Facility, based on historical data from the past decade, relatively low numbers of Green Sturgeon would occur in CCF. Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months, thereby overlapping the highest historical period of occurrence of Green Sturgeon in salvage (Table 6A-12 in Appendix 6A). Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and could temporally coincide with occurrence of Green Sturgeon. Fish occurrence near mechanical removal activities is more likely if both fish and weeds are concentrated into removal areas by prevailing water movement in CCF. Any potential adverse effects on individual Green Sturgeon from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes (although such risk is likely to be lower for Green Sturgeon because of their protective scutes and larger size than for smaller-bodied fish) and increases in salvage efficiency because of reduced smothering by weeds. However, such positive or negative effects would only be on limited numbers of Green Sturgeon individuals.

6.4.7.9 Suisun Marsh Operations

Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement coincides with the spring upstream migration period of adult Green Sturgeon, as well as with general occurrence of adult and juvenile Green Sturgeon. Operational criteria are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt Summer and Fall Habitat Actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.7.2, "Delta Smelt Summer and Fall Habitat Actions.") Montezuma Slough provides an upstream migration route, but the proportion of the total run utilizing this route is unknown; existing studies suggest that Suisun and Honker Bays are more utilized (National Marine Fisheries Service 2019:463). Operation of the SMSCG is unlikely to negatively affect juvenile Green Sturgeon because the juveniles are relatively large and unlikely prey for predators such as Striped Bass and Sacramento Pikeminnow (National Marine Fisheries Service 2019:463). In addition, the multi-year estuarine residence of juvenile southern DPS Green Sturgeon often includes long periods of localized, non-directional movement interspersed with occasional long-distance movements (Kelly et al. 2007), and such movements are unlikely to be negatively affected by periodic delays ranging from a few hours to a few days (National Marine Fisheries Service 2019:463). Any effect such as short-term migration delay of a few hours to several days would be consistent between the Proposed Project and Baseline Conditions scenarios. Any effects of the other Suisun Marsh facilities (MIDS, RRDS, and the Goodyear Slough Outfall) would be expected to be minor for the reasons discussed for Delta Smelt (e.g., no observed entrainment at MIDS; Enos et al. 2007) and would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.7.10 Georgiana Slough Salmonid Migratory Barrier Operations

This analysis is adapted from the National Marine Fisheries Service (2012) analysis of BAFF operations for the 2012 BAFF study at Georgiana Slough. Juvenile, sub-adult, and adult Green Sturgeon are expected to be present in the Sacramento River and Georgiana Slough at various times during the November through April period for which GSSMB operations are assumed to occur (see operational assumptions described for Delta Smelt in Section 6.4.1.10). Adult Green Sturgeon are expected to be moving upriver to reach their spawning grounds in the upper Sacramento River. Juveniles and sub-adults are expected to be within the waters of the Delta, using it as a migratory corridor and rearing area. As shown in Figure 6-51, the BAFF proposed for operations under the GSSMB would be clear of the substrate by 2-12 feet. Therefore, adult, sub-adult, and juvenile Green Sturgeon are expected to easily pass beneath the structures if they choose to do so. Green Sturgeon are generally benthically oriented (Moyle 2002), but may also be found swimming high in the water column (Kelly et al. 2007).

The auditory stimuli used for the BAFF have the potential to affect Green Sturgeon behavior. Based on auditory studies conducted with other Acipenseridae, Lovell et al. (2005) concluded that acipenserids did not have the hearing sensitivity of teleost fish considered to be hearing specialists to pressure-dominated sound fields such as are used for the BAFF. However, as noted by National Marine Fisheries Service (2012: 96), the comparisons done in that study were between hearing specialists (non-native Asian carp) and Shovelnose Sturgeon (*Acipenser fulvescens*) and Paddlefish (*Polyodon spathula*). Salmonids are hearing generalists, so that the level of separation between hearing thresholds of salmonids and Green Sturgeon may not be as substantial as would be expected from the Lovell et al. (2005) study where hearing sensitivities between the native shovelnose and paddlefish were compared to the non-native Silver Carp (*Hypopthalmichthys molitrix*) and Bighead

Carp (*Aristichthysc nobilis*). Acipenseridae possess large swim bladders, and may use sound as a form of communication (Johnston and Phillips 2003, Popper 2005). Acipenseridae also may have the ability to detect electrical currents in the water (Teeter et al. 1980), and the electrical field surrounding the BAFF during operations (e.g., electrical current flowing to the lights and sound generators of the BAFF) may affect the behavior of Green Sturgeon; however, assessment of effects of an underwater electrical cable on Green Sturgeon in the Bay-Delta found limited effects (Wyman et al. 2022). Any effects of the BAFF would be limited relatively close to the BAFF because the stimuli are not wide-ranging (the BAFF's acoustic stimulus is largely enclosed within the bubble curtain).

The most poorly developed sense in sturgeons is sight (Cooke et al. 2020). However, the visual stimuli used for the BAFF may have the potential to affect Green Sturgeon behavior. Ford et al. (2018) demonstrated that age-0 White Sturgeon are influenced by the color and strobe rate of light stimuli. Elvidge et al. (2019) showed sturgeon behavioral responses to various colors could change based on the ontogeny of the fish. Overall, Banan et al. (2011) indicated that while there are some light color effects on sturgeon, they appear limited so the BAFF visual stimuli will likely have minor behavioral influence on Green Sturgeon.

Overall, although it is possible that there may be negative effects to Green Sturgeon from GSSMB operations, such effects would be limited.

6.4.7.11 Significance of Impacts on North American Green Sturgeon

The Proposed Project would be consistent with Baseline Conditions in terms of having a low level of entrainment risk and similar Delta flow conditions for North American Green Sturgeon. Based on the analysis presented above (Section 6.4.7.1, "Delta SWP Facility Operations;" Section 6.4.7.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.7.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.7.4, "Delta Smelt Supplementation;" Section 6.4.7.5, "Water Transfers;" Section 6.4.7.6, "Agricultural Barriers;" Section 6.4.7.7, "Barker Slough Pumping Plant;" Section 6.4.7.8, "Clifton Court Forebay Weed Management;" Section 6.4.7.9, "Suisun Marsh Operations;" and Section 6.4.7.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on North American Green Sturgeon would be less than significant. No mitigation is required.

6.4.8 White Sturgeon

6.4.8.1 Delta SWP Facility Operations

Although there has historically been more salvage of White Sturgeon than Green Sturgeon, the salvage density of White Sturgeon is still relatively low (tens of fish or fewer per year). As a result, salvage as assessed with the salvage-density method (see Appendix 6B, Section 6B.1) would be expected to be low under the Proposed Project and Baseline Conditions, with limited differences anticipated between the scenarios based on modeled exports (Table ~~6-79~~ 6-81) and generally similar entrainment risk. As described in Section 2.3.4, "White Sturgeon Protection Measures," DWR proposes to convene a sturgeon technical team and develop studies (e.g., enhanced monitoring, life cycle model development) to better understand factors influencing White Sturgeon movement into the south Delta and CCF, with data from these studies being used to consider take reduction measures for implementation by 2027 through adaptive management. In the interim, DWR and

CDFW will develop information forming the basis for an assessment that would identify the need for take reduction measures related to SWP entrainment. Operational reduction measures implemented for other species (i.e., winter-run and spring-run Chinook Salmon, Delta Smelt, and Longfin Smelt) may also provide reduced entrainment risk for White Sturgeon.

Table ~~6-79~~ 6-81. Mean Number of White Sturgeon Juveniles Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~19~~ 21	~~20 (4%)~~ 21 (2%)
Above Normal	N/A	~~(1%)~~ (2%)
Below Normal	11	~~11 (-4%)~~ 10 (-5%)
Dry	~~3~~ 4	4 ~~(18%)~~ (17%)
Critically Dry	0	0 (0%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-7 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

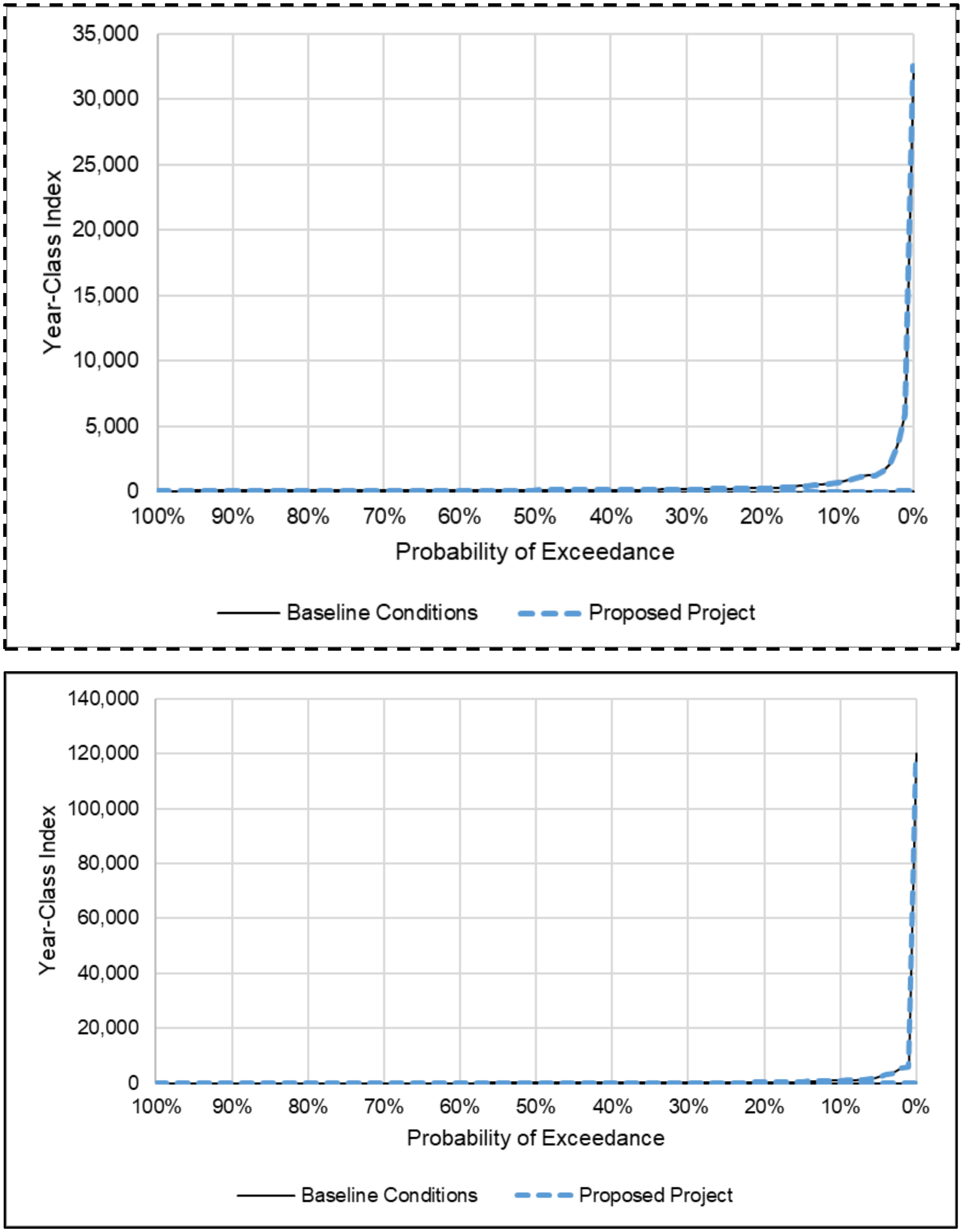
As discussed in Appendix 6A, previous studies have shown positive relationships between White Sturgeon year class strength and Delta outflow. The mechanism behind the importance of higher flows for White Sturgeon is not known and may involve both upstream and downstream (Delta) factors. Hypotheses for the mechanism underlying flow effects include higher flows facilitating young White Sturgeon dispersal downstream, providing increased freshwater rearing habitat, increasing spawning activity cued by higher upstream flows, increasing nutrient loading into nursery areas, or increasing downstream migration rate and survival through reduced exposure time to predators (U.S. Fish and Wildlife Service 1995:2-VII-39; Israel pers. comm. Feb. 20, 2012). Higher spring flows may also benefit incubating eggs (Heublein et al. 2017b:17), an effect occurring upstream of the Delta. Regression analyses were conducted that relate White Sturgeon year class strength to March–July and April–May Delta outflow (Appendix 6B, Section 6B.15, "White Sturgeon Delta Outflow—Year Class Strength Regression"). These analyses illustrated that there would be little difference in White Sturgeon year class strength between the Proposed Project and Baseline Conditions for either March–July or April–May Delta outflow periods (Table ~~6-80~~ 6-82, Figure 6-122, Table ~~6-81~~ 6-83, and Figure 6-123).[24]

[24] Comments received on the DEIR suggested that segmented regressions as opposed to linear regressions would be more appropriate; examination of this is provided in Appendix 6B, Section 6B.15, "White Sturgeon Delta Outflow—Year Class Strength Regression," and illustrates that the patterns are similar to those provided in this chapter, which would not change the significance conclusion provided in Section 6.4.8.11, "Significance of Impacts on White Sturgeon."

Table ~~6-80~~ 6-82 . Mean Annual White Sturgeon Year Class Strength, from the Regression Including March–July Delta Outflow and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped By Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~72.0~~ 159.4	~~71.8 (-0.4%)~~ 158.9 (-0.3%)
Above Normal	~~7.5~~ 7.3	~~7.4 (-1.3%)~~ 7.3 (-0.8%)
Below Normal	~~3.6~~ 3.8	~~3.6 (-0.6%)~~ 3.8 (-0.3%)
Dry	2.1	2.1 ~~(1.1%)~~ (2.0%)
Critically Dry	1.4	1.4 ~~(-0.8%)~~ (-0.5%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-122 for 95% prediction intervals)



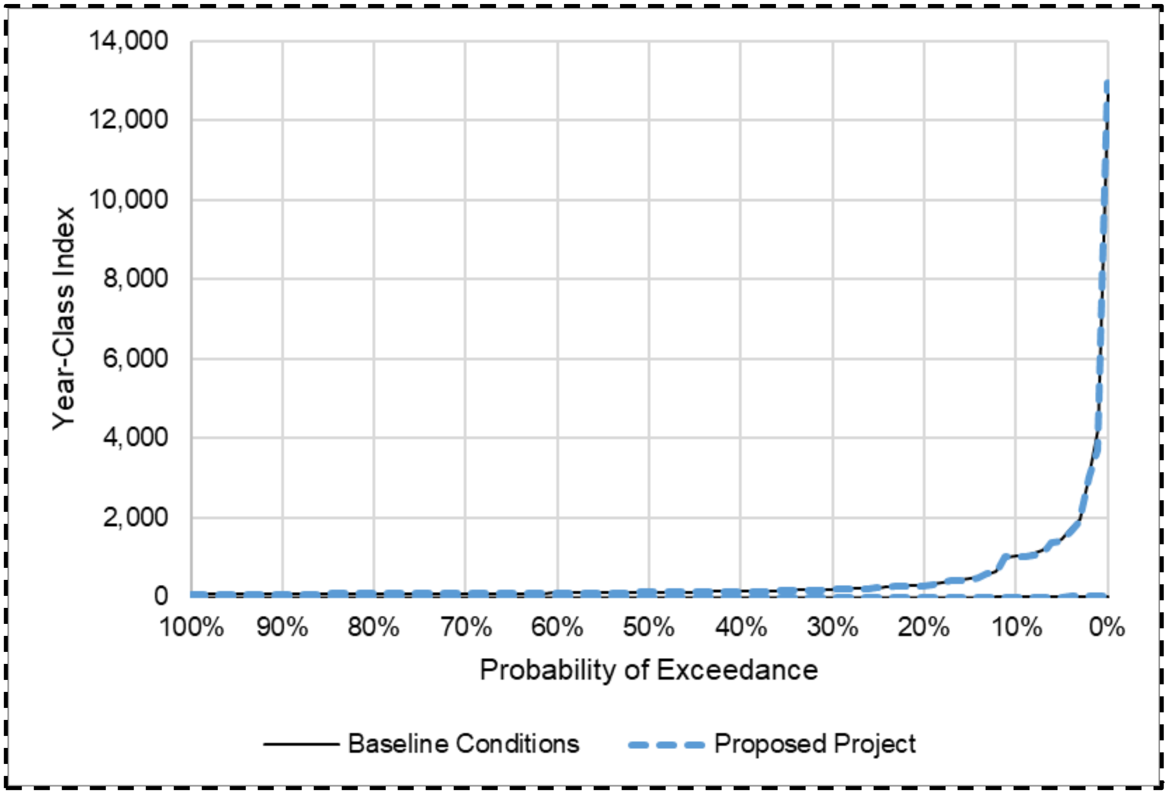
Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

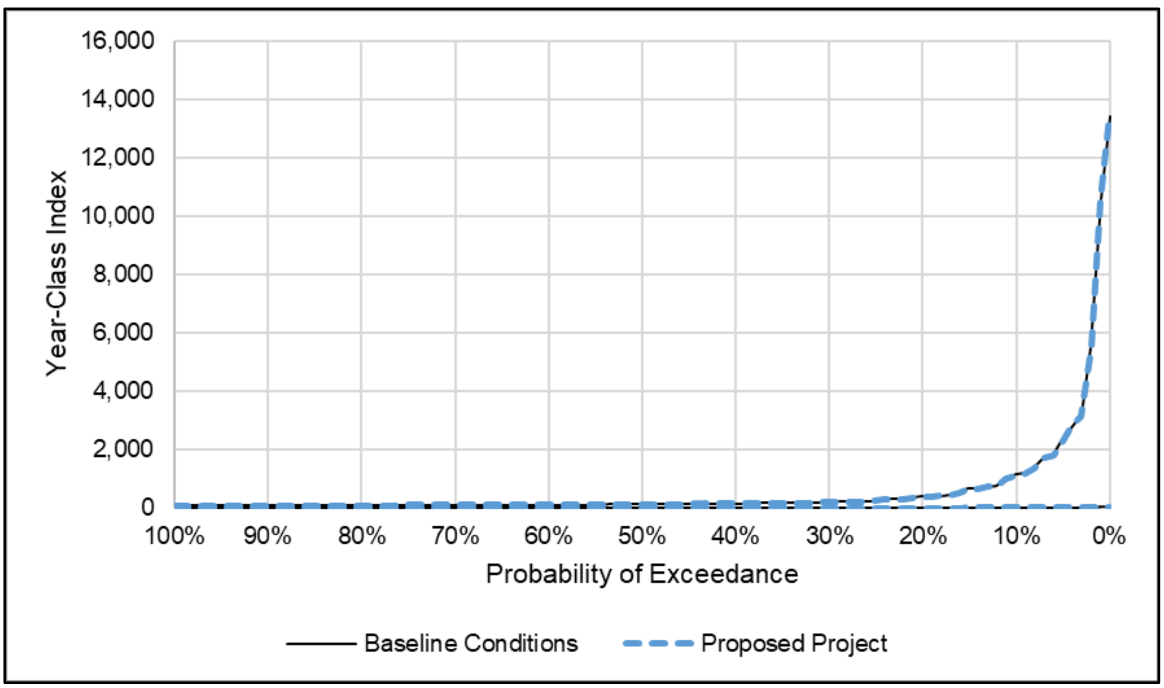
Figure 6-122. Exceedance Plot of White Sturgeon Year Class Strength Prediction Interval, Based on the Regression Including March–July Delta Outflow

Table ~~6-8~~ ~~1~~ 6-83 . Mean Annual White Sturgeon Year Class Strength, from the Regression Including April–May Delta Outflow and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped By Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~44.8~~ 59.0	~~43.7 (-2.4%)~~ 58.4 (-1.1%)
Above Normal	6.7	6.4 ~~(-4.0%)~~ (-4.2%)
Below Normal	4.7	4.5 (-4.2%)
Dry	~~2.5~~ 2.4	2.5 ~~(0.2%)~~ (1.4%)
Critically Dry	~~1.8~~ 1.7	1.7 ~~(-1.6%)~~ (-1.4%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-123 for 95% prediction intervals)





Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

Figure 6-123. Exceedance Plot of White Sturgeon Year Class Strength Prediction Interval, Based on the Regression Including April–May Delta Outflow

6.4.8.2 Delta Smelt Summer and Fall Habitat Actions

There would be considerable temporal overlap of Delta Smelt Summer and Fall Habitat Actions with White Sturgeon occurrence in the Delta (Tables 6A-11 and 6A-12 in Appendix 6A), although it is unknown what proportion of individuals may encounter the SMSCG in Montezuma Slough. Boat lock passage would be available past the gates when closed under both the Proposed Project and Baseline Conditions. Any short delays occurring would be unlikely to greatly affect the ability of White Sturgeon to move within their overall range, and the winter/spring adult upstream migration period (see Appendix 6A) would not coincide with the Delta Smelt Summer and Fall Habitat Actions.

6.4.8.3 John E. Skinner Delta Fish Protective Facility

Any activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—would have limited effects on White Sturgeon because there would be few White Sturgeon being exposed to the facility, as discussed in Section 6.4.8.1, “Delta SWP Facility Operations.” To the extent that White Sturgeon do occur at the facility, salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss (although predation-related losses are likely to be lower than smaller-bodied species that lack scutes such as juvenile salmonids), but such decreases or increases would be of relatively few fish in population-level terms.

6.4.8.4 Delta Smelt Supplementation

There is some limited dietary overlap between White Sturgeon and Delta Smelt as both have been noted as eating benthic prey such as amphipods and mysids (Appendix 6A, Section 6A.1.8, “White Sturgeon”; Slater et al. 2019). However, supplementation of Delta Smelt would be unlikely to have appreciable negative effects on White Sturgeon because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential competitors with White Sturgeon for prey resources.

6.4.8.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and overlaps White Sturgeon occurrence in the Delta. The potential for greater south Delta entrainment would exist for White Sturgeon occurring during the water transfer window, but numbers of fish would be limited based on salvage data from the past decade (Section 6.4.8.1, “Delta SWP Facility Operations”). This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.8.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on White Sturgeon would be similar between the scenarios. The proportion of the White Sturgeon population exposed to the agricultural barriers is likely low because of the barrier location in the south Delta, as suggested by relatively few White Sturgeon salvaged at the south Delta export facilities in recent years (see Section 6.4.8.1 and Appendix 6A) and observations that most spawning occurs in the Sacramento River (see Appendix 6A). Operation of the barriers beginning in May would not overlap the adult winter upstream migration period through the Delta and therefore would not be a substantial impediment. Juvenile and non-migrating adult White Sturgeon in the Delta could encounter the barriers and have movement blocked but such effects would be expected to occur on only a small proportion of the population.

6.4.8.7 Barker Slough Pumping Plant

Operations of the BSPP would be expected to have minimal effects on White Sturgeon because BSPP fish screens are designed to protect juvenile salmonids per NMFS criteria. These criteria include low approach velocity that is generally below recommended water flow velocity to protect present White Sturgeon life stages (Verhille et al. 2014). As described in Appendix 6A, White Sturgeon larvae may occur in the Delta during spring of higher outflow years, potentially making them susceptible to entrainment through the fish screens given that there is no recommended approach velocity during this time period (Verhille et al. 2014). Any such larval entrainment risk would be similar between the Proposed Project and Baseline Conditions because BSPP diversions would be similar between the scenarios (see Tables 4B.3-1-1a, 4B.3-1-1b, and 4B.3-1-1c in Attachment 3 of Appendix 4B). BSPP diversion restrictions described in Chapter 2 for protection of larval Longfin Smelt (January 1–March 31 of Dry and Critically Dry water years) and larval Delta Smelt (March 1–June 30 of Dry and Critically Dry water years) would also reduce the already low potential for effects on White Sturgeon.

Sediment removal by suction dredge at BSPP would have the potential to entrain larval and juvenile White Sturgeon, although the numbers would be expected to be limited given low numbers of larvae and juveniles expected to occur in the area and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on White Sturgeon given that abundance would be expected to be low in the vicinity and any White Sturgeon present nearby could swim away from the disturbance.

6.4.8.8 Clifton Court Forebay Weed Management

As described previously in the discussion regarding the Skinner Fish Facility, based on historical data from the past decade, relatively low numbers of White Sturgeon would occur in CCF. Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months, a time period when historical salvage of White Sturgeon has occurred (as reflected in the monthly results from the salvage-density method; see Table 6B-7 in Appendix 6B). Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and therefore could coincide with occurrence of White Sturgeon, with occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual White Sturgeon from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes (although such risk is likely to be lower for White Sturgeon with scutes than for smaller-bodied fish) and increases in salvage efficiency because of reduced smothering by weeds. However, such positive or negative effects would only be on limited numbers of White Sturgeon individuals.

6.4.8.9 Suisun Marsh Operations

Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement coincides with the winter/spring upstream migration period of adult White Sturgeon, as well as with general occurrence of adult and juvenile White Sturgeon (Miller et al. 2020). Operational criteria are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt summer and fall habitat actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.8.2, "Delta Smelt Summer and Fall Habitat Actions.") Montezuma Slough provides an upstream migration route, but the proportion of the total run utilizing this route is unknown; existing studies for Green Sturgeon suggest that Suisun and Honker Bays are more utilized (National Marine Fisheries Service 2019:463), which could also be the case for White Sturgeon. As previously noted, operation of the SMSCG is unlikely to negatively affect juvenile Green Sturgeon because the juveniles are relatively large and unlikely prey for predators such as Striped Bass and Sacramento Pikeminnow (National Marine Fisheries Service 2019:463); this would also be true for White Sturgeon. As with Green Sturgeon, the generalized movements of White Sturgeon are unlikely to be negatively affected by periodic delays ranging from a few hours to a few days caused by SMSCG operations (National Marine Fisheries Service 2019:463). Any effect such as short-term migration delay of a few hours to several days would be consistent between the Proposed Project and Baseline Conditions scenarios. Any effects of the other Suisun Marsh facilities (MIDS, RRDS, and the Goodyear Slough Outfall) would be expected to be minor for the reasons discussed for Delta Smelt (e.g., no observed entrainment at MIDS; Enos et al. 2007) and would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.8.10 Georgiana Slough Salmonid Migratory Barrier Operations

Although there are differences in life history between White Sturgeon and Green Sturgeon (see Appendix 6A), the effects of the GSSMB on White Sturgeon would be expected to be generally similar to those discussed for Green Sturgeon in Section 6.4.7.10, "Georgiana Slough Salmonid Migratory Barrier Operations." Although it is possible that there may be negative effects to White Sturgeon from GSSMB operations, such effects would be limited.

6.4.8.11 Significance of Impacts on White Sturgeon

The Proposed Project would be consistent with Baseline Conditions in terms of having a low level of entrainment risk and similar Delta outflow conditions for White Sturgeon, with studies and adaptive management to address south Delta entrainment risk. Based on the analysis presented above (Section 6.4.8.1, "Delta SWP Facility Operations;" Section 6.4.8.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.8.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.8.4, "Delta Smelt Supplementation;" Section 6.4.8.5, "Water Transfers;" Section 6.4.8.6, "Agricultural Barriers;" Section 6.4.8.7, "Barker Slough Pumping Plant;" Section 6.4.8.8, "Clifton Court Forebay Weed Management;" Section 6.4.8.9, "Suisun Marsh Operations;" and Section 6.4.8.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on White Sturgeon would be less than significant. No mitigation is required.

6.4.9 Pacific Lamprey and Western River Lamprey

6.4.9.1 Delta SWP Facility Operations

Application of the salvage-density method (Appendix 6B, Section 6B.1) indicated that there would be little difference in SWP south Delta exports between the Proposed Project and Baseline Conditions during the time period of lamprey[25] salvage (Table ~~6-82~~ 6-84). It is not known what proportion of lamprey are entrained at the south Delta export facilities, but the available information on overall Delta habitat occupancy suggests that the proportion would be low, given low occurrence in the south Delta (Goertler et al. 2020).

Table ~~6-82~~ 6-84. Mean Number of Lamprey Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~863~~ 952	~~863 (0%)~~ 943 (-1%)
Above Normal	N/A	~~(-2%)~~ (-3%)
Below Normal	~~167~~ 174	~~163 (-2%)~~ 168 (-3%)
Dry	~~120~~ 119	~~118 (-2%)~~ 107 (-10%)
Critically Dry	~~125~~ 123	~~145 (15%)~~ 136 (11%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-8 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

In contrast to some other fish and aquatic species occurring in the Delta, there are no established quantitative relationships between Delta flows and Pacific Lamprey or Western River Lamprey. Any effects of the Proposed Project on Pacific Lamprey and Western River Lamprey relative to Baseline Conditions would be expected to be limited given the limited differences in Delta flow conditions between the scenarios (see flow summaries presented in Appendix 4B, Attachment 2).

6.4.9.2 Delta Smelt Summer and Fall Habitat Actions

The proportion of Pacific Lamprey and Western River Lamprey populations encountering the SMSCG during operations for Delta Smelt Summer and Fall Habitat Actions is unknown but likely to be low. The two lamprey species occur in Suisun Marsh (O'Rear et al. 2023) but overall the occupancy of the area is much lower than the northern and central portions of the Delta (Goertler et al. 2020). Boat lock passage would be available past the gates when closed under both the Proposed Project and Baseline Conditions. Any short delays occurring would be unlikely to greatly affect the ability of Pacific Lamprey or Western River Lamprey to move within their overall range. The Pacific Lamprey adult upstream migration period (spring, March–June; see Section 6A.1.9, "Pacific Lamprey" in Appendix 6A) would not coincide with the Delta Smelt Summer and Fall Habitat Actions, whereas the Western River Lamprey adult upstream migration period (fall through late

[25] Lamprey are generally not identified to species in salvage samples, so were grouped for this analysis.

winter; see Section 6A.1.10, "Western River Lamprey," in Appendix 6A) could partly coincide with the Delta Smelt Summer and Fall Habitat Actions. As noted above, any delays would only be on the order of hours long, not likely affecting upstream migration to any great degree.

6.4.9.3 John E. Skinner Delta Fish Protective Facility

Any activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—would have limited effects on Pacific Lamprey and Western River Lamprey because the available distribution information indicates low occurrence in the south Delta and therefore relatively few individuals being exposed to the facility, as discussed in Section 6.4.9.1, "Delta SWP Facility Operations." To the extent that Pacific Lamprey and Western River Lamprey do occur at the facility, salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss, but such decreases or increases would be of relatively few fish in population-level terms.

6.4.9.4 Delta Smelt Supplementation

Delta Smelt supplementation would have essentially no effect on Pacific Lamprey or Western River Lamprey because release of Delta Smelt would not be likely to provide a source of prey or potential competition or predation risk for lampreys, given the ecology of the species (Moyle et al. 2015).

6.4.9.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and overlaps Pacific Lamprey and Western River Lamprey occurrence in the Delta. The potential for greater south Delta entrainment would exist for Pacific Lamprey and Western River Lamprey occurring during the water transfer window, but numbers of fish would be limited because the water transfer window does not overlap the main migratory periods (see Appendix 6A and monthly results from the salvage-density method in Appendix 6B). This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.9.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on Pacific Lamprey and Western River Lamprey would be similar between the scenarios. The proportion of the Pacific Lamprey and Western River Lamprey populations exposed to the agricultural barriers is likely low because of the barrier location in the south Delta and low occupancy by lamprey of the south Delta (see Section 6.4.9.1). Operation of the barriers beginning in May would overlap the Pacific Lamprey adult spring upstream migration period through the Delta and therefore could partly impede upstream migration; however, as described in Appendix 2A, one culvert at each of the three barriers will be left open and not operated tidally until June 1, allowing passage of fish. Notching of the Old River Tracy and Middle River barriers occurs in August or September to facilitate upstream passage of adult fall-run Chinook Salmon returning to the San Joaquin River Basin, which also would provide passage opportunities for upstream-migrating adult Western River Lamprey if encountering the barriers during their fall/winter migration (see Appendix 6A).

6.4.9.7 Barker Slough Pumping Plant

Pacific Lamprey and Western River Lamprey ammocoetes could be entrained at BSPP if they are passing close by during operational periods and of sufficiently small size (Rose and Mesa 2012). It is not known what proportion of the two species' ammocoetes may occur near BSPP, although it is likely to be low given the location of the pumping plant near the end of a tidal slough that is some distance away from likely main migratory pathways such as Cache Slough and the Sacramento River. Larger migrating juvenile lamprey (macrophthalmia, around 120-mm total length) would not be at risk of entrainment because of their size. Impingement risk for lamprey macrophthalmia would be very low because the intakes' fish screens are designed to be protective of listed fish and include approach velocity that is low relative to the magnitude of velocity noted to create impinge risk (Moser et al. 2015). Given the tendency for elevated river flows/precipitation events to coincide with Pacific Lamprey macrophthalmia migrating in very high numbers (Goodman et al. 2015) or ammocoetes being flushed from burrows (Rose and Mesa 2012), the winter/spring period may be the main period of movement and vulnerability to diversion flow effects. Any such vulnerability would be similar between the scenarios because BSPP operations would be similar between the scenarios (see Tables 4B.3-1-1a, 4B.3-1-1b, and 4B.3-1-1c in Attachment 3 of Appendix 4B).

Sediment removal by suction dredge at BSPP would have the potential to entrain Pacific Lamprey and Western River Lamprey, although the numbers would be expected to be limited given the very low portion of overall potentially occupied habitat that would be affected and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on Pacific Lamprey and Western River Lamprey, given the very low portion of overall potentially occupied habitat that would be affected.

6.4.9.8 Clifton Court Forebay Weed Management

There would be limited effects on Pacific Lamprey and Western River Lamprey from CCF weed management because the available distribution information indicates low occurrence in the south Delta and therefore relatively few individuals likely to occur in CCF (see further discussion regarding Skinner Fish Facility). Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months, a time period when limited historical salvage of Pacific Lamprey and Western River Lamprey has occurred (as reflected in the monthly results from the salvage-density method; see Table 6B-88 in Appendix 6B). Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and therefore could coincide with occurrence of Pacific Lamprey and Western River Lamprey, with occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual lamprey from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds (although salvage efficiency for lampreys is low in any case; Goodman et al. 2017). Any positive or negative effects would only be on limited numbers of Pacific Lamprey and Western River Lamprey individuals.

6.4.9.9 Suisun Marsh Operations

Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement coincides with upstream migration periods of adult Pacific Lamprey (spring) and adult Western River Lamprey (fall/winter) described in Appendix 6A. Operational criteria are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt summer and fall habitat actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.9.2, "Delta Smelt Summer and Fall Habitat Actions.") Montezuma Slough provides an upstream migration route, but the proportion of the total Pacific Lamprey and Western River Lamprey populations utilizing this route is unknown. Negative effects on Pacific Lamprey and Western River Lamprey as a result of SMSCG operations such as short-term migration delay would be limited to a few hours to several days and would be consistent between the Proposed Project and Baseline Conditions scenarios. Any effects of the other Suisun Marsh facilities (MIDS, RRDS, and the Goodyear Slough Outfall) would be expected to be minor for the reasons discussed for Delta Smelt (e.g., no observed entrainment at MIDS; Enos et al. 2007) and would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.9.10 Georgiana Slough Salmonid Migratory Barrier Operations

Pacific Lamprey and Western River Lamprey from the Sacramento River basin may encounter GSSMB operations during upstream migration as adults or downstream migration/movement as ammocoetes/macropthalmia. As discussed further for Delta Smelt in Section 6.4.1.10, "Georgiana Slough Salmonid Migratory Barrier Operations," there is limited evidence that negative effects such as greater predation from predators associated with the BAFF in-water structure would occur. On the basis of lamprey deterrence results from similar types of barrier (Maes et al. 2004), Pacific Lamprey and Western River Lamprey would not be expected to be significantly deterred from either upstream or downstream migration. Although it is possible that there may be negative effects to Pacific Lamprey from GSSMB operations, such effects would be limited.

6.4.9.11 Significance of Impacts on Pacific Lamprey and Western River Lamprey

The Proposed Project would have a generally similar and likely low level of entrainment risk for Pacific Lamprey and Western River Lamprey as Baseline Conditions, as well similar Delta flow conditions. Based on the analysis presented above (Section 6.4.9.1, "Delta SWP Facility Operations;" Section 6.4.9.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.9.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.9.4, "Delta Smelt Supplementation;" Section 6.4.9.5, "Water Transfers;" Section 6.4.9.6, "Agricultural Barriers;" Section 6.4.9.7, "Barker Slough Pumping Plant;" Section 6.4.9.8, "Clifton Court Forebay Weed Management;" Section 6.4.9.9, "Suisun Marsh Operations;" and Section 6.4.9.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on Pacific Lamprey and Western River Lamprey would be less than significant. No mitigation is required.

6.4.10 Native Minnows (Sacramento Hitch, Sacramento Splittail, Hardhead, and Central California Roach)

6.4.10.1 Delta SWP Facility Operations

Hardhead occur in relatively small numbers in the Delta compared to upstream (see discussion in Appendix 6A), so Delta SWP facility operations effects on the species would be limited. Sacramento Hitch abundance is relatively low in the Delta and the species is widespread upstream of the Delta in the Sacramento River (Appendix 6A and Moyle et al. 2015:287–288). As described in Appendix 6A, Central California Roach is mostly distributed upstream of the Delta ~~, resulting in limited potential effects of the north Delta intakes~~ . Data collated for the salvage-density method (Appendix 6B, Section 6B.1) indicate that very few Sacramento Hitch, Hardhead, or Central California Roach are salvaged at the south Delta export facilities, reflecting very low abundance in the south Delta, so operations under the Proposed Project would be similar to Baseline Conditions in entraining very few individuals (Tables ~~6-83, 6-84, and 6-85~~ <u>6-85, 6-86, and 6-87</u>).

Relative to the other native minnow species, Sacramento Splittail can be salvaged in very high numbers. The salvage-density method indicated that there is the potential for appreciably higher entrainment of Sacramento Splittail under the Proposed Project in Wet and Above Normal years relative to Baseline Conditions (Table ~~6-86~~). This results from species overlap with the spring period of greater south Delta exports under the Proposed Project. Sacramento Splittail may receive some ancillary protection from entrainment with OMR flow management implemented for listed smelts and salmon. Although entrainment may increase, the main driver of Sacramento Splittail population dynamics appears to be spring inundation of floodplain habitat such as the Yolo Bypass (Sommer et al. 1997), which as discussed in Section 6.4.1, "Delta Smelt" would not change under the Proposed Project relative to Baseline Conditions.

Table ~~6-83~~ <u>6-85</u> . Mean Number of Sacramento Hitch Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	1	~~1 (5%)~~ <u>2 (12%)</u>
Above Normal	N/A	~~(100%)~~ <u>(72%)</u>
Below Normal	~~7~~ <u>6</u>	~~7 (-3%)~~ <u>6 (-2%)</u>
Dry	1	1 ~~(1%)~~ <u>(4%)</u>
Critically Dry	0	0 (0%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-9 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table ~~6-84~~ 6-86. Mean Number of Hardhead Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	1	1 ~~(5%)~~ (12%)
Above Normal	N/A	~~(100%)~~ (72%)
Below Normal	0	0 (0%)
Dry	0	0 (0%)
Critically Dry	2	2 ~~(1%)~~ (0%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-10 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table ~~6-85~~ 6-87. Mean Number of Central California Roach Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	0	0 (0%)
Above Normal	N/A	~~0~~ (0%)
Below Normal	0	0 (0%)
Dry	0	0 (0%)
Critically Dry	0	0 ~~(-5%)~~ (-12%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-11 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table ~~6-86~~ 6-88. Mean Number of Sacramento Splittail Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~650,024~~ 760,088	~~854,297 (31%)~~ 897,948 (18%)
Above Normal	N/A	~~(38%)~~ (45%)
Below Normal	~~6,440~~ 6,681	~~6,486 (1%)~~ 6,677 (0%)
Dry	~~568~~ 586	~~594 (5%)~~ 562 (-4%)
Critically Dry	~~245~~ 233	~~239 (-2%)~~ 231 (-1%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-12 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

6.4.10.2 Delta Smelt Summer and Fall Habitat Actions

Operation of the SMSCG generally would provide a similar extent of low-salinity habitat in Suisun Marsh under the Proposed Project and Baseline Conditions. Long-term sampling (1979–2022) found that Sacramento Splittail is by far the most commonly collected native minnow species in Suisun Marsh, two orders of magnitude more abundant than Sacramento Hitch; during the 1979–2022 sampling period there was only one Hardhead collected, and zero Central California Roach (O'Rear et al. 2023), reflecting the primarily upstream distribution of these species. Lowering of salinity in Suisun Marsh may have limited effect on Sacramento Splittail because the species occurs within the range 0–12 ppt and has high salinity tolerance (Young and Cech 1996; Feyrer et al. 2015c), but may provide a greater extent of habitat for Sacramento Hitch, which tolerate low salinity (Moyle et al. 2015). Boat lock passage would be available past the gates when closed under both the Proposed Project and Baseline Conditions. SMSCG operations for the Delta Smelt Summer and Fall Habitat Actions would avoid the main winter/spring upstream migration period of Sacramento Splittail to spawn in areas such as the Yolo Bypass (see Appendix 6A).

6.4.10.3 John E. Skinner Delta Fish Protective Facility

Activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—could potentially affect native minnows (primarily Sacramento Splittail, per the discussion above in Section 6.4.10.1, "Delta SWP Facility Operations"). Salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss during the salvage process. Any such effects would be limited because entrainment mortality is not the main driver of population dynamics, as described in Section 6.4.10.1.

6.4.10.4 Delta Smelt Supplementation

As previously noted, Sacramento Splittail is main native minnow species occurring in the Delta. There is some limited dietary overlap between Sacramento Splittail and Delta Smelt as both have been noted to eat benthic prey such as amphipods (Slater et al. 2019; Colombano et al. 2021). However, supplementation of Delta Smelt would be unlikely to have appreciable negative effects on Sacramento Splittail because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential competitors with Sacramento Splittail for prey resources.

6.4.10.5 Water Transfers

As previously noted, Sacramento Splittail is the main native minnow species occurring in the Delta and therefore is most likely to experience any effects from water transfers. The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and overlaps Sacramento Splittail occurrence in the Delta. The potential for greater south Delta entrainment would exist for Sacramento Splittail occurring during the water transfer window, although the water transfer window is outside the main period of entrainment risk see (see monthly salvage-density Table 6B-12 in Appendix 6B). As described in Section 6.4.10.1, entrainment mortality is not the main driver of population dynamics. This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.10.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on native minnows (primarily Sacramento Splittail, per discussion in Section 6.4.10.1) would be similar between the scenarios. Historical salvage data indicate appreciable numbers of Sacramento Splittail occurring in the south Delta. Operation of the barriers beginning in May would be unlikely to have appreciable temporal overlap with adult Sacramento Splittail's winter/spring upstream migration period through the Delta (Appendix 6A) and therefore would be unlikely to impede upstream migration to any considerable degree. Downstream-migrating Sacramento Splittail juveniles could be at risk from barrier effects such as near-field predation, although the effects would be consistent between the Proposed Project and Baseline Conditions.

6.4.10.7 Barker Slough Pumping Plant

As previously noted, Sacramento Splittail is the main native minnow species occurring in the Delta and therefore most likely to experience any effects from the BSPP, although Yip et al. (2017, 2019) also collected Sacramento Hitch during larval entrainment sampling in 2015–2016. Laboratory investigations suggest Splittail exposed to fish screens do not have significant sublethal effects or increased mortality (Danley et al. 2002); therefore, the BSPP fish screens would be protective of individuals large enough to be screened, and possibly also to some degree for larvae that are smaller than expected to be screened based on size (as shown for other species; Nobriga et al. 2004). The entrainment rate of larval Sacramento Splittail or other native minnows would be expected to be similar between the Proposed Project and Baseline Conditions given the similarity in modeled pumping between the scenarios (see Tables 4B.3-1-1a, 4B.3-1-1b, and 4B.3-1-1c in Attachment 3 of Appendix 4B).

Sediment removal by suction dredge at BSPP would have the potential to entrain native minnows, although the numbers would be expected to be limited given the very low portion of overall potentially occupied habitat that would be affected and relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on native minnows, given the very low portion of overall potentially occupied habitat that would be affected.

6.4.10.8 Clifton Court Forebay Weed Management

Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months, a time period when historical salvage of native minnows (primarily Sacramento Splittail, per the discussion in Section 6.4.10.1) has occurred (as reflected in the monthly results from the salvage-density method; see Tables 6B-9 through 6B-12 in Appendix 6B). Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and therefore could coincide with occurrence of Sacramento Splittail, with fish occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual native minnows from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds. As noted previously, entrainment-related effects are not major drivers of Sacramento Splittail population dynamics, indicating that any positive or negative effects attributable to CCF weed management would have minimal consequence for the Sacramento Splittail population.

6.4.10.9 Suisun Marsh Operations

Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement coincides with the winter/spring upstream migration period of Sacramento Splittail described in Appendix 6A. Operational criteria are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt Summer and Fall Habitat Actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.10.2, "Delta Smelt Summer and Fall Habitat Actions.") Negative effects on Sacramento Splittail as a result of SMSCG operations such as short-term migration delay would be limited to a few hours to several days and would be consistent between the Proposed Project and Baseline Conditions scenarios. There may be effects from the other Suisun Marsh facilities including entrainment at MIDS (Enos et al. 2007) and entrainment through and out of the Goodyear Slough Outfall. The RRDS has fish screens operated to low approach velocity (see Chapter 2); as described for the BSPP, laboratory investigations suggest Splittail exposed to fish screens do not have significant sublethal effects or increased mortality (Danley et al. 2002). Any effects of Suisun Marsh operations would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.10.10 Georgiana Slough Salmonid Migratory Barrier Operations

Of the various native minnow species, Sacramento Splittail likely have the greatest potential to encounter the operations of the GSSMB, both as juveniles moving downstream in spring/early summer and as adults moving upstream prior to spring spawning. Sacramento splittail are cyprinids, a family of fish that is regarded as hearing specialists and therefore would be expected to be sensitive to the acoustic stimuli of the BAFF (Nedwell et al. 2004). This sensitivity could deter juveniles migrating from the Sacramento River from entering the interior Delta, which if similar to juvenile salmonids, could give positive effects to survival in the Delta; this is uncertain. As described in more detail for Delta Smelt in in Section 6.4.1.10, "Georgiana Slough Salmonid Migratory Barrier Operations," although there could be negative effects to adult upstream migration Georgiana Slough to the Sacramento River, there is space around and underneath the barrier that adult Sacramento Splittail could use for migration. As also discussed in more detail for Delta Smelt, there is limited evidence for potential negative effects related to greater predation from predators associated with the BAFF in-water structure. Although it is possible that there may be negative effects to Sacramento Splittail from GSSMB operations, such effects would be limited; as noted above, the potential for positive effects may exist (deterrence from entry into the interior Delta), although given the apparent importance of floodplain inundation (particularly the Yolo Bypass) in driving the species' population dynamics (Sommer et al. 1997), any effects from GSSMB operations would be limited at the population level.

6.4.10.11 Significance of Impacts on Native Minnows

The Proposed Project would have similar, very low risk of entrainment for Sacramento Hitch, Hardhead, and Central California Roach compared to Baseline Conditions. Although entrainment risk could increase under the Proposed Project for Sacramento Splittail, some ancillary protection may occur from OMR flow management implemented for listed smelts and salmon, and any increases in entrainment would not result in significant impacts because the main driver of population dynamics (floodplain inundation) would not differ between the Proposed Project and Baseline Conditions. Based on the analysis presented above (Section 6.4.10.1, "Delta SWP Facility

Operations;" Section 6.4.10.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.10.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.10.4, "Delta Smelt Supplementation;" Section 6.4.10.5, "Water Transfers;" Section 6.4.10.6, "Agricultural Barriers;" Section 6.4.10.7, "Barker Slough Pumping Plant;" Section 6.4.10.8, "Clifton Court Forebay Weed Management;" Section 6.4.10.9, "Suisun Marsh Operations;" and Section 6.4.10.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on native minnows would be less than significant. No mitigation is required.

6.4.11 Starry Flounder

6.4.11.1 Delta SWP Facility Operations

Application of the salvage-density method (Appendix 6B, Section 6B.1) indicated that SWP south Delta exports under the Proposed Project would be somewhat greater than under Baseline Conditions during the period that Starry Flounder salvage has historically occurred (Table ~~6-87~~ 6-89). This indicates the potential for somewhat greater entrainment risk under the Proposed Project, but overall salvage has historically been quite low, as would be expected given the species' distribution primarily in areas farther downstream (Baxter 1999; Appendix 6A).

Table ~~6-87~~ 6-89. Mean Number of Starry Flounder Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~68~~ 72	~~73 (8%)~~ 76 (5%)
Above Normal	N/A	(8%)
Below Normal	~~134~~ 143	~~155~~ 166 (16%)
Dry	~~17~~ 16	~~19 (15%)~~ 17 (7%)
Critically Dry	1	1 ~~(-1%)~~ (0%)

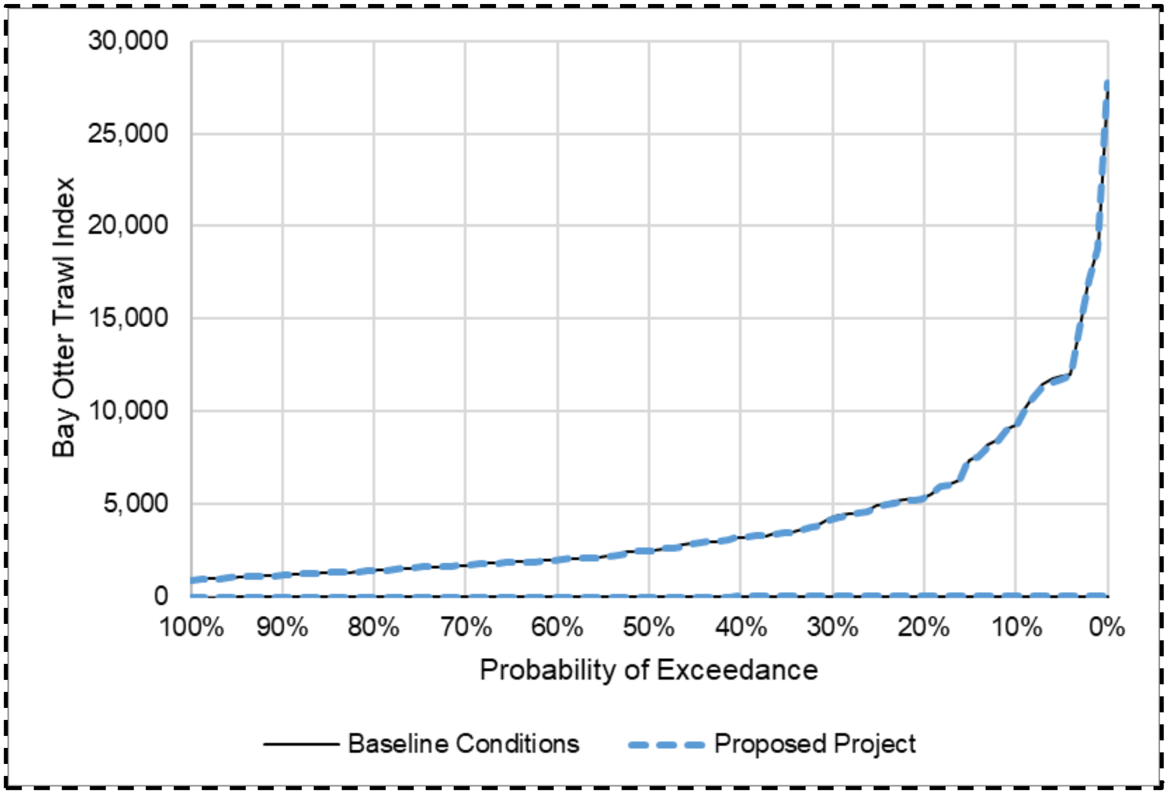
Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-13 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

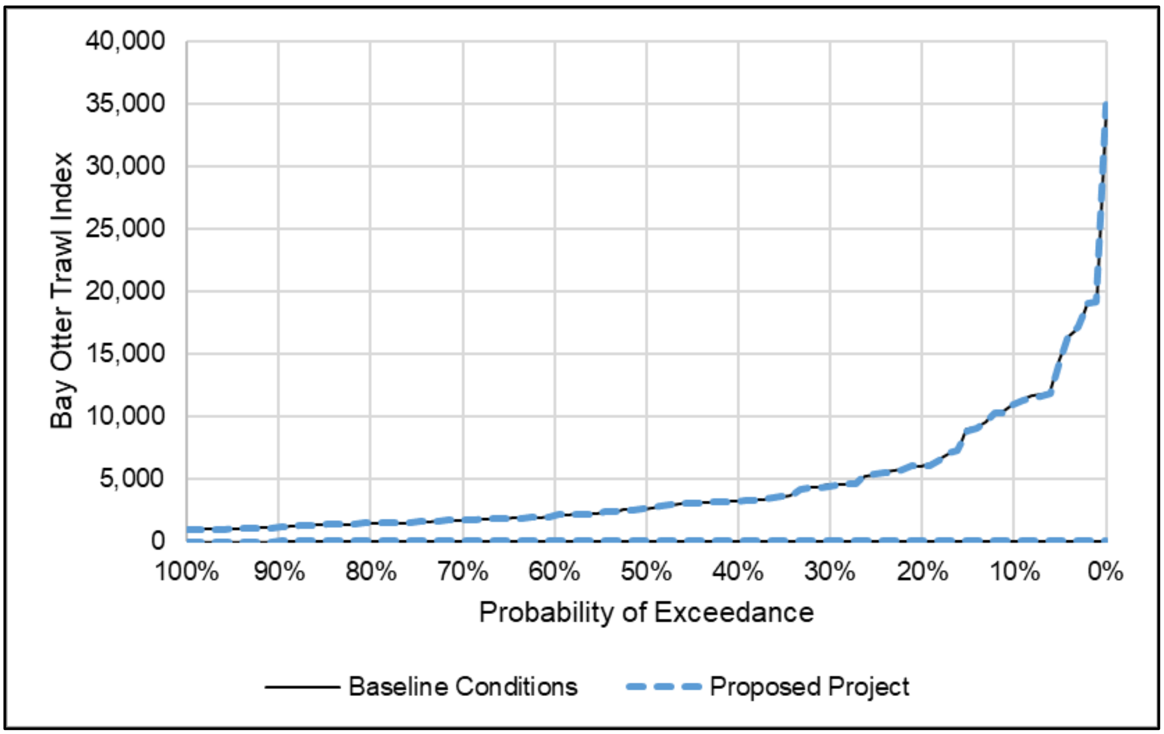
The abundance index of Age 1+ Starry Flounder has been found to be negatively correlated with spring (March–June) X2 (Kimmerer et al. 2009), indicating a positive correlation with Delta outflow. A statistically significant positive regression relationship based on 2003–2022 data was used to assess the potential effect of the Proposed Project on Starry Flounder (Appendix 6B, Section 6B.16, "Delta Outflow–Abundance Index Regressions (Starry Flounder, Striped Bass, American Shad, and California Bay Shrimp)"). The results of this analysis indicated little difference between the Proposed Project and Baseline Conditions (Table ~~6-88~~ 6-90 and Figure 6-124).

Table ~~6-88~~ 6-90 . Mean Annual Starry Flounder Age 1+ Bay Study Otter Trawl Abundance Index, from the Regression Including March–June Delta Outflow and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped By Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~243.2~~ 266.3	~~241.4 (-0.8%)~~ 265.0 (-0.5%)
Above Normal	~~145.0~~ 142.0	~~144.5 (-0.3%)~~ 142.2 (0.1%)
Below Normal	~~88.3~~ 91.5	~~88.2 (-0.1%)~~ 91.8 (0.4%)
Dry	~~56.7~~ 56.3	~~57.5 (1.5%)~~ 57.8 (2.6%)
Critically Dry	~~36.1~~ 35.0	~~35.7 (-1.2%)~~ 34.7 (-0.8%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-124 for 95% prediction intervals)





Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

Figure 6-124. Exceedance Plot of Starry Flounder Age 1+ Bay Study Otter Trawl Abundance Index, Based on the Regression Including March–June Delta Outflow

6.4.11.2 Delta Smelt Summer and Fall Habitat Actions

Operation of the SMSCG generally would provide a similar extent of low-salinity habitat in Suisun Marsh under the Proposed Project and Baseline Conditions. Long-term sampling (1979–~~2014~~ 2022) found that Starry Flounder commonly occurs in Suisun Marsh (O'Rear et al. 2023). Lowering of salinity in Suisun Marsh would have limited effect on Starry Flounder because habitat criteria for young-of-the-year fish include salinity less than 22 ppt (Appendix 6A). Boat lock passage would be available past the gates when closed under both the Proposed Project and Baseline Conditions. Operation of the SMSCG for the Delta Smelt Summer and Fall Habitat Actions would not disrupt major migratory movements because the species spawns in the nearshore coastal ocean and is broadly distributed (Appendix 6A).

6.4.11.3 John E. Skinner Delta Fish Protective Facility

Activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—could potentially affect Starry Flounder. Salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss during the salvage process. Any such effects would be limited because salvage has historically been quite low, reflecting the species' distribution primarily in areas farther downstream (Section 6.4.11.1, "Delta SWP Facility Operations").

6.4.11.4 Delta Smelt Supplementation

There is likely to be limited dietary overlap between Starry Flounder and Delta Smelt, as both have been noted to eat benthic prey such as amphipods, although Delta Smelt's primary prey is non-benthic zooplanktonic prey (Slater et al. 2019; Appendix 6A). Starry Flounder have also been noted to prey upon small fishes (Appendix 6A). Supplementation of Delta Smelt would be unlikely to have appreciable effects on Starry Flounder because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential prey sources and relative to other potential competitors with Starry Flounder for prey resources.

6.4.11.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and overlaps Starry Flounder occurrence in the Delta. The potential for greater south Delta entrainment would exist for Starry Flounder occurring during the water transfer window, although the water transfer window is outside the main period of entrainment risk (see monthly salvage-density Table 6B-13 in Appendix 6B). As described in Section 6.4.11.1, salvage has historically been low, reflecting the species' distribution primarily in areas farther downstream. This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.11.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on Starry Flounder would be similar between the scenarios. Historical salvage data suggested limited numbers of Starry Flounder occurring in the south Delta where the barriers are located. Operation of the barriers beginning in May would not disrupt major migratory movements because the species spawns in the nearshore coastal ocean and is broadly distributed (Appendix 6A). Starry Flounder occurring near the barriers could be at risk from effects such as near-field predation, although the effects would be consistent between the Proposed Project and Baseline Conditions.

6.4.11.7 Barker Slough Pumping Plant

BSPP operations would be unlikely to affect many Starry Flounder because of the species' distribution primarily in areas farther downstream (Appendix 6A). Entrainment would be avoided because of the fish screens at the BSPP (Chapter 2). Sediment removal by suction dredge at BSPP would have the potential to entrain Starry Flounder, although the numbers would be expected to be limited given the very low portion of overall potentially occupied habitat that would be affected, relative infrequency of the work, and the main downstream distribution. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on Starry Flounder, again given the very low portion of overall potentially occupied habitat that would be affected and the species' main downstream distribution.

6.4.11.8 Clifton Court Forebay Weed Management

Algal bloom treatments may occur year-round but are most likely to occur during summer and fall months, a time period when historical salvage of Starry Flounder has occurred but is less common than during spring, for example (as reflected in the monthly results from the salvage-density method; see Table 6B-13 in Appendix 6B). Mechanical removal of aquatic weeds in CCF would occur on an as needed basis and therefore could coincide with occurrence of Starry Flounder, with fish occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual Starry Flounder from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds. The species is primarily distributed downstream of CCF, indicating that any positive or negative effects attributable to CCF weed management would have minimal consequence for the Starry Flounder population.

6.4.11.9 Suisun Marsh Operations

Operational criteria for Suisun Marsh facility operations are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt Summer and Fall Habitat Actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.11.2, "Delta Smelt Summer and Fall Habitat Actions.") Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement would not disrupt major migratory movements because the species spawns in the nearshore coastal ocean and is broadly distributed (Appendix 6A). Entrainment at MIDS would be expected to be minimal based on only one individual collected in entrainment samples during a two-year period (Enos et al. 2007). As discussed for Delta Smelt in Section 6.4.1.10, "Significance of Impacts on Delta Smelt," Starry Flounder entrained into Goodyear Slough could exit at the intake or the outfall. The RRDS has fish screens operated to low approach velocity (see Chapter 2), which would be expected to protect Starry Flounder from entrainment and impingement. Any effects of Suisun Marsh operations would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.11.10 Georgiana Slough Salmonid Migratory Barrier Operations

Starry Flounder would be most likely to occur in the vicinity of the GSSMB during low outflows as young-of-the-year fish, with abundance tending to be very low prior to June, when recruitment begins in earnest (Baxter 1999). Although found in the west Delta from July to December, the relative abundance of young-of-the-year Starry Flounder is very low compared to other areas such as Suisun Bay and San Pablo Bay (Baxter 1999). As the species grows, it tends to move into higher salinity waters and so would be unlikely to be present near the GSSMB as yearling or older fish. Any Starry Flounder occurring near the BAFF would be unlikely to experience negative effects because the species is primarily benthic and therefore can pass beneath the barrier; in addition, flatfish generally have low sensitivity to audio stimuli (Nedwell et al. 2004; Maes et al. 2004). As discussed further for Delta Smelt in Section 6.4.1.10, “Georgiana Slough Salmonid Migratory Barrier Operations,” there is limited evidence that negative effects such as greater predation from predators associated with the BAFF in-water structure would occur. Although it is possible that there may be negative effects to Starry Flounder from GSSMB operations, such effects would be limited.

6.4.11.11 Significance of Impacts on Starry Flounder

The Proposed Project would have limited potential for differing effects on Starry Flounder relative to Baseline Conditions, given the species’ distribution farther downstream from south Delta entrainment risk and the overall similarity in Delta outflow during the period correlated with the species’ Age 1+ abundance index. Based on the analysis presented above (Section 6.4.11.1, “Delta SWP Facility Operations;” Section 6.4.11.2, “Delta Smelt Summer and Fall Habitat Actions;” Section 6.4.11.3, “John E. Skinner Delta Fish Protective Facility;” Section 6.4.11.4, “Delta Smelt Supplementation;” Section 6.4.11.5, “Water Transfers;” Section 6.4.11.6, “Agricultural Barriers;” Section 6.4.11.7, “Barker Slough Pumping Plant;” Section 6.4.11.8, “Clifton Court Forebay Weed Management;” Section 6.4.11.9, “Suisun Marsh Operations;” and Section 6.4.11.10, “Georgiana Slough Salmonid Migratory Barrier Operations”), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on Starry Flounder would be less than significant. No mitigation is required.

6.4.12 Northern Anchovy

6.4.12.1 Delta SWP Facility Operations

Northern Anchovy are not found in the salvage database used for the salvage-density method, indicating no salvage has occurred. This reflects the species’ downstream distribution in Central, San Pablo, and South Bays (Appendix 6A). Therefore any differences in SWP south Delta exports would not affect the species in terms of entrainment risk. Any potential differences in salinity as a result of the Proposed Project relative to Baseline Conditions would be small in relation to the salinity tolerance of Northern Anchovy (Fleming 1999). Neither indices of Northern Anchovy abundance nor indices of Northern Anchovy habitat extent are related to X2 (Kimmerer et al. 2009), which is an index of Delta outflow and its effects. This indicates that the minor differences in salinity between the project alternatives and existing conditions (see, for example, Appendix 4B, Attachment 4, Tables 4B.4-1-1a, 4B.4-1-1b, and 4B.4-1-1c) would have little effect on Northern Anchovy.

6.4.12.2 Delta Smelt Summer and Fall Habitat Actions

As described in Appendix 6A, food web changes in the 1980s resulted in Northern Anchovy mostly occupying higher salinity water. Operation of the SMSCG would be unlikely to have appreciable effects on Northern Anchovy because the species tends to occur in higher-salinity water.

6.4.12.3 John E. Skinner Delta Fish Protective Facility

As described in Section 6.4.12.1, "Delta SWP Facility Operations," Northern Anchovy are not found in the salvage database used for the salvage-density method, indicating no salvage has occurred. This reflects the species' primarily downstream distribution in Central, San Pablo, and South Bays (Appendix 6A) and indicates that activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—would not affect Northern Anchovy.

6.4.12.4 Delta Smelt Supplementation

There would likely be limited effects on Northern Anchovy from Delta Smelt supplementation. The species would most likely spatially overlap in Suisun Marsh or Suisun Bay, where both may prey on copepods (Slater et al. 2019; Appendix 6A). Although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential prey sources and relative to other potential competitors with Northern Anchovy for prey resources, with the extent of spatial overlap also being limited by Northern Anchovy primarily occurring in downstream areas (Central, San Pablo, and South Bays; Appendix 6A).

6.4.12.5 Water Transfers

As described in Section 6.4.12.1, Northern Anchovy are not found in the salvage database used for the salvage-density method, indicating no salvage has occurred. This reflects the species' primarily downstream distribution in Central, San Pablo, and South Bays (Appendix 6A) and indicates water transfers during July–November would not affect Northern Anchovy.

6.4.12.6 Agricultural Barriers

As described in Section 6.4.12.1, the lack of Northern Anchovy in the south Delta salvage database indicates that few if any Northern Anchovy occur in the south Delta and therefore there would not be effects from the agricultural barriers.

6.4.12.7 Barker Slough Pumping Plant

It is unlikely that Northern Anchovy would encounter the local effects of the BSPP because the species is primarily distributed in Central, San Pablo, and South Bays (Appendix 6A); any effects would be similar between the Proposed Project and Baseline Conditions given the similarity in modeled pumping between the scenarios (see Tables 4B.3-1-1a, 4B.3-1-1b, and 4B.3-1-1c in Attachment 3 of Appendix 4B).

6.4.12.8 Clifton Court Forebay Weed Management

As described in Section 6.4.12.1, the lack of Northern Anchovy in the south Delta salvage database indicates that no Northern Anchovy would be expected to occur in CCF and therefore there would be no effects from the CCF weed management.

6.4.12.9 Suisun Marsh Operations

Northern Anchovy occur in Suisun Marsh (O'Rear et al. 2023) but as noted in Section 6.4.12.2, "Delta Smelt Summer and Fall Habitat Actions," there are relatively few Northern Anchovy in the marsh because the species tends to occur at higher salinity. Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement therefore would have limited effects on Northern Anchovy.

6.4.12.10 Georgiana Slough Salmonid Migratory Barrier Operations

Northern Anchovy abundance would be expected to be zero or very low in the vicinity of the GSSMB given that the species is primarily marine/estuarine and occurs seaward of the BAFF's location, particularly following the invasion of *P. amurensis* (Kimmerer 2006), which reduced abundance in the low salinity zone that is well downstream of the Sacramento River-Georgiana Slough junction. Therefore there is likely to be limited if any effect of the GSSMB on Northern Anchovy.

6.4.12.11 Significance of Impacts on Northern Anchovy

The Proposed Project would have limited potential for differing effects on Northern Anchovy relative to Baseline Conditions, given the species' distribution farther downstream from south Delta entrainment risk, the absence of relationships between Delta outflow and the species or its habitat, and the limited operations-related differences in salinity as a result of the Proposed Project. Based on the analysis presented above (Section 6.4.12.1, "Delta SWP Facility Operations;" Section 6.4.12.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.12.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.12.4, "Delta Smelt Supplementation;" Section 6.4.12.5, "Water Transfers;" Section 6.4.12.6, "Agricultural Barriers;" Section 6.4.12.7, "Barker Slough Pumping Plant;" Section 6.4.12.8, "Clifton Court Forebay Weed Management;" Section 6.4.12.9, "Suisun Marsh Operations;" and Section 6.4.12.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on Northern Anchovy would be less than significant. No mitigation is required.

6.4.13 Striped Bass

6.4.13.1 Delta SWP Facility Operations

Application of the salvage-density method (Appendix 6B, Section 6B.1) indicated that SWP south Delta exports under the Proposed Project would be similar to Baseline Conditions during the period that Striped Bass salvage has historically occurred (Table ~~6-89~~ 6-91), indicating that entrainment risk under the Proposed Project and Baseline Conditions would be similar. As discussed in Appendix 6A, south Delta entrainment mortality has not been found to be a driver of population dynamics.

Table ~~6-89~~ 6-91. Mean Number of Striped Bass Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~334,139~~ 336,539	~~336,672 (1%)~~ 337,103 (0%)
Above Normal	N/A	(1%)
Below Normal	~~357,342~~ 355,939	~~367,797~~ 365,328 (3%)
Dry	~~113,048~~ 108,574	~~111,194 (-2%)~~ 105,240 (-3%)
Critically Dry	~~33,928~~ 33,427	~~34,518 (2%)~~ 34,600 (4%)

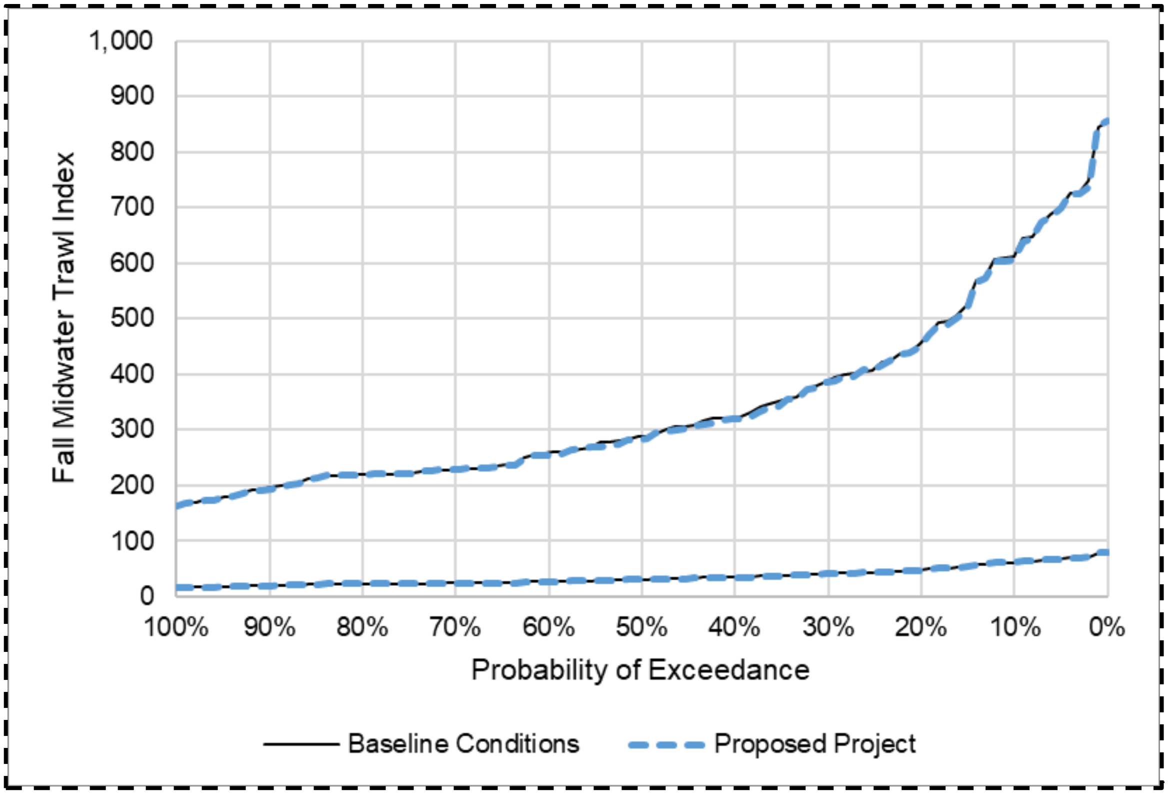
Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-14 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

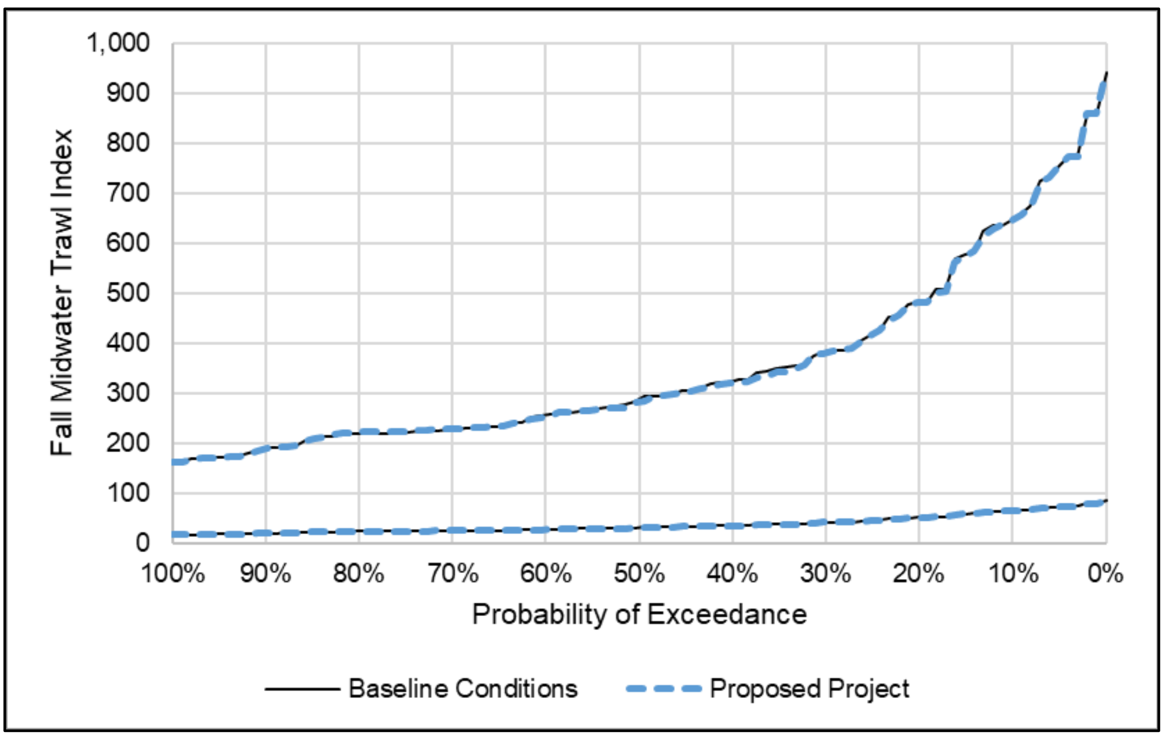
As discussed in Appendix 6A, there are statistically significant correlations between Delta outflow and young-of-the-year Striped Bass abundance indices. A statistically significant positive regression relationship based on April–June outflow and the FMWT abundance index for 2003–2022 data was used to assess the potential effect of the Proposed Project on Striped Bass (Appendix 6B, Section 6B.16). The results of this analysis indicated little difference between the Proposed Project and Baseline Conditions (Table ~~6-90~~ 6-92 and Figure 6-125).

Table ~~6-90~~ 6-92. Mean Annual Striped Bass Fall Midwater Trawl Abundance Index, from the Regression Including April–June Delta Outflow and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped By Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~169.0~~ 174.1	~~167.6 (-0.8%)~~ 173.3 (-0.5%)
Above Normal	~~122.5~~ 121.9	~~121.6 (-0.8%)~~ 121.3 (-0.5%)
Below Normal	~~100.1~~ 99.6	~~99.1 (-1.0%)~~ 98.8 (-0.8%)
Dry	~~78.0~~ 77.3	~~78.2 (0.2%)~~ 78.1 (1.1%)
Critically Dry	~~61.7~~ 60.4	~~61.1 (-0.9%)~~ 60.0 (-0.8%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-125 for 95% prediction intervals)





Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

Figure 6-125. Exceedance Plot of Striped Bass Fall Midwater Trawl Abundance Index, Based on the Regression Including April–June Delta Outflow

6.4.13.2 Delta Smelt Summer and Fall Habitat Actions

Striped Bass are highly abundant in Suisun Marsh, being the second most abundant fish species collected during sampling from 1979 to 2022 (O'Rear et al. 2023). As described in Appendix 6A and discussed by Kimmerer et al. (2013), young-of-the-year Striped Bass are found in relatively high abundance at low salinity, so operation of the SMSCG to provide a greater extent of low-salinity water in Suisun Marsh could provide more habitat for Striped Bass, although there generally would be limited differences between the Proposed Project and Baseline Conditions. The seasonality of SMSCG operation for the Delta Smelt Summer and Fall Habitat Actions would not overlap with the major spring upstream migration period of adult Striped Bass.

6.4.13.3 John E. Skinner Delta Fish Protective Facility

Activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—could potentially affect Striped Bass. Salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss during the salvage process. Any such effects would be limited because south Delta entrainment-associated mortality has not been found to be a driver of population dynamics (Section 6.4.13.1, "Delta SWP Facility Operations").

6.4.13.4 Delta Smelt Supplementation

There is some limited dietary overlap between Striped Bass and Delta Smelt as both have been noted to eat benthic prey such as amphipods (Slater et al. 2019; Colombano et al. 2021). Striped Bass are also predators of Delta Smelt (Schreier et al. 2016; Nobriga and Smith 2020). Supplementation of Delta Smelt would be unlikely to have appreciable effects on Striped Bass because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential prey sources and relative to other potential competitors with Striped Bass for prey resources.

6.4.13.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and overlaps Striped Bass occurrence in the Delta. The potential for greater south Delta entrainment would exist for Striped Bass occurring in the south Delta during the water transfer window, with the water transfer window overlapping periods with historically relatively high Striped Bass salvage (see monthly salvage-density Table 6B-14 in Appendix 6B). As described in Section 6.4.13.1, effects would be limited because south Delta entrainment-associated mortality has not been found to be a driver of population dynamics. This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.13.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on Striped Bass would be similar between the scenarios. Historical salvage data indicate appreciable numbers of Striped Bass occurring in the south Delta. Operation of the barriers beginning in May would not impede Striped Bass upstream migration to spawn because spawning primarily occurs either in the Sacramento River or else in the San Joaquin River between Antioch and Venice Island, downstream of the agricultural barriers. Small Striped Bass could be at risk from barrier effects such as near-field predation, although the effects would be consistent between the Proposed Project and Baseline Conditions.

6.4.13.7 Barker Slough Pumping Plant

The BSPP fish screens would be protective of Striped Bass individuals large enough to be screened, and possibly also to some degree for larvae that are smaller than expected to be screened based on size (Nobriga et al. 2004), as suggested by only two Striped Bass larvae having been collected during entrainment sampling in 2015–2016 (Yip et al. 2017, 2019). The entrainment rate of larval Striped Bass would be expected to be similar between the Proposed Project and Baseline Conditions given the similarity in modeled pumping between the scenarios (see Tables 4B.3-1-1a, 4B.3-1-1b, and 4B.3-1-1c in Attachment 3 of Appendix 4B). Sediment removal by suction dredge at BSPP would have the potential to entrain Striped Bass, although the numbers would be expected to be limited given the very low portion of overall potentially occupied habitat that would be affected and the relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on Striped Bass, again given the very low portion of overall potentially occupied habitat that would be affected.

6.4.13.8 Clifton Court Forebay Weed Management

Algal bloom treatments may occur year-round but are most likely to occur during summer and fall, a time period when historical salvage of Striped Bass has occurred (as reflected in the monthly results from the salvage-density method; see Tables 6.B-14 in Appendix 6B). Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and therefore could coincide with occurrence of Striped Bass, with fish occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual Striped Bass from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds. As noted previously, south Delta entrainment-associated mortality has not been found to be a driver of population dynamics, indicating that any positive or negative effects attributable to CCF weed management would have minimal consequence for the Striped Bass population.

6.4.13.9 Suisun Marsh Operations

Operational criteria for Suisun Marsh facility operations are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt Summer and Fall Habitat Actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.13.2, "Delta Smelt Summer and Fall Habitat Actions.") Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement would overlap adult Striped Bass upstream migration to spawn in the Sacramento River or San Joaquin River, but any SMSCG closures would be unlikely to have major effects on spawning success as delays would be short-term (hours or days). Entrainment at MIDS would be expected to be low based on few individuals having been collected in entrainment samples during a two-year period (Enos et al. 2007). As discussed for Delta Smelt in Section 6.4.1.10, Striped Bass entrained into Goodyear Slough could exit at the intake or the outfall. The RRDS has fish screens operated to low approach velocity (see Chapter 2), which would be expected to protect Striped Bass from entrainment and impingement. Any effects of Suisun Marsh operations would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.13.10 Georgiana Slough Salmonid Migratory Barrier Operations

Spatiotemporal overlap of Striped Bass with GSSMB operations would be likely to occur. Larvae/eggs moving downstream would not experience negative effects because movement is passive. Adults migrating upstream to spawn in the Sacramento River in spring could be deterred from entering the Sacramento River from Georgiana Slough, although it is unknown what proportion of adults takes this migration pathway. As discussed further for Delta Smelt in Section 6.4.1.10, "Georgiana Slough Salmonid Migratory Barrier Operations," space exists for upstream-migrating fish to move around or even under the barrier. As also discussed for Delta Smelt, there is limited evidence for predation-related effects from predatory fish associated with the in-water structure of the BAFF; thus, there would be limited potential for positive effects (e.g., larger Striped Bass preying on fish startled by the BAFF) or negative effects (e.g., predation of smaller Striped Bass by predatory fish associated with the BAFF). Although it is possible that there may be negative effects to Striped Bass from GSSMB operations, such effects would be limited.

6.4.13.11 Significance of Impacts on Striped Bass

The Proposed Project would have limited potential for differing effects on Striped Bass relative to Baseline Conditions, given the overall similarity in SWP south Delta exports and Delta outflow during the period correlated with the species' FMWT abundance index. Based on the analysis presented above (Section 6.4.13.1, "Delta SWP Facility Operations;" Section 6.4.13.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.13.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.13.4, "Delta Smelt Supplementation;" Section 6.4.13.5, "Water Transfers;" Section 6.4.13.6, "Agricultural Barriers;" Section 6.4.13.7, "Barker Slough Pumping Plant;" Section 6.4.13.8, "Clifton Court Forebay Weed Management;" Section 6.4.13.9, "Suisun Marsh Operations;" and Section 6.4.13.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on Striped Bass would be less than significant. No mitigation is required.

6.4.14 American Shad

6.4.14.1 Delta SWP Facility Operations

Application of the salvage-density method (Appendix 6B, Section 6B.1) indicated that SWP south Delta exports under the Proposed Project would be similar to Baseline Conditions during the period that American Shad salvage has historically occurred (Table ~~6-91~~ 6-93), indicating that entrainment risk under the Proposed Project and Baseline Conditions would be similar.

Table ~~6-91~~ 6-93. Mean Number of American Shad Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~342,074~~ 343,792	~~350,797 (3%)~~ 351,253 (2%)
Above Normal	N/A	~~(2%)~~ (3%)
Below Normal	~~258,010~~ 236,540	~~257,564~~ 235,363 (0%)
Dry	~~107,352~~ 91,475	~~105,332 (-2%)~~ 90,597 (-1%)
Critically Dry	~~17,821~~ 17,705	~~17,410~~ 17,334 (-2%)

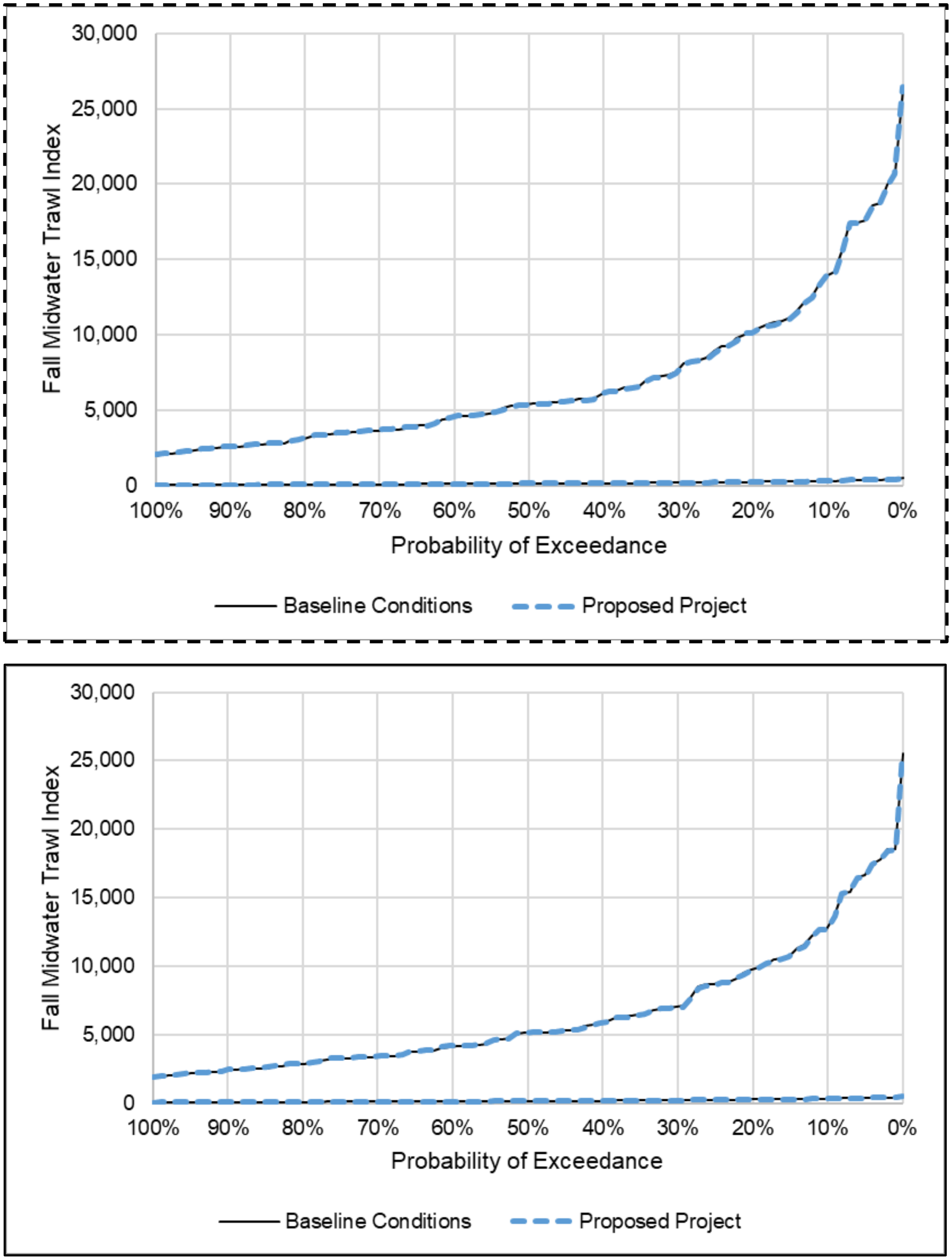
Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-15 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

As discussed in Appendix 6A, there is a statistically significant correlation between Delta outflow and American Shad abundance indices. A statistically significant positive regression relationship based on February–June outflow and the FMWT abundance index for 2003–2022 data was used to assess the potential effect of the Proposed Project on American Shad (Appendix 6B, Section 6B.16). The results of this analysis indicated little difference between the Proposed Project and Baseline Conditions (Table ~~6-92~~ 6-94 and Figure 6-126).

Table ~~6-92~~ 6-94. Mean Annual American Shad Fall Midwater Trawl Abundance Index, from the Regression Including February–June Delta Outflow and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Grouped By Water Year Type

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~1,938.2~~ 1,841.4	~~1,926.8 (-0.6%)~~ 1,833.3 (-0.4%)
Above Normal	~~1,321.9~~ 1,154.8	~~1,318.3 (-0.3%)~~ 1,153.3 (-0.1%)
Below Normal	~~886.2~~ 842.3	~~883.4 (-0.3%)~~ 843.3 (0.1%)
Dry	~~625.7~~ 579.5	~~635.1 (1.5%)~~ 590.3 (1.9%)
Critically Dry	~~442.2~~ 403.2	~~442.5 (0.1%)~~ 404.3 (0.3%)

Note: Table only includes mean responses and does not consider model uncertainty (see Figure 6-126 for 95% prediction intervals)



Note: Data are sorted by upper 95% limit, with 95% prediction intervals shown.

Figure 6-126. Exceedance Plot of American Shad Fall Midwater Trawl Abundance Index, Based on the Regression Including February–June Delta Outflow

6.4.14.2 Delta Smelt Summer and Fall Habitat Actions

American Shad are relatively abundant in Suisun Marsh (O'Rear et al. 2023). As described by Kimmerer et al. (2013), juvenile American Shad are found in relatively high abundance at low salinity, so operation of the SMSCG to provide a greater extent of low-salinity water in Suisun Marsh may provide more habitat for American Shad, although there generally would be limited differences between the Proposed Project and Baseline Conditions. The seasonality of SMSCG operation for the Delta Smelt Summer and Fall Habitat Actions would not overlap with the major spring upstream migration period of adult American Shad.

6.4.14.3 John E. Skinner Delta Fish Protective Facility

Activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—could potentially affect American Shad. Salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss during the salvage process. As noted in Appendix 6A, an appreciable portion of the American Shad population rears upstream of the Delta and therefore is not susceptible to entrainment in the south Delta, so would not be affected by Skinner Fish Facility activities.

6.4.14.4 Delta Smelt Supplementation

There is some dietary overlap between American Shad and Delta Smelt as both have been noted to eat mysid shrimp (Slater and Baxter 2014; Colombano et al. 2021). Supplementation of Delta Smelt would be unlikely to have appreciable effects on American Shad because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other competitors with American Shad for prey.

6.4.14.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and overlaps American Shad occurrence in the Delta. The potential for greater south Delta entrainment would exist for American Shad occurring in the south Delta during the water transfer window, with the water transfer window overlapping the July–August period historically the highest American Shad salvage (see monthly salvage-density Table 6B-15 in Appendix 6B). As noted in Appendix 6A, an appreciable portion of the American Shad population rears upstream of the Delta and therefore is not susceptible to entrainment in the south Delta. This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.14.6 Agricultural Barriers

As discussed in Appendix 6A, most American Shad spawning occurs in the Sacramento River, but there is some spawning in San Joaquin River tributaries. Operation of the agricultural barriers beginning in May could impede some American Shad migrating upstream to spawn in the San Joaquin River Basin. Near-field effects such as predation could occur to American Shad juveniles occurring near the barriers. Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios and so any impacts would be the same.

6.4.14.7 Barker Slough Pumping Plant

The BSPP fish screens would be protective of American Shad individuals large enough to be screened, and possibly also to some degree for any larvae occurring in the area that are smaller than expected to be screened based on size (Nobriga et al. 2004), as suggested by no larvae having been collected during entrainment sampling in 2015–2016 (Yip et al. 2017, 2019). The entrainment rate of larval American Shad would be expected to be similar between the Proposed Project and Baseline Conditions given the similarity in modeled pumping between the scenarios (see Tables 4B.3-1-1a, 4B.3-1-1b, and 4B.3-1-1c in Attachment 3 of Appendix 4B). Sediment removal by suction dredge at BSPP would have the potential to entrain American Shad, although the numbers would be expected to be limited given the very low portion of overall potentially occupied habitat that would be affected and the relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on American Shad, again given the very low portion of overall potentially occupied habitat that would be affected.

6.4.14.8 Clifton Court Forebay Weed Management

Algal bloom treatments may occur year-round but are most likely to occur during summer and fall, a time period including the highest period historical salvage of American Shad (as reflected in the monthly results from the salvage-density method; see Table 6B-15 in Appendix 6B). Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and therefore could coincide with occurrence of American Shad, with fish occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual American Shad from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) might be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds.

6.4.14.9 Suisun Marsh Operations

Operational criteria for Suisun Marsh facility operations are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt Summer and Fall Habitat Actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.14.2, "Delta Smelt Summer and Fall Habitat Actions.") Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement would overlap adult American Shad upstream migration to spawn, but any SMSCG closures would be unlikely to have major effects on spawning success as delays would be short-term (hours or days). Entrainment at MIDS would be expected to be low based on few individuals having been collected in entrainment samples during a two-year period (Enos et al. 2007). As discussed for Delta Smelt in Section 6.4.1.10, American Shad entrained into Goodyear Slough could exit at the intake or the outfall. The RRDS has fish screens operated to low approach velocity (see Chapter 2), which would be expected to protect American Shad from entrainment and impingement. Any effects of Suisun Marsh operations would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.14.10 Georgiana Slough Salmonid Migratory Barrier Operations

Spatiotemporal overlap of American Shad from the Sacramento River basin with GSSMB operations would be likely to occur. Adults migrating upstream to spawn in the Sacramento River or tributaries in spring could be deterred from entering the Sacramento River from Georgiana Slough, although it is unknown what proportion of adults takes this migration pathway. As discussed further for Delta Smelt in Section 6.4.1.10, "Georgiana Slough Salmonid Migratory Barrier Operations," space exists for upstream-migrating fish to move around or even under the barrier. As described in Appendix 6A, Section 6A.1.18, "American Shad", downstream migration of juveniles tends to occur after (May-December) the period of GSSMB operations. Although it is possible that there may be negative effects to American Shad from GSSMB operations, such effects would be limited.

6.4.14.11 Significance of Impacts on American Shad

The Proposed Project would have limited potential for differing effects on American Shad relative to Baseline Conditions, given the overall similarity in SWP south Delta exports and Delta outflow during the period correlated with the species' FMWT abundance index. Based on the analysis presented above (Section 6.4.14.1, "Delta SWP Facility Operations;" Section 6.4.14.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.14.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.14.4, "Delta Smelt Supplementation;" Section 6.4.14.5, "Water Transfers;" Section 6.4.14.6, "Agricultural Barriers;" Section 6.4.14.7, "Barker Slough Pumping Plant;" Section 6.4.14.8, "Clifton Court Forebay Weed Management;" Section 6.4.14.9, "Suisun Marsh Operations;" and Section 6.4.14.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on American Shad would be less than significant. No mitigation is required.

6.4.15 Threadfin Shad

6.4.15.1 Delta SWP Facility Operations

Application of the salvage-density method (Appendix 6B, Section 6B.1) indicated that SWP south Delta exports under the Proposed Project would be similar to Baseline Conditions during the period that Threadfin Shad salvage has historically occurred (Table ~~6-93~~ 6-95), indicating that entrainment risk under the Proposed Project and Baseline Conditions would be similar.

Table ~~6-93~~ 6-95 . Mean Number of Threadfin Shad Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~517,704~~ 517,332	~~534,190~~ 532,615 (3%)
Above Normal	N/A	~~(3%)~~ (4%)
Below Normal	~~1,464,036~~ 1,356,633	~~1,444,340 (-1%)~~ 1,330,976 (-2%)
Dry	~~960,634~~ 726,453	~~970,990 (1%)~~ 743,103 (2%)
Critically Dry	~~159,786~~ 163,867	~~159,176 (0%)~~ 162,475 (-1%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-16 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

6.4.15.2 Delta Smelt Summer and Fall Habitat Actions

Threadfin Shad are abundant in Suisun Marsh, being the ninth most abundant fish species collected during sampling from 1979 to 2022 (O'Rear et al. 2023), although abundance in Suisun Marsh is relatively low compared to the lower San Joaquin River near Stockton (Feyrer et al. 2009). As described in Appendix 6A and discussed by Kimmerer et al. (2013), Threadfin Shad are found in relatively high abundance at low salinity, so operation of the SMSCG to provide a greater extent of low-salinity water in Suisun Marsh may provide more habitat for Threadfin Shad, although there generally would be limited differences between the Proposed Project and Baseline Conditions. The seasonality of SMSCG operation for the Delta Smelt Summer and Fall Habitat Actions would overlap with the Threadfin Shad spawning season, but the species is not noted as having major migrations that could be disrupted by gates operations and any short-term delays would be of little consequence given that areas for spawning (e.g., submerged aquatic vegetation; see Appendix 6A) would remain available regardless of any delay.

6.4.15.3 John E. Skinner Delta Fish Protective Facility

Activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—could potentially affect Threadfin Shad. Salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss during the salvage process. Any such effects would be limited because entrainment does not appear to be of population-level consequence (see further discussion in Section 6.4.15.6, "Water Transfers").

6.4.15.4 Delta Smelt Supplementation

Threadfin Shad and Delta Smelt both consume zooplankton but supplementation of Delta Smelt would be unlikely to have appreciable effects on Threadfin Shad because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other competitors with Threadfin Shad for prey. In addition, Threadfin Shad are found in higher abundance at low turbidity (Feyrer et al. 2009), in contrast to Delta Smelt (Sommer and Mejia 2013), so there would be limited spatial overlap in the main areas occupied by the two species.

6.4.15.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and overlaps Threadfin Shad occurrence in the Delta. The potential for greater south Delta entrainment would exist for Threadfin Shad occurring in the south Delta during the water transfer window, with the water transfer window overlapping periods with historically relatively high Threadfin Shad salvage (particularly July/August; see monthly salvage-density Table 6B-16 in Appendix 6B). Effects would be limited as entrainment appears unlikely to have population-level consequences because abundance in the fall is poorly related to abundance in summer, potentially as a result of factors such as toxicity of *Microcystis* blooms (Acuña et al. 2012a, 2020) being more important (Feyrer et al. 2009; Baxter et al. 2010). This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.15.6 Agricultural Barriers

Abundance of Threadfin Shad is relatively high in the south Delta and lower San Joaquin River (Appendix 6A), so there could be effects on Threadfin Shad from operation of the agricultural barriers beginning in May (e.g., predation of Threadfin Shad occurring near the barriers by structure-associated predatory fish). Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios and so any impacts would be the same.

6.4.15.7 Barker Slough Pumping Plant

The BSPP fish screens would be protective of Threadfin Shad individuals large enough to be screened, and possibly also to some degree for any larvae occurring in the area that are smaller than expected to be screened based on size (Nobriga et al. 2004). The entrainment rate of larval Threadfin Shad would be expected to be similar between the Proposed Project and Baseline Conditions given the similarity in modeled pumping between the scenarios (see Tables 4B.3-1-1a, 4B.3-1-1b, and 4B.3-1-1c in Attachment 3 of Appendix 4B). Sediment removal by suction dredge at BSPP would have the potential to entrain Threadfin Shad, although the numbers would be expected to be limited given the very low portion of overall potentially occupied habitat that would be affected and the relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on Threadfin Shad, again given the very low portion of overall potentially occupied habitat that would be affected.

6.4.15.8 Clifton Court Forebay Weed Management

Algal bloom treatments may occur year-round but are most likely to occur during summer and fall, a time period including the highest period historical salvage of Threadfin Shad (as reflected in the monthly results from the salvage-density method; see Table 6B-16 in Appendix 6B). Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and therefore could coincide with occurrence of Threadfin Shad, with fish occurrence near mechanical removal activities being more likely if both fish and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual Threadfin Shad from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) might be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds.

6.4.15.9 Suisun Marsh Operations

Operational criteria for Suisun Marsh facility operations are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt Summer and Fall Habitat Actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.15.2, "Delta Smelt Summer and Fall Habitat Actions.") Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement would have limited overlap with the April–August spawning period (Appendix 6A) but as noted in Section 6.4.15.2, Threadfin Shad have not been noted to make major migrations that could be disrupted by gate operations. Entrainment at MIDS would be expected to be low based on relatively few individuals having been collected in entrainment samples during a two-year period (Enos et al. 2007). As discussed for Delta Smelt in Section 6.4.1.10, Threadfin Shad entrained into Goodyear Slough could exit at the intake or the outfall. The RRDS has fish screens operated to low approach velocity (see Chapter 2), which would be expected to protect Threadfin Shad from entrainment and impingement. Any effects of Suisun Marsh operations would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.15.10 Georgiana Slough Salmonid Migratory Barrier Operations

Although some Threadfin Shad would be likely to encounter the operations of GSSMB, effects would be limited because as previously noted and described further in Appendix 6A, Section 6A.1.19, "Threadfin Shad", the species is widely distributed and is most abundant in the southeast Delta. Threadfin Shad encountering the BAFF could experience some negative effects such as deterrence from movement pathways given that pelagic species tend to have good hearing ability (Maes et al. 2004), but such effects would be limited.

6.4.15.11 Significance of Impacts on Threadfin Shad

The Proposed Project would have limited potential for differing effects on Threadfin Shad relative to Baseline Conditions, given the overall similarity in SWP south Delta exports and, as discussed for other species, the overall similarity in hydrological conditions. Based on the analysis presented above (Section 6.4.15.1, "Delta SWP Facility Operations;" Section 6.4.15.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.15.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.15.4, "Delta Smelt Supplementation;" Section 6.4.15.5, "Water Transfers;" Section 6.4.15.6, "Agricultural Barriers;" Section 6.4.15.7, "Barker Slough Pumping Plant;" Section 6.4.15.8, "Clifton Court Forebay Weed Management;" Section 6.4.15.9, "Suisun Marsh Operations;" and Section 6.4.15.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on Threadfin Shad would be less than significant. No mitigation is required.

6.4.16 Black Bass

6.4.16.1 Delta SWP Facility Operations

Historical salvage data show few Smallmouth Bass or Spotted Bass are entrained at the SWP south Delta export facility, whereas Largemouth Bass are entrained in relatively high numbers. Application of the salvage-density method (Appendix 6B, Section 6B.1) indicated that SWP south

Delta exports under the Proposed Project would be similar to or higher than Baseline Conditions during the period that Largemouth Bass salvage has historically occurred (Table ~~6-94~~ 6-96), with minimal levels of Smallmouth Bass and Spotted Bass salvage expected under both scenarios (Tables ~~6-95 and 6-96~~ 6-97 and 6-98). The salvage-density method is solely a calculation of differences in SWP south Delta exports between the Proposed Project and Baseline Conditions weighted by historical density of observed fish in salvage and is not a prediction of actual salvage expected. Analyses by Grimaldo et al. (2009a) did not find a significant relationship between Largemouth Bass salvage and OMR flows, an indicator of entrainment risk for other species such as Delta Smelt and Longfin Smelt. Grimaldo et al. (2009a) suggested that the littoral (nearshore) habitat occupied by Largemouth Bass probably provides a buffer from entrainment. As such, the differences in entrainment risk suggested by the salvage-density method are likely to be small. This observation, combined with the widespread occurrence of Largemouth Bass in the Delta (e.g., Conrad et al. 2016; Mahardja et al. 2017), indicates population-level effects from changes in entrainment risk as a result of the Proposed Project would be small.

Table ~~6-94~~ 6-96. Mean Number of Largemouth Bass Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	~~21,379~~ 21,680	~~21,409 (0%)~~ 21,336 (-2%)
Above Normal	N/A	(0%)
Below Normal	~~16,846~~ 16,958	~~19,794 (17%)~~ 20,157 (19%)
Dry	~~14,163~~ 12,615	~~14,408 (2%)~~ 12,734 (1%)
Critically Dry	~~12,230~~ 11,664	~~11,548 (-6%)~~ 11,392 (-2%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-17 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table ~~6-95~~ 6-97. Mean Number of Smallmouth Bass Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	7	7 ~~(0%)~~ (-1%)
Above Normal	N/A	(-6%)
Below Normal	8	~~8 (-3%)~~ 7 (-6%)
Dry	8	8 ~~(1%)~~ (4%)
Critically Dry	0	0 (0%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-18 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

Table ~~6-96~~ 6-98 . Mean Number of Spotted Bass Salvaged (Fish Per Year) at the State Water Project South Delta Export Facility for Baseline Conditions and Proposed Project Scenarios Grouped by Water Year Type, and Differences between the Scenarios (Proposed Project minus Baseline Conditions) Expressed as a Percentage Difference (parentheses), Based on the Salvage-Density Method

Water Year Type	Baseline Conditions	Proposed Project
Wet	0	0 (0%)
Above Normal	N/A	0 (0%)
Below Normal	2	1 ~~(-20%)~~ (-22%)
Dry	0	0 (0%)
Critically Dry	0	0 (0%)

Note: N/A indicates there were no Above Normal years in the historical record for the 2009–2022 period used to provide loss density data for the analysis; for Above Normal years, the Wet year pattern was used, with only the percentage difference shown. Values by month are presented in Table 6B-19 in Appendix 6B. Absolute and percentage values are rounded; as a result, differences between absolutes and differences between percentages may not always appear consistent.

6.4.16.2 Delta Smelt Summer and Fall Habitat Actions

Only six Largemouth Bass and no Smallmouth Bass or Spotted Bass have been collected during long-term (1979–2022) sampling in Suisun Marsh, indicating that there would be minimal effects from Delta Smelt Summer and Fall Habitat Actions on black bass.

6.4.16.3 John E. Skinner Delta Fish Protective Facility

Activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—could potentially affect black bass (primarily Largemouth Bass based on historical salvage discussed in Section 6.4.16.1, “Delta SWP Facility Operations”). Salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss during the salvage process. Any such effects would be of minimal consequence to Largemouth Bass given the widespread occurrence of the species in the Delta.

6.4.16.4 Delta Smelt Supplementation

Supplementation of Delta Smelt would be unlikely to have appreciable effects on black bass because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential prey sources for larger, piscivorous black bass, and would also remain low relative to other potential competitors with larval black bass for zooplankton prey.

6.4.16.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and overlaps black bass occurrence in the Delta. Although Largemouth Bass are salvaged in relatively high numbers during the water transfer window (see monthly salvage-density Table 6B-17 in Appendix 6B), it does not follow that there would be increased entrainment risk because salvage has not been linked to OMR flows (see Section 6.4.13.1), therefore any effects would be limited. This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.16.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on black bass—primarily Largemouth Bass, based on historical salvage data discussed previously—would be similar between the scenarios. Largemouth Bass spawning (April–June) would overlap the barrier operation period beginning in May but the species does not make major migratory movements that could be impeded by the barriers. Largemouth Bass occurring near the barriers could experience mixed effects from the barriers (i.e., greater predation risk for small individuals by structure-associated predators; greater predation success for larger individuals using the barrier in-water structure for prey ambush), although the effects would be consistent between the Proposed Project and Baseline Conditions.

6.4.16.7 Barker Slough Pumping Plant

The BSPP fish screens would be protective of black bass large enough to be screened, and possibly also to some degree for larvae that are smaller than expected to be screened based on size (Nobriga et al. 2004). Unidentified centrarchid larvae (possibly including black bass) were among the most commonly collected larval fish collected in entrainment samples at BSPP during 2015–2016 (Yip et al. 2017, 2019). The entrainment rate of larval black bass would be expected to be similar between the Proposed Project and Baseline Conditions given the similarity in modeled pumping between the scenarios (see Tables 4B.3-1-1a, 4B.3-1-1b, and 4B.3-1-1c in Attachment 3 of Appendix 4B), and would be expected to have limited population-level consequence given the widespread occurrence of black bass in the Delta. Sediment removal by suction dredge at BSPP would have the potential to entrain black bass, although the numbers would be expected to be limited given the very low portion of overall potentially occupied habitat that would be affected and the relative infrequency of the work. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on black bass, again given the very low portion of overall potentially occupied habitat that would be affected.

6.4.16.8 Clifton Court Forebay Weed Management

Algal bloom treatments may occur year-round but are most likely to occur during summer and fall, a time period when relatively high historical salvage of black bass (almost entirely Largemouth Bass) has occurred (as reflected in the monthly results from the salvage-density method; see Tables 6B-17 through 6B-19 in Appendix 6B). Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis. Weed management in CCF would decrease available habitat for Largemouth Bass because the species is associated with submerged aquatic vegetation, although effects would be limited relative to the overall broad distribution of the species in the Delta.

6.4.16.9 Suisun Marsh Operations

As previously described, only six Largemouth Bass and no Smallmouth Bass or Spotted Bass have been collected during long-term (1979–2022) sampling in Suisun Marsh, indicating that there would be minimal effects from Suisun Marsh facility operations on black bass.

6.4.16.10 Georgiana Slough Salmonid Migratory Barrier Operations

Black bass do not undertake significant migratory movements and so would be unlikely to experience negative effects such as deterrence from migratory pathways by GSSMB operations. As discussed further for Delta Smelt in Section 6.4.1.10, "Georgiana Slough Salmonid Migratory Barrier Operations," there is limited evidence for predation-related effects associated with BAFF operations, indicating that effects to black bass (either positive or negative, depending on the role as predator or prey) would be limited, particularly given the broad extent of habitat occupied by the species in the Delta.

6.4.16.11 Significance of Impacts on Black Bass

The Proposed Project would have limited potential for differing effects on black bass relative to Baseline Conditions, given factors such as limited entrainment risk for Smallmouth Bass and Spotted Bass, and limited differences in SWP south Delta exports coupled with nearshore distribution providing a buffer to entrainment for Largemouth Bass. Based on the analysis presented above (Section 6.4.16.1, "Delta SWP Facility Operations;" Section 6.4.16.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.16.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.16.4, "Delta Smelt Supplementation;" Section 6.4.16.5, "Water Transfers;" Section 6.4.16.6, "Agricultural Barriers;" Section 6.4.16.7, "Barker Slough Pumping Plant;" Section 6.4.16.8, "Clifton Court Forebay Weed Management;" Section 6.4.16.9, "Suisun Marsh Operations;" and Section 6.4.16.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on black bass would be less than significant. No mitigation is required.

6.4.17 California Bay Shrimp

6.4.17.1 Delta SWP Facility Operations

California Bay Shrimp are not counted in south Delta salvage sampling, so the extent of entrainment is unknown. San Francisco Bay Study otter trawl data illustrate that the abundance of California Bay Shrimp is likely to be relatively low, for trawl catch per unit effort in the lower San Joaquin River (the most proximate stations to the SWP south Delta export facility) is one to four orders of magnitude lower than areas farther downstream (Table ~~6-97~~ 6-99; see also Appendix 6A). The period of greatest entrainment risk may be August–December based on the highest catch per unit effort occurring in these months. During these months, water year type mean SWP exports under the Proposed Project generally range from similar to Baseline Conditions to ~1,000 cfs greater than Baseline Conditions (September of Wet and Above Normal water years) (Tables 4B.3-4-1a, 4B.3-4-1b, and 4B.3-4-1c in Appendix 4B). This indicates that there is the potential for greater south Delta entrainment under the Proposed Project than Baseline Conditions, but the species' primary distribution in areas downstream of south Delta entrainment risk indicates that the impact would be limited.

Table ~~6-97~~ 6-99 . California Bay Shrimp Catch Per 1,000 Square Meters Sampled by San Francisco Bay Study Otter Trawl, 2003–2022

Month	South San Francisco Bay	Central San Francisco Bay	San Pablo Bay	Suisun Bay	West Delta	Lower Sacramento River	Lower San Joaquin River
Jan	59.0	172.5	181.7	219.0	113.6	13.1	6.7
Feb	77.6	160.9	138.3	146.3	40.5	3.9	3.5
Mar	98.7	101.8	110.9	55.4	13.4	1.5	0.0
Apr	70.1	83.6	124.5	113.2	18.1	0.0	0.0
May	133.0	114.3	371.6	348.2	96.0	4.2	1.0
Jun	271.1	98.2	484.7	872.6	278.2	50.6	25.2
Jul	392.1	276.5	457.2	1,320.1	369.6	17.3	2.1
Aug	272.1	241.9	563.4	1,103.9	259.9	30.1	31.1
Sep	187.4	320.3	430.4	800.4	556.3	25.0	37.1
Oct	77.8	323.8	240.4	556.2	367.7	31.2	30.1
Nov	47.0	237.3	136.6	216.7	288.8	79.5	57.1
Dec	36.7	126.8	110.9	167.0	198.0	49.8	44.4

Source: https://filelib.wildlife.ca.gov/Public/BayStudy/, accessed 30 August, 2023.

As noted in Appendix 6A, previous studies have found statistically significant correlations between spring X2 (an indicator of Delta outflow) and California Bay Shrimp abundance indices. An updated regression analysis was undertaken for this impact analysis as described in Appendix 6B, Section 6B.16. The regression relationship was not statistically significant ($P = 0.3012$). This, coupled with the limited differences in spring Delta outflow as indicated by the spring outflow–zooplankton regressions undertaken for Delta Smelt (see "Food Availability" in Section 6.4.1.1), indicates that there would be little effect on California Bay Shrimp from operations under the Proposed Project relative to Baseline Conditions.

6.4.17.2 Delta Smelt Summer and Fall Habitat Actions

California Bay Shrimp occur in relatively high numbers in Suisun Marsh (O'Rear et al. 2023). Operation of the SMSCG would provide a greater extent of low-salinity water in Suisun Marsh, although there generally would be limited differences between the Proposed Project and Baseline Conditions. California Bay Shrimp tend to be more abundant at higher salinity but frequently occur over a range of salinity from 2–20 ppt (Kimmerer et al. 2013), so the Delta Smelt Summer and Fall Habitat Actions would likely have limited effects on California Bay Shrimp. SMSCG operations under the Proposed Project and Baseline Conditions would be unlikely to hinder movement of California Bay Shrimp to spawning grounds in Central Bay or the Gulf of the Farallones (see Appendix 6A).

6.4.17.3 John E. Skinner Delta Fish Protective Facility

Activities associated with the Skinner Fish Facility—i.e., maintenance and repair, facility improvements, and salvage release site improvements—could potentially affect California Bay Shrimp. Salvage disruptions during maintenance and repair could increase loss due to entrainment, whereas facility and salvage release site improvements could decrease loss during the salvage process. Any such effects would be limited because the species' distribution is primarily in areas farther downstream (Section 6.4.17.1, "Delta SWP Facility Operations").

6.4.17.4 Delta Smelt Supplementation

There is some dietary overlap between California Bay Shrimp and Delta Smelt (e.g., copepods and amphipods; see Appendix 6A and Slater et al. 2019). Supplementation of Delta Smelt would be unlikely to have appreciable negative effects on California Bay Shrimp because although abundance of Delta Smelt would increase, overall Delta Smelt abundance would likely remain low relative to other potential competitors with California Bay Shrimp for prey resources, particularly because of spatial overlap between the species only being a portion of the overall California Bay Shrimp range.

6.4.17.5 Water Transfers

The July–November water transfer period is consistent between the Proposed Project and Baseline Conditions and would overlap with the August–December period previously noted as having the highest catch per unit effort of California Bay Shrimp in the lower San Joaquin River (Table ~~6-97~~ 6-99). This indicates the potential for greater south Delta entrainment of California Bay Shrimp occurring during the water transfer window, but the abundance of California Bay Shrimp being entrained would likely be relatively low in relation to the overall distribution, which is centered in areas downstream of the region most susceptible to south Delta entrainment risk (Table ~~6-97~~ 6-99). This EIR does not provide environmental compliance for individual water transfer proposals.

6.4.17.6 Agricultural Barriers

Installation and operation of the agricultural barriers in the south Delta would not differ between Proposed Project and Baseline Conditions scenarios, so effects on California Bay Shrimp would be similar between the scenarios. As previously described in the context of south Delta entrainment, California Bay Shrimp abundance is relatively low in the south Delta (Table ~~6-97~~ 6-99). Operation of the barriers beginning in May would not disrupt major migratory movements because the species spawns in the nearshore coastal ocean/Central Bay and is broadly distributed (Appendix 6A). California Bay Shrimp occurring near the barriers could be at risk from effects such as near-field predation, although the effects would be consistent between the Proposed Project and Baseline Conditions.

6.4.17.7 Barker Slough Pumping Plant

BSPP operations would be unlikely to affect many California Bay Shrimp because of the species' distribution primarily in areas farther downstream; Bay Study catch per unit in the lower Sacramento River, for which the most upstream station is near Rio Vista and therefore well downstream of the BSPP, is relatively low (Table ~~6-97~~ 6-99). Entrainment would be avoided because of the fish screens at the BSPP (Chapter 2). Any effects from operations would be expected to be similar between the Proposed Project and Baseline Conditions given the similarity in modeled pumping between the scenarios (see Tables 4B.3-1-1a, 4B.3-1-1b, and 4B.3-1-1c in Attachment 3 of Appendix 4B). Sediment removal by suction dredge at BSPP would have the potential to entrain California Bay Shrimp, although the numbers would be expected to be limited given the very low portion of overall potentially occupied habitat that would be affected, relative infrequency of the work, and the main downstream distribution of the species. Removal of aquatic weeds with grappling hooks from the BSPP fish screens would be expected to have little effect on California Bay Shrimp, again given the very low portion of overall potentially occupied habitat that would be affected and the species' main downstream distribution.

6.4.17.8 Clifton Court Forebay Weed Management

Algal bloom treatments may occur year-round but are most likely to occur during summer and fall, a time period when it is most likely that California Bay Shrimp could occur in the general area based on catch data from the Bay Study; however, numbers would be expected to be relatively low compared to areas farther downstream such as Suisun Bay (Table ~~6-97~~ 6-99). Mechanical removal of aquatic weeds in CCF would occur on an as-needed basis and therefore could temporally coincide with occurrence of California Bay Shrimp, with shrimp occurrence near mechanical removal activities being more likely if both shrimp and weeds are concentrated into particular areas by prevailing water movement in CCF. Any potential adverse effects on individual California Bay Shrimp from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency because of reduced smothering by weeds. As noted previously, the species is primarily distributed downstream of CCF, indicating that any positive or negative effects attributable to CCF weed management would have minimal consequence for the California Bay Shrimp population.

6.4.17.9 Suisun Marsh Operations

Operational criteria for Suisun Marsh facility operations are the same under the Proposed Project and Baseline Conditions. (SMSCG operations for Delta Smelt Summer and Fall Habitat Actions are separate from operation to meet salinity standards and would differ between the Proposed Project and Baseline Conditions; see Section 6.4.17.2, "Delta Smelt Summer and Fall Habitat Actions.") Operation of the SMSCG from September through May to meet salinity standards set by the State Water Board and Suisun Marsh Preservation Agreement would not disrupt major migratory movements because the species spawns in Central Bay and the nearshore coastal ocean and is broadly distributed (Appendix 6A). Entrainment at MIDS has not been studied but may be low based on only one individual of another benthic species (Starry Flounder) being collected in entrainment samples during a two-year period (Enos et al. 2007). As discussed for Delta Smelt in Section 6.4.1.10, California Bay Shrimp entrained into Goodyear Slough could exit at the intake or the outfall. The RRDS has fish screens operated to low approach velocity (see Chapter 2), which would be expected to protect California Bay Shrimp from entrainment and impingement. Any effects of Suisun Marsh operations would be consistent between the Proposed Project and Baseline Conditions scenarios.

6.4.17.10 Georgiana Slough Salmonid Migratory Barrier Operations

Operations of the GSSMB would be expected to have limited effects on California Bay Shrimp because the species' main distribution is well downstream of the GSSMB location; there are no directed, migratory movements past the GSSMB location necessary; and effects would be limited to a small area near the BAFF and the species is benthic and therefore may not spatially overlap with the sound/lights/bubble of the BAFF, which is 2-12 feet above the substrate (Figure 6-51).

6.4.17.11 Significance of Impacts on California Bay Shrimp

The Proposed Project would have limited potential for differing effects on California Bay Shrimp relative to Baseline Conditions, given factors such as likely limited entrainment risk because of the more downstream distribution of the species relative to the south Delta and limited differences in Delta outflow during the period correlated with the species' Bay Otter Trawl abundance index. Based on the analysis presented above (Section 6.4.17.1, "Delta SWP Facility Operations;" Section 6.4.17.2, "Delta Smelt Summer and Fall Habitat Actions;" Section 6.4.17.3, "John E. Skinner Delta Fish Protective Facility;" Section 6.4.17.4, "Delta Smelt Supplementation;" Section 6.4.17.5, "Water Transfers;" Section 6.4.17.6, "Agricultural Barriers;" Section 6.4.17.7, "Barker Slough Pumping Plant;" Section 6.4.17.8, "Clifton Court Forebay Weed Management;" and Section 6.4.17.9, "Suisun Marsh Operations;" and Section 6.4.17.10, "Georgiana Slough Salmonid Migratory Barrier Operations"), the Proposed Project would not meet any of the threshold of significance conditions described in Section 6.3. Therefore, the impact of the Proposed Project on California Bay Shrimp would be less than significant. No mitigation is required.

6.4.18 Killer Whale

6.4.18.1 Significance of Impacts on Killer Whale

As discussed in Section 6A.1.22, "Southern Resident Killer Whale" in Appendix 6A, Central Valley streams produce Chinook Salmon that contribute to the diet of southern resident killer whale. The analyses presented above found that the Proposed Project would have less-than-significant impacts on Central Valley Chinook Salmon (Sections 6.4.3, "Winter-Run Chinook Salmon," 6.4.4, "Spring-Run Chinook Salmon," and 6.4.5, "Fall-Run and Late-Fall-Run Chinook Salmon"). Therefore, the impact of the Proposed Project on killer whale would be less than significant. No mitigation is required.

6.5 Mitigation Measures

No mitigation is necessary because the Proposed Project would not have significant impacts on aquatic biological resources.