WOCM 2:
Fremont Weir and Yolo Bypass Inundation

Scientific Evaluation Worksheet

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Action Description and Clarifying Assumptions

Option #1 Period of Potential Operation: December 1-May 15

Desired Duration of Inundation: 45 days
Target Spill Discharge into Bypass: 4000 cfs
Predicted area of inundation: 22,982 acres
Predicted mean depth of inundated area: 2.2 feet
Predicted travel time: 6.5 days
Spill Frequency of Fremont Weir (assuming 4000 cfs and 45 day duration with a spill intermission of no more than 7 days): 48% of years (38 of 79), compared to 6% of years (5 out of 79) at existing weir height.

Option #2 Period of Potential Operation: January 1-April 15

Desired Duration of Inundation: 30 days
Target Spill Discharge into Bypass: 2000 cfs
Predicted area of inundation: 17,421 acres
Predicted mean depth of inundated area: 2.3 feet
Predicted travel time: 9.3 days
Spill Frequency of Fremont Weir (assuming 2000 cfs and 30 day duration with a spill intermission of no more than 7 days): 54% of years (43 of 79), compared to 6% of years (5 out of 79) at existing weir height.

Approach

1. Fremont Weir would be notched to an elevation of 17.5 feet (NAVD88) approximately 225 feet wide and fitted with an operable gate(s) that, when operated, would allow Sacramento River water to flow into the Yolo Bypass when Sacramento River stage at the weir exceeds 17.5 feet. Channel dimensions would avoid channel velocities of >3 ft/s.
2. A trapezoidal canal (225’ width, side slopes 2:1) would be excavated to convey water past the higher elevation natural levee of the Sacramento River upstream of the new gate at the Fremont Weir and 10,000 feet past accumulated sediment below the new gate in the Bypass to the Tule Canal.
3. The existing Fremont Weir fish ladder would be removed and replaced with a new fish passage facility designed to effectively allow for the passage of adult salmonids and sturgeon from the Yolo Bypass past the weir into the Sacramento River.
4. To the extent necessary, the Bypass would be graded, existing berms or levees would be removed, and berms or levees would be constructed to improve the distribution and hydrodynamic characteristics of water moving through the Bypass, prevent stranding of covered fish species, and protect property.
5. If needed, a structure would be constructed in the Sacramento River in the vicinity of the new weir gate to encourage the passage of juvenile salmonids migrating down the Sacramento River into the bypass.

Note: At flood stage (>33.5 feet) the weir would overtop as under current conditions.

Intended Outcomes as Stated in Conservation Measure

Positive Outcomes:

P1 (intended): Create additional spawning habitat for splittail

P2 (intended): Create additional juvenile rearing habitat for Chinook salmon, splittail, steelhead, and green and white sturgeon

P3 (intended): Increase production of food for rearing of Chinook salmon, splittail, steelhead, (onsite = seasonal floodplain only)

P4 (intended): Increase frequency and magnitude of export of DOM, POM and organisms from seasonal floodplain to provide food in Delta for Delta smelt, longfin smelt, Chinook salmon, splittail, steelhead, and green and white sturgeon

P5 (intended): Increase frequency and magnitude of transport of organic carbon and organisms from Cache Slough/Bypass tidal marshes to support Delta foodweb for Delta smelt, longfin smelt, Chinook salmon, splittail, steelhead, and green and white sturgeon

P6 (intended): Reduce losses due to stranding and illegal harvest Chinook salmon, steelhead, and green and white sturgeon

P7: Increase delivery of readily suspendable sediments to north Delta and improved Delta smelt habitats

P8 (intended): Increase survival of out migrating juvenile salmonids by providing migration route with lower predation and entrainment (at North and South Delta diversions) risk.

Negative Outcomes:

N1: Increased MeHg and impact on covered species (on floodplain and downstream)

N2: Increased resuspension/mobilization and export of toxic compounds w/impact on covered species

N3: Increased stranding of covered species (consider grading proposed in the approach)

N4: Reduced flows in Sacramento River and distributaries to support successful outmigration.

N5: Increased habitat for non-native predators/competitors to covered species

Conceptual Model Information Regarding Intended Outcomes

Additional spawning habitat for splittail is supported by the Floodplain Model (Opperman, 2008) which notes that splittail population dynamics are strongly associated with annual patterns of flow and floodplain inundation (Moyle et al., 2004), and the importance of flooding of the Yolo Bypass in particular as a factor influencing the strength of the splittail year class (Sommer et al., 1997). Adult splittail move into inundated areas in late February or early March and spawning occurs in March and April. Recent research from the Yolo Bypass suggests that spawning is most likely to occur near the vernal equinox (late March) (Feyrer et al. 2006). Opperman, 2008 also notes the use of floodplain habitats, including the Yolo Bypass, by juvenile Chinook salmon but notes that little is known regarding steelhead. The Floodplain model makes no mention of green or white sturgeon, but the sturgeon models (as noted in the Outcomes Table) document loss of habitat as a stressor. Both sturgeon models note that Freemont Weir is a barrier for sturgeon. The Outcomes Table identified food production and increased food availability as outcomes in the Floodplain model and as drivers in the Delta smelt and longfin smelt models. Opperman, 2008 notes that salmon emigrate from floodplains as long as drainage connectivity is available and that certain features, such as pits, can lead to stranding.

Assumptions

Provided in BDCP Conservation Measure
The Toe drain would be graded where appropriate

Added by Evaluation Team
The evaluation team recognized that there may be future changes in land use but since predictions were not available only current land use was considered relative to the availability of toxic compounds for resuspension (Outcome N2).

Problem(s) with Action as Written

None identified

Scale of Action

Large

Rationale:
This represents an order of magnitude increase in frequency of inundation of existing floodplain habitat in the Delta.

Evaluation Summary Tables

Summary tables listing magnitude and certainty scores for each outcome, by species, are provided in Appendix A. Details regarding each of the listed scores, and the rationales for the scores are provided in the discussion of positive and negative outcomes following this section.

Relation to Existing Conditions

Would the action result in a change to system dynamics (either within the Delta or as inputs to the Delta) such that the current understanding of how the system works may no longer hold?

No. While this action represents a huge increase in the area of frequently inundated floodplain within the Delta it is expected that the area will function similarly to existing floodplains and the understanding generated from studies of Yolo Bypass and the Cosumnes River, as well as other areas, will be applicable to understanding the consequences of this action.

Potential Positive Ecological Outcome(s)

Outcome P1: Create additional spawning habitat for Splittail

P1a.1 Splittail Scenario 1

The Splittail Model (Kratville, 2009 - pages 9 and 12) describes how floodplain habitat supports splittail spawning:

- "Splittail are considered to be obligate flood plain spawners (Moyle 2002)."
- "Large scale spawning occurs only in years with significant inundation of flood plains in the Sacramento-San Joaquin watershed."
- "Splittail need water levels and inundation duration in ranges that were historically present (30 - 90 days)…The minimum length of inundation is required to achieve strong year classes when associated with large scale flood plain inundation as occurs on the Yolo Bypass. Longer inundation periods allow for extended and multiple spawning events as well as other food web associated benefits."

On page 14 of Splittail Model (Kratville, 2009), modification and loss of floodplain habitats is identified as a key limiting factor:

- **"**The substantial loss of floodplain from conversion to agriculture and urban areas and loss of river edge spawning habitat is probably the key limiting factor for splittail populations (Moyle et al. 2004)."

Magnitude = 4
The action is expected to have a landscape scale effect based on the increased frequency of flooding and extent of additional floodplain habitat.

Certainty = 4
The importance of floodplains for splittail spawning is well established by published papers based on evidence from this system.

P1a.2 Splittail Scenario 2

The rationale for the important of floodplain habitat to splittail spawning is same as for P1a.1 above.

Magnitude = 3
The lesser extent and decreased duration of flooding (30 days) compared to P1a.1 makes this scenario a regional scale habitat effect.

Certainty = 4
The importance of floodplains for splittail spawning is well established by published papers based on evidence from this system.

Outcome P2: Create additional juvenile rearing habitat for splittail, green and white sturgeon, steelhead and Chinook salmon

P2a.1 Splittail Scenario 1

Table 1 page 3 in Splittail Model (Kratville, 2009) indicates larvae use floodplains February through May and juveniles use floodplain February through July. Page 8 states “must have seasonally flooded lands on which to spawn for early rearing of larval and juvenile fish”. Page 12 notes “Although some are swept off floodplains and downstream by flood currents (Baxter et al. 1996), many splittail larvae and juveniles remain in riparian or annual vegetation along shallow edges on floodplains as long as water temperatures remain cool” (Sommer et al. 2002, Moyle et al. 2004). This outcome is supported by peer reviewed publications from the Cosumnes River and Yolo Bypass (Crain et al. 2004, Moyle et al. 2004, Sommer et al. 1997, 2001, 2007, Feyrer 2006, 2007).

Magnitude = 4
Splittail rely on shallow water habitat which is extremely limited without floodplain inundation (Sommer et al. 2008)

Certainty = 4
Supported by publications based on the Yolo Bypass in peer reviewed journals.

P2a.2 Splittail Scenario 2

The rationale for the importance of floodplain habitat to splittail rearing is same as for P2a.1 above.

Magnitude = 3
The lesser extent and decreased duration of flooding (30 days) compared to P2a.1 makes this scenario a regional scale habitat effect.

Certainty = 4
Supported by publications based on the Yolo Bypass in peer reviewed journals.

P2b. Green/white sturgeon Scenario 1 and 2

There is no evidence of juvenile sturgeon use of floodplains. Sturgeon caught in Yolo Bypass studies are adults (Harrell and Sommer 2003).

Magnitude = 1
There is little evidence of floodplain use by sturgeon.

Certainty = 2
Some data available but only for adults.

P2c. Steelhead Scenarios 1 and 2

Steelhead are present in the area at the time of flooding (McEwan 2001, Figure 3). According to Mossdale trawl data from the Sacramento River steelhead are emigrating January through August, with the peak in January through May. The Floodplain Model (Opperman, 2008, pg 27) indicated little information is available on steelhead use of floodplain habitats. However, the steelhead model (Williams and Rosenfield, in preparation, page 155, Figure 2) shows floodplain use. Juvenile steelhead have been caught on the floodplain in Yolo (Sommer et al. 2001). There is some reference to additional observations in Williams 2006 (Chapter 9, page 174). McEwan (2001) and Moyle (2002) also support the presence of steelhead on floodplains.

Magnitude = 4
There is sufficient evidence of the use of floodplains by steelhead; Action includes major increase in habitat availability.

Certainty = 2
Few direct observations of steelhead benefiting from floodplain habitat.

P2d. Chinook salmon Scenario 1 and 2

Chinook salmon juveniles are present in the area during the proposed floodplain inundation period of late winter and spring.

- Knights Landing data indicates:
  Winter Run Juvenile peaks Nov –Feb
  Fall run peaks Jan – Feb then Apr -May
  Late Fall run peaks on Dec and April
  Spring Run peaks are Dec-Jan and March – April (CDFG rotary screw trap)

Chinook salmon juveniles use the floodplain for rearing. The restored floodplain would create rearing habitat for fry/parr that enter the Delta in the winter, coincident with inundation of the floodplain. These fry would be able to feed and grow in the floodplain, and their larger size would increase the likelihood of survival in the ocean.

- "Recent work shows that the bypasses do indeed provide habitat for juvenile Chinook, that they grow well there, and that most avoid stranding". (Williams 2006)
- Juvenile salmon collected from the inundated Yolo Bypass were substantially larger and grew more rapidly then juveniles collected from Sacramento River (Sommer et al. 2001).

Fall-run Chinook fry (<70mm) rear primarily in the upper freshwater delta. Peak fry rearing is February through March and young fry appear to be most abundant in shallow water and shoreline habitat. Rearing occurs for two months or more (Kjelson et al. 1982).

- Central Valley Chinook salmon may have relied extensively on floodplain in the past; historically much of the Central Valley was floodplain habitat (Hunter et al. 1999)
- Sommer et al. (2005) reported extensive use of Yolo and Sutter bypasses by fall-run Chinook salmon.
- Moyle et al. (2007) reported use of Cosumnes River floodplain by Chinook salmon.

Magnitude = 4
Compared to current conditions, the frequency and extent of inundated floodplain habitat for Chinook salmon will be significantly increased representing a landscape scale habitat effect.

Certainty = 4
There is high certainty that juvenile salmon are in the vicinity (based on data), and juveniles rear in restored floodplain based on documented rearing in the Yolo Bypass and the restored Cosumnes River floodplain (various published papers).

Outcome P3: Increase production of food for rearing of Chinook salmon, green and white sturgeon, splittail, and steelhead, on the seasonal floodplain

P3a. Splittail Scenario 1 and 2

The use of floodplains for rearing is established (P2a above). The Splittail Model (Kratville, 2009) notes, “After yolk sac absorption the larvae begin feeding on small rotifers (Bailey 1994). Prey composition shifts as they increase in size to cladocerans and chironomid larvae (Kurth and Nobriga 2001). Larval splittail to 15mm feed heavily on zooplankton, primarily made up of cladocerans. Chironomid larvae begin to dominate after 15mm in length has been achieved (Feyrer et al. 2007).” The model also notes that flooding of the Yolo bypass is associated with “a large hatch of an endemic chironomid, *Hydrobaenus saetheri*” (Cranston et al. 2007, Benigno and Sommer 2008). Floodplain Model (Opperman, 2008 - pgs 20-25 and Figure 5) describes floodplain food production and notes a positive relationship between temperature and zooplankton and the influence of floodplain flow velocity on macroinvertebrates,

Magnitude = 4
Splittail are floodplain dependent (Moyle et al. 2004; Sommer et al. 2007) and food resources are large on the floodplain.

Certainty = 4
There are substantial data and publications on splittail use of seasonal floodplain.

P3b. Green and white sturgeon Scenarios 1 and 2

The draft White Sturgeon Model (Israel et. al., 2009 - page 8) indicates “White sturgeons are unique in that their digestive systems are nearly fully formed both physically and physiologically at the larval stage (Gawlicka et al. 1995). Nothing is known about the diets of white sturgeon larvae in the wild, although laboratory studies suggested that they consist of benthos, periphyton, and possibly pelagic fry and zooplankton (Brannon et al. 1984, Buddington and Christofferson 1985).” Juvenile white sturgeon also may consume tube dwelling amphipods, mysids (*Neomysis spp*), isopods, benthic invertebrates, and fish eggs or fry, including those of other sturgeon (Brannon et al. 1987, PSMFC 1992). The draft Green Sturgeon Model (Israel and Klimley, 2008 - page 9) indicates that no studies have been undertaken of food resources for larval green sturgeon. However, there is no evidence of juvenile sturgeon use of floodplains. Sturgeon caught in Yolo Bypass have been adults (Harrell and Sommer 2003).

Magnitude = 1
There is no evidence of juvenile sturgeon use of floodplains. Sturgeon caught in Yolo Bypass have been adults.

Certainty = 2
Historical sampling in Yolo Bypass has not been well-designed to capture young sturgeon, thereby reducing certainty about this issue.

P3c.1 Steelhead Scenario 1

We know of no observations in the literature that support steelhead feeding on floodplains; however, it can be assumed that they are utilizing the same food sources as juvenile salmon (see P3d), given their life-history similarities. Moyle et al. 2004 states that stream-dwelling rainbow trout feed mostly on drifting aquatic organisms, terrestrial insects, and bottom dwelling organisms which are in abundance on floodplains.

Magnitude = 3
Effect demonstrated for species with similar life histories.

Certainty = 3
There have been some studies on similar species within the system.

P3c.2 Steelhead Scenario 2

We Know of no observations in the literature that support steelhead feeding on floodplains, however, it can be assumed that they are utilizing the same food sources as juvenile salmon (see P3d), given their life-history similarities. Moyle et al. 2004 states that stream-dwelling rainbow trout feed mostly on drifting aquatic organisms, terrestrial insects, and bottom dwelling organisms which are in abundance on floodplains.

Magnitude = 2
Magnitude is lower than scenario 1 because inundation frequency and duration is lower

Certainty = 3
See P3c.1

P3d.1 Chinook Salmon Scenario 1

Juvenile Chinook salmon use of floodplain habitats is well established (Sommer et al. 2001b, Whitener and Kennedy 1999). Opperman, 2008 (page 29) notes that the higher growth rates of juvenile Chinook on Central Valley floodplains, relative to river habitats, has largely been attributed to the greater availability of prey items within floodplain habitats (Jeffres et al. 2007, Sommer et al. 2001b). This includes Dipterans (Sommer et al., 2001) and zooplankton (Grosholz and Gallo 2006). Chinook salmon likely take advantage of small fishes on the floodplain (Williams and Rosenfield, In preparation pg 8) and (Moyle et al. 2004).

Magnitude =4
Extensive floodplain area inundated and high likelihood of appropriate food production.

Certainty = 3
Juvenile Chinook salmon use of floodplain habitats is well established.

P3d.2 Chinook Salmon Scenario 2

Rationale is similar to P3d.1. Differences in scores reflect reduction in scale of floodplain inundation.

Magnitude = 3-4
Reduced scale and duration of floodplain inundation compared to P3d.1

Certainty = 3
Juvenile Chinook use of floodplain habitats is well established.

Outcome P4: Increase frequency and magnitude of export of DOM, POM and organisms from seasonal floodplain to provide food in Delta for Delta smelt, longfin smelt, Chinook salmon, splittail, steelhead, and green and white sturgeon

P4a. Delta smelt Scenarios 1 and 2

Delta smelt Model (Norbriga and Herbold, 2008 - pg 12) describes the importance of zooplankton to Delta smelt. Opperman, 2008 notes that the most important variables influencing zooplankton production on floodplain are hydraulic residence time and the availability of food resources (e.g., phytoplankton and periphyton). Grosholz and Gallo (2006) also found that zooplankton densities peaked about 2-3 weeks after disconnection between river and floodplain (draining phase). The Foodweb Model (Durand, 2008) notes that DOC reaches the estuarine foodweb via bacteria and notes this is well understood in this estuary. The model also notes recent studies by Sobczak et al. (2005) that indicates that some zooplankton tend not to use phytoplankton exclusively, supplementing their diets substantially with particulate organic matter or ciliates: According to the fall midwater and Kodiak trawl data and Sommer et al. (in prep), Delta smelt rear in areas immediately downstream of Yolo Bypass.

Magnitude = 3
Delta smelt rear immediately downstream from Yolo Bypass where exported food would be readily available.

Certainty = 3
Delta smelt Model (Norbriga and Herbold, 2008 - pg 12) describes the importance of zooplankton to Delta smelt. Opperman, 2008 notes that the most important variables influencing zooplankton production on floodplains are hydraulic residence time and the availability of food resources (e.g., phytoplankton and periphyton) - see above paragraph.

P4b. Longfin Smelt Scenarios 1 and 2

The Longfin Smelt Model (Rosenfield, 2008 - pg 15) notes that early stage longfin smelt juveniles probably rely on *Eurytemora affinis* as a prey item during April and May with other copepods becoming important later in the year. Food limitation is considered a stressor on juveniles and sub adults. Opperman, 2008 notes that the most important variables influencing zooplankton production on floodplains are hydraulic residence time and the availability of food resources (e.g., phytoplankton and periphyton). Grosholz and Gallo (2006) also found that zooplankton densities peaked about 2-3 weeks after disconnection between river and floodplain (draining phase). The Foodweb Model (Durand, 2008) notes that dissolved organic carbon (DOC) reaches the estuarine foodweb via bacteria and that this is well understood in this estuary. The model also notes recent studies by Sobczak et al. (2005) that indicates that some zooplankton tend not to use phytoplankton exclusively, supplementing their diets substantially with particulate organic matter or ciliates.

Magnitude = Between 2 and 3
The shift in the longfin smelt-X2 relationships after the introduction of *Corbula* suggest longfin smelt are sensitive to food availability (Kimmerer 2002). Young longfin smelt occur close to Yolo Bypass but the benefit to longfin smelt further downstream may be limited due to the role of *Corbula*.

Certainty = 2
The relative importance of exported floodplain carbon to longfin smelt is unclear, particularly given high densities of the grazer *Corbula* between floodplain and main brackish habitat of longfin smelt.

P4c. Splittail Scenarios 1 and 2

Opperman, 2008 (pg 20) describes the importance of exporting food to downstream foodwebs and the links between carbon produced on floodplains and the downstream foodweb (Sobczak et al. 2005). The use and importance of these food resources has been described for splittail in outcome P3a.

Magnitude = 3
Splittail use Yolo bypass, but the benefit to splittail further downstream may be limited due to role of *Corbula.*

Certainty = 2
The relative importance of exported floodplain carbon to splittail is unclear, particularly given high densities of the grazer *Corbula* between floodplain and downstream habitat of splittail.

P4d. Green/white sturgeon Scenarios 1 and 2

Opperman, 2008 (pg 20) describes the importance of export of food to downstream food webs and the links between carbon produced on floodplains and the downstream foodweb (Sobczak et al. 2005). The use and importance of these food resources has been described for green and white surgeon in outcome P3b.

Magnitude =2
The White Sturgeon Model (Israel et. al., 2009 - pg 11) notes feeding on highly-abundant suspension-feeding bivalves such as *Corbula amurensis.* The Green Sturgeon Model (Israel and Klimley, 2008) notes that invasive *Corbula* has replaced native mollusks and shrimp as food for green sturgeon in recent years. Sturgeon may indirectly benefit from the export of food through the *Corbula* foodweb linkage.

Certainty = 2
Importance of food exported from floodplains for sturgeon directly or indirectly is unclear. Little evidence available.

P4e.1 Steelhead Scenarios 1 and 2

Opperman, 2008 (pg 20) describes the importance of exporting food to downstream foodwebs and the links between carbon produced on floodplains and the downstream foodweb (Sobczak et al. 2005). The use and importance of these food resources has been described for steelhead in outcome P3c.

Magnitude = 2-3
Floodplains produce aquatic insects. Increased flows will export these resources downstream. Steelhead feed mostly on drifting aquatic organisms, terrestrial insects, and bottom dwelling organisms (Moyle et al. 2004).

Certainty = 2
It can be assumed that steelhead are utilizing similar food sources as juvenile salmon given their life-history similarities (see P3d), however there is little documentation.

P4f.1 Chinook Salmon Scenario 1 and 2

Opperman, 2008 (pg 20) describes the importance of exporting food to downstream food webs and the links between carbon produced on floodplains and the downstream foodweb (Sobczak et al. 2005). The availability of these food resources has been described for Chinook salmon in outcome P3d, However the importance of these food resources in downstream habitats is not as well documented.

Magnitude = 2-3
Floodplains produce aquatic insects. Increased flows will export these resources downstream. Steelhead feed mostly on drifting aquatic organisms, terrestrial insects, and bottom dwelling organisms (Moyle et al. 2004).

Certainty = 2
The importance of these food resources in downstream habitats is not as well documented.

Outcome P5: Increase frequency and magnitude of transport of OC and organisms from Cache Slough/Bypass tidal marshes to support Delta foodweb for Delta smelt, longfin smelt, Chinook salmon, splittail, steelhead, and green and white sturgeon

P5a. Delta smelt Scenarios 1 and 2

Marsh production of phytoplankton is high in Liberty Island (Lehman et al. 2007); Phytoplankton supports the delta food web (Sobzack et al. 2002; Mueller-Solger et al. 2002). Production from lower Yolo Bypass including. Liberty and Cache slough marshes stays relatively intact as it moves down the estuary (Monsen 2003). Delta smelt diets are largely comprised of zooplankton (Delta smelt model p. 5), especially larval stages of specific copepods. Food is potentially an important limiting factor for Delta smelt but its effect cannot be readily separated from water temperature (Norbriga and Herbold, 2008 pg. 8).

Magnitude = 3
Magnitude is higher than other species because Delta smelt are planktivorous.

Certainty = 2
It is uncertain whether the increased production associated with the action will be reduced by *Corbicula.*

P5b. Longfin Smelt Scenarios 1 and 2

Marsh production of phytoplankton is high in Liberty Island (Lehman et al. 2007); Phytoplankton supports the delta food web (Sobzack et al. 2002; Mueller-Solger et al. 2002). Production from lower Yolo Bypass, including Liberty and Cache slough marshes, stays relatively intact as it moves down the estuary (Monsen 2003). Longfin Smelt Model (Rosenfield, 2008 - pg 15) notes that early stage longfin smelt juveniles probably rely on *Eurytemora affinis* as a prey item during April and May with other copepods becoming important later in the year. Food limitation is considered a stressor on juveniles and sub adults (Rosenfield, 2008 Figure 4).

Magnitude = 3
Magnitude is higher than other species because longfin smelt are planktivorous.

Certainty = 2
It is uncertain whether the increased production associated with the action will be reduced by *Corbicula.*

P5c. Splittail Scenarios 1 and 2

Marsh production of phytoplankton is high in Liberty Island (Lehman et al. 2007); Phytoplankton supports the delta food web (Sobzack et al. 2002; Mueller-Solger et al. 2002). Production from lower Yolo Bypass, including Liberty and Cache slough marshes, stays relatively intact as it moves down the estuary (Monsen 2003). According to the Splittail Model (Kratville, 2008), larval splittail up to 15mm feed heavily on zooplankton, primarily made up of cladocerans. Chironomid larvae begin to dominate the diet after 15mm in length has been achieved (Feyrer et al. 2007). Moyle et al. (2004)

notes that growth rates, especially in the first year or two of life, may be strongly dependent on availability of high quality food, as suggested by changes in growth rate following the invasion of the overbite clam in the 1980s and by the collapse of *Neomysis* populations upon which splittail historically specialized (Feyrer et al. 2003).

Magnitude = 2
Food availability is not identified as key stressor in the Splittail Model.

Certainty = 2
It is uncertain whether the increased production associated with the action will be reduced by *Corbicula.*

P5d. Green and White Sturgeon Scenario 1 and 2

Marsh production of phytoplankton is high in Liberty Island (Lehman et al. 2007); Phytoplankton supports the delta food web (Sobzack et al. 2002; Mueller-Solger et al. 2002). Production from lower Yolo Bypass, including Liberty and Cache slough marshes, stays relatively intact as it moves down the estuary (Monsen 2003). The Draft White Sturgeon Model (Israel et. al., 2009) indicates nothing is known about the diets of white sturgeon larvae in the wild, although laboratory studies suggested that they consist of benthos, periphyton, and possibly pelagic fry and zooplankton (Brannon et al. 1984, Buddington and Christofferson 1985). Juvenile white sturgeon also may consume tube dwelling amphipods, mysids (*Neomysis spp*), isopods, benthic invertebrates, and fish eggs or fry, including those of other sturgeon (Brannon et al. 1987, PSMFC 1992). The Draft Green Sturgeon Model (Israel and Klimley, 2008 - page 9) indicates that no studies have been undertaken of food resources for larval green sturgeon.

Magnitude =2
There is limited evidence that sturgeon will benefit from this additional food resource.

Certainty = 2
Few studies have been conducted to support juvenile sturgeon feeding. It is uncertain whether the increased production associated with the action will be reduced by *Corbicula.*

P5e. Steelhead Scenario 1 and 2

Marsh production of phytoplankton is high in Liberty Island (Lehman et al. 2007); Phytoplankton supports the delta food web (Sobzack et al. 2002; Mueller-Solger et al. 2002). Production from lower Yolo bypass, including Liberty and Cache slough marshes, stays relatively intact as it moves down the estuary (Monsen 2003). Steelhead feeding strategies and dietary preferences are similar to those of Chinook salmon (Williams and Rosenfield, In preparation p.38). Fish in the wild are expected to be food-limited (Moyle and Cech 2004). Marshes produce aquatic insects; increased flows will export these resources downstream. Steelhead feed mostly on drifting aquatic organisms, terrestrial insects, and bottom dwelling organisms (Moyle et al. 2004).

Magnitude = 2
Marshes produce aquatic insects; increased flows will export these resources downstream. Steelhead feed mostly on drifting aquatic organisms, terrestrial insects, and bottom dwelling organisms.

Certainty = 2
It is uncertain whether the increased production will be consumed by *Cobicula* and thus be unavailable to sturgeon downstream of Yolo.

P5f. Chinook Salmon Scenario 1 and 2

Marsh production of phytoplankton is high in Liberty Island (Lehman et al. 2007); Phytoplankton supports the delta food web (Sobzack et al. 2002; Mueller-Solger et al. 2002). Production from lower Yolo bypass, including Liberty and Cache slough marshes, stays relatively intact as it moves down the estuary (Monsen 2003). Chinook salmon in the wild are expected to be food-limited (Moyle and Cech 2004).

Magnitude = 2
See above

Certainty = 2
It is uncertain whether the increased production will be consumed by *Cobicula* and thus be unavailable to salmon downstream of Yolo.

Outcome P6: Reduce losses due to stranding, illegal harvest and blocked/delayed passage for Chinook salmon, steelhead, green/white sturgeon

P6a. Green and White Sturgeon Scenario 1 and 2

Adult passage of white and green sturgeon is likely constrained in the Yolo Bypass (Harrell and Sommer 2003). Current configuration of Fremont and Sacramento weirs create stranding and poaching problems for white and green sturgeon (Sommer et al. 2005, (Israel et. al., 2009 pg 20), (Israel and Klimley, 2008 page 18); hence efforts to improve passage and redesign weirs will reduce poaching and stranding.

Magnitude = 4
Blocked passage (and resulting legal and illegal harvest) is substantial; loss of spawners is particularly harmful to the populations. Frequent poaching has been well-documented by the Department of Fish and Game.

Certainty = 4
Studies within Yolo have identified the problem (DFG Unpublished Data, Harrell and Sommer 2003; Harrell et al. in prep).

P6b. Steelhead Scenarios 1 and 2

Adult passage of salmon (and steelhead) is likely constrained in the Yolo Bypass (Harrell and Sommer 2003). Current Fremont and Sacramento weirs create stranding problems for salmon (Sommer et al. 2005); hence efforts to improve passage and redesign weirs will reduce poaching and stranding.

Magnitude = 4
Blocked passage is more of a problem than stranding.

Certainty = 3
Studies within Yolo have identified the stranding problem (DFG Unpublished Data, Harrell and Sommer 2003; Harrell et al. in prep). But it is less well documented for steelhead due to relatively low catch of adults.

P6c. All Races Chinook Salmon Scenarios 1 and 2

Adult passage of salmon is likely constrained in the Yolo Bypass (Harrell and Sommer 2003). Current Fremont and Sacramento weirs create stranding problems for salmon (Sommer et al. 2005); hence efforts to improve passage and redesign weirs will reduce poaching and stranding. Williams (2006) indicates that water flowing through the Yolo Bypass attracts migrating adult salmon into this seasonally flooded wetland; however, the Fremont Weir, at the top of the Bypass does not allow salmon passage. This barrier represents either a serious delay to spawning; or a literal “dead end” (Williams and Rosenfield, In preparation page 55).

Magnitude = 4
A serious delay in salmon spawning has been documented. Blocked passage involved an extensive (~100 mile) increase in passage.

Certainty = 3 to 4
Studies within Yolo have identified the problem (DFG Unpublished Data, Harrell and Sommer 2003; Harrell et al. in prep). The certainty is lower for spring and winter-run salmon because of lower numbers and lower catch rates in sampling.

Outcome P7: Increase delivery of readily suspendable sediments to north Delta and improved Delta smelt habitats

<u>Scenario 1:</u>
Sedimentation Model (Schoellhamer et. al., 2007 - page 9) describes Yolo Bypass as the second largest source of sediment for the Delta. Lehman et al. (2008) also found that the concentration of suspended solids were higher in the Yolo Bypass than in the Sacramento River.

The Delta smelt Model (Norbriga and Herbold, 2008 – pages 4-5 and 11) shows that Delta smelt spawn in the Cache Slough region of the northern Delta and that larval Delta smelt have an improved ability to see prey in water with enhanced turbidity. There is an additional hypothesis that Delta smelt use turbidity to conceal themselves from predators (Norbriga and Herbold, 2008 - page 7).

<u>Scenario 2:</u>
Sedimentation Model (Schoellhamer et. al., 2007 - pages 6 and 10) shows that sediment transport is flow dependant, also Floodplain Model (Opperman, 2008 - page 10) states

that floodplain benefits are proportional to the spatial extent of floodplains; however, given the relatively small difference in flow and inundation area between the two scenarios, it seems likely the benefits of enhanced turbidity provided under scenario 1 would be similar to scenario 2.

Magnitude = 3
Increase in quality and quantity of larval/juvenile Delta smelt habitat based on substantial increase in frequency and duration of inundation and sediment delivery over current conditions.

Certainty = 3
There is a high understanding but with many variables.

Outcome P8: Increase survival of out migrating juveniles (steelhead and Chinook salmon) by providing migration route with lower predation and entrainment (at North and South Delta diversions) risk.

Passage through the bypass and reentering the Sacramento River near Rio Vista avoids possible migratory routes into the central delta. As floodwaters recede from the Yolo Bypass, the juveniles exit to the south, ultimately into the toe drain which provides the only means of passage into the delta (Sommer et al. 2001, 2005). Thus Yolo Bypass when inundated during winter/spring months will provide additional migratory paths for emigrating Chinook salmon and steelhead juveniles above the location of the proposed peripheral canal. This would also mitigate entrainment exposure at this new facility

Newman (2008) showed that survival rates were 66% higher for juvenile salmon released in the lower mainstem of Sacramento River (near Ryde) than for those released in central delta (Georgiana Slough). Vogel (2008) conducted an acoustical tag study in 2006 and 2007 which showed there were reach specific characteristics for loss rates on juvenile salmon released in Sacramento River near Old Town. Preliminary results showed that loss in Delta Cross Channel and Georgiana Slough was at least 2 times greater then on main stem or Sutter and Steamboat Slough. This effect is likely similar for steelhead although few specific data are available.

Note: Evaluation assumes that new North Delta facilities would increase predation risks.

Magnitude = 3-4
This action provides an additional migratory route that currently exists but increases the frequency and duration of its availability. The action will benefit upper Sacramento migrating juveniles when functioning properly on a biennial basis. Fish will be able to avoid predators that will likely congregate in the vicinity of the North Deltas diversion as well as being able to benefit from the food resources/habitat provided by the bypass.

Certainty = 3 for Chinook salmon, 2 for Steelhead
Migratory routes for salmon in the north delta have been shown through several studies to have higher survival rates then those in the central Delta (Vogel 2008, Newman 2008) Little data available for steelhead – reduced certainty is based on the assumption that they respond the same as Chinook salmon.

Potential Negative Ecological Outcome(s)

Outcome N1: Increased MeHg and impact on covered species (on floodplain and downstream)

Proximity to mining-related mercury loading sources is an important factor affecting methyl mercury (MeHg) exposure and bioaccumulation in fish in the Bay-Delta (Alpers et al. 2008, page 23). The Yolo Bypass is downstream of mining-related mercury sources in the Cache Creek and Putah Creek watersheds.

Inundation frequency is another important factor affecting MeHg production. Habitats with the highest levels of MeHg production, concentration and exposure to biota are those with periodic flooding events separated by sufficient time to allow complete drying, such as the seasonal floodplains that would be enhanced in this project (Alpers et al. 2008, pages 15 and 17), also cites Marvin-DiPasquale et al. (2007).

The project would result in inundation of larger areas of floodplain, for longer periods of time, and in more years than the baseline weir height condition. These changes from baseline may result in higher MeHg concentrations in the Yolo Bypass aquatic food chain as conditions are improved for development of the phytoplankton and zooplankton communities. The single largest concentration jump in food web MeHg bioaccumulation occurs between aqueous MeHg and algal cells or phytoplankton (Alpers et. al., 2008, page 19). The frequency and magnitude of export of MeHg downstream would increase over baseline, resulting in increased exposure to covered fish species downstream in the Delta.

The linkage of seasonal flooding to MeHg production and subsequent bioaccumulation of MeHg in fish and their prey is well documented. Fish tend to accumulate greater burdens and concentrations of MeHg over time, so older individuals typically have higher body burdens and higher absolute concentrations of MeHg than younger ones (Wiener and Spry 1996). Effects of this bioaccumulation on covered fish species are more uncertain, due to lack of studies of toxicological effects of MeHg on covered species, uncertainty about sensitivity of covered species relative to species that have been studied, and the subtle nature of the behavioral effects that are among the most sensitive endpoints for MeHg toxicity and are difficult to detect. Some of the sub-lethal effects related to Hg in fish include: altered hormone expression, reduced spawning success, reduced reproductive output, reduced gonadosomatic indices and testicular atrophy, liver necrosis, and altered predator avoidance behavior (Alpers et. al., 2008, pg 31).

The Mercury Model (Alpers et. al., 2008, pg 31) indicates that an Hg concentration of 0.20 ppm, (wet-wt) in fish tissue is a threshold for the onset of adverse effects in fish (Beckvar et al. 2005). Concentrations of Hg in some fish from some parts of the Yolo Bypass may currently exceed this effect concentration. For example, Ackerman et al. (2008) found average Hg concentrations of 1.76 ppm, dry-wt (approximately 0.35 ppm wet-wt, assuming wet-weight concentrations are approximately 20% of dry-weight concentrations) in caged mosquitofish placed at the outlets of white rice fields and exposed for 60 days in the Yolo Bypass. Similarly, Hg concentrations in wild mosquitofish and wild silverside were 1.09 ppm, dry-weight (approximately 0.218 ppm, wet-weight) and 1.25 ppm, dry-weight (approximately 0.25 ppm, wet-weight), respectively, at white rice outlets. Mercury concentrations were lower in fish sampled at the inlets to rice fields and in permanent wetlands in the Yolo Bypass (Ackerman et al. 2008). Previous studies focused on canals and permanent ponds in the Yolo Bypass found Hg concentrations in small fish were below effects concentrations (Slotton et al. 2002, Davis et al. 2007). A recent, unpublished study of MeHg bioaccumulation in juvenile Chinook salmon found that the rate of MeHg bioaccumulation was higher in the Yolo Bypass than the mainstream Sacramento River, but the concentrations of MeHg in the juvenile salmon remained below the threshold for toxic effects (Henery et al., in review).

Magnitude = 1-2
The proposed action could result in increases in MeHg production and bioaccumulation that would cause fish tissue Hg concentrations to exceed effects levels for sub-lethal impacts to fish health. The magnitude of this negative outcome would vary depending on species and life-stage due to differences in exposure (a function of distribution and diet) and sensitivity. Acute toxicity (i.e., death from mercury poisoning) would be very unlikely to occur in any covered fish species. Chronic toxicity manifested as adverse behavioral or physiological effects may occur in some individual fish of covered species that spawn in the Yolo Bypass (e.g., splittail), rear in the Bypass (e.g., splittail, salmon and steelhead) or rear immediately downstream in the Cache Slough area (Delta smelt). The risk of chronic toxicity from Hg methylation and bioaccumulation in the Yolo Bypass would be minimal in species that do not use the Yolo Bypass or Cache Slough area for spawning or rearing (e.g., sturgeon and longfin smelt).

Certainty = 2
The linkage of seasonal flooding to MeHg production and subsequent bioaccumulation of MeHg in fish and their prey is well documented. However, potential effects of this bioaccumulation on covered fish species are less clear because of lack of information on the sensitivity of these species to MeHg and uncertainty in predicting the degree to which MeHg concentrations in fish would increase as a result of the action. Two of the most relevant studies of MeHg bioaccumulation in fish in the Yolo Bypass are recent studies that have not yet been published.

Outcome N2: Increased resuspension/mobilization and export of toxic compounds w/impact on covered species

A wide variety of crops are grown in the Yolo Bypass and surrounding areas, and many different pesticides are used on these crops (Smalling et al. 2007) including, but not limited to, pyrethroids (Werner et al. 2008, pg 3). Pesticides were detected in water samples collected in the inflows to the Yolo Bypass and within the Bypass in 2004 (Smalling et al. 2007). Pesticides detected in water samples included herbicides, especially hexazinone and simazine, and insecticides, especially diazinon (Smalling et al. 2007). The concentrations of dissolved pesticides were below levels known to cause acute or chronic toxicity to fish; however, some of the herbicide concentrations (e.g., hexazinone) were high enough to potentially adversely affect primary productivity (Smalling et al. 2007).

Sediments and soils from the Bypass and its inflows contained other pesticides, such as pyrethroids and DDTs (Smalling et al. 2007). The concentrations of pesticides associated with sediments were below levels known to cause acute toxicity to fish; however, the concentration of at least one pyrethroid (lambda-cyhalothrin) in suspended sediment was high enough to adversely affect benthic macroinvertebrates that fish rely on for food (Smalling et al. 2007).

Increased seasonal flooding of agricultural lands may mobilize pyrethroids and other pesticides from soils and increase exposure to covered fish species in the Yolo Bypass and downstream. One of the goals of the project is to facilitate spawning by splittail and rearing by splittail and other species. Pyrethroids can be toxic to fish, especially to early life stages (Werner et al. 2008, pg 16). Teh et al. (2005) showed sub-lethal effects and delayed mortality to larval splittail exposed to orchard storm water runoff that contained a pyrethroid (esfenvalerate) and an organophosphate (diazinon). These fish showed higher mortality rates and slowed growth even after a three month recovery period. Combinations of low concentration toxic chemicals (Pyrethroids, Organophosphates, Organochlorines, etc.) which may have low effects on fish directly can have significant negative impacts on Chironomids (Lydy and Austin 2004), and other invertebrates (Hunt et al. 1999, Hunt et al. 2003, Amweg et al. 2005, Weston et al. 2008). Pyrethroid concentrations would be expected to peak during the winter/spring storm season and after peak agricultural application in the summer and fall (Werner et al. 2008, pg 2). Late-winter and spring are also the times splittail would use the enhanced floodplain habitat to spawn (Kratville**,** 2008, pg 1).

There are critical data gaps on pyrethroids and other pesticides that make it difficult to evaluate risk to covered fish (Werner et al. 2008, pg 32; Werner et. al., 2008, pg 25). In general, little is known about the toxic effects of contaminants known to be present in the Delta on resident Delta species, and even less is known about the sub lethal effects of contaminants (Werner et. al., 2008, pg 25). The potential effects of complex mixtures of low level pesticides, such as those detected in the Yolo Bypass by Smalling et al. (2007) are also poorly understood. Due to additive and synergistic effects, mixtures of pesticides that have been commonly reported in salmon habitats may pose a more important challenge for species recovery than previously anticipated (Laetz et al. 2009).

Magnitude = 1-2
The highest concentrations of dissolved pesticides enter the Bypass as a pulse during the first high-flow event following winter pesticide application (Smalling et al. 2007). Late-winter and spring are also the times splittail would use the enhanced floodplain habitat to spawn (Splittail model, pg 1). The magnitude of potential adverse effects to splittail and other covered fish would vary depending on species and life-stage due to differences in distribution and sensitivity. Species that spawn in the Yolo Bypass (e.g., splittail) or rear in the Bypass (e.g., splittail, salmon and steelhead) or immediately downstream in the Cache Slough area (Delta smelt) would be at greater risk of toxicity than species that do not use these areas for spawning or rearing (e.g., sturgeon and long-fin smelt).

Certainty = 2
There are critical data gaps on pyrethroids and other pesticides that make it difficult to evaluate risk to covered fish (Werner and Oram, 2008 pg 32; Werner et. al., 2008, pg 25). The potential effects of complex mixtures of low level pesticides, such as those detected in the Yolo Bypass by Smalling et al. (2007) are also poorly understood.

Outcome N3: Increased stranding of covered species

N3a.1 & N3a.2 Splittail adult and juvenile Scenarios 1 and 2

Connectivity problems can strand splittail (Opperman, 2008 pg 27 citing Sommer et al. 2005). The approach specified for this action includes grading which may reduce this risk, however the specifics are not known.

Magnitude = 1
Densities of splittail are low in isolated ponds in the Yolo Bypass (DWR unpublished data; Feyrer et al. 2004)

Certainty = 4
Sommer et al (2005) showed that there is relatively little ponded area following floodplain inundation. Low level of ponding reduces stranding.

N3b. Green/white Sturgeon adult/juvenile Scenarios 1 and 2

Current Fremont and Sacramento weirs create stranding and passage problems for white sturgeon and green sturgeon, (Sommer et al. 2005; Harrell and Sommer 2003). Observations indicate substantial legal/illegal harvest resulting from blocked passage.

Poaching may be a major issue for white sturgeon (White Sturgeon model pg 20)

Magnitude = 1
Blocked passage will be minimal behind the modified weir as it will be designed to improve passage, and grading will limit stranding on the floodplain for adults

Certainty = 4
The assumption is that the problem of blocked passage will be resolved by the modifications to the weir.

N3c. Steelhead Scenarios 1 and 2

Adult passage of white sturgeon, green sturgeon, splittail, steelhead and salmon is likely constrained in the Yolo Bypass (Harrell and Sommer 2003). Current Fremont and Sacramento weirs create stranding problems for white sturgeon and green sturgeon (Sommer et al. 2005); hence efforts to improve passage and redesign weirs will reduce stranding (Harrell and Sommer 2003).

Magnitude = 1 (adults), 2 (juveniles)
Blocked passage will be minimal behind the modified weir as it will be designed to improve passage, and grading will limit stranding on the floodplain for adults. Juveniles are more susceptible to stranding thus the effect is greater.

Certainty = 4
Evidence is good that efficient drainage results in low stranding (Sommer et al. 2005); hence additional grading should prevent stranding.

N3d. Chinook Salmon Scenarios 1 and 2

Most juvenile Chinook salmon can exit the existing floodplain configuration (Sommer et al. 2005). Adult passage of salmon is likely constrained in the Yolo Bypass (Harrell and Sommer 2003). Current Fremont and Sacramento weirs create stranding problems for salmonids (Sommer et al. 2005); hence efforts to improve passage and redesign weirs will reduce stranding. (Harrell and Sommer 2003)

Assumption is that is operable gates/ladders would be operable at all times to allow for year-round passage.

Magnitude = 1 (adults), 2 (juveniles)
Stranding is minimal on the Yolo Bypass now. This project will further reduce stranding behind the weir because the new weir design will improve passage and the floodplain will be graded. There is some possibility of reduced passage if migrating salmon encounter the modified structure when it is closed or there is insufficient flow to allow passage.

Certainty = 4
Evidence is good that efficient drainage results in low stranding (Sommer et al. 2005) hence additional grading should prevent stranding.

Outcome N4: Reduced flows in Sacramento River and distributaries to support successful outmigration (Scenarios 1 and 2).

Juvenile salmon survival is dependent on sufficient river flow and water quality (NMFS 2008). Diversions for habitat restoration reduce flow in the mainstem Sacramento River in the same way as diversions for water use. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta have been diverted. Depleted flows have contributed to higher temperatures, lower DO levels, and decreased recruitment of gravel and large woody debris (LWD). More uniform flows year round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation (NMFS 2008)

Direct relationships exist between water temperature, water flow, and juvenile salmonid survival (Brandes and McLain 2001).

Elevated water temperatures in the Sacramento River have limited the survival of young salmon in those waters. Juvenile fall-run Chinook salmon survival in the Sacramento River is also directly related to June streamflow and June and July Delta outflow (Dettman et al. 1987).

Magnitude = 2
The effect of this action is limited to the diversion of 2000-4000 cfs at a time when the river flow is approximately 30,000 cfs. It is difficult to evaluate the net negative effect of this action via this outcome as water diverted through the bypass is presumably going to remain in the system to support another migratory route. The action will only affect the Sacramento River between the Fremont Weir and it's confluence with Cache slough. There is no spawning habitat in this reach and rearing habitat is limited – hence its

primary benefit for emigrating salmonids is as a migration corridor. Since the river is constrained in a well-defined channel by levees, reduction in flow should not affect its' ability to pass fish downstream to any great degree.

Certainty = 3
The relationship between river flow and salmon survival has been well documented (Newman and Rice 2002, Brandes and McLain 2001).

Outcome N5: Increased habitat for predators/competitors to covered species.

N5a. Delta smelt

Evidence from Yolo and Cosumnes of non-natives taking advantage of floodplain (ref Sommer et al 2004, Moyle et al 2006). Opperman (2008 page 10) discusses sources of invasive species.

Delta smelt model (semi final with note – do not cite) – notes that DS are adapted to sustain high mortality during the adult stage (Winemiller and Rose 1992). Predation is one of two primary factors for population dynamics (Figure 7). The most likely ancestral Delta smelt predators would have been piscivorous birds, salmonid fishes, and, secondarily, longfin smelt as a larval predator and predatory freshwater fishes like Sacramento pikeminnow, Sacramento perch, (Moyle 2002). All of the above species could be expected to inhabit the proposed inundated floodplain habitat. Though predation on the floodplain is not specifically addressed in the Delta smelt model, the evaluation team thought predation of Delta smelt on the lower portion of the bypass was significant. Wetlands that flood only in spring and winter (as does the Yolo Bypass) provide substantial benefits for larval and juvenile native fishes, but only limited benefits (as compared to perennially flooded habitats) for non-native larval fish that were spawned later in the year (Grimaldo et al. 2004).

Magnitude = 2
Adaptation to high mortality and the occurrence of many native predators implies that an increased predation rate is not substantial.

Certainty = 3
It is likely the introduction of striped bass (*Morone saxatilis*) in the 1870s greatly increased predation pressure on Delta smelt by placing a resident low-salinity zone predator where there was not one historically (Moyle 2002). Striped bass are likely to inhabit the area downstream of the bypass increasing the certainty of this predation effect.

N5b. Longfin smelt

Predation is a source of direct mortality to eggs and larvae (Rosenfield, 2008). Some fish species (e.g. suckers, splittail, and sturgeon) may feed on longfin smelt eggs. Larval longfin smelt are not strong swimmers and are thus highly vulnerable to predation (Wang 1986). Striped bass and inland silverside are probably major predators on longfin smelt larvae. Terns, gulls, and cormorants may also prey on this life stage. Predation and competition are characterized as medium importance and medium understanding

(Rosenfield, 2008, Figure 5), but floodplain predation and competition are not specifically addressed.

Magnitude = 2
Predation and competition are characterized as medium importance and medium understanding.

Certainty = 3
There is good evidence that predation is an important stressor for juvenile longfin smelt.

N5c. Splittail

Splittail model - Bird predation appears limited until water recedes and floodplains begin to isolate from main channels at which point fish are exposed to wading birds (Moyle 2004). Predation by non native predators in floodplain habitats is characterized as medium with high understanding (Figure 5 and Table 3).

Magnitude = 2
The action will increase the availability of floodplain habitat to splittail but will not influence the presence of the avian predators

Certainty = 4
Good evidence of this predation impact from within the system.

N5d. Green and white sturgeon

The White Sturgeon Model (Israel et. al., 2009, Figure 7) and Green Sturgeon Model (Israel et. al., 2009, Figure 2) both indicate probable distribution of sturgeon in this reach. Due to the benthic nature of green and white sturgeon and the timing of floodplain inundation they are not expected to be found on the floodplain (Josh Israel pers comm.). Juvenile sturgeon are subject to greater predation effects, however, there is no evidence of juvenile sturgeon use of floodplains. Sturgeon caught in Yolo Bypass are adults (Harrell and Sommer 2003).

Magnitude = 1
Juvenile sturgeon are subject to greater predation effects, however, there is no evidence of juvenile sturgeon use of floodplains.

Certainty = 3
Little documentation of effect on juveniles.

N5e. Steelhead and Chinook salmon

The Chinook Salmon Model (Williams and Rosenfield, In preparation) and Steelhead Model (Williams and Rosenfield, In preparation) both indicate non-native predation and competition with invasive species and hatchery produced salmonids is of medium importance in rearing and emigration estuarine habitats, including floodplain (Opperman, 2008, Figure 2a).

Magnitude = 2 (see text above)

Certainty = 4 (see text above)

Important Gaps in Information and/or Understanding

Data Needs

The number of salmonids and sturgeon attracted into the Yolo Bypass and their ultimate fate (death, loss of spawning opportunity, eventual return to the Sacramento River).

Research Needs

- Major gaps – rearing habitat for steelhead? Rearing habitat for juvenile sturgeon?
- Hg accumulation in fish has been documented, but does not indicate there is an effect on fish.
- Degree of contaminants affects on POD.
- Degree of sediment settling on floodplains.
- Degree of predation/competition within floodplains on native covered fish species by non-native fish species.
- Better diet information is needed for floodplain use of steelhead, green and white sturgeon;
- More info is needed about relative importance of food to population level effects for all of the species.
- Transport studies are needed to evaluate the footprint of food transport from floodplains.
- Timing duration of rearing for steelhead, green and white sturgeon.
- Additional information is needed to help quantify the contribution of suspended sediment that Yolo Bypass provides to the north Delta region. Understanding the duration of the suspended sediment benefit would be helpful. Is the increased sediment load only part of a first flush? Can the flows and inundation areas described in scenario 1 and 2 result in the anticipated turbidity benefit?
- Telemetry study of salmonid and sturgeon to study movement of these species in the Yolo Bypass
- Assess Reversibility and Opportunity for Learning
- Better understanding of physiological toxicity affects of in situ native fish

Reversibility

Yes/Easy: As the action includes operable gates the action would not necessarily have to be implemented on the proposed schedule or at all if adverse consequences made its reversal necessary. Grading aspects of the action could theoretically be reversed but this would be more challenging and is less likely to occur.

Opportunity for Learning

High: The operable gates would allow the flooding timing and duration of the bypass to be experimentally manipulated allowing the exploration of specific relationships between floodplain inundation and covered species.

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Appendix A