Chapter 11
Fish and Aquatic Resources

11.1 Environmental Setting/Affected Environment

11.1.1 Areas of Potential Environmental Effects

11.1.1.2 Upstream of the Delta

As discussed in Chapter 3, *Description of Alternatives*, the areas upstream of the Plan Area that could potentially be affected by the BDCP alternatives include those areas in the SWP and CVP system that may be affected by alterations in SWP and CVP operations, including the reservoirs, rivers, and other components of the SWP and CVP. These components include the following instream, reservoir, and riparian areas.

- Claire Engle Lake, Lewiston Lake, and the Trinity River
- Shasta Lake and the upper and lower Sacramento River
- Whiskeytown Reservoir and Clear Creek
- Oroville Reservoir, Thermalito Afterbay, and the lower Feather River
- Folsom Reservoir, Lake Natoma and the lower American River
- New Melones Reservoir and the Stanislaus River
- Millerton Reservoir and the San Joaquin River

The timing, duration, and magnitude of water exports affect hydrodynamic conditions that may affect species present in the river reaches and reservoirs upstream of the Delta. Flows within the rivers and tributaries are altered by SWP and CVP facilities and operations, and are important to the movement and migration behaviors, straying potential, habitat availability and suitability, and stranding potential of numerous aquatic species. Operational changes to flow timing, duration, and magnitude can directly affect anadromous species adult immigration, spawning, egg incubation, rearing, and outmigration, as well as resident non-migratory species habitat availability for all life stages.

Water management and conveyance, hydrology, and water quality in these upstream rivers and reservoirs are discussed in Chapter 5, *Water Supply*; Chapter 6, *Surface Water*; and Chapter 8, *Water Quality*, respectively. Therefore, the following sections focus primarily on aquatic resources and provide a summary of the key stressors within each geographic area, as appropriate.

~~Table 11-2 shows t~~The assumed timing of each fish species life stage for each of the areas evaluated is provided in the text of the specific impacts. This timing ~~This table was developed~~was determined in coordination with FWS, NMFS, and DFW biologists. As noted below in Section ~~X~~11.3.2, Methods, not all of the available models capture the same range of life stage occurrence. These discrepancies are noted in the description of each model as applicable.

~~Table 11-2. BDCP Covered Species Phenology Table~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Fall~~	~~American River~~	~~Adult Migration~~	~~Sept~~	~~Dec~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.~~
~~Chinook~~	~~Fall~~	~~American River~~	~~Spawner~~	~~Oct~~	~~Dec~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.~~
~~Chinook~~	~~Fall~~	~~American River~~	~~Egg/alevin~~	~~Oct~~	~~Dec~~	~~Meyers 1998, Snider and Titus 2002~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages; Snider, B. and R. G. Titus. 2002. Lower American River emigration survey, October 1998–September 1999. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program, Technical Report No. 02-2. 20 p. (plus appendices)~~
~~Chinook~~	~~Fall~~	~~American River~~	~~Fry~~	~~Jan~~	~~May~~	~~Snider and Titus 2002~~	~~Snider, B. and R. G. Titus. 2002. Lower American River emigration survey, October 1998–September 1999. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program, Technical Report No. 02-2. 20 p. (plus appendices)~~
~~Chinook~~	~~Fall~~	~~American River~~	~~Pre-smolt/ smolt~~	~~Mar~~	~~July~~	~~Snider and Titus 2002~~	~~Snider, B. and R. G. Titus. 2002. Lower American River emigration survey, October 1998–September 1999. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program, Technical Report No. 02-2. 20 p. (plus appendices)~~
~~Chinook~~	~~Fall~~	~~Battle Creek~~	~~Adult Migration~~	~~Aug~~	~~Nov~~	~~Battle Creek Fall Chinook counts USFWS~~	~~Past Daily Fall Chinook Counts from Battle Creek; http://www.fws.gov/REDBLUFF/he_reports.aspx#BattleCreekFallChinookCounts~~
~~Chinook~~	~~Fall~~	~~Battle Creek~~	~~Spawner~~	~~Sept~~	~~Dec~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Fall~~	~~Battle Creek~~	~~Egg/alevin~~	~~Oct~~	~~Mar~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Fall~~	~~Battle Creek~~	~~Fry~~	~~Dec~~	~~Feb~~	~~Whitton et al 2010~~	~~Whitton, K. S., D. J. Colby, J. M. Newton, and M. R. Brown. 2011. Juvenile salmonid monitoring in Battle Creek, California, November 2009 through July 2010. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Fall~~	~~Battle Creek~~	~~Pre-smolt/smolt~~	~~Feb~~	~~May~~	~~Whitton et al 2010~~	~~Whitton, K. S., D. J. Colby, J. M. Newton, and M. R. Brown. 2011. Juvenile salmonid monitoring in Battle Creek, California, November 2009 through July 2010. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Fall~~	~~Clear Creek~~	~~Adult Migration~~	~~Aug~~	~~Dec~~	~~Meyers 1998; Newton et al 2004~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.; Newton, J. M., and M. R. Brown. 2004. Adult spring Chinook salmon monitoring in Clear Creek, California, 1999–2002. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Fall~~	~~Clear Creek~~	~~Spawner~~	~~Sept~~	~~Dec~~	~~Newton et al 2004~~	~~Newton, J. M., and M. R. Brown. 2004. Adult spring Chinook salmon monitoring in Clear Creek, California, 1999–2002. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Fall~~	~~Clear Creek~~	~~Egg/alevin~~	~~Sep~~	~~Feb~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Fall~~	~~Clear Creek~~	~~Fry~~	~~Nov~~	~~Jun~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Fall~~	~~Clear Creek~~	~~Pre-smolt/ smolt~~	~~Jan~~	~~Jun~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Fall~~	~~Delta~~	~~Adult Migration~~	~~Jun~~	~~Dec~~	~~State Water Project and Federal Water Project fish salvage data 1981–1988.~~	~~http://www.dfg.ca.gov/delta/apps/salvage/SalvageExportCalendar.aspx~~
~~Chinook~~	~~Fall~~	~~Delta~~	~~Emigration-Fry~~	~~Dec~~	~~May~~	~~Knights landing Rotary Screw-trap data 1995–2000~~	
~~Chinook~~	~~Fall~~	~~Delta~~	~~Emigration-Pre-smolt/ smolt~~	~~Nov~~	~~Sept~~	~~Delta Juvenile Fish Monitoring Program, 2000~~	

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Fall~~	~~Feather~~	~~Adult Migration~~	~~Aug~~	~~Dec~~	~~Seesholtz et al 2004~~	~~Seesholtz, A., Cavallo, B.,Kindopp, J., and R. Kurth. 2004. 2004 Feather River Salmon Spawning Escapement Survey Summary. California Department of Water Resources Division of Environmental Services.~~
~~Chinook~~	~~Fall~~	~~Feather~~	~~Spawner~~	~~Sept~~	~~Dec~~	~~Seesholtz et al 2004~~	~~Seesholtz, A., Cavallo, B.,Kindopp, J., and R. Kurth. 2004. 2004 Feather River Salmon Spawning Escapement Survey Summary. California Department of Water Resources Division of Environmental Services.~~
~~Chinook~~	~~Fall~~	~~Feather~~	~~Egg/alevin~~	~~Sept~~	~~Jan~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005-2007.~~
~~Chinook~~	~~Fall~~	~~Feather~~	~~Fry~~	~~Dec~~	~~Apr~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005-2007.~~
~~Chinook~~	~~Fall~~	~~Feather~~	~~Pre-smolt/smolt~~	~~Apr~~	~~Jun~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005-2007.~~
~~Chinook~~	~~Fall~~	~~Merced~~	~~Adult Migration~~	~~Aug~~	~~Jan~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.~~
~~Chinook~~	~~Fall~~	~~Merced~~	~~Spawner~~	~~Oct~~	~~Jan~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.~~
~~Chinook~~	~~Fall~~	~~Merced~~	~~Egg/alevin~~	~~Oct~~	~~Mar~~		
~~Chinook~~	~~Fall~~	~~Merced~~	~~Fry~~	~~No Fry~~	~~No Fry~~	~~Montgomery et al 2007~~	~~Montgomery, J., Gray, A., Watry, C. B., and B. Pyper 2007. Using Rotary Screw Traps to Determine Juvenile Chinook Salmon Out-Migration Abundance, Size and Timing in the Lower Merced River, California. Prepared for U.S. Fish and Wildlife Service, Anadromous Fish Restoration Program, Grant No. 813326G009.~~
~~Chinook~~	~~Fall~~	~~Merced~~	~~Pre-smolt/ smolt~~	~~Apr~~	~~May~~	~~Montgomery et al 2007~~	~~Montgomery, J., Gray, A., Watry, C. B., and B. Pyper 2007. Using Rotary Screw Traps to Determine Juvenile Chinook Salmon Out-Migration Abundance, Size and Timing in the Lower Merced River, California. Prepared for U.S. Fish and Wildlife Service, Anadromous Fish Restoration Program, Grant No. 813326G009.~~
~~Chinook~~	~~Fall~~	~~Mokelumne~~	~~Adult Migration~~	~~Aug~~	~~Dec~~	~~Miyamoto and Hartwell 2001~~	~~Miyamoto, J., and R.D. Hartwell 2001. Population Trends and Escapement Estimation of Mokelumne River Fall-run Chinook salmon (*Oncorhynchus tshawytscha*). Volume 1. Fish Bulletin 179. E. Randall L. Brown. Bodega Bay, California, California Department of Fish and Game. 1: 1-297.~~
~~Chinook~~	~~Fall~~	~~Mokelumne~~	~~Spawner~~	~~Oct~~	~~Jan~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.; Newton, J. M., and M. R. Brown. 2004. Adult spring Chinook salmon monitoring in Clear Creek, California, 1999–2002. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Fall~~	~~Mokelumne~~	~~Egg/alevin~~	~~Oct~~	~~Mar~~	~~Bilski et al 2010~~	~~Bilski, R., Shillam, J., Hunter, C., Saldate, M., and E. Rible. 2010. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tschawytscha*) and Steelhead (*Oncorhynchus mykiss*) in the Lower Mokelumne River, December 2009 through July 2010. East Bay Municipal Utility District, Lodi, California.~~
~~Chinook~~	~~Fall~~	~~Mokelumne~~	~~Fry~~	~~Dec~~	~~Apr~~	~~Bilski et al 2010~~	~~Bilski, R., Shillam, J., Hunter, C., Saldate, M., and E. Rible. 2010. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tschawytscha*) and Steelhead (*Oncorhynchus mykiss*) in the Lower Mokelumne River, December 2009 through July 2010. East Bay Municipal Utility District, Lodi, California.~~
~~Chinook~~	~~Fall~~	~~Mokelumne~~	~~Pre-smolt/ smolt~~	~~Jan~~	~~Jul~~	~~Bilski et al 2010, Workman et al 2003~~	~~Bilski, R., Shillam, J., Hunter, C., Saldate, M., and E. Rible. 2010. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tschawytscha*) and Steelhead (*Oncorhynchus mykiss*) in the Lower Mokelumne River, December 2009 through July 2010. East Bay Municipal Utility District, Lodi, California.; Workman, M. L. 2003. Lower Mokelumne River Upstream Fish Migration Monitoring conducted at Woodbridge Irrigation District Dam August 2002 through July 2003. Unpublished EBMUD report. Lodi, CA 18pp + Appendix.~~
~~Chinook~~	~~Fall~~	~~San Joaquin River~~	~~Adult Migration~~	~~Aug~~	~~Jan~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.~~
~~Chinook~~	~~Fall~~	~~San Joaquin River~~	~~Fry~~	~~Dec~~	~~Jun~~	~~Delta Juvenile Fish Monitoring Program, 1994–2010~~	
~~Chinook~~	~~Fall~~	~~San Joaquin River~~	~~Pre-smolt/ smolt~~	~~Feb~~	~~Jun~~	~~Delta Juvenile Fish Monitoring Program, 1994–2010~~	
~~Chinook~~	~~Fall~~	~~Stanislaus~~	~~Adult Migration~~	~~Aug~~	~~Jan~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.~~
~~Chinook~~	~~Fall~~	~~Stanislaus~~	~~Spawner~~	~~Oct~~	~~Nov~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.~~
~~Chinook~~	~~Fall~~	~~Stanislaus~~	~~Egg/alevin~~	~~Oct~~	~~Jan~~	~~Watry and others 2012~~	~~Cramer Fish Sciences (CFS). 2012. Juvenile Salmonid Out-migration Monitoring at Caswell Memorial State Park in the Lower Stanislaus River, California. 2010-2011 Biannual Report. Prepared for U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program. Grant No. 813326G008. 48 pp.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Fall~~	~~Stanislaus~~	~~Fry~~	~~Feb~~	~~Mar~~	~~Miller et al 2010~~	~~Miller, J. A., Gray, A., and J. Merz 2010. Quantifying the contribution of juvenile migratory phenotypes in a population of Chinook salmon *Oncorhynchus tshawytscha*. Mar Ecol Prog Ser 408:227-240.~~
~~Chinook~~	~~Fall~~	~~Stanislaus~~	~~Pre-smolt/ smolt~~	~~Feb~~	~~May~~	~~Watry and others 2012~~	~~Cramer Fish Sciences (CFS). 2012. Juvenile Salmonid Out-migration Monitoring at Caswell Memorial State Park in the Lower Stanislaus River, California. 2010–2011 Biannual Report. Prepared for U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program. Grant No. 813326G008. 48 pp.~~
~~Chinook~~	~~Fall~~	~~Trinity~~	~~Adult Migration~~	~~Aug~~	~~Dec~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Chinook~~	~~Fall~~	~~Trinity~~	~~Spawner~~	~~Oct~~	~~Dec~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Chinook~~	~~Fall~~	~~Trinity~~	~~Egg/alevin~~	~~Oct~~	~~Mar~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Chinook~~	~~Fall~~	~~Trinity~~	~~Fry~~	~~Jan~~	~~Apr~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Chinook~~	~~Fall~~	~~Trinity~~	~~Pre-smolt/smolt~~	~~Feb~~	~~Oct~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Chinook~~	~~Fall~~	~~Tuolumne~~	~~Adult Migration~~	~~Sept~~	~~Jan~~	~~Cuthburt 2011~~	~~Cuthbert, R., Becker, C., and A. Fuller 2012. Fall/Winter Migration Monitoring at the Tuolumne River Weir 2011 Report. Unpublished Report, FISHBIO.~~
~~Chinook~~	~~Fall~~	~~Tuolumne~~	~~Spawner~~	~~Oct~~	~~Jan~~	~~Blakeman 2005~~	~~D., Blakeman 2005. 2004 Tuolumne River Fall Chinook Salmon Escapement Survey Federal Energy Regulatory Commission Annual Report FERC Project #2299, Report 2004-2.~~
~~Chinook~~	~~Fall~~	~~Tuolumne~~	~~Egg/alevin~~	~~Oct~~	~~Jan~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.~~
~~Chinook~~	~~Fall~~	~~Tuolumne~~	~~Fry~~	~~Jan~~	~~Apr~~	~~Fuller 2008~~	~~A. Fuller 2008. 2007 Rotary Screw Trap Report, Federal Energy Regulatory Commission Annual Report FERC Project #2299, Report 2007-4.~~
~~Chinook~~	~~Fall~~	~~Tuolumne~~	~~Pre-smolt/smolt~~	~~Feb~~	~~May~~	~~Fuller 2008~~	~~A. Fuller 2008. 2007 Rotary Screw Trap Report, Federal Energy Regulatory Commission Annual Report FERC Project #2299, Report 2007-4.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Fall~~	~~Upper Sac~~	~~Adult Migration~~	~~Jul~~	~~Dec~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Fall~~	~~Upper Sac~~	~~Adult holding~~	~~Aug~~	~~Sep~~		
~~Chinook~~	~~Fall~~	~~Upper Sac~~	~~Spawner~~	~~Sept~~	~~Dec~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Fall~~	~~Upper Sac~~	~~Egg/alevin~~	~~Sep~~	~~Mar~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Fall~~	~~Upper Sac~~	~~Fry~~	~~Dec~~	~~Apr~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Chinook~~	~~Fall~~	~~Upper Sac~~	~~Pre-smolt/ smolt~~	~~Jan~~	~~Sept~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Chinook~~	~~Late Fall~~	~~Battle Creek~~	~~Adult Migration~~	~~Jan~~	~~Apr~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Late Fall~~	~~Battle Creek~~	~~Spawner~~	~~Jan~~	~~Jun~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Late Fall~~	~~Battle Creek~~	~~Egg/alevin~~	~~Jan~~	~~Jun~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Late Fall~~	~~Battle Creek~~	~~Fry~~	~~Mar~~	~~May~~	~~Whitton et al 2011~~	~~Whitton, K. S., D. J. Colby, J. M. Newton, and M. R. Brown. 2011. Juvenile salmonid monitoring in Battle Creek, California, November 2009 through July 2010. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Late Fall~~	~~Battle Creek~~	~~Pre-smolt/ smolt~~	~~Jun~~	~~Dec~~	~~Whitton et al 2011~~	~~Whitton, K. S., D. J. Colby, J. M. Newton, and M. R. Brown. 2011. Juvenile salmonid monitoring in Battle Creek, California, November 2009 through July 2010. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Late Fall~~	~~Clear Creek~~	~~Adult Migration~~	~~Nov~~	~~Apr~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Late Fall~~	~~Clear Creek~~	~~Spawner~~	~~Dec~~	~~Apr~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Late Fall~~	~~Clear Creek~~	~~Egg/alevin~~	~~Dec~~	~~May~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Late Fall~~	~~Clear Creek~~	~~Fry~~	~~Apr~~	~~Jun~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Late Fall~~	~~Clear Creek~~	~~Pre-smolt/ smolt~~	~~May~~	~~Dec~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Late Fall~~	~~Delta~~	~~Adult Migration~~	~~Oct~~	~~Apr~~	~~Moyle 2002~~	
~~Chinook~~	~~Late Fall~~	~~Delta~~	~~Fry~~	~~Apr~~	~~Jun~~	~~Knights landing Rotary Screw-trap data 1995–2000~~	
~~Chinook~~	~~Late Fall~~	~~Delta~~	~~Pre-smolt/ smolt~~	~~Oct~~	~~Feb~~	~~Knights landing Rotary Screw-trap data 1995–2000~~	
~~Chinook~~	~~Late Fall~~	~~Upper Sac~~	~~Adult Migration~~	~~Nov~~	~~Apr~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Late Fall~~	~~Upper Sac~~	~~Adult Holding~~	~~Oct~~	~~Jan~~		
~~Chinook~~	~~Late Fall~~	~~Upper Sac~~	~~Spawner~~	~~Jan~~	~~Apr~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Late Fall~~	~~Upper Sac~~	~~Egg/alevin~~	~~Dec~~	~~Jun~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Late Fall~~	~~Upper Sac~~	~~Fry~~	~~Mar~~	~~Jul~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Chinook~~	~~Late Fall~~	~~Upper Sac~~	~~Pre-smolt/ smolt~~	~~Jun~~	~~Jan~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Chinook~~	~~Winter~~	~~Upper Sac~~	~~Adult Migration~~	~~Dec~~	~~Jul~~	~~Vogel and Marine 1991, NMFS BO 2009~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices; NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessed June 2012).~~
~~Chinook~~	~~Winter~~	~~Upper Sac~~	~~Adult Holding~~	~~Jul~~	~~Apr~~		
~~Chinook~~	~~Winter~~	~~Upper Sac~~	~~Spawner~~	~~Apr~~	~~Aug~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Winter~~	~~Upper Sac~~	~~Spawner~~	~~Mar~~	~~Aug~~	~~Meyers 1998~~	~~National Marine Fisheries Service. 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-35. 443 pages.~~
~~Chinook~~	~~Winter~~	~~Upper Sac~~	~~Egg/alevin~~	~~Jun~~	~~Oct~~	~~Vogel and Marine 1991~~	~~Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. Prepared for the U.S. Bureau of Reclamation, Central Valley Project. July 1991. 55 p. with appendices.~~
~~Chinook~~	~~Winter~~	~~Upper Sac~~	~~Fry~~	~~Jul~~	~~Nov~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Chinook~~	~~Winter~~	~~Upper Sac~~	~~Pre-smolt/ smolt~~	~~Aug~~	~~Apr~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Chinook~~	~~Winter~~	~~Delta~~	~~Adult Migration~~	~~Nov~~	~~Jun~~	~~Hallock and Fisher 1985~~	

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Winter~~	~~Sacramento River~~	~~Fry~~	~~Nov~~	~~Mar~~	~~Knights landing Rotary Screw-trap data 1995–2000~~	
~~Chinook~~	~~Winter~~	~~Lower Sacramento River~~	~~Pre-smolt/ smolt~~	~~Sep~~	~~Apr~~	~~DJFMP~~	
~~Chinook~~	~~Winter~~	~~Delta~~	~~Pre-smolt/ smolt~~	~~Sep~~	~~Apr~~	~~DJFMP~~	
~~Chinook~~	~~Spring~~	~~Butte Creek~~	~~Adult Migration~~	~~Feb~~	~~Jun~~	~~NMFS BO 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Chinook~~	~~Spring~~	~~Butte Creek~~	~~Adult Holding~~	~~June~~	~~Aug~~		
~~Chinook~~	~~Spring~~	~~Butte Creek~~	~~Spawner~~	~~Aug~~	~~Oct~~	~~NMFS BO 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Chinook~~	~~Spring~~	~~Butte Creek~~	~~Egg/alevin~~	~~Aug~~	~~Mar~~	~~Ward et al 2002~~	~~Ward, P. D., McReynolds, T. R., and C. Garman 2002. Butte and Big Chico Creeks Spring-Run Chinook Salmon, *Oncoryhnchus Tshawytscha* Life History Investigation 2000–2001. Department of Fish and Game, Inland Fisheries Administrative Report No.___ 2002~~
~~Chinook~~	~~Spring~~	~~Butte Creek~~	~~Fry~~	~~Nov~~	~~May~~	~~Ward et al 2002~~	~~Ward, P. D., McReynolds, T. R., and C. Garman 2002. Butte and Big Chico Creeks Spring-Run Chinook Salmon, *Oncoryhnchus Tshawytscha* Life History Investigation 2000–2001. Department of Fish and Game, Inland Fisheries Administrative Report No.___ 2002~~
~~Chinook~~	~~Spring~~	~~Butte Creek~~	~~Pre-smolt/smolt~~	~~Sep~~	~~Jun~~	~~Ward et al 2002~~	~~Ward, P. D., McReynolds, T. R., and C. Garman 2002. Butte and Big Chico Creeks Spring-Run Chinook Salmon, *Oncoryhnchus Tshawytscha* Life History Investigation 2000–2001. Department of Fish and Game, Inland Fisheries Administrative Report No.___ 2002~~
~~Chinook~~	~~Spring~~	~~Clear Creek~~	~~Adult Migration~~	~~Apr~~	~~Aug~~	~~Newton and Brown 2004~~	~~Newton, J. M., and M. R. Brown. 2004. Adult spring Chinook salmon monitoring in Clear Creek, California, 1999–2002. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Spring~~	~~Clear Creek~~	~~Adult Holding~~	~~Apr~~	~~Aug~~		
~~Chinook~~	~~Spring~~	~~Clear Creek~~	~~Spawner~~	~~Sep~~	~~Nov~~	~~Newton and Brown 2004~~	~~Newton, J. M., and M. R. Brown. 2004. Adult spring Chinook salmon monitoring in Clear Creek, California, 1999–2002. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Spring~~	~~Clear Creek~~	~~Egg/alevin~~	~~Sep~~	~~Jan~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Spring~~	~~Clear Creek~~	~~Fry~~	~~Nov~~	~~Feb~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Spring~~	~~Clear Creek~~	~~Pre-smolt/smolt~~	~~Feb~~	~~Mar~~	~~Earley et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Chinook~~	~~Spring~~	~~Delta~~	~~Migration~~	~~Nov~~	~~Jul~~	~~NMFS BO 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Chinook~~	~~Spring~~	~~Delta~~	~~Fry~~	~~Nov~~	~~Mar~~	~~Knights landing Rotary Screw-trap data 1995–2000~~	
~~Chinook~~	~~Spring~~	~~Delta~~	~~Pre-smolt/ smolt~~	~~Nov~~	~~Aug~~	~~DJFMP~~	
~~Chinook~~	~~Spring~~	~~Sacramento River~~	~~Juvenile~~	~~Nov~~	~~March~~	~~Knights landing Rotary Screw-trap data 1995–2000~~	
~~Chinook~~	~~Spring~~	~~Lower Sac River~~	~~Juvenile~~	~~Nov~~	~~Aug~~	~~DJFMP~~	
~~Chinook~~	~~Spring~~	~~Feather River~~	~~Adult Migration~~	~~Mar~~	~~Jun~~	~~Seesholtz et al 2004~~	~~Seesholtz, A., Cavallo, B.,Kindopp, J., and R. Kurth. 2004. 2004 Feather River Salmon Spawning Escapement Survey Summary. California Department of Water Resources Division of Environmental Services.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Spring~~	~~Feather River~~	~~Adult Holding~~	~~June~~	~~Sept~~		
~~Chinook~~	~~Spring~~	~~Feather River~~	~~Spawner~~	~~Sep~~	~~Oct~~	~~Seesholtz et al 2004~~	~~Seesholtz, A., Cavallo, B.,Kindopp, J., and R. Kurth. 2004. 2004 Feather River Salmon Spawning Escapement Survey Summary. California Department of Water Resources Division of Environmental Services.~~
~~Chinook~~	~~Spring~~	~~Feather River~~	~~Egg/alevin~~	~~Sep~~	~~Dec~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005–2007.~~
~~Chinook~~	~~Spring~~	~~Feather River~~	~~Fry~~	~~Nov~~	~~Mar~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005–2007.~~
~~Chinook~~	~~Spring~~	~~Feather River~~	~~Pre-smolt/ smolt~~	~~Mar~~	~~Jun~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005–2007.~~
~~Chinook~~	~~Spring~~	~~Mill and Deer Creeks~~	~~Adult Migration~~	~~Mar~~	~~May~~	~~NMFS BO 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Chinook~~	~~Spring~~	~~Mill and Deer Creeks~~	~~Adult Holding~~	~~April~~	~~Aug~~		
~~Chinook~~	~~Spring~~	~~Mill and Deer Creeks~~	~~Spawner~~	~~Sep~~	~~Oct~~	~~Harvey, C. D. 1994~~	~~Harvey, C. D. 1994. Juvenile Spring-Run Chinook Salmon Emergence, Rearing and Outmigration Patterns in Deer and Mill Creeks, Tehama County, for the 1994 Brood Year. Sport Fish Restoration Annual Progress Report, Department of Fish and Game, Inland Fisheries Division.~~
~~Chinook~~	~~Spring~~	~~Mill and Deer Creeks~~	~~Egg/alevin~~	~~Sep~~	~~Apr~~	~~Harvey, C. D. 1994~~	~~Harvey, C. D. 1994. Juvenile Spring-Run Chinook Salmon Emergence, Rearing and Outmigration Patterns in Deer and Mill Creeks, Tehama County, for the 1994 Brood Year. Sport Fish Restoration Annual Progress Report, Department of Fish and Game, Inland Fisheries Division.~~
~~Chinook~~	~~Spring~~	~~Mill and Deer Creeks~~	~~Fry~~	~~Nov~~	~~Jun~~	~~Harvey, C. D. 1994~~	~~Harvey, C. D. 1994. Juvenile Spring-Run Chinook Salmon Emergence, Rearing and Outmigration Patterns in Deer and Mill Creeks, Tehama County, for the 1994 Brood Year. Sport Fish Restoration Annual Progress Report, Department of Fish and Game, Inland Fisheries Division.~~
~~Chinook~~	~~Spring~~	~~Mill and Deer Creeks~~	~~Pre-smolt/ smolt~~	~~Oct~~	~~Jun~~	~~Harvey, C. D. 1994~~	~~Harvey, C. D. 1994. Juvenile Spring-Run Chinook Salmon Emergence, Rearing and Outmigration Patterns in Deer and Mill Creeks, Tehama County, for the 1994 Brood Year. Sport Fish Restoration Annual Progress Report, Department of Fish and Game, Inland Fisheries Division.~~
~~Chinook~~	~~Spring~~	~~Trinity River~~	~~Adult Migration~~	~~Apr~~	~~June~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Spring~~	~~Trinity River~~	~~Adult Holding~~	~~May~~	~~Sept~~		
~~Chinook~~	~~Spring~~	~~Trinity River~~	~~Spawner~~	~~Sept~~	~~Nov~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Chinook~~	~~Spring~~	~~Trinity River~~	~~Egg/alevin~~	~~Oct~~	~~Mar~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Chinook~~	~~Spring~~	~~Trinity River~~	~~Fry~~	~~Jan~~	~~Apr~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Chinook~~	~~Spring~~	~~Trinity River~~	~~Pre-smolt/ smolt~~	~~Feb~~	~~Oct~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Chinook~~	~~Spring~~	~~Upper Sac~~	~~Adult Migration~~	~~March~~	~~June~~	~~NMFS BO 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Chinook~~	~~Spring~~	~~Upper Sac~~	~~Adult Holding~~	~~June~~	~~Sept~~		
~~Chinook~~	~~Spring~~	~~Upper Sac~~	~~Spawner~~	~~Sep~~	~~Oct~~	~~NMFS BO 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Chinook~~	~~Spring~~	~~Upper Sac~~	~~Egg/alevin~~	~~Sept~~	~~Jan~~	~~NMFS BO 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Chinook~~	~~Spring~~	~~Upper Sac~~	~~Fry~~	~~Oct~~	~~Feb~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Chinook~~	~~Spring~~	~~Upper Sac~~	~~Pre-smolt/ smolt~~	~~Feb~~	~~Jul~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Steelhead~~	~~Winter~~	~~Upper Sac~~	~~Adult Migration~~	~~Jun~~	~~Mar~~	~~NMFS BO, 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Upper Sac~~	~~Spawner~~	~~Dec~~	~~May~~	~~NMFS BO, 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012). Hallock R. 1989 Report to U.S. Fish and Wildlife Service.~~
~~Steelhead~~	~~Winter~~	~~Upper Sac~~	~~Egg/alevin~~	~~Feb~~	~~Jun~~	~~NMFS BO,2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Upper Sac~~	~~Fry~~	~~Mar~~	~~Sep~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Steelhead~~	~~Winter~~	~~Upper Sac~~	~~Sub yearling~~	~~Jan~~	~~Dec~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Steelhead~~	~~Winter~~	~~Upper Sac~~	~~Yearling~~	~~Jan~~	~~Dec~~	~~Gaines and Martin 2002~~	~~Gaines, P. D. and C. D. Martin. 2001. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U.S. Fish and Wildlife Service, Red Bluff, CA.~~
~~Steelhead~~	~~Winter~~	~~American River~~	~~Adult Migration~~	~~Nov~~	~~Apr~~	~~OCAP BA USBR~~	~~U.S. Department of the Interior Bureau of Reclamation 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.~~
~~Steelhead~~	~~Winter~~	~~American River~~	~~Spawner~~	~~Dec~~	~~Apr~~	~~OCAP BA USBR~~	~~U.S. Department of the Interior Bureau of Reclamation 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.~~
~~Steelhead~~	~~Winter~~	~~American River~~	~~Egg/alevin~~	~~Feb~~	~~Jun~~	~~Snider and Titus 2001~~	~~Snider, B., and R. G. Titus. 2001. Lower American River emigration survey, October 1997-September 1998. Calif. Dept. Fish Game, Habitat Conservation Division, Stream Evaluation Program Technical Report No. 01-6. 21pp. + 18 figs, app.~~
~~Steelhead~~	~~Winter~~	~~American River~~	~~Fry~~	~~Mar~~	~~Jun~~	~~Snider and Titus 2001~~	~~Snider, B., and R. G. Titus. 2001. Lower American River emigration survey, October 1997-September 1998. Calif. Dept. Fish Game, Habitat Conservation Division, Stream Evaluation Program Technical Report No. 01-6. 21pp. + 18 figs, app.~~
~~Steelhead~~	~~Winter~~	~~American River~~	~~Sub yearling~~	~~Jun~~	~~Aug~~	~~Snider and Titus 2001~~	~~Snider, B., and R. G. Titus. 2001. Lower American River emigration survey, October 1997-September 1998. Calif. Dept. Fish Game, Habitat Conservation Division, Stream Evaluation Program Technical Report No. 01-6. 21pp. + 18 figs, app.~~
~~Steelhead~~	~~Winter~~	~~American River~~	~~Yearling~~	~~Jan~~	~~Dec~~	~~Snider and Titus 2001~~	~~Snider, B., and R. G. Titus. 2001. Lower American River emigration survey, October 1997-September 1998. Calif. Dept. Fish Game, Habitat Conservation Division, Stream Evaluation Program Technical Report No. 01-6. 21pp. + 18 figs, app.~~
~~Steelhead~~	~~Winter~~	~~Clear Creek~~	~~Adult Migration~~	~~Oct~~	~~Mar~~	~~OCAP BA USBR~~	~~U.S. Department of the Interior Bureau of Reclamation 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.~~
~~Steelhead~~	~~Winter~~	~~Clear Creek~~	~~Spawner~~	~~Dec~~	~~Jun~~	~~Giovannetti and Brown 2007~~	~~Giovannetti, S. L., and M. R. Brown. 2007. Central Valley Steelhead and Late Fall Chinook Salmon Redd Surveys on Clear Creek, California 2007. Unpublished report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Clear Creek~~	~~Egg/alevin~~	~~Dec~~	~~Aug~~	~~Giovannetti and Brown 2007~~	~~Giovannetti, S. L., and M. R. Brown. 2007. Central Valley Steelhead and Late Fall Chinook Salmon Redd Surveys on Clear Creek, California 2007. Unpublished report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Steelhead~~	~~Winter~~	~~Clear Creek~~	~~Fry~~	~~Jan~~	~~Jul~~	~~Early et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Clear Creek~~	~~Sub yearling~~	~~May~~	~~Jul~~	~~Early et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Clear Creek~~	~~Yearling~~	~~Jan~~	~~Dec~~	~~Early et al 2010~~	~~Earley, J. T., D. J. Colby, and M. R. Brown. 2010. Juvenile salmonid monitoring in Clear Creek, California, from October 2008 through September 2009. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Battle Creek~~	~~Adult Migration~~	~~Mar~~	~~Aug~~	~~Newton and Stafford 2011~~	~~Newton, J. M., and L.A. Stafford. 2011. Monitoring adult Chinook salmon, rainbow trout, and steelhead in Battle Creek, California, from March through November 2009. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Battle Creek~~	~~Spawner~~	~~Oct~~	~~Apr~~	~~Newton and Stafford 2011~~	~~Newton, J. M., and L.A. Stafford. 2011. Monitoring adult Chinook salmon, rainbow trout, and steelhead in Battle Creek, California, from March through November 2009. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Battle Creek~~	~~Egg/alevin~~	~~Dec~~	~~Mar~~	~~Whitton et al. 2011~~	~~Whitton, K. S., D. J. Colby, J. M. Newton, and M. R. Brown. 2011. Juvenile salmonid monitoring in Battle Creek, California, November 2009 through July 2010. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Battle Creek~~	~~Fry~~	~~Mar~~	~~Jul~~	~~Whitton et al. 2011~~	~~Whitton, K. S., D. J. Colby, J. M. Newton, and M. R. Brown. 2011. Juvenile salmonid monitoring in Battle Creek, California, November 2009 through July 2010. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Battle Creek~~	~~Sub yearling~~	~~Dec~~	~~Jul~~	~~Whitton et al. 2011~~	~~Whitton, K. S., D. J. Colby, J. M. Newton, and M. R. Brown. 2011. Juvenile salmonid monitoring in Battle Creek, California, November 2009 through July 2010. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Battle Creek~~	~~Yearling~~	~~Jan~~	~~Dec~~	~~Whitton et al. 2011~~	~~Whitton, K. S., D. J. Colby, J. M. Newton, and M. R. Brown. 2011. Juvenile salmonid monitoring in Battle Creek, California, November 2009 through July 2010. USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.~~
~~Steelhead~~	~~Winter~~	~~Feather River~~	~~Adult Migration~~	~~Sep~~	~~Mar~~	~~OCAP BA USBR~~	~~U.S. Department of the Interior Bureau of Reclamation 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Steelhead~~	~~Winter~~	~~Feather River~~	~~Spawner~~	~~Dec~~	~~Apr~~	~~OCAP BA USBR~~	~~U.S. Department of the Interior Bureau of Reclamation 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.~~
~~Steelhead~~	~~Winter~~	~~Feather River~~	~~Egg/alevin~~	~~Dec~~	~~Apr~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005-2007.~~
~~Steelhead~~	~~Winter~~	~~Feather River~~	~~Fry~~	~~Mar~~	~~Jun~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005-2007.~~
~~Steelhead~~	~~Winter~~	~~Feather River~~	~~Sub yearling~~	~~Apr~~	~~May~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005-2007.~~
~~Steelhead~~	~~Winter~~	~~Feather River~~	~~Yearling~~	~~Feb~~	~~Apr~~	~~Bilski and Kindopp 2009~~	~~Bilski, R., and J. Kindopp 2009. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Feather River, 2005-2007.~~
~~Steelhead~~	~~Winter~~	~~Feather River~~	~~Emigration~~	~~Feb~~	~~Sep~~		~~Oroville FERC Relicensing (Project No. 2100) Interim Report Sp-F3.2 Task 2 SP-F3.2 Task 2, Appendix A Steelhead, 2003~~
~~Steelhead~~	~~Winter~~	~~Mokelumne~~	~~Adult Migration~~	~~Aug~~	~~May~~	~~Workman, M.L. 2001,2004~~	~~Workman, M. L. 2001. Lower Mokelumne River Upstream Fish Migration Monitoring Conducted at Woodbridge Irrigation District Dam August 2000 through April 2001. Annual Report, East Bay Municipal Utility District, Lodi, CA; Workman, M. L. 2004. Lower Mokelumne River Upstream Fish Migration Monitoring Conducted at Woodbridge Irrigation District Dam August 2003 through April 2001. Lower Mokelumne River Upstream Fish Migration Monitoring Conducted at Woodbridge Irrigation District Dam August 2000 through April 20014. Annual Report, East Bay Municipal Utility District, Lodi, CA.~~
~~Steelhead~~	~~Winter~~	~~Mokelumne~~	~~Spawner~~	~~Jan~~	~~Mar~~	~~Mulchaey and Setka 2007~~	~~Mulchaey, B., and J. Setka 2007. Salmonid Survey Spawning Report, October 2006 Through March 2007, Mokelumne River, California. Annual Report, East Bay Municipal Utility District, Orinda, CA.~~
~~Steelhead~~	~~Winter~~	~~Mokelumne~~	~~Egg/alevin~~	~~Jan~~	~~May~~		
~~Steelhead~~	~~Winter~~	~~Mokelumne~~	~~Fry~~	~~Mar~~	~~Jul~~	~~Bilski et al 2010~~	~~Bilski, R., Shillam, J., Saldate, M., and E. Rible 2010. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Lower Mokelumne River, December 2009 through July 2010.~~
~~Steelhead~~	~~Winter~~	~~Mokelumne~~	~~Sub yearling~~	~~Apr~~	~~May~~	~~Bilski et al 2010~~	~~Bilski, R., Shillam, J., Saldate, M., and E. Rible 2010. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Lower Mokelumne River, December 2009 through July 2010.~~
~~Steelhead~~	~~Winter~~	~~Mokelumne~~	~~Yearling~~	~~Feb~~	~~May~~	~~Bilski et al 2010~~	~~Bilski, R., Shillam, J., Saldate, M., and E. Rible 2010. Emigration of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Lower Mokelumne River, December 2009 through July 2010.~~
~~Steelhead~~	~~Winter~~	~~Trinity river~~	~~Adult Migration~~	~~Nov~~	~~Apr~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Steelhead~~	~~Winter~~	~~Trinity river~~	~~Spawner~~	~~Feb~~	~~May~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Steelhead~~	~~Winter~~	~~Trinity river~~	~~Egg/alevin~~	~~Feb~~	~~Jun~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Steelhead~~	~~Winter~~	~~Trinity river~~	~~Fry~~	~~Mar~~	~~Jun~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Steelhead~~	~~Winter~~	~~Trinity river~~	~~Sub yearling~~	~~May~~	~~Dec~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Steelhead~~	~~Winter~~	~~Trinity river~~	~~Yearling~~	~~Jan~~	~~Dec~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Steelhead~~	~~Winter~~	~~Trinity river~~	~~Smolt~~	~~Mar~~	~~Jul~~	~~USFWS & HVT1999~~	~~U.S. Fish and Wildlife Service (USFWS) and Hoopa Valley Tribe. 1999. Trinity River Flow Evaluation. Final Report to U.S. Department of the Interior. U.S. Fish and Wildlife Service, Arcata, CA.~~
~~Steelhead~~	~~Winter~~	~~Stanislaus River~~	~~Adult Migration~~	~~Oct~~	~~Dec~~	~~NMFS BO,2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Stanislaus River~~	~~Spawner~~	~~Dec~~	~~Feb~~	~~NMFS BO,2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Stanislaus River~~	~~Egg/alevin~~	~~Dec~~	~~May~~	~~NMFS BO,2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Steelhead~~	~~Winter~~	~~Stanislaus River~~	~~Fry~~	~~Jan~~	~~Feb~~		
~~Steelhead~~	~~Winter~~	~~Stanislaus River~~	~~Sub yearling~~	~~Apr~~	~~Jun~~		
~~Steelhead~~	~~Winter~~	~~Stanislaus River~~	~~Yearling~~	~~Jan~~	~~Dec~~	~~Watry et al. 2012~~	~~Cramer Fish Sciences (CFS). 2012. Juvenile Salmonid Out-migration Monitoring at Caswell Memorial State Park in the Lower Stanislaus River, California. 2010-2011 Biannual Report. Prepared for U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program. Grant No. 813326G008. 48 pp.~~
~~Steelhead~~	~~Winter~~	~~Stanislaus River~~	~~Smolt~~	~~Jan~~	~~Jun~~	~~Watry et al. 2012~~	~~Cramer Fish Sciences (CFS). 2012. Juvenile Salmonid Out-migration Monitoring at Caswell Memorial State Park in the Lower Stanislaus River, California. 2010-2011 Biannual Report. Prepared for U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program. Grant No. 813326G008. 48 pp.~~
~~Steelhead~~	~~Winter~~	~~Tuolumne River~~	~~Adult Migration~~	~~Jul~~	~~Mar~~	~~NMFS BO,2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Tuolumne River~~	~~Migration~~	~~Sept~~	~~Nov~~	~~Cuthbert et al 2012 FISHBIO~~	~~Cuthbert, R., Becker, C., and A. Fuller 2012. Fall/Winter Migration Monitoring at the Tuolumne River Weir 2011 Report. Unpublished Report, FISHBIO.~~
~~Steelhead~~	~~Winter~~	~~Tuolumne River~~	~~Spawner~~	~~Dec~~	~~Apr~~	~~NMFS BO, 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Tuolumne River~~	~~Egg/alevin~~	~~Dec~~	~~May~~	~~NMFS BO, 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Steelhead~~	~~Winter~~	~~Tuolumne River~~	~~Fry~~	~~Jan~~	~~Feb~~		
~~Steelhead~~	~~Winter~~	~~Tuolumne River~~	~~Sub yearling~~	~~Apr~~	~~Jun~~	~~Palmer and Sonke 2008 FISHBIO~~	~~Palmer, M. L., and C. L. Sonke 2008. Outmigrant Trapping of Juvenile Salmonids in the Lower Tuolumne River, 2008. Final Report to Turlock and Modesto Irrigation Districts. FISBIO Chico, CA.~~
~~Steelhead~~	~~Winter~~	~~Tuolumne River~~	~~Yearling~~	~~Jan~~	~~Dec~~	~~Palmer and Sonke 2008 FISHBIO~~	~~Palmer, M. L., and C. L. Sonke 2008. Outmigrant Trapping of Juvenile Salmonids in the Lower Tuolumne River, 2008. Final Report to Turlock and Modesto Irrigation Districts. FISBIO Chico, CA.~~
~~Steelhead~~	~~Winter~~	~~Tuolumne River~~	~~Smolt~~	~~Jan~~	~~Jun~~	~~Palmer and Sonke 2008 FISHBIO~~	~~Palmer, M. L., and C. L. Sonke 2008. Outmigrant Trapping of Juvenile Salmonids in the Lower Tuolumne River, 2008. Final Report to Turlock and Modesto Irrigation Districts. FISBIO Chico, CA.~~
~~Steelhead~~	~~Winter~~	~~Merced~~	~~Adult Migration~~	~~Jul~~	~~Mar~~	~~NMFS BO, 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Merced~~	~~Spawner~~	~~Dec~~	~~Apr~~	~~NMFS BO, 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Merced~~	~~Egg/alevin~~	~~Dec~~	~~May~~	~~NMFS BO, 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Merced~~	~~Fry~~	~~Feb~~	~~Jul~~		
~~Steelhead~~	~~Winter~~	~~Merced~~	~~Sub yearling~~	~~Apr~~	~~Aug~~		

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Steelhead~~	~~Winter~~	~~Merced~~	~~Yearling~~	~~Mar~~	~~Jul~~	~~NMFS BO,2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Merced~~	~~Smolt~~	~~Mar~~	~~Jul~~	~~NMFS BO,2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Steelhead~~	~~Winter~~	~~Delta~~	~~Adult Migration~~	~~Jul~~	~~Mar~~	~~Hallock et al. 1957~~	~~Hallock, R. J., FRY, D. H., and D. A. LaFaunce. 1957. The use of wire fyke traps to estimate the runs of adult salmon and steelhead in the Sacramento River. Calif. Fish and Game, 43(4):271-298~~
~~Steelhead~~	~~Winter~~	~~Sac River at Hood~~	~~Emigration~~	~~Nov~~	~~May~~	~~Schaffter 1980~~	~~Schaffter, R. G. 1980. Fish Occurrence, Size and Distribution in the Sacramento River near Hood, California During 1973 and 1974. Calif. Dept. Fish & Game, Anad. Fish. Br. Admin. Rept. No 80-3. Report-Fisheries No. 461. 9 pp.~~
~~Steelhead~~	~~Winter~~	~~Chipps Island~~	~~Emigration~~	~~Oct~~	~~Jul~~	~~Nobriga and Cadrett 2003~~	~~Nobriga, M., P. Cadrett. 2003. Differences among hatchery and wild steelhead: evidence from Delta fish monitoring programs. Interagency Ecological Program for the San Francisco Estuary Newsletter. 14(3):30-38.~~
~~Steelhead~~	~~Winter~~	~~San Joaquin River~~	~~Emigration~~	~~Jul~~	~~Mar~~	~~Based on limited unpublished data from DFG Steelhead Report Card~~	
~~Steelhead~~	~~Winter~~	~~SJ River (Mossdale)~~	~~Emigration~~	~~Oct~~	~~Jul~~	~~DFG unpublished data~~	
~~Delta smelt~~		~~Delta~~	~~Migrant~~	~~Dec~~	~~Mar~~	~~Moyle 2002~~	~~Moyle, P. B. 2002. Inland fishes of California, Revised and Expanded. University of California Press, Berkeley, CA. 517 pp.~~
~~Delta smelt~~		~~Delta~~	~~Spawner~~	~~Mar~~	~~June~~	~~Bennett 2005, Moyle 2002~~	~~Bennett, W. A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science [online serial]. Vol. 3, Issue 2 (September 2005), Article 1.; Moyle, P. B. 2002. Inland fishes of California, Revised and Expanded. University of California Press, Berkeley, CA. 517 pp.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Delta smelt~~		~~Delta~~	~~Yolk-sac larvae~~	~~Mar~~	~~June~~	~~Moyle 2002~~	~~Moyle, P. B. 2002. Inland fishes of California, Revised and Expanded. University of California Press, Berkeley, CA. 517 pp.~~
~~Delta smelt~~		~~Delta~~	~~Post-Larvae~~	~~May~~	~~July~~	~~Bennett 2005~~	~~Bennett, W. A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science [online serial]. Vol. 3, Issue 2 (September 2005), Article 1~~
~~Delta smelt~~	~~-~~	~~Delta~~	~~Juvenile~~	~~July~~	~~Dec~~	~~Nobriga and Herbold 2009~~	~~Nobriga, M., and B. Herbold. 2009*. The little fish in California's water supply: a literature review and life-history conceptual model for delta smelt (*Hypomesus transpacificus*) for the Delta Regional Ecosystem Restoration and Implementation Plan (DRERIP). Sacramento-San Joaquin Delta Regional Ecosystem Restoration Implementation Plan. 57 pp.~~
~~Longfin smelt~~		~~Delta~~	~~Migrant~~	~~Nov~~	~~Mar~~	~~Rosenfield 2010~~	~~Rosenfield, J. A. 2010. Life history conceptual model and sub-models for longfin smelt, San Francisco Estuary Population. 45 pp.~~
~~Longfin smelt~~		~~Delta~~	~~Spawner~~	~~Dec~~	~~Apr~~	~~Rosenfield 2010~~	~~Rosenfield, J. A. 2010. Life history conceptual model and sub-models for longfin smelt, San Francisco Estuary Population. 45 pp.~~
~~Longfin smelt~~		~~Delta~~	~~Egg-sac larvae~~	~~Jan~~	~~Jun~~	~~Rosenfield 2010~~	~~Rosenfield, J. A. 2010. Life history conceptual model and sub-models for longfin smelt, San Francisco Estuary Population. 45 pp.~~
~~Longfin smelt~~		~~Delta~~	~~Post-Larvae~~	~~Apr~~	~~Jul~~	~~Rosenfield 2010~~	~~Rosenfield, J. A. 2010. Life history conceptual model and sub-models for longfin smelt, San Francisco Estuary Population. 45 pp.~~
~~Longfin smelt~~		~~Delta~~	~~Juvenile~~	~~May~~	~~Dec~~	~~Rosenfield 2010~~	~~Rosenfield, J. A. 2010. Life history conceptual model and sub-models for longfin smelt, San Francisco Estuary Population. 45 pp.~~
~~Splittail~~		~~Sutter Bypass (Feather)~~	~~Migrant~~	~~Nov~~	~~Apr~~	~~Baxter and Garman 1999~~	~~Baxter RD, Garman G. 1999. Splittail investigations. Interagency Ecological Program Newsletter 12(3):6. Available at: http://www.water.ca.gov/iep/newsletters/1999/1999fall.pdf~~
~~Splittail~~		~~Sutter Bypass (Feather)~~	~~Spawner~~	~~Jan~~	~~Apr~~	~~Sommer et al 2001~~	~~Sommer T., Harrell B., Nobriga M., Brown R., Moyle P., Kimmerer W., Schemel L. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.~~
~~Splittail~~		~~Sutter Bypass (Feather)~~	~~Larvae~~	~~Apr~~	~~June~~	~~Sommer et al 2001~~	~~Sommer T., Harrell B., Nobriga M., Brown R., Moyle P., Kimmerer W., Schemel L. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.~~
~~Splittail~~		~~Sutter Bypass (Feather)~~	~~Juvenile~~	~~Apr~~	~~Following April~~	~~Moyle et al 2004~~	~~Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, S. A. Matern. 2004. Biology and population dynamics of the Sacramento splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial]. Volume 2, Issue 2 (May 2004), Article 4.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Splittail~~		~~American River (Discovery Park)~~	~~Migrant~~	~~Nov~~	~~Apr~~	~~Baxter and Garman 1999~~	~~Baxter RD, Garman G. 1999. Splittail investigations. Interagency Ecological Program Newsletter 12(3):6. Available at: http://www.water.ca.gov/iep/newsletters/1999/1999fall.pdf~~
~~Splittail~~		~~American River (Discovery Park)~~	~~Spawner~~	~~Jan~~	~~Apr~~	~~Sommer et al 2001~~	~~Sommer T., Harrell B., Nobriga M., Brown R., Moyle P., Kimmerer W., Schemel L. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.~~
~~Splittail~~		~~American River (Discovery Park)~~	~~Larvae~~	~~Apr~~	~~June~~	~~Sommer et al 2001~~	~~Sommer T., Harrell B., Nobriga M., Brown R., Moyle P., Kimmerer W., Schemel L. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.~~
~~Splittail~~	~~-~~	~~American River (Discovery Park)~~	~~Juvenile~~	~~Apr~~	~~Following April~~	~~Moyle et al 2004~~	~~Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, S. A. Matern. 2004. Biology and population dynamics of the Sacramento splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial]. Volume 2, Issue 2 (May 2004), Article 4.~~
~~Splittail~~		~~Sac Mainstem~~	~~Migrant~~	~~Nov~~	~~Apr~~	~~Baxter and Garman 1999~~	~~Baxter R. D., Garman G. 1999. Splittail investigations. Interagency Ecological Program Newsletter 12(3):6. Available at: http://www.water.ca.gov/iep/newsletters/1999/1999fall.pdf~~
~~Splittail~~		~~Sac Mainstem~~	~~Spawner~~	~~Jan~~	~~Apr~~	~~Sommer et al 2001~~	~~Sommer T., Harrell B., Nobriga M., Brown R., Moyle P., Kimmerer W., Schemel L. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.~~
~~Splittail~~		~~Sac Mainstem~~	~~Larvae~~	~~Apr~~	~~June~~	~~Sommer et al 2001~~	~~Sommer T., Harrell B., Nobriga M., Brown R., Moyle P., Kimmerer W., Schemel L. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.~~
~~Splittail~~	~~-~~	~~Sac Mainstem~~	~~Juvenile~~	~~Apr~~	~~Following April~~	~~Moyle et al 2004~~	~~Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, S. A. Matern. 2004. Biology and population dynamics of the Sacramento splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial]. Volume 2, Issue 2 (May 2004), Article 4.~~
~~Splittail~~		~~Delta~~	~~Migrant~~	~~Nov~~	~~Apr~~	~~Baxter and Garman 1999~~	~~Baxter R. D., Garman G. 1999. Splittail investigations. Interagency Ecological Program Newsletter 12(3):6. Available at: http://www.water.ca.gov/iep/newsletters/1999/1999fall.pdf~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Splittail~~		~~Delta~~	~~Spawner~~	~~Jan~~	~~Apr~~	~~Sommer et al 2001~~	~~Sommer T., Harrell B., Nobriga M., Brown R., Moyle P., Kimmerer W., Schemel L. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.~~
~~Splittail~~		~~Delta~~	~~Larvae~~	~~Apr~~	~~June~~	~~Sommer et al 2001~~	~~Sommer T., Harrell B., Nobriga M., Brown R., Moyle P., Kimmerer W., Schemel L. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26(8):6-16.~~
~~Splittail~~	-	~~Delta~~	~~Juvenile~~	~~Apr~~	~~Following April~~	~~Moyle et al 2004~~	~~Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, S. A. Matern. 2004. Biology and population dynamics of the Sacramento splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: a review. San Francisco Estuary and Watershed Science [online serial]. Volume 2, Issue 2 (May 2004), Article 4.~~
~~Green sturgeon~~		~~Upper Sacramento~~	~~Migrant~~	~~Jan~~	~~Dec~~	~~NMFS 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Green sturgeon~~		~~Upper Sacramento~~	~~Adult Migration~~	~~Feb~~	~~Jun~~	~~USBR OCAP~~	~~U.S. Department of the Interior Bureau of Reclamation 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.~~
~~Green sturgeon~~		~~Upper Sacramento~~	~~Adult river holding~~	~~Mar~~	~~Dec~~	~~Israel and Klimley 2008~~	~~Israel, J. A. and A. P. Klimley. 2008. Life History Conceptual Model for North American Green Sturgeon (*Acipenser medirostris*). 49 pp.~~
~~Green sturgeon~~		~~Upper Sacramento~~	~~Adult summer emigration~~	~~Mar~~	~~Aug~~		
~~Green sturgeon~~		~~Upper Sacramento~~	~~Eggs~~	~~Mar~~	~~Jul~~	~~NMFS 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Green sturgeon~~		~~Upper Sacramento~~	~~Eggs~~	~~Mar~~	~~Jun~~	~~USBR OCAP~~	~~U.S. Department of the Interior Bureau of Reclamation 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.~~
~~Green sturgeon~~		~~Upper Sacramento~~	~~Eggs~~	~~Apr~~	~~Jul~~	~~Israel and Klimley 2008~~	~~Israel, J. A. and A. P. Klimley. 2008. Life History Conceptual Model for North American Green Sturgeon (*Acipenser medirostris*). 49 pp.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Green sturgeon~~		~~Upper Sacramento~~	~~Larvae-post larvae~~	~~May~~	~~Oct~~	~~NMFS 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Green sturgeon~~		~~Upper Sacramento~~	~~Larvae-post larvae~~	~~May~~	~~Oct~~	~~USBR OCAP~~	~~U.S. Department of the Interior Bureau of Reclamation 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.~~
~~Green sturgeon~~		~~Upper Sacramento~~	~~Larvae-post larvae~~	~~May~~	~~Oct~~	~~Israel and Klimley 2008~~	~~Israel, J. A. and A. P. Klimley. 2008. Life History Conceptual Model for North American Green Sturgeon (*Acipenser medirostris*). 49 pp.~~
~~Green sturgeon~~		~~Bay-Delta~~	~~Adult Bay-Delta holding~~	~~July~~	~~Dec~~		
~~Green sturgeon~~		~~S. Delta~~	~~Older juvenile >10 months~~	~~Jan~~	~~Dec~~	~~NMFS 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Green sturgeon~~		~~Sac-SJ Delta~~	~~Older juvenile >10 months (use most conserv)~~	~~Jan~~	~~Dec~~	~~NMFS 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Green sturgeon~~		~~Sac-SJ Delta~~	~~Older juvenile >10 months~~	~~Apr~~	~~Oct~~	~~NMFS 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Green sturgeon~~	-	~~Suisun Bay~~	~~Older juvenile >10 months~~	~~Jan~~	~~Dec~~	~~NMFS 2009~~	~~NMFS (National Marine Fisheries Service). 2009a. Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project. NMFS, Long Beach, California. Available from http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the _CVP_and_SWP.pdf (accessedJune 2012).~~
~~Green sturgeon~~	-	~~Feather~~	~~Migrant~~	~~Dec~~	~~May~~	~~Department of Water Resources 2011~~	~~A. Seesholtz, Healey Vincik 2011~~
~~Green sturgeon~~		~~Feather~~	~~Pre-spawn~~	~~Mar~~	~~April~~	~~Department of Water Resources 2011~~	~~A. Seesholtz~~
~~Green sturgeon~~		~~Feather~~	~~Spawner~~	~~Feb~~	~~June~~	~~Department of Water Resources 2011~~	~~A. Seesholtz, Moyle P. B. (2002)~~
~~Green sturgeon~~		~~Feather~~	~~Larvae-post larvae~~	~~Jun~~	~~Aug~~		
~~Green sturgeon~~		~~Feather~~	~~Post spawn migration~~	~~Sept~~	~~Nov~~		~~A. Seesholtz, Healey Vincik 2011~~
~~Green sturgeon~~	-	~~Trinity River~~	~~Migrants~~	~~Jun~~	~~Aug~~	~~Bensen et al 2006~~	~~Bensen, R. L., Turo, S., and B. W. McCovey Jr. 2006. Migration and movement patterns of green sturgeon (*Acipenser medirostris)* in the Klamath and Trinity rivers, California, USA. Environ Biol Fish (2007) 79:269–279~~
~~White Sturgeon~~	-	~~Feather~~	~~Migrant~~	~~Dec~~	~~May~~	~~DFG~~	~~J Navicky (2006), R. Vincik, M. Healey (2011)~~
~~White Sturgeon~~		~~Feather~~	~~Pre-spawn~~	~~Dec~~	~~April~~	~~DFG~~	~~R. Vincik, M. Healey (2011)~~
~~White Sturgeon~~		~~Feather~~	~~Spawner~~	~~Feb~~	~~Jun~~		
~~White Sturgeon~~		~~Feather~~	~~Larvae-post larvae~~	~~Mar~~	~~Jun~~		
~~White Sturgeon~~		~~Feather~~	~~Post spawn migration~~	~~Nov~~	~~May~~	~~DWR, DFG~~	~~A. Seesholtz, R. Vincik, M. Healey 2011~~
~~White Sturgeon~~		~~Mainstem Sac~~	~~Larvae~~	~~Mar~~	~~June~~		
~~White sturgeon~~		~~Lower Sacramento River~~	~~Spawning/ Postspawning/ Mature adult~~	~~Nov~~	~~May~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~White sturgeon~~		~~Lower San Joaquin River~~	~~Spawning/ Postspawning/ Mature adult~~	~~Nov~~	~~May~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~North Delta~~	~~Spawning/ Postspawning/ Mature adult~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~South Delta~~	~~Spawning/ Postspawning/ Mature adult~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~West Delta~~	~~Spawning/ Postspawning/ Mature adult~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~Suisun Bay~~	~~Spawning/ Postspawning/ Mature adult~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~Lower Sacramento River~~	~~Juveniles~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~Lower San Joaquin River~~	~~Juveniles~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~North Delta~~	~~Juveniles~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~South Delta~~	~~Juveniles~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~West Delta~~	~~Juveniles~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~White sturgeon~~		~~Suisun Bay~~	~~Juveniles~~	~~Jan~~	~~Dec~~	~~Israel et al. 2009~~	~~Israel, J. A. Drauch, and M. Gingras. 2009. Life History Conceptual Model for White Sturgeon (*Acipenser transmontanus*). 54 pp.~~
~~Pacific Lamprey~~		~~Sacramento-San Joaquin River Systems~~	~~Adult (spawning)~~	~~Apr~~	~~July~~	~~Beamish 1980~~	~~Beamish, R.J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~Pacific Lamprey~~		~~Sacramento-San Joaquin River Systems~~	~~Ammocoete (filter feeding)~~	~~June~~	~~July~~	~~Beamish 1980~~	~~Beamish, R.J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~Pacific Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Ammocoete-macropthalmia (metamorphosis)~~	~~July~~	~~Aug~~	~~Beamish 1980~~	~~Beamish, R.J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~Pacific Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Macropthalmia (emigration)~~	~~Dec~~	~~June~~	~~Beamish 1980~~	~~Beamish, R.J. 1980. Adult biology of the river lamprey (lampetra ayresi) and the pacific lamprey (lampetra tridentata) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~Pacific Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Juvenile-adult (ocean feeding)~~	~~Oct~~	~~June~~	~~Beamish 1980~~	~~Beamish, R.J. 1980. Adult biology of the river lamprey (lampetra ayresi) and the pacific lamprey (lampetra tridentata) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~Pacific Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Adult (immigration; sexual maturity)~~	~~Apr~~	~~Sept~~	~~Beamish 1980~~	~~Beamish, R.J. 1980. Adult biology of the river lamprey (lampetra ayresi) and the pacific lamprey (lampetra tridentata) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~Pacific Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Adult (overwinter)~~	~~Sept~~	~~Apr~~	~~Beamish 1980~~	~~Beamish, R. J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~River Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Adult (spawning)~~	~~Apr~~	~~May~~	~~Beamish 1980~~	~~Beamish, R. J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~River Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Ammocoete (filter feeding)~~	~~May~~	~~July~~	~~Beamish 1980~~	~~Beamish, R. J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~River Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Ammocoete-macropthalmia (metamorphosis)~~	~~July~~	~~Aug~~	~~Beamish 1980~~	~~Beamish, R. J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~River Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Macropthalmia (emigration)~~	~~May~~	~~July~~	~~Beamish 1980~~	~~Beamish, R. J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~

~~Species~~	~~Run~~	~~River~~	~~Life stage~~	~~Month begin~~	~~Month end~~	~~Author~~	~~Reference~~
~~River Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Juvenile-adult (ocean feeding)~~	~~June~~	~~Sept~~	~~Beamish 1980~~	~~Beamish, R. J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~
~~River Lamprey~~		~~Sacramento -San Joaquin River Systems~~	~~Adult (immigration; sexual maturity)~~	~~Sept~~	~~Mar~~	~~Beamish 1980~~	~~Beamish, R. J. 1980. Adult biology of the river lamprey (*lampetra ayresi*) and the pacific lamprey (*lampetra tridentata*) from the pacific coast of Canada. Can J. Fish. Aquat. Sci 37: 1906-1923.~~

11.1.2.2 Noncovered Aquatic Natural Communities

Low Salinity Zone

The "low salinity zone" (LSZ) within the San Francisco Estuary is defined as the area within the estuary where salinity is approximately 0.5 to 6 parts per thousand (ppt). The LSZ has been noted to be important nursery habitat for zooplankton and early life stages of fish in various estuaries (Bennett et al. 2002). Pelagic (open-water) fish habitat may include the LSZ and is characterized by physical and chemical properties such as salinity, turbidity, and water temperature, and biological properties such as prey production. Pelagic fish habitat suitability in the San Francisco Estuary is partially influenced by variation in freshwater flow (e.g., Delta outflow) as a function of natural hydrological variation and water operations (Jassby et al. 1995; Kimmerer 2004), as well as other, non-flow-related factors. Several fish species use a variety of behaviors to maintain themselves within open-water areas where water quality and food resources are favorable (Bennett et al. 2002), including the LSZ and a number of tidal channel and littoral habitats (Sommer and Mejia 2013). For example, Delta smelt, longfin smelt, striped bass, and threadfin shad distribute themselves at different concentrations of salinity within the estuarine salinity gradient (Feyrer et al. 2007; Kimmerer 2002a; Kimmerer et al. 2013), indicating that, at any point in time, salinity is a major factor affecting the geographic distributions of these species. The range of salinity occupied varies by species and life stage within species, with some life stages having relatively broad distributions.

X2 (i.e., roughly the center of the LSZ), is defined as the distance from the Golden Gate Bridge upstream to where salinity near the bottom of the water column is approximately 2 ppt. Salinity between 2 and approximately 30 ppt is roughly linearly distributed between X2 and the mouth of the estuary (Monismith et al. 1996). X2 reflects the physical response of the San Francisco Estuary to changes in flow and provides a geographic frame of reference for estuarine conditions (Kimmerer 2002b). The estuary responds to freshwater flow, as characterized by the inverse statistical relationship between X2 and Delta outflow lagged by approximately two weeks (Kimmerer 2004). Because the position of X2 relies on a number of physical parameters, including river flows, water diversions and tides, its position shifts over many kilometers on a daily and seasonal cycle. Over the course of a year, the location of X2 can range from San Pablo Bay during high river flow periods to up into the Delta during low-flow periods (generally summer/fall). As discussed by Jassby et al. (1995), X2 was chosen as an appropriate ecosystem indicator because from a physical standpoint it was a useful length scale for parameterizing the spatial structure of the salt field in the northern San Francisco Estuary. In addition, X2 had ecological significance because it indicated the boundary between upstream and downstream reaches that differ greatly in baroclinic pressure gradients and density stratification, which result in it being an indicator of entrapment location at which the estuarine turbidity maximum often occurs and where spatial maxima of important zooplankton species (*Eurytemora affinis* and *Neomysis mercedis*) as well as fishes (e.g., larval striped bass) are found in close proximity (Jassby et al. 1995). Jassby et al. (1995) found that X2 meets several critical criteria listed by Messer (1990, as cited by Jassby et al. 1995) for use as an indicator in environmental monitoring/assessment:

- Correlation with changes in ecosystem processes: the correlations with X2 found by Jassby et al. (1995) included phytoplankton particulate organic carbon in Suisun Bay, zooplankton consumers (*Neomysis*), epibenthic crustaceans (*Crangon*), benthic consumers in Suisun Bay (molluscs), bottom-foraging fish (starry flounder), and survival (striped bass) and abundance (longfin smelt and striped bass) of fish that feed in the water column.

- Integration of effects over space and time: X2 integrates over space by acting as a scalar representation of the entire salinity field and integrates over time through application of a mean X2 value to an appropriate time period such as the early life stages of fish such as longfin smelt.
- Unambiguous and monotonic relation with a habitat variable: X2 has unambiguous relationships with a number of habitat variables, including the salinity distribution and net outflow, in addition to related habitat characteristics such as geographic extent and location of the low-salinity zone,
- Quantifiable by automated or synoptic monitoring: X2 is estimated by interpolation of conductivity recorded at various monitoring locations.

Kimmerer (2002a) found that distributions of fish species including striped bass, Sacramento splittail, longfin smelt, delta smelt, and starry flounder, substantially overlapped with the LSZ, and that large parts of some of the populations also were outside the LSZ. Relationships between X2 and abundance indices of fish and aquatic species have been developed for many estuary-dependent copepods, mysids, bay shrimp, and several fishes—including longfin smelt, Pacific herring, starry flounder, Sacramento splittail, American shad, and striped bass (Kimmerer 2002a). In some cases (striped bass and American shad), the mechanism for these relationships may be increased availability of habitat (including the LSZ) with greater flow (lower X2) (Kimmerer et al. 2009; Kimmerer et al. 2013). In the case of splittail, the mechanism is likely to be availability of floodplain habitat for the early life stages, which correlates with X2, rather than the extent of tidal habitat including the LSZ. In the case of other species, particularly longfin smelt, it is unclear what the mechanism explaining the X2-abundance correlation may be; Kimmerer et al. (2013: 13) suggested that "dynamic attributes of habitat that vary with flow, such as retention by estuarine circulation or transport to rearing areas, may be more important than quantity of habitat for some fish species." Feyrer et al. (2007) found that a simple linear regression between the delta smelt fall midwater trawl index (representing parental stock) and the delta smelt summer townet index (representing juvenile recruitment) was significantly improved when including average fall salinity (specific conductance), which the authors suggested provided evidence that the decline in the area of suitable physical and chemical habitat played a role in declines in delta smelt abundance.

According to California Department of Fish and Game (2010a), the available data and information indicate that (1) the abundance of many fish and aquatic species is related to water flow timing and quantity; (2) for many fish and aquatic species, more water flow translates into greater species production or abundance; (3) fish and aquatic species are adapted to use the water resources of the Delta during all seasons of the year, but for many species, important life history stages or processes consistently coincide with increased winter-spring flows; and (4) the source, quality, and timing of water flows through the estuary influences the production of Chinook salmon in both the San Joaquin River and Sacramento River Basins (California Department of Fish and Game 2010b).

The extent of the low salinity zone, which is positively correlated with freshwater outflow and negatively correlated with the position of the 2-ppt isohaline, largely overlaps with the distribution of other essential physical resources and key biotic resources that are necessary to support delta smelt, but is not the only factor that defines the extent of habitat for delta smelt. The delta smelt fall abiotic habitat index developed by Feyrer et al. (2011) is based on the probability of presence of delta smelt given certain water clarity and salinity and does not account for other abiotic (e.g., water velocity, depth) and biotic (e.g., food density) factors that may interact with water clarity and salinity to influence the probability of occurrence. The three physical variables (temperature, salinity, and turbidity) combined could explain just a quarter of the variance in patterns of delta smelt presence and absence in the estuary. It is unclear what portion of that fractional explained variance is actually due to turbidity, rather than salinity. While temperature was not found to be a predictor of delta smelt presence in the fall, it has been shown to be important during summer months (Nobriga et al. 2008).

The overall relationship between X2 and the delta smelt fall abiotic habitat index is the result of two linked statistical analyses, each of which include uncertainties that are compounded when the analyses are combined. In addition, while the position of X2 is correlated with the distribution of salinity and turbidity regimes (Feyrer et al. 2007), the relationship of that distribution and smelt abundance indices is not clear (National Research Council 2010). Nevertheless, this method has been previously applied to analyses for delta smelt habitat and therefore is included in this analysis of relative comparisons between action alternatives and baseline conditions (see summary of methods in section 11.3.2.2 below).

The appreciable uncertainty related to the significance of the LSZ and fall outflow management for delta smelt have led to research efforts to be initiated under a Collaborative Science and Adaptive Management Program (CSAMP). The CSAMP was launched following a decision by the United States District Court for the Eastern District of California on April 9, 2013, issued in response to a motion to extend the court-ordered remand schedule for completing revisions to the NMFS (2009) and USFWS (2008) SWP/CVP BiOps. Under the CSAMP, a Collaborative Adaptive Management Team (CAMT) has the mission of working to develop a robust science and adaptive management program that will inform both the implementation of the current BiOps and the development of future BiOps. This adaptive management team has formulated a workplan that identifies a number of key questions and possible investigative approaches to the issue of fall outflow management (Table 11-4; Collaborative Adaptive Management Team 2014); the investigations resulting from this work would directly inform the uncertainty surrounding fall outflow management for delta smelt.

Table 11-4. Key Questions and Possible Investigative Approaches to Address Fall Outflow Management as Part of the Collaborative Adaptive Management Team Fall Outflow Workplan

Key Questions	Possible Investigative Approaches
Are there biases in the IEP survey data? How should the survey data be utilized if biases do exist?	Convene a workshop to discuss possible survey problems and identify opportunities to address in 2014 with existing data. Consider ongoing work and approaches of Emilio Laca. Many of these issues have been proposed by FWS to be addressed through a package of gear efficiency and smelt distribution studies; however, that package includes extensive field work, and some elements have timelines extending beyond the remand period.
Under what circumstances does survival in the fall affect subsequent winter abundance?	Quantitatively determine the contribution of delta smelt survivorship in the fall to inter-annual population variability. Review available lifecycle models for applicability.
Under what circumstances do environmental conditions in the fall season contribute to determining the subsequent abundance of delta smelt?	Investigate the relationship between fall outflow and the relative change in delta smelt abundance using univariate and multivariate and available historic data. Related to work undertaken in the Management, Analysis, and Synthesis Team (MAST) report, which examined pairs of dry and wet years in 2005/6 and 2010/11. Also explore effects occurring through other avenues (e.g. growth or fecundity).

Key Questions	Possible Investigative Approaches
How much variability in tidal, daily, weekly, and monthly fluctuations in fall X2 is attributable to water project operations?	Hydrological modeling tools to determine the prospective locations of X2 in the fall under circumstances with and without project operations. An analysis of historical data will also be carried out to examine outflow during periods when the projects were required to meet specific outflow requirements, to evaluate the degree of control that has been possible at various time scales. See work addressing this issue by: Grossinger, Hutton, and a paper by Cloern and Jassby (2012)
Under what circumstances is survival of delta smelt through the fall related to survival or growth rates in previous life stages?	Compare delta smelt survival during the fall to both survival in prior seasons and to fork length at the end of the summer/start of the fall. New data are being collected as part of the Fall Outflow Adaptive Management Plan (FOAMP). Consider individual-based modeling (IBM).
Does outflow during the fall have significant effects on habitat attributes that may limit the survival and growth of delta smelt during the fall?	There may be competing approaches that will be simultaneously pursued. One is to develop graphs and conduct univariate and multivariate analyses involving survival ratios and growth rates. Test whether month-to-month declines in abundance or growth during the fall is greater when X2 is located further east. See also the analytical approach in MAST report, work by Kimmerer, Burnham & Manly.
Can an index based on multiple habitat attributes provide a better surrogate for delta smelt habitat than one based only on salinity and turbidity?	Review approaches in existing literature. There may be competing approaches that will be simultaneously pursued, depending on expert advice. One possible approach is to develop suitability index curves and combine geometrically to create a habitat quality index. Utilize data from areas where delta smelt are frequently observed to assess habitat quality. See work by Burnham, Manly, and Guay.
Under what conditions (e.g., distribution of the population, prey density, contaminants) do fall operations have significant effects on survival?	Utilizing relationships identified in the above studies, simulate how changes in project operations may influence survival of delta smelt during the fall.
Source: Collaborative Adaptive Management Team (2014)	

11.1.4 Ecological Processes and Functions

11.1.4.1 Hydrology

A full description of hydrology is provided in Chapter 5*, Water Supply* and Chapter 6, *Surface Water.* The following is provided as a brief overview of hydrologic conditions.

The volume and distribution of water in the watershed influence important ecological processes and functions. Streamflows within the watershed are extremely variable. Most of the precipitation occurs from December through June. A large part of the total flow volume occurs during relatively short periods, caused either by rainfall or snowmelt. Construction and operation of dams on major rivers and streams has reduced peak winter and spring flows, and increased summer and fall flows. Dry-year flows can be higher in regulated streams than in unregulated streams because of release of carryover storage from reservoirs. Within tributaries to the Plan Area, winter and spring peak flows, and summer and fall base flows are important to maintain ecological processes such as sediment transport, stream meandering, and riparian habitat regeneration. Native fish species evolved with these flow patterns, and spawning and migrating fish depend on the natural seasonal and interannual streamflow patterns. Native habitats and species in the watershed's ecosystem evolved in the context of a highly variable flow regime punctuated by extreme seasonal and interannual changes in flow (CALFED Bay-Delta Program 2000a). Within the Plan Area, most sediment is delivered during high flows in winter/spring (Wright and Schoellhamer 2005), and high pulses of sediment are tied to biological responses such as migration of delta smelt prior to spawning (Grimaldo et al. 2009; Sommer et al. 2011). Flow pulses on the main tributaries to the Plan Area are correlated with downstream movement of large pulses of juvenile salmonids such as winter-run Chinook salmon (del Rosario et al. 2013), and the extent of inundation of floodplains such as the Yolo Bypass and resulting access by fish varies greatly each year because of differences in hydrology (Roberts et al. 2013).

The volume and distribution of water in the watershed influence important ecological processes and functions. The natural hydrograph in the watershed is extremely variable with most of the unimpeded flow occurring from December through June during relatively short periods, caused either by rainfall or snowmelt. Native fish species evolved with these flow patterns, and spawning and migrating fish depend on naturally variable seasonal and interannual streamflow patterns for maintenance of the habitat conditions needed to successfully complete their life cycles (CALFED Bay-Delta Program 2000a). Construction and operation of dams on major rivers and streams has reduced peak winter and spring flows and increased summer and fall flows, altering the natural processes that sustain these habitats (e.g. sediment transport, stream meandering, and riparian regeneration) and creating more stable hydrologic conditions favored by non-native species. River-transported sediments are an essential component of the physical structure and nutrient base of the Bay-Delta ecosystem and its riverine and tidal arteries. The coarse sediment supply is highly variable between the streams and tidal sloughs of the Sacramento and San Joaquin Rivers and Bay-Delta ecosystems. Most sediment is transported and deposited during winter and spring runoff events. Typically, bars, shoals, and braided deltas form or expand as floodwaters decline and stabilize during the dry season. Due to the construction of reservoirs on the major rivers in the watershed, sediment transport to the lower rivers below the reservoirs has been reduced.

Stream meander is a dynamic natural process, and is also a term used to describe the shape of the river as a sinuous or bending wave form. Rivers with active stream channel meander zones generally support a greater diversity of aquatic and terrestrial habitats and biotic communities. Central Valley streams have been affected by physical modifications that diminish stream meandering and associated aquatic and riparian habitats. However, substantial reaches of several large rivers still support full or partial characteristics of a dynamic stream meander pattern. The best example in California is the Sacramento River between Red Bluff and Butte City. Other important examples include the San Joaquin River (from Mossdale to Merced River); the Merced, Tuolumne, Cosumnes, Feather, and Yuba Rivers; and Cottonwood, Stony, and Cache Creeks.

Floodplains and flood processes provide important seasonal habitat for fish and wildlife, and provide sediment and nutrients to both the flooded lands and aquatic habitats of the rivers and Bay-Delta. Today, mostly primary open water channels remain, lacking floodplains, are bordered by steep-sided riprapped levees often lacking in native vegetation. The Delta waterways generally contain freshwater, with brief incursions of slightly brackish water (e.g., water with greater than 1,000 parts pf chloride per million parts of water; see Figure 8-5 in Chapter 8, *Water Quality*) into the western Delta (see also Figures 8-24 and 8-25 in Chapter 8, *Water Quality*). As described in section 8.2.3.7 of Chapter 8, *Water Quality*, although the primary source of salinity in the Delta is seawater intrusion from the west (CALFED Bay-Delta Program 2000), salinity also is elevated in the San Joaquin River inflows as a result of irrigated agricultural drainage on southern San Joaquin

Valley soils of marine origin that are naturally high in salts, and from salt in Delta waters that are used for irrigation and returned back to the Delta. The major incursions of brackish water into the legal Delta generally have occurred in the fall (Feyrer et al. 2007; Cloern and Jassby 2012); they are very rare during spring. Delta hydrodynamics are determined by a combination of flow parameters including Delta inflow, Delta diversions, tidal flows, and facility operations (e.g., operation of the Delta Cross Channel [DCC] gates); the effects of these parameters varies by geographic location. For example, cross-Delta water flow to the south Delta pumping plants generally reduces residence time of water in the Delta and alters flow direction and magnitude (Arthur et al. 1996; Kimmerer and Nobriga 2008), and flow direction and magnitude are also influenced by natural hydrology and reservoir operations in San Joaquin River tributaries that influence inflows to the South Delta subregion. Kimmerer and Nobriga (2008) found that the Delta residence time of simulated particles released in the northern Delta were relatively short and influenced by export flow at low inflow (reflecting river domination), whereas southern Delta particle residence times generally were much longer and strongly influenced by export flows.

Plant contributions to the estuary food web consist mostly of benthic algae and phytoplankton produced in the estuary and its watershed. The watershed food web is subject to seasonal and annual trends in response to variation in hydrologic and other environmental factors. The proportion of the organic material that moves through the Delta and reaches Suisun Bay varies considerably from year to year and depends, in part, on prevailing flow conditions. At higher flows, much of the organic material brought in by the rivers will travel to Suisun Bay or farther downstream to San Pablo Bay or central San Francisco Bay. At low flows, a greater proportion remains in the Delta or is exported from the South Delta pumping plants(Jassby and Cloern 2000).

For detailed discussion of water flow and hydrodynamics refer to Chapter 6, *Surface Water*.

11.1.5 Factors Affecting Species Success

There are a number of environmental factors, including actions, environmental characteristics or organisms that may affect fish and aquatic resources, ecological processes, and habitats. An overview of factors affecting fish and aquatic resources is first presented by geographic area (i.e., upstream of the Plan Area, the Plan Area, and downstream of the Plan Area). More detailed discussions regarding species-, run-, and life stage-specific stressors are provided in Appendix 11A.

Numerous documents were reviewed to identify factors affecting fish and aquatic resources in the watershed. These documents include the draft BDCP Habitat Conservation Plan (HCP)/Natural Community Conservation Plan (NCCP), the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) Conceptual Models, the MSCS, the 2009 NMFS BiOp (National Marine Fisheries Service 2009a), the U.S. Fish and Wildlife Service (USFWS) BiOp (U.S. Fish and Wildlife Service 2008), NMFS and USFWS species recovery plans, primary literature, agency technical memoranda, and others. Common to many of these documents was the identification of major categories of factors that negatively affect fish and aquatic species, ecological processes, and habitats within the watershed, including (1) water development and conveyance; (2) water quality, contaminants, and toxicity; (3) nonnative aquatic resources; (4) harvest and hatchery management; and (5) recreational and commercial activities.

11.1.5.1 Water Development and Conveyance

Current hydrodynamic conditions within the Delta act as ecosystem stressors by affecting species movement among habitats, limiting habitat availability and suitability, creating conditions favoring nonnative invasive species, and limiting food production (e.g., by direct export of a portion of primary production; Jassby et al. 2002). SWP and CVP exports have direct and indirect effects on fishes in the Delta. Specifically, exports entrain fish, alter hydrodynamics, and affect food webs. A full description of the export facilities is included in Chapter 5, *Water Supply.* A brief overview of the facilities is described below for reference.

The amount and timing of water exports from the Delta affects the level of entrainment. These hydrodynamic conditions affect water quantity and quality due to higher water velocities and reduced residence time, which alter various habitat types that are dependent upon natural flow patterns. In addition, the rate and location that water is diverted from the Delta affects the residence time of water in many Delta channels that, in combination with other factors, affects primary and secondary production (California Department of Fish and Game 2008b).

CVP and SWP South Delta Entrainment and Salvage Operations

Entrainment of Delta fish in water diversions has been an important focus for scientific investigation in the Delta and a key consideration for management of water operations and fish conservation. The south Delta SWP and CVP facilities are the largest water diversions in the Delta, and have been the subject of most scientific investigation and management actions relating to entrainment. In the past, these facilities have entrained large numbers of Delta fish species. Before fish reach the CVP and SWP facilities, there are other ways mortality occurs. Through-Delta survival can be negatively affected by export operations (Newman 2003; Newman and Brandes 2010; but see also Zeug and Cavallo 2013), which may be a combination of direct entrainment losses within the south Delta export facilities and predation in channels leading to the facilities. For example, between 1979 and 1993 up to 435,000 juvenile Chinook salmon and 56,000 delta smelt were salvaged annually at the SWP south Delta fish facility (Brown et al. 1996). The actual entrainment losses were likely an order of magnitude greater than measured salvage, due to predation in Clifton Court Forebay and the relatively low diversion efficiency of the louver fish exclusion system (the percentage of fish that are successfully directed to holding tanks and counted) (Brown et al. 1996; Castillo et al. 2012). Note that identification to species has been made more consistent than prior to 1993 and the methods for calculating salmon entrainment have changed since the 1990s, so that absolute comparisons between previous and current timeframes may not be accurate; nevertheless, it is evident that entrainment loss at the south Delta export facilities was previously appreciably higher than occurs today (discussed further below). Entrainment by agricultural diversions also occurs (Nobriga et al. 2004) but is not believed to be as substantial because of the small size of these intakes, although predation levels in the vicinity of the structures may be high (Vogel 2011).

In recent years, entrainment of pelagic species (e.g., delta smelt and longfin smelt) and other Delta fish from the south Delta facilities has been substantially reduced due to changes in export operations as well as declining abundance of some fish such as delta smelt (Kimmerer 2011).

11.1.5.2 Hydrograph and Hydrodynamic Alterations

Delta Outflow

Delta outflow is the primary driver of the salinity gradient in Suisun Bay. Delta outflow controls, in balance with upstream salinity intrusion from the Bay, the location of the LSZ (Kimmerer 2004; Kimmerer et al. 2009; U.S. Fish and Wildlife Service 2008; National Marine Fisheries Service 2009a). Delta outflows can also affect the distribution of some species of larval fish and other aquatic organisms, as well as nutrients and food supplies into the lower reaches of the Delta and Suisun Bay. As previously discussed under *Pelagic Habitat Areas*, the abundance of many species inhabiting the Delta is related to water flow timing and quantity and salinity (California Department of Fish and Game 2010b).

Nearly 20% of the total mean Sacramento River outflow occurs between April and June under current SWP and CVP operations, compared to nearly 50% of the total mean outflow occurring between April and June during the later portion of the nineteenth century, before the two projects existed (The Bay Institute 1998; National Marine Fisheries Service 2009a). In all water-year types (wet, average, dry) the Sacramento River and its tributaries represent the largest flow into the Delta, followed by the San Joaquin River and then the eastside tributaries such as the Mokelumne and Cosumnes rivers. Delta outflow varies by water year type. For example, in the above normal 2000 water year more than 70% of water entering the Delta passed through the system as outflow (Governor's Delta Blue Ribbon Task Force 2008). In the dry 2001 and wet 1998 water year about 54% and 90%, respectively, of the water entering the Delta was outflow (Governor's Delta Blue Ribbon Task Force 2008).

Delta outflow targets have been developed to protect delta smelt and longfin smelt (U.S. Fish and Wildlife Service 2008; California Department of Fish and Game 2009). To improve delta smelt habitat, the 2008 USFWS Biological Opinion on the Coordinated Long-term Operation of the CVP and SWP (2008 USFWS BiOp sets forth targets for managing the location of X2 through increasing Delta outflow during fall when the preceding water year was wetter than normal (U.S. Fish and Wildlife Service 2008). Subject to adaptive management, USFWS (2008a) prescribes that sufficient Delta outflow be provided to maintain average location of X2 for September and October no greater (more eastward) than 74 km (about 46 miles) in the fall following wet years and 81 km (about 50 miles) in the fall following above-normal years. The monthly average X2 must be maintained at or seaward of these values for each individual month and not averaged over the 2-month period. In November, the inflow to SWP and CVP reservoirs in the Sacramento River Basin will be added to reservoir releases to provide an added increment of Delta inflow and to augment Delta outflow up to the fall target (U.S. Fish and Wildlife Service 2008). This action is to be implemented between September 1 and November 30 (U.S. Fish and Wildlife Service 2008). On-going litigation affected X2 implementation in 2011. In 2011, the District Court enjoined Reclamation and DWR from implementing Fall X2 at 74km but set the action at no more west than 79 km. As described in more detail in the Low Salinity Zone portion of section 11.1.2.2 above, the appreciable uncertainty related to the significance of the LSZ and fall outflow management for delta smelt have led to research efforts to be initiated under a Collaborative Science and Adaptive Management Program (CSAMP). This effort aims to reduce the uncertainty around the importance of fall outflow to delta smelt by facilitating a number of research efforts (Collaborative Adaptive Management Team 2014).

Old and Middle River Flows

Old and Middle Rivers are two major distributary channels that serve as the primary conveyance of water through the Delta to the SWP and CVP pumping facilities (Grimaldo et al. 2009). Old and Middle River Net flow can be positive (i.e., seaward) or negative (i.e., towards SWP and CVP) depending San Joaquin River inflow and SWP and CVP exports. In general, net flow in the Old and Middle River are negative.(U.S. Fish and Wildlife Service 2008). OMR flow toward the pumps is increased seasonally by installation of the South Delta Temporary Barriers Project (TBP) (U.S. Fish and Wildlife Service 2008). The measure of San Joaquin flow that goes past Jersey Point is known as Qwest and represents the lower San Joaquin River flow (U.S. Fish and Wildlife Service 2008).

SWP and CVP Fish Facility data show that salvage of key species of interest, including juvenile salmon, delta smelt, and longfin smelt, generally increases as OMR flow become more negative (Kimmerer 2008, Grimaldo et al. 2009). For salmonids, route selection has been found to affect entrainment risk as well (Cavallo et al. 2015Based on particle tracking modeling, Kimmerer and Nobriga (2008) found that footprint (i.e., zone of influence) for larval delta smelt extends into the Sacramento River under high export, low inflow scenarios. Based on this work, the USFWS determined that OMR flows greater than -2,000 ± 500 cfs in Old and Middle Rivers mostly reduced the zone of entrainment to the southern region of the Delta (FWS 2008) NMFS (2009a) considered this information useful in analyzing the potential “zone of effects” for entraining emigrating juvenile and smolting salmonids. A similar pattern is observed in juvenile salmon and smolt salvage analyses conducted by DWR (National Marine Fisheries Service 2009a). Loss of older juveniles at the SWP and CVP fish collection facilities increases sharply at Old and Middle River flows of approximately -5,000 cfs and departs from the initial slope at flows below this. Using the proposed operational scenario in the Biological Assessment (Reclamation 2008) and given the data derived from Reclamation (2008), flows in Old and Middle Rivers are consistently greater than the -2,000 ± 500 cfs threshold for entrainment (i.e., more upstream flow) (National Marine Fisheries Service 2009a). Assuming that, in the normal (natural) flow patterns in the Delta, juvenile and smolting Chinook salmon and steelhead will use flow as a cue in their movements and will orient to the ambient flow conditions prevailing in the Delta waterways, then upstream flows will direct fish toward the pumps during current operations (National Marine Fisheries Service 2009a), when the Old and Middle Rivers flows are more negative than -2,000 cfs.

Old and Middle River Flow Targets

To protect pre-spawning adult delta smelt from entrainment during the initial high flows of the wet season (first flush), and to provide advantageous hydrodynamic conditions early in the migration period, the 2008 USFWS BiOp (U.S. Fish and Wildlife Service 2008) stipulates an average daily OMR flow of no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average of no more negative than -2,500 cfs (within 25%) (i.e., Action 1). The cue for when this action is triggered depends on the date, as summarized below.

- ***December 1 to December 20*** – Based on an examination of turbidity data from Prisoner’s Point, Holland Cut, and Victoria Canal; salvage data from the SWP and CVP; and other parameters important to the protection of delta smelt including, but not limited to, preceding conditions of X2, Fall Midwater Trawl, and river flows, the Smelt Working Group (SWG) may recommend a start date to USFWS (U.S. Fish and Wildlife Service 2008).
- ***After December 20*** – The action will begin if the 3-day average turbidity at Prisoner’s Point, Holland Cut, and Victoria Canal exceeds 12 nephelometric turbidity units (NTUs). However, the

SWG can recommend a delayed start or interruption based on other conditions, such as Delta inflow, that may affect vulnerability to entrainment (U.S. Fish and Wildlife Service 2008).

Subsequent to implementation of Action 1 (above), Action 2 is then implemented using an adaptive process to tailor protection to changing environmental conditions. As in Action 1, the intent of Action 2 is to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions (U.S. Fish and Wildlife Service 2008). Action 2 prescribes that the range of net daily OMR flows will be no more negative than -1,250 cfs to -5,000 cfs. Depending on extant conditions (and the general guidelines below), specific OMR flows within this range are recommended by the SWG from the onset of Action 2 through its termination. The OMR flow requirements do not apply whenever a three-day flow average is greater than or equal to 90,000 cfs in the Sacramento River at Rio Vista and 10,000 cfs in the San Joaquin River at Vernalis (U.S. Fish and Wildlife Service 2008). Once such flows have abated, the OMR flow requirements of Action 2 take effect (U.S. Fish and Wildlife Service 2008).

The window for triggering Action 1 and Action 2 concludes when either of the following conditions is met: (1) water temperature reaches 53.6°F (12°C) based on a three-station daily mean at Mossdale, Antioch, and Rio Vista; or (2) delta smelt spawning begins (presence of spent females in the Spring Kodiak Trawl spawning survey or observed in salvage at Banks or Jones pumping plant) (U.S. Fish and Wildlife Service 2008).

To minimize the number of larval delta smelt entrained at the facilities, once spawning is believed to have initiated (as determined by the two offramp conditions under Actions 1 and 2, above), net daily OMR flow will be no more negative than -1,250 cfs to -5,000 cfs based on a 14-day running average, with a simultaneous 5-day running average within 25% of the applicable requirement for OMR (U.S. Fish and Wildlife Service 2008). Offramp conditions for Action 3 include: (1) June 30; or (2) when water temperature reaches a daily average of 77ºF (25ºC) for three consecutive days at CCF (U.S. Fish and Wildlife Service 2008).

The 2009 NMFS BiOp also prescribes actions related to Old and Middle River flows and exports from January 1 through June 15 to protect listed anadromous salmonids, which limits negative flows to -2,500 cfs to -5,000 cfs in Old and Middle Rivers, depending on the presence of salmonids (National Marine Fisheries Service 2009a). Reverse flows are managed to reduce flows toward the pumps during periods of increased salmonid presence. The negative flow objective within the range will be determined based on a decision process, as described in National Marine Fisheries Service (2012a). On-going litigation modified implementation of these actions in 2012. In 2012, OMR flow conditions were set at -2,500 cfs for April 8–14, 2012 and -3,500 cfs April 15–30, 2012 (National Marine Fisheries Service 2012a). Of considerable importance to addressing uncertainty related to Old and Middle River flow actions for south Delta entrainment of listed salmonids is the work related to salmonid survival that is currently being initiated under the CSAMP (Table 11-5).

Table 11-5. Key Questions and Possible Investigative Approaches to Address South Delta Salmonid Survival as Part of the Collaborative Adaptive Management Team OMR/Entrainment Workplan

Key Questions	Possible Investigative Approaches
What are key uncertainties, agreements, and disagreements in the understanding of direct and indirect effects of south Delta water operations on salmonid survival as linked to the South Delta Salmonid Research Collaborative (SDSRC) conceptual model? What are the areas/issues of scientific agreements and disagreements that contribute to the controversy over the effects of project operations on salmonid survival? Can the population level effects of a single management action be evaluated? If so, what tools are available?	Convene a series of working sessions to review and potentially refine the current SDSRC conceptual model; identify, screen and document published reports and empirical data, as linked to the conceptual model. Identify key information gaps. Identify key scientific agreements and disagreements. Review public water agency (PWA) questions and hypotheses in this context, and develop a collaboratively produced report.
Can synthesis of data from previous Delta salmonid tagging studies be combined and analyzed to address key questions/uncertainties about the direct and indirect ecological effects of exports on salmonid survival?	Pending review and agreement on a proposal: 1) establish a working group to plan and oversee the strategy for "identification and meta"analysis of existing data; 2) identify initial questions to address and relevant data sets; and 3) conduct preliminary analyses.
Are there alternative or additional metrics (e.g., OMR flows, export volumes, monthly export limits, etc.) that can be used to manage south Delta water operations, and improve survival of migrating salmonids in the south Delta?	Convene a working group to synthesize and evaluate existing data to identify potential metrics and evaluate their benefits and limitations.
To what extent and under what conditions do the export management actions reduce mortality of migrating salmonids?	Summarize tools available or in development that can be used to evaluate the efficacy of export management actions.
Are there questions important to CAMT that cannot be answered using the NMFS Southwest Fishery Science Center Life Cycle Model? Are there elements of other salmon models that would be beneficial to incorporate or link to the winter-run model (e.g., IOS, DPM, OBAN, SALMOD, Reclamation egg mortality model, CALSIM, DSM2, etc.)? Are there alternative management actions that can address water project effects on listed salmonids?	Pending acquisition of new resources, convene a working group to evaluate the potential for existing models or new tools to inform the consultation on project operations including: 1) Review available information (including literature, data, and models) to identify controllable factors, linked to project operations, with greatest influence on survival; 2) Identify actions which might be taken to improve survival; 3) Evaluate actions and report relative contribution to survival
Are there experimental modifications of the 6-year steelhead study that will enhance the understanding of the effect of inflow/export conditions on south Delta survival of steelhead?	Identify opportunities and develop plans to enhance learning from the 6-year steelhead survival study (RPA IV.2.2) by testing untested or underrepresented I:Es, testing combinations of very high and very low San Joaquin inflows and very high and very low export levels; and testing similar I:Es at different discharge volumes (e.g., 1:1 at 1,500cfs/1,500cfs; 6,000cfs/6,000cfs. Any new experimental components will include a clear statement of objective, approach, and statistical analysis plan.

Key Questions	Possible Investigative Approaches
Does tidal forcing in combination with export volumes affect migrational behavior and survival of migrating south Delta salmonids?	Convene a working group to develop a detailed proposal suitable for peer review; including objectives, experimental approach, and a detailed statistical analysis plan. Arrange for and submit to external peer review. Review results of Enhanced PTM tool in development by SWFSC. A prerequisite for this element is completing the testing and validation of the technology to distinguish a free swimming tagged salmonid from one that has been preyed upon.
Are results of tests using hatchery-reared salmonids representative of results of natural-origin salmonids? Are the results of tests using one run of Chinook salmon representative of results of other runs? Are the results of tests using Chinook salmon representative of steelhead? If not, in each case can a correction factor be developed to allow for application of such test results?	Convene a working group to review and synthesize existing information on hatchery- and natural-origin surrogacy; if warranted, develop a concept proposal to investigate surrogacy.

Source: Collaborative Adaptive Management Team (2014)

11.1.5.3 Migration Barriers

Delta Cross Channel Operations

The DCC diverts Sacramento River water into Snodgrass Slough and the Mokelumne River (when the DCC gates are open), where the water then flows through natural channels within the Central Delta until it reaches the SWP and CVP pumping plants, about 50 miles away (CALFED Bay-Delta Program 2001). A detailed discussion of DCC operations is provided in Chapter 5, *Water Supply*. As noted there, the DCC operation (open) improves water quality in the Central Delta by improving circulation patterns of good quality water from the Sacramento River and reducing salt water intrusion in the western Delta). The enhanced stability of the freshwater pool in the Delta has enabled nonnative species, such as centrarchids and catfish, as well as invasive plants, such as Brazilian waterweed *Egeria* and water hyacinth, to thrive (Brown and Michniuk 2007; National Marine Fisheries Service 2009a; Hestir 2010).

While the DCC improves water quality, the modification in water flows creates false attraction (attraction during adult immigration to non-natal rivers) to fish species such as Chinook salmon drawing these species into the lower San Joaquin River (National Marine Fisheries Service 2009a). Adult Chinook salmon that enter this area of the Delta are delayed in their upstream migration while they search for the distinctive olfactory (scent) migration cues of the Sacramento River in the lower San Joaquin River (National Marine Fisheries Service 2009a).

Fish such as juvenile salmonids that are in the central Delta generally have lower survival rates than fish that continue migrating downstream in the Sacramento River toward the west Delta. Recent studies appear to support the conclusion that closing the DCC gates will improve the survival of juvenile salmonids originating from the Sacramento River and migrating through the Delta (Bureau of Reclamation 2008a). Specifically, a recent particle tracking study (Kimmerer and Nobriga 2008) shows that DCC gate closure results in substantial increases in the proportion of Sacramento River water flowing into Georgiana Slough, Threemile Slough, and at the confluence of the Sacramento and San Joaquin Rivers, resulting in an overall similar proportion of flow diverted to the central Delta. This suggests that DCC gate closure may have less influence on the potential for central Delta fish mortality than previously thought (Bureau of Reclamation 2008a).

Studies for 2006–2007 by Perry and Skalski (2008 as cited in National Marine Fisheries Service 2009a) indicate that by closing the DCC gates when fish are present, total through-Delta survival of marked fish to Chipps Island increases by nearly 50% for fish moving downstream in the Sacramento River system. For 2007–2008 Perry and Skalski (2009) also found that fish survival in the interior Delta was lower than in the Sacramento River. However, closure of the DCC gates and the reduced flow did not result in a proportional reduction of salmon entry into the interior Delta. They found that a 30% reduction in DCC flow only resulted in a 15% entry reduction because more fish entered through the natural Georgiana Slough channel. The chance of fish entry into Georgiana Slough actually increased with the DCC gates closed, during that evaluation.

Perry et al. (2012) address migration routes and survival through the system in 2009-2010, which experienced higher flows than previous years in the study (see previous paragraph). They report lower survival rates for interior Delta migration compared to the Sacramento River migration route. The DCC gates were closed for all but one of their studied release groups.

The 2009 NMFS BiOp prescribes additional monitoring and alerts to trigger changes in DCC operations in order to reduce loss of emigrating salmonids and green sturgeon (National Marine Fisheries Service 2009a). Monitoring of salmonids and green sturgeon will be conducted in the Delta and upstream areas. Information collected from the monitoring programs will be used to make real-time decisions regarding DCC gate operation and export pumping (National Marine Fisheries Service 2009a).

The 2009 NMFS BiOp also prescribes modifications to DCC gate operations to reduce direct and indirect mortality of emigrating juvenile salmonids and green sturgeon (National Marine Fisheries Service 2009a). Between November 1 and June 15, DCC gate operations will be modified to reduce loss of emigrating salmonids and green sturgeon. The operating criteria provide for longer periods of gate closures during the emigration season to reduce direct and indirect mortality of yearling anadromous salmonids (National Marine Fisheries Service 2009a). From December 1 to January 31, the gates will remain closed, except as operations are allowed using the implementation procedures/modified Salmon Decision Tree, as described in NMFS (2009a). Exceptions to the general prescription of DCC gate operations from the 2009 NMFS BiOp were made in response to the 2014 drought in order to provide for salinity management in the Delta, with enhanced monitoring and triggering required to inform opening and closure of the gates for protection of listed species (Reclamation and DWR 2014).

Navigation and Flood Control

Levees and Levee Maintenance

The development of the water conveyance system in the Delta has resulted in construction of more than 1,100 miles of armored levees to increase channel flood capacity elevations and flow capacity of the channels (Mount 1995). Creation of levees and the deep water shipping channels has reduced the natural tendency of the San Joaquin and Sacramento Rivers to create floodplains along their banks with seasonal inundations (Bureau of Reclamation 2008a). These annual inundations provided habitat for rearing and foraging juvenile native fish that evolved with this flooding process (National Marine Fisheries Service 2009a). The construction of levees disrupts the natural hydrologic processes, resulting in a multitude of habitat-related effects, including isolation of the natural floodplain behind the levee from the active channel and its fluctuating hydrology (National Marine Fisheries Service 2009a). Alterations in channel form and fluvial geomorphology reportedly have led to loss of shallow water habitats, channel deepening, reduced floodplain areas, aquatic habitat degradation, and alteration of lotic (in-water biological, chemical and physical interactions) conditions in the Delta and the North San Francisco Bay (North Bay) (CALFED Bay-Delta Program 1997), in addition to parts of upstream rivers (National Marine Fisheries Service 2009a).

Many of these levees use riprap to armor the bank from erosive forces. The effects of channelization and riprapping include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (National Marine Fisheries Service 2009a). These changes affect the quantity and quality of nearshore habitat for juvenile fishes and have been well studied (National Marine Fisheries Service 2009a). Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators (National Marine Fisheries Service 2009a). In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney et al. 2004).

In addition to direct effects of levees on aquatic habitat and fishes, riparian vegetation is eliminated in the riprapped portion of leveed banks, eliminating overhanging vegetation and future woody debris sources (Bureau of Reclamation 2008a). Large woody debris provides valuable habitat to fish such as salmonids (Bureau of Reclamation 2008a). Woody debris also has been removed from some rivers because it is perceived as a hazard to swimmers and boaters and impedes navigation (Bureau of Reclamation 2008a). The cumulative habitat loss from lack of woody debris recruitment, woody debris removal, and riprapping could be a factor in the decline of some Central Valley salmon populations (Bureau of Reclamation 2008a).

Most levees in the Delta were constructed from materials dredged from low-lying edges of islands, or adjacent channels. Emergency levee repairs have required importation of large amounts of riprap and other materials. Due to current concerns about the impacts of dredging on listed fish species and water quality, dredging for levee maintenance has slowed (Delta Protection Agency 2007). Active maintenance actions of reclamation districts have precluded the establishment of ecologically important riparian vegetation, introduction of valuable instream woody materials from these riparian corridors, and the productive intertidal mudflats characteristic of the undisturbed Delta habitat (National Marine Fisheries Service 2009). Other consequences of reduced riparian habitats include the loss of shaded riverine aquatic habitat, channel complexity, and food supplies (CALFED Bay-Delta Program 1997).

More recent levee repairs have focused on providing not only bank protection but also habitat features such as low-slope riparian benches and anchored woody material, in order to restore some functioning of these habitats for fish and other animals. Studies conducted to date suggest that such habitat supports greater abundance of juvenile Chinook salmon than at unmitigated sites consisting only of rip-rap repairs (FISHBIO 2012).

Water Quality, Contaminants, and Toxicity

Contaminants are organic and inorganic chemicals and biological pathogens that can cause adverse physiological response in humans, plants, fish, or wildlife (California Department of Fish and Game 2008b). A variety of contaminants are present in Delta waterways that have potential for varying levels of direct effects on fish species and food web processes. A detailed description of contaminants affecting Delta waterways, their potential effects on the physical environment, and the regulatory environment governing water quality is provided in Chapter 8, *Water Quality*. Chapter 11 provides an analysis of the potential effects on aquatic resources based on changes to water quality and contaminant bioavailability associated with the alternatives.

Sediment and Turbidity

Sediment contamination can impact the ecological condition of the Delta. Numerous bottom-dwelling fish species, such as sturgeon and common carp, forage on invertebrates and detritus associated with sediments. These fish may be exposed to contaminants through direct ingestion of toxic materials in the sediments or indirectly by ingesting sediment-dwelling organisms that have accumulated toxic materials in their tissues (i.e., bioaccumulation). A detailed discussion of sediment accumulation of toxic compounds and turbidity is provided in Chapter 8, *Water Quality*.

Turbidity levels affect fish in different ways. Higher turbidity may be beneficial to delta smelt (as suggested by the negative correlation of the species' occurrence with water clarity [Nobriga et al. 2008; Feyrer et al. 2011; Sommer and Mejia 2013] and greater feeding efficiency with higher turbidity, as prey contrast with the background increases [Baskerville-Bridges et al. 2004]), and to other prey fish that use it to avoid predation. Very high levels of turbidity also have the potential to negatively affect some fish species such as salmonids by temporarily disrupting normal behaviors that are essential to growth and survival such as feeding, sheltering, and migrating. For example, behavioral avoidance of turbid waters may be one of the most important effects of suspended sediments on salmonids (Birtwell et al. 1984; DeVore et al. 1980; Scannell 1988). Disruption of feeding behaviors increases the likelihood that individual fish would face increased competition for food and space, and experience reduced growth rates, or possibly weight loss. Elevated turbidity levels also may affect the sheltering abilities of some juvenile fishes and may increase their likelihood of survival by decreasing their susceptibility to predation. However, turbidity also has been reported to reduce predation risk to fish species such as migrating Chinook salmon in other estuaries (e.g., the Fraser River) (Nobriga 2008). Very high levels of turbidity are most likely to occur in association with major channel disturbances (e.g., dredging).

Mercury and Methylmercury

In general, levels of mercury in the delta system are elevated in water, sediment, soils and biota, with higher levels in certain areas. The Delta and Suisun Marsh (as part of the San Francisco Bay) are both listed on the Clean Water Act Section 303(d) list as impaired water bodies for mercury (See Section 5D.4.1.1).

The major sources of mercury to the delta are former mining areas located in the mountains that drain into the Sacramento River watershed, especially through Yolo Bypass, and to a lesser extent, through the Cosumnes-Mokelumne River(Wood et al. 2010). In general, sediment total mercury concentrations are highest in the northern tributaries near the source areas, and follow a decreasing concentration gradient to the central and southern delta (Heim et al 2008). The same trend is seen in water concentrations and loading. Mercury has also come from the San Joaquin River watershed, but at minor levels relative to the Sacramento River watershed contribution.

Mercury in an inorganic or elemental form tends to adhere to soils and has limited bioavailability. Under certain conditions, mercury may be converted by bacteria to a different form, called methylmercury, which is much more bioavailable and toxic than inorganic forms, and has a strong tendency to bioaccumulate in organisms. The toxicity and tissue concentrations of methylmercury are amplified as it biomagnifies through the foodchain. As a consequence, the filet mercury concentrations of most sportfish in the Delta exceed fish advisory guidelines.

The multiple environmental parameters that influence mercury environmental chemistry and methylation are complex (Windham-Meyers et al. 2010). Some habitats (e.g., high tidal marsh, seasonal wetlands, and floodplains) more readily facilitate the methylation of mercury, resulting in greater exposure to wildlife, whereas perennial aquatic habitats and low tidal areas have relatively lower methylation potential (Alpers et al. 2008; Ackerman and Eagles-Smith 2010; Wood et al. 2010).

Mercury is of concern in the Delta in terms of bioaccumulation within the foodweb, and potential for effects on terrestrial species and humans, rather than direct effects on lower trophic levels (Davis et al. 2012; Melwani et al. 2009; Ackerman et al. 2012). Forage fishes similar to delta smelt show high spatial variability in the bioaccumulation of methylmercury (Gehrke et al. 2011; Greenfield et al. 2013) as do juvenile Chinook salmon (Henery et al. 2010). It has not been demonstrated that these accumulations impair these small fishes, though they may be of concern for passing mercury up the food web to predator fish, birds and humans. There is no evidence for acute toxicity of mercury being related to recent declines of pelagic fish such as delta smelt, although mercury, selenium, and copper may have chronically affected these species (Brooks et al. 2012).

A detailed discussion of mercury and methylmercury concentrations and distribution in the Delta is provided in Chapter 8, *Water Quality*.

Selenium and Other Metals

The main controllable sources of selenium in the Bay-Delta estuary are agricultural drainage (generated by irrigation of seleniferous soils in the western side of the San Joaquin basin) and discharges from North Bay refineries (in processing selenium-rich crude oil). Both the San Joaquin River and North Bay selenium loads have declined in the last 15 years in response to, first, a control program in the San Joaquin Grassland area, and, second, National Pollutant Discharge Elimination System (NPDES) permit requirements established for refineries in the late 1990s. The annual loads of selenium (mostly as selenate) entering the Bay-Delta estuary from the San Joaquin and Sacramento Rivers vary by water year (that is, by flow), but dissolved selenium loadings averaged 2,380 kilograms per year (kg/year) from the San Joaquin and 1,630 kg/year from the Sacramento in the 1990–2007 period. The Sacramento River selenium concentration, however, is essentially at background levels (.06 +/-.02 µg/L), without evidence of significant controllable sources (U.S. Environmental Protection Agency 2011a).

The San Joaquin watershed, and specifically the Grassland section of the watershed, historically has been identified as a source of selenium to the Delta. However, mitigation measures have been put into place to manage selenium discharges to meet regulatory requirements. According to the *Grassland Bypass Project Report 2006–2007*, selenium loads already had been reduced by 75% in 2007 relative to 1996 levels (McGahan 2010:Chapter 2). Concentrations of selenium in Salt Slough reportedly met the monthly mean goal of 2 µg/L (U.S. Environmental Protection Agency 2011b). Selenium concentrations measured in the San Joaquin River were consistently below 5 µg/L (McGahan 2010:Chapter 2),). As selenium discharge from the Grassland Bypass Project continues to decrease as the 5 µg/L goal is approached, concentrations in the San Joaquin River also can be expected to decrease.

Under the Grassland Bypass Project, selenium discharges to Mud Slough (in the San Joaquin watershed) must be substantially reduced by December 31, 2019. Further, the Central Valley Regional Water Quality Control Board (2010b) recently approved an amendment to the basin plan in light of this project. The amendment requires that agricultural drainage be halted after December 31, 2019, unless water quality objectives are met in Mud Slough (north) and the San Joaquin River between Mud Slough (north) and the mouth of the Merced River. Also, if the State Water Resources Control Board (State Water Board) finds that timely and adequate mitigation is not being implemented, it can prohibit discharge any time before December 31, 2019. As a result, a substantial reduction in selenium inputs (unrelated to the BDCP) to the San Joaquin River by 2019 would be expected to result in lower selenium inputs to the Delta from the San Joaquin River.

Although selenium is soluble in an oxidized state, the majority typically becomes reduced and partitions into the sediment/particulate phases in an aqueous system; these reduced sediment/particulate phases are the most bioavailable (Presser and Luoma 2010). Selenium in soils is taken up by plant roots and microbes and enters the food chain through uptake by lower organisms. A portion of the selenium also is recycled into sediments as biological detritus. Lemly and Smith (1987) indicate that up to 90% of the total selenium in an aquatic system may be in the upper few centimeters of sediment and overlying detritus (Lemly 1998).

In the Delta, water residence time also influences selenium concentrations and bioavailability. The longer the residence time of surface waters, the higher the particulate concentration resulting in higher potential for selenium uptake in wetlands and shallows (Presser and Luoma 2006, 2010). Aquatic systems in shallow, slow-moving water with low flushing rates are thought to accumulate selenium most efficiently (Presser and Luoma 2006; Lemly 1998).

Water column selenium concentrations are sometimes not reliable indicators of risk to biota (Presser and Luoma 2010) . The ratio of selenium in particulates (which is more bioavailable) to selenium in the water column is a complex relationship that can vary across different hydrologic regimes and seasons (Presser and Luoma 2010). The type of food chain is also an important determinant of selenium risk and bioaccumulation. Plankton excrete most of the selenium they consume, and do not tend to bioaccumulate through the food chain (Stewart et al. 2004). Sessile filter feeders, such as the bivalve overbite clam (*Potamocorbula amurensis*), can bioaccumulate hundreds of times the waterborne concentration of selenium, and transfer it up a benthic-based food chain. In Suisun Bay, the bivalve overbite clam (*Potamocorbula amurensis*) is reported to be a highly efficient accumulator of selenium, and is present in great abundances, resulting in a high risk of exposures in the benthic-based food chain. However, the particulate concentrations of selenium in Suisun Bay are considered low. This is an important factor that mitigates bioaccumulation in some of the covered fish species, and is more fully discussed in later sections of this chapter.

Selenium effects on fish are typically manifested as deformities, which occur in developing embryos when selenium replaces sulfur in sulfur-rich hard tissues (Diplock 1976). For example, recent field surveys identified Sacramento splittail from Suisun Bay (where selenium concentrations are highest) that have deformities typical of selenium exposure (Stewart et al. 2004).

Accumulation and distribution of selenium and other metals is described in detail in Chapter 8, *Water Quality*.

Nonnative Species

Nonnative Invertebrates

Overbite Clam and Asian Clam

Two species of nonnative bivalves, the Asian clam (*Corbicula fluminea*) and the overbite clam (*Potamocorbula amurensis*, previously *Corbula amurensis*), are two of the major consumers of phytoplankton in the Bay-Delta (Jassby et al. 2002).

Based on analysis of 27 years of benthic data, Peterson and Vayssieres (2010) documented the establishment of the overbite clam during the 1987–1994 drought under high salinity conditions that favored the clam. Recruitment of larval overbite clams is dependent on salinity (2-30 ppt), benthic habitat that is not so turbulent as to inhibit attachment to the substrate, and the density of adult overbite clam (because of their water filtering, which may consume the larvae and create habitat that is too turbulent) (Thompson and Parchaso 2012). Adult overbite clams are able to tolerate lower salinities than larval recruits, so that the adults can persist in areas colonized by larvae even when salinity decreases to low levels (0.1 ppt) for limited periods. The population of overbite clam has persisted and extended its geographic range within the Delta (Kimmerer and Orsi 1996, Jassby et al. 2002). This increase in the population of overbite clam resulted in profound changes to the zooplankton community. Predation (i.e., filter feeding) of copepod nauplii by overbite clams has been documented and is implicated in the decline of several species. Within 1 year after the overbite clam invasion, the abundance of three common estuarine copepods declined by 53 to 91%. (Kimmerer et al. 1994). Changes in nutrient ratios related to increased ammonia have also been linked to the changes in zooplankton species assemblages (Glibert 2010; Glibert et al. 2011).

Prior to 1987, the mysid shrimp dominated the macrozooplankton community of the Bay-Delta and was an important food item for fish, including juvenile striped bass. Following the overbite clam invasion, mysid shrimp abundance decreased sharply. Additional mysid species (e.g., *Acanthomysis bowmani*) have invaded the Bay-Delta, and compete with native mysid shrimp for food. Nonnative amphipod crustaceans may substitute for a depressed mysid shrimp population and a food source for juvenile fish; however, the relative contribution of this substitution is not well understood (Feyrer et al. 2003; Toft et al. 2003).

As filter feeders, overbite clams consume phytoplankton, bacterioplankton, and small zooplankton such as rotifers and copepod nauplii (Werner and Hollibaugh 1993; Kimmerer et al. 1994). The coincident decline of phytoplankton with the proliferation of the overbite clam indicates that the clams are over-grazing the systems (CALFED 2008; Cloern and Nichols 1985). Alternative consumers have partially replaced those existing before the overbite clam invasion. For example, introduced copepods such as *Pseudodiaptomus forbesi* have replaced *Eurytemora affinis*, and nonnative mysids have partially compensated for the loss of *Neomysis mercedis*.

Overbite clams eliminated summer-long phytoplankton blooms starting in 1987, but responses of zooplankton and most fish were somewhat muted. When the overbite clam invaded, northern anchovy shifted in distribution seaward, reducing summer abundance by 94% in the Bay-Delta in direct response to reduced food availability. After overbite clams became abundant, all planktivores exhibited reduced food consumption and anchovy left; the departure of the anchovy mitigated the effects of the loss of phytoplankton productivity, making a greater proportion of the reduced zooplankton productivity available to other fish species (Kimmerer 2006). The departure of the anchovy from the Delta could potentially have resulted in additional food web-related effects in the Delta that have not been evaluated.

In Suisun Bay, overbite clams are more reproductively active in wet years than in dry years, and this is believed to be a response to food availability/quality. During wet years, organic matter from upstream riverine sources augment food in Suisun Bay. During dry years, oceanic inputs provide a supplemental, but qualitatively different food source. Initiation and maintenance of reproductive activity is closely correlated with shifts in food availability/quality. The ability of the overbite clam to use a wide variety of food sources is a key to its success as an invasive species (Parchaso and Thompson 2002).

Overbite clams are preyed upon heavily by migratory waterfowl, to the point of localized depletion during winter (Pulton et al. 2004) in San Pablo Bay and Grizzly Bay. Additional predators on overbite clams include white sturgeon, green sturgeon, Sacramento splittail and dungeness crab (Stewart et al. 2004). The role of overbite clams as prey in the Bay-Delta is an important step in the transfer of contaminants to higher trophic levels. Overbite clams have been observed to bioaccumulate selenium in their tissues at concentrations high enough to induce reproductive anomalies in predators, such as waterfowl and benthic-feeding fish, including white sturgeon and Sacramento splittail, and perhaps dungeness crab (Stewart et al. 2004). The clams exhibit high tissue concentrations, which is passed up through the food web to consumers of clams.

The Asian clam *C. fluminea* invaded the San Francisco Estuary in 1945 (Hanna 1966). As with the overbite clam, the Asian clam has been noted to exert considerable grazing pressure (Lopez et al. 2006; Lucas and Thompson 2012). Recruits tolerate salinity of 2 ppt or less, whereas adults can tolerate salinity up to 10 ppt, so there is a zone of overlap with the overbite clam (Thompson 2007). Within the mostly freshwater portions of the Delta, the Asian clam occupies a wide range of habitat, with density tending to be higher in areas with high phytoplankton growth rate and within the channels connecting the north and central Delta to the south Delta (Thompson 2007). Adult Asian clams are able to survive emersion from water for a number of days, allowing occupation of intertidal areas (Byrne et al. 1990).

11.2 Regulatory Setting

11.2.1 Federal Plans, Policies, and Regulations

11.2.1.2 Long-Term Central Valley 2008 and 2009 USFWS and NMFS Biological Opinions

Collaborative Science and Adaptive Management Program (CSAMP)

As noted above (see the Low Salinity Zone portion of section 11.1.2.2 and the Old and Middle River Flow Targets portion of section 11.1.5.2), the appreciable uncertainty related to the implementation of the USFWS and NMFS BiOps led to the launching of the CSAMP and its associated Collaborative Adaptive Management Team (CAMT). In addition to the workplan items noted in sections 11.1.2.2 (related to fall outflow management for delta smelt) and 11.1.5.2 (related to south Delta salmonid survival), the CAMT's workplan also includes a number of key questions and possible investigative approaches to the issue of delta smelt entrainment (Table 11-6).

Table 11-6. Key Questions and Possible Investigative Approaches to Address Entrainment Management as Part of the Collaborative Adaptive Management Team OMR/Entrainment Workplan

Key Questions	Possible Investigative Approaches
What factors affect adult delta smelt entrainment during and after winter movements to spawning areas? a. How should winter "first flush" be defined for the purposes of identifying entrainment risk and managing take of delta smelt at the south Delta facilities? b. What habitat conditions (e.g., first flush, turbidity, water source, food, time of year) lead to adult delta smelt entering and occupying the central and south Delta?	Summarization of environmental and fish distribution/abundance data (e.g., FMWT, SKT). Multivariate analyses and modeling (e.g., 3D particle tracking) to examine whether fall conditions affect winter distribution. Completion of First Flush Study analyses. The Delta Conditions Team (DCT) is currently developing a scope of work to use turbidity modeling to examine various "first flush" conditions, expected entrainment risks, and potential preventative actions that could be taken to reduce entrainment, consistent with key question (a). The DCT could also conduct analyses to address key question (b).
What are the effects of entrainment on the population? a. What is the magnitude (e.g., % of population) of adult and larval entrainment across different years and environmental conditions? b. How do different levels of entrainment for adults and larvae affect population dynamics, abundance, and viability?	a. Application of different models (e.g., IBM, life history) to estimate proportional entrainment. A direct approach to addressing question (a) has been proposed by Kimmerer 2008 as modified in 2011. This or a derivative approach should be explored as a means to directly estimate the proportional entrainment that has occurred in recent years. Apply to as much of historical record as possible. b. Application of different models (e.g., IBM, life history, population viability analysis [PVA]) to simulate effects on population dynamics, abundance, and variability.

Key Questions	Possible Investigative Approaches
How many adult delta smelt and larval/post-larval delta smelt are entrained by the water projects?	Workshop or expert panel review. Testing of new field methodologies such as SmeltCAM. Gear efficiency and expanded trawling experiments. Evaluation of alternative models to estimate abundance, distribution and entrainment.
What conditions prior to movement to spawning areas affect adult delta smelt entrainment? Is there a relationship between delta smelt distribution and habitat conditions (e.g., turbidity, X2, temperature, food) during fall and subsequent distribution (and associated entrainment risk) in winter?	Summarization of environmental and fish distribution/abundance data (e.g., FMWT, SKT). Multivariate analyses and modeling (e.g., 3D particle tracking) to examine whether fall conditions affect winter distribution. Completion of First Flush Study analyses.
What factors affect larval and post-larval delta smelt entrainment? a. How does adult spawning distribution affect larval and post-larval entrainment? b. What conditions (e.g., first flush, spawning distribution, turbidity, water source, food, time of year) lead to larvae and post-larvae occupying the central and south Delta?	Summarization of environmental and fish distribution/abundance data. Statistical analysis and modeling (e.g., 3D PTM) of effects of adult distribution (e.g., SKT) on larval (e.g., 20 mm) distributions. Summarization of environmental and fish distribution/abundance data (e.g., 20 mm). Multivariate analyses/modeling to identify conditions promoting occupancy of central and south Delta.
What new information would inform future consideration of management actions to optimize water project operations while ensuring adequate entrainment protection for delta smelt? a. Can habitat conditions be managed during fall or early winter to prevent or mitigate significant entrainment events? b. Should habitat conditions (including OMR) be more aggressively managed in some circumstances as a preventative measure during the upstream movement period (e.g., following first flush) to reduce subsequent entrainment?	Synthesis of available information and study results by CAMT Entrainment Team, designated expert panel, or both. Consultation with regulatory agencies and operators about the feasibility of different actions.

Source: Collaborative Adaptive Management Team (2014)

Longfin Smelt Settlement Agreement

Similar to the CSAMP discussed above, the Longfin Smelt Settlement Agreement aims to reduce the uncertainty related to longfin smelt, in order to expand current understanding of longfin smelt distribution, abundance, abundance trends, spawning location(s), and the relationship between Delta outflow and longfin smelt abundance. The primary objectives of the study to be undertaken for the Longfin Smelt Settlement Agreement are as follows:

- Longfin smelt distribution and regional contribution to overall abundance
    - Quantify the relative abundance of early life stages and adult Longfin Smelt in Bay tributaries (e.g. Napa River, Sonoma Creek, Petaluma River, Alameda Creek and Coyote Creek) during the spawning and rearing seasons occurring during wet and dry years.
    - Determine if geochemical signatures of Bay tributaries vary to the extent that otolith geochemistry could be used to determine the relative contribution of Bay tributaries to recruited juvenile and adult fish collected in IEP-DFW surveys in the San Francisco Bay.
    - Determine the extent to which initial rearing in different salinity zones and geographic areas contribute to the Longfin Smelt population and compare these contributions between wet and dry years.
    - Determine if geochemical signatures of the ocean environment can inform the extent to which Longfin Smelt use the near-shore ocean environment using otolith geochemical signatures.
- Longfin smelt vertical distribution behavior
    - Determine the extent to which Longfin Smelt exhibit regular vertical movements within the water column during the day-night cycle, and whether these behaviors vary among different regions of the estuary or seasonally.
    - Determine the relationship between water transparency and the Longfin Smelt catch in the Bay Study MWT and otter trawl surveys.
    - Determine whether changes may be needed in current Longfin Smelt survey index calculation methods, and whether the new information provides better insight into the proper formulation of quantitative population estimates.

11.3 Environmental Consequences

11.3.1.1 Potential Impacts Resulting from Construction and Maintenance of Water Conveyance Facilities

Table 11-8. Life Stages of Covered Species Present in the North, East and South Delta Subregions during the In-Water Construction Window (June 1–October 31)

	North Delta			East Delta			South Delta		
Fish Species	**Life Stage**	**Timing**	**Size**[a]	**Life Stage**	**Timing**	**Size**	**Life Stage**	**Timing**	**Size**
Delta smelt	Adult	Jun	>2g	Adult	Jun	>2g	Adult	Jun	>2g
	Larva	Jun–Jul	<2g	Larva	Jun–Jul	<2g	Larva	Jun–Jul	<2g
Longfin smelt	Adult	Not Present	>2g	Adult	Not Present	>2g	Adult	Not Present	>2g
	Larva	Not Present	<2g	Larva	Not Present	<2g	Larva	Not Present	<2g
Central Valley steelhead	Adult	Jun–Sep Oct	>2g	Adult	Not Present	>2g	Adult	Not Present	>2g
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
Winter-run Chinook salmon	Adult	Jun-Jul	>2g	Adult	Not Present		Adult	Not Present	
	Juvenile	Aug–Oct	<2g, >2g	Juvenile	Not Present	<2, >2	Juvenile	Not Present	<2, >2
Spring-run Chinook salmon	Adult	Jun Jul–Aug	>2g	Adult	Not Present		Adult	Not Present	
	Juvenile	Jun	<2g, >2g	Juvenile	Jun	<2g, >2g	Juvenile	Jun	<2g, >2g
Late fall–run Chinook salmon	Adult	Oct	>2g	Adult	Not Present		Adult	Not Present	
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
Fall-run Chinook salmon	Adult	Aug–Sep Oct	>2g	Adult	Aug–Sep Oct	>2g	Adult	Aug–Sep Oct	>2g
	Juvenile	Jun	>2g	Juvenile	Jun	<2g, >2g	Juvenile	Jun	<2g, >2g
Splittail	Larva	Jun	<2g	Larva	Jun		Larva	Jun	<2g
	Juvenile	Jun–Jul	<2g	Juvenile	Jun–Jul		Juvenile	Jun–Jul	<2g
Green sturgeon	Adult	Jun–Oct	>2g	Adult	Jun–Oct	>2g	Adult	Jun–Oct	>2g
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
White sturgeon	Adult	Jun–Oct	>2g	Adult	Jun–Oct	>2g	Adult	Jun-Oct	>2g
	Larva	Jun	<2g	Larva	Jun	<2g	Larva	Jun	<2g
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
Pacific lamprey	Adult	Jun–Aug	>2g	Adult	Jun–Aug	>2g	Adult	Jun–Aug	>2g
	Ammocoetes	Jun–Oct	>2g	Ammocoetes	Jun–Oct	>2g	Ammocoetes	Jun–Oct	>2g
River lamprey	Adult	Sep–Oct	>2g	Adult	Sep–Oct	>2g	Adult	Sep–Oct	>2g
	Ammocoetes	Jan–Dec	>2g	Ammocoetes	Jan–Dec	>2g	Ammocoetes	Jan–Dec	>2g
	Macropthalmia	Jun–Jul	>2g	Macropthalmia	Jun–Jul	>2g	Macropthalmia	Jun–Jul	>2g

Black =abundant ■ Medium Gray=semi-abundant ▩ Light Gray=low abundance ░ White=unsure if present □

Source: California Department of Water Resources 2013.

[a] Size categories represent thresholds for assessing potential injury to fish from pile driving underwater noise (see "Underwater Noise").

Barge Unloading Facilities

Temporary barge unloading facilities would be necessary to provide access for equipment and materials to the construction sites. The barge unloading facilities would be constructed at some of the locations listed below, depending on alternative; these locations are shown in Mapbooks M3-1, M3-2, M3-3, and M3-4.

- State Route 160 west of Walnut Grove (Alternatives 1A, 2A, 3, 5, 6A, 7, and 8).
- Venice Island (Alternatives 1A, 2A, 3, 4, 5, 6A, 7, and 8).
- Bacon Island (Alternatives 1A, 2A, 3, 4, 5, 6A, 7, 8, and 9).
- Woodward Island (Alternatives 1A, 2A, 3, 5, 6A, 7, and 8. Two barge facilities would be constructed at this location under Alternative 9).
- Victoria Island (Alternatives 1A, 2A, 3, 4, 5, 6A, 7, 8, and 9).
- Tyler Island (Alternatives 1A, 2A, 3, 5, 6A, 7, and 8).
- Hog Island (Alternatives 1B, 2B, and 6B).
- Ryer Island (Alternatives 1C, 2C, and 6C).
- Brannan Island (Alternatives 1C, 2C, and 6C).
- Clifton Court Forebay (Alternative 4).
- Glannvale Tract on Snodgrass Slough near the proposed intermediate forebay (Alternative 4).
- Bouldin Island on San Joaquin River (Alternative 4).
- Mandeville Island at the intersection of Middle River and San Joaquin River (Alternative 4).
- Webb Tract (two barge facilities would be constructed on Webb Tract under Alternative 9—one at the northwest corner, and one on the eastern side).
- Upper Jones Tract (Alternative 9).

These temporary barge unloading facilities could consist of the landing approach over the levees and construction of a temporary dock to facilitate loading and unloading of the barges. The temporary docks would be supported by piles that would be driven in the river. The dimensions of the docks are anticipated to be approximately 50 by 300 feet. Where feasible, floating or existing docks could be used to reduce the amount of in-water construction activities required to construct the uploading facilities. Under Alternative 4, barge loading/unloading activities could require construction of a working pad on the landside of the levee, construction of a backfilled sheetpile wall to serve as a marginal wharf where barges could be moored, or construction of on-land or in-water mooring dolphins to secure barges during loading and unloading. Loading and unloading could be performed by a crane barge, ramps, a tracked or fixed-base crane, and/or conveyor.

At the barge unloading facilities, piles likely would need to be driven to secure the barges or support docks for the transit of equipment and material to and from the portal sites. Sediments could be disturbed by propeller wash or wakes from the vessels used for transport and landing of the barges.

Depending on the alternative, approximately 3,000 to 5,600 barge trips are projected to carry construction materials to the sites listed above. The landings would be in operation through construction activities at each associated portal (from 1 to 3 years, depending on which portals are serviced).

After construction serviced by a landing is completed, the dock would be removed, and the area of the landing would be restored to pre-construction conditions.

Underwater Noise

Underwater noise can be generated by a variety of activities during construction and operation of North Delta intakes, barge landings, and other in-water structures. Pile driving in or near aquatic habitat is of particular concern because the sounds generated by impact driving can reach levels that can injure or kill fish and other aquatic organisms. Each of the action alternatives includes a number of physical or structural components that will require vibratory and/or impact driving of temporary and permanent piles during construction. Several of these components involve pile driving activities within or adjacent to water bodies supporting sensitive fish species, resulting in potential exposure of these species to pile driving noise.

Research indicates that impact pile driving can result in adverse effects to fish due to the high level of underwater sound produced (Popper and Hastings 2009). The effects of pile driving noise on fish may include behavioral responses, physiological stress, temporary and permanent hearing loss, tissue damage (auditory and non-auditory), and direct mortality. Factors that may influence the magnitude of effects include species, life stage, and size of fish; type and size of pile and hammer; frequency and duration of pile driving; site characteristics (e.g., depth); and distance of fish from the source.

Dual interim criteria have been established to provide guidance for assessing the potential for injury of fish resulting from pile driving noise (Fisheries Hydroacoustic Working Group 2008), and were used in the present analysis. The dual criteria for impact pile driving are (1) 206 decibels (dB) for the peak sound pressure level; and (2) 187 dB for the cumulative sound exposure level ($\text{SEL}_{\text{cumulative}}$) for fish larger than 2 grams, and 183 dB $\text{SEL}_{\text{cumulative}}$ for fish smaller than 2 grams. The peak SPL is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL is considered the total amount of acoustic energy that a fish can receive from single or multiple strikes without injury. The $\text{SEL}_{\text{cumulative}}$ threshold is based on the cumulative daily exposure of a fish to noise from sources that are discontinuous (i.e., noise that occurs only for about 8 to 12 hours in a day, with 12 to 16 hours between exposure). This assumes that the fish is able to recover from any effects during this 12 to 16 hour period. These criteria relate to impact pile driving only. Vibratory pile driving is generally accepted as an effective measure for minimizing or eliminating the potential for injury of fish during in-water pile driving operations. The potential for physical injury to fish from exposure to pile driving sounds was evaluated using a spreadsheet model developed by NMFS to calculate the distances from the pile that sound attenuates to the peak or cumulative criteria. These distances define the area in which the criteria are expected to be exceeded as a result of impact pile driving. The NMFS spreadsheet calculates these distances based on estimates of the single-strike sound levels for each pile type (measured at 10 meters from the pile) and the rate at which sound attenuates with distance. In the following analysis, the standard sound attenuation rate of 4.5 dB per doubling of distance was used in the absence of other data. To account for the exposure of fish to multiple pile driving strikes, the model computes a cumulative SEL for multiple strikes based on the single-strike SEL and the number of strikes per day or pile driving event. The NMFS spreadsheet also employs the concept of "effective quiet". This assumes that cumulative exposure of fish to pile driving sounds of less than 150 dB SEL does not result in injury.

The following analysis also considers the potential for pile driving sound to adversely affect fish behavior. Potential mechanisms include startle or avoidance responses that can disrupt or alter normal activities (e.g., migration, holding, or feeding) or expose individuals to increased predation risk. Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper et al. 2006). NMFS generally assumes that a noise level of 150 dB root mean square (RMS) is an appropriate threshold for behavioral effects. NMFS acknowledges this uncertainty in other biological opinions but believes this noise level is appropriate for identifying the potential for behavioral effects of pile driving sound on fish until new information indicates otherwise.

Table B.7-79 in Appendix B presents a summary of the pile driving assumptions and impact metrics for each of the major facilities or structures within or adjacent to water bodies supporting the species of concern. Estimated single-strike sound levels were based on measured sound levels produced by similar piles and pile driving methods (Caltrans 2014). DWR proposes to install piles using vibratory methods or other non-impact driving methods, wherever feasible, to minimize adverse effects on fish and other aquatic organisms. However, the degree to which vibratory driving can be performed effectively is unknown at this time due to as yet undetermined geologic conditions at the construction sites. Some uncertainty also exists in the extent to which the cofferdams can be dewatered and therefore the effectiveness of this measure in minimizing underwater noise. To address these uncertainties, the following assessment presents worst-case impacts based on the use of an impact driver with no attenuation, but also considers potential opportunities to minimize these impacts by using vibratory methods or other non-impact pile driving methods that would minimize negative effects to aquatic species.

The following sections discuss the spatial and temporal extent of potential pile driving impacts for each of the major construction facilities or structures where underwater pile driving noise may exceed current injury thresholds (see Mapbooks M3-1, M3-2, M3-3, and M3-4 for the locations of these facilities and structures, and Table 11-12 for the months in which the key fish species and life stages could be exposed to pile driving sounds). Impact pile driving within or adjacent to open water of the Sacramento River would be limited to June 1 through October 31 to minimize potential adverse effects on listed fish species. Table 11-11 presents the estimates of the total distances and areas of open water potentially subject to sound levels exceeding the injury and behavioral thresholds, the total number of days that such exposures could occur, and the proposed construction schedule for each facility or structure. The computed distances over which pile driving sounds are expected to exceed the injury and behavioral thresholds assume an unimpeded open water propagation path. However, site conditions such as major channel bends and other channel features can impede sound waves and limit the extent of underwater sounds exceeding these thresholds.

Cofferdams

Temporary sheet pile cofferdams will be required to construct the new intakes, new embankments at Clifton Court Forebay, and the Head of Old River operable barrier. The sheet piles will be installed primarily with vibratory driving although some impact driving likely will be necessary. Based on impact driving alone, it is estimated that 15 sheet piles can be driven per day with each pile requiring 700 strikes to install (10,500 strikes per day). Impact driving of sheet piles is anticipated to result in single-strike sound levels of 205 dB_{peak} and 179 dB SEL measured at a distance of 10 meters (Table B.7-79 in Appendix B). Therefore, source levels are not expected to exceed the single-strike SPL criterion of 206 dB_{peak} and SEL criteria of 187 dB (fish ≥ 2 grams) and 183 dB (fish < 2 grams). However, based on an attenuation rate of 4.5 dB per doubling of distance, cumulative exposures to pile driving sounds could result in injury of fish up to 858 meters (2,814 feet) from the source piles.

The estimation of potential noise impacts associated with cofferdam construction can be illustrated using Intake 2 as an example. Assuming impact driving would be the principal pile driving method, the potential for injury of fish would extend across the entire width of the Sacramento River (average channel width at the proposed intake location is approximately 645 feet) and upstream and downstream of the source piles by up to 858 meters (2,814 feet), resulting in a potential impact area of approximately 83 acres (Table 11-11). Based on a threshold of 150 dB RMS, potential behavioral effects could occur up to 3,981 meters (13,058 feet) away assuming an unimpeded propogation path. However, noise levels of this magnitude would likely not reach this far because of the presence of major bends in the river channel upstream and downstream of the proposed construction site (Figure M3-1: Sheet 1 of 13).

Construction of the temporary cofferdams is currently scheduled for the first two to three years of project construction activities depending on the selected alternative. Based on concurrent operation of four pile drivers per site, it is estimated that 60 piles can be driven per day with each pile requiring 700 strikes to install (42,000 strikes per day) (Table B.7-79). At this rate, a total of 42 days would be required to complete cofferdam construction. The number of days for pile driving would vary depending on the number of rigs used.

Intake Structure Foundation

Construction of each intake structure foundation will require the installation of approximately 500 steel piles (42-inch diameter). Assuming that the temporary cofferdams cannot be dewatered, single-strike peak SPLs exceeding the 206 dB injury threshold could extend up to 14 meters (45 feet) from the source piles (Table B.7-79) but would likely not extend beyond the limits of the cofferdam sheetpiles. Cumulative SELs exceeding the interim thresholds for fish ≥ 2 grams (187 dB) and fish < 2 grams (183 dB) could occur up to 1,000 meters (3,280 feet) from the source piles based on the distance to effective quiet (150 dB SEL). Based on a threshold of 150 dB RMS, potential behavioral effects could theoretically occur up to 10,000 meters (32,800 feet), although this likely significantly overestimates the potential impact area due to the presence of major bends in the river channel upstream and downstream of the proposed construction sites (Figure M3-1: Sheets 1 and 2 of 13).

Construction of the intake structure foundations is currently scheduled for the first two to three years of project construction activities depending on the selected alternative. Under *AMM9 Underwater Sound Control and Abatement Plan*, ~~I~~impact pile driving within or adjacent to open water of the Sacramento River would be limited to June 1 through October 31 to minimize potential adverse effects on listed fish species. Construction of the intake structure foundation is scheduled for the first year of construction and would be completed in one season (June 1 through October 31). Based on concurrent operation of four pile drivers per site, it is estimated that 60 piles can be driven per day with each pile requiring 1,500 strikes to install (90,000 strikes per day) (Table B.7-79). At this rate, a total of 8 days would be required to complete pile installation.

SR 160 Realignment

Approximately 150 steel piles (42-inch diameter) will be used to support the realignment of SR160 over Intakes 2, 3, and 5 (Alternative 4). All piles would be driven on land adjacent to open water in the Sacramento River. Single-strike peak SPL and SELs within the adjacent Sacramento River are not expected to exceed the injury thresholds (Table B.7-79). Assuming impact driving would be the principal pile driving method, cumulative SELs exceeding the 187 dB and 183 dB thresholds could occur up to 464 meters (1,522 feet) from the source piles. Based on a threshold of 150 dB RMS, potential behavioral effects could occur up to 2,154 meters (7,065 feet) from the source piles assuming an unimpeded propagation path. The potential for injury would extend across the entire river channel but the distance upstream and downstream to the limits of potential injury and behavioral effects would vary depending on the location of the sites relative to major river bends. In addition, these distances may be further reduced by the attenuation of pile driving sounds from on-land sources.

Construction of the piers for the realignment is currently scheduled for the first two years of project construction activities. Under *AMM9 Underwater Sound Control and Abatement Plan*, ~~I~~impact pile driving within or adjacent to open water of the Sacramento River would be limited to June 1 through October 31 to minimize potential adverse effects on listed fish species. Based on concurrent operation of two pile drivers per site, it is estimated that 30 piles can be driven per day with each pile requiring 1,200 strikes to install (36,000 strikes per day) (Table B.7-79). At this rate, a total of 5 days would be required to complete pile installation.

Intake Control Structures

Construction of the control structures at each of the three intakes (Alternative 4) will require the installation of approximately 650 steel piles per site (42-inch diameter). All piles would be driven on land at distances over 300 meters from open water in the Sacramento River. The potential distances over which pile driving noise could exceed the injury and behavioral thresholds are the same as those described for the SR 160 realignment.

Construction of the control structures is currently scheduled for the first two years of project construction activities. Under *AMM9 Underwater Sound Control and Abatement Plan*, ~~I~~impact pile driving within or adjacent to open water of the Sacramento River would be limited to June 1 through October 31 to minimize potential adverse effects on listed fish species. Based on concurrent operation of four pile drivers per site, it is estimated that 60 piles can be driven per day with each pile requiring 1,200 strikes to install (72,000 strikes per day) (Table B.7-79). At this rate, a total of 11 days would be required to complete pile installation.

Barge Unloading Facilities

Construction of each barge unloading facility will require the installation of approximately 800 temporary steel piles (18-inch diameter) at locations adjacent to construction work areas for the intake, canal, and pipeline/tunnel facilities. The piles will be installed primarily with vibratory driving although some impact driving likely will be necessary. Based on impact driving alone, single-strike peak SPLs exceeding the 206 dB injury threshold could extend up to 14 meters (45 feet), and cumulative SELs exceeding the 187 dB and 183 dB thresholds could occur up to 541 meters (1,774 feet) from the source piles based on the distance to effective quiet (150 dB SEL). The upstream and downstream extent of potential injury and behavioral effects would vary depending on the location of the sites relative to major river bends or other structures that could block or diffract underwater sound waves.

Construction of the barge unloading facilities is currently scheduled for the first year of project construction activities. Under *AMM9 Underwater Sound Control and Abatement Plan*, ~~I~~impact pile driving within or adjacent to open water of the Sacramento River would be limited to June 1 through October 31 to minimize potential adverse effects on listed fish species. Based on concurrent operation of four pile drivers per site, it is estimated that 60 piles can be driven per day with each pile requiring 1,050 strikes to install (63,000 strikes per day) (Table B.7-79). At this rate, a total of 13 days would be required to complete pile installation.

Siphon at North Outlet of Clifton Court Forebay

Siphon construction at the north outlet of CCF (Alternative 4) will require the installation of approximately 2,160 concrete or steel pipe piles (14-inch diameter). Assuming in-water pile installation, single-strike peak SPLs exceeding the 206 dB injury threshold could extend up to 14 meters (45 feet), and cumulative SELs exceeding the 187 dB and 183 dB thresholds could occur up to 541 meters (1,774 feet) from the source piles, potentially affecting fish residing in forebay and adjacent channel (Table B.7-79).

Construction of the siphon is currently scheduled for the first year of project construction activities. Based on concurrent operation of two pile drivers, it is estimated that 30 piles can be driven per day with each pile requiring 1,050 strikes to install (31,500 strikes per day) (Table B.7-79). At this rate, a total of 72 days would be required to complete pile installation.

Siphon at Byron Highway

Construction of the siphon connecting the north cell of the expanded CCF to the existing canal leading to the Banks pumping plant will require the installation of approximately 1,600 concrete or steel pipe piles (14-inch diameter). All piles would be driven on land at distances greater than 200 meters from open water in CCF. Single-strike peak SPL and SELs reaching open water in CCF are not expected to exceed injury thresholds (Table B.7-79). Cumulative SELs exceeding the 187 dB and 183 dB injury thresholds could occur up to 251 meters (823 feet), and RMS levels exceeding the 150 dB threshold could occur up to 1,585 meters (5, 199 feet) from the source piles. However, because of significant attenuation of pile driving sounds before reaching open water, these distances likely overestimate the size of potential impact areas in CCF.

Foundation for Operable Barrier at Head of Old River

Construction of the foundation for the operable barrier at head of Old River will require the installation of approximately 100 steel piles (42-inch diameter), and would be subject to the same minimization measures as the new intakes. Assuming the temporary cofferdams cannot be dewatered, single-strike peak SPLs exceeding the 206 dB injury threshold could extend up to 14 meters (45 feet) from the source piles (Table B.7-79) but would likely not extend beyond the limits of the cofferdam sheetpiles. Cumulative SELs exceeding the 187 dB and 183 dB injury thresholds could occur up to 541 meters (1,774 feet) from the source piles, resulting in cumulative exposures that could adversely affect fish in Old River and the adjacent channel of the San Joaquin River. Based on a threshold of 150 dB RMS, potential behavioral effects could occur up to 2,929 meters (9,607 feet), although this is likely a substantial overestimate of the potential impact area due to the proximity of major bends and relatively narrow channel widths at the junction of Old River and the San Joaquin River.

Construction of the foundation of the Head of Old River barrier is currently scheduled for the first year of project construction activities. Based on operation of a single driver, it is estimated that 15 piles can be driven per day with each pile requiring 1,050 strikes to install (15,750 strikes per day) (Table B.7-79). At this rate, a total of 7 days would be required to complete pile installation.

Table 11-10. Estimated distances and areas of waterbodies subject to pile driving noise levels exceeding interim injury and behavioral thresholds, and proposed timing and duration of pile driving activities for facilities or structures in or adjacent to sensitive rearing and migration corridors of the covered species

Facility or Structure	Average Width of Water Body (feet)	Distance to Cumulative 187 and 183 dB SEL Injury Threshold[1, 2] (feet)	Potential Impact Area[3] (acres)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Year of Construction[4]	Duration of Pile Driving (days)
Intake 1						
Cofferdam	425	2,814	55	13,058	Year 3	42
Foundation		3,280	64	32,800	Year 4	8
Control Structure		1,522	30	7,065	Year 4	11
SR-160 Bridge		1,522	30	7,065	Year 5	5
Intake 2						
Cofferdam	645	2,814	83	13,058	Year 3	42
Foundation		3,280	97	32,800	Year 4	8
Control Structure		1,522	45	7,065	Year 4	11
SR-160 Bridge		1,522	45	7,065	Year 5	5
Intake 3						
Cofferdam	560	2,814	72	13,058	Year 3	42
Foundation		3,280	84	32,800	Year 4	8
Control Structure		1,522	39	7,065	Year 4	11
SR-160 Bridge		1,522	39	7,065	Year 5	5
Intake 4						
Cofferdam	615	2,814	80	13,058	Year 3	42
Foundation		3,280	93	32,800	Year 4	8
Intake 5						
Cofferdam	535	2,814	69	13,058	Year 3	42
Foundation		3,280	81	32,800	Year 4	8
Intake 6						
Cofferdam	345	2,814	45	13,058	Year 3	42
Foundation		3,280	52	32,800	Year 4	8
Intake 7						
Cofferdam	340	2,814	44	13,058	Year 3	42
Foundation		3,280	51	32,800	Year 4	8
Barge Unloading Facilities						
Piers	300-1,350	1,774	24-110	9,607	Year 5	13
Clifton Court Forebay						
Cofferdams	10,500	2,814	364	13,058	Year 8	450
Siphon – N. Outlet	10,500	1,774	144	9.607	Year 9	72
Siphon – Byron Highway	10,500	823	31	5,199	Year 9	53

Facility or Structure	Average Width of Water Body (feet)	Distance to Cumulative 187 and 183 dB SEL Injury Threshold[1, 2] (feet)	Potential Impact Area[3] (acres)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Year of Construction[4]	Duration of Pile Driving (days)
Head of Old River Operable Barrier						
Cofferdams	170	2,814	22	13,058	Year 7	37
Foundation	170	1,774	14	9,607	Year 7	7

[1] Distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL).

[2] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, vibratory driving or other non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

[3] Based on the area of open water subject to underwater sound levels exceeding the cumulative SEL thresholds for fish larger than 2 grams (187 dB) and smaller than 2 grams (183 dB); for open channels, this area is calculated by multiplying the average channel width by twice the distance to the injury thresholds, assuming an unimpeded propagation path upstream and downstream of the source piles.

[4] Proposed construction schedule for individual facilities or structures applies to all applicable alternatives; however, Alternatives 4 and 4a differ in that cofferdam and foundation piles for the proposed intakes will be driven in years 2 and 3 (Intake 5), years 3 and 4 (Intake 3), and years 4 and 5.

Table 11-11. Species Present during Cofferdam Installation

Species/Life Stage Present	Lifestage and Month(s) Present in Areas Affected by Underwater Sound during Cofferdam Installation
Delta smelt	Adult—June Larval—June, July
Chinook (fall-run)	Adults—August through October Juveniles—May
Chinook (late fall-run)	Adults—October Juveniles—June through October
Chinook (winter-run)	Adults—June/July Juveniles—September through October
Chinook (spring-run)	Adult—June through August
Steelhead	Adult—June through October Juvenile—June through October
Sacramento splittail	Adults—June through October Larvae—June Juveniles—June/July through October
Green sturgeon	Adult—June through October Juveniles—June through October
White sturgeon	Adults—June through October Juveniles—June through October Larvae—June

Species/Life Stage Present	Lifestage and Month(s) Present in Areas Affected by Underwater Sound during Cofferdam Installation
Pacific lamprey	Adults—June through August Ammocoetes—June through October
River lamprey	Adults—September/October Ammocoetes—June through October Macropthalmia—June/July

11.3.2 Methods for Analysis

Several quantitative and qualitative models were used to develop the analysis of impacts on fish and aquatic resources. The following sections describe the methods used for each major environmental factor that could be affected by the alternatives. These methods reflect the best available information and tools, but remain imperfect. As part of the description of each method, a description of uncertainties or limitations is also provided.

11.3.2.1 Entrainment Analysis

Entrainment occurs when fish are removed from a water body as water is diverted. In the Delta, entrainment occurs at several locations, including the south Delta SWP/CVP intake facilities, Mirant power plants, agricultural diversions, and other intake facilities such as those operated by Contra Costa Water District (CCWD) and Freeport Regional Water Authority (FRWA) (ICF International 2012; USFWS 2008; California Department of Water Resources 2005). Entrainment has been a major issue of concern related to the aquatic species covered in the BDCP, and as such must be evaluated carefully in the EIR/EIS. A key element of the BDCP is the proposed new intake facilities in the north Delta, which would allow for more effective screening of fish and less reliance on the south Delta facilities. This component of the BDCP is intended to reduce entrainment through changes in Delta water management.

The methods used to assess entrainment risk are based on historical salvage data, CALSIM outputs, assumed and measured locations of fish, previous studies in the Delta, Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) analyses, life cycle models, and professional judgment. The methods used for each species and life stage reflect the best available tools and data regarding fish abundance, movement, and behavior. These methods were applied to a comparison of baseline conditions with conditions under the alternatives. For methods based on CALSIM, variation in entrainment under different flow conditions was summarized by water-year type. In general, baseline population abundance is not known for most species, so that inferences of changes in entrainment are made based on potential changes in indices of entrainment (e.g., number of salvaged fish) as a result of differences in export flows between alternatives. For a complete description of the methods used for assessing entrainment effects, please see *BDCP Effects Analysis – Appendix B, Entrainment, Section B.5 Methods of Biological Analysis (hereby incorporated by reference)*.

The main methods used to evaluate entrainment are listed below. Benefits and limitations of the methods are summarized in Table 11-13.

- **Salvage density:** uses historical salvage data and CALSIM outputs to estimate entrainment under various flow conditions.
- **Old and Middle River (OMR) flow proportional entrainment regressions:** uses linear regression (based on USFWS 2008) and incorporates the adjustment of Kimmerer (2011) and CALSIM data to estimate the proportion of delta smelt population that would be entrained.
- **DSM2 particle-tracking model:** uses data from Interagency Ecological Program (IEP) from trawls to estimate the movement of larval delta smelt and larval longfin smelt that are assumed to be influenced primarily by flows.
- **Effectiveness of nonphysical barriers:** uses results of recent studies at Georgiana Slough and Old River to determine potential effectiveness of barriers in other Delta locations that would exclude fish from diversions.
- **North Delta intakes screening effectiveness analysis:** estimates direct loss and impingement at screens for different sizes of fish based on literature and professional judgment.
- **North Delta intakes impingement and screen contact analysis:** uses laboratory-based studies to assess potential for covered fish species to interact with proposed north Delta intake screens through screen contact and mortality or passage time.
- **DRERIP analysis of nonproject diversions:** qualitative assessment of the population-level benefits of screening nonproject diversions.

No single one of these methods could be used for all life stages of all species. Accordingly, it was necessary to use these methods in combination to complete the assessment of entrainment (Table 11-14). For example, OMR proportional entrainment regressions are applicable only to delta smelt. Similarly, the assessment of the north Delta screening efficiency was specific to that facility and focused primarily on larval life stages. Each of these analytical methods have technical limitations, which are generally described in Table 11-13.

These methods were applied to each species and life stage as appropriate, and the results of the assessment are presented in *Determination of Adverse Effects*. The conclusions presented in the analysis synthesize multiple results because multiple methods were applied to some species and life stages.

1 **Table 11-13. Main Assumptions, Benefits, and Limitations of Methods Used to Analyze Entrainment.**

Method	Description of Method	Main Assumptions	Benefits	Limitations
Salvage-Density Method	Uses historical salvage and flow data to predict indices of entrainment that may represent salvage or entrainment loss (i.e., salvage expanded to account for salvage-related losses such as predation and louver efficiency).	Changes in export flow would give a linearly proportional change in entrainment; salvage density (fish salvage per volume of water exported) in a given water-year type would be similar to levels observed historically for that water -year type. For some species, entrainment loss incorporates prescreen mortality, louver efficiency losses, and release mortality consistent with established values for these attributes.	Numerous data exist for all species. Method has been used before to analyze effects of other projects.	Assumes a linear relationship between flow and entrainment, which may not be justified. Estimates of numbers of fish entrained should be viewed as highly uncertain, and focus should be on relative change between scenarios. Historical salvage of some species could not be normalized to population abundances due to lack of appropriate population indices. Method does not account for possible changes in distribution of a species and is reliant on historically observed salvage numbers.
OMR Flow Proportional Entrainment Regressions	Estimates the proportion of the larval/juvenile and adult delta smelt population that would be lost to entrainment at the south Delta export facilities, based on initial estimates from Kimmerer (2008) that were related to OMR flows and X2 by USFWS (2008), and then adjusted by Kimmerer (2011)	Historical relationship between entrainment loss and flow and X2 will remain similar in the future; all delta smelt entrained at the south Delta export facilities are lost from the population.	Provides estimates of the overall proportion of the delta smelt population that is lost to entrainment (although these estimates are still best treated comparatively rather than in absolute terms).	Regressions are based on relatively few data points and on predictors averaged over several months, which may simplify underlying dynamics. The adult regression explains a relatively low proportion of the variance in the original data Some delta smelt may survive the salvage process and therefore loss estimates may be slightly higher than actually occurs (although the main loss at the SWP facility occurs across CCF, prior to salvage operations).

Method	Description of Method	Main Assumptions	Benefits	Limitations
DSM2 PTM	Estimates entrainment by various water diversions (south Delta and north Delta export facilities, North Bay Aqueduct, and agricultural diversion) of larval delta and longfin smelt that originate from various spawning locations using one-dimensional modeling of Delta hydrodynamics.	Simulated movement of particles is representative of the movement of weakly swimming smelt larvae. The DSM2 modeling grid for existing biological conditions has newly restored areas added to represent evaluated starting operations conditions in the early long-term and late long-term (Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*, and Attachment 5C.A, *CALSIM and DSM2 Modeling Results for the Evaluated Starting Operations Scenarios*).	Allows assessment of entrainment potential at numerous locations from a variety of starting points.	Assumes smelt larvae are passive particles without behaviors that may alter responses to flows rather than solely being carried by prevailing flows. Estimates of entrained numbers of larvae should be viewed with considerable caution, and focus should be on relative change between scenarios. One-dimensional modeling is best suited for shallow, channelized regions of the Plan Area and is less well suited to other areas such as Suisun Bay.
Effectiveness of Nonphysical Barriers	Discusses results of recent studies at Georgiana Slough and Old River as well as literature studies to determine potential effectiveness of barriers at the entrances to the south Delta export facilities.	Nonphysical barriers would be installed at the south Delta entrance canals leading to CCF and the Delta-Mendota Canal. Main factors governing potential utility of nonphysical barriers include fish hearing ability, fish swimming ability, and fish position in the water column.	Based partly on Delta-specific studies.	Considerable uncertainty about velocities in barrier vicinity and potential predation. Qualitative discussion only.
Screening Effectiveness Analysis (North Delta Intake)	Estimate of potential for screening based on different sizes of fish approaching the north Delta intakes	North Delta intake screen mesh size is 1.75 mm. Fish would be screened from entrainment based on published relationships (e.g., a comparison of fineness ratio [body depth/standard length] to mesh size).	Based on published literature for exclusion of fish at screened intakes, including some studies specific to species from the Plan Area.	Little is known of the occurrence of larval fish in the area and how fish may respond to such large intakes. Qualitative discussion based on likely sizes of fish that would be excluded.

Method	Description of Method	Main Assumptions	Benefits	Limitations
Impingement and Screen Contact Analysis (North Delta Intake)	Uses laboratory-based studies to discuss potential for covered fish species to interact with proposed north Delta intake screens through screen contact and mortality or passage time.	Laboratory observations are reasonably representative of how fish would behave in the wild when encountering the proposed intake screens. Representative lengths of screen and a variety of different approach and sweeping velocities are presented to cover a broad range, although actual criteria for the fish screens have not been finalized.	Analysis is based on studies specifically conducted using covered fish species from the Plan Area, for which a wide range of test conditions were undertaken.	It is unknown the extent to which the laboratory studies would be representative of the conditions in the field. Some of the equations do not appear to work well for the long fish screens proposed for the north Delta. Some calculations require linkage of several equations with varying degrees of uncertainty at each step. Analysis is a general discussion because specific operational criteria and fish screen lengths have not been finalized. Detailed modeling to provide a better sense of velocities near the intakes during operations is underway.
DRERIP Analysis of Nonproject Diversions	Qualitative assessment of the population-level benefits of screening nonproject diversions that was previously proposed as a BDCP conservation measure	Qualitative discussion.	Represents the analysis of a panel of experts	Qualitative analysis only (however, estimates of number of diversions to be decommissioned as part of BDCP habitat restoration allow some context for the extent of entrainment reduction).

CCF = Clifton Court Forebay
CWT = coded wire tag
DPM = Delta Passage Model
DRERIP = Delta Regional Ecosystem Restoration Implementation Plan
OMR = Old and Middle River
PTM = Particle Tracking Model
ROA = restoration opportunity areas
SWP = State Water Project

Table 11-14. Methods Used to Analyze Entrainment Effects, by Entrainment Location, Species, and Life Stage.

Entrainment Location or Species	Geographic Subregion or Life Stage	Salvage-Density Method	OMR Flow Proportional Entrainment Regressions	DSM2 PTM	Effectiveness of Nonphysical Barriers	North Delta Intakes Screening Effectiveness Analysis	North Delta Intakes Impingement/Screen Contact	DRERIP Evaluation of Nonproject Diversions
SWP/CVP south Delta export facilities	South Delta Subregion	X	X	X	X			
SWP/CVP north Delta intake	North Delta Subregion			X		X	X	
SWP North Bay Aqueduct Barker Slough Pumping Plant and Alternative Intake	Cache Slough Subregion			X				
Agricultural diversions	Plan Area			X				X
Steelhead	Juvenile	X			X	X	X	X
Winter-run Chinook salmon	Juvenile	X			X	X	X	X
Spring-run Chinook salmon	Juvenile	X			X	X	X	X
Fall-/late fall–run Chinook salmon	Juvenile	X			X	X	X	X
Delta smelt	Larvae		X	X	X	X		X
	Juvenile		X		X	X	X	X
	Adult		X		X	X	X	X
Longfin smelt	Larvae			X	X	X		X
	Juvenile	X			X	X		X
	Adult	X			X	X		X
Sacramento splittail	Juvenile	X			X	X	X	X
	Adult	X			X	X		X
White sturgeon	Egg/embryo					X		X
	Larvae				X	X		X
	Juvenile	X			X	X		X
Green sturgeon	Juvenile	X			X	X		X
Pacific lamprey	Ammocoete					X		
	Macropthalmia	X			X	X		
	Adult	X			X	X		
River lamprey	Ammocoete					X		
	Macropthalmia	X			X	X		
	Adult	X			X	X		

11.3.2.2 Flow, Passage, Salinity, and Turbidity Analysis

The methods used to assess flows and the various flow-related parameters are based on CALSIM and DSM2 outputs, several upstream temperature models (e.g., Reclamation temperature model, Sacramento River Water Quality Model [SRWQM]), multiple biological models, assumed and measured locations of fish, previous studies in the Delta, Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) analyses, life cycle models, and professional judgment. A full description of these methods and a complete analysis can be found in the *BDCP Effects Analysis – Appendix 5.C, Flow, Passage, Salinity, and Turbidity Appendix (hereby incorporated by reference)*. Over twenty different models or indices were used to evaluate flow-related effects.

As with all analytical tools, the methods used to evaluate flow and related parameters have technical benefits and limitations that are summarized in Table 11-15 and are discussed in more detail in the appendices to Chapter 5. A summary of the methods and the species/life stages that they address are provided in Table 11-16. These methods were applied to a comparison of the alternatives with existing conditions and the No Action Alternative. For some methods, five water-year types were modeled based on the historical CALSIM record to determine the variation in flow-related effects under different flow conditions. Data and analyses are presented in *Appendix 11C CALSIM II Model Results Utilized in Fish Analysis* and are incorporated into tables and discussion throughout this chapter. Although it is recognized that there are statistically significant correlations between freshwater flow (or its proxy, X2) and abundances of several fish species (e.g., Kimmerer 2002, USFWS 2005), these correlations generally were not used in the EIR/EIS analysis to estimate fish population responses to alternatives because they do not directly include the effects of tidal marsh and floodplain restoration on fish populations; the exception was longfin smelt, for which X2-abundance index regressions were used (see below).

Physical modeling outputs each month and water year type were compared between model scenarios at multiple locations to determine whether there were differences between scenarios at each location. A "difference" was defined as a >5% difference between the pair of model scenarios in at least one water year type in at least 1 month. A >5% difference was chosen because smaller differences generally represent the typical "noise" associated with models such as CALSIM. However, this is not a threshold of significance for determining biological impacts (please see *Methodology used for Reaching a Conclusion for the BDCP EIR/S for fish Impacts Related to Water Operations* for this information). If a difference was found at a location, a subsequent biological analysis was conducted to determine whether the difference would be expected to have a biologically meaningful effect on the fish species that occur in that location. This analysis involved the use of a biological model, if available, or best professional judgement based on a knowledge of the species' biological requirements~~.~~. If no differences in physical modeling were found, subsequent biological modeling and analyses for fish species that occur in that location, which are based entirely on this physical modeling, were deemed unnecessary and were not conducted. These instances are noted in the text as they occur. Locations include individual rivers or river reaches and vary according to the species and life stage analyzed. The time ranges analyzed also vary by species and life stage, and were based on Table 11-5, the applicable model parameters (i.e., some models have built-in timeframes for evaluation), or specific requests from the fisheries agencies (i.e., some of the NMFS water temperature threshold analyses have different time ranges than the phenology table).

Table 11-15. Description of Methods Used to Assess the Effects of Flow and Related Parameters and the Benefits and Limitations of Each Method

Method	Description of Method	Benefits of Method	Limitations of Method
CALSIM	The CALSIM II planning model simulates the operation of the CVP and SWP over a range of hydrologic conditions based on an assumed set of demands, regulatory requirements and climate-related factors using an 82-year record of hydrology. CALSIM II produces key outputs that include river flow volumes and diversion volumes, reservoir storage, Delta flow volumes and export volumes, Delta inflow volumes and outflow volumes, deliveries to project and nonproject users, and controls on project operations. The model operates at a monthly time step, but for the BDCP analysis daily flows on the Sacramento River were used to estimate Fremont Weir diversions and north Delta intake bypass flow requirements. These daily Sacramento River flows were estimated from the historical daily patterns adjusted to match the monthly CALSIM flows.	Based on a long, hydrologically diverse record and system-wide. Allows comparisons of changes in flows under a range of alternative operations. Used extensively to determine change in water operations and flows.	Monthly time step limits use for daily or instantaneous effects analysis; does not accurately simulate real-time operational strategies to meet temperature objectives or flood control requirements.
DSM2-HYDRO	DSM2-HYDRO estimates flow rates, velocities, and depths for the Delta for a given scenario (e.g., the BDCP or climate change). It is tidally averaged. Outputs are used to determine the effects of these hydrodynamic parameters on covered terrestrial and fish species and as inputs to other biological models. The model operates at a 15-minute time step.	Numerous output nodes throughout the Plan Area. Provides information in short time steps that can be used to assess tidal hydrodynamics. Used extensively to determine change in water operations and flows. The 16 years modeled in DSM2 represent the range of conditions found in the 82 CALSIM II years.	One-dimensional model; very data-intensive; runs for limited period (only 16 years). Open-water areas are treated as a fully mixed system, which is an oversimplification.

Method	Description of Method	Benefits of Method	Limitations of Method
DSM2-QUAL	The DSM2-QUAL module simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by HYDRO. Outputs are used to estimate changes in salinity and their effects on covered species as a result of the BDCP and climate change. The model operates at a 15-minute time step.	Numerous output nodes throughout the Plan Area. Used extensively in Central Valley fishery assessments.	One-dimensional model; very data-intensive; runs for limited period (only 16 years).
DSM2-Fingerprinting	Calculates the proportion of water from different sources at specific locations in the Delta. The model operates at a 15-minute time step, although the fingerprinting outputs are monthly-averages for the 16-year period.	Allows assessment of water composition at numerous locations throughout the Plan Area. Useful for assessing changes in potential olfactory cues and attraction flows as well as water movement through the Delta.	One-dimensional model; very data-intensive; runs for limited period (only 16 years).
MIKE-21	MIKE-21 is a two-dimensional hydrodynamic model used to model steady-state inundation. Outputs of MIKE-21 are used to estimate the area of inundated habitat in the Yolo Bypass for species such as splittail and Chinook salmon. Because the model is not temporally explicit, there is no time step.	Two-dimensional model provides improved definition over one-dimensional models. Can be used to assess changes in physical habitat conditions for fish within the inundated floodplain as a function of specific flows.	The model is steady-state such that changes in flows are not modeled dynamically.
Sacramento splittail habitat area	Estimates suitable habitat area for splittail spawning and early rearing habitat in the Yolo Bypass as a function of area weighted by depth. Because this analysis is not temporally explicit, there is no time step.	Accounts for the duration of flooding required for successful spawning and rearing.	No weighting is applied across months; does not account for sources of inundation to the Yolo Bypass
Reclamation Temperature Model	The Reclamation Temperature Model is used to assess the effects of operations on water temperatures in the Feather, Stanislaus, Trinity, and American river basins, which are then used as inputs to the Reclamation Salmon Mortality Model and species-specific habitat evaluations. The model operates at a monthly time step.	Large geographic extent makes model widely spatially applicable to the ESO effects analysis area. Used extensively in Central Valley fishery assessments. Uses modified meteorological data that future climate change for ELT and LLT scenarios.	Monthly time step limits use for daily or instantaneous effects analysis; does not accurately simulate real-time reservoir operational strategies to meet temperature objectives.

Method	Description of Method	Benefits of Method	Limitations of Method
Sacramento River Water Quality Model	SRWQM is an application developed to use the HEC-5Q model to simulate mean daily (using 6-hour meterology) reservoir and river temperatures at key locations in the Sacramento River from Shasta Dam to Knights Landing. Output (temperature and flow) from the SRWQM is used as an input to a number of biological models for upstream life stages of salmonids and sturgeon. The model operates at a daily time step.	Daily time step allows more accurate simulation and can be used to assess temperature effects at a more biologically meaningful time step. Provides input to the Reclamation egg mortality and SALMOD models, as well as IOS and OBAN Used extensively in Central Valley fishery assessments. Uses modified meteorological data that incorporates future climate change for ELT and LLT scenarios.	Temporal downscaling routines have limited precision and are not always accurate. Cannot reflect real-time management decisions for coldwater pool and temperature management.
Delta Passage Model	DPM simulates migration and mortality of Chinook salmon smolts entering the Delta from the Sacramento, Mokelumne, and San Joaquin Rivers through a simplified Delta channel network, and provides quantitative estimates of relative Chinook salmon smolt survival through the Delta to Chipps Island. DPM is used to estimate through-Delta survival for winter-, spring-, fall-, and late fall–run juvenile Chinook salmon passing through the Delta, as well as estimates of salvage in the south Delta export facilities. Model inputs are DSM2-HYDRO and CALSIM data. The model operates at a daily time step.	Provides estimates of overall proportions of migrating juvenile Chinook salmon runs that are lost to entrainment, while accounting for movement down different Delta channels; allows differentiation of fall-run populations by Sacramento, San Joaquin, and Mokelumne River basins. Reach-specific survival/behavior at junctions can be post-processed to investigate specific hypotheses regarding conservation measures not included in the model.	Many of the model assumptions are based on results from large, hatchery-reared fall-run Chinook salmon that may not be representative of smaller, wild-origin fish. Model is applicable only to migrating fish and not to those rearing in the Delta. Model is mostly limited to operations-related effects on flow. Model only accounts for smolts and not other migrating juvenile life stages.
Fall-run/spring-run Chinook salmon smolt survival (based on Newman 2003)	Estimates through-Delta survival of fall-run and spring-run Chinook salmon smolts on the Sacramento River, based on the coefficients determined by Newman (2003). Model inputs are DSM2-HYDRO and DSM2-QUAL data. The model operates at a daily time step.	Based on peer-reviewed paper including many years of coded-wire tag survival studies and includes numerous covariates (Sacramento River flow, south Delta exports, water temperature, turbidity, conductivity, position of Delta Cross Channel); provides information applicable to smaller size smolts (80 mm) than DPM.	Applied only to fall-run and spring-run Chinook salmon from the Sacramento River; limited to operations-related covariates (flow and exports, plus Delta Cross Channel gate position); does not account for potential benefits of the Yolo Bypass for migrating smolts.

Method	Description of Method	Benefits of Method	Limitations of Method
Sacramento Ecological Flows Tool	Links flow management actions to changes in the physical habitats and predicts effects of habitat changes to several fish species. The model operates at a daily time step.	Incorporates flow and water temperature inputs with multiple model concepts and field and laboratory studies to predict effects on multiple performance measures for fish species; peer-reviewed model.	Limited to upper Sacramento River; limited set of focal species (steelhead, Chinook salmon, and green sturgeon); third in a sequence of models (CALSIM and SRWQM), so limitations of previous models are compounded.
SALMOD	SALMOD is a simulation model for salmonids in the Sacramento River from Keswick to Red Bluff that is used to assess the effects of flows in the Sacramento River on habitat quality and quantity and ultimately on juvenile production of all races of Chinook salmon. The model operates at a weekly time step.	Measures effects of flows and water temperatures on spawning, egg incubation, and juvenile growth in terms of smolt production. Used extensively in Central Valley fishery assessments.	Model only extends from Keswick to Red Bluff. Not all life stages are represented (e.g., outmigration, ocean dwelling, upstream migration). Only assesses effects of flow and water temperature; not reasonably accurate for small spawner numbers (<500 fish). The number of spawners for each year is defined by the user.
Reclamation Egg Mortality Model	The Salmon Mortality Model is used to assess temperature-related proportional losses of eggs and fry for each race of Chinook salmon in the Trinity, Sacramento, Feather, American, and Stanislaus Rivers. The model operates at a daily time step and provides output on an annual time step.	Assesses effects at multiple locations within multiple rivers. Used extensively in Central Valley fishery assessments.	Limited to effects of water temperature on eggs only; daily time step requires linear interpolation between monthly temperatures to compute daily temperatures; third in a sequence of models (CALSIM and Reclamation Water Temperature Model), so limitations of previous models are compounded.
DRERIP	Used to assess importance of stressors, develop methods, and aid in qualitative assessments of covered activities in the Plan Area.	Conceptual models have been peer-reviewed and include individual fish species and habitat functions. Provides information on potential stressors and mechanisms for effects analysis.	Outputs are limited to qualitative assessments based on best professional judgment of topical experts.
Longfin Smelt Winter-Spring X2–Abundance Regression	Used to estimate relative abundance of longfin smelt in the fall based on winter-spring X2 (as an indication of outflow). Model input is from CALSIM data.	Method has been peer-reviewed and includes regressions based on observed data.	Changes in the nature of the relationship in recent years appear to have occurred as a result of factors other than outflow; method does not account for population dynamics such as stock-recruitment relationships; the specific mechanism(s) underlying the flow/abundance relationship are not clearly understood.

Method	Description of Method	Benefits of Method	Limitations of Method
Delta Smelt Abiotic Habitat Index	Used to calculate area of delta smelt abiotic habitat in fall (September–December) based on the relationship described by Feyrer et al. (2011). Model input is CALSIM data for Fall X2.	Method has been peer-reviewed and includes relationships based on observed data, and the approach has been reasonably predictive of recent indices (e.g., the strong index in 2011).	Was developed based on a portion of delta smelt fall habitat (primarily Suisun Bay, Suisun Marsh, and West Delta subregions) that does not incorporate other areas where recent occurrence has been appreciable; based on two abiotic factors; based on linked statistical models without accounting for uncertainty in each model.
Straying Rate of Adult San Joaquin River Region Fall-Run Chinook Salmon (Marston et al. 2012)	Estimates straying rate of San Joaquin River adult fall-run Chinook salmon as a function of south Delta exports and San Joaquin River inflow.	Based on peer-reviewed published work, allowing assessment of the potential biological importance of changes in the ratio of San Joaquin River flow to south Delta exports in the fall.	It is uncertain the extent to which exports or inflow or both drive the observed relationships, as models with similar explanatory ability were found for several different combinations of predictor variables.
North Delta Diversion Bypass Flow Effects on Chinook Salmon Smolt Survival	Estimates survival of Sacramento River Chinook salmon from Sacramento River-Georgiana Slough/Delta Cross Channel Divergence as a function of north Delta diversion bypass flow (based on Perry 2010), with differences across the various pulse protection flow levels; also uses the results of the analysis based on Newman (2003) for a similar purpose.	Allows more detailed examination of potential differences in survival under different bypass flow levels, to assess the relative differences between the levels.	Method only provides perspective on survival over a portion, albeit major, of potential migration pathways. Method limited to changes caused by changes in Sacramento River flow and the assumed flow-survival relationship. Method does not provide perspective on changes that could result from other conservation measures.
Reverse flows analysis	Estimates percentage of time that Sacramento River at Georgiana Slough has reverse flows and what proportion of flow enters Georgiana Slough or the Delta Cross Channel, based on 15-minute DSM2-HYDRO data. Also uses DPM results to examine proportion of Chinook salmon smolts entering Georgiana Slough and Steamboat/Sutter Sloughs.	Allows detailed examination of percentage of time that flow is reversing and what proportion of flow is entering the interior Delta through Georgiana Slough.	Results may be challenging to interpret because it is difficult to isolate differences between scenarios caused by changes in water operations (CM1) versus changes caused by tidal habitat restoration (CM4).
Yolo Bypass Fry Growth Model	Used to estimate the differences in growth of Chinook salmon fry in the Yolo Bypass compared with the mainstem lower Sacramento River. Model input is from CALSIM data.	Provides comparison of alternate migratory routes for fry in terms of growth and size-related survival.	Enhanced growth rate on Yolo Bypass modeled as a function of duration of flooding and does not floodplain is include potential benefits of productivity related to flooded area.

Method	Description of Method	Benefits of Method	Limitations of Method
Water Clarity	Qualitative and quantitative assessment of the potential for changes in water clarity because of factors such as sediment removal by the proposed north Delta intakes, sedimentation in restoration areas, water depth, and water velocity.	Method provides useful framework from which the influence of different potential factors affecting water clarity can be judged. Includes quantitative modeled data (CALSIM and DSM2-HYDRO) where possible.	Many uncertainties exist and a full analysis would require a suspended sediment model, currently unavailable.
Lower Sutter Bypass Inundation	Assesses potential negative effect of *CM2 Yolo Bypass Fisheries Enhancement* on Sutter Bypass inundation caused by Sacramento River backwatering. Model input is from CALSIM data.	Provides information on potential trade-off between enhanced inundation in the Yolo Bypass and less inundation in the Sutter Bypass.	Does not account for previous days of inundation in Sutter Bypass; assumes that empirically derived Verona flow-stage rating curve can be applied to CALSIM flow outputs at Verona.

CVP = Central Valley Project.
DRERIP = Delta Regional Ecosystem Restoration Implementation Plan.
PTM = particle tracking model.
Reclamation = Bureau of Reclamation.
SRWQM = Sacramento River Water Quality Model.
SWP = State Water Project.

Table 11-16. Summary of Methods Used to Assess the Effects of Flow and Related Parameters for Each Region and Species Life Stage

Flow Parameter Change or Species Affected	Geographic Region or Life Stage	CALSIM	DSM2-HYDRO	DSM2-QUAL	DSM2-Fingerprinting	MIKE21	Sacramento Splittail Habitat Area	Reclamation Temperature Model	Sacramento River Water Quality Model	Delta Passage Model	Salmon Smolt Survival (Newman 2003)	PTM Nonlinear Regression	DRERIP	Sacramento Ecological Flows Tool	Reclamation Egg Mortality Model	SALMOD	Winter/Spring X2–Abundance Regression	Delta Smelt Abiotic Habitat Index	Yolo Bypass Fry Growth Model	Wetland Bench Inundation	Straying Rate of Adult SJR Region Fall-Run Chinook Salmon (Marston et al. 2012)	North Delta Diversion Bypass Flow Effects on Chinook Salmon Smolt Survival	Reverse Flows Analysis	Water Clarity	Sutter Bypass Inundation
Upstream Abiotic Habitat	Sacramento River and San Joaquin River	X						X	X					X	X	X									
Fish Movement (Migration, Transport, and Passage)	Sacramento River, Delta	X	X		X					X	X	X	X								X	X	X		
Delta Habitat (Plan Area)	Delta	X	X	X		X							X				X	X	X	X				X	X
Steelhead	Eggs/Embryo	X						X	X					X											
	Fry and Rearing Juveniles	X	X					X	X					X											
	Juvenile Migrants	X	X	X				X	X																
	Adults	X		X	X			X	X				X												
Winter-Run Chinook Salmon	Eggs/Embryo	X						X	X					X	X	X									
	Fry	X						X	X					X		X			X						
	Juvenile Migrants	X	X	X						X			X									X			
	Adults	X		X	X			X	X				X												
Spring-Run Chinook Salmon	Eggs/Embryo	X						X	X					X	X	X									
	Fry	X						X	X					X		X									
	Juvenile Migrants	X	X	X						X	X		X									X			
	Adults	X		X	X			X	X				X												
Fall-/Late Fall–	Eggs/Embryo	X						X	X					X	X	X									

Flow Parameter Change or Species Affected	Geographic Region or Life Stage	CALSIM	DSM2-HYDRO	DSM2-QUAL	DSM2-Fingerprinting	MIKE21	Sacramento Splittail Habitat Area	Reclamation Temperature Model	Sacramento River Water Quality Model	Delta Passage Model	Salmon Smolt Survival (Newman 2003)	PTM Nonlinear Regression	DRERIP	Sacramento Ecological Flows Tool	Reclamation Egg Mortality Model	SALMOD	Winter/Spring X2–Abundance Regression	Delta Smelt Abiotic Habitat Index	Yolo Bypass Fry Growth Model	Wetland Bench Inundation	Straying Rate of Adult SJR Region Fall-Run Chinook Salmon (Marston et al. 2012)	North Delta Diversion Bypass Flow Effects on Chinook Salmon Smolt Survival	Reverse Flows Analysis	Water Clarity	Sutter Bypass Inundation
Run Chinook Salmon	Fry	X						X	X					X		X			X						
	Juvenile Migrants	X	X	X						X	X	X	X								X	X			
	Adults	X		X	X			X	X				X												
Delta Smelt	Eggs			X																					
	Larva	X		X																					
	Juvenile	X		X														X							
	Adult			X																					
Longfin Smelt	Eggs			X																					
	Larva	X	X	X																					
	Juvenile	X		X													X								
	Adult			X																					
Sacramento Splittail	Eggs/Embryo	X				X	X	X	X																
	Fry	X				X	X	X	X																
	Juveniles	X				X	X						X												
	Adults	X				X	X	X	X				X												
White Sturgeon	Egg/embryo	X						X	X				X												
	Larva	X						X	X				X												
	Juvenile	X		X				X	X				X												
	Adult	X		X				X	X				X												
Green Sturgeon	Egg/embryo	X						X	X					X											
	Larva	X						X	X																
	Juvenile	X		X				X	X				X												
	Adult	X		X				X	X				X												

Flow Parameter Change or Species Affected	Geographic Region or Life Stage	CALSIM	DSM2-HYDRO	DSM2-QUAL	DSM2-Fingerprinting	MIKE21	Sacramento Splittail Habitat Area	Reclamation Temperature Model	Sacramento River Water Quality Model	Delta Passage Model	Salmon Smolt Survival (Newman 2003)	PTM Nonlinear Regression	DRERIP	Sacramento Ecological Flows Tool	Reclamation Egg Mortality Model	SALMOD	Winter/Spring X2–Abundance Regression	Delta Smelt Abiotic Habitat Index	Yolo Bypass Fry Growth Model	Wetland Bench Inundation	Straying Rate of Adult SJR Region Fall-Run Chinook Salmon (Marston et al. 2012)	North Delta Diversion Bypass Flow Effects on Chinook Salmon Smolt Survival	Reverse Flows Analysis	Water Clarity	Sutter Bypass Inundation
Pacific Lamprey	Eggs	X						X	X																
	Ammocoetes	X						X	X																
	Macropthalmia	X		X																					
	Adult	X		X	X																				
River Lamprey	Eggs	X						X	X																
	Ammocoetes	X						X	X																
	Macropthalmia	X		X																					
	Adult	X		X	X																				

Methodology used for Reaching a Conclusion for the BDCP EIR/S for fish Impacts Related to Water Operations

The general methodology for reaching a conclusion for an impact was to use the weight of evidence to determine the direction and magnitude of the potential effects on each life stage. (see Table 11-20 for indicators used for each life stage impact). Due to variation in sensitivity among analytical tools, our analysis relied on multiple indicators showing similar effects to result in a conclusion of a change, either positive or negative. For example, if Indicator X results that suggested a significant impact, but Indicators Y, Z, and A did not, the conclusion drawn would usually be less than significant unless there was high value or confidence in Indicator X. Biological models typically provided similar answers. However, the models used for this analysis had different sensitivities to different factors potentially affected by the alternatives. For this reason, a weight of evidence approach was used to make a determination when possible.

Numerical significance thresholds were not used due the complexity and variation caused by natural hydrology; modeling deviation; the number of models used with varying results for the same analysis; and variation in sensitivity to various environmental factors by species, life stage, and location. Key temperature and flow thresholds based on existing literature, regulatory requirements, and coordination with NMFS and DFW were evaluated, and their exceedances noted, but those results were summarized and used in combination with other results to arrive at an overall determination for an impact. The CEQA and NEPA determination was ultimately based on expert opinion using the weight of evidence of assessed biologically relevant changes caused by an alternative on each indicator relative to the applicable baseline.

In general, for habitat and migration-related impacts, if changes in flows were ~less than 15% under the alternative relative to the baseline for a small proportion of months in which a fish is present (e.g., 1 or 2 of 7 months), there was no adverse effect. If changes in flows were greater than 15% in a substantial proportion of total months (e.g., 2 of 3 months), it would be considered substantial and warranted further biological evaluation. If there was a flow reduction that was considered substantial but no other changes were seen in other indicators, such as weighted usable area, temperatures, etc., the effect would be based on the biological importance of the change based on known life stage requirements and conditions. Full life cycle models were not available for most species, so expert understanding of the fish life cycle needs were applied to these varying results.

Water temperatures and flows were considered separately, but both indicators were given equal weighting for determining effects for habitat and migration-related impacts, despite a lack of substantial variation in water temperatures among action alternatives. The same general procedure used to determine effects for flows applied to water temperature. In the case of water temperature~~,~~ (reported in °F), published thresholds were used to determine the potential for alternatives to cause changes in the frequency and duration of which those temperature tolerances were exceeded. A change of ~15% was considered substantial and warranted further biological evaluation. As for flows, the determination of effect were based on the biological importance of the change based on known life stage requirements and conditions.

The analysis considered equally all waterways in which a species may occur despite differences in abundance among waterways to ensure adequate treatment of independent populations. Except in the Feather River, multiple locations of known species presence within tributaries were also considered equally. In the Feather River, the high-flow channel has very little suitable spawning and rearing habitat, resulting in low numbers of spawning and rearing salmonids and, therefore, effects estimated in that portion of the river were weighted with lower importance than effects estimated in the low-flow channel where the vast majority of spawning and rearing occurs. Table 11-17 summarizes how the various methods described above for entrainment, flow, turbidity and temperature were applied to determine the level of significance and to determine if a change was adverse or not.

Table 11-17. Application of Methods for Each Species and Life Stage

Species	Impact #	Impact	Indicators Used	Indicator Weighting
Delta smelt	3	Entrainment	South Delta SWP/CVP: Proportional entrainment loss regressions North Delta SWP/CVP: larvae - particle tracking; juveniles and adults: Best professional judgment (BPJ) North Bay Aqueduct: larvae - particle tracking; juveniles and adults: BPJ Predation associated with entrainment: BPJ	Greatest weighting given to South Delta SWP/CVP entrainment and associated predation
	4	Spawning and egg incubation habitat	Water temperature	N/A
	5	Larval and juvenile rearing habitat	Fall abiotic habitat index	N/A
	6	Migration conditions	Water temperature and turbidity: BPJ	Greater weighting to turbidity
Longfin smelt	21	Entrainment	South Delta SWP/CVP: larvae – particle tracking; juveniles and adults – salvage density North Delta SWP/CVP: BPJ North Bay Aqueduct: larvae - particle tracking; juveniles and adults: BPJ	Greatest weighting given to South Delta SWP/CVP entrainment
	22	Spawning and egg incubation habitat	Kimmerer et al. 2009 winter-spring X2-abundance correlations	N/A
	23	Larval and juvenile rearing habitat	Kimmerer et al. 2009 winter-spring X2-abundance correlations	N/A
	24	Migration conditions	Kimmerer et al. 2009 winter-spring X2-abundance correlations	N/A

Species	Impact #	Impact	Indicators Used	Indicator Weighting
Winter-run Chinook salmon	39	Entrainment	South Delta SWP/CVP: salvage density North Delta SWP/CVP: BPJ North Bay Aqueduct: BPJ	Greatest weighting given to South Delta SWP/CVP entrainment
	40	Spawning and egg incubation habitat	Flow changes; reservoir storage changes; water temperature changes; water temperature threshold exceedance; Reclamation egg mortality model; SacEFT spawning WUA, redd scour, egg incubation, redd dewatering	Biological model weighting higher than flow, reservoir, and temperature changes
	41	Fry and juvenile rearing habitat	Flow changes; water temperature changes; SacEFT rearing WUA, stranding risk; SALMOD habitat-related mortality	Biological model weighting higher than flow, reservoir, and temperature changes
	42	Migration conditions	Upstream: Flow changes; water temperature changes Through-Delta: Flow changes; DPM; Predation – bioenergetics model, fixed percent loss per intake; Habitat loss – BPJ	Equal
Spring-run Chinook salmon	57	Entrainment	South Delta SWP/CVP: salvage density North Delta SWP/CVP: BPJ North Bay Aqueduct: BPJ	Greatest weighting given to South Delta SWP/CVP entrainment
	58	Spawning and egg incubation habitat	Sac: Flow changes; reservoir storage changes; water temperature changes; water temperature threshold exceedance; Reclamation egg mortality model; SacEFT spawning WUA, redd scour, egg incubation, redd dewatering Clear Creek: Flow changes Feather: Flow changes; reservoir storage changes; water temperature changes; water temperature threshold exceedance	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting, except Feather River high-flow channel (see text)
	59	Fry and juvenile rearing habitat	Sac: Flow changes; reservoir storage changes; water temperature changes; SacEFT rearing WUA, stranding risk (Sac River only); SALMOD habitat-related mortality Clear Creek: Flow changes Feather: Flow changes; reservoir storage changes; water temperature changes; water temperature threshold exceedance	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting, except Feather River high-flow channel (see text)
	60	Migration conditions	Upstream: Flow changes; water temperature changes (Sac and Feather only) Through-Delta: Flow changes; DPM; Predation – bioenergetics model, fixed percent loss per intake; Habitat loss – BPJ	Equal

Species	Impact #	Impact	Indicators Used	Indicator Weighting
Fall-/Late fall-run Chinook salmon	75	Entrainment	South Delta SWP/CVP: salvage density North Delta SWP/CVP: BPJ North Bay Aqueduct: BPJ	Greatest weighting given to South Delta SWP/CVP entrainment
	76	Spawning and egg incubation habitat	Sac: Flow changes; reservoir storage changes; water temperature changes; water temperature threshold exceedance; Reclamation egg mortality model; SacEFT spawning WUA, redd scour, egg incubation, redd dewatering Clear Creek (fall-run only): Flow changes Feather (fall-run only): Flow changes; reservoir storage changes; water temperature changes; water temperature threshold exceedance; Reclamation egg mortality model American (fall-run only): Flow changes; water temperature changes; water temperature threshold exceedance; Reclamation egg mortality model Stanislaus (fall-run only): Flow changes; water temperature changes San Joaquin (fall-run only): Flow changes Mokelumne (fall-run only): Flow changes	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting, except Feather River high-flow channel (see text)
	77	Fry and juvenile rearing habitat	Sac: Flow changes; reservoir storage changes; water temperature changes; SacEFT rearing WUA, stranding risk; SALMOD habitat-related mortality Clear Creek (fall-run only): Flow changes Feather (fall-run only): Flow changes; reservoir storage changes; water temperature changes American (fall-run only): Flow changes; water temperature changes Stanislaus (fall-run only): Flow changes; water temperature changes San Joaquin (fall-run only): Flow changes Mokelumne (fall-run only): Flow changes	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting, except Feather River high-flow channel (see text)
	78	Migration conditions	Upstream: Flow changes; water temperature changes (Sac, Feather, American, and Stanislaus only) Through-Delta: Flow changes; DPM; Predation – bioenergetics model, fixed percent loss per intake; Habitat loss – BPJ	Equal

Species	Impact #	Impact	Indicators Used	Indicator Weighting
Steelhead	93	Entrainment	South Delta SWP/CVP: salvage density North Delta SWP/CVP: BPJ North Bay Aqueduct: BPJ	Greatest weighting given to South Delta SWP/CVP entrainment
	94	Spawning and egg incubation habitat	Sac: Flow changes; water temperature changes; SacEFT spawning WUA, redd scour, egg incubation, redd dewatering Clear Creek: Flow changes Feather: Flow changes; water temperature changes; water temperature threshold exceedance American: Flow changes; water temperature changes; water temperature threshold exceedance Stanislaus: Flow changes; water temperature changes Mokelumne: Flow changes	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting, except Feather River high-flow channel (see text)
	95	Fry and juvenile rearing habitat	Sac: Flow changes; water temperature changes; SacEFT rearing WUA, stranding risk Clear Creek: Flow change; greatest minimum flow reduction Feather: Flow changes; water temperature changes; water temperature threshold exceedance American: Flow changes; water temperature changes; water temperature threshold exceedance Stanislaus: Flow changes; water temperature changes San Joaquin: Flow changes Mokelumne: Flow changes	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting, except Feather River high-flow channel (see text)
	96	Migration conditions	Upstream: Flow changes; water temperature changes (Sac, Feather, American, and Stanislaus only) Through-Delta: Flow changes; DPM; Predation – bioenergetics model, fixed percent loss per intake; Habitat loss – BPJ	Equal

Species	Impact #	Impact	Indicators Used	Indicator Weighting
Splittail	111	Entrainment	South Delta SWP/CVP: Days of Yolo Bypass inundation method; per capita method; salvage density method North Delta SWP/CVP: BPJ North Bay Aqueduct: BPJ Predation Associated with Entrainment: BPJ	Greatest weighting given to South Delta SWP/CVP entrainment
	112	Spawning and egg incubation habitat	Floodplain habitat: Yolo Bypass inundation frequency; Sutter Bypass inundation area Channel margin/side-channel habitat: flow changes; water temperature threshold exceedance Stranding potential: BPJ	Equal
	113	Fry and juvenile rearing habitat	Same as Impact AQUA-112	Equal
	114	Migration conditions	Upstream: Flow changes; water temperature changes Through-Delta: Flow changes	Equal
Green sturgeon	129	Entrainment	South Delta: Salvage density Predation associated with entrainment: BPJ	Equal
	130	Spawning and egg incubation habitat	Sac: Flow changes; water temperature changes; water temperature threshold exceedance Feather: Flow changes; water temperature changes; water temperature threshold exceedance San Joaquin: Flow changes	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting
	131	Fry and juvenile rearing habitat	Sac: Water temperature changes Feather: Water temperature changes; water temperature threshold exceedance	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting
	132	Migration conditions	Upstream of Delta: Flow changes; Delta outflow changes Through-Delta: see Impact AQUA-114	Delta outflow changes given lower weighting due to lack of understanding in Delta outflow-year class strength correlation

Species	Impact #	Impact	Indicators Used	Indicator Weighting
White sturgeon	147	Entrainment	South Delta: Salvage density Predation associated with entrainment: BPJ	Equal
	148	Spawning and egg incubation habitat	Sac: Flow changes; water temperature changes; water temperature threshold exceedance Feather: Flow changes; water temperature changes San Joaquin: Flow changes	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting
	149	Fry and juvenile rearing habitat	Sac: Water temperature changes Feather: Water temperature changes	Biological model weighting higher than flow, reservoir, and temperature changes; all rivers and locations within rivers given equal weighting
	150	Migration conditions	Upstream of Delta: Flow changes; Flow threshold exceedance; Delta outflow changes Through-Delta: see Impact AQUA-114	Delta outflow changes given lower weighting due to lack of understanding in Delta outflow-year class strength correlation
Pacific and River Lamprey	165, 183	Entrainment	South Delta: Salvage density North Delta Intake, North Bay Aqueduct: BPJ Predation associated with entrainment: BPJ	Greatest weighting given to South Delta SWP/CVP entrainment
	166, 184	Spawning and egg incubation habitat	Redd dewatering risk, water temperature threshold exceedance	Equal among indicators and locations
	167, 185	Fry and juvenile rearing habitat	Stranding risk, water temperature threshold exceedance	Equal among indicators and locations
	168, 186	Migration conditions	Flow changes	N/A

11.3.2.6 Reservoir Coldwater Fish Habitat Analysis

Upstream SWP/CVP reservoirs that may be affected by changes in operations (i.e., Trinity, Shasta, Oroville, Folsom, New Melones, and San Luis) were analyzed to determine the effects on coldwater fish habitat, principally with respect to suitable temperatures for rainbow trout and kokanee salmon (see further discussion below). According to Moyle (2002, pg 36, 37), foothill water supply reservoirs of the Central Valley can be described with four major habitat zones: 1) the littoral or edge-water habitat around the shoreline of the reservoir, 2) the epilimnetic or near-surface habitat located above the thermocline (water temperature gradient) and generally in the euphotic zone (>1% of surface light) where phytoplankton grow, 3) hypolimnetic or deep-water habitat located below the thermocline, where the water temperatures remain less than 15^0C (59^0F) during the stratified spring-summer and fall months, and 4) the deepwater benthic habitat located near the bottom of the hypolimnetic portion of the reservoir. There are relatively distinct fish assemblages within each of these habitat zones, with different feeding and reproductive behaviors (strategies). Reservoirs are generally less productive (lower fish biomass and growth rates) than lakes of a comparable surface area because reservoir water surface elevations fluctuate more and have steeper slopes, which limits the littoral benthic zone, and may interfere with reproduction (Moyle 2002 pg 36).

Seasonal temperature stratification (vertical water temperature gradient) and phytoplankton production in the epilimnetic near-surface zone are the dominant seasonal habitat features of reservoirs. The evaluation of possible effects of reservoir operations simulated for the action alternatives on reservoir fish populations considers the effects on warm-water fish in the epilimnetic and littoral habitat zones together, and will consider the coldwater fish in the hypolimnetic and deep water benthic habitat zones together. In some lakes and reservoirs, the dissolved oxygen in the hypolimnion can become depleted from inflowing organic materials or, more commonly, by settling of detritus from the productive epilimnion. Lake Almanor is a good example of this condition in California. Low dissolved oxygen is not a problem in the major CVP and SWP reservoirs, however, and will not be included in the coldwater habitat evaluation. Because the water depths are relatively shallow and water surface elevations of the regulating reservoirs (i.e., Lewiston, Whiskeytown, Keswick, Thermalito, Natoma, and Tulloch Reservoirs) are largely independent of flow, the habitat conditions are similar from year to year, and the fish populations in the regulating reservoirs are stable; fish populations in these regulating reservoirs are not evaluated for the BDCP alternatives.

Although the seasonal variations in water surface elevations (storage level), temperature stratification and primary production (light availability) in the major water supply reservoirs are somewhat similar from year to year, the end-of-water-year (end-of September) storage volumes can be quite different. Because the water supply reservoirs are generally filled in the spring and are drawn-down during the summer and fall for water supply releases, the minimum storage each year usually occurs in September (or October) and can be greatly reduced in a sequence of dry years (i.e., drought). Drawdown of reservoir storage from June through October can diminish the volume of cold water, thereby reducing the amount of habitat for coldwater fish species during these months. Kokanee salmon and rainbow trout are common coldwater species that support important recreational fisheries in Central Valley reservoirs. Potential impacts can therefore be assessed based on the availability of suitable water temperatures for these species during the late summer or early fall when coldwater habitat is most restricted. Preferred habitat for kokanee is well-oxygenated open water in reservoirs where temperatures are 50–59° F, while rainbow trout growth is optimal when temperatures are around 59°F–64°F (Moyle 2002). Thus, a water temperature index of 60 °F was used in the following assessment as a general indicator of the availability of coldwater habitat in Central Valley reservoirs. This temperature index is specific to analysis of reservoir operations, while areas downstream of the reservoirs use a different temperature index (National Marine Fisheries Service 2009a, 2009b).

The basic approach is to determine the relationship between total storage volume and the coldwater volume in each reservoir. The maximum suitable temperature for the coldwater habitat was assumed to be 60°F. The minimum coldwater habitat volume or the reduction in coldwater habitat volume that would be classified as a substantial change must be identified for each reservoir. Finally the percentage of additional years (out of the 82-year simulation period) that would be considered an adverse effect on the fish populations within each reservoir must be determined. The methods for coldwater reservoir fish are based on an analysis of Shasta Reservoir; the approach for Shasta Reservoir is then combined with the results from the CALSIM modeling for the other major CVP and

SWP reservoirs, along with the selected minimum coldwater habitat volumes. The evaluation of the Shasta Reservoir coldwater habitat volume can be described in three basic steps: 1) describe the reservoir geometry (volume and surface area) as a function of elevation, 2) describe the seasonal (monthly) water temperatures as a function of the elevation, storage level and outlet elevation(s), and 3) determine the portion of the reservoir volume with temperatures less than 60°F for the full range of carryover storages simulated with CALSIM. The coldwater habitat assessment compares the number of years with carryover storage less than the selected minimum volume index corresponding to the minimum acceptable coldwater habitat volume between the NAA and the alternatives, for each reservoir.

The reservoir geometry (surface area and volume) as a function of the water elevation and the elevation of the reservoir outlets are the basic features that determine the coldwater habitat in each reservoir. Table 11-19 gives a summary of the Shasta Reservoir area (acres) and volume (acre-feet) for 25-feet increments of elevation. Figure 11-1A-6 shows the Shasta Reservoir volume (thousand acre-feet [taf]) as a function of elevation. The bottom of Shasta Reservoir is at 630 feet msl, but there is very little storage volume (50 taf) below an elevation of 700 ft. The maximum elevation of about 1,065 corresponds to a maximum storage of about 4,550 taf. Figure 11-1A-6 shows the Shasta Reservoir surface area (acres) as a function of elevation. The bottom sediment area (where benthic food organisms live) is about the same as the water surface area (where photosynthesis and heat exchange occurs).

The elevations of the reservoir outlets are also important for understanding the coldwater pool. The coldest water at the bottom of the reservoir (below the outlet penstocks to the hydropower turbines) remains at nearly the same temperature during the stratified period. Shasta Dam has river outlets with gate sills (bottoms) located at elevation 742 feet and 942 feet (the river gate at 842 feet is no longer operational). The gates are about 8 feet high, so water comes from a zone approximately 20 feet high centered at about 750 feet and 950 feet (when they are used). The intakes for the 15-feet diameter penstocks to the hydropower turbines are located with a centerline elevation of 815 feet, so water is drawn from elevations of approximately 800 feet to 830 feet. The spillway crest elevation is at 1,037 feet. During the 1976–1977 and the 1987–1992 drought periods, when Shasta Reservoir storage was low and water temperatures released through the hydropower plant were greater than 55°F, the low-level river outlets (at 750 feet and 850 feet) were used to blend with the hydropower releases (from 800–830 feet) to provide cooler release temperatures at Keswick Dam for winter run spawning and egg incubation. Subsequently, to protect winter-run spawning and egg incubation temperatures and also make full hydropower releases, the temperature control device (TCD) was designed and constructed. The TCD, which began operating in 1998, allows all releases to be made through the hydropower penstocks. Three levels of louver “gates” allow the penstock water to be blended from three elevation zones. Higher level releases are used early in the summer to preserve as much of the cold water as possible; the open gate levels are adjusted towards the bottom gate during the summer. By preserving the coldest water for the early fall period (September and October), the cold water habitat in the reservoir is also protected through the summer months; however, use of the low level gate allows more of the cold water from the bottom of the reservoir to be released in September and October. Table 11-19 indicates that the storage volume located below the penstocks (800 feet) is about 350 taf with a benthic area within this protected cold water habitat of about 5,000 acres.

Table 11-19. Shasta Reservoir Geometry

Elevation (feet)	Surface Area (acres)	Volume (acre-feet)
1,075	30,908	4,792,000
1,050	27,654	4,068,649
1,025	24,633	3,388,333
1,000	21,800	2,830,000
975	19,200	2,345,000
950	16,600	1,860,000
925	14,300	1,505,000
900	12,000	1,150,000
875	10,100	907,500
850	8,200	665,000
825	6,617	490,624
800	5,080	342,000
775	3,800	233,333
750	2,800	150,000
725	1,914	85,714
700	1,200	50,000
675	771	18,750
650	343	3,437

The seasonal (monthly) reservoir release temperature and the vertical temperature profiles within the reservoir are directly linked and depend on the elevation of the outlets and the reservoir geometry and water surface elevation. The relationships between carryover storage and release temperatures for the major CVP and SWP reservoirs are shown and described in Appendix 29C "Climate Change and Effects of Reservoir Operations on Water Temperatures." Release temperatures are relatively cool and stable until the fall months. The release temperatures increase and the remaining coldwater habitat volume decreases as the carryover reservoir storage is reduced in dry years. Only if the carryover storage is reduced below a specific volume (taf) are the release temperatures moderately increased. For storages below this threshold, the release temperature increases as the storage is reduced and the coldwater habitat volume is substantially reduced.

Warming of the reservoir below the surface heated layer is caused by water releases from the outlets; warmer water from above is drawn down to replace the water released from the penstock (elevation 800 feet) or the low-level river outlet (elevation 750 feet). The warming may also depend on the reservoir inflow and outflow during these summer months. Inflowing water will usually be cooler than the surface temperature and will enter the reservoir profile at the matching temperature; this will expand the depth of this temperature layer. The effects of inflowing water can be stronger during the fall, when the cooler inflow contributes to the deepening of the surface mixed layer.

The effects of reservoir storage drawdown on the coldwater habitat volume can be tracked by evaluating the coldwater habitat volume available through the year. Figure 11-1A-7 shows the entire reservoir was coldwater habitat (<60°F) from January through April. The surface layer was warmer than 60^0F in the summer months, but the reservoir volume below elevation 900 feet was less than 60^0F at the end of September and the volume below elevation 875 feet was less than 60^0F at the end of October. The minimum Shasta Reservoir storage at the end of September 1995 was about 3,400 taf (1,025 feet). The coldwater habitat volume would likely be more limited in years with a lower carryover storage volume. The end-of-September storage simulated with the CALSIM reservoir operation model will be used as the annual index for assessing coldwater habitat volume. A relationship between end of September storage and coldwater habitat volume was determined from the temperature profiles simulated with the Sacramento River Water Quality Model (SRWQM) developed for Reclamation by RMA. This model was used for each of the alternatives to simulate reservoir temperatures, release temperatures and downstream river temperatures. The model predicts reservoir profiles that were used to develop carryover storage-cold water habitat relationship for Shasta Reservoir.

Figure 11-1A-8 shows an example of the simulated relationship between reservoir storage and coldwater habitat (defined as less than 58°F in this example) for the No Action Baseline for 1922 to 2003. August was used in this example because September temperatures were not available in the coldwater habitat results. The SRWQM results show a strong relationship between August storage and coldwater habitat volume. The maximum coldwater habitat volume in August was about 1,500 taf (below elevation 925 feet) for $<58^0$F. The coldwater habitat volumes were reduced when the August storage volume was less than about 3,000 taf (below elevation 1,000 feet). Figure 11-1A-9 shows the SRWQM-simulated relationship between Shasta Reservoir volume and coldwater habitat volume for the end of August. The relationship between Shasta Reservoir storage and coldwater habitat volume can be used to assess the effects of reduced end-of-year storage on coldwater habitat volume.

The evaluation of the annual carryover storage effects on coldwater habitat volumes can be made using either a specified "threshold" for coldwater habitat impact for each reservoir, or using a "scale" for coldwater habitat effects that would vary with carryover volume for each reservoir. Impacts could then be measured as the increase in the number of years with storage below the selected threshold value, or as the reduction in the average coldwater habitat effects calculated from a baseline carryover storage sequence to an alternative sequence of carryover storage values. However, because a rating scale will provide the average coldwater habitat benefits rather than emphasizing the poor conditions in the lower storage years, large impacts in a few years will be masked by the generally suitable conditions. For this reason, the threshold storage method is preferred for impact evaluation. The impact evaluation of Shasta Reservoir operations on coldwater habitat volume was based on a specified threshold storage that would protect sufficient coldwater habitat volume for the fish populations in the reservoir.

Figure 11-1A-9 can be used as the basis for a specified threshold volume or for a specified "scaling" of carryover storage coldwater benefits. Assuming 60^0F as the upper limit for coldwater habitat, carryover storage of about 3,500 taf (maximum end-of September Shasta storage) would provide a coldwater habitat volume of 1,500 taf. Carryover storage of 2,500 taf would provide a coldwater habitat volume of about 750 taf, which is about half of the maximum coldwater habitat volume of 1,500 taf. Carryover storage of 2,000 taf would provide a coldwater habitat volume of about 500 taf, which is about 33% of the maximum coldwater habitat volume. Carryover storage of 1,500 taf would provide a coldwater habitat volume of about 250 taf, which is about 15% of the maximum coldwater habitat volume. Carryover storage of 1,000 taf would provide a coldwater habitat volume of about 50 taf, which is less than 5% of the maximum coldwater habitat volume. Because the minimum coldwater volume needed to protect the coldwater fish population in Shasta Reservoir is not known, the assessments for three carryover storage thresholds (2,500 taf, 2,000 taf, and 1,500 taf) were compared. Table 11-1A-101 shows the summary of the Shasta Reservoir coldwater habitat for three possible threshold values. The number of years with carryover storage less than the selected threshold (indicating a substantial reduction in coldwater habitat) for each alternative was compared to the number of years below the threshold storage for the baseline. As the carryover storage threshold is reduced, the likely impacts on coldwater habitat will be greater, but the impacts will be less frequent (measured as the number of years with carryover storage below the threshold). A coldwater habitat adverse effect determination was based on the number of additional years with carryover storage below the specified threshold value. An increase of greater than 5% of the years (5 more years) was selected as a substantial change in coldwater habitat conditions because these low storage conditions are expected infrequently during multi-year dry periods.

A comparison of the baseline cases shows the expected impacts on coldwater habitat from the effects of climate change shifts in hydrology as well as operational changes related to the Fall X2 requirements (USFWS BO) compared to the previous D-1641 Delta outflow criteria. The Shasta Reservoir carryover storage for the Existing Conditions baseline with no Fall X2 requirement (Existing Conditions) was less than 2,500 taf in 19 years, was less than 2,000 taf in 13 years and was less than 1,500 taf in 9 years (out of 82 years). The Shasta Reservoir carryover storage for the No Action Alternative (NAA) was less than 2,500 taf in 44 years, was less than 2,000 taf in 22 years and was less than 1,500 taf in 15 years. The increases for all of the storage thresholds would be judged adverse because an increase of greater than 5% of the years (5) was selected as the significance criteria. About 20–25% of the baseline carryover storage values should be less than the selected storage threshold, so that the threshold represents the lowest 20–25% of the years and so that the number of years with these impacted coldwater habitat conditions could be increased if the carryover storage values were reduced substantially by an alternative. The Shasta carryover storage threshold was selected to be 2,000 taf; the storage was less than this threshold in about 27% of the years (22/82) for the NAA.

Methods Used to Consider Mitigation

The construction and operation of the project or its alternatives would result in a range of short-term and long-term beneficial and adverse effects on environmental conditions in the Sacramento River and the Delta. This would in turn result in a range of direct and indirect effects on fish and aquatic resources that depend on the affected habitats. The BDCP conservation measures have been designed to avoid and minimize such impacts to covered fish species and natural communities and improve overall habitat conditions in the Plan Area. The project also incorporates environmental commitments (referred to as Avoidance and Minimization Measures in the Draft BDCP) which have been designed to avoid and minimize effects where possible. To the extent that effects remain, and such effects are deemed to be adverse or significant, feasible measures will be implemented to mitigate these effects to less-than-significant levels.

Each alternative is evaluated for each specific component of that alternative and its effects on individual life stages for each species. All effects identified as adverse and/or potentially significant have been evaluated for the feasibility of mitigation after first considering whether the entirety of conservation measures or environmental commitments built into the alternative would lessen the significant adverse environmental effects. Permanent and temporary impacts have been treated the same in considering the need for mitigation.

In situations where neither the conservation measures nor the environmental commitments (which include Best Management Practices [BMPs]) are capable of adequately avoiding or minimizing potential adverse effects, mitigation measures are presented, to the extent feasible, that will reduce adverse effects to levels that are not adverse or less than significant. In situations where feasible mitigation for significant adverse effects is not identified, the effect is considered significant and unavoidable.

11.3.2.7 Effects on Downstream Aquatic Habitat

Methodology to Determine Downstream Impacts of Restoration

To evaluate the annual volume of sediment needed to maintain marsh elevation as sea level rises, the vertical accretion of mineral and organic sediment across the area of marshes with and without restoration was modeled (depending on the alternative). Vertical accretion approximates the amount of suspended sediment that settles during each period of tidal inundation summed over the period of interest.

The Marsh98 model was used to calculate the marsh area across the period of interest for the existing conditions, No Action alternative, and action alternatives. The methodology and assumptions for this calculation are discussed in detail in Appendix 3B, *BDCP Tidal Habitat Evolution Assessment* of the Draft BDCP. The changing tidal area for each delta region, based on the incremental accretion over the period of interest for 10m x 10m areas and their associated elevations, was calculated using corrected LiDAR data and accelerated, nonlinear, sea level rise assumptions.

The vertical accretion model estimates sediment deposition for each tidal inundation period over the period of interest (Existing Conditions to Late Long-Term, 50 years). The amount of mineral sediment deposited at each period was determined by calculating the length of time inundated, the depth of inundation over that period, the suspended sediment concentration, and the assumed sediment density and settling velocity. In addition, there is an assumed 2 mm/year accretion rate of organic sediment consistent with historical records (ESA 2012). Values for sediment density[1] and settling velocity[2] were based on estimated values from the Sacramento River (Bliss 2004, Ganju 2005).

The depth and duration of inundation were calculated by comparing the water depth over the tidal period to the elevation of the marsh area at the timestep. The California Coast experiences mixed, semi-diurnal tides. This means that there are two unequal high tides and two unequal low tides during each day. For each region, an approximation of this cycle was calculated using a sine curve from the mean higher high water (MHHW), mean high water (MHW), mean low water (MLW), and the mean lower low water (MLLW). The model compares depth of water at each hour of this cycle to the marsh elevation and determines the length of time inundation in hours and the depth in meters. The vertical accretion is determined by calculating the ratio of the settling time by the period of inundation, the suspended sediment concentration (SSC), the depth of inundation and the density of the sediment (EQN 1).

The suspended sediment concentration historical record from 2013 recorded at the USGS station below Freeport was used for this model. The record from this year was used to account for the

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[1] Sediment Density is assumed to be 2650 kg/m^3

[2] Settling velocities in the Sacramento River were estimated to be between 0.01 and 0.10 mm/s

natural variation throughout the winter and summer months. SSC dramatically increases following winter storms and declines an order of magnitude during the drier summer months. The year 2013 was selected rather than the average of the historical record in order to retain the spikes in SSC concentration following storms and because as a dry year this provides a relatively conservative estimate of the concentration of sediment in the water column.

$$\frac{\left(\frac{Settling\ Time\ (hr)}{Inudation\ Time\ (hr)}\right)\left(SSC\frac{g}{m^3}\right)(Depth\ (m))}{Density\ \frac{m^3}{g}} = Depth\ Accreted(m) \qquad \text{(EQN 1)}$$

For each tidal period or time step, the depth accreted is added to the marsh elevation. At the next tidal period, the length of time inundated in hours and inundation depth are calculated with respect to the new marsh elevation. As the elevation increases, the length of time inundated in hours and inundation depth decrease and the amount of sediment accreted each time step declines as the marsh comes to equilibrium. This sequence occurs 350 times per year[3] and at the end of each year the final marsh elevation is set as the initial elevation and the process repeats until the full period of interest has been iterated through. Accelerated sea level rise is incorporated into this process by adjusting the water depths of the tidal period according to the sea level rise curve estimated in the Bay Delta Conservation Plan (Figure 2 and Table 11-20).

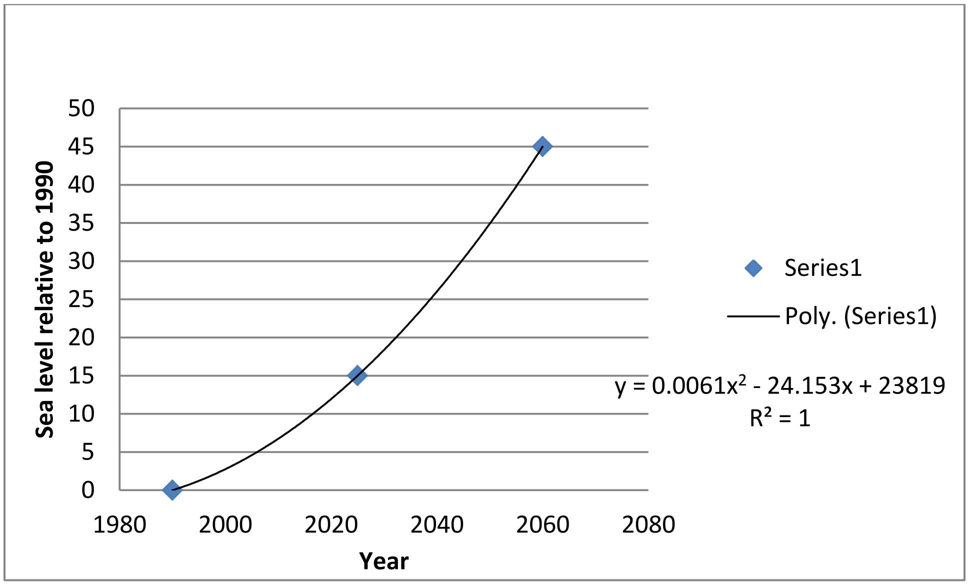

Figure 2. Calculated SLR curve for the Plan

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[3] A full tidal period is 25 hours and thus there are 350 tidal periods in one year

Table 11-20. Plan Sea Level and Associated Rate for Existing Conditions, ELT and LLT.

Year	SLR cm	Rate of SLR cm/yr
1990	0	0.125
2025	15	0.552
2060	45	0.979

The annual sediment volume needed to maintain marsh elevation is calculated from the difference in marsh elevation at the beginning and end of the year multiplied by the acreage of the marsh area and divided by the assumed sediment density value. Because the elevation of the marsh varies throughout, the model repeats the calculations for the minimum and maximum elevations for each marsh region and averages the annual sediment volume from both simulations. The model was run using the hypothetical acreages with and without restoration, depending on the alternative and thus produces an estimate annual sediment volume with and without restoration.

One of the most sensitive parameters of this model is the assumed settling velocity of Sacramento River watershed sediment. A range of settling velocities in the Sacramento River was estimated (Ganju and associates at the USGS 2005) to be between 0.01 and 0.10 mm/s. For the purposes of this model, a high, medium, and low estimate was produced using the average of this range and the 25th and 75th quartile values of this range.

Major assumptions of this model include:

- Suspended sediment concentration is uniform throughout that water column and throughout the marsh areas;
- Settling velocities are uniform throughout the marsh areas and throughout the tidal period;
- Marsh bed elevations are evenly distributed between the maximum and minimum elevations.

Similar to the Marsh98 model, this model does not take into account the influence of waves, which become more important as site size increases and availability of sediment diminishes. Furthermore, it does not distinguish between vegetation colonization for marsh areas with higher or lower salinity. Observations of accretion rates in delta marshes have shown that the type of vegetation (typical of fresh or brackish marshes) affects the rate of sediment deposition (Kiwan 2013).

11.3.2.8 Critical Habitat and Essential Fish Habitat

For federally listed species for which critical habitat has been designated, the analysis of whether there is an adverse effect to critical habitat is included within the analysis of effects to all habitat for the species. Prior to deciding whether to issue permits, USFWS and NMFS will undertake an analysis of the BDCP pursuant to the Section 7 consultation process to ensure that issuance of the permits and implementation of the BDCP is not likely to result in the destruction or adverse modification of critical habitat.

NMFS will also undertake an Essential Fish Habitat (EFH) consultation concurrent with the ESA Section 7 consultation.

11.3.3 Determination of Effects

The covered and non-covered fish and aquatic resource species discussed above have similar life history requirements (i.e., habitat, water quality) as all aquatic resource species in the project area. Because there are so many aquatic species in the project area, the covered and non-covered aquatic resource species are used as assessment species for the impact analysis. The impacts of the action alternatives on fish and aquatic biological resources may result from construction, maintenance, and operation of BDCP water conveyance facilities, as well as construction and implementation of other conservation measures. This impact analysis assumes that an action alternative would have an impact on fish and aquatic resources if it directly or indirectly harmed or harassed individuals or populations of the species considered in this chapter, or substantially removed or damaged the habitat of these species. Action alternatives that meet this initial screening threshold are then analyzed using the criteria described below.

The CEQA Guidelines (Title 14, Division 6, Chapter 3 of the California Code of Regulations [CCR]), at Section 15064.7, encourage public agencies to develop thresholds of significance to use in determining the significance of environmental effects when complying with CEQA. In this same section, the CEQA Guidelines define a threshold of significance as "an identifiable quantitative, qualitative or performance level of a particular environmental effect, non-compliance with which means the effect will normally be determined to be significant by the agency and compliance with which means the effect normally will be determined to be less than significant." Although Section 15064.7 authorizes a public agency subject to CEQA to conduct a formal public process for formulating significance thresholds that would apply to all of the agency's projects, the courts have recognized that, in preparing an individual CEQA document, a lead agency may informally develop significance criteria applicable to particular projects, provided that such criteria are supported by substantial evidence[4].

Here the significance criteria used to evaluate impacts on fish and aquatic resources are based on and incorporate guidance contained in Section 1508.27 of the Council on Environmental Quality (CEQ) NEPA regulations regarding significance determinations; the mandatory findings of significance, as listed in Section 15065 of the State CEQA Guidelines (Title 14, Chapter 3 of the CCR); and criteria contained in Appendix G, "Environmental Checklist Form," of the State CEQA Guidelines.

Section 1508.27 of the CEQ NEPA regulations defines the word "significantly," which comes into play in the statutory mandate under NEPA for federal agencies to prepare Environmental Impact Statements for major federal actions *significantly* affecting the human environment. (42 U.S.C. § 4321.) Under section 1508.27, federal agencies, in determining whether a major federal action significantly affects the human environment, should consider both the "context" and the "intensity" of the effects at issue. Context relates to the setting for the proposed action (i.e., whether it is regional or local in scale). Intensity "refers to the severity of impact." Among the factors to be considered in assessing intensity are "[t]he degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973."

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[4] See, e.g., Oakland Heritage Alliance v. City of Oakland (2011) (2011) 195 Cal.App.4th 884.896-897; Citizens for Responsible Equitable Environmental Development v. City of Chula Vista (2011) 197 Cal.App.4th 327, 336.)

In enacting CEQA, the California Legislature found and declared that it was the policy of the state, among other things, to "[p]revent the elimination of fish or wildlife species due to man's activities" and "insure that fish and wildlife populations do not drop below self-perpetuating levels[.]" (Cal. Pub. Resources Code section 21001[c]). CEQA Guidelines section 15065, which echoes this policy statement, identified several broadly framed impact categories that often serve as significance thresholds.

Similarly, the sample Initial Study Checklist found in Appendix G to the CEQA Guidelines identifies questions lead agencies should generally ask with respect to a proposed project's potential impacts on Biological Resources. The impact categories from CEQA Guidelines section 15065 and the Appendix G questions are often used to formulate more specific significance thresholds. For this analysis impact categories from CEQA Guidelines section 15065 and the Appendix G questions have been refined to apply to potential impacts on fish and other aquatic resources and impacts are considered significant under CEQA or adverse under NEPA if the BDCP Alternative would

- substantially reduce the habitat of a fish, aquatic, or wildlife species*;*
- cause a fish or wildlife population to drop below self-sustaining levels*;*
- threaten to eliminate a plant or animal community*;*
- substantially reduce the number or restrict the range of an endangered, rare or threatened species;
- have a substantial adverse effect, either directly or through habitat modifications, on any [aquatic] species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service [or by the National Marine Fisheries Service];
- have a substantial adverse effect on any … sensitive [aquatic] natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service; or
- interfere substantially with the movement of any native resident or migratory fish … species.

These seven enumerated thresholds have been applied to all determinations of effect, adverse for purposes of NEPA, and significant for purposes of CEQA, for each impact mechanism discussed in the following pages. All aspects of the alternatives are subject to these criteria, including the construction, maintenance, and operation of BDCP water conveyance facilities (CM1), and implementation of CM2–CM21. Consistent with the impact categories in CEQA Guidelines 15065, these thresholds are broadly framed and leave room for expert judgement and application to the numerous aspects of the alternatives and the multiple species evaluated. In both sets of analyses, the Lead Agencies have relied on computer models that represent best available science; however, any predictions of conditions 50 years from the present are inherently limited and reflect a single point (i.e., average or centroid position) in a predicted range.

Each alternative is analyzed in comparison to its relevant baseline. Under the CEQA analysis, each action alternative is compared against existing conditions at the time the NOP was prepared (State CEQA Guidelines, section 15125[a]). Under the NEPA analysis, each action alternative is compared against the anticipated future condition (CEQ Regulations, sections. 1502.14, 150216[d]) that would occur under the No Action Alternative in 2060. CEQA and NEPA baselines are more fully described in Chapter 4, Section 4.2.1.1. The NEPA baseline includes the projected climate change (changed precipitation patterns) and sea level rise, and many other programs, projects, and policies expected to occur by 2060, as well as the implementation of most of the required actions under both the December 2008 USFWS BiOp and the June 2009 NMFS BiOp (e.g., inclusion of Fall X2 criteria). As a result of differences between the CEQA and NEPA baselines, it is sometimes possible for CEQA and NEPA significance conclusions to vary between one another under the same impact discussion. Although the NAA represents projected future conditions, the manner in which some of the required actions under the BiOps would be implemented, and their resulting effects, remain uncertain at present. As a result, some of these required actions were not incorporated, and could not be accurately incorporated, into modeling for the NAA or for any of the action alternatives. However, they are still assumed to occur under both NAA and future conditions with alternatives because they are expected to be implemented under any future scenario (i.e., with or without Alternative 4A). While it is possible that the implementation of these unmodeled actions over time could alter the resultant magnitude of effects under the implementation of action alternatives, the unmodeled actions are intended to improve conditions for fisheries, so that their full implementation over time should contribute to reduced adverse environmental effects and to increased environmental benefits to species and their habitats. Thus, the analyses contained in this EIR/EIS are considered conservative with respect to any potential adverse environmental consequences related to the implementation of these unmodeled actions, and likely somewhat overstate the adverse effects of both the No Action Alternative and the proposed action alternatives. As a result, the future conditions in 2060 will likely be more environmentally benign than is reflected in the modeling results presented in the EIR/EIS.

Under CEQA, the absence of sea level rise and climate change in Existing Conditions results in model-generated differences between the CEQA baseline (Existing Conditions; no sea level rise or climate change) and alternatives (including sea level rise and climate change) that would occur under any future scenario (i.e., with our without Alternative 4A). As a consequence, the CEQA conclusions in many instances either overstate the effects of the action alternatives or suggest significant effects that are largely or entirely attributable to sea level rise and climate change, and not to the action alternatives.

In the interest of informing the public of what DWR believes to be the reasonably foreseeable impacts of the action alternatives, DWR has focused in its CEQA analysis primarily on the contribution of the action alternatives, as opposed to the impacts of sea level rise and climate change, in assessing the significance of the impacts of these action alternatives. As such, the CEQA analysis takes into account the results of the NEPA analysis to determine if and to what extent future sea level rise and climate change conditions are influencing the modeled differences in the CEQA comparison of Existing Conditions to the action alternatives, and adjusts the ultimate CEQA conclusion as necessary to describe the significance of the impacts of the action alternative only. The opposite approach, which would treat the impacts of sea level rise and climate change as though they were impacts of the action alternatives, would overestimate the effects of the action alternatives, diminishing the value of the analysis of effects. The approach taken here by DWR also has the effect of highlighting the substantial nature of the consequences of sea level rise and climate change on California's water system which up until this analysis, has not been comprehensively evaluated or disclosed for the CVP and SWP systems.

11.3.4 Effects and Mitigation Approaches

11.3.4.1 No Action Alternative

The No Action Alternative for the BDCP EIR/EIS means that the BDCP would not be implemented and incidental take permits would not be issued. This alternative entails programs, projects, and policies by federal, state and local agencies included in Existing Conditions assumptions and those with clearly defined management and/or operational plans, including facilities under construction as of February 13, 2009. The No Action Alternative assumptions also include facilities and programs that received approvals and permits in 2009 because those programs were consistent with existing management direction as of the NOP. As the NEPA baseline, the No Action Alternative includes continuation of operations of the SWP and CVP, with through-Delta conveyance only under currently authorized operational criteria as described in the 2008 BA with operational assumptions modified by the 2008 USFWS and 2009 NMFS BiOps and other relevant plans and projects that would likely occur in the absence of BDCP actions. This also assumes implementation of the Fall X2 RPA action (FWS 2008), which requires additional water releases in September, October and November following wet and above normal years. The No Action Alternative scenario (NAA) takes into account sea level rise and climate change that were modeled to occur around Year 2060.

The NAA assumes compliance with the California Endangered Species Act (CESA) and the federal Endangered Species Act (ESA) will continue on a case-by-case basis for future programs and projects that have a potential to take listed species under each act. It also assumes utilization of senior water rights in the Sacramento and San Joaquin river watersheds by Year 2025 utilizing facilities currently available or under construction.

The NAA assumes continued operations of flood management facilities by the federal, state, and local agencies. It also assumes that future levee failures due to flooding, erosion, subsidence, wave action, seismic events, burrowing animals, physical encroachment (such as barge collisions), or other causes would be repaired under ongoing programs.

Existing Conditions, the CEQA baseline, are defined in Appendix 3D, *Defining Existing Conditions, No Action Alternative, No Project Alternative, and Cumulative Impact Conditions*. Briefly, Existing Conditions include the 2008 USFWS and 2009 NMFS BiOps, facilities and ongoing programs in place as of February 13, 2009, but do not include implementation of Fall X2, which had not been implemented at the time the NOP was prepared (in 2009).

A summary of the programs, plans, and projects included under the NAA and Existing Conditions, as well as detailed descriptions of these baselines, are provided in Appendix 3D, *Defining Existing Conditions, No Action Alternative, No Project Alternative, and Cumulative Impact Conditions*. The projects that could affect fish and aquatic resources are summarized here in Table 11-21, along with their anticipated effects on covered fish species (see Section 11.1.3.1) and aquatic resources.

Table 11-21. Effects on Covered Fish Species from the Plans, Policies, and Programs for the No Action Alternative

Agency	Program/ Project	Status	Description of Program/Project	Effects on Covered Fish Species
California Department of Water Resources	FERC License Renewal for Oroville Project	Draft Water Quality Certification issued December 6, 2010 and comments on Draft received December 10, 2010. FERC license will be issued and operations will be in accordance with NMFS BiOp and final FERC license.	The renewed federal license will allow the Oroville Facilities to continue providing hydroelectric power and regulatory compliance with water supply and flood control.	No adverse effects on aquatic habitat or covered fish species are expected based upon environmental documentation for this project (California Department of Water Resources 2008).
Contra Costa Water District	Contra Costa Canal Fish Screen Project	Completed in 2011.	The project installed a fish screen at the Contra Costa Canal diversion at Rock Slough.	Beneficial effects on aquatic habitat or covered fish species are expected.
Contra Costa Water District, U.S. Bureau of Reclamation, and California Department of Water Resources	Middle River Intake and Pump Station (previously known as the Alternative Intake Project)	Completed in 2011.	The project includes a 250 cfs pump station, a screened intake structure along Victoria Canal on Victoria Island, and a pipeline across Victoria Island tunneled under Old River to the District's Old River Pump Station where it connects to existing conveyance facilities.	No adverse effects on aquatic habitat or covered fish species are expected based upon environmental documentation for this project (Contra Costa Water District 2006).
Freeport Regional Water Authority and U.S. Bureau of Reclamation	Freeport Regional Water Project	Completed in 2010.	The project includes an intake/pumping plant near Freeport on the Sacramento River and a conveyance structure to transport water through Sacramento County to the Folsom South Canal. The pumping plant diverts 185 million gallons per day.	No adverse effects on aquatic habitat or covered fish species are anticipated based upon environmental documentation for this project (Freeport Regional Water Authority 2003).
City of Stockton	Delta Water Supply Project	Completed in 2012.	This project consists of a new intake structure and pumping station adjacent to the San Joaquin River; a water treatment plant along Lower Sacramento Road; and water pipelines along Eight Mile, Davis, and Lower Sacramento Roads.	No adverse effects on surface water resources or covered fish species are anticipated based upon environmental documentation for this project (City of Stockton 2005).

Agency	Program/ Project	Status	Description of Program/Project	Effects on Covered Fish Species
Reclamation District 2093	Liberty Island Conservation Bank	Completed in 2011.	The project consists of restoration of 186 acres on Liberty Island in unincorporated Yolo County. Restoration was focused on enhancing and creating tidal aquatic habitat suitable for special-status fish species (including salmon and delta smelt).	No adverse effects on aquatic habitat or covered fish species are anticipated based upon environmental documentation for this project (Bureau of Reclamation 2009).
Tehama Colusa Canal Authority and U.S. Bureau of Reclamation	Red Bluff Diversion Dam Fish Passage Project	Pumping plant and fish screen was completed in 2012. Operations of the pumping plant began September 2012. Expected decommissioning of the old structure to begin September 2013.	Proposed improvements include modifications made to upstream and downstream anadromous fish passage and water delivery to agricultural lands within CVP.	No adverse effects on aquatic habitat or covered fish species are anticipated based upon environmental documentation for this project (Bureau of Reclamation 2002).
U.S. Bureau of Reclamation and State Water Resources Control Board	Battle Creek Salmon and Steelhead Restoration Project	Construction is being implemented in three phases and is currently underway. The final phase is estimated to occur between 2013 and 2015.	This project includes modification of facilities at Battle Creek Hydroelectric Project diversion dam sites located on the North Fork Battle Creek, South Fork Battle Creek, and Baldwin Creek. Fish screens and ladders will be installed at various location; a fish barrier will be installed on Baldwin Creek; an Inskip Powerhouse tailrace connector and bypass will be installed on the South Fork; a South Powerhouse tailrace connector will be installed; and Lower Ripley Creek Feeder, Soap Creek Feeder, Coleman and South diversion dams, and appurtenant conveyance systems will be removed.	

Agency	Program/ Project	Status	Description of Program/Project	Effects on Covered Fish Species
U.S. Bureau of Reclamation, California Department of Fish and Game, and Natomas Central Mutual Water Company	American Basin Fish Screen and Habitat Improvement Project	Expected completion in 2012.	This three-phase project includes consolidation of diversion facilities; removal of decommissioned facilities; aquatic and riparian habitat restoration; and installing fish screens in the Sacramento River. Total project footprint encompasses about 124 acres east of the Yolo Bypass.	No adverse effects on aquatic habitat or covered fish species are anticipated based upon environmental documentation for this project (Bureau of Reclamation 2008c).
Yolo County	General Plan Update	Adopted in November 2009.	The Yolo County general plan provides comprehensive and long-term policies for the county and determines land use planning throughout the unincorporated area.	No adverse effects on aquatic habitat or covered fish species are anticipated.
Zone 7 Water Agency and Department of Water Resources	South Bay Aqueduct Improvement and Enlargement Project	Under construction. Estimated completion in 2012.	This project includes upgrades to the South Bay Pumping Plant; raised linings on open channel sections of the aqueduct; the addition of a 450 acre-foot Dyer Reservoir; and 4.5 miles of pipeline connecting to the South Bay Pumping Plant	No adverse effects on aquatic habitat or covered fish species are anticipated based upon environmental documentation for this project (California Department of Water Resources 2004c).

Impact AQUA-NAA1: Effects of Construction of Facilities on Covered Fish Species

~~***NEPA Effects:*** Overall, the potential impact mechanisms on covered fish species from construction of other projects under NAA would include effects from increased turbidity, accidental spills, disturbance of contaminated sediment, underwater noise, fish stranding, in-water work activities, loss of spawning, rearing or migration habitat, and predation. However, as described above, these effects would not be adverse because of the limited extent, intensity, and duration of expected construction and maintenance projects in the Plan Area. In addition, any such construction projects would be subject to a separate environmental compliance process, with permit stipulations which would include the implementation of project-specific AMMs, BMPs, environmental commitments and/or mitigation measures. This would include project-specific erosion and sediment control plans; hazardous materials management plans; SWPPPs; spill prevention and control plans; and limiting in-water activities to periods of low flow and/or to times when covered fish species are not likely to be present. Therefore, the effects of construction projects on covered fish species would not be expected to be adverse, and no additional mitigation would be required. However, if the effects were determined to be adverse, it is assumed that appropriate mitigation would be implemented.~~

~~***NEPA Effects:*** The discussion of maintenance activity effects are provided above with the construction effects (Impact AQUA-NAA1), and the conclusions would also not be adverse.~~

CEQA Conclusion: The ~~conclusion~~ analysis provided above for the construction activity effects (Impact AQUA-NAA1)~~, would typically be very similar to those~~also includes impacts expected to occur during maintenance activities, ~~and conclusions would also not be~~with the same conclusion that the impact is less than significant.

Water Operations ~~of CM1~~

Impact AQUA-NAA3: Effects of Water Operations on Entrainment of Covered Fish Species

Delta Smelt

Simulations of entrainment for baseline conditions differ depending on the time period modeled because the climate change scenarios change operations somewhat. However, the average annual proportion of the delta smelt population lost to entrainment at the south Delta facilities under Existing Conditions, increased under model simulations of future conditions (NAA), most notably in wet, above-normal and below-normal water years. This proportional entrainment loss reflects differences attributable to simulated differences in south Delta export pumping (which influences OMR flows) and Delta outflow/sea level~~s~~ (which influences X2 and therefore the distribution of delta smelt). Despite these modeled increases in entrainment, the differences are not expected to reach the level of adverse effects on the delta smelt population~~s~~ (i.e., ~5% of the adult population, or the mean level of larval/juvenile entrainment estimated to have occurred in 2005–2008~~less than 5% of the population~~), primarily due to the implementation of restrictions ~~implemented as~~that are part of the USFWS 2008 BiOp and the incidental benefits of the NMFS 2009 BiOp, and continued improvements in water export and fish salvage operations at the south Delta facilities~~s, as well as efforts to divert delta smelt from exposure to these facilities~~. Overall the effect would not be adverse.

Delta smelt are also entrained at agricultural and waterfowl management diversions in the Plan Area (Pickard et al. 1982; Cook and Buffaloe 1998; Nobriga et al. 2004). Water export operations (through their effects on Delta flow and residence time) may also affect delta smelt entrainment in irrigation diversions (Kimmerer and Nobriga 2008), although Delta smelt are not considered highly vulnerable to entrainment at Delta agricultural diversions (Nobriga and Herbold 2009; Nobriga et al. 2004).

~~***NEPA Effects:*** As indicated above, despite the modeled increases in entrainment, the differences are not expected to reach the level of adverse effects on delta smelt populations (less than 5% of the population). This is primarily due to the compliance with the USFWS 2008 BiOp and the NMFS 2009 BiOp, and continued improvements in water export processes, fish screens, and fish salvage operations at the south Delta facilities. Therefore, the effect would not be adverse.~~

CEQA Conclusion: Implementation of south Delta export pumping restrictions under the USFWS (2008) BiOp has considerably limited entrainment loss of ~~adult~~ delta smelt. This would continue into the future, under the No Action Alternative. Along with other improvements in SWP/CVP facilities and operations expected to occur in the future (e.g., salvage improvements under the NMFS 2009 BiOp), the impact of entrainment ~~the effect~~ would be less than significant and no mitigation would be required.

Longfin Smelt

Entrainment at the SWP and CVP facilities is not believed to be an important stressor influencing the survival of longfin smelt larvae in recent years because of the implementation of the SWP California Department of Fish and Wildlife longfin smelt Incidental Take Permit (ITP) No. 2081-2009-001-03 (California Department of Fish and Wildlife 2009). ~~However, if entrainment were to be a problem for longfin smelt, its effect would be seen~~The potential effect of entrainment is greater in dry years when recruitment is expected to be lower relative to wet years, and the population is distributed further upstream. ~~Consequently, the population-level impact of this stressor on longfin smelt larvae is believed to be low. Further, e~~Entrainment of longfin smelt is expected to remain low, primarily due to the restrictions implemented as part of the longfin smelt ITP and USFWS 2008 BiOp for delta smelt, and ~~and~~ the incidental benefits provided by the NMFS 2009 BiOp, as modeled in the NAA. Overall the effect of entrainment would not be adverse.

Longfin smelt are also entrained at agricultural and waterfowl management diversions in the Plan Area (Pickard et al. 1982; Cook and Buffaloe 1998; Nobriga et al. 2004; Enos et al. 2007), and water export operations, through their effect on Delta flow and residence time may affect longfin smelt entrainment in irrigation diversions (Kimmerer and Nobriga 2008). Longfin smelt are not considered highly vulnerable to entrainment in Delta agricultural diversions.

~~NEPA Effects:~~ ~~Under the NAA, entrainment would be reduced by continued efforts to screen these intakes. Therefore, the effect would not be adverse.~~

perational activities associated with water exports from SWP/CVP south Delta facilities during the NAA period, would not result in an overall substantial increase in entrainment for longfin smelt under most circumstances. ~~Improvements in water export and fish salvage operations as a result on on-going studies, t~~The continued implementation of the longfin smelt ITP and the USFWS 2008 BiOp ~~(U.S. Fish and Wildlife Service 2008) and actions taken by the water project operators in accordance with this BiOp~~ are expected to ~~result in an overall beneficial effect~~limit entrainment to the levels observed under Existing Conditions. ~~Consequently, no mitigation would be required.~~

~~*Chinook Salmon*~~

~~Four races of Chinook salmon can occur in the Plan Area: Sacramento winter, spring, fall, and late fall-run ESUs. Each of these Chinook salmon races uses the Delta as migratory and rearing habitat during their respective life histories, implying that they would be subject to a similar range of effects from water export operations. Although the duration, extent, and timing of occurrence in the lower Sacramento River and the Delta varies between these races, and they would be subject to different stressor exposures and degree of potential effects, the mechanisms of effect would be very similar.~~ Along with other improvements in SWP/CVP facilities and operations expected to occur in the future (e.g., salvage improvements under the NMFS 2009 BiOp), the impact of entrainment would be less than significant and no mitigation would be required.

Winter-Run Chinook Salmon

Under baseline conditions, losses of juvenile winter-run Chinook salmon begin in December and climb to peaks in March at both facilities, before sharply declining in April. In general, entrainment losses of winter-run Chinook salmon, as estimated by the salvage density method, were ~~approximately five to 10 times greater at the SWP facility than those estimated for the CVP export facility. Estimated annual losses at SWP across all water years averaged approximately 6,000 fish, while the annual average loss at CVP was approximately 830–860 fish under baseline. Only a small~~

~~proportion of the population would be lost to entrainment based on the simplified assumption that the annual number of winter-run Chinook salmon juveniles approaching the Delta is 500,000 fish. Proportional losses averaged across all years were 1.4% under NAA.~~very similar between Existing Conditions and NAA. It is expected that there would be very little difference in entrainment between these scenarios because the NAA would continue to implement the same NMFS 2009 BiOp restrictions on OMR flows as occur under Existing Conditions. Along with other improvements in SWP/CVP facilities and operations expected to occur in the future (e.g., salvage improvements under the NMFS 2009 BiOp), the impact of entrainment would be less than significant and no mitigation would be required.

Spring-Run Chinook Salmon

~~In general, estimated losses of spring-run Chinook salmon at the SWP facility were approximately two to three times greater than those estimated for the CVP export facility. Estimated annual losses at SWP across all water years averaged approximately 22,000–24,000 juvenile spring-run Chinook salmon under baseline; for the CVP, the annual average loss was approximately 15,000 fish under baseline conditions. Losses were greatest in wet years (>40,000 fish) and lowest in below-normal years (1,000–5,000 fish) at both facilities under baseline conditions. The estimated percentage of juvenile spring-run Chinook salmon salvaged at the SWP/CVP south Delta export facilities averaged approximately 0.06–0.10% for baseline scenarios. Under the assumption that the annual number of juvenile spring-run Chinook salmon juveniles approaching the Delta was 750,000 fish, the percentage of the population lost to entrainment across all years averaged approximately 5.0–5.3% under baseline scenarios. However, genetic testing indicates that many fall-run juveniles are misidentified as spring-run based on the length-at-date criteria that are currently used to assign run origin of juveniles salvaged at the export facilities (Harvey pers. comm.).~~ As with winter-run Chinook salmon, entrainment losses of spring-run Chinook salmon, as estimated by the salvage density method, were very similar between Existing Conditions and NAA. It is expected that there would be very little difference in entrainment between these scenarios because the NAA would continue to implement the same NMFS 2009 BiOp restrictions on OMR flows as occur under Existing Conditions~~the estimates of salvage from the Delta Passage Model were considerably less than the entrainment loss estimates from the salvage density method, even accounting for losses not included in the Delta Passage Model estimates~~. Along with other improvements in SWP/CVP facilities and operations expected to occur in the future (e.g., salvage improvements under the NMFS 2009 BiOp), the impact of entrainment would be less than significant and no mitigation would be required.

Fall- and Late-Fall Run Chinook Salmon

As with winter-run and spring-run Chinook salmon, entrainment losses of fall- and late fall-run Chinook salmon, as estimated by the salvage density method, were similar between Existing Conditions and NAA. It is expected that there would be very little difference in entrainment between these scenarios because, although not specifically intended to protect fall- and late fall-run Chinook salmon, the NAA would continue to implement the same USFWS 2008 BiOp and NMFS 2009 BiOp restrictions on OMR flows as occur under Existing Conditions, which would provide incidental benefit to fall- and late-fall run Chinook salmon. Along with other improvements in SWP/CVP facilities and operations expected to occur in the future (e.g., salvage improvements under the NMFS 2009 BiOp), the impact of entrainment would be less than significant and no mitigation would be required.~~As noted above for juvenile spring-run Chinook salmon, the seasonal entrainment pattern is the best index of entrainment—as opposed to the actual numbers of fish—because of the overlap~~

~~between juvenile fall- and spring-run Chinook salmon and the length-at-date criteria used to characterize race. Entrainment loss of fall-run Chinook salmon peaks in May at both the SWP and CVP facilities, with a second similar peak in February at the CVP facility.~~

~~In general, estimated losses of fall-run Chinook salmon were approximately 1.5 to three times greater at the SWP export facility compared to the CVP export facility. Estimated losses of late fall–run Chinook salmon varied between the two facilities, with entrainment loss at the CVP generally being lower than at the SWP, but not in all water-year types.~~

~~For fall-run Chinook salmon, estimated annual losses at the SWP across all water years averaged approximately 36,000 fish, and approximately 19,000 fish at the CVP, under baseline conditions. Losses of fall-run Chinook salmon were greatest in wet years (77,000–82,000 fish at SWP; 50,000 fish at CVP), and lowest in below-normal years at the SWP (8,000 fish) and in dry years at the CVP (2,500–2,700 fish) under baseline conditions.~~

~~For late fall–run Chinook salmon, estimated annual losses averaged across all water years at the SWP and CVP facilities were nearly 900 and 1,000 fish, respectively under baseline scenarios. Entrainment losses of late fall–run Chinook salmon were greatest in wet years (SWP: 2,600–2,800 fish); CVP: 3,200–3,400 fish) under baseline conditions. Entrainment losses in other water-year types were one or two orders of magnitude lower than in wet years.~~

~~Under the assumption that the annual number of juvenile fall-run Chinook salmon approaching the Delta was 23 million fish, the percentage of the population lost to entrainment across all years averaged 0.24% under baseline scenarios. The percentage of all juveniles lost to entrainment was greatest in wet years (0.6%). The percentage of fall-run and late fall–run Chinook salmon estimated to be lost to entrainment from the salvage density method was well below 1%, and the estimated salvage from the Delta Passage Model for Sacramento River–origin fish was also very low (below 0.1%). The estimated salvage of San Joaquin–origin fall-run Chinook salmon was above 1% for baseline conditions, reflecting the greater likelihood of fish from the San Joaquin watershed reaching the south Delta export facilities than the Sacramento River–origin fish.~~

~~***NEPA Effects:*** General improvements implemented during the NAA timeframe are expected to reduce entrainment losses of Chinook salmon through the implementation of the NMFS and USFWS BiOp requirements (National Marine Fisheries Service 2009a; U.S. Fish and Wildlife Service 2008), particularly the reduced reverse OMR flow criteria and actions taken by the water project operators in accordance with this BiOp. The improvements expected to occur in the rate of entrainment at the SWP/CVP south Delta facilities, under NAA are likely to be generally beneficial, and would not be adverse to Chinook salmon.~~

~~General on-going improvements implemented under Existing Conditions during the NAA timeframe are expected to reduce entrainment losses of Chinook salmon through the implementation of the NMFS and USFWS BiOp requirements (National Marine Fisheries Service 2009a; U.S. Fish and Wildlife Service 2008), particularly the reverse OMR flow criteria, court-ordered restrictions on water operations, and actions taken by the water project operators in accordance with this BiOp. Therefore, the overall effects for the NAA period are expected to be less than significant, and likely to be generally beneficial. Consequently, no mitigation would be necessary.~~

Steelhead

As with Chinook salmon, entrainment losses of steelhead, as estimated by the salvage density method, were similar between Existing Conditions and NAA. It is expected that there would be very little difference in entrainment between these scenarios because the NAA would continue to implement the same USFWS 2008 BiOp and NMFS 2009 BiOp restrictions on OMR flows as occur under Existing Conditions. Along with other improvements in SWP/CVP facilities and operations expected to occur in the future (e.g., salvage improvements under the NMFS 2009 BiOp), the impact of entrainment would be less than significant and no mitigation would be required.~~Under baseline conditions, entrainment peaks in February at both SWP and CVP facilities and is also relatively high in January and March. Estimated entrainment losses for juvenile steelhead were approximately four times greater at the SWP export facilities compared to the CVP export facilities, with losses at both facilities, due to entrainment, generally from 1,000 to 10,000 fish per year. Losses were greatest in above-normal and below-normal years, and least in critical water years. However, on-going and future operational improvements at the SWP and CVP south Delta facilities would likely result in a general decrease in entrainment for juvenile steelhead under NAA.~~

~~***NEPA Effects:*** Consequently, the effect would likely be slightly beneficial, and would not be adverse.~~

~~n-going and future operational improvements at the SWP and CVP south Delta facilities would likely result in a general decrease in entrainment for juvenile steelhead under NAA. Potential impacts of the No Action Alternative on entrainment of steelhead could be slightly beneficial, and no mitigation would be required.~~

Sacramento Splittail

~~The methods used to estimate juvenile splittail entrainment were designed to account for the very large effect of Sacramento splittail abundance on entrainment (detailed in *Appendix 5B Entrainment, Section B.5.4.5*), and the bulk of salvage occurs in wet years.~~ Across all water years, estimated May–July salvage of juvenile Sacramento splittail under the NAA was ~~generally several times higher at the CVP facilities than the SWP facilities~~appreciably lower than under Existing Conditions, based on the per capita entrainment (salvage) index. The overall mean salvage of adult splittail (December-March) was also less under NAA than Existing Conditions. Splittail presumably would incidentally benefit from the various BiOp pumping restrictions intended for smelts and salmonids, as well as other improvements in SWP/CVP facilities and operations expected to occur in the future (e.g., salvage improvements under the NMFS 2009 BiOp). ~~, with the differences in salvage estimates between the facilities diminishing with lower Delta inflow.~~

~~***NEPA Effects:*** Overall, the effects of the No Action Alternative on Sacramento splittail entrainment in the NAA period are not expected to be adverse, and may be somewhat beneficial due to on-going structural and operational improvements at the south Delta export facilities.~~

~~perational cassociated with water exports from SWP/CVP south Delta facilities are not expected to result in an overall increase in per capita entrainment for Sacramento splittail in the NAA, and could be somewhat beneficial.~~Therefore, impacts of the No Action Alternative on entrainment are considered less than significant, and no mitigation would be required.

Sturgeon

~~Available information on the distribution and abundance of sturgeon in the Plan Area is provided in Appendix 11A, *Covered Fish Species Descriptions*. Total annual average baseline salvage of juvenile green sturgeon at the SWP south delta facilities was estimated at approximately 70 fish while baseline salvage levels at the CVP ranged from 37 to 45 green sturgeon. Total annual average~~

~~salvage of juvenile white sturgeon at the SWP was estimated to be somewhat higher at 135–160 fish under baseline scenarios, and from 110 to 130 fish at the CVP.~~

~~perational cassociated with water exports from south SWP/CVP facilities are expected to continue to improve over time, as more information is obtained from studies regularly conducted in the area regarding the fish behavior, project operations, and entrainment. This information, and any resulting structural and operational changes, are expected to result in a slight decrease in entrainment of white and green sturgeon.~~

~~***NEPA Effects:*** Based on available information, overall entrainment effects on sturgeon, at the south Delta water export facilities are not expected to substantially change under the NAA. Consequently, the effect would not be adverse.~~

CEQA Conclusion: Estimates of entrainment (salvage) from the salvage-density method showed that salvage on average presumably would incidentally benefit from the various BiOp pumping restrictions intended for smelts and salmonids, as well as other improvements in SWP/CVP facilities and operations expected to occur in the future (e.g., salvage improvements under the NMFS 2009 BiOp)~~As described above, structural and operational changes associated with water exports from south SWP/CVP facilities are not expected to substantially change the entrainment of sturgeon in the NAA, based on continued improvements implemented under the 2009 NMFS and 2008 USFWS BiOps~~. Overall, impacts of water operations on sturgeon entrainment would be less than significant and no mitigation would be required.

Lamprey

~~Although somewhat limited, the available information on the distribution and abundance of lamprey in the Plan Area is provided in Appendix 11A, Covered Fish Species Descriptions. The~~The entrainment analysis for Pacific and river lamprey was combined because the CVP and SWP fish salvage facilities do not distinguish between the two species. ~~Estimated average expanded salvage densities of lamprey for each month as reported by the facilities during water years 1996–2009 used in this analysis reflect historical expanded salvage density data. Estimated average expanded salvage under baseline scenarios (all time periods) ranged from zero in September at the SWP to more than 1,300 at the CVP in January, for average annual totals of approximately 720–740 lamprey at the SWP and 2,600 lamprey at the CVP.~~Across all years, estimated salvage based on the salvage-density method was similar between NAA and Existing Conditions. As with other species, h presumably would incidentally benefit from the various BiOp pumping restrictions intended for smelts and salmonids, as well as other improvements in SWP/CVP facilities and operations expected to occur in the future (e.g., salvage improvements under the NMFS 2009 BiOp).

~~***NEPA Effects:*** Based on available information, overall entrainment effects on lamprey populations are not expected to substantially change under the NAA. Therefore it is anticipated that there will not be an adverse effect on lamprey.~~

~~As described above, structural and operational activities associated with water exports from south SWP/CVP facilities are not expected to substantially change entrainment of lamprey through the NAA period.~~ Overall, the impacts of water operations ~~to~~ on entrainment of Pacific and river lamprey are considered less than significant, and no mitigation is required.

Impact AQUA-NAA4: Effects of Water Operations on Spawning and Egg Incubation Habitat for Covered Fish Species

~~Water operations in the NAA are not expected to substantially or consistently affect spawning habitat for most covered fish species~~ in relation to Existing Conditions~~. Upstream of the Delta, flows could be affected by changes in water storage volumes associated with meeting the Fall X2 targets included in the USFWS BiOp. Such changes could affect upstream spawning conditions for some covered fish species.~~

~~Shasta Reservoir storage volume at the end of May influences flow rates below the dam during the May through September winter-run Chinook salmon spawning and egg incubation period. Although results of various analyses did not show appreciable differences for winter-run Chinook salmon. The other Chinook salmon populations typically spawn in tributaries—in which spawning habitat and egg mortality would not be substantially affected by the project operations.~~

~~Reduced summer flows could affect green sturgeon spawning conditions in some water years and could have the potential to increase exposure of a number of other covered fish species to their respective upper temperature thresholds.~~

~~***NEPA Effects:*** The effect of the NAA operations on delta smelt, longfin smelt, and Sacramento splittail spawning habitat is not adverse, because there would be little change~~ in ~~spawning conditions that the Project can influence under NAA. Longfin smelt spawning flows would be slightly reduced by 2% relative to Existing Conditions when climate change effects are accounted for (NAA), but not to an adverse level. Decreased summer flows could adversely affect spawning habitat and egg survival for some covered fish species, such as winter-run Chinook salmon and green sturgeon, although no major or consistent impacts were found on upstream spawning and egg incubation habitat conditions. Consequently, impacts on spawning and incubation for the covered species are considered less than significant.~~

CEQA Conclusion: ~~As described above, o~~Operations under NAA ~~generally~~ would cause significant effects relative to~~be similar to~~ Existing Conditions~~, and would typically have no biologically meaningful effect on spawning habitat of most covered fish species. However, Shasta Reservoir storage volume at the end of May would be lower than storage volume under Existing Conditions in below normal, dry, and critical water years, indicating a small–to-moderate impact from summer water flows and temperatures. These conditions could affect spawning habitat and egg survival for some covered fish species, such as winter-run Chinook salmon and green sturgeon, although no major or consistent effects were identified. The effect could be significant for sturgeon over the NAA period.~~There would be minor differences between the NAA and Existing Conditions in flows in the Sacramento River that would not cause a biologically meaningful effect to spawning. ~~No other major or consistent significant impacts were found on upstream spawning and egg incubation habitat conditions for other covered fish species. Consequently, overall, impacts for these other covered species are considered less than significant.~~In the Feather River, flows in late fall and winter (October through March) would generally be lower under the NAA. Flows in May though September would generally be higher. Reduced flows have the potential for negative effects on spawning spring-run and fall-run Chinook salmon, steelhead, and green and white sturgeon. However, flows in the low flow channel, where most salmonids spawn, would not be affected by NAA. Therefore, only effects to green and white sturgeon spawning would be significant in the Feather River. In the American River, flows would generally be lower in most months, other than January through April. Therefore, spawning for fall-run Chinook salmon and steelhead would be significantly affected.

Flows in the Stanislaus and San Joaquin Rivers would be lower during the same months as in the American River. Therefore, spawning fall-run Chinook salmon would be significantly affected in these rivers. Differences in flows in Clear Creek between NAA and Existing Conditions would be negligible.

~~-~~In the Delta, there also generally would be little effect of the NAA on delta smelt and longfin smelt in relation to Existing Conditions. Spawning/egg incubation/rearing habitat for longfin smelt, as estimated with the X2-abundance relationships from Kimmerer et al. (2009), would be considerably lower under NAA than Existing Conditions (e.g., 33% lower for the all-year-average Fall Midwater Trawl Index). This reflects greater salinity (and therefore higher X2) as a result of sea level rise, and not simply an operational effect, because a no action alternative (EBC2) without sea level rise and including current climate gives a very similar abundance index estimate to Existing Conditions (see Table 5C.5.4-38 in Appendix 5.C of the public draft BDCP). Given the expected rise in sea level, and the resulting greater X2 for a given outflow, as well less inflow in spring (May/June) because of climate change (more precipitation as rain, as opposed to snow), it would be expected that baseline conditions would gradually decline with respect to the X2-abundance relationship, while still oscillating around greater or lesser values depending on the variability in outflow in each year. Therefore, primarily as a result of climate change, the impact of NAA ~~when accounting for climate change, the impact~~ would be ~~less than~~ significant~~ and no mitigation would be required.~~

Impact AQUA-NAA5: Effects of Water Operations on Rearing Habitat for Covered Fish Species

CEQA Conclusion:The SWP/CVP operations are managed to meet instream flow requirements, water rights agreements, and refuge water supply agreements in the Sacramento and San Joaquin Valleys. Water supplies are provided in a consistent manner under Existing Conditions, and this would be expected to continue into the future under the NAA. However, the NAA includes sea level rise and other anticipated climate changes, as well as expected increase in water rights demands, implementation of facilities currently under construction, and on-going implementation of Fall X2 criteria, all of which affect operations relative to ~~current conditions~~Existing Conditions. Detailed discussions of what is included in the NAA are provided in Appendix 3D, Defining Existing Conditions, No Action Alternative, No Project Alternative, and Cumulative Impact Conditions. Operations to meet Fall X2 criteria would require release of water from the SWP/CVP reservoirs in the fall of wet and above-normal years to increase Delta outflow, which would increase rearing habitat in the Delta in the fall, but would also likely reduce flows (and rearing habitat) at other times of the year. Habitat suitability would also decrease slightly over time, because of anticipated increases in summer-early fall air (and thus water) temperatures associated with climate change. Changes in temperature and salinity, due to sea level rise and climate change, and associated operational responses, are expected to alter the distribution of covered fish species, based on behavioral responses of the fish to these stressors.

~~Lower summer~~Changes in flows described in AQUA-NAA-4 flows under NAA compared to Existing Conditions in some areas are expected to affect rearing conditions for ~~most, if not~~ all ~~covered fish species~~salmonids and sturgeon~~,~~ somewhere in the system. ~~For example, reduced summer flows would have the potential to reduce the quality and quantity of rearing habitat for the covered fish species, such as spring- and fall-run Chinook salmon and green sturgeon in the Feather River, and delta smelt, sturgeon and splittail in the estuary. In tributary streams, lower summer flows may increase the frequency of water temperatures exceeding the upper tolerance thresholds for some species~~. Thus, the effect of ~~lower summer river flows~~these changes to upstream flows ~~could~~ would be ~~adverse~~ significant for covered fishes under the NAA operations relative to Existing Conditions.

~~Under the No Action Alternative, peak monthly flows into the Yolo Bypass at Fremont Weir would be less than under Existing Conditions and less than the Yolo Bypass capacity of 343,000 cfs at Fremont Weir. This would result in a reduction in the rearing habitat in the Yolo Bypass, particularly for salmon populations, as well as a reduced spawning habitat for Sacramento splittail. As a result, the availability and quality of tributary stream and Delta floodplain rearing habitat would likely be reduced in the NAA, relative to Existing Conditions; Delta outflows would also be reduced, relative to Existing Conditions.~~

~~NEPA Effects: While these reductions could be greater than 5%, compared to the overall available habitat in the Plan Area, the loss of this restored habitat is not expected to be adverse for the covered fish species.~~

~~CEQA Conclusion:lows would also be generally similar to, or greater than, flows under Existing Conditions throughout most months and water flow years, although some reductions are expected. For example, reduced summer flows would affect rearing habitat conditions for winter-run Chinook salmon, and green and white sturgeon, which would include increased water temperatures, and could result in decreased survival over the NAA period. The effect could be significant for these covered species over the NAA period. The overall effects of the No Action Alternative would be less than significant for the other covered fish species.~~

Impact AQUA-NAA6: Effects of Water Operations on Migration Habitat for Covered Fish Species

Reverse flow conditions for Old and Middle River flows on a long-term average basis under NAA would be similar to Existing Conditions, except in September through November. During wet and above-normal years, fall flows in Old and Middle River could be more positive due to compliance with Fall X2, which may reduce water diversion rates at the SWP/CVP south Delta intakes during September-November. This is expected to benefit fall-run Chinook salmon migration conditions by providing improved olfactory cues, thereby potentially reducing straying.

Changes in water operations under the No Action Alternative would typically result in lower summer flows, compared to Existing Conditions, although such changes would be largely due to the overall effects of climate change on upstream reservoir management. This would adversely affect migration conditions for some covered fish species, particularly juvenile winter-run Chinook and green sturgeon.

The No Action Alternative would not affect the first flush of winter precipitation and the turbidity cues associated with adult delta smelt, ~~long-fin smelt, splittail, and steelhead~~ migration. In-Delta water temperatures would change ~~only slightly~~very little due to flow changes, because the water temperatures are in thermal equilibrium with atmospheric conditions and not strongly influenced by flows.

Juvenile Chinook salmon survival through the Delta generally would be similar or slightly lower under NAA than Existing Conditions, as shown with the results of the Delta Passage Model; however, the differences are small (1% or less absolute difference), with these differences being driven by differences in flows during the migration periods in certain years.~~Therefore, there would be no substantial change in the number of stressful or lethal temperature days, due to the expected flow changes.~~

Mean monthly flows at Rio Vista under the No Action Alternative through most of the fall through spring period, averaged across all years, would be limited (<10% difference) from those under Existing Conditions, but up to 28% lower than Existing Conditions in drier water year types.

~~NEPA Effects: The proportion of Sacramento River flows in the Delta under the No Action Alternative would be similar to Existing Conditions, and represent 57-66% of Delta outflows. This is not expected to adversely affect migration conditions or olfactory cues for the covered fish species.~~

CEQA Conclusion: As described above, operations under the No Action Alternative would not substantially alter the turbidity cues associated with winter flush events that may initiate migration, nor would there be appreciable changes in water temperatures in the Delta. Consequently, the impact on adult delta smelt migration conditions would be less than significant, and no mitigation is required. Average Delta outflow would be similar to Existing Conditions during the majority of the winter and spring, which would have limited effects on migration and survival of covered fish species migrating downstream in the spring, e.g., juvenile salmonids. However, upstream conditions would be degraded due to reduced flows and increased temperatures that may affect migration, and as such this impact is significant for salmonids and sturgeon.

Restoration Measures ~~(CM2, CM4–CM7, and CM10)~~

Impact AQUA-NAA7: Effects of Habitat Restoration on Covered Fish Species

Under the No Action Alternative, the assumption is that no large-scale, long-term comprehensive habitat restoration program would occur. Tidal wetland restoration would continue to occur on a much smaller scale throughout the Delta. For example, 8,000 acres of tidal wetland restoration would occur as required by the USFWS BiOp. Small amounts of freshwater wetland and riparian woodland restoration are also likely to occur as part of voluntary restoration efforts or as mitigation for small projects under the No Action Alternative.

Restoration activities from various programs in the region would occur, and although the extent of these activities would typically be limited they would likely include enhancing existing habitat, breaching levees and converting agricultural and other upland areas to tidal, shallow water, open water, and floodplain habitats, as well as enhancement of channel margin habitat.

The construction of these restoration measures under the No Action Alternative is likely to result in a range of effects similar to those described above for construction and maintenance of the projects and programs under the No Action Alternative (see Impact AQUA-1). Such in-water and shoreline restoration measures may result in short-term adverse effects on the covered species through direct disturbance of contaminated soils and sediments, short-term water quality impacts, or increased exposure to contaminants, especially methylmercury, but the overall effects on covered fish species are expected to be localized and of low magnitude. It is assumed that these effects would be minimized by limiting in-water restoration activities to the approved in-water construction window, when the least numbers of covered species would typically be present in or near the restoration sites, and other environmental permit stipulations. These would include the implementation of the environmental commitments, such as erosion and sediment control plans, hazardous materials management plans, spill prevention, containment and countermeasure plans, and SWPPPs. As a result, the effects of short-term restoration activities would likely not be adverse to the covered fish species, relative to Existing Conditions.

~~NEPA Effects: The No Action Alternative assumes that no large-scale reserve system that would protect and link a wide diversity of natural communities and habitat for native and covered species would occur. The No Action Alternative also does not include a comprehensive long-term management and monitoring program to ensure the continued maintenance and improvement of natural communities and native species habitat. Small amounts of habitat protection would occur under the No Action Alternative associated with mitigation for specific projects.~~

CEQA Conclusion: As described above, the No Action Alternative assumes that no long-term, large-scale comprehensive habitat restoration program would occur, to restore habitat functions in the Plan Area, and benefit the covered fish species. Although ~~conservation measures~~restoration on a smaller ~~-~~scale, and over shorter time periods would continue to occur into the future, it is expected that there would be no comprehensive monitoring program, or adaptive management process to ensure that these actions were providing a net improvement over Existing Conditions, or providing a benefit to the species. Despite these uncertainties, the effects would be less than significant.

Non-Covered Fish Species of Primary Concern

Construction and Maintenance

Impact AQUA-NAA9: Effects of Construction of Facilities on Non-Covered Fish Species

The effects described for the covered fish species in Impact AQUA-NAA1 would be similar in type, duration and magnitude to those expected for the non-covered species (e.g., turbidity, accidental spills, disturbance of contaminated sediment, underwater noise, fish stranding, in-water work activities, loss of spawning, rearing or migration habitat, and predation). However, as described above, these effects would not be adverse because of the limited extent, intensity, and duration of expected construction projects in the Plan Area under the NAA and Existing Conditions.

In addition, any such construction projects would be subject to a separate environmental compliance process, with permit stipulations which would include the implementation of project-specific AMMs, BMPs, environmental commitments and/or mitigation measures. This would include project-specific erosion and sediment control plans; hazardous materials management plans; SWPPPs; spill prevention and control plans; and limiting in-water activities to periods of low flow and/or to times when non-covered fish species are not likely to be present.

~~NEPA Effects: The effects of construction projects on the non-covered fish species would not be adverse, and no additional mitigation would be required.~~

CEQA Conclusion: For any projects implemented under the No Action Alternative within the NAA period, that include in-water construction and maintenance activities, there would be the potential to stress, injure, or kill non-covered fish species through direct or indirect effects, and the potential to alter spawning, rearing and/or migration habitat of non-covered fish species through direct loss or modification. However, such projects would be subject to specific environmental permitting processes, which would minimize potential effects through the implementation of project-specific AMMs, BMPs, environmental commitments and/or mitigation measures. Thus, the construction-related effects under the NAA would be less than significant, and no additional mitigation would be required.

Impact AQUA-NAA10: Effects of Maintenance of Facilities on Non-Covered Fish Species

~~***NEPA Effects:*** The discussion of potential maintenance activity effects would be similar to the discussion provided above with the construction effects (Impact AQUA-NAA1) on the covered fish species, and as concluded, the effect would not be adverse.~~

CEQA Conclusion: The conclusion provided above for the construction activity effects (Impact AQUA-NAA1), would typically be very similar to those expected to occur during maintenance activities. Thus, the effect would be less than significant.

Water Operations

Impact AQUA-NAA11: Effects of Water Operations on Entrainment of Non-Covered Fish Species

Available information on the distribution and abundance of the non-covered fish species is provided in Appendix 11B, *Non-covered Fish and Aquatic Species Descriptions*. Under Existing Conditions, non-covered fish species are expected to occur in salvage operations at the south Delta facilities throughout the year. This would include eggs, larvae, juvenile, and adult life stages of the various fish species entrained at varying times throughout the year. This entrainment would continue into the future under the No Action Alternative, although there is no evidence that south Delta exports currently affect the population level of these species. Further, improvements in the water export operations and the salvage processes for listed fishes (as required under the USFWS 2008 BiOp and the NMFS 2009 BiOp) are expected to reduce the rate of non-covered fish entrainment loss over time.

~~***NEPA Effects:*** The effect of entrainment of the non-covered fish species would not be adverse.~~

CEQA Conclusion: The impact of water operations on entrainment of non-covered fish species would be ~~the same~~ as described ~~immediately~~ above. The changes in entrainment under the No Action Alternative would not substantially reduce the non-covered fish populations. Thus, the impact would be less than significant and no mitigation would be required.

Impact AQUA-NAA12: Effects of Water Operations on Spawning and Egg Incubation Habitat for Non-Covered Fish Species

As described above under AQUA-NAA4 for the covered fish species, water operations in the NAA are not expected to substantially or consistently affect spawning habitat, compared to Existing Conditions. Upstream of the Delta, flows could be affected by changes in water storage volumes, associated with meeting Fall X2 targets included in the USFWS BiOp. Such changes could affect downstream spawning conditions for some non-covered fish species, when climate change effects are accounted for (NAA).

~~***NEPA Effects:*** The effect would not be adverse over the NAA period, because there would be little change in suitable spawning conditions under NAA, compared to Existing Conditions.~~

CEQA Conclusion: As discussed above, and in Impact AQUA-NAA4, existing water operations would continue into the future under the No Action Alternative, and the potential effects on spawning habitat for non-covered fish species would be similar. Therefore, the overall effect would be less than significant.

Impact AQUA-NAA13: Effects of Water Operations on Rearing Habitat for Non-Covered Fish Species

As described above under AQUA-NAA5 for the covered fish species, water operations under the No Action Alternative are not expected to substantially or consistently affect rearing habitat, compared to Existing Conditions. Existing water operations would continue into the future, and the potential effects on rearing habitat for non-covered fish species would be similar. Juvenile striped bass may benefit from the Fall X2 action of the USFWS 2008 BiOp that is included in the NAA, given that there is some evidence for their abundance being negatively related to fall X2 (Mac Nally et al. 2010).

~~***NEPA Effects:*** The overall effect would not be adverse.~~

CEQA Conclusion: As discussed above, in Impact AQUA-NAA5, existing water operations would continue into the future, under the No Action Alternative, and the potential effects on rearing habitat for non-covered fish species of primary concern would be similar. Therefore, the overall effect would be less than significant.

Impact AQUA-NAA14: Effects of Water Operations on Migration Habitat for Non-Covered Fish Species

As described above under AQUA-NAA6 for the covered fish species, water operations under the No Action Alternative are not expected to substantially or consistently affect overall migration conditions for the non-covered species. Existing water operations would continue into the future, and the potential effects on migration habitat of non-covered fish species would be similar.

~~***NEPA Effects:*** The overall effects would not be adverse.~~

CEQA Conclusion: As described above under AQUA-NAA6 for the covered fish species, water operations under the No Action Alternative are not expected to substantially or consistently affect overall migration conditions for the non-covered species. Any existing effects are expected to continue into the future, under the No Action Alternative. As a result, the potential effects on migration habitat for non-covered fish species would likely be similar to Existing Conditions. Therefore, the overall effect would be less than significant.

Restoration Measures ~~(CM2, CM4–CM7, and CM10)~~

Impact AQUA-NAA15: Effects of Habitat Restoration on Non-Covered Fish Species

As described in detail above for the covered fish species, under the No Action Alternative, no large-scale, long-term comprehensive habitat restoration program is expected to occur. While restoration activities from various programs and projects in the region would still occur, the extent of these activities would typically be limited in size or distribution. These activities would be expected to include enhancing existing habitat, breaching levees and converting agricultural and other upland areas to tidal, shallow water, open water, and floodplain habitats, as well as enhancement of channel margin habitat. Therefore, restoration actions would likely occur on a relatively small scale, and with a typically sporadic and inconsistent implementation schedule.

~~***NEPA Effects:*** As the purpose of the restoration measures is intended to benefit aquatic species, the effects would be unlikely to be adverse.~~

CEQA Conclusion: As described above, the No Action Alternative would not include a long-term, large-scale comprehensive habitat restoration program, to restore habitat functions in the Plan

Area, and benefit the covered and non-covered fish species. Although conservation measures on a smaller-scale would likely continue to occur into the future, it is unlikely for there to be a comprehensive monitoring program, or adaptive management process to ensure that these actions were providing a net improvement over Existing Conditions, or providing a substantial benefit to the species. Despite these uncertainties, the effects would be less than significant.

Other Conservation Measures ~~(CM12–CM19 and CM21)~~

Impact AQUA-NAA16: Effects of Other Conservation Measures on Non-Covered Fish Species

As indicated above for the covered fish species, the No Action Alternative would be unlikely to provide a long-term comprehensive program to address other stressors on the covered and non-covered fish species. However, some existing and future conservation measures would continue to occur under the No Action Alternative. These conservation measures are intended to reduce stressors to covered and non-covered fish species and generally have only neutral or beneficial effects. Exceptions include measures to reduce predation pressure; however, this is not intended to reduce the overall predator populations, but instead to alleviate predation issues at specific areas.

~~***NEPA Effects:*** The overall effects would be beneficial.~~

CEQA Conclusion: As indicated above, the conservation measures occurring in the future under NAA are expected to benefit both covered and non-covered fish species. Therefore, the effect would be expected to be less than significant.

[Note to reviewers: this is all new text, and therefore, has not been shown in redline/strikeout].

11.3.5 Updated and New Impact Discussions Applicable To Multiple Alternatives

There were a number of impact discussions in the DEIR/EIS that have been updated in addition to impacts that were not previously included for those Alternatives that were in the DEIR/EIS. The following impacts and conclusions provide CEQA and NEPA discussions and conclusions for effects that are applicable to multiple alternatives. Alternatives not previously included in the DEIR/EIS are not discussed in this section. Please refer to Section 4.3.7 for Alternative 4A discussion; Section 4.4.7 for Alternative 2D discussion, and Section 4.5.7 for Alternative 5A discussion.

11.3.5.1 Updated Discussion for Effects of Underwater Noise During Construction

The effects of construction on fish remain the same as presented in the DEIR/EIS, including the NEPA and CEQA determinations that for all alternatives, the impacts of construction would be less than significant with mitigation/not adverse; however additional analyses have been conducted relative to pile driving effects on underwater noise. The following discussion supplements the underwater noise discussion and evaluation presented in impacts AQUA-1, AQUA-19, AQUA-37, AQUA-55, AQUA-73, AQUA-91, AQUA-109, AQUA-127, AQUA-145, AQUA-163, and AQUA-181for Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8, and 9. (Alternatives 4A, 2D, and 5A contains a separate discussion of construction and underwater noise impacts in Sections 4.3.7, 4.4.7, and 4.5.7, respectively.)

This assessment provides the most conservative analysis for all alternatives because it takes into account construction of five intakes, Clifton Court Forebay modifications, and the Head of Old River operable barrier; other alternatives include 5 or fewer intakes and do not include modifications to the Clifton Court Forebay and Head of Old River operable barrier. For those alternatives under which fewer intakes would be constructed (Alternatives 3, 4, 5, 7, 8, and 9), impacts resulting from pile driving activities associated with intake construction would be anticipated to be proportionally smaller than those described below. For example, because Alternative 5 would construct only one intake, underwater noise impacts resulting from intake-related pile driving would be 80% lower than those below. However, impacts associated with pile driving for other facilities would likely be similar across these alternatives (e.g., barge unloading facilities, etc.).

The assessment of underwater noise impacts on fish is based on the overlap of construction activities (timing, location, duration) with the spatial and temporal distribution of sensitive species and life stages, as well as expected fish behavior if encountering underwater noise. An important measure for reducing the potential exposure of the population to pile driving noise is the restriction of in-water impact pile driving activities to June 1 through October 31, a period when most fish are not present in the construction area. If impact pile-driving is implemented outside this window, Mitigation Measure AQUA-1b will be implemented to minimize underwater noise. Additionally, the project proponents intend to construct sheetpile cofferdams at the NDD intakes and at the head of Old River barrier using vibratory pile driving for at least 80–90% of the time, depending on the specific site conditions. In addition, the project proponents propose to install piles for the intakes using vibratory methods or other non-impact driving methods, wherever feasible, when working outside the work window to minimize adverse effects on fish and other aquatic organisms

(Mitigation Measure AQUA-1a). However, the degree to which vibratory driving can be performed effectively is unknown at this time due to as yet undetermined geologic conditions at the construction sites. The remaining pile driving would be conducted using an impact pile driver, and if outside the work window, will include implementation of Mitigation Measure AQUA-1b. Once constructed, if the foundation design requires piles, pile driving to construct foundations would be conducted from within the cofferdam; it is still undetermined if the foundation will use piles or drill-shaft methods, which does not require pile driving. If piles are included in the design, project proponents will isolate pile driving activities within dewatered cofferdams as a means of minimizing noise levels and potential adverse effects on fish (Mitigation Measure AQUA-1b). However, some uncertainty also exists regarding the extent to which the cofferdams can be dewatered and therefore the magnitude at which this measure can minimize underwater noise. If the cofferdams cannot be dewatered, or if pile driving noise exceeds applicable thresholds, project proponents will construct a bubble curtain or other attenuation device to minimize underwater noise (Mitigation Measure AQUA-1b). Project proponents will work with contractors to minimize pile driving, particularly impact pile driving, by using floating docks instead of pile-supported docks, wherever feasible considering the load requirements of the landings and the site conditions. If pile supported docks are required, piles would be designed to safely support the docks and to minimize underwater noise. If dock piles for barge landings cannot be installed using vibratory methods, attenuation devices will be used to reduce the area that would be exposed to underwater sound levels (Mitigation Measure AQUA-1b). Since the specific construction mechanisms are currently under development, this analysis presents worst-case impacts based on the use of an impact driver in open water with no attenuation measures. It should also be recognized that the computed distances over which pile driving sounds are expected to exceed the injury and behavioral thresholds assume an unimpeded open water propagation path. However, site conditions such as major channel bends and other in-water structures can reduce these distances by impeding the propagation of underwater sound waves.

Table 11-mult-1 presents the computed impact areas and schedule for each facility or structure where pile driving is proposed to occur in open water or on land adjacent to open water (<200 feet) under the alternatives. Sound monitoring data from similar pile driving operations (impact driving in open water) indicate that single-strike peak SPLs and SELs exceeding the interim injury thresholds are expected to be limited to areas within 10–14 meters (33–46 feet) of the source piles (Table 11-mult-28), potentially causing direct injury or mortality of fish in close proximity to the source piles. Cumulative exposure to pile driving sounds could result in injury of fish at distances ranging from 1,522 feet (SR-160 bridge) to 3,280 feet (intake foundation pile installation) from the source piles assuming no attenuation. The duration of pile driving activities resulting in such exposures are estimated to range from 5 days during SR-160 bridge construction activities to 450 days for the installation of cofferdams in Clifton Court Forebay.

Other construction activities that can generate underwater noise exceeding background levels (e.g., barge operations) are not expected to result in direct harm to fish. These kinds of activities typically produce noise levels below the behavioral effects threshold of 150 dB RMS, which may temporarily alter fish behavior but does not result in permanent harm or injury.

Table 11-mult-1. Estimated distances and areas of waterbodies subject to pile driving noise levels exceeding interim injury and behavioral thresholds, and proposed timing and duration of proposed pile driving activities for facilities or structures in or adjacent to sensitive rearing and migration corridors of the covered species (Alternative 2D)

Facility or Structure	Average Width of Water Body (feet)	Distance to Cumulative 187 and 183 dB SEL Injury Threshold[1, 2] (feet)	Potential Impact Area[3] (acres)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Year of Construction	Duration of Pile Driving (days)
Intake 1						
Cofferdam	425	2,814	55	13,058	Year 3	42
Foundation		3,280	64	32,800	Year 4	8
SR-160 Bridge		1,522	30	7,065	Year 5	5
Intake 2						
Cofferdam	645	2,814	83	13,058	Year 4	42
Foundation		3,280	97	32,800	Year 5	8
SR-160 Bridge		1,522	45	7,065	Year 6	5
Intake 3						
Cofferdam	560	2,814	72	13,058	Year 3	42
Foundation		3,280	84	32,800	Year 4	8
SR-160 Bridge		1,522	39	7,065	Year 5	5
Intake 4						
Cofferdam	615	2,814	79	13,058	Year 3	42
Foundation		3,280	93	32,800	Year 4	8
SR-160 Bridge		1,522	43	7,065	Year 5	5
Intake 5						
Cofferdam	535	2,814	69	13,058	Year 2	42
Foundation		3,280	81	32,800	Year 3	8
SR-160 Bridge		1,522	37	7,065	Year 4	5
Barge Unloading Facilities (6)						
Piers	300–1,350	1,774	24-110	9,607	Year 5	13
Clifton Court Forebay						
Cofferdams	10,500	2,814	364	13,058	Year 8	450
Siphon – N. Inlet		1,774	144	9,607	Year 9	72
Siphon – N. Outlet		1,774	144	9,607	Year 9	72
Head of Old River Operable Barrier						
Cofferdams	700	2,814	22	13,058	Year 7	37
Foundation		1,774	14	9,607	Year 7	7

[1] Distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL).

[2] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, vibratory driving or other non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

[3] Based on the area of open water subject to underwater sound levels exceeding the cumulative SEL thresholds for fish larger than 2 grams (187 dB) and smaller than 2 grams (183 dB); for open channels, this area is calculated by multiplying the average channel width by twice the distance to the injury thresholds, assuming an unimpeded propagation path upstream and downstream of the source piles.

Supplemental Information for Impact AQUA-1 Effects of Underwater Noise during Construction of Water Conveyance Facilities on Delta Smelt

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Table 11-4 presents the life stages of delta smelt and the months of their potential presence in the north, east, and south Delta during the proposed in-water construction window (June 1–October 31). Delta smelt are considered highly vulnerable to pile driving noise because of their small size and inability of eggs and larvae to actively avoid elevated noise levels. Larval and juvenile delta smelt are smaller than 2 grams while adults are close to 2 grams in size (mature male and female delta smelt average 2.1 grams and 2.7 grams with a standard error of 0.3 and 0.6 grams, respectively [Foott and Bigelow 2010]); therefore, the interim threshold of 183 dB SEL is applicable to the majority of the population when evaluating the potential for injury or mortality of delta smelt due to pile driving noise.

Because delta smelt are generally found in the west Delta and Cache Slough/Liberty Island area during the spring and summer, the majority of individuals would not be exposed to construction-related underwater noise. However, delta smelt could be present at low abundance in the north, east, and south Delta during the period when in-water construction activity would occur, indicating some potential for exposure. Adults, which complete their spawning cycle and die by mid- to late June, could be exposed to pile driving noise following the onset of in-water pile driving in June. If a portion of the population spawns upstream of the construction areas, larvae could potentially drift through the areas affected by underwater sound. Thus, the potential exists for small numbers of spawning adults (during June) or larval delta smelt (during June and July) to occur in the vicinity of the intakes and the barge landings during the in-water construction period. With implementation of proposed timing restrictions on in-water impact pile driving activities (June 1 through October 31), the use of vibratory pile driving methods whenever feasible (Mitigation Measure AQUA-1a), and the monitoring and attenuation of noise if impact pile driving is used (Mitigation Measure AQUA-1b), potential injury or mortality of delta smelt from pile driving noise is expected to be minimal and unlikely to have significant population-level effects.

Table 11-4. Life Stages of Covered Species Present in the North. East and South Delta Subregions during the In-Water Construction Window (June 1-October 31).

	North Delta			East Delta			South Delta		
Fish Species	**Life Stage**	**Timing**	**Size[a]**	**Life Stage**	**Timing**	**Size**	**Life Stage**	**Timing**	**Size**
Delta smelt	Adult	Jun	>2g	Adult	Jun	>2g	Adult	Jun	>2g
	Larva	Jun–Jul	<2g	Larva	Jun–Jul	<2g	Larva	Jun–Jul	<2g
Longfin smelt	Adult	Not Present	>2g	Adult	Not Present	>2g	Adult	Not Present	>2g
	Larva	Not Present	<2g	Larva	Not Present	<2g	Larva	Not Present	<2g
Central Valley steelhead	Adult	Jun–Sep ■	>2g	Adult	Not Present	>2g	Adult	Not Present	>2g
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
Winter-run Chinook salmon	Adult	Jun-Jul	>2g	Adult	Not Present		Adult	Not Present	
	Juvenile	Aug–Oct	<2g, >2g	Juvenile	Not Present	<2, >2	Juvenile	Not Present	<2, >2
Spring-run Chinook salmon	Adult	Jun Jul–Aug	>2g	Adult	Not Present		Adult	Not Present	
	Juvenile	Jun	<2g, >2g	Juvenile	Jun	<2g, >2g	Juvenile	Jun	<2g, >2g
Late fall–run Chinook salmon	Adult	Oct	>2g	Adult	Not Present		Adult	Not Present	
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
Fall-run Chinook salmon	Adult	Aug–Sep Oct	>2g	Adult	Aug–Sep Oct	>2g	Adult	Aug–Sep Oct	>2g
	Juvenile	Jun	>2g	Juvenile	Jun	<2g, >2g	Juvenile	Jun	<2g, >2g
Splittail	Larva	Jun	<2g	Larva	Jun		Larva	Jun	<2g
	Juvenile	Jun–Jul	<2g	Juvenile	Jun–Jul		Juvenile	Jun–Jul	<2g
Green sturgeon	Adult	Jun–Oct	>2g	Adult	Jun–Oct	>2g	Adult	Jun–Oct	>2g
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
White sturgeon	Adult	Jun–Oct	>2g	Adult	Jun–Oct	>2g	Adult	Jun-Oct	>2g
	Larva	Jun	<2g	Larva	Jun	<2g	Larva	Jun	<2g
	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g	Juvenile	Jun–Oct	>2g
Pacific lamprey	Adult	Jun–Aug	>2g	Adult	Jun–Aug	>2g	Adult	Jun–Aug	>2g
	Ammocoetes	Jun–Oct	>2g	Ammocoetes	Jun–Oct	>2g	Ammocoetes	Jun–Oct	>2g
River lamprey	Adult	Sep–Oct	>2g	Adult	Sep–Oct	>2g	Adult	Sep–Oct	>2g
	Ammocoetes	Jan–Dec	>2g	Ammocoetes	Jan–Dec	>2g	Ammocoetes	Jan–Dec	>2g
	Macropthalmia	Jun–Jul	>2g	Macropthalmia	Jun–Jul	>2g	Macropthalmia	Jun–Jul	>2g

Black =abundant	■	Medium Gray=semi-abundant	▩	Light Gray=low abundance	░	White=unsure if present	□

Source: California Department of Water Resources 2013.

[a] Size categories represent thresholds for assessing potential injury to fish from pile driving underwater noise (see "Underwater Noise").

Mitigation Measure AQUA-1a: Minimize the Use of Impact Pile Driving to Address Effects of Pile Driving and Other Construction-Related Underwater Noise

BDCP proponents will include specification in any construction contracts involving the installation of in-water or nearshore pilings, that piles will be installed using vibratory methods, or other non-impact driving methods, wherever feasible, especially outside of the in-water work window. Such methods have been shown to effectively minimize physical or substantial behavioral effects on fish and other aquatic species. The method selected will be based on geotechnical studies that will be conducted to determine the feasibility of vibratory installation of sheet pile, intake pipe foundation piles, and dock piles for barge landings. Additionally, the vibratory hammer will be started gradually to alert fish in the area that vibration will occur.

Mitigation Measure AQUA-1b: Monitor Underwater Noise and if Necessary, Use an Attenuation Device to Reduce Effects of Pile Driving and Other Construction-Related Underwater Noise

If Mitigation Measure AQUA-1a cannot be implemented during pile driving activities that occur in-water, project proponents will implement Mitigation Measure AQUA-1b, which would include the monitoring of noise and if necessary, the attenuation of noise through either the dewatering of the cofferdam area and/or the installation of a bubble curtain or other attenuation device to minimize underwater noise. This measure would not be applicable to sheet pile installations, where it would not be feasible to surround the entire sheet pile wall, and which are expected to be installed using a vibratory hammer for at least 80-90% of the time. Where impact pile driving is required, DWR will monitor underwater sound levels to determine compliance with the underwater noise effects thresholds at a distance appropriate for protection of the species (183 dB $\text{SEL}_{\text{cumulative}}$ for fish less than 2 grams; 187 dB $\text{SEL}_{\text{cumulative}}$ for fish greater than 2 grams). If noise is expected to exceed applicable thresholds, an attenuation device or other mechanism to minimize noise will be implemented.

Supplemental Information for Impact AQUA-19: Effects of Underwater Noise during Construction of Water Conveyance Facilities on Longfin Smelt

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Table 11-4 presents the life stages of longfin smelt and the months of their potential presence in the north, east, and south Delta during the proposed in-water construction window (June 1–October 31). Construction of the barge landings in the east and south Delta would be the primary locations where longfin smelt could be affected by pile driving, as longfin smelt are only expected to occur at the intake construction sites during the early portion of the in-water work window. Based on general similarities in species life histories, body size, and behavior (e.g., pelagic foraging), the effects of pile driving noise on longfin smelt would be expected to be similar to those described for delta smelt. Therefore, as discussed for delta smelt, implementation of Mitigation Measures AQUA-1a and AQUA-1b would minimize potential adverse effects associated with pile driving noise.

Supplementation Information for Impact AQUA-37: Effects of Underwater Noise during Construction of Water Conveyance Facilities on Chinook Salmon (Winter-Run ESU)

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Table 11-4 presents the life stages of the four runs of Chinook salmon and the months of their potential presence in the north, east, and south Delta during the proposed in-water construction period (June 1–October 31). Winter-run, spring-run, fall-run, and late fall–run Chinook salmon eggs and fry would not be exposed to underwater noise from pile driving activities because the proposed construction activities are located in areas that do not provide suitable habitat for these life stages or because these life stages would not be present during the proposed in-water construction period.

Under the alternatives, the potential for exposure of adult and juvenile winter-, spring-, and late fall-run Chinook salmon to pile driving noise is highest in the north Delta (Sacramento River in the vicinity of the five proposed intakes) which serves as the primary migration route utilized by adults to access upstream spawning areas, and the primary migration route for juveniles entering the Delta and estuary from upstream spawning and rearing areas. Restricting in-water pile driving to June 1 to October 31 avoids the peak migration periods of winter-, spring-, and late fall-run adults and juveniles. Some overlap with winter-run and spring-run adults may occur at the end of the migration season in June or July, and with late fall-run adults at the beginning of the migration season in October. Adult fall-run Chinook salmon, which migrate through the north, east, and south Delta on their way to upstream spawning areas in the Sacramento, San Joaquin, and east Delta tributaries, may be present in the vicinity of the intake structures, barge unloading facilities, and Head of Old River operable barrier during in-water pile driving activities from August through October. Most juvenile Chinook salmon occur in the Delta from late fall through spring (November through May) although some fall- and spring-run smolts may encounter pile driving noise at the end of the outmigration season in June.

As described earlier, the estimated impact distances above are worst-case estimates based on impact driving with no attenuation and an unimpeded underwater propagation path. In addition, the potential area of exposure to pile driving sounds could be magnified by the operation of multiple pile drivers at multiple intake sites on the Sacramento River. Based on the distances separating intake sites and the location of major channel bends separating the intakes, it is unlikely that the areas subject to cumulative SELs exceeding the injury thresholds will overlap. However, exceedance of the behavioral thresholds could overlap and affect fish over a 10-15 mile reach of the Sacramento River. Several factors likely reduce the potential for injury or mortality of adult and juvenile Chinook salmon during pile driving activities at the proposed intake structures. To mitigate potential adverse effects, DWR proposes to use vibratory driving to the extent feasible to minimize both the area and duration of potentially harmful underwater noise levels associated with impact driving in open water. In addition, to the extent feasible, if impact driving is used, dewatered cofferdams or other attenuation devices will be used to isolate the foundation piles from open water in river (Mitigation Measure AQUA-1b), increasing the amount of attenuation occurring before pile driving sounds reach the open water of the Sacramento River. Although pile driving activities could occur up to 50 days per season at each intake location, in-water pile driving will not be continuous and limited to daylight hours only, resulting in 12-16 hour periods each day for migrating fish to pass the construction sites undisturbed. Further, Environmental Commitment 3B.1.11, Develop and Implement Noise Abatement Plan, would also limit pile driving to the time periods between 7:00 am to 6:00 pm.

It is unlikely that pile driving sounds will cause injury or mortality of adult salmon based on the large size, mobility, and anticipated behavior during their migration through the affected areas. Adult Chinook salmon are large (typically 9-10 kilograms) and presumably much less vulnerable to pile driving noise than smaller fish targeted for protection by the SPL and SEL injury criteria (approximately 2 grams or smaller). In addition, migrating adult salmon are expected to readily avoid or swim away from areas of elevated noise. Similar pile driving operations indicate that single-strike peak SPLs and SELs exceeding the injury criteria would be limited to small areas immediately adjacent to source piles (<33-46 feet) and thus would affect only a small portion of the total channel width available for adults to pass (Table 11-mult-28). However, the potential for injury still exists because migrating adults would be faced with passing through larger channel reaches (spanning the entire channel width at most locations) subject to noise levels exceeding the cumulative thresholds for >2-gram fish (187 dB SEL). The potential for injury is considered low due to the large size of adults and rapid migration rates to upstream holding and spawning areas. While limited evidence suggests that pile driving operations may disrupt normal migratory behavior in salmonids (Feist et al. 1992), any delays in migration are expected to be minor because of the intermittent nature of pile driving and the daily cessation of pile driving at night.

Juvenile salmon are at higher risk of injury and mortality than adults because of their small size. However, the June 1 through October 31 pile driving period will avoid the primary juvenile outmigration period for all runs of Chinook salmon (November through May), and thus minimize the potential for adverse effects. Most juveniles migrating through the Delta after June 1 or before October 31 are large, actively migrating smolts (> 2 grams) that are known to migrate rapidly through the Delta and estuary during their seaward migration (Williams 2006). These juveniles may be exposed to noise levels exceeding the injury thresholds for >2-gram fish (187 dB SEL) as they pass through the affected channel reaches. However, exposure is expected to be limited due to by their rapid migration rate and nightly opportunities to pass the affected reaches at night after daily pile driving operations have ceased. In general, downstream movement of salmonids occurs mainly at night or during the hours between dusk and dawn, limiting exposure of juveniles to pile driving noise to daylight hours. As discussed above, limited evidence suggests that pile driving noise may disrupt normal migratory behavior in salmonids. For juveniles, these behavioral effects may include responses that disrupt normal feeding, resting, and sheltering behavior, resulting in potential adverse effects on growth and survival (e.g., increased vulnerability to predation). Thus, pile driving activities could lead to indirect mortality of juveniles if individuals are within the range of noise levels that could cause behavioral effects.

Based on the foregoing analysis, the potential exists for some injury and mortality of juvenile Chinook salmon from pile driving noise but only a small proportion of the population is at risk based on the low degree of overlap of pile driving activities with outmigration timing, and the relatively large size and mobility of juveniles that may encounter pile driving noise (migrating smolts). Implementation of Mitigation Measures AQUA-1a and AQUA-1b will further reduce this risk.

Supplemental Information for Impact AQUA-55: Effects of Underwater Noise during Construction of Water Conveyance Facilities on Chinook Salmon (Spring-Run ESU)

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Based on similarities in species histories, body size, and behavior, the potential effects of underwater noise as a result of construction of the water conveyance facilities on spring-run Chinook salmon would be the same as described above for winter-run Chinook (Impact AQUA-37). Mitigation Measures AQUA-1a and AQUA-1b would minimize the potential for underwater noise effects on spring-run Chinook salmon.

Supplemental Information for Impact AQUA-73: Effects of Underwater Noise during Construction of Water Conveyance Facilities on Chinook Salmon (Fall-/Late Fall–Run ESU)

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Based on general similarities in species histories, body size, and behavior, the potential effects of underwater noise as a result of construction of the water conveyance facilities on fall-/late fall-run Chinook salmon would be the same as described above for winter-run Chinook (Impact AQUA-37). Mitigation Measures AQUA-1a and AQUA-1b would minimize the potential for underwater noise effects on fall-/late fall–run Chinook salmon.

Supplemental Information for Impact AQUA-91: Effects of Underwater Noise during Construction of Water Conveyance Facilities on Steelhead

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Table 11-4 presents the life stages of CCV steelhead and the months of their potential presence in the north, east, and south Delta during the proposed in-water construction period (June 1–October 31). Steelhead eggs and fry would not be exposed to underwater noise from pile driving activities because the proposed construction activities are located in areas that are downstream from the principal spawning and early rearing areas.

Under the alternatives, adult steelhead could be exposed to pile driving sound during their migrations past the construction sites of the proposed intakes and barge unloading facilities. Based on historical migration timing, migrating adults may be present in the Delta and lower Sacramento and San Joaquin Rivers during their upstream migration from August through November and during their downstream migration as kelts (post-spawn adults) from February through May (Hallock 1961, Busby et al. 1995). Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows, with peaks in abundance in the spring (March through June) and fall (October through November) (McEwan 2001, Snider and Titus 2000, Nobriga and Cadrett 2001).

Similar to Chinook salmon, the risk of injury or mortality of adult steelhead from pile driving noise is low because of their large size, high mobility, and rapid migration rates through the Delta and lower rivers. The risk of exposure to harmful levels of underwater noise and/or delays in migration is further reduced by the intermittent nature of pile driving activities, the daily cessation of pile driving at night, and the implementation of vibratory driving or other non-impact pile driving methods whenever feasible. Based on the general timing of steelhead outmigration through the Delta, exposure of juvenile steelhead to pile driving noise will be substantially minimized by the restriction of in-water pile driving period to June 1 through October 31. Most steelhead potentially encountering pile driving noise are large, yearling and older smolts (> 10 grams) that are expected to migrate rapidly through the Delta based on recent telemetry studies (Delaney et al. 2014). As discussed for Chinook salmon, the restriction of pile driving to daylight hours would also reduce the exposure of juvenile steelhead to pile driving noise because of the general tendency for salmonids to migrate at night. However, another potential mechanism that may indirectly affect survival is the potential disruption of feeding, resting, and sheltering behavior of individuals that are within the range of noise levels associated with behavioral effects.

Based on the foregoing analysis, the potential exists for some injury and mortality of juvenile steelhead from pile driving noise but only a small proportion of the population is at risk based on the low degree of overlap of pile driving activities with outmigration timing, and the relatively large size and mobility of juveniles that may encounter pile driving noise (migrating smolts). Implementation of Mitigation Measures AQUA-1a and AQUA-1b will further reduce this risk.

Supplemental Information for Impact AQUA-109: Effects of Underwater Noise during Construction of Water Conveyance Facilities on Sacramento Splittail

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Table 11-4 presents the life stages of Sacramento splittail and the months of their potential presence in the north, east, and south Delta during the proposed in-water construction window (June 1–October 31). Under the alternatives, underwater noise generated by impact pile driving in or near open waters of the Delta can reach levels associated with potential injury of fish, including Sacramento splittail. The potential exists for relatively large numbers of young-of-the-year to occur on the vicinity of pile driving activities at the north Delta intakes and barge unloading facilities as larvae and juveniles disperse from upstream spawning and early rearing areas (riparian margins and floodplain) to the estuary in April-August. However, because of the relatively small area of open water affected by noise exceeding the injury thresholds (Table 11-mult-2), the limited duration of pile driving activities (Table 11-mult-1), and the lack of suitable rearing habitat in the affected areas, adverse effects would be limited to a small proportion of the population. Implementation of Mitigation Measures AQUA-1a and AQUA-1b would further reduce these impacts. No significant population-level effects are expected.

Supplemental Information for Impact AQUA-127: Effects of Underwater Noise during Construction of Water Conveyance Facilities on Green Sturgeon

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Table 11-4 presents the life stages of green sturgeon and months of their potential presence in the north, east, and south Delta during the proposed in-water construction window (June 1–October 31). Based on the proposed timing of pile driving activities and the occurrence of sensitive life stages of the covered species in the affected reaches, green sturgeon are considered most vulnerable to pile driving impacts because of their year-round presence in the plan area.

Under the alternatives, impact pile driving could result in exposure of juvenile and adult green sturgeon to underwater noise levels exceeding the injury thresholds at the five intake structures in the north Delta and six barge unloading facilities in the east and south Delta. The potential for exposure of adults and juveniles to pile driving noise is highest in the north Delta (Sacramento River in the vicinity of the three proposed intakes) which serves as the primary migration route utilized by adults to access upstream spawning areas, and the primary migration route for juveniles entering the Delta from natal rearing areas in the upper Sacramento River. Restricting impact pile driving to June 1 to October 31 avoids the peak periods of upstream migration of adults (late February to early May) although some adults may migrate through the Delta as late as June or July. Some adults may also be exposed to pile driving noise during their outmigration; outmigration of tagged adults has been observed during summer (June-August) and late fall or winter (November-December) coincident with increases in flow from the first significant rain events (Heublein et al. 2009). Juvenile and sub-adult green sturgeon may be present in the Delta year-round and therefore could be affected by pile driving noise at all sites proposed for in-water pile driving. Following the larval rearing period, young-of-the-year juveniles enter the Delta where they continue to rear for up to three years before entering the ocean. Fish salvage data collected at the state and federal water export facilities in the southern Delta indicate that juvenile green sturgeon in the Delta range in length from 100 to 600 mm, with most being greater than 200 mm (Adams et al. 2002, Beamesderfer et al. 2007).

As described earlier, the estimated impact distances above are worst-case estimates based on impact driving with no attenuation and an unimpeded underwater propagation path. In addition, the potential area of exposure to pile driving sounds could be magnified by the operation of multiple pile drivers at multiple intake sites on the Sacramento River. Based on the distances separating intake sites and the location of major channel bends separating the intakes, it is unlikely that the areas subject to cumulative SELs exceeding the injury thresholds will overlap. However, exceedance of the behavioral thresholds could overlap and affect fish over a 10-15 mile reach of the Sacramento

River. Several factors likely reduce the potential for injury or mortality of adult and juvenile sturgeon during pile driving activities at the proposed intake structures. To mitigate potential adverse effects, DWR proposes to use vibratory driving to the extent feasible to minimize both the area and duration of potentially harmful underwater noise levels associated with impact driving in open water. In addition, cofferdams will be used to isolate the foundation piles from open water in river, increasing the amount of attenuation occurring before pile driving sounds reach the open water of the Sacramento River. Although pile driving activities could occur up to 50 days per season at each intake location, in-water pile driving will not be continuous and limited to daylight hours only, resulting in 12-16 hour periods each day for migrating fish to pass the construction sites undisturbed.

Several aspects of green sturgeon life history and biology affect the potential for injury or mortality of adult and juvenile green sturgeon to pile driving noise. All in-water pile driving will be performed after June 1 and before October 31, avoiding the primary upstream and downstream migration periods of pre- and post-spawning adults. Adult sturgeon are very large (up to 90 kilograms) and presumably much less vulnerable to pile driving noise than smaller fish (approximately 2 grams or smaller) targeted for protection by the SPL and SEL injury criteria. In addition, adult sturgeon are highly mobile and thus able to rapidly avoid or swim away from areas of elevated noise. Their exposure would also be limited by their rapid migration rate; recent telemetry studies indicate that adult green sturgeon migrate rapidly to and from spawning areas in the upper Sacramento River, traversing the estuary and Delta in less than one week (Heublein et al. 2009). The behavioral responses of green sturgeon to pile driving noise are unknown but could include disruptions of normal migratory behavior and potential delays in migration. However, given the intermittent nature of pile driving and the daily cessation of pile driving at night, such delays are expected to be minor and not affect the ability of adults to successfully reach the spawning grounds.

Because of their relatively small body size, widespread distribution, and year-round presence in the Delta and estuary, juvenile and sub-adult green sturgeon are at higher risk of injury and mortality to pile driving noise than adults. Similar to adults, the potential for exposure to pile driving noise is highest in the North Delta (Sacramento River in the vicinity of the three proposed intakes) which serves as the primary migration route for young-of-the-year juveniles entering the Delta from natal rearing areas in the upper Sacramento River. Based on the size distribution of juveniles observed at the export facilities in the southern Delta, most juveniles entering the Delta would be expected to be actively swimming juveniles (>100 mm in length) capable of avoiding or swimming away from areas of elevated noise. Because juveniles spend the majority of their lives in deep brackish portions of the estuary before entering the ocean (Moyle 2002, Welch et al. 2006), the Sacramento River adjacent to the proposed intake locations likely serves primarily as a migratory corridor, reducing the duration of potential exposures of juveniles to pile driving sound.

A number of data sources suggest that the distribution of juvenile green sturgeon is widespread in the Delta and estuary, indicating that juvenile green sturgeon could be exposed to pile driving sounds at any of the locations where in-water pile driving is proposed. In the absence of information on the movements and distribution of juveniles in the Delta, potential impacts to the population can be generally assessed based on the proportion of total habitat subject to pile driving sounds. Under existing conditions, the Delta comprises an estimated 84,280 acres of subtidal aquatic habitat (see Table 5.E.4-9 in *BDCP Effects Analysis, Appendix 5E – Habitat Restoration; Section 5.E.4.4.2.1 hereby incorporated by reference*). Using this estimate as a measure of the total amount of potential foraging and rearing habitat available to juveniles, Table 11-mult-2 shows the percentage of habitat that would be subjected to pile driving noise exceeding the injury thresholds during each year of pile driving activities.

Table 11-mult-2. Potential underwater noise impact areas in each year of pile driving activities as a percentage of the total amount of subtidal aquatic habitat in the Delta

Construction Year	Facilities/Structures	Potential Impact Area (acres)	Approximate Percentage of Subtidal Habitat
3	Intakes 1-5 cofferdams	358	0.4%
4	Intakes 1-5 foundation piles	419	0.5%
5	SR-160 bridges	194	0.2%
5	Barge unloading facilities (6)	270	0.3%
7	Head of Old River operable barrier cofferdams	22	<0.1%
7	Head of Old River operable barrier foundation piles	14	<0.1%
8	Clifton Court Forebay cofferdams	364	0.4%
9	Clifton Court Forebay siphons	288	0.3%

These estimates represent a general order-of-magnitude estimate of the potential exposure of the population to impact pile driving noise. Thus, the potential for exposure of the population to project pile driving noise is low. The total area affected in any given construction year would range from <0.1% in year 7 to 0.5% in years 4 and 5, representing a very small fraction of the total amount of subtidal habitat potentially occupied by juvenile green sturgeon. This potential impact is even further reduced when one considers the broader distribution of juvenile sturgeon in the San Francisco estuary, which expands beyond the Delta into the lower estuary and bays as juveniles increase their salinity tolerance. Juveniles typically achieve full tolerance by the end of their first year at sizes larger than 250 mm (Adams et al. 2002). Thus, there is a low likelihood of significant population-level effects on green sturgeon due to impact pile driving noise. Additionally, Mitigation Measures AQUA-1a and AQUA-1b would avoid and minimize underwater noise.

Supplemental Information for Impact AQUA-145: Effects of Underwater Noise during Construction of Water Conveyance Facilities on White Sturgeon

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Table 11-4 presents the life stages of white sturgeon and months of their potential presence in the north, east, and south Delta during the proposed in-water construction window (June 1–October 31). White sturgeon adults and juveniles occur year-round in the Delta and therefore could be exposed to pile driving noise during construction of the proposed intakes and barge unloading facilities. Larvae may also be exposed to pile driving noise but are generally at lower risk than juveniles and adults because of only minor spatial and temporal overlap with in-water pile driving activities. Because the majority of the population spawns in the Sacramento River, adults, larvae, and juveniles are most likely to encounter pile driving noise at the proposed intake locations in the north Delta as they migrate or disperse to and from upstream spawning areas. Similar to green sturgeon, adult white sturgeon are large and less susceptible to noise from impact driving, and are able to avoid injurious exposure to underwater noise from pile driving. They may experience short delays in migration upon encountering pile driving noise; however, pile driving would occur only intermittently through a portion of the day, and minor migration delays are not expected to affect their ability to successfully reach the spawning grounds.

Because of their relatively small body size, larval and juvenile white sturgeon are at higher risk of injury or mortality from pile driving noise. Juveniles are most likely to encounter pile driving noise because of their widespread distribution and year-round presence in the Delta. Although juvenile white sturgeon are capable of actively avoiding pile driving noise and other in-water disturbances, some may be injured or killed if they remain in the areas subject to cumulative SELs exceeding the injury thresholds (Table 11-mult-1). Similar to green sturgeon, potential impacts to the population can be generally assessed based on the proportion of total habitat subject to pile driving sounds. This assessment, described above for green sturgeon, is generally applicable to white sturgeon based on general similarities in juvenile life history and distribution in the San Francisco estuary. Therefore, there is a low likelihood of significant population-level effects on white sturgeon due to pile driving noise. Additionally, Mitigation Measures AQUA-1a and AQUA-1b would avoid and minimize underwater noise.

Supplemental Information for Impact AQUA-163: Effects of Underwater Noise during Construction of Water Conveyance Facilities on Pacific Lamprey

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Table 11-4 presents the life stages of Pacific lamprey and months of their potential presence in the north, east, and south Delta during the proposed in-water construction window (June 1–October 31). Potential impacts of pile driving noise on Pacific lamprey are different from other fish species. In a study of hearing in sturgeon and lamprey, Popper (2005) found that lamprey do not have the typical hearing structures of other fish. Although there have been no studies to determine responses of lamprey to sound (Popper 2005), ammocoetes are partially buried in the substrate, and the substrate dampens vibrations and noise. As a result, at least some life stages of Pacific lamprey may be less susceptible to injury from impact pile driving than other fish species.

Under the alternatives, adult, ammocoete, and macropthalmia life stages could be present in the vicinity of the proposed in-water pile driving locations (intakes and barge unloading facilities) during in-water pile driving activities. While adults would primarily occur between June and July and macropthalmia in June, ammocoetes would occur throughout the year. However, the abundance of ammocoetes is low at all in-water pile driving sites. Adults are considered moderately abundant in June and July near the intakes, but of low abundance in the east and south Delta where barge landings, Clifton Court Forebay modifications, and Head of Old River operable barrier would be located. Macropthalmia would be primarily migrating downstream, and during only a portion of the in-water construction period. Therefore their exposure to pile driving sound levels would likely be limited.

Given the likely low numbers in the east and south Delta, the relatively small areas affected by underwater noise in the east and south Delta, and the intermittent nature of pile driving activities, exposure of Pacific lamprey to potentially harmful pile driving noise is expected to be limited to a small proportion of the total population. Implementation of Mitigation Measures AQUA-1a and AQUA-1b would reduce the magnitude of these effects. Overall, underwater pile driving noise would be expected to adversely affect small numbers of Pacific lamprey. No significant population-level effects are expected.

Supplemental Information for Impact AQUA-181: Effects of Underwater Noise during Construction of Water Conveyance Facilities on River Lamprey

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Table 11-4 presents the life stages of river lamprey and months of their potential presence in the north, east, and south Delta during the proposed in-water construction window (June 1–October 31). Little is known about the distribution and abundance of river lamprey in the Central Valley, but records indicate that they could be present in the Delta during this period. It is assumed that the discussion above for Pacific lamprey generally applies to river lamprey based on general similarities in species life histories, body size, and behavior. Thus, underwater pile driving noise impacts would be limited to small numbers of river lamprey. Additionally, Mitigation Measures AQUA-1a and AQUA-1b would avoid and minimize underwater noise.

11.3.5.2 Changed NEPA and/or CEQA Conclusions for Changed Analyses and Conclusions for Effects of Water Operations (CM1)

A number of impacts related to the effects of water operations were re-examined and resulted in changed conclusions. This section includes revised analyses, discussions, and NEPA and/or CEQA conclusions, **that replace the impact analyses, discussions, and conclusions presented in the Public Draft EIS/EIR**.

Impact AQUA-41: Effects of Water Operations on Rearing Habitat for Chinook Salmon (Winter-Run ESU) Impact AQUA-41 was re-examined in light of reviewing additional documentation for SacEFT and SALMOD models. Both models provide information about juvenile rearing habitat conditions and the impact treated both models with equal weight for the DEIR/DEIS. However, SacEFT provides results for single variables, such as juvenile stranding risk and juvenile rearing weighted usable area. SALMOD integrates these variables and others together by determining the total effect of an alternative on early life stages of Chinook salmon. In this way, SALMOD acts like more of a life cycle model than SacEFT and can better predict biologically relevant effects at a population level. As a result, this impact now preferentially uses SALMOD results over SacEFT results.

Alternative 2A was changed from adverse to not adverse as a result of this re-examination because the impact hinged on a discrepancy in results between the two models. For all other alternatives, there were either other factors that caused the effect to be adverse, SacEFT and SALMOD results were consistent, or a negative effect in SacEFT was deemed not large enough to cause a biologically meaningful effect to winter-run Chinook salmon. Therefore, no other impacts change

Alternative 2A (not adverse/less than significant) In general, Alternative 2A would not reduce the quantity and quality of rearing habitat for fry and juvenile winter-run Chinook salmon relative to NAA.

Sacramento River flows upstream of Red Bluff were examined for the juvenile winter-run Chinook salmon rearing period (August through December) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Lower flows can lead to reduced extent and quality of fry and juvenile rearing habitat. Flows under A2A_LLT would generally be lower than flows under NAA by up to 17% during August and November, and similar to or greater than flows under NAA during September, October, and December.

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the August through December winter-run juvenile rearing period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 2A in any month or water year type throughout the period at either location.

SacEFT predicts that the percentage of years with good juvenile rearing habitat availability, measured as weighted usable area, under A2A_LLT would not be different from the percentage of years under NAA (Table 11-2A-15). In addition, the percentage of years with good (low) juvenile stranding risk under A2A_LLT is predicted to be 45% (14% on an absolute scale) lower than under NAA. This indicates that the quantity and quality of juvenile rearing habitat in the Sacramento River would be lower under A2A_LLT relative to NAA.

Table 11-2A-15. Difference and Percent Difference in Percent Mortality of Winter-Run Chinook Salmon Eggs in the Sacramento River (Egg Mortality Model)

Water Year Type	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
Wet	1 (252%)	-0.1 (-7%)
Above Normal	2 (339%)	-0.1 (-3%)
Below Normal	2 (239%)	1 (82%)
Dry	7 (477%)	1 (20%)
Critical	42 (157%)	-2 (-3%)
All	9 (189%)	0.3 (2%)

SALMOD predicts that winter-run smolt equivalent habitat-related mortality under A2A_LLT would have a negligible difference (<5%) in habitat-related mortality with NAA.

Both SacEFT and SALMOD are considered to be reliable models for winter-run Chinook salmon in the Sacramento River. SALMOD has been used for decades for assessing changes in flows associated with SWP and CVP and SacEFT has been peer-reviewed. Therefore, results of both models were used to draw conclusions about winter-run Chinook salmon rearing conditions. The SALMOD model incorporates effects to all early life stages, including eggs, fry, and juveniles. Therefore, although SacEFT predicts that juvenile stranding risk may increase under Alternative 2A, when combined with all early life stage effects in SALMOD, the effects of this increased stranding risk are not seen in SALMOD when carried through multiple life stages. Further, these results indicate that the August through November flow reductions in the Sacramento River identified above would not have a biological effect on winter-run Chinook salmon rearing.

NEPA Effects: Collectively, these results indicate that the effect of Alternative 2A is not adverse because it does not have the potential to substantially reduce the amount of suitable habitat and substantially interfere with the movement of fish. There would be no substantial effects of Alternative 2A on flows or water temperatures. SALMOD and SacEFT predicted contradicting results regarding habitat-related mortality. SacEFT found that juvenile stranding risk is expected to increase.. However, the SALMOD model found that Alternative 2A would provide no effect on early life stages of winter-run Chinook salmon. The SALMOD results include the effects to all early life stages combined and, therefore, are more representative of the overall effects to winter-run Chinook salmon in the upper Sacramento River.

CEQA Conclusion: In general, Alternative 2A would not reduce the quantity and quality of fry and juvenile rearing habitat for winter-run Chinook salmon relative to the Existing Conditions.

Sacramento River flows upstream of Red Bluff were examined for the juvenile winter-run Chinook salmon rearing period (August through December) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A2A_LLT would generally be similar to or greater than flows under Existing Conditions during October and December, but up to 24% lower than Existing Conditions during August, September, and November.

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the August through December winter-run rearing period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). Mean monthly water temperature would be up to 14% higher under Alternative 2A in July through October depending on month, water year type, and location. There would be no differences (<5%) between Existing Conditions and Alternative 2A in mean monthly water temperature during November and December at either location.

SacEFT predicts that the percentage of years with good juvenile rearing habitat availability, measured as weighted usable area, under A2A_LLT would be 48% lower (24% on an absolute scale) than under Existing Conditions (Table 11-2A-15). In addition, the percentage of years with good (low) juvenile stranding risk under A2A_LLT is predicted to be 15% lower (3% on an absolute scale) than under Existing Conditions. This indicates that the quantity, but not the quality, measured as stranding risk, of juvenile rearing habitat in the Sacramento River would be lower under A2A_LLT relative to Existing Conditions.

SALMOD predicts that winter-run smolt equivalent habitat-related mortality under A2A_LLT would be 15% higher than under Existing Conditions.

Summary of CEQA Conclusion

These results indicate that the impact could be significant because it has the potential to substantially reduce the amount of suitable habitat and substantially interfere with the movement of fish. Differences in flows are moderately large during the majority of months and water years types. Further, water temperatures would be higher than those under NAA in the Sacramento River during a substantial portion of the winter-run rearing period. Both SacEFT and SALMOD predict that juvenile rearing habitat conditions will be degraded by Alternative 2A.

As discussed in Section 11.3.3, because of differences between the CEQA and NEPA baselines, it is sometimes possible for CEQA and NEPA significance conclusions to vary between one another under the same impact discussion. The baseline for the CEQA analysis is Existing Conditions at the time the NOP was prepared. Both the action alternative and the NEPA baseline (NAA_ELT) models anticipated future conditions that would occur around 15 years after project approval (ELT implementation period), including the projected effects of climate change (precipitation patterns), sea level rise and future water demands, as well as implementation of required actions under the 2008 USFWS BiOp and the 2009 NMFS BiOp. Because the action alternative modeling does not partition the effects of implementation of the alternative from the effects of sea level rise, climate change, and future water demands, the comparison to Existing Conditions may not offer a clear understanding of the impact of the alternative on the environment. The comparison to the NAA_ELT is a better approach because it isolates the effect of the alternative from those of sea level rise, climate change, and future water demands.

When compared to NAA_ELT and informed by the NEPA analysis above, flows and water temperatures in the Sacramento River would generally be similar between NAA_ELT and Alternative 2A. SacEFT predicts that juvenile stranding risk may increase under Alternative 2A, but when combined with all early life stage effects in SALMOD, the effects of the alternative would be marginally beneficial to winter-run Chinook salmon. These results represent the increment of change attributable to the alternative, demonstrating the general similarities in flows and water temperature under Alternative 2A and the NAA_ELT, and addressing the limitations of the CEQA baseline (Existing Conditions). Therefore, this impact is found to be less than significant and no mitigation is required.

Impact AQUA-78: Effects of Water Operations on Migration Conditions for Chinook Salmon (Fall-/Late Fall–Run ESU)

Alternative 5 (not adverse/less than significant)

In general, the effects of Alternative 5 on fall- and late fall-run Chinook salmon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Sacramento River

Water temperatures in the Sacramento River under Alternative 5 would be the same as those under Alternative 1A, Impact AQUA-78, which indicates there would be no effect of Alternative 1A on temperatures throughout the period evaluated relative to NAA.

Fall-Run

Flows in the Sacramento River upstream of Red Bluff were examined for juvenile fall-run migrants during February through May. Flows under A5_LLT would be similar to or greater than flows under NAA throughout the juvenile fall-run migration period in all water year types) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in the Sacramento River upstream of Red Bluff were examined during the adult fall-run Chinook salmon upstream migration period (August through December). Mean flows under A5_LLT would be up to 17% lower than those under NAA during November and would generally be similar to or greater than those under NAA during August through October and December, except for 14% lower flow during August of dry years and September of below normal years (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Late Fall-Run

Flows in the Sacramento River upstream of Red Bluff for juvenile late fall–run migrants (January through March) under A5_LLT would generally be similar to or greater than flows under NAA except in dry years during January (5% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in the Sacramento River upstream of Red Bluff were examined during the adult late fall–run Chinook salmon upstream migration period (December through February). Flows under A5_LLT would nearly always be similar to or greater than flows under NAA except in dry years during January (5% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Clear Creek

Water temperature modeling was not conducted in Clear Creek.

Fall-Run

Flows in Clear Creek below Whiskeytown Reservoir were examined for juvenile fall-run migrants during February through May. Flows under A5_LLT would almost always be similar to or greater than those under NAA, except in below normal years during March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in Clear Creek below Whiskeytown Reservoir were examined during the adult fall-run Chinook salmon upstream migration period (August through December). Mean flows under A5_LLT would be similar to or slightly greater than flows under NAA throughout the migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Feather River

Water temperatures in the Feather River under Alternative 5 would be the same as those under Alternative 1A, Impact AQUA-78, which indicates there would be no effect of Alternative 1A on temperatures throughout the period evaluated relative to NAA.

Fall-Run

Flows in the Feather River at the confluence with the Sacramento River were reviewed during the February through May fall-run juvenile migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would always be similar to or greater than flows under NAA.

Mean flows in the Feather River at the confluence with the Sacramento River during the August through December fall-run Chinook salmon adult migration period under A5_LLT would generally be lower by up to 47% than flows under NAA during August and September and would be similar to or up to 39% greater than flows under NAA during October through December, with minor exceptions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

American River

Water temperatures in the American River under Alternative 5 would be the same as those under Alternative 1A, Impact AQUA-78, which indicates there would be no effect of Alternative 1A on temperatures throughout the period evaluated relative to NAA.

Fall-Run

Flows in the American River at the confluence with the Sacramento River were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would always be similar to or greater than flows under NAA.

Flows in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under A5_LLT would generally be lower (up to 43% lower) than those under NAA during August and would generally be similar or up to 24% greater than flows under NAA during September through December, with some exceptions. .

Stanislaus River

Water temperatures in the Stanislaus River for Alternative 5 are not different from those for Alternative 1A, AQUA-78, which indicates there would be no effect of Alternative 1A on temperatures throughout the period evaluated relative to NAA.

Fall-Run

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would be nearly identical to flows under NAA throughout the period.

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under A5_LLT would be nearly the same as flows under NAA throughout the period.

San Joaquin River

Fall-Run

Flows in the San Joaquin River at Vernalis were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under Alternative 5 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the San Joaquin River at Vernalis were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under Alternative 5 would be similar to those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Flows in the Mokelumne River at the Delta were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under Alternative 5 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the Mokelumne River at the Delta were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under Alternative 5 would be the same as those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the Mokelumne River.

Through-Delta

Sacramento River

Fall-Run

Juveniles

During the juvenile fall-run Chinook salmon emigration period (November to early May), mean monthly flows in the Sacramento River below the north Delta intake under Alternative 5 averaged across years would be 6% to 11% lower in most months, and 17% lower in November compared to NAA. Flows would be up to 23% lower in November of above normal years compared to NAA.

As described above in Impact AQUA-39, the north Delta export facilities would replace aquatic habitat and likely attract piscivorous fish around the intake structures. Estimates of potential predation losses at the single intake range from about 0.2% (bioenergetics model, Table 11-mult-56) to 4.5% (based on a fixed 5% loss per intake) of the juvenile fall-run population that reaches the Delta (Appendix 5F, *Biological Stressors*).

Through-Delta survival by emigrating juvenile fall-run Chinook salmon under Alternative 5 (A5_LLT) would average 24.6% across all years. Under Alternative 5, juvenile survival was similar to NAA (Table 11-mult-3).

Table 11-mult-3. Through-Delta Survival (%) of Emigrating Juvenile Fall-Run Chinook Salmon under Baseline and Alternative 5 Scenarios

	Percentage Survival			Difference in Percentage Survival (Relative Difference)	
Year Types	EXISTING CONDITIONS	NAA	A5_LLT	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Sacramento River					
Wetter Years	34.5	31.1	30.1	-4.4 (-13%)	-1.0 (-3%)
Drier Years	20.6	20.8	21.3	0.8 (4%)	0.6 (3%)
All Years	25.8	24.7	24.6	-1.2 (-4%)	0.0 (0%)
Mokelumne River					
Wetter Years	17.2	15.7	15.6	-1.6 (-9%)	-0.1 (-1%)
Drier Years	15.6	15.9	15.8	0.2 (1%)	-0.1 (-1%)
All Years	16.2	15.9	15.7	-0.5 (-3%)	-0.1 (-1%)
San Joaquin River					
Wetter Years	19.3	20.3	19.3	0.0 (0%)	-0.9 (-5%)
Drier Years	10.0	9.5	9.8	-0.1 (-1%)	0.3 (3%)
All Years	13.5	13.6	13.4	-0.1 (-1%)	-0.2 (-1%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and above normal water years (6 years).
Drier = Below normal, dry and critical water years (10 years).

Adults

The adult fall-run migration extends from September-December. The proportion of Sacramento River water in the Delta under Alternative 5 would be similar (<10% change) to NAA during the entire migration period (Table 11-mult-58). Olfactory cues for fall-run adults would likely still be strong, as the proportion of Sacramento River under Alternative 5 would still represent 66–72% of Delta outflows. Flows at Rio Vista would be greater (1–121% increase) under Alternative 5 than under Alternative 1A in September, November and December, but substantially lower (25%) in October. However, because the proportion of Sacramento River water in the Delta would not substantially change during the peak adult migration period under Alternative 5, there would not be an adverse effect on adult fall-run migration success through the Delta.

Late Fall–Run

Juveniles

During the juvenile late fall-run Chinook salmon emigration period (October-February), mean monthly flows in the Sacramento River below the north Delta intake under Alternative 5 averaged across years would be 6% to 9% lower in most months, and 17% lower in November compared to NAA. Flows would be up to 23% lower in November of above normal years compared to NAA.

Estimates of potential predation losses at the single intake range from about 0.2% (bioenergetics model, Table 11-mult-56) to 4.5% (based on a fixed 5% loss per intake) of the juvenile late fall-run population that reaches the Delta (Appendix 5F, *Biological Stressors*).

Through-Delta survival by emigrating juvenile late fall–run Chinook salmon under Alternative 5 (A5_LLT) would average 23% across all years, ranging from 21% in drier years to 27% in wetter years. Under Alternative 5, juvenile survival would be slightly greater (0.4% greater survival, or 3% more in relative percentage) compared to NAA (Table 11-mult-4). Overall, Alternative 5 would not have an adverse effect on late fall–run Chinook salmon juvenile survival through the Delta.

Table 11-mult-4. Through-Delta Survival (%) of Emigrating Juvenile Late Fall–Run Chinook Salmon under Baseline and Alternative 5 Scenarios

	Percentage Survival			Difference in Percentage Survival (Relative Difference)	
Year Types	EXISTING CONDITIONS	NAA	A5_LLT	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Wetter Years	28.8	27.3	27.4	-1.4 (-5%)	0.1 (<1%)
Drier Years	18.8	20.2	20.8	2.1 (11%)	0.6 (3%)
All Years	22.5	22.9	23.3	0.8 (3%)	0.4 (2%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and above normal water years (6 years).
Drier = Below normal, dry and critical water years (10 years).

Adults

The adult late fall–run migration is from November through March, peaking in January through March. Mean monthly flows in Sacramento River at Rio Vista under Alternative 5 would be similar in December through March, and reduced about 20% in November compared to NAA. The proportion of Sacramento River water in the Delta would be similar (<10%) to NAA throughout the migration period (Table 11-mult-58). Based on the similarity in Sacramento River olfactory cues and increase in Rio Vista flows during the adult late fall–run migration, it is assumed that adult migration success through the Delta would be similar or improved relative to those described for Alternative 1A. Therefore, Alternative 5 would not have an adverse effect on late fall–run adult migration.

Mokelumne River

Juveniles

Through-Delta survival by emigrating juvenile fall-run Chinook salmon under Alternative 5 would be 15.7%, which is similar to NAA (Table 11-mult-3).

San Joaquin River

Fall-Run

Juveniles

The only changes to San Joaquin River flows at Vernalis would result from the modeled effects of climate change on inflows to the river downstream of Friant Dam and reduced tributary inflows. There no flow changes associated with the alternatives. Alternative 5 would have no effect on fall-run migration success through the Delta (Table 11-mult-3).

Adults

Alternative 5 would slightly increase the proportion of San Joaquin River water in the Delta in September through December by 0.4 to 1.4 % (compared to NAA) (Table 11-mult-58). The proportion of San Joaquin River water would be similar to or slightly more than NAA. Therefore migration conditions under Alternative 5 would be similar to slightly improved to those described for Alternative 1A. Alternative 5 would have no effect to a slight beneficial effect on the fall-run adult migration, because of the relative increase in olfactory cues from the San Joaquin River basin.

NEPA Effects: Upstream of the Delta, the results indicate that the impact would not be adverse because it does not have the potential to substantially reduce the quantity or quality of migration habitat or interfere with the movement of fish. Upstream flows under Alternative 5 would not be reduced substantially and water temperatures would not be increased substantially in any upstream river compared to NAA.

Near-field effects of Alternative 5 NDD on fall- and late fall-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating fall- and late fall-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 1 new intake would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to larger effects (~ 5% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction surveys to better understand how to minimize losses associated with the 1 new intake structure will be implemented as part of the final NDD screen design effort. Alternative 5 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for fall- and late fall-run Chinook. However, at this time, due to the absence of comparable facilities anywhere in the lower Sacramento River/Delta, the degree of mortality expected from near-field effects at the NDD remains highly uncertain.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 5 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass, reduced interior Delta entry, and reduced south Delta entrainment. The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the plan area is uncertain, and remains an area of active investigation for the BDCP.

The DPM is a flow-based model being developed for BDCP which attempts to combine the effects of all of these elements of BDCP operations and conservation measures to predict smolt migration survival throughout the entire Plan Area. The current draft of this model predicts that smolt migration survival under Alternative 5 would be similar to those estimated for NAA. Further refinement and testing of the DPM, along with several ongoing and planned studies related to salmonid survival at and downstream of, the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve our understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of BDCP implementation on migration conditions for Chinook salmon.

CEQA Conclusion: In general, Alternative 5 would not reduce migration conditions for fall-/late fall–run Chinook salmon relative to Existing Conditions.

Upstream of the Delta

Sacramento River

Water temperatures in the Sacramento River under Alternative 5 would be the same as those under Alternative 1A, Impact AQUA-78, which indicates there would be no effect of Alternative 1A on temperatures throughout the period evaluated.

Fall-Run

Flows in the Sacramento River upstream of Red Bluff were examined for juvenile fall-run migrants were evaluated during February through May. Flows under A5_LLT would generally be similar to or greater than those under Existing Conditions, except in wet years during May (18% lower) and below normal years during March and May (10% and 6% lower, respectively) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in the Sacramento River upstream of Red Bluff were evaluated during the adult fall-run Chinook salmon upstream migration period (August through December). Mean flows would generally be slightly lower than those under Existing Conditions during November, and would be similar to or up to 64% greater (September of above normal years) than those under Existing Conditions during the other four months of the migration period, except for 23% and 24% lower flows in August of critical years and September of dry years, respectively (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Late Fall–Run

Flows in the Sacramento River upstream of Red Bluff were examined for juvenile late fall–run migrants (January through March). Flows under A5_LLT would almost always be similar to or greater than flows under Existing Conditions, except in below normal water years during March (10% reduction) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in the Sacramento River upstream of Red Bluff were examined during the adult late fall–run Chinook salmon upstream migration period (December through February). Flows under A5_LLT would generally be similar to or greater than those under Existing Conditions except in wet and below normal years during December (9% and 6% lower, respectively) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Clear Creek

Water temperature modeling was not conducted in Clear Creek.

Fall-Run

Flows in Clear Creek below Whiskeytown Reservoir were examined during the juvenile fall-run Chinook salmon upstream migration period (February through May). Flows under A5_LLT would be similar to or greater than those under Existing Conditions throughout the period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in Clear Creek below Whiskeytown Reservoir were examined during the adult fall-run Chinook salmon upstream migration period (August through December). Flows under A5_LLT would generally be similar to those under Existing Conditions except in critical years during August and September (17% and 28% lower, respectively) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Feather River

Water temperatures in the Feather River under Alternative would be the same as those under Alternative 1A, Impact AQUA-78, which indicates that there would be no differences in temperatures under Alternative 1A during the periods evaluated.

Fall-Run

Flows in the Feather River at the confluence with the Sacramento River were evaluated during the fall-run juvenile migration period (February through May) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would generally be similar to or greater than flows under Existing Conditions, except in below normal years during February and March (12% and 18% lower, respectively) and wet and above normal years during May (18% and 14% lower, respectively).

Mean flows in the Feather River at the confluence with the Sacramento River during the August through December fall-run Chinook salmon adult migration period under A5_LLT would generally be lower (by up to 48%) than those under Existing Conditions during August and September and would generally be similar to or up to 39% greater than flows under Existing Conditions during October through December (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

American River

Water temperatures in the American River under Alternative 5 would be the same as those under Alternative 1A, Impact AQUA-78, which indicates that temperatures would be higher during substantial portions of the periods evaluated.

Fall-Run

Flows in the American River at the confluence with the Sacramento River were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT during February through April would generally be similar to or greater than flows under Existing Conditions, except for critical years during February and March (18% and 7% lower, respectively) and above and below normal years during April (9% and 7% lower, respectively). Flows during May under A5_LLT would generally be up to 34% lower than flows under Existing Conditions.

Flows in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under A5_LLT would generally be lower than flows under Existing Conditions throughout the adult migration period, ranging from 23% to 61% lower for August, September and November, and from 9% to 23% lower for October and December. However, mean flow during October of below normal years would be 29% higher under A5_LLT.

Stanislaus River

Water temperatures in the Stanislaus River for Alternative 5 are not different from those for Alternative 1A, which indicates that temperatures under Alternative 1A would be higher during substantial portions of the periods evaluated relative to Existing Conditions.

Fall-Run

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would predominantly be lower than flows under Existing Conditions by up to 36%.

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under A5_LLT would generally be up to 18% lower than flows under Existing Conditions during October through December, and would generally be similar in August and September, except for 23% and 17% lower flows in wet years.

San Joaquin River

Flows in the San Joaquin River at Vernalis were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly flows under Alternative 5 would generally be similar to flows under Existing Conditions in all months. Wetter water years under Alternative 5 would have similar or greater flows than those under Existing Conditions, whereas drier years would have lower flows under Alternative 5.

Flows in the San Joaquin River at Vernalis were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under A5_LLT would generally be lower than those under Existing Conditions during August through October (up to 25% lower in August of wet years), and would generally be similar in November and December.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Fall-Run

Flows in the Mokelumne River at the Delta were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under Alternative 5 would be similar to or up to 15% greater than those under Existing Conditions during February and March, but up to 18% lower than flows under Existing Conditions during April and May.

Flows in the Mokelumne River at the Delta were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly flows under A5_LLT would be up to 51% lower than flows under Existing Conditions during August, up to 29% lower than those under Existing Conditions during September, and up to 14% lower during October through November. Flows during December would be up to 15% greater than those under Existing Conditions.

Water temperature modeling was not conducted in the Mokelumne River.

Through-Delta

Sacramento River

As described above, Sacramento River flows below the north Delta intake would be reduced under Alternative 5 compared to Existing Conditions. Estimates of potential predation losses at the single intake range from 0.2% to 4.5% of the population that reaches the Delta. Compared to Existing Conditions, through-Delta survival by emigrating juveniles under Alternative 5 would be 2.1% greater (11% relative increase) in drier years for late-fall run Chinook salmon and 4.4% lower (13% relative decrease) in wetter years for fall-run Chinook salmon (Table 11-mult-3).

Mokelumne River

Through-Delta survival by emigrating juvenile fall-run Chinook salmon under Alternative 5 would be 15.7% (Table 11-mult-3). Compared to Existing Conditions, survival would be similar in most years, but 1.6% lower (9% relative decrease) in wetter years.

San Joaquin River

Through-Delta survival by emigrating juvenile fall-run Chinook salmon under Alternative 5 would be similar to Existing Conditions (Table 11-mult-3).

Summary of CEQA Conclusion

Collectively, the modeling results of the Impact AQUA-78 CEQA analysis indicate that the difference between the CEQA baseline and Alternative 5 could be significant because, under the CEQA baseline, the alternative could substantially reduce migration habitat. Flows in the American, Stanislaus, Mokelumne, and San Joaquin Rivers would be lower than flows in under the CEQA baseline during substantial portions of the migration periods evaluated. Flow reductions during juvenile migration could reduce the downstream migratory ability of juveniles, which could delay smoltification and reduce survival. Flow reductions during adult migration could reduce olfactory cues from natal streams and increase straying. Further, water temperatures in the Feather, American, and Stanislaus Rivers would be higher under Alternative 5 relative to CEQA Existing Conditions, which would further increase stress and mortality of juvenile and adult fall-run migrants.

These results are primarily caused by four factors: differences in sea level rise, differences in climate change, future water demands, and implementation of the alternative. The analysis described above comparing Existing Conditions to the alternative does not partition the effect of implementation of the alternative from those of sea level rise, climate change and future water demands using the model simulation results presented in this chapter. However, the increment of change attributable to the alternative is well informed by the results from the NEPA analysis, which found this effect to be not adverse. In addition, CALSIM modeling has been conducted for Existing Conditions in the LLT implementation period, which does include future sea level rise, climate change, and water demands. Therefore, the comparison of results between the alternative and Existing Conditions in the LLT, both of which include sea level rise, climate change, and future water demands, isolates the effect of the alternative from those of sea level rise, climate change, and water demands.

The additional comparison of CALSIM flow and reservoir storage outputs between Existing Conditions in the late long-term implementation period and the alternative indicates that flows and reservoir storage in the locations and during the months analyzed above would generally be similar between Existing Conditions and the alternative. This indicates that the differences between Existing Conditions and the alternative found above would generally be due to climate change, sea level rise, and future demand, and not the alternative. As a result, the CEQA conclusion regarding Alternative 5, if adjusted to exclude sea level rise and climate change, is similar to the NEPA conclusion, and therefore would not in itself result in a significant impact on migration habitat conditions for fall-/late fall-run Chinook salmon. This impact is found to be less than significant and no mitigation is required.

Impact AQUA-132: Effects of Water Operations on Migration Conditions for Green Sturgeon

Alternatives 2A and 7 (not adverse/less than significant)

Alternative 2A

In general, Alternative 2A would not reduce green sturgeon migration conditions relative to NAA.

Upstream of the Delta

Analyses for green sturgeon migration conditions focused on flows in the Sacramento River between Keswick and Wilkins Slough and in the Feather River between Thermalito and the confluence with the Sacramento River during the April through October larval migration period, the August through March juvenile migration period, and the November through June adult migration period (Appendix

11C, *CALSIM II Model Results utilized in the Fish Analysis*). Because these periods encompass the entire year, flows during all months were compared. Reduced flows could slow or inhibit downstream migration of larvae and juveniles and reduce the ability to sense upstream migration cues and pass impediments by adults.

Sacramento River flows under A2A_LLT would generally be similar to or greater than flows under NAA in all months except July, August, and November, during which flows would be up to 28% lower depending on location, month, and water year type. These flow reductions would be small and infrequent and, therefore, would not cause substantial effects to green sturgeon migration.

Feather River flows under A2A_LLT would generally be lower by up to 52% than those under NAA during July through August. Flows during other months under A2A_LLT would generally be similar to or greater than flows under NAA with some exceptions. Given the benthic nature of green sturgeon and that flows in the Feather River would be consistent with the flow schedule provided by NMFS during the project planning process that is meant to better mimic the natural flow regime while providing adequate storage to meet downstream temperature and water quality requirements, the reductions in summer flows at both locations in the Feather River are not expected to have a substantial effect on green sturgeon.

Larval transport flows were also examined by utilizing the positive correlation between white sturgeon year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved green sturgeon larval transport that results in improved year class strength. However, there is high uncertainty about what the mechanism responsible for this relationship with white sturgeon year class strength is because many flow variable correlate throughout the Central Valley. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. In addition, this correlation was developed using data collected in the absence of north Delta intakes. Also, there are temporal and spatial differences between green and white sturgeon larval presence that make this analysis highly uncertain and potentially not applicable (Murphy et al. 2011). In particular, during April and May, green sturgeon adults would be would be spawning and larvae would be rearing in the upper Sacramento River and Feather River. This mismatch in timing and location limits the confidence in using this as a surrogate for green sturgeon and suggests that year-class strength correlated with flow at another location upstream or during a different period, if at all.

Regardless, for lack of a known relationship for green sturgeon year-class strength, the results using white sturgeon as a surrogate for green sturgeon were examined here. Results for white sturgeon presented in Impact AQUA-150 below suggest that, using the positive correlation between Delta outflow and year class strength, green sturgeon year class strength would be lower under Alternative 2A.

Through-Delta

As described for other species (e.g., Sacramento splittail in Impact AQUA-114), migration conditions in the southern Delta generally would be considerably improved relative to NAA, because of reduced frequency of reverse OMR flows. The effect on green sturgeon would not be adverse.

NEPA Effects: Collectively, these results indicate that the effect is not adverse because it does not have the potential to substantially interfere with the movement of green sturgeon. Sacramento River flows would generally be similar between Alternative 2A and NAA. In the Feather River, there would be some summer flow reductions under Alternative 2A, but given the benthic nature of green sturgeon and that the flow regime is consistent with NMFS recommendations provided to mimic a more natural flow regime to benefit of natives species, these reductions are not expected to adversely affect green sturgeon.

Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 2A and NAA. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 2A was appreciably lower than that under NAA. Analysis of white sturgeon year-class strength (USFWS 1995), used here as a surrogate for green sturgeon, found a positive correlation between year class strength and Delta outflow during April and May. However, there are several problems with approach, as described above that make this analysis highly uncertain and potentially inappropriate.

Determining whether a relationship exists between green sturgeon year class strength and river/Delta outflow and addressing the scientific uncertainty regarding which mechanisms are responsible for the positive correlation between white sturgeon year class strength and river/Delta flow will occur through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 2A operations such that the effect on green sturgeon Delta flow conditions would not be adverse. This, combined with similarities in flow conditions between Alternative 2A and NAA in the Sacramento River, the benthic nature of green sturgeon, and a lack of confidence in using white sturgeon as a surrogate for green sturgeon given the differences in timing and location of the two species, indicate that Alternative 2A would not be adverse to migration conditions for green sturgeon.

CEQA Conclusion: In general, these results indicate that Alternative 2A could reduce the quantity and quality of migration habitat for green sturgeon relative to Existing Conditions. However, as further described below in the Summary of CEQA Conclusion, reviewing the alternative's impacts in relation to the NAA is a better approach because it isolates the effect of the alternative from those of sea level rise, climate change, and future water demand. Informed by the NAA comparison, Alternative 2A would not affect the quantity and quality of migration habitat for green sturgeon.

Upstream of the Delta

Analyses for green sturgeon migration conditions focused on flows in the Sacramento River between Keswick and Wilkins Slough and in the Feather River between Thermalito and the confluence with the Sacramento River during the April through October larval migration period, the August through March juvenile migration period, and the November through July adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Because these periods encompass the entire year, flows during all months were compared. Reduced flows could slow or inhibit downstream migration of larvae and juveniles and reduce the ability to sense upstream migration cues and pass impediments by adults.

Sacramento River flows under A2A_LLT would generally be similar to or greater than flows under Existing Conditions in all months except August, September, and November. Flows during other months would generally be similar to or greater than flows under Existing Conditions.

Flows in the Feather River under A2A_LLT would generally be up to 53% lower than flows under Existing Conditions in July, August, November, and December. Flows during other months under A2A_LLT would generally be similar to or greater than flows under Existing Conditions.

Given the benthic nature of green sturgeon and that flows in the Feather River would be consistent with the flow schedule provided by NMFS during the project planning process that is meant to better mimic the natural flow regime while providing adequate storage to meet downstream temperature and water quality requirements, the reductions in summer flows at both locations in the Feather River are not expected to have a substantial effect on green sturgeon.

For Delta outflow, the percent of months exceeding flow thresholds under A2A_LLT would consistently be lower than those under Existing Conditions for each flow threshold, water year type, and month (8% to 75% lower on a relative scale) (Table 11-mult-114).

Through-Delta

As described for other species (e.g., Sacramento splittail in Impact AQUA-114), migration conditions in the southern Delta generally would be considerably improved relative to NAA, because of reduced frequency of reverse OMR flows. The effect on green sturgeon would not be adverse.

Summary of CEQA Conclusion

Under Alternative 2A, there would be frequent small to large reductions in flows in the Sacramento River upstream of the Delta that would reduce the ability of all three life stages of green sturgeon to migrate successfully. Exceedances of Delta outflow thresholds would be lower under Alternative 2A than under Existing Conditions, although there is high uncertainty that year class strength is due to Delta outflow or if both year class strength and Delta outflows co-vary with another unknown factor. Also, the appropriateness of using white sturgeon as a surrogate for green sturgeon is questionable, as described for the NEPA Effects section above. Contrary to the NEPA conclusion set forth above, these results indicate that the difference between Existing Conditions and Alternative 2A could be significant because the alternative could substantially reduce upstream migration conditions for green sturgeon.

However, this interpretation of the biological modeling is likely attributable to different modeling assumptions for four factors: sea level rise, climate change, future water demands, and implementation of the alternative. As discussed in Section 11.3.3, because of differences between the CEQA and NEPA baselines, it is sometimes possible for CEQA and NEPA significance conclusions to vary between one another under the same impact discussion. The baseline for the CEQA analysis is Existing Conditions at the time the NOP was prepared. Both the action alternative and the NEPA baseline (NAA) models anticipated future conditions that would occur in 2060 (LLT implementation period), including the projected effects of climate change (precipitation patterns), sea level rise and future water demands, as well as implementation of required actions under the 2008 USFWS BiOp and the 2009 NMFS BiOp. Because the action alternative modeling does not partition the effects of implementation of the alternative from the effects of sea level rise, climate change, and future water demands, the comparison to Existing Conditions may not offer a clear understanding of the impact of the alternative on the environment. This suggests that the comparison in results between the alternative and NAA, is a better approach because it isolates the effect of the alternative from those of sea level rise, climate change, and future water demands.

When compared to NAA and informed by the NEPA analysis above, there would be negligible effects on green sturgeon migration conditions in upstream areas. Within the Plan Area, the Adaptive Management Program will evaluate water operations and make adjustments as necessary to protect green sturgeon abundance and ensure the impacts of water operations on migration conditions for green sturgeon are less than significant. Therefore, this impact is found to be less than significant and no mitigation is required.

Alternative 7

In general, Alternative 7 would not reduce green sturgeon migration conditions relative to NAA.

Upstream of the Delta

Analyses for green sturgeon migration conditions focused on flows in the Sacramento River between Keswick and Wilkins Slough and in the Feather River between Thermalito and the confluence with the Sacramento River during the April through October larval migration period, the August through March juvenile migration period, and the November through June adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Because these periods encompass the entire year, flows during all months were compared. Reduced flows could slow or inhibit downstream migration of larvae and juveniles and reduce the ability to sense upstream migration cues and pass impediments by adults.

Sacramento River flows under A7_LLT would generally be similar to or greater than flows under NAA in all months except for November and December (at Keswick only) during which flows would be up to 17% lower depending on location, month, and water year type. These flow reductions would be small and infrequent and, therefore, would not cause substantial effects to green sturgeon migration.

Feather River flows under A7_LLT would generally be lower by up to 38% than those under NAA during July through September and December. Flows during other months under A7_LLT would generally be similar to or greater than flows under NAA with some exceptions. Given the benthic nature of green sturgeon and that flows in the Feather River would be consistent with the flow schedule provided by NMFS during the project planning process that is meant to better mimic the natural flow regime while providing adequate storage to meet downstream temperature and water quality requirements, the reductions in summer flows at both locations in the Feather River are not expected to have a substantial effect on green sturgeon.

Larval transport flows were also examined by utilizing the positive correlation between white sturgeon year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved green sturgeon larval transport that results in improved year class strength. However, there is high uncertainty about what the mechanism responsible for this relationship with white sturgeon year class strength is because many flow variable correlate throughout the Central Valley. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. In addition, this correlation was developed using data collected in the absence of north Delta intakes. Also, there are temporal and spatial differences between green and white sturgeon larval presence that make this analysis highly uncertain and potentially not applicable (Murphy et al. 2011). In particular, during April and May, green sturgeon adults would be spawning and larvae would be rearing in the upper Sacramento River and Feather River. This mismatch in timing and location limits the confidence in using this as a surrogate for green sturgeon and suggests that year-class strength correlated with flow at another location upstream or during a different period, if at all.

Regardless, for lack of a known relationship for green sturgeon year-class strength, the results using white sturgeon as a surrogate for green sturgeon were examined here. Results for white sturgeon presented in Impact AQUA-150 below suggest that, using the positive correlation between Delta outflow and year class strength, green sturgeon year class strength would be lower under Alternative 7 than those under NAA (up to 33% lower).

Through-Delta

As described for other species (e.g., Sacramento splittail in Impact AQUA-114), migration conditions in the southern Delta generally would be considerably improved relative to NAA, because of reduced frequency of reverse OMR flows. The effect on green sturgeon would not be adverse.

NEPA Effects: Collectively, these results indicate that the effect is not adverse because it does not have the potential to substantially interfere with the movement of green sturgeon. Sacramento River flows would generally be similar between Alternative 7 and NAA. In the Feather River, there would be some summer flow reductions under Alternative 7, but given the benthic nature of green sturgeon and that the flow regime is consistent with NMFS recommendations provided to mimic a more natural flow regime to benefit of natives species, these reductions are not expected to adversely affect green sturgeon.

Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 7 and NAA. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 7 was appreciably lower than that under NAA. Analysis of white sturgeon year-class strength (USFWS 1995), used here as a surrogate for green sturgeon, found a positive correlation between year class strength and Delta outflow during April and May. However, there are several problems with approach, as described above that make this analysis highly uncertain and potentially inappropriate.

Determining whether a relationship exists between green sturgeon year class strength and river/Delta outflow and addressing the scientific uncertainty regarding which mechanisms are responsible for the positive correlation between white sturgeon year class strength and river/Delta flow will occur through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 7 operations such that the effect on green sturgeon Delta flow conditions would not be adverse. This, combined with similarities in flow conditions between Alternative 7 and NAA in the Sacramento River, the benthic nature of green sturgeon, and a lack of confidence in using white sturgeon as a surrogate for green sturgeon given the differences in timing and location of the two species, indicate that Alternative 7 would not be adverse to migration conditions for green sturgeon.

CEQA Conclusion: In general, these results indicate that Alternative 7 could reduce the quantity and quality of migration habitat for green sturgeon relative to Existing Conditions. However, as further described below in the Summary of CEQA Conclusion, reviewing the alternative's impacts in relation to the NAA is a better approach because it isolates the effect of the alternative from those of sea level rise, climate change, and future water demand. Informed by the NAA comparison, Alternative 7 would not affect the quantity and quality of migration habitat for green sturgeon.

Upstream of the Delta

Analyses for green sturgeon migration conditions focused on flows in the Sacramento River between Keswick and Wilkins Slough and in the Feather River between Thermalito and the confluence with the Sacramento River during the April through October larval migration period, the August through March juvenile migration period, and the November through June adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Because these periods encompass the entire year, flows during all months were compared. Reduced flows could slow or inhibit downstream migration of larvae and juveniles and reduce the ability to sense upstream migration cues and pass impediments by adults.

Sacramento River flows at Keswick under A7_LLT would generally be lower than flows under Existing Conditions during April, September, and December by up to 23% depending on location, month, and water year type. Flows during other months would generally be similar to or greater than flows under Existing Conditions with some exceptions.

Flows in the Feather River at Thermalito under A7_LLT would generally be up to 53% lower than flows under Existing Conditions during January, March, May, July, November, and December. Flows during other months under A7_LLT would generally be similar to or greater than flows under Existing Conditions with some exceptions.

Given the benthic nature of green sturgeon and that flows in the Feather River would be consistent with the flow schedule provided by NMFS during the project planning process that is meant to better mimic the natural flow regime while providing adequate storage to meet downstream temperature and water quality requirements, the reductions in summer flows at both locations in the Feather River are not expected to have a substantial effect on green sturgeon.

For Delta outflow, the percent of months exceeding flow thresholds under A7_LLT would generally be lower than those under Existing Conditions (up to 50% lower) with few exceptions (see Table 11-mult-124 below).

Through-Delta

As described for other species (e.g., Sacramento splittail in Impact AQUA-114), migration conditions in the southern Delta generally would be considerably improved relative to NAA, because of reduced frequency of reverse OMR flows. The effect on green sturgeon would not be adverse.

Summary of CEQA Conclusion

Under Alternative 7, there would be frequent small to large reductions in flows in the Sacramento River upstream of the Delta that would reduce the ability of all three life stages of green sturgeon to migrate successfully. Exceedances of Delta outflow thresholds would be lower under Alternative 7 than under Existing Conditions, although there is high uncertainty that year class strength is due to Delta outflow or if both year class strength and Delta outflows co-vary with another unknown factor. Also, the appropriateness of using white sturgeon as a surrogate for green sturgeon is questionable, as described for the NEPA Effects section above. Contrary to the NEPA conclusion set forth above, these results indicate that the difference between Existing Conditions and Alternative 7 could be significant because the alternative could substantially reduce upstream migration conditions for green sturgeon.

However, this interpretation of the biological modeling is likely attributable to different modeling assumptions for four factors: sea level rise, climate change, future water demands, and implementation of the alternative. As discussed in Section 11.3.3, because of differences between the CEQA and NEPA baselines, it is sometimes possible for CEQA and NEPA significance conclusions to vary between one another under the same impact discussion. The baseline for the CEQA analysis is Existing Conditions at the time the NOP was prepared. Both the action alternative and the NEPA baseline (NAA) models anticipated future conditions that would occur in 2060 (LLT implementation period), including the projected effects of climate change (precipitation patterns), sea level rise and future water demands, as well as implementation of required actions under the 2008 USFWS BiOp and the 2009 NMFS BiOp. Because the action alternative modeling does not partition the effects of implementation of the alternative from the effects of sea level rise, climate change, and future water demands, the comparison to Existing Conditions may not offer a clear understanding of the impact of the alternative on the environment. This suggests that the comparison in results between the alternative and NAA, is a better approach because it isolates the effect of the alternative from those of sea level rise, climate change, and future water demands.

When compared to NAA and informed by the NEPA analysis above, there would be negligible effects on green sturgeon migration conditions in upstream areas. Within the Plan Area, the Adaptive Management Program will evaluate water operations and make adjustments as necessary to protect green sturgeon abundance and ensure the impacts of water operations on migration conditions for green sturgeon are less than significant. Therefore, this impact is found to be less than significant and no mitigation is required.

Impact AQUA-201: Effects of Water Operations on Entrainment of Non-Covered Aquatic Species of Primary Management Concern

This recirculated analysis of the effects of water operations on non-covered aquatic species of primary concern includes updated assessments of entrainment potential and rearing/migration habitat within the Plan Area for the following species:

- Striped Bass
- American Shad
- Threadfin Shad
- Largemouth Bass
- Sacramento Tule Perch
- Sacramento-San Joaquin roach – California species of special concern
- Hardhead – California species of special concern
- California bay shrimp

As with the public draft EIR-EIS, this analysis includes consideration of all alternatives in relation to Existing Conditions and the No Action Alternative. Also included is an analysis of the NAA_ELT scenario in relation to Alternatives 2D, 4A, and 5A; however, the impact conclusions for those alternatives are presented in their respective subsections of Section 4 of the RDEIR/SDEIS .

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7 and 8 (adverse/significant); alternative 9 (not adverse/less than significant)

NEPA Effects: Impact AQUA-3 under delta smelt provides a general relevant discussion of the effects of water operations on the type, magnitude and range of impact mechanisms that are relevant to the aquatic environment and aquatic species, including non-covered aquatic species of primary management concern. Striped bass, American shad, and threadfin shad are similar to delta smelt in being pelagic species that are susceptible to entrainment at the south Delta facilities in proportion to broadscale hydrodynamic factors such as OMR flows (shown for striped bass by Grimaldo et al. 2009). Operation of north Delta intakes under all alternatives (except Alternative 9) would be expected to reduce overall entrainment of screenable life stages (i.e., early juveniles and older, around 20 mm long) because of the reduction in use of the south Delta facilities, which do not have the state of the art fish screens proposed for the north Delta intakes. Differences in potential entrainment as a function of exports that were provided for juvenile Sacramento splittail under Impact AQUA-111 are representative of the late spring/early summer differences in entrainment that could occur for juvenile striped bass and the shads.

Earlier life stages (eggs and larvae) of striped bass, American shad, and threadfin shad would be susceptible to entrainment at the proposed north Delta intakes; for striped bass and American shad in particular, much of the overall Central Valley populations may be spawned upstream of the proposed north Delta intakes and therefore could be susceptible. In the Sacramento River, striped bass spawning usually takes place between Colusa (river km 195) and the mouth of the Feather River (river km 125), and to a much lesser extent within the Delta (Moyle 2002). Eggs and larvae would be vulnerable as they are passively transported downstream from spawning areas within the Sacramento River. Data from the striped bass egg and larval survey (several years during 1977-1994) showed that early life history stages of striped bass (eggs and larvae <15mm) occur in the north Delta intakes area from April until June with the primary occurrence in May, with occasional occurrence as early as March and as late as July.

American shad are known to rear upstream of the north Delta intakes area (Moyle 2002), although Stevens (1966) identified the lower Sacramento River (Isleton) and the backwater sloughs of the Mokelumne River as primary rearing areas. He postulated that shad larvae were advected from the Sacramento River through the Delta Cross-Channel into the Mokelumne River and then into the San Joaquin River. This suggests two contrasting rearing scenarios that are probably dependent on flow and water temperature (Crecco and Savoy 1985; Moyle 2002). Early life history stages of American shad (eggs and larvae) could occur in the north Delta intakes area from April until June, with the primary occurrence in May-June, and occasional occurrence as early as February and as late as July based on the historic striped bass egg and larval survey data. American shad larvae that rear successfully upstream of the proposed North Delta intake would be large enough to avoid entrainment, but if river conditions (high flow, low temperatures) moved the larvae through the area of the water intake structures as small larvae there would be the potential to be entrained at similar rates to striped bass larvae, which are mostly moving into the Plan Area as opposed to remaining upstream.

Particle tracking modeling results for ten monthly periods during March-June generally suggested that overall entrainment of early life stages (eggs and larvae) of striped bass and American shad originating in the Sacramento River upstream of the Plan Area and moving downstream into the Plan Area could increase under most alternatives relative to NAA (Table 11-mult-5). The potential increase in mean entrainment ranged from 5.2% more (an 84% relative increase) under Alternative

5 to 17.3% more (a 279% relative increase) under Alternative 2. Potential entrainment under Alternative 4A was 14.3% more (a 220% relative increase) than under NAA_ELT. Overall entrainment was 0.8% less (an 11% decrease) than NAA under Alternative 9, which does not have north Delta intakes. Entrainment under NAA and NAA_ELT scenarios was moderately lower (18-22% relative difference in mean entrainment) than under Existing Conditions (Table 11-mult-5). The effects of entrainment under NAA, NAA_ELT, and Alternative 9 for striped bass and American shad therefore would not be adverse.

For the alternatives proposing water conveyance with north Delta intakes, then, there is the potential for an appreciable increase in magnitude of entrainment of early life stages. It is important to consider the context within which the entrainment is occurring. For striped bass entrainment at the south Delta intakes, Grimaldo et al. (2009) noted:

> Population-level consequences [of entrainment] have been best studied for striped bass. Striped bass larval production was historically explained by river flows and southern Delta exports (Stevens et al. 1985). However, Kimmerer et al. (2001) found that export effects were small and sporadic, primarily occurring during the first several months of life. Moreover, striped bass population dynamics is best explained by density dependence between age-1 and age-2 year classes, a bottleneck that dampens variation from effects early in life (Kimmerer et al. 2000). However, our analyses indicate that if there are years when density dependence is relaxed, then age-0 striped bass losses could be reduced by managing export flows during periods when these fish are abundant in the Delta.

Baxter et al. (2010) stated that the reasons for the continued decline of the age-0 striped bass abundance index to record lows during the POD years, despite an increase in the adult abundance index and by extension, egg supply, are unknown. Recent statistical evaluations found water clarity, fall outflow (as indexed by X2), and food to be important in explaining trends in abundance (Mac Nally et al. 2010; Thomson et al. 2010), whereas entrainment was not found to be an important predictor. However, given the potential for appreciably greater entrainment of the earliest life stages, it is concluded with some uncertainty that the effects of entrainment on striped bass from Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, and 8 would be adverse. Although American shad early life stages may rear to sufficiently large size above the Plan Area, they could also be entrained in appreciably greater magnitude than currently occurs and therefore it is also concluded that the effects of entrainment on American shad from Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 2D, 3, 4, 4A, 5, 5A, 6A, 6B, 6C, 7, and 8 would be adverse. Note that entrainment of the early life stages of striped bass and American shad at the north Delta intakes may be moderated by real-time operational adjustments during the spring to benefit covered fishes such as spring-run Chinook salmon, and that the results presented in Table 11-mult-5 for Alternative 4 and Alternative 4A reflect the H3 and H3_ELT scenarios, whereas spring entrainment under the H4 and H4_ELT scenarios would be somewhat less. Note also that although the north Delta intake screens are estimated to exclude larvae or juvenile fish of around 20-22 mm and larger, they may also exclude smaller fish to some extent, based on observations from other fish screens in the Delta (Nobriga et al. 2004).

Threadfin shad early life stages are present in the area occupied by the north Delta intakes during April, May, June, and July, but are most abundant during May and June, based on the historic striped bass egg and larval survey data. Threadfin shad eggs are not easily entrained as they are spawned on floating debris or vegetation and are adhesive (Moyle 2002). As shown for striped bass and American shad, the potential for entrainment of any threadfin shad eggs or larvae small enough to be entrained that enter the Plan Area from the Sacramento River generally would be greater under most scenarios (Table 11-mult-5). However, as noted by Baxter et al. (2010), the species is widely distributed but is most commonly encountered and most abundant in the southeastern Delta, especially the San Joaquin River near and just downstream of Stockton, where suitable abiotic habitat coincides with high prey abundance (Feyrer et al. 2009); these regions also have a relatively high density of SAV, which provides important spawning and larval rearing habitat (Grimaldo et al. 2004). Baxter et al. (2010) also noted that historic surveys by Turner (1966) found relatively high abundance in the northeast Delta in dead-end sloughs and suggests that relatively few threadfin shad would be susceptible to entrainment at the north Delta intakes. Given the reduction in entrainment at the south Delta intakes under the proposed alternatives, as well as the NAA and NAA_ELT alternatives, the effects of entrainment would not be adverse.

Table 11-mult-5. Percentage of Particles Originating in the Sacramento River at Sacramento That Were Entrained by the South Delta Export Facilities, Delta Island Consumptive Use, the North Bay Aqueduct Barker Slough Pumping Plant, or the Proposed North Delta Intakes, by Alternative, with Differences From Existing Conditions and the No Action Alternative (NAA or NAA_ELT Scenarios)

Month/ year	Existing Conditions	NAA	Alt. 1A, 1B, 1C	Alt. 2A, 2B, 2C	Alt. 2D	Alt. 3	Alt. 4 (H3)	NAA_ ELT	Alt. 4A (H3_ELT)	Alt. 5	Alt. 5A	Alt. 6A, 6B, 6C	Alt. 7	Alt. 8	Alt. 9
Apr-29	2.8	1.8	7.1	7.7	6.3	6.6	8.2	1.8	6.9	3.9	4.4	7.4	6.1	5.3	2.8
May-66	6.3	4.8	16.6	10.4	17.7	15.2	9.4	5.1	13.9	6.3	7.7	15.5	12.2	8.2	10.9
Jun-34	17.3	14.3	15.9	15.6	15.6	15.8	15.8	14.1	15.6	12.6	13.2	16.8	15.8	15.8	11.6
Jun-40	23.1	10.4	45.4	42.2	55.9	27.1	33.5	16.0	44.0	22.1	26.2	55.1	34.3	38.9	5.5
May-37	3.1	3.7	9.4	8.4	10.6	7.5	8.7	3.3	11.3	6.8	10.6	9.9	8.8	35.2	9.0
Mar-61	14.3	5.9	11.4	11.1	11.2	8.9	10.5	7.5	14.9	7.7	17.8	6.9	5.8	6.7	1.6
May-35	1.7	1.5	28.0	29.8	16.9	15.1	22.1	1.6	17.8	8.8	9.9	28.5	23.5	20.5	2.9
Apr-86	0.3	0.5	25.9	36.5	36.4	12.5	24.4	0.7	22.9	8.2	7.4	38.9	24.7	22.8	0.6
Mar-01	3.1	3.4	16.8	16.9	16.8	21.8	21.1	3.4	21.2	12.8	13.8	14.3	17.0	21.4	0.8
Jun-93	7.1	15.6	35.1	56.2	43.2	35.9	41.8	11.3	39.2	25.0	22.2	35.3	26.2	42.5	8.4
Mean	7.9	6.2	21.1	23.5	23.0	16.6	19.6	6.5	20.8	11.4	13.3	22.9	17.4	21.7	5.4
Differences															
vs. Existing Conditions	—	-1.7 (-22%)	13.2 (168%)	15.6 (197%)	15.2 (192%)	8.7 (111%)	11.7 (148%)	-1.4 (-18%)	12.9 (163%)	3.5 (45%)	5.4 (69%)	15.0 (189%)	9.5 (121%)	13.8 (175%)	-2.5 (-32%)
vs. NAA (vs. NAA_ELT for Alts. 2D, 4A, and 5A)	—	—	14.9 (241%)	17.3 (279%)	16.6 (256%)	10.5 (169%)	13.4 (216%)	—	14.3 (220%)	5.2 (84%)	6.8 (106%)	16.7 (269%)	11.3 (182%)	15.5 (251%)	-0.8 (-13%)

Notes: Modeling results from DSM2-PTM. Relative differences are given in parentheses. Negative values indicate less entrainment under an alternative than Existing Conditions or NAA/NAA_ELT. Also included are comparisons of the NAA and NAA_ELT scenarios to Existing Conditions.

Whereas striped bass and the two shad species are pelagic species and therefore more susceptible to entrainment at the earlier life stages because of broad-scale hydrodynamic effects, other non-covered aquatic species of primary management concern occupy nearshore littoral habitat and therefore are less likely to vary in entrainment rate in proportion to water diverted (Grimaldo et al. 2009). Largemouth bass are nearshore littoral species that have not been shown to be entrained in proportion to hydrodynamic factors such as OMR flows (Grimaldo et al. 2009). Similarly, tule perch is a live-bearing surf perch usually found nearshore in heavy cover or rip-rap and is unlikely to be affected, as the population is widespread and is not easily entrained, and on average it makes up only a fraction of all species salvaged at the south Delta facilities. Therefore the effects of the alternatives on entrainment of these two species would not be adverse.

Other non-covered aquatic species of primary management concern are unlikely to overlap the regions affected by operations of CM1. California bay shrimp do not occur in freshwater and would not be affected, and it is unlikely that either hardhead or roach would be affected, because their distributions are almost exclusively in upstream areas. Consequently, the effects on these species from the alternatives would not be adverse.

CEQA Conclusion: For the reasons described above in the *NEPA Effects* conclusion, for most non-covered aquatic species the entrainment impacts would be less than significant. However, the potential for entrainment of eggs and larvae of striped bass and American shad would be appreciably greater than Existing Conditions under Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, and 8 (Table 11-mult-5). The impact of entrainment for striped bass and American shad therefore would be significant and unavoidable for Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, and 8. The impact of entrainment for striped bass and American shad would be less than significant for Alternative 9, NAA, and NAA_ELT.

Impact AQUA-203: Effects of Water Operations on Rearing Habitat of Non-Covered Aquatic Species of Primary Management Concern

Water operations have the potential to affect striped bass and American shad juvenile abundance through changes in the extent of rearing habitat in the Plan Area as indexed by X2 (Kimmerer et al. 2009). In addition, bay shrimp have the potential to be affected by water operations, possibly because of an increase in residual circulation in the estuary with increasing outflow (again, as indexed by X2) that could translate to more rapid or more complete entrainment into the estuary, or more rapid transport to rearing grounds, both of which presumably could increase survival from hatching to settlement (Kimmerer et al. 2009). The X2-abundance index and X2-survival index relationships from Kimmerer et al. (2009) were used to assess effects on these three species related to rearing habitat. The effects of water operations on rearing habitat of the other non-covered aquatic species of primary management concern are as described in the public draft EIR-EIS, under Alternative Impact AQUA-203.

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

Striped Bass

NEPA Effects: Several X2-abundance index or X2-survival index relationships from Kimmerer et al. (2009) were applied to striped bass. Application of these relationships suggested that, in relation to NAA/NAA_ELT, under most alternatives there could be relatively small effects (<5% change) of water operations in mean annual rearing habitat and resulting survival or abundance of juvenile striped bass; the exceptions were Alternatives 1A-1C, 2D, 3A-3C, and 5A for which the analysis suggested 5-10% reductions in some cases, and Alternative 8, for which increases in the range of >5-15% were found (Table 11-mult-6, Table 11-mult-7, Table 11-mult-8, Table 11-mult-9, Table 11-mult-10). These results indicate that the operational effects would not be adverse, because they would not result in a substantial reduction in the rearing habitat for striped bass. This is particularly true given that most alternatives also include substantial habitat restoration that would provide additional habitat. Therefore the effects of a change in rearing habitat related to water operations for striped bass would not be adverse under any alternative.

Table 11-mult-6. Striped Bass Townet Survey Survival Index, Based on Equation from Kimmerer et al. (2009)

Water Year Type	Existing Conditions	NAA	Alt. 1A, 1B, 1C	Alt. 2A, 2B, 2C	Alt. 2D	Alt. 3	Alt. 4 (H1)	Alt. 4 (H2)	Alt. 4 (H3)	Alt. 4 (H4)	NAA_ELT	Alt. 4A (H3_ELT)	Alt. 4A (H4_ELT)	Alt. 5	Alt. 5A	Alt. 6A, 6B, 6C	Alt. 7	Alt. 8	Alt. 9
All	145	116	107	110	125	107	111	122	111	121	135	126	139	113	129	114	117	132	118
Wet	230	174	166	169	196	167	171	186	171	185	212	199	216	175	203	172	177	191	180
Above Normal	160	133	114	121	138	115	123	139	123	139	153	140	161	127	144	124	130	146	131
Below Normal	121	98	86	92	104	86	93	108	93	106	111	105	126	92	106	97	99	121	97
Dry	88	76	71	72	76	70	72	75	72	75	81	76	81	72	77	76	77	94	81
Critical	58	53	50	50	55	50	50	51	50	50	57	55	56	50	55	54	57	65	53
Differences from Existing Conditions																			
All		-29 (-20%)	-38 (-26%)	-35 (-24%)	-20 (-14%)	-38 (-26%)	-33 (-23%)	-23 (-16%)	-34 (-23%)	-24 (-16%)	-10 (-7%)	-19 (-13%)	-5 (-4%)	-32 (-22%)	-16 (-11%)	-31 (-22%)	-28 (-19%)	-12 (-9%)	-26 (-18%)
Wet		-56 (-24%)	-64 (-28%)	-62 (-27%)	-34 (-15%)	-64 (-28%)	-59 (-26%)	-44 (-19%)	-59 (-26%)	-45 (-19%)	-18 (-8%)	-31 (-14%)	-15 (-6%)	-55 (-24%)	-27 (-12%)	-58 (-25%)	-53 (-23%)	-40 (-17%)	-50 (-22%)
Above Normal		-27 (-17%)	-46 (-29%)	-40 (-25%)	-22 (-14%)	-46 (-28%)	-37 (-23%)	-21 (-13%)	-37 (-23%)	-21 (-13%)	-7 (-4%)	-20 (-13%)	0 (0%)	-34 (-21%)	-17 (-10%)	-36 (-23%)	-30 (-19%)	-15 (-9%)	-30 (-18%)
Below Normal		-23 (-19%)	-35 (-29%)	-29 (-24%)	-17 (-14%)	-35 (-29%)	-28 (-23%)	-13 (-11%)	-28 (-23%)	-14 (-12%)	-10 (-8%)	-16 (-13%)	5 (4%)	-28 (-24%)	-15 (-12%)	-24 (-20%)	-22 (-18%)	0 (0%)	-24 (-20%)
Dry		-11 (-13%)	-17 (-19%)	-15 (-18%)	-11 (-13%)	-17 (-20%)	-15 (-17%)	-13 (-14%)	-15 (-18%)	-13 (-15%)	-7 (-8%)	-11 (-13%)	-6 (-7%)	-16 (-18%)	-10 (-12%)	-12 (-14%)	-11 (-12%)	6 (7%)	-6 (-7%)
Critical		-5 (-9%)	-8 (-14%)	-8 (-14%)	-3 (-5%)	-8 (-14%)	-8 (-14%)	-8 (-13%)	-8 (-14%)	-8 (-13%)	-2 (-3%)	-3 (-5%)	-2 (-4%)	-8 (-13%)	-3 (-5%)	-4 (-8%)	-1 (-1%)	6 (11%)	-5 (-9%)
Differences from NAA (from NAA_ELT for Alts. 2D, 4A, and 5A)																			
All			-9 (-8%)	-6 (-5%)	-10 (-7%)	-9 (-8%)	-5 (-4%)	6 (5%)	-5 (-4%)	5 (4%)		-9 (-6%)	5 (3%)	-3 (-3%)	-6 (-5%)	-2 (-2%)	1 (1%)	16 (14%)	2 (2%)
Wet			-8 (-5%)	-6 (-3%)	-16 (-8%)	-8 (-4%)	-3 (-2%)	12 (7%)	-4 (-2%)	11 (6%)		-14 (-6%)	3 (2%)	1 (0%)	-9 (-4%)	-3 (-2%)	2 (1%)	16 (9%)	6 (3%)
Above Normal			-19 (-14%)	-12 (-9%)	-15 (-10%)	-18 (-14%)	-10 (-8%)	6 (5%)	-10 (-8%)	7 (5%)		-13 (-9%)	8 (5%)	-6 (-5%)	-9 (-6%)	-9 (-7%)	-3 (-2%)	13 (10%)	-2 (-2%)
Below Normal			-12 (-12%)	-6 (-6%)	-7 (-6%)	-12 (-13%)	-5 (-5%)	10 (10%)	-6 (-6%)	8 (8%)		-7 (-6%)	15 (13%)	-6 (-6%)	-5 (-5%)	-1 (-1%)	1 (1%)	22 (23%)	-1 (-1%)
Dry			-6 (-7%)	-4 (-5%)	-5 (-6%)	-6 (-8%)	-4 (-5%)	-1 (-2%)	-4 (-5%)	-2 (-2%)		-5 (-6%)	0 (0%)	-4 (-6%)	-4 (-5%)	-1 (-1%)	0 (1%)	18 (23%)	5 (7%)
Critical			-3 (-6%)	-3 (-6%)	-1 (-2%)	-3 (-6%)	-3 (-5%)	-3 (-5%)	-3 (-6%)	-3 (-5%)		-1 (-3%)	-1 (-1%)	-3 (-5%)	-1 (-2%)	1 (1%)	4 (8%)	11 (22%)	0 (-1%)

Note: Values calculated from CalSim-II X2 outputs. Relative differences are given in parentheses. Negative values indicate lower survival under an alternative than Existing Conditions or NAA/NAA_ELT. Also included are comparisons of the NAA and NAA_ELT scenarios to Existing Conditions.

Table 11-mult-7. Striped Bass Townet Survey Abundance Index, Based on Equation from Kimmerer et al. (2009)

Water Year Type	Existing Conditions	NAA	Alt. 1A, 1B, 1C	Alt. 2A, 2B, 2C	Alt. 2D	Alt. 3	Alt. 4 (H1)	Alt. 4 (H2)	Alt. 4 (H3)	Alt. 4 (H4)	NAA_ELT	Alt. 4A (H3_ELT)	Alt. 4A (H4_ELT)	Alt. 5	Alt. 5A	Alt. 6A, 6B, 6C	Alt. 7	Alt. 8	Alt. 9
All	1.1	1.0	0.9	0.9	1.0	0.9	0.9	1.0	0.9	1.0	1.1	1.0	1.1	0.9	1.0	0.9	1.0	1.1	1.0
Wet	1.6	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.3	1.4	1.5	1.5	1.6	1.3	1.5	1.3	1.3	1.4	1.4
Above Normal	1.3	1.1	1.0	1.0	1.1	1.0	1.0	1.1	1.0	1.1	1.2	1.1	1.3	1.0	1.1	1.0	1.1	1.2	1.1
Below Normal	1.0	0.9	0.8	0.8	0.9	0.8	0.8	0.9	0.8	0.9	0.9	0.9	1.0	0.8	0.9	0.9	0.9	1.0	0.9
Dry	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8
Critical	0.6	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.6	0.5	0.6	0.6	0.5
Differences from Existing Conditions																			
All		0 (-15%)	-0.2 (-20%)	-0.2 (-19%)	-0.1 (-11%)	-0.2 (-20%)	-0.2 (-18%)	-0.1 (-12%)	-0.2 (-18%)	-0.1 (-12%)	0 (-5%)	-0.1 (-10%)	0.0 (-3%)	-0.2 (-17%)	-0.1 (-9%)	-0.2 (-16%)	-0.2 (-14%)	-0.1 (-6%)	-0.2 (-14%)
Wet		0 (-19%)	-0.4 (-22%)	-0.4 (-21%)	-0.2 (-12%)	-0.4 (-22%)	-0.3 (-20%)	-0.2 (-15%)	-0.3 (-21%)	-0.2 (-15%)	0 (-6%)	-0.2 (-11%)	-0.1 (-5%)	-0.3 (-19%)	-0.2 (-9%)	-0.3 (-20%)	-0.3 (-18%)	-0.2 (-13%)	-0.3 (-17%)
Above Normal		0 (-13%)	-0.3 (-23%)	-0.2 (-19%)	-0.1 (-11%)	-0.3 (-23%)	-0.2 (-18%)	-0.1 (-10%)	-0.2 (-18%)	-0.1 (-10%)	0 (-4%)	-0.1 (-10%)	0.0 (0%)	-0.2 (-17%)	-0.1 (-8%)	-0.2 (-18%)	-0.2 (-15%)	-0.1 (-7%)	-0.2 (-15%)
Below Normal		0 (-15%)	-0.2 (-23%)	-0.2 (-19%)	-0.1 (-11%)	-0.2 (-23%)	-0.2 (-18%)	-0.1 (-8%)	-0.2 (-18%)	-0.1 (-9%)	0 (-6%)	-0.1 (-10%)	0.0 (3%)	-0.2 (-18%)	-0.1 (-10%)	-0.2 (-15%)	-0.1 (-14%)	0.0 (0%)	-0.2 (-15%)
Dry		0 (-10%)	-0.1 (-15%)	-0.1 (-14%)	-0.1 (-10%)	-0.1 (-15%)	-0.1 (-13%)	-0.1 (-11%)	-0.1 (-14%)	-0.1 (-11%)	0 (-6%)	-0.1 (-10%)	0.0 (-6%)	-0.1 (-14%)	-0.1 (-9%)	-0.1 (-11%)	-0.1 (-10%)	0.0 (6%)	0.0 (-5%)
Critical		0 (-7%)	-0.1 (-11%)	-0.1 (-11%)	0.0 (-4%)	-0.1 (-11%)	-0.1 (-11%)	-0.1 (-10%)	-0.1 (-11%)	-0.1 (-10%)	0 (-2%)	0.0 (-4%)	0.0 (-3%)	-0.1 (-10%)	0.0 (-4%)	0.0 (-6%)	0.0 (-1%)	0.0 (8%)	0.0 (-7%)
Differences from NAA (from NAA_ELT for Alts. 2D, 4A, and 5A)																			
All			-0.1 (-6%)	0.0 (-4%)	-0.1 (-6%)	-0.1 (-6%)	0.0 (-3%)	0.0 (4%)	0.0 (-4%)	0.0 (3%)		-0.1 (-5%)	0.0 (3%)	0.0 (-2%)	0.0 (-4%)	0.0 (-2%)	0.0 (1%)	0.1 (11%)	0.0 (1%)
Wet			-0.1 (-4%)	0.0 (-3%)	-0.1 (-6%)	-0.1 (-4%)	0.0 (-2%)	0.1 (5%)	0.0 (-2%)	0.1 (5%)		-0.1 (-5%)	0.0 (2%)	0.0 (0%)	-0.1 (-4%)	0.0 (-2%)	0.0 (1%)	0.1 (7%)	0.0 (2%)
Above Normal			-0.1 (-11%)	-0.1 (-7%)	-0.1 (-8%)	-0.1 (-11%)	-0.1 (-6%)	0.0 (4%)	-0.1 (-6%)	0.0 (4%)		-0.1 (-7%)	0.0 (4%)	0.0 (-4%)	-0.1 (-5%)	-0.1 (-5%)	0.0 (-2%)	0.1 (7%)	0.0 (-2%)
Below Normal			-0.1 (-9%)	0.0 (-5%)	0.0 (-5%)	-0.1 (-10%)	0.0 (-4%)	0.1 (8%)	0.0 (-4%)	0.1 (6%)		0.0 (-4%)	0.1 (10%)	0.0 (-5%)	0.0 (-4%)	0.0 (-1%)	0.0 (1%)	0.1 (17%)	0.0 (-1%)
Dry			0.0 (-6%)	0.0 (-4%)	0.0 (-4%)	0.0 (-6%)	0.0 (-4%)	0.0 (-1%)	0.0 (-4%)	0.0 (-2%)		0.0 (-4%)	0.0 (0%)	0.0 (-4%)	0.0 (-4%)	0.0 (-1%)	0.0 (0%)	0.1 (17%)	0.0 (5%)
Critical			0.0 (-5%)	0.0 (-4%)	0.0 (-2%)	0.0 (-4%)	0.0 (-4%)	0.0 (-4%)	0.0 (-4%)	0.0 (-4%)		0.0 (-2%)	0.0 (-1%)	0.0 (-4%)	0.0 (-2%)	0.0 (1%)	0.0 (6%)	0.1 (16%)	0.0 (0%)

Note: Values calculated from CalSim-II X2 outputs. Relative differences are given in parentheses. Negative values indicate lower abundance index under an alternative than Existing Conditions or NAA/NAA_ELT. Also included are comparisons of the NAA and NAA_ELT scenarios to Existing Conditions.

Table 11-mult-8. Striped Bass Fall Midwater Trawl Survey Abundance Index, Based on Equation from Kimmerer et al. (2009)

Water Year Type	Existing Conditions	NAA	Alt. 1A, 1B, 1C	Alt. 2A, 2B, 2C	Alt. 2D	Alt. 3	Alt. 4 (H1)	Alt. 4 (H2)	Alt. 4 (H3)	Alt. 4 (H4)	NAA_ELT	Alt. 4A (H3_ELT)	Alt. 4A (H4_ELT)	Alt. 5	Alt. 5A	Alt. 6A, 6B, 6C	Alt. 7	Alt. 8	Alt. 9
All	287	263	252	256	269	252	257	268	257	267	278	270	283	258	272	260	264	280	264
Wet	360	319	309	312	333	310	315	329	314	328	347	335	351	318	339	315	320	332	322
Above Normal	310	285	266	273	289	267	275	292	275	292	303	291	310	278	294	276	282	297	282
Below Normal	273	249	236	243	256	235	244	260	243	259	263	257	279	243	257	248	251	273	249
Dry	238	224	217	219	224	216	219	222	219	222	230	224	230	219	225	223	225	246	231
Critical	199	191	186	186	195	186	187	187	186	187	197	195	196	187	195	192	198	208	191
Differences from Existing Conditions																			
All		-25 (-9%)	-35 (-12%)	-32 (-11%)	-18 (-6%)	-35 (-12%)	-30 (-11%)	-20 (-7%)	-31 (-11%)	-20 (-7%)	-9 (-3%)	-17 (-6%)	-4 (-1%)	-29 (-10%)	-15 (-5%)	-27 (-10%)	-24 (-8%)	-8 (-3%)	-23 (-8%)
Wet		-41 (-11%)	-50 (-14%)	-48 (-13%)	-27 (-8%)	-50 (-14%)	-45 (-13%)	-31 (-9%)	-46 (-13%)	-32 (-9%)	-13 (-4%)	-25 (-7%)	-9 (-3%)	-42 (-12%)	-21 (-6%)	-45 (-12%)	-40 (-11%)	-28 (-8%)	-38 (-11%)
Above Normal		-24 (-8%)	-43 (-14%)	-36 (-12%)	-20 (-7%)	-43 (-14%)	-35 (-11%)	-18 (-6%)	-35 (-11%)	-18 (-6%)	-7 (-2%)	-19 (-6%)	1 (0%)	-31 (-10%)	-15 (-5%)	-33 (-11%)	-28 (-9%)	-13 (-4%)	-28 (-9%)
Below Normal		-24 (-9%)	-38 (-14%)	-30 (-11%)	-17 (-6%)	-38 (-14%)	-29 (-11%)	-13 (-5%)	-30 (-11%)	-15 (-5%)	-10 (-4%)	-17 (-6%)	6 (2%)	-31 (-11%)	-16 (-6%)	-25 (-9%)	-23 (-8%)	0 (0%)	-25 (-9%)
Dry		-14 (-6%)	-21 (-9%)	-19 (-8%)	-14 (-6%)	-22 (-9%)	-19 (-8%)	-16 (-7%)	-19 (-8%)	-16 (-7%)	-8 (-3%)	-14 (-6%)	-8 (-3%)	-19 (-8%)	-13 (-5%)	-15 (-6%)	-13 (-6%)	8 (3%)	-7 (-3%)
Critical		-8 (-4%)	-13 (-6%)	-13 (-6%)	-4 (-2%)	-13 (-6%)	-12 (-6%)	-12 (-6%)	-13 (-6%)	-12 (-6%)	-2 (-1%)	-4 (-2%)	-3 (-2%)	-12 (-6%)	-4 (-2%)	-7 (-3%)	-1 (0%)	9 (5%)	-8 (-4%)
Differences from NAA (from NAA_ELT for Alts. 2D, 4A, and 5A)																			
All			-11 (-4%)	-7 (-3%)	-9 (-3%)	-10 (-4%)	-6 (-2%)	5 (2%)	-6 (-2%)	4 (2%)		-8 (-3%)	5 (2%)	-4 (-2%)	-4 (-2%)	-3 (-1%)	1 (0%)	17 (6%)	2 (1%)
Wet			-10 (-3%)	-7 (-2%)	-14 (-4%)	-9 (-3%)	-4 (-1%)	10 (3%)	-5 (-2%)	9 (3%)		-11 (-3%)	4 (1%)	-1 (0%)	-1 (0%)	-4 (-1%)	1 (0%)	13 (4%)	3 (1%)
Above Normal			-19 (-7%)	-12 (-4%)	-13 (-4%)	-19 (-7%)	-10 (-4%)	7 (2%)	-10 (-4%)	7 (2%)		-12 (-4%)	8 (2%)	-7 (-2%)	-7 (-2%)	-9 (-3%)	-3 (-1%)	12 (4%)	-3 (-1%)
Below Normal			-14 (-6%)	-7 (-3%)	-7 (-3%)	-14 (-6%)	-6 (-2%)	11 (4%)	-6 (-3%)	9 (4%)		-6 (-2%)	16 (6%)	-7 (-3%)	-7 (-3%)	-1 (-1%)	1 (0%)	24 (10%)	-1 (0%)
Dry			-7 (-3%)	-5 (-2%)	-6 (-3%)	-8 (-4%)	-5 (-2%)	-2 (-1%)	-5 (-2%)	-3 (-1%)		-6 (-3%)	0 (0%)	-6 (-3%)	-6 (-3%)	-1 (0%)	1 (0%)	21 (10%)	7 (3%)
Critical			-5 (-3%)	-5 (-3%)	-2 (-1%)	-5 (-3%)	-5 (-2%)	-4 (-2%)	-5 (-3%)	-4 (-2%)		-2 (-1%)	-1 (-1%)	-4 (-2%)	-4 (-2%)	1 (1%)	7 (4%)	17 (9%)	0 (0%)

Note: Values calculated from CalSim-II X2 outputs. Relative differences are given in parentheses. Negative values indicate lower abundance index under an alternative than Existing Conditions or NAA/NAA_ELT. Also included are comparisons of the NAA and NAA_ELT scenarios to Existing Conditions.

Table 11-mult-9. Striped Bass Bay Midwater Trawl Survey Abundance Index, Based on Equation from Kimmerer et al. (2009)

Water Year Type	Existing Conditions	NAA	Alt. 1A, 1B, 1C	Alt. 2A, 2B, 2C	Alt. 2D	Alt. 3	Alt. 4 (H1)	Alt. 4 (H2)	Alt. 4 (H3)	Alt. 4 (H4)	NAA_ELT	Alt. 4A (H3_ELT)	Alt. 4A (H4_ELT)	Alt. 5	Alt. 5A	Alt. 6A, 6B, 6C	Alt. 7	Alt. 8	Alt. 9
All	1,242	976	896	923	1,059	896	935	1,028	933	1,023	1,150	1,072	1,192	950	1,093	954	987	1,124	998
Wet	2,035	1,507	1,435	1,456	1,713	1,439	1,481	1,615	1,477	1,609	1,866	1,741	1,895	1,516	1,781	1,484	1,532	1,660	1,562
Above Normal	1,372	1,121	954	1,010	1,166	956	1,029	1,179	1,029	1,180	1,307	1,184	1,375	1,065	1,220	1,040	1,094	1,238	1,101
Below Normal	1,012	809	703	756	863	700	764	897	759	882	925	866	1,057	758	8,77	799	817	1,010	799
Dry	713	614	565	579	614	562	580	604	579	601	656	615	659	578	623	608	618	769	657
Critical	459	415	389	389	434	389	391	394	389	393	446	433	439	393	435	421	452	513	413
Differences from Existing Conditions																			
All		-267 (-21%)	-347 (-28%)	-320 (-26%)	-183 (-15%)	-346 (-28%)	-307 (-25%)	-215 (-17%)	-310 (-25%)	-219 (-18%)	-93 (-7%)	-171 (-14%)	-51 (-4%)	-292 (-24%)	-149 (-12%)	-288 (-23%)	-255 (-21%)	-119 (-10%)	-245 (-20%)
Wet		-528 (-26%)	-600 (-29%)	-579 (-28%)	-322 (-16%)	-596 (-29%)	-553 (-27%)	-420 (-21%)	-558 (-27%)	-426 (-21%)	-169 (-8%)	-294 (-14%)	-139 (-7%)	-519 (-25%)	-254 (-12%)	-550 (-27%)	-503 (-25%)	-375 (-18%)	-473 (-23%)
Above Normal		-251 (-18%)	-418 (-30%)	-361 (-26%)	-206 (-15%)	-416 (-30%)	-343 (-25%)	-193 (-14%)	-343 (-25%)	-192 (-14%)	-65 (-5%)	-187 (-14%)	4 (0%)	-307 (-22%)	-152 (-11%)	-332 (-24%)	-278 (-20%)	-134 (-10%)	-270 (-20%)
Below Normal		-202 (-20%)	-309 (-31%)	-256 (-25%)	-149 (-15%)	-311 (-31%)	-248 (-24%)	-115 (-11%)	-253 (-25%)	-129 (-13%)	-86 (-9%)	-146 (-14%)	45 (4%)	-254 (-25%)	-135 (-13%)	-213 (-21%)	-194 (-19%)	-2 (0%)	-213 (-21%)
Dry		-99 (-14%)	-149 (-21%)	-134 (-19%)	-99 (-14%)	-152 (-21%)	-133 (-19%)	-109 (-15%)	-134 (-19%)	-112 (-16%)	-58 (-8%)	-98 (-14%)	-55 (-8%)	-136 (-19%)	-91 (-13%)	-106 (-15%)	-95 (-13%)	56 (8%)	-56 (-8%)
Critical		-44 (-10%)	-70 (-15%)	-70 (-15%)	-25 (-6%)	-70 (-15%)	-68 (-15%)	-65 (-14%)	-70 (-15%)	-66 (-14%)	-13 (-3%)	-26 (-6%)	-20 (-4%)	-66 (-14%)	-24 (-5%)	-38 (-8%)	-7 (-1%)	54 (12%)	-46 (-10%)
Differences from NAA (from NAA_ELT for Alts. 2D, 4A, and 5A)																			
All			-80 (-8%)	-53 (-5%)	-90 (-8%)	-80 (-8%)	-41 (-4%)	52 (5%)	-43 (-4%)	47 (5%)		-78 (-7%)	42 (4%)	-26 (-3%)	-57 (-5%)	-21 (-2%)	11 (1%)	148 (15%)	22 (2%)
Wet			-72 (-5%)	-51 (-3%)	-153 (-8%)	-68 (-5%)	-26 (-2%)	107 (7%)	-30 (-2%)	102 (7%)		-125 (-7%)	30 (2%)	9 (1%)	-85 (-5%)	-23 (-2%)	25 (2%)	152 (10%)	55 (4%)
Above Normal			-167 (-15%)	-111 (-10%)	-140 (-11%)	-165 (-15%)	-92 (-8%)	58 (5%)	-92 (-8%)	59 (5%)		-122 (-9%)	69 (5%)	-56 (-5%)	-87 (-7%)	-81 (-7%)	-27 (-2%)	116 (10%)	-20 (-2%)
Below Normal			-106 (-13%)	-54 (-7%)	-62 (-7%)	-109 (-13%)	-45 (-6%)	88 (11%)	-51 (-6%)	73 (9%)		-59 (-6%)	131 (14%)	-52 (-6%)	-49 (-5%)	-11 (-1%)	8 (1%)	201 (25%)	-11 (-1%)
Dry			-50 (-8%)	-35 (-6%)	-41 (-6%)	-53 (-9%)	-34 (-6%)	-10 (-2%)	-35 (-6%)	-13 (-2%)		-40 (-6%)	3 (1%)	-37 (-6%)	-33 (-5%)	-7 (-1%)	4 (1%)	155 (25%)	43 (7%)
Critical			-27 (-6%)	-26 (-6%)	-12 (-3%)	-26 (-6%)	-24 (-6%)	-22 (-5%)	-26 (-6%)	-22 (-5%)		-13 (-3%)	-7 (-2%)	-23 (-5%)	-10 (-2%)	6 (1%)	37 (9%)	98 (24%)	-2 (-1%)

Note: Values calculated from CalSim-II X2 outputs. Relative differences are given in parentheses. Negative values indicate lower abundance index under an alternative than Existing Conditions or NAA/NAA_ELT. Also included are comparisons of the NAA and NAA_ELT scenarios to Existing Conditions.

Table 11-mult-10. Striped Bass Bay Otter Trawl Survey Abundance Index, Based on Equation from Kimmerer et al. (2009)

Water Year Type	Existing Conditions	NAA	Alt. 1A, 1B, 1C	Alt. 2A, 2B, 2C	Alt. 2D	Alt. 3	Alt. 4 (H1)	Alt. 4 (H2)	Alt. 4 (H3)	Alt. 4 (H4)	NAA_ELT	Alt. 4A (H3_ELT)	Alt. 4A (H4_ELT)	Alt. 5	Alt. 5A	Alt. 6A, 6B, 6C	Alt. 7	Alt. 8	Alt. 9
All	2,511	2,194	2,071	2,113	2,282	2,072	2,129	2,257	2,125	2,250	2,396	2,296	2,455	2,147	2,322	2,161	2,207	2,397	2,216
Wet	3,444	2,888	2,776	2,808	3,083	2,782	2,839	3,015	2,834	3,008	3,264	3,116	3,311	2,882	3,163	2,846	2,904	3,056	2,932
Above Normal	2,753	2,443	2,213	2,296	2,497	2,217	2,319	2,523	2,319	2,524	2,668	2,518	2,761	2,364	2,560	2,336	2,405	2,592	2,408
Below Normal	2,298	2,012	1,852	1,934	2,092	1,848	1,947	2,141	1,938	2,119	2,174	2,095	2,364	1,934	2,108	1,997	2,025	2,298	2,000
Dry	1,875	1,719	1,636	1,659	1,716	1,631	1,661	1,696	1,660	1,692	1,784	1,718	1,784	1,657	1,730	1,708	1,725	1,962	1,792
Critical	1,446	1,363	1,311	1,313	1,399	1,313	1,316	1,321	1,312	1,320	1,421	1,398	1,409	1,319	1,403	1,375	1,436	1,542	1,359
Differences from Existing Conditions																			
All		-317 (-13%)	-439 (-17%)	-398 (-16%)	-229 (-9%)	-439 (-17%)	-382 (-15%)	-254 (-10%)	-385 (-15%)	-261 (-10%)	-114 (-5%)	-214 (-9%)	-55 (-2%)	-364 (-14%)	-188 (-7%)	-349 (-14%)	-304 (-12%)	-113 (-5%)	-295 (-12%)
Wet		-556 (-16%)	-668 (-19%)	-636 (-18%)	-361 (-10%)	-663 (-19%)	-605 (-18%)	-429 (-12%)	-610 (-18%)	-436 (-13%)	-180 (-5%)	-328 (-10%)	-134 (-4%)	-562 (-16%)	-281 (-8%)	-598 (-17%)	-541 (-16%)	-388 (-11%)	-512 (-15%)
Above Normal		-310 (-11%)	-540 (-20%)	-458 (-17%)	-257 (-9%)	-536 (-19%)	-435 (-16%)	-230 (-8%)	-435 (-16%)	-229 (-8%)	-86 (-3%)	-235 (-9%)	7 (0%)	-390 (-14%)	-193 (-7%)	-417 (-15%)	-349 (-13%)	-162 (-6%)	-345 (-13%)
Below Normal		-285 (-12%)	-446 (-19%)	-364 (-16%)	-206 (-9%)	-450 (-20%)	-351 (-15%)	-157 (-7%)	-360 (-16%)	-179 (-8%)	-123 (-5%)	-202 (-9%)	66 (3%)	-364 (-16%)	-190 (-8%)	-301 (-13%)	-273 (-12%)	0 (0%)	-297 (-13%)
Dry		-157 (-8%)	-240 (-13%)	-216 (-12%)	-159 (-8%)	-245 (-13%)	-215 (-11%)	-179 (-10%)	-216 (-12%)	-183 (-10%)	-92 (-5%)	-157 (-8%)	-91 (-5%)	-219 (-12%)	-146 (-8%)	-167 (-9%)	-151 (-8%)	87 (5%)	-84 (-4%)
Critical		-83 (-6%)	-134 (-9%)	-133 (-9%)	-46 (-3%)	-133 (-9%)	-130 (-9%)	-124 (-9%)	-133 (-9%)	-126 (-9%)	-24 (-2%)	-48 (-3%)	-37 (-3%)	-127 (-9%)	-43 (-3%)	-70 (-5%)	-10 (-1%)	97 (7%)	-87 (-6%)
Differences from NAA (from NAA_ELT for Alts. 2D, 4A, and 5A)																			
All			-122 (-6%)	-81 (-4%)	-114 (-5%)	-122 (-6%)	-65 (-3%)	63 (3%)	-68 (-3%)	56 (3%)		-100 (-4%)	59 (2%)	-47 (-2%)	-74 (-3%)	-32 (-1%)	13 (1%)	204 (9%)	22 (1%)
Wet			-112 (-4%)	-80 (-3%)	-181 (-6%)	-106 (-4%)	-49 (-2%)	127 (4%)	-54 (-2%)	120 (4%)		-148 (-5%)	46 (1%)	-6 (0%)	-101 (-3%)	-42 (-1%)	16 (1%)	168 (6%)	44 (2%)
Above Normal			-230 (-9%)	-148 (-6%)	-171 (-6%)	-226 (-9%)	-124 (-5%)	80 (3%)	-125 (-5%)	81 (3%)		-149 (-6%)	93 (3%)	-80 (-3%)	-108 (-4%)	-107 (-4%)	-38 (-2%)	149 (6%)	-35 (-1%)
Below Normal			-161 (-8%)	-79 (-4%)	-83 (-4%)	-164 (-8%)	-66 (-3%)	129 (6%)	-74 (-4%)	107 (5%)		-79 (-4%)	190 (9%)	-78 (-4%)	-67 (-3%)	-16 (-1%)	12 (1%)	286 (14%)	-12 (-1%)
Dry			-83 (-5%)	-60 (-3%)	-67 (-4%)	-88 (-5%)	-58 (-3%)	-23 (-1%)	-59 (-3%)	-26 (-2%)		-65 (-4%)	1 (0%)	-62 (-4%)	-54 (-3%)	-11 (-1%)	6 (0%)	244 (14%)	73 (4%)
Critical			-52 (-4%)	-51 (-4%)	-22 (-2%)	-50 (-4%)	-47 (-3%)	-42 (-3%)	-51 (-4%)	-43 (-3%)		-23 (-2%)	-12 (-1%)	-44 (-3%)	-19 (-1%)	12 (1%)	73 (5%)	179 (13%)	-4 (0%)

Note: Values calculated from CalSim-II X2 outputs. Relative differences are given in parentheses. Negative values indicate lower abundance index under an alternative than Existing Conditions or NAA/NAA_ELT. Also included are comparisons of the NAA and NAA_ELT scenarios to Existing Conditions.

CEQA Conclusion: The analysis of potential water operations-related rearing habitat effects illustrated that in relation to Existing Conditions (Table 11-mult-6, Table 11-mult-7, Table 11-mult-8, Table 11-mult-9, Table 11-mult-10), there could be significant impacts of the BDCP alternatives on survival or abundance of striped bass, in contrast to the conclusion presented above in the NEPA Effects section. Because of differences between the CEQA and NEPA baselines, it is sometimes possible for CEQA and NEPA significance conclusions to vary between one another under the same impact discussion. The baseline for the CEQA analysis is Existing Conditions at the time the NOP was prepared. Both the action alternative and the NEPA baseline (NAA/NAA_ELT) models anticipated future conditions that would occur in the ELT (for Alternatives 4A, 2D, and 5A) or LLT (all other alternatives), including the projected effects of climate change (precipitation patterns), sea level rise and future water demands. Because the action alternative modeling does not partition the effects of implementation of the alternative from the effects of sea level rise, climate change, and future water demands, the comparison to Existing Conditions may not offer a clear understanding of the impact of the alternative on the environment. The comparison to the NAA/NAA_ELT is a better approach because it isolates the effect of the alternative from those of sea level rise, climate change, and future water demands. In the case of the X2-related analyses of rearing habitat for striped bass, the effect of sea level rise in particular confounds the interpretation of the effects of the alternatives. Based on the discussion presented above for the NEPA Effects, the change in rearing habitat would be less than significant, particularly given the extensive restoration proposed under most alternatives.

American Shad

NEPA Effects: Mean annual abundance indices estimated from the Kimmerer et al. (2009) X2 relationships were <5% different from NAA/NAA_ELT under all alternatives except for Alternative 8, for which increases of 9-12% were found (Table 11-mult-11, Table 11-mult-12). As noted for striped bass, these results indicate that the operational effects would not be adverse, because they would not result in a substantial reduction in the rearing habitat for American shad, particularly given that most alternatives also include substantial habitat restoration. Therefore the effects of a change in rearing habitat related to water operations for American shad would not be adverse under any alternative.

Table 11-mult-11. American Shad Fall Midwater Trawl Survey Abundance Index, Based on Equation from Kimmerer et al. (2009)

Water Year Type	Existing Conditions	NAA	Alt. 1A, 1B, 1C	Alt. 2A, 2B, 2C	Alt. 2D	Alt. 3	Alt. 4 (H1)	Alt. 4 (H2)	Alt. 4 (H3)	Alt. 4 (H4)	NAA_ELT	Alt. 4A (H3_ELT)	Alt. 4A (H4_ELT)	Alt. 5	Alt. 5A	Alt. 6A, 6B, 6C	Alt. 7	Alt. 8	Alt. 9
All	2,554	2,313	2,263	2,280	2,394	2,269	2,300	2,393	2,291	2,380	2,472	2,404	2,511	2,308	2,424	2,359	2,379	2,516	2,366
Wet	3,291	2,951	2,943	2,954	3,102	2,947	2,980	3,093	2,971	3,086	3,203	3,120	3,242	3,002	3,160	2,976	3,001	3,077	3,035
Above Normal	2,941	2,651	2,556	2,596	2,755	2,564	2,633	2,771	2,615	2,754	2,855	2,771	2,910	2,653	2,805	2,642	2,674	2,810	2,691
Below Normal	2,410	2,148	2,059	2,077	2,205	2,059	2,103	2,259	2,083	2,230	2,296	2,211	2,414	2,094	2,222	2,183	2,201	2,402	2,183
Dry	1,992	1,839	1,772	1,788	1,845	1,786	1,795	1,838	1,796	1,830	1,911	1,850	1,904	1,796	1,854	1,924	1,932	2,140	1,905
Critical	1,585	1,499	1,469	1,480	1,547	1,474	1,483	1,489	1,480	1,479	1,550	1,543	1,552	1,478	1,537	1,599	1,616	1,707	1,498
Differences from Existing Conditions																			
All		-241 (-9%)	-292 (-11%)	-274 (-11%)	-160 (-6%)	-286 (-11%)	-254 (-10%)	-161 (-6%)	-263 (-10%)	-174 (-7%)	-83 (-3%)	-150 (-6%)	-43 (-2%)	-246 (-10%)	-131 (-5%)	-195 (-8%)	-175 (-7%)	-38 (-1%)	-189 (-7%)
Wet		-340 (-10%)	-347 (-11%)	-337 (-10%)	-189 (-6%)	-344 (-10%)	-311 (-9%)	-197 (-6%)	-320 (-10%)	-204 (-6%)	-88 (-3%)	-171 (-5%)	-48 (-1%)	-289 (-9%)	-131 (-4%)	-315 (-10%)	-290 (-9%)	-213 (-6%)	-256 (-8%)
Above Normal		-289 (-10%)	-384 (-13%)	-345 (-12%)	-186 (-6%)	-377 (-13%)	-308 (-10%)	-170 (-6%)	-326 (-11%)	-187 (-6%)	-86 (-3%)	-170 (-6%)	-31 (-1%)	-287 (-10%)	-136 (-5%)	-298 (-10%)	-267 (-9%)	-131 (-4%)	-250 (-8%)
Below Normal		-262 (-11%)	-351 (-15%)	-333 (-14%)	-205 (-8%)	-351 (-15%)	-307 (-13%)	-151 (-6%)	-327 (-14%)	-180 (-7%)	-114 (-5%)	-199 (-8%)	4 (0%)	-316 (-13%)	-188 (-8%)	-226 (-9%)	-209 (-9%)	-8 (0%)	-227 (-9%)
Dry		-153 (-8%)	-220 (-11%)	-205 (-10%)	-147 (-7%)	-206 (-10%)	-198 (-10%)	-154 (-8%)	-196 (-10%)	-162 (-8%)	-82 (-4%)	-142 (-7%)	-88 (-4%)	-196 (-10%)	-138 (-7%)	-69 (-3%)	-60 (-3%)	147 (7%)	-88 (-4%)
Critical		-87 (-5%)	-116 (-7%)	-105 (-7%)	-38 (-2%)	-111 (-7%)	-103 (-6%)	-97 (-6%)	-106 (-7%)	-107 (-7%)	-35 (-2%)	-42 (-3%)	-33 (-2%)	-107 (-7%)	-48 (-3%)	14 (1%)	31 (2%)	121 (8%)	-88 (-6%)
Differences from NAA (from NAA_ELT for Alts. 2D, 4A, and 5A)																			
All			-50 (-2%)	-33 (-1%)	-77 (-3%)	-45 (-2%)	-13 (-1%)	80 (3%)	-22 (-1%)	67 (3%)		-67 (-3%)	39 (2%)	-5 (0%)	-48 (-2%)	46 (2%)	66 (3%)	203 (9%)	53 (2%)
Wet			-7 (0%)	3 (0%)	-101 (-3%)	-4 (0%)	29 (1%)	142 (5%)	20 (1%)	136 (5%)		-83 (-3%)	39 (1%)	51 (2%)	-43 (-1%)	25 (1%)	50 (2%)	126 (4%)	84 (3%)
Above Normal			-95 (-4%)	-55 (-2%)	-100 (-4%)	-87 (-3%)	-18 (-1%)	120 (5%)	-36 (-1%)	102 (4%)		-84 (-3%)	55 (2%)	2 (0%)	-50 (-2%)	-9 (0%)	22 (1%)	158 (6%)	40 (1%)
Below Normal			-88 (-4%)	-71 (-3%)	-91 (-4%)	-89 (-4%)	-45 (-2%)	111 (5%)	-65 (-3%)	82 (4%)		-85 (-4%)	118 (5%)	-54 (-3%)	-74 (-3%)	36 (2%)	53 (2%)	254 (12%)	35 (2%)
Dry			-67 (-4%)	-52 (-3%)	-66 (-3%)	-53 (-3%)	-45 (-2%)	-1 (0%)	-43 (-2%)	-9 (0%)		-60 (-3%)	-7 (0%)	-44 (-2%)	-57 (-3%)	84 (5%)	93 (5%)	300 (16%)	65 (4%)
Critical			-30 (-2%)	-19 (-1%)	-3 (0%)	-24 (-2%)	-16 (-1%)	-10 (-1%)	-19 (-1%)	-20 (-1%)		-6 (0%)	2 (0%)	-21 (-1%)	-13 (-1%)	100 (7%)	117 (8%)	208 (14%)	-1 (0%)

Note: Values calculated from CalSim-II X2 outputs. Relative differences are given in parentheses. Negative values indicate lower abundance index under an alternative than Existing Conditions or NAA/NAA_ELT. Also included are comparisons of the NAA and NAA_ELT scenarios to Existing Conditions.

Table 11-mult-12. American Shad Bay Midwater Trawl Survey Abundance Index, Based on Equation from Kimmerer et al. (2009)

Water Year Type	Existing Conditions	NAA	Alt. 1A, 1B, 1C	Alt. 2A, 2B, 2C	Alt. 2D	Alt. 3	Alt. 4 (H1)	Alt. 4 (H2)	Alt. 4 (H3)	Alt. 4 (H4)	NAA_ELT	Alt. 4A (H3_ELT)	Alt. 4A (H4_ELT)	Alt. 5	Alt. 5A	Alt. 6A, 6B, 6C	Alt. 7	Alt. 8	Alt. 9
All	6,271	5,459	5,310	5,362	5,741	5,326	5,427	5,734	5,399	5,694	5,998	5,774	6,130	5,458	5,842	5,599	5,664	6,101	5,636
Wet	8,765	7,540	7,535	7,566	8,096	7,545	7,655	8,039	7,624	8,014	8,449	8,160	8,579	7,733	8,301	7,640	7,726	7,991	7,847
Above Normal	7,483	6,489	6,180	6,311	6,844	6,202	6,432	6,902	6,374	6,847	7,190	6,899	7,385	6,504	7,016	6,463	6,568	7,027	6,629
Below Normal	5,684	4,850	4,576	4,631	5,033	4,573	4,708	5,208	4,649	5,119	5,326	5,052	5,710	4,685	5,084	4,960	5,014	5,652	4,959
Dry	4,375	3,916	3,717	3,763	3,930	3,757	3,783	3,914	3,789	3,891	4,129	3,946	4,110	3,789	3,960	4,160	4,187	4,818	4,104
Critical	3,185	2,944	2,862	2,892	3,075	2,877	2,899	2,916	2,891	2,889	3,085	3,066	3,090	2,887	3,049	3,219	3,266	3,526	2,941
Differences from Existing Conditions																			
All		-812 (-13%)	-961 (-15%)	-908 (-14%)	-530 (-8%)	-944 (-15%)	-844 (-13%)	-537 (-9%)	-872 (-14%)	-577 (-9%)	-273 (-4%)	-497 (-8%)	-141 (-2%)	-813 (-13%)	-428 (-7%)	-672 (-11%)	-607 (-10%)	-170 (-3%)	-635 (-10%)
Wet		-1224 (-14%)	-1230 (-14%)	-1199 (-14%)	-669 (-8%)	-1219 (-14%)	-1109 (-13%)	-726 (-8%)	-1141 (-13%)	-751 (-9%)	-316 (-4%)	-605 (-7%)	-186 (-2%)	-1032 (-12%)	-463 (-5%)	-1124 (-13%)	-1039 (-12%)	-774 (-9%)	-917 (-10%)
Above Normal		-994 (-13%)	-1303 (-17%)	-1171 (-16%)	-638 (-9%)	-1280 (-17%)	-1050 (-14%)	-580 (-8%)	-1108 (-15%)	-635 (-8%)	-293 (-4%)	-583 (-8%)	-97 (-1%)	-979 (-13%)	-466 (-6%)	-1019 (-14%)	-914 (-12%)	-456 (-6%)	-853 (-11%)
Below Normal		-833 (-15%)	-1108 (-19%)	-1053 (-19%)	-651 (-11%)	-1111 (-20%)	-975 (-17%)	-475 (-8%)	-1035 (-18%)	-565 (-10%)	-358 (-6%)	-632 (-11%)	27 (0%)	-999 (-18%)	-599 (-11%)	-724 (-13%)	-670 (-12%)	-31 (-1%)	-725 (-13%)
Dry		-459 (-10%)	-658 (-15%)	-612 (-14%)	-445 (-10%)	-618 (-14%)	-592 (-14%)	-461 (-11%)	-586 (-13%)	-484 (-11%)	-246 (-6%)	-429 (-10%)	-265 (-6%)	-586 (-13%)	-415 (-9%)	-215 (-5%)	-188 (-4%)	443 (10%)	-271 (-6%)
Critical		-241 (-8%)	-323 (-10%)	-293 (-9%)	-110 (-3%)	-309 (-10%)	-286 (-9%)	-270 (-8%)	-294 (-9%)	-296 (-9%)	-100 (-3%)	-119 (-4%)	-95 (-3%)	-298 (-9%)	-136 (-4%)	34 (1%)	81 (3%)	340 (11%)	-244 (-8%)
Differences from NAA (from NAA_ELT for Alts. 2D, 4A, and 5A)																			
All			-150 (-3%)	-97 (-2%)	-258 (-4%)	-133 (-2%)	-32 (-1%)	275 (5%)	-60 (-1%)	235 (4%)		-224 (-4%)	132 (2%)	-1 (0%)	-156 (-3%)	140 (3%)	205 (4%)	642 (12%)	177 (3%)
Wet			-6 (0%)	26 (0%)	-353 (-4%)	5 (0%)	115 (2%)	498 (7%)	84 (1%)	474 (6%)		-289 (-3%)	130 (2%)	192 (3%)	-147 (-2%)	100 (1%)	186 (2%)	450 (6%)	307 (4%)
Above Normal			-309 (-5%)	-177 (-3%)	-346 (-5%)	-286 (-4%)	-56 (-1%)	414 (6%)	-114 (-2%)	358 (6%)		-290 (-4%)	196 (3%)	15 (0%)	-174 (-2%)	-25 (0%)	79 (1%)	538 (8%)	141 (2%)
Below Normal			-274 (-6%)	-220 (-5%)	-293 (-5%)	-278 (-6%)	-142 (-3%)	358 (7%)	-201 (-4%)	269 (6%)		-274 (-5%)	385 (7%)	-165 (-3%)	-241 (-5%)	109 (2%)	164 (3%)	802 (17%)	109 (2%)
Dry			-199 (-5%)	-153 (-4%)	-199 (-5%)	-159 (-4%)	-133 (-3%)	-3 (0%)	-128 (-3%)	-25 (-1%)		-183 (-4%)	-19 (0%)	-128 (-3%)	-169 (-4%)	243 (6%)	271 (7%)	902 (23%)	188 (5%)
Critical			-82 (-3%)	-52 (-2%)	-9 (0%)	-68 (-2%)	-45 (-2%)	-29 (-1%)	-53 (-2%)	-55 (-2%)		-18 (-1%)	6 (0%)	-57 (-2%)	-36 (-1%)	275 (9%)	322 (11%)	581 (20%)	-3 (0%)

Note: Values calculated from CalSim-II X2 outputs. Relative differences are given in parentheses. Negative values indicate lower abundance index under an alternative than Existing Conditions or NAA/NAA_ELT. Also included are comparisons of the NAA and NAA_ELT scenarios to Existing Conditions.

CEQA Conclusion: Similar to striped bass, the analysis of potential water operations-related rearing habitat effects illustrated that in relation to Existing Conditions, there could be significant impacts of the BDCP alternatives on survival or abundance of American shad (Table 11-mult-11, Table 11-mult-12), in contrast to the conclusion presented above in the NEPA Effects sections. As noted for striped bass, because of differences between the CEQA and NEPA baselines, it is sometimes possible for CEQA and NEPA significance conclusions to vary between one another under the same impact discussion. The comparison to the NAA/NAA_ELT is a better approach than comparison to Existing Conditions because it isolates the effect of the alternative from those of sea level rise, climate change, and future water demands. In the case of the X2-related analyses of rearing habitat for American shad, the effect of sea level rise in particular confounds the interpretation of the effects of the alternatives. Based on the discussion presented above for the NEPA Effects, the change in rearing habitat would be less than significant, particularly given the extensive restoration proposed under most alternatives.

Bay Shrimp

NEPA Effects: Application of the relationship from Kimmerer et al. (2009) showed that estimated mean annual bay otter trawl abundance index was <5% different than NAA/NAA_ELT under nearly all alternatives (Table 11-mult-13). The exceptions were Alternative 4 scenarios H2 and H4 for which there was around a 5-6% increase because of increased spring outflow; Alternative 8, for which there was a 13% increase because of appreciably increased spring outflow; and Alternative 2D, for which there was a 6% decrease because of slightly decreased spring outflow. Based on these results, the effects of a change in rearing habitat related to water operations for bay shrimp would not be adverse under any alternative.

Table 11-mult-13. Bay Shrimp Bay Otter Trawl Survey Abundance Index, Based on Equation from Kimmerer et al. (2009)

Water Year Type	Existing Conditions	NAA	Alt. 1A, 1B, 1C	Alt. 2A, 2B, 2C	Alt. 2D	Alt. 3	Alt. 4 (H1)	Alt. 4 (H2)	Alt. 4 (H3)	Alt. 4 (H4)	NAA_ELT	Alt. 4A (H3_ELT)	Alt. 4A (H4_ELT)	Alt. 5	Alt. 5A	Alt. 6A, 6B, 6C	Alt. 7	Alt. 8	Alt. 9
All	290	247	235	239	259	236	242	261	241	260	275	261	284	245	266	249	252	278	254
Wet	415	349	344	347	376	345	351	376	350	375	398	380	407	357	389	351	356	373	362
Above Normal	346	295	272	281	308	273	286	315	284	314	332	312	344	293	321	287	293	319	297
Below Normal	255	213	194	200	219	194	202	233	200	229	236	220	261	202	223	213	216	254	215
Dry	200	175	162	165	172	163	166	173	166	172	185	173	183	167	176	179	181	217	184
Critical	138	126	121	121	131	121	122	123	121	122	133	131	132	122	131	133	135	151	127
Differences from Existing Conditions																			
All		-43 (-15%)	-54 (-19%)	-51 (-17%)	-31 (-11%)	-54 (-19%)	-48 (-16%)	-28 (-10%)	-49 (-17%)	-30 (-10%)	-14 (-5%)	-29 (-10%)	-6 (-2%)	-45 (-15%)	-23 (-8%)	-41 (-14%)	-38 (-13%)	-12 (-4%)	-36 (-12%)
Wet		-65 (-16%)	-70 (-17%)	-68 (-16%)	-39 (-9%)	-70 (-17%)	-63 (-15%)	-38 (-9%)	-65 (-16%)	-39 (-10%)	-16 (-4%)	-35 (-8%)	-7 (-2%)	-57 (-14%)	-26 (-6%)	-63 (-15%)	-59 (-14%)	-42 (-10%)	-53 (-13%)
Above Normal		-51 (-15%)	-73 (-21%)	-65 (-19%)	-38 (-11%)	-72 (-21%)	-60 (-17%)	-31 (-9%)	-62 (-18%)	-32 (-9%)	-13 (-4%)	-34 (-10%)	-2 (-1%)	-53 (-15%)	-25 (-7%)	-59 (-17%)	-53 (-15%)	-27 (-8%)	-49 (-14%)
Below Normal		-42 (-17%)	-61 (-24%)	-55 (-22%)	-36 (-14%)	-61 (-24%)	-53 (-21%)	-22 (-9%)	-55 (-22%)	-26 (-10%)	-19 (-7%)	-35 (-14%)	6 (2%)	-53 (-21%)	-32 (-13%)	-42 (-17%)	-39 (-15%)	-1 (-1%)	-40 (-16%)
Dry		-25 (-13%)	-37 (-19%)	-35 (-18%)	-28 (-14%)	-36 (-18%)	-34 (-17%)	-27 (-13%)	-34 (-17%)	-27 (-14%)	-14 (-7%)	-27 (-13%)	-17 (-8%)	-33 (-16%)	-24 (-12%)	-20 (-10%)	-19 (-10%)	18 (9%)	-15 (-8%)
Critical		-12 (-9%)	-17 (-12%)	-16 (-12%)	-7 (-5%)	-17 (-12%)	-16 (-12%)	-15 (-11%)	-16 (-12%)	-16 (-11%)	-5 (-4%)	-7 (-5%)	-6 (-4%)	-16 (-11%)	-7 (-5%)	-5 (-4%)	-2 (-2%)	13 (9%)	-11 (-8%)
Differences from NAA (from NAA_ELT for Alts. 2D, 4A, and 5A)																			
All			-12 (-5%)	-8 (-3%)	-17 (-6%)	-11 (-4%)	-5 (-2%)	14 (6%)	-6 (-3%)	13 (5%)		-15 (-5%)	8 (3%)	-2 (-1%)	-9 (-3%)	2 (1%)	5 (2%)	31 (13%)	7 (3%)
Wet			-5 (-1%)	-2 (-1%)	-23 (-6%)	-4 (-1%)	2 (1%)	27 (8%)	1 (0%)	26 (7%)		-19 (-5%)	9 (2%)	8 (2%)	-9 (-2%)	2 (1%)	7 (2%)	24 (7%)	13 (4%)
Above Normal			-23 (-8%)	-14 (-5%)	-24 (-7%)	-22 (-7%)	-9 (-3%)	20 (7%)	-11 (-4%)	19 (6%)		-21 (-6%)	11 (3%)	-2 (-1%)	-12 (-3%)	-8 (-3%)	-2 (-1%)	24 (8%)	2 (1%)
Below Normal			-18 (-9%)	-13 (-6%)	-17 (-7%)	-19 (-9%)	-10 (-5%)	21 (10%)	-13 (-6%)	16 (8%)		-16 (-7%)	25 (11%)	-11 (-5%)	-13 (-6%)	0 (0%)	3 (2%)	41 (19%)	3 (1%)
Dry			-12 (-7%)	-10 (-6%)	-13 (-7%)	-11 (-6%)	-9 (-5%)	-2 (-1%)	-9 (-5%)	-2 (-1%)		-12 (-7%)	-2 (-1%)	-8 (-4%)	-9 (-5%)	5 (3%)	6 (3%)	43 (24%)	10 (6%)
Critical			-5 (-4%)	-4 (-4%)	-2 (-2%)	-5 (-4%)	-4 (-3%)	-3 (-3%)	-4 (-4%)	-4 (-3%)		-2 (-2%)	-1 (-1%)	-4 (-3%)	-2 (-2%)	7 (5%)	10 (8%)	25 (20%)	1 (0%)

Note: Values calculated from CalSim-II X2 outputs. Relative differences are given in parentheses. Negative values indicate lower abundance index under an alternative than Existing Conditions or NAA/NAA_ELT. Also included are comparisons of the NAA and NAA_ELT scenarios to Existing Conditions.

CEQA Conclusion: Similar to striped bass and American shad, the analysis of potential water operations-related rearing habitat effects illustrated that in relation to Existing Conditions, there could be significant impacts of the BDCP alternatives on abundance of bay shrimp (Table 11-mult-13), in contrast to the conclusion presented above in the NEPA Effects sections. As noted for striped bass and American shad, because of differences between the CEQA and NEPA baselines, it is sometimes possible for CEQA and NEPA significance conclusions to vary between one another under the same impact discussion. The comparison to the NAA/NAA_ELT is a better approach than comparison to Existing Conditions because it isolates the effect of the alternative from those of sea level rise, climate change, and future water demands. In the case of the X2-related analyses of rearing habitat for bay shrimp, the effect of sea level rise in particular confounds the interpretation of the effects of the alternatives. Based on the discussion presented above for the NEPA Effects, the change in rearing habitat would be less than significant, particularly given the extensive restoration proposed under most alternatives.

11.3.5.3 Updated Discussion for Contaminant-related Effects of Restoration Measures for Salmonids, Splittail, Sturgeon, and Lamprey

The effects of contaminants related to restoration on Chinook salmon, steelhead, splittail, green and white sturgeon, and Pacific and River lamprey, remain the same as presented in the DEIR/EIS, including the NEPA and CEQA determinations that for all alternatives, the impacts of construction would be less than significant with mitigation/not adverse; however additional analyses have been conducted and included below. The following discussion replaces the impact discussion and evaluation presented in impacts AQUA-44, AQUA-62, AQUA-80, AQUA-98, AQUA-116, AQUA-134, AQUA-152, AQUA-170, AQUA-188, and AQUA-206 for Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9. (Alternatives 4A, 2D, and 5A contains a separate discussion of construction and underwater noise impacts in Sections 4.3.7, 4.4.7, and 4.5.7.) The effects of contaminants associated with restoration on delta smelt and longfin smelt did not include NEPA conclusions in the Public Draft EIR/EIS and are therefore presented in Section 11.3.6 below.

Impact AQUA-44: Effects of Contaminants Associated with Restoration Measures on Chinook Salmon (Winter-Run ESU)

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

The basis of the analysis of effects presented for delta smelt (Impact AQUA-8) is applicable to Chinook salmon, including the background on contaminant biogeochemistry and mechanisms for restoration actions to affect contaminant bioavailability. Effects and exposures to most contaminants are also similar, but vary for mercury based on differences in trophic level and habitat through the lifecycle of Chinook salmon compared to delta smelt. Although Chinook salmon is very different than Delta smelt in terms of trophic level, because they both feed on planktonic food sources that do not accumulate selenium, effects from selenium due to restoration are expected to be similar.

Differences in mercury effects in Chinook salmon relative to Delta smelt are discussed below, with a focus on specific research information on the Chinook salmon species.

Henery et al (2010) reports research on methylmercury in Chinook salmon in the Yolo Bypass. As discussed earlier (see Impact AQUA-8), Yolo Bypass is recognized as a primary area of elevated mercury levels in the delta system, with Cache Creek and Putah Creek contributing the majority of mercury. Juvenile Chinook salmon could inhabit Yolo Bypass floodplains over a 1 to 12 week rearing phase. Henery et al (2010) found varying annual patterns in methylmercury uptake in Chinook salmon over the four years studied, and linked increased inputs from Cache Creek relative to the Sacramento River as the factor determining higher methylmercury accumulations; increased contributions from Cache Creek result in increased mercury. BDCP actions will not affect flows from Cache Creek, but will increase flooding from the Sacramento River. Data generated from CM12, which will require pre- and post-restoration monitoring for methylmercury, and the current water quality model being developed by the DWR Mercury Assessment Group will provide additional information on the effects of restoration actions on mercury in Yolo Bypass.

Henery et al (2010) also reported higher methylmercury accumulation rates for fish reared in the Yolo Bypass compared to those reared in the Sacramento River, and higher methylmercury concentrations per weight at out-migration from the Yolo Bypass. However, they also note that the overall implications of methylmercury accumulation for Chinook salmon must be considered in the context of life stage. The young fall-run Chinook salmon may spend 1 to 12 weeks of their 3 to 6-year lives rearing in the Yolo Bypass, and will grow approximately three orders of magnitude over their lives. Thus resultant methylmercury tissue concentrations in later life stages will be considerably lower than for the juvenile fish. In total, fish reared in the Yolo Bypass floodplains compared to the Sacramento River showed indications for improved growth rates and survival for juveniles, and increased methylmercury accumulation, with rates dependent on the amount of inflows from Cache Creek. Data generated from CM12, which will require pre- and post-restoration monitoring for methylmercury, and the current water quality model being developed by the DWR Mercury Assessment Group will provide additional information on the effects of restoration actions on mercury in Yolo Bypass. Additionally, CM12 includes the evaluation of site-specific restoration conditions and include design elements that minimize any conditions that could be conducive to increases of bioavailable mercury (methylmercury) in restored areas. Alternative 1A will substantially increase access to floodplain for Chinook salmon, providing improved rearing conditions, with some increased risk of methylmercury exposure. However, the implementation of CM12 will ensure this effect is not adverse.

NEPA Effects: Overall, the effects of contaminants associated with restoration measures would not be adverse for Chinook salmon with respect to mercury, selenium, copper, ammonia and pesticides.

CEQA Conclusion: As described above, implementation of *CM12 Methylmercury Management* would help to minimize the increased mobilization of methylmercury at restoration areas. Thus, the potential impact of contaminants associated with restoration measures is considered less than significant.

Impact AQUA-62: Effects of Contaminants Associated with Restoration Measures on Chinook Salmon (Spring-Run ESU)

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

The analysis of effects presented for Chinook salmon (winter-run) in Impact AQUA-44a is applicable to Chinook salmon (spring-run) due to their similar potential for exposure based on their life histories. The specific research information presented in Henery et al (2010) on the Chinook salmon species is also applicable to the spring-run.

NEPA Effects: Overall, the effects of contaminants associated with restoration measures would not be adverse for Chinook salmon with respect to mercury, selenium, copper, ammonia and pesticides.

CEQA Conclusion: As described above, implementation of *CM12 Methylmercury Management* would help to minimize the increased mobilization of methylmercury at restoration areas. Thus, the potential impact of contaminants associated with restoration measures is considered less than significant.

Impact AQUA-80: Effects of Contaminants Associated with Restoration Measures on Chinook Salmon (Fall-/Late Fall–Run ESU)

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

The analysis of effects presented for Chinook salmon (winter-run) in Impact AQUA-44a is applicable to Chinook salmon (fall-/late fall-run) due to their similar potential for exposure based on their life histories. The specific research information presented in Henery et al (2010) on the Chinook salmon species is also applicable to the fall/late fall-run.

NEPA Effects: Overall, the effects of contaminants associated with restoration measures would not be adverse for Chinook salmon with respect to mercury, selenium, copper, ammonia and pesticides.

CEQA Conclusion: As described above, implementation of *CM12 Methylmercury Management* would help to minimize the increased mobilization of methylmercury at restoration areas. Thus, the potential impact of contaminants associated with restoration measures is considered less than significant.

Impact AQUA-98: Effects of Contaminants Associated with Restoration Measures on Steelhead

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

The effects of contaminants on steelhead are expected to be similar to those of delta smelt and Chinook salmon. The potential for bioaccumulation is low given their diet (i.e., relatively low trophic position) and, in particular, the short duration that steelhead spend in the Delta over the course of their life cycle.

NEPA Effects: The analysis presented for delta smelt of potential for increased contaminant bioavailability associated with restoration actions, and the more specific details relative to steelhead habitat and life stages, indicates a low risk of contaminant impacts on steelhead, because while steelhead may be slightly higher on the foodchain and therefore have a greater potential for bioaccumulation, they spend a very short period of time in the Delta. The uncertainty associated with these analyses, and the potential for mobilization of mercury and selenium specifically, will be addressed by implementation of AMM27 (selenium) and CM12 (methylmercury management), which will allow project-specific evaluations. Similar to delta smelt and Chinook salmon, no adverse effects are anticipated to steelhead from contaminants due to restoration actions.

CEQA Conclusion: The analysis presented for delta smelt of potential for increased contaminant bioavailability associated with restoration actions, and the more specific details relative to steelhead habitat and life stages, indicates a low risk of contaminant impacts on steelhead. The uncertainty associated with these analyses, and the potential for mobilization of mercury and selenium specifically, will be addressed by implementation of AMM27 (selenium) and CM12 (methylmercury management), which will allow project-specific evaluations, avoidance, and minimization .

Therefore, the impact of contaminants is considered less than significant because it would not substantially effect steelhead either directly or through habitat modifications and, with restoration, would be beneficial in the long-term. Consequently no mitigation would be required.

Impact AQUA-116: Effects of Contaminants Associated with Restoration Measures on Sacramento Splittail

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

The basis of the analysis of effects presented for delta smelt (Impact AQUA-8) is applicable to Sacramento splittail, including the background on contaminant biogeochemistry and mechanisms for restoration actions to affect contaminant bioavailability. Effects and exposures to most contaminants are also similar, but vary based on differences in life cycle and food sources, as discussed below.

The potential for methylation associated with restoration actions is discussed in detail in the delta smelt section, but there are some differing factors that could affect exposures to Sacramento splittail since they spawn on floodplains during seasonal inundation. When floodplains are not seasonally inundated due to lower flows in the Yolo or Sutter Bypasses, Sacramento splittail may migrate further upstream to suitable habitat (Feyrer et al. 2005). Although some level of mercury methylation in Yolo Bypass is possible under the proposed restoration alternatives, exposures to methylmercury would likely be lower than if Sacramento splittail traveled further upstream to find inundated spawning areas, where mercury is generally higher than at downstream locations. However, exposure to methylmercury in the Yolo Bypass has the potential to be high depending on the specific design of restoration, which will affect the areas and the frequency at which theses areas are inundated. There is substantial ongoing research into the effects of Yolo Bypass restoration on methylmercury and this research will be considered as part of the design of restoration, along with other components of CM12, which would provide project specific site screening, monitoring and adaptive management strategies to minimize methylation potential associated with restoration actions.

The feeding habit of Sacramento splittail, a benthic forager, results in higher potential for selenium exposures compared to planktonic feeders such as delta smelt. Potential for increased exposures to selenium through ingestion of clams, especially in Suisun Marsh, are increased for this species. Because splittail are benthic feeders, and specifically may eat sessile filter feeders, such as clams, in Suisun Marsh, they are more susceptible to selenium exposures. Bioavailability of selenium is maximized under reducing conditions, low flows, increased water residence times, and feeding on filter-feeders that can rapidly bioaccumulate and biomagnify selenium in their tissues. A combination of restoration actions and water flows under the Alternatives could increase residence times in Suisun Marsh, resulting in increased selenium availability to benthic feeders, including sturgeon species and splittail. The quantitative analysis of alternative water operations effects on selenium presented in Impact WQ-25, and Impact AQUA-219, represents an increase in residence time that would also be possible under restoration scenarios, and is referenced here. Results of this analysis, must be considered along with the beneficial effects of providing additional habitat for aquatic species, along with the overall reduction in selenium loading to the Delta system through enforcement actions in the Grasslands area and restoration of agricultural lands to tidal systems that would not involve recycling irrigation water and concentrating selenium.

Selenium Mitigation/Exposure Reduction by BDCP

In recognition of the potential for increased selenium exposures resulting from restoration actions, the complexity of the factors that determine this exposure, and the inability to currently quantify the exposure, AMM27 will be implemented to address uncertainties in the impacts analysis at the site/project level. AMM27 will involve pre-assessment of the potential for selenium mobilization associated with each proposed restoration project, and were required, implementation of restoration design elements to minimize conditions conducive to selenium mobilization into the food web, along with monitoring and an adaptive management framework.

For each restoration project, a project-specific selenium management evaluation (or plan, as needed) will be developed to evaluate the likelihood that BDCP actions would result in increased selenium entering the food web. The plan would specify measures to minimize the conditions known to support mobilization of selenium, and monitoring programs, if required. Each project-specific evaluation will include the following components:

1. A brief review of available information to determine the likelihood that elevated levels of selenium and supportive biogeochemical conditions are present; projects within the South Delta and Suisun Marsh would likely be candidates
2. A brief review of predicted changes in water residence time and increasing reducing conditions at the project site that could promote mobilization of selenium into fish and invertebrates
3. Based on results of Steps 1 and 2 above, a determination if pre-construction sampling for characterization of selenium concentrations is warranted to determine if selenium is elevated under pre-restoration conditions
4. Development and implementation of a project-specific plan for conducting sampling for pre-restoration characterization, if warranted
5. Re-evaluation of the likelihood that the project could result in selenium mobilization, and recommendations for restoration design elements and post-construction monitoring to address those risks

NEPA Effects: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for Sacramento splittail with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of CM12 and AMM27.

CEQA Conclusion: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for Sacramento splittail with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of *CM12 Methylmercury Management* and *AMM27*. Therefore, the impact is considered less than significant because it would not substantially affect Sacramento splittail either directly or through habitat modifications. Consequently, no mitigation would be required.

Impact AQUA-134: Effects of Contaminants Associated with Restoration Measures on Green Sturgeon

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

The basis of the analysis of effects presented for delta smelt (Impact AQUA-8) is applicable to green sturgeon, including the background on contaminant biogeochemistry and mechanisms for restoration actions to affect contaminant bioavailability. Effects and exposures to most contaminants are also similar, but vary based on differences in life cycle and food sources, as discussed below.

Because green sturgeon are benthic feeders, and specifically may eat sessile filter feeders, such as clams, in Suisun Marsh, and because they spend a significant amount of time in the Delta where they can bioaccumulate, they are more susceptible to selenium exposures. Bioavailability of selenium is maximized under reducing conditions, low flows, increased water residence times, and feeding on filter-feeders that can rapidly bioaccumulate and biomagnify selenium in their tissues. A combination of restoration actions and water flows under the Alternatives could increase residence times in Suisun Marsh, resulting in increased selenium availability to benthic feeders, including sturgeon species and splittail. The quantitative analysis of alternative water operations effects on selenium presented in Impact WQ-25, and Impact AQUA-219, represents an increase in residence time that would also be possible under restoration scenarios, and is referenced here. Results of this analysis, must be considered along with the beneficial effects of providing additional habitat for aquatic species, along with the overall reduction in selenium loading to the Delta system through enforcement actions in the Grasslands area and restoration of agricultural lands to tidal systems that would not involve recycling irrigation water and concentrating selenium.

Because selenium would be mobilized into the food chain under a narrow set of conditions, the overall effects within the Plan Area are likely low. However, AMM27 would be implemented to provide for restoration site assessment, and pre- and post-restoration monitoring, with special consideration of any restoration programs in Suisun Marsh. See Impact AQUA-116a for impacts to splittail for a full description of AMM27.

NEPA Effects: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for green sturgeon with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of CM12 and AMM27.

CEQA Conclusion: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for green sturgeon with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of *CM12 Methylmercury Management* and *AMM27*. Therefore, the impact is considered less than significant because it would not substantially affect Sacramento splittail either directly or through habitat modifications. Consequently, no mitigation would be required.

Impact AQUA-152: Effects of Contaminants Associated with Restoration Measures on White Sturgeon

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

Effects of contaminants on white sturgeon would be similar to those described for green sturgeon under Impact AQUA-134 due to the similar amount of time they spend in the Delta and their similar diets. While white sturgeon are less sensitive than green sturgeon to selenium contamination, white sturgeon are a resident species and could have more prolonged exposure to San Joaquin River selenium concentrations.

NEPA Effects: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for white sturgeon with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of CM12 and AMM27.

CEQA Conclusion: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for white sturgeon with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of *CM12 Methylmercury Management* and *AMM27*. Therefore, the impact is considered less than significant because it would not substantially affect Sacramento splittail either directly or through habitat modifications. Consequently, no mitigation would be required.

Impact AQUA-170: Effects of Contaminants Associated with Restoration Measures on Pacific Lamprey

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

The basis of the analysis of effects presented for delta smelt (Impact AQUA-8) is applicable to Pacific lamprey, including the background on contaminant biogeochemistry and mechanisms for restoration actions to affect contaminant bioavailability. Effects and exposures to most contaminants are also similar, but vary based on differences in life cycle and food sources, as discussed below.

Pacific lamprey are anadromous, spawning in upstream waters and migrating through the delta to the ocean, where they are marine predators. They spawn in high flow, coarse bottoms, which do not support the low energy conditions critical to mercury methylation and selenium bioavailability. However, ammocoetes remain in fresh water for approximately 5 to 7 years, where they feed on algae, organic material, and microorganisms. During this time the potential for exposure to methylmercury and selenium are likely highest. However, following metamorphosis into their predatory life stage as juveniles and adults, they migrate out of the delta to begin their marine life stage for up to 3 or 4 years (Moyle 2002).

Although they spend more time in the pre-juvenile life stage in the delta, the effects of contaminants on adult fish is likely similar to that described in Impact AQUA-44a for Chinook salmon because the majority of growth occurs outside of the delta. The ammocoete life stage has the highest risk of restoration-related contaminant exposure, but body burdens do not change much over this stage, which ends in metamorphosis when the fish is 14 to 16 inches in length. Similar to the conclusion for Chinook salmon, no adverse effects from contaminants related to restoration actions are anticipated to affect Pacific lamprey.

NEPA Effects: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for Pacific lamprey with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of CM12 and AMM27.

CEQA Conclusion: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for Pacific lamprey with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of *CM12 Methylmercury Management* and *AMM27*. Therefore, the impact is considered less than significant because it would not substantially affect Pacific lamprey either directly or through habitat modifications. Consequently, no mitigation would be required.

Impact AQUA-188: Effects of Contaminants Associated with Restoration Measures on River Lamprey

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

The basis of the analysis of effects presented for delta smelt (Impact AQUA-8) is applicable to river lamprey, including the background on contaminant biogeochemistry and mechanisms for restoration actions to affect contaminant bioavailability. Effects and exposures to most contaminants are also similar, except for but vary based on differences in life cycle and food sources, as discussed below.

Effects of contaminants from restoration actions on river lamprey would be similar to those of the Pacific lamprey described above. River lamprey spends the same amount of time in the delta as an ammocoetes, but less time in the marine environment, with an overall shorter life span than Pacific lamprey. However, similar to Pacific lamprey, they are very small during the ammocoete stage, with most growth occurring during and after migration.

NEPA Effects: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for river lamprey with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of CM12 and AMM27.

CEQA Conclusion: Based on the analysis presented above, effects of contaminants associated with restoration measures would not be adverse for river lamprey with respect to methylmercury, selenium, copper, ammonia and pesticides, given the implementation of *CM12 Methylmercury Management* and *AMM27*. Therefore, the impact is considered less than significant because it would not substantially affect Pacific lamprey either directly or through habitat modifications. Consequently, no mitigation would be required.

Impact AQUA-206: Effects of Contaminants Associated with Restoration Measures on Non-Covered Aquatic Species of Primary Management Concern

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 2D, 3, 4, 4A, 5, 5A, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

Important background on the potential effects of contaminants associated with restoration measures on non-covered aquatic species of primary management concern is provided in Impact AQUA-8 for delta smelt, discussed in Section 11.3.6. As discussed in that section, the main contaminants of concern associated with restoration measures are selenium and mercury. Noncovered species generally would not be at risk for any effects of contaminant measures, either because their distribution is primarily outside the Plan Area (i.e., Sacramento-San Joaquin roach, hardhead) or because they feed at a low trophic level (American shad, threadfin shad, and California bay shrimp). Per Moyle (2002: 426, and references therein) Sacramento tule perch in the San Francisco estuary feed mostly on small amphipods and secondarily on benthic prey such as midge larvae, small clams, brachyuran crabs, and mysid shrimp. As such, the analysis presented above for Sacramento splittail covers sufficiently similar mechanisms of effect.

Of the noncovered species, striped bass and largemouth bass appear to be the species with the greatest potential to be negatively affected by contaminants associated with restoration measures: they are long-lived and feed at a relatively high trophic level, and there is already evidence that contaminant accumulation is at or above levels of concern (Stewart et al. 2004; Gehringer et al. 2013). However, as discussed for delta smelt and other covered species, inclusion of AMM27 for selenium and CM12 for mercury would limit the potential for negative effects. AMM27 will be implemented to address uncertainties in the impacts analysis at the site/project level. AMM27 will involve pre-assessment of the potential for selenium mobilization associated with each proposed restoration project, and were required, implementation of restoration design elements to minimize conditions conducive to selenium mobilization into the food web, along with monitoring and an adaptive management framework. As discussed in more detail for delta smelt under Impact AQUA-8 in section 11.3.5, CM12 will involve various site-specific elements: assessment of pre-restoration conditions to determine the risk that the project could result in increased mercury methylation and bioavailability; definition of design elements that minimize conditions conducive to generation of methylmercury in restored areas; and definition of adaptive management strategies that can be implemented to monitor and minimize actual postrestoration creation and mobilization of methylmercury.

NEPA Effects: Based on the above discussion and in consideration of the inclusion of AMM27 and CM12 in the alternatives, there would not be an adverse effect of contaminants associated with restoration measures on non-covered aquatic species of primary management concern.

CEQA Conclusion: Based on the above discussion and in consideration of the inclusion of AMM27 and CM12 in the alternatives, contaminants associated with restoration measures would have a less-than-significant impact on non-covered aquatic species of primary management concern. No mitigation would be necessary.

11.3.5.4 New Impact Assessments for Restoration- and Operations-related Downstream Effects and Operations-related Contaminants

The following section includes impact discussions for impacts not previously explicitly evaluated in the Public Draft EIR/EIS. Specifically, impacts related to restoration-related and operations-related downstream effects, and operations-related contaminant effects. (Restoration-related contaminant effects are described above.)

Impact AQUA-220: Downstream Sediment Supply Effects of Delta Restoration Measures

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8, and 9 (not adverse/less than significant)

The BDCP Alternatives 1-9 would restore a total of up to 65,000 acres of tidal wetlands (Alternative 5 would restore only 25,000). For restoration to be successful, tidal habitat areas must act as sediment sinks to maintain elevation, and this sink rate will increase as sea level rises. By increasing the overall area of tidal habitat, the overall volume of sediment required in the Plan Area would increase and the same area of tidal habitat today would require more sediment fifty years from now to maintain the appropriate elevation to be classified as tidal habitat. Therefore, tidal wetland restoration under Alternatives 1-9have the potential to reduce sediment supply downstream of the Plan Area.

Potential adverse impacts related to reduced sediment supply downstream of the Plan Area include accelerated shoreline erosion and increased phytoplankton growth from greater water clarity in the open water habitat of the San Francisco Bay. There is some evidence that increasing water clarity may have contributed to post-2000 declines in abundance of some pelagic fish species in the San Francisco estuary (Thomson et al. 2010)..

NEPA Effects: Based on an ICF vertical sediment accretion model, annual sediment requirements of the restored and existing tidal wetlands, assuming that up to 65,000 acres would be restored, would be on average 83% higher than the existing tidal wetlands alone, requiring approximately 310,000 tons of additional sediment over the course of the permit term. However, this change represents a small portion of the sediments that would enter the Bay downstream of the Plan Area, as the proportional contribution of sediment load from the Delta and its tributaries to the San Francisco Bay was estimated to be approximately 39% with the remaining 61% from smaller urbanized and tectonically active tributaries that drain directly to San Francisco Bay (McKee 2013). Without restoration, the anticipated sediment load to the Bay or downstream area would be approximately 24,500,000 tons of sediment in the Late Long Term. With restoration, the anticipated sediment load to the Bay or downstream area would be approximately 24,190,000 tons of sediment in the Late Long Term. The resulting decrease in sediment load from restoration from this sum would be approximately 1.3% of the overall supply. This change does not account for any materials, such as RTM, that could be applied to restored areas.

As such, this potential effect can be reduced by supplementing the sediment load with reused materials from the sediment entrained in North Delta Diversion or RTM. Approximately 2,650,000 tons of sediment is estimated to be entrained at the NDD, and it is expected that some portion can be available for reuse. By supplementing the sediment supply with just 11% of the entrained sediment, the change in sediment load to downstream bays would be reduced from approximately 310,000 tons to 0 tons or from 1.3% to 0%. This range is a small reduction that will not adversely affect areas downstream of the Plan Area.

CEQA Conclusion: With no reuse of entrained sediment, the reduction to areas downstream of the Plan area would be approximately 1.3% from restoration. If 11% of the entrained sediment were available for reuse, there would be no reduction in sediment supply to the areas downstream of the Plan area from restoration. This range of sediment supply reduction to areas downstream of the Plan area would be less than significant and no mitigation is required.

Impact AQUA-218: Changes in Sediment Loading Effects on Downstream Bays as a Result of Operations

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 2D, 3, 4, 4A, 5, 5A, 6A, 6B, 6C, 7, 8 and 9 (not adverse/less than significant)

The effects of Alternatives 1 through 9 would be similar to those described for Alternative 4A, with the exception of the range of inflows to the bay, which vary based on the operations, and the restoration-related effects caused by changes in sediment demand and DO. Overall, the conclusions are the same.

Under all alternatives, no actions are proposed downstream of the Carquinez Strait. However, there are several physical and biological linkages between the Delta and bay ecosystems (Cloern et al 2012), and as such there are several possible mechanisms for indirect effects on fish and aquatic resources seaward of the Plan Area. Because net flows move seaward from the Delta toward the bays, everything in the Delta water column, including inorganic sediments and nutrients to plankton and nekton, could potentially be transported seaward. In addition, physical factors such as dissolved oxygen and water temperature, could be influenced by upstream conditions. As a result, the following characteristics in the bays seaward of the BDCP Plan Area were evaluated to determine if they would be affected by changes under the alternatives:

- Flow
- Temperature
- Dissolved oxygen
- Sediment inputs
- Biological effects

H3_ELT/ESO_ELT

Inflow to the Bays

As noted above, the materials in the water column within the BDCP Plan Area have the potential to be transported into the bays downstream of the Plan Area. The total quantity of Delta outflow was used as a representation of inflow to the bays downstream of the BDCP Plan Area, and was compared over a representative selection of alternatives that range from relatively high exports to low exports.

The quantity of Delta outflow varied by Alternative and season. For Alternatives 1A/1B/1C, there was little difference from NAA in October to March, whereas there were appreciable reductions in April-September, depending on water-year type (Table 11-mult-14). Overall, the mean total Delta outflow was 7% lower than NAA. Similar patterns were observed for Alternative 3 (Table 11-mult-15). Alternative 2 generally had similar or lower Delta outflow than NAA, but the differences were not as great as for Alternatives 1 and 3 (Table 11-mult-14). Alternative 8 had appreciably greater Delta outflow than NAA in October-June, resulting in mean year-round Delta outflow that is nearly 10% greater than NAA (Table 11-mult-15).

For the alternatives considered in the early long term, Alternative 4A's Delta outflow was similar or slightly lower than NAA_ELT (for H3_ELT) and similar to NAA_ELT (for H4_ELT) (Table 11-mult-16). Delta outflow under Alternatives 2D and 5A generally was similar to or lower than under NAA_ELT, with the greatest differences in wetter April-June periods (Table 11-mult-17).

Table 11-mult-14. Mean Delta Outflow (Thousand Acre-Feet) for Alternatives 1 and 2 in Relation to the No Action Alternative

	Oct–Dec			Jan–Mar			Apr–Jun			Jul–Sep			Full Year		
	NAA	A1_LLT	A2_LLT	NAA	A1_LLT	A2_LLT	NAA	A1_LLT	A2_LLT	NAA	A1_LLT	A2_LLT	NAA	A1_LLT	A2_LLT
Wet	4,315	4,154 (-4%)	4,269 (-1%)	16,987	17,001 (0%)	16,499 (-3%)	6,199	5,528 (-11%)	5,575 (-10%)	2,161	1,060 (-51%)	2,096 (-3%)	29,662	27,744 (-6%)	28,438 (-4%)
Above Normal	2,414	2,232 (-8%)	2,418 (0%)	10,348	10,032 (-3%)	9,856 (-5%)	3,790	3,128 (-17%)	3,284 (-13%)	1,731	986 (-43%)	1,587 (-8%)	18,282	16,378 (-10%)	17,146 (-6%)
Below Normal	1,764	1,682 (-5%)	1,870 (6%)	4,780	4,626 (-3%)	4,395 (-8%)	2,596	2,321 (-11%)	2,503 (-4%)	991	834 (-16%)	879 (-11%)	10,131	9,463 (-7%)	9,647 (-5%)
Dry	1,470	1,396 (-5%)	1,589 (14%)	3,335	3,104 (-7%)	3,091 (0%)	1,894	1,846 (-3%)	1,899 (3%)	905	843 (-7%)	852 (1%)	7,605	7,190 (-5%)	7,431 (3%)
Critical	1,150	1,276 (11%)	1,277 (11%)	2,250	2,200 (-2%)	2,255 (0%)	1,275	1,236 (-3%)	1,231 (-3%)	812	908 (12%)	932 (15%)	5,487	5,621 (2%)	5,694 (4%)
All	2,514	2,424 (-4%)	2,563 (2%)	8,778	8,652 (-1%)	8,433 (-4%)	3,566	3,193 (-10%)	3,273 (-8%)	1,425	941 (-34%)	1,370 (-4%)	16,282	15,210 (-7%)	15,638 (-4%)

Table 11-mult-15. Mean Delta Outflow (Thousand Acre-Feet) for Alternatives 3 and 8 in Relation to the No Action Alternative

	Oct–Dec			Jan–Mar			Apr–Jun			Jul–Sep			Full Year		
	NAA	A3_LLT	A8_LLT	NAA	A3_LLT	A8_LLT	NAA	A3_LLT	A8_LLT	NAA	A3_LLT	A8_LLT	NAA	A3_LLT	A8_LLT
Wet	4,315	4,190 (-3%)	4,923 (14%)	16,987	17,036 (0%)	17,017 (0%)	6,199	5,537 (-11%)	6,420 (4%)	2,161	1,073 (-50%)	2,061 (-5%)	29,662	27,836 (-6%)	30,421 (3%)
Above Normal	2,414	2,291 (-5%)	2,867 (19%)	10,348	10,111 (-2%)	10,744 (4%)	3,790	3,124 (-18%)	4,163 (10%)	1,731	1,003 (-42%)	1,501 (-13%)	18,282	16,529 (-10%)	19,276 (5%)
Below Normal	1,764	1,663 (-6%)	2,388 (35%)	4,780	4,650 (-3%)	5,672 (19%)	2,596	2,324 (-11%)	3,351 (29%)	991	863 (-13%)	802 (-19%)	10,131	9,500 (-6%)	12,214 (21%)
Dry	1,470	1,426 (-3%)	2,163 (52%)	3,335	3,235 (-3%)	4,357 (35%)	1,894	1,829 (-3%)	2,444 (34%)	905	836 (-8%)	803 (-4%)	7,605	7,326 (-4%)	9,767 (33%)
Critical	1,150	1,276 (11%)	1,685 (46%)	2,250	2,246 (0%)	2,901 (29%)	1,275	1,238 (-3%)	1,670 (31%)	812	914 (13%)	794 (-2%)	5,487	5,675 (3%)	7,050 (28%)
All	2,514	2,447 (-3%)	3,110 (24%)	8,778	8,714 (-1%)	9,317 (6%)	3,566	3,192 (-10%)	3,998 (12%)	1,425	952 (-33%)	1,303 (-9%)	16,282	15,305 (-6%)	17,727 (9%)

Table 11-mult-16. Mean Delta Outflow (Thousand Acre-Feet) for Alternative 4A in Relation to the No Action Alternative

	Oct–Dec			Jan–Mar			Apr–Jun			Jul–Sep			Full Year		
	NAA_ELT	H3_ELT	H4_ELT	NAA_ELT	H3_ELT	H4_ELT	NAA_ELT	H3_ELT	H4_ELT	NAA_ELT	H3_ELT	H4_ELT	NAA_ELT	H3_ELT	H4_ELT
Wet	4,592	4,531 (-1%)	4,597 (0%)	16,460	16,203 (-2%)	16,310 (-1%)	6,694	6,058 (-9%)	6,633 (-1%)	2,059	2,016 (-2%)	2,006 (-3%)	29,805	28,808 (-3%)	29,545 (-1%)
Above Normal	2,330	2,311 (-1%)	2,326 (0%)	10,060	9,866 (-2%)	9,924 (-1%)	3,883	3,384 (-13%)	4,014 (3%)	1,605	1,525 (-5%)	1,487 (-7%)	17,878	17,086 (-4%)	17,752 (-1%)
Below Normal	1,716	1,763 (3%)	1,790 (4%)	4,848	4,595 (-5%)	4,895 (1%)	2,649	2,458 (-7%)	3,066 (16%)	947	883 (-7%)	876 (-8%)	10,160	9,699 (-5%)	10,627 (5%)
Dry	1,389	1,490 (7%)	1,482 (0%)	3,270	3,104 (-5%)	3,218 (4%)	1,823	1,732 (-5%)	1,853 (7%)	808	740 (-8%)	754 (2%)	7,290	7,066 (-3%)	7,307 (3%)
Critical	1,001	1,085 (8%)	1,089 (9%)	2,190	2,162 (-1%)	2,172 (-1%)	1,236	1,206 (-2%)	1,222 (-1%)	738	664 (-10%)	670 (-9%)	5,166	5,117 (-1%)	5,152 (0%)
All	2,541	2,562 (1%)	2,588 (2%)	8,557	8,364 (-2%)	8,484 (-1%)	3,724	3,392 (-9%)	3,799 (2%)	1,335	1,273 (-5%)	1,267 (-5%)	16,157	15,590 (-4%)	16,138 (0%)

Table 11-mult-17. Mean Delta Outflow (Thousand Acre-Feet) for Alternatives 2D and 5A in Relation to the No Action Alternative

	Oct–Dec			Jan–Mar			Apr–Jun			Jul–Sep			Full Year		
	NAA_ELT	A2D_ELT	A5A_ELT	NAA_ELT	A2D_ELT	A5A_ELT	NAA_ELT	A2D_ELT	A5A_ELT	NAA_ELT	A2D_ELT	A5A_ELT	NAA_ELT	A2D_ELT	A5A_ELT
Wet	4,592	4,497 (-2%)	4,490 (-2%)	16,460	16,092 (-2%)	16,281 (-1%)	6,694	5,960 (-11%)	6,317 (-6%)	2,059	2,010 (-2%)	2,047 (-1%)	29,805	28,559 (-4%)	29,135 (-2%)
Above Normal	2,330	2,280 (-2%)	2,179 (-6%)	10,060	9,763 (-3%)	9,875 (-2%)	3,883	3,325 (-14%)	3,594 (-7%)	1,605	1,515 (-6%)	1,570 (-2%)	17,878	16,883 (-6%)	17,218 (-4%)
Below Normal	1,716	1,754 (2%)	1,683 (-2%)	4,848	4,544 (-6%)	4,577 (-6%)	2,649	2,445 (-8%)	2,500 (-6%)	947	877 (-7%)	901 (-5%)	10,160	9,620 (-5%)	9,661 (-5%)
Dry	1,389	1,485 (7%)	1,386 (-7%)	3,270	3,056 (-7%)	3,115 (2%)	1,823	1,731 (-5%)	1,745 (1%)	808	740 (-8%)	776 (5%)	7,290	7,011 (-4%)	7,022 (0%)
Critical	1,001	1,086 (9%)	1,012 (1%)	2,190	2,182 (0%)	2,128 (-3%)	1,236	1,207 (-2%)	1,216 (-2%)	738	669 (-9%)	663 (-10%)	5,166	5,144 (0%)	5,019 (-3%)
All	2,541	2,544 (0%)	2,482 (-2%)	8,557	8,297 (-3%)	8,384 (-2%)	3,724	3,350 (-10%)	3,517 (-6%)	1,335	1,269 (-5%)	1,300 (-3%)	16,157	15,460 (-4%)	15,683 (-3%)

The relative proportion of fresh to salt water varies at multiple time scales depending on the tides, lunar cycle, and Delta outflow. According to the Delta Atlas (DWR 1995), average historical tidal flow through the Golden Gate Bridge is 2,300,000 cubic feet per second (cfs) and average historical tidal flow at Chipps Island is 170,000 cfs. According to CALSIM modeling, the greatest reduction in mean monthly Delta outflow under any alternative compared to the baseline would be 5,645 cfs during September under Alternative 3 (Appendix 11). This equates to a worst case (greatest reduction) of 0.2% and 3% of average tidal flow at the Golden Gate Bridge and Chipps Island, respectively. Mean change in monthly Delta outflow due to Alternative 3 would be -1,360 cfs. There would be increased Delta outflow under Alternative 3 relative to NAA in 4 months (33%) with the greatest increase of 1,413 cfs occurring during October under H4_ELT. Because Alternative 3 represents the greatest reduction in Delta outflow, Delta outflow in all other alternatives would be greater than that for Alternative 3.

These values indicate that historical average tidal flows are two to three orders of magnitude larger than the largest mean monthly change in projected flows due to the alternatives such that any project impacts on fish, wildlife, and plants in the bays would be well within the current range of daily tidal flows. In general, the differences in Delta outflow between the alternatives and the NAA are limited to 10% or less, such that and there would be no biological adverse effect on biological resources in downstream areas.

Water Temperature

The USFWS OCAP BiOp (USFWS 2008, p. 194) states:

> The [state and federal] water projects have little if any ability to affect water temperatures in the Estuary (Kimmerer 2004). Estuarine and Delta water temperatures are driven by air temperature. Water temperatures at Freeport can be cooled up to about 3°C by high Sacramento River flows, but only by very high river flows that cannot be sustained by the projects. Note also that the cooling effect of the Sacramento River is not visible in data from the west Delta at Antioch (Kimmerer 2004) so the area of influence is limited.

Therefore, water temperatures seaward in the bays would not be affected by alternative operations. More recent work by Wagner et al. (2011) has further confirmed that there is little or no effect of CVP/SWP operations on in-Delta water temperatures by finding no relationship (maximum R2=0.07) with Sacramento River flows and a low relationship (R2=0.14) with San Joaquin River flows.

As such, there would be a negligible effect to water temperatures downstream of the Delta. There is high certainty in this conclusion because the lack of effects of operations on water temperatures in the estuary by Kimmerer 2004, Wagner et al. 2011) has been derived from field data.

Dissolved Oxygen

All alternatives besides Alternatives 4A, 2D, and 5A include substantial tidal restoration, which may result in increased primary productivity. Changes in production can alter biochemical oxygen demand (BOD) and, therefore, the concentration of dissolved oxygen (DO). Alternatives that include substantial restoration may produce more pelagic food (phytoplankton and zooplankton) in the Delta and Suisun Bay and Marsh. The actual changes in pelagic food composition, quantity, and location (and potential for export) is uncertain as described in Draft BDCP Appendix 5.E and elsewhere in Chapter 5. It is unknown whether an increase in production upstream, and therefore increase in BOD and reduction in DO, would be exported to areas seaward of Suisun Bay, especially considering the large effect that invasive clams (*Potamocorbula amurensis*) are known to have on plankton in the west Delta and Suisun Bay (Cloern and Jassby 2012). Some experts (e.g., Herbold et al. 2014) believe that food from restored tidal marshes will not be exported any significant distance. However, because seaward bays and Delta are inextricably linked, changes to the amount of BOD, and therefore DO concentrations, in the Delta may migrate seaward into the bays.

Habitat restoration on retired agricultural land (proposed under several alternatives) is expected to reduce nutrient-rich agricultural runoff entering Delta waterways. There are two potential outcomes of this based on two competing hypotheses of the limiting factors of phytoplankton production. First, the Delta and Suisun Bay are thought to be eutrophic and light limited, meaning that reductions in nutrient loads would not necessarily decrease phytoplankton production unless nutrient concentrations dropped below a level at which they were more limiting than light levels (Cole and Cloern 1984, Cloern 1987). Under this hypothesis, habitat restoration and the resulting reduction in nutrient loading would not cause low dissolved oxygen sags. Second, nutrient forms and ratios could limit phytoplankton production such that a shift would alter phytoplankton production or the type of primary producer (Glibert et al. 2011, Parker et al. 2012). There is no reason to believe that the form or ratio of nutrients would change in a systematic way as a result of agricultural land retirement. Various forms of nutrient are used for agricultural crops depending on crop type and other factors. Therefore, regardless of the hypothesis regarding limitations of primary production in the Delta and Suisun Bay, the retirement of agricultural lands is not expected to affect BOD and therefore DO concentration. Further, as with salinity and water temperature, the influence of the Delta on DO concentrations would dissipate and ocean effects on water quality would be more dominant closer to the ocean (e.g., San Francisco Bay). Therefore, collectively, the negligible changes to DO concentration that may occur in seaward bays as a result of the alternatives would not result in biologically meaningful effects.

Sediment Inputs

Sediment in the Delta and Suisun Bay may be altered under the alternatives in multiple ways (Draft BDCP, Attachment 5C-D, *Water Clarity—Suspended Sediment Concentration and Turbidity*). Changes in operations and large-scale restoration affecting sediment load in the Delta may affect sediment load entering seaward bays, which can affect transport of sediment-bound contaminants to the bays, exposure to contaminants currently buried as surface sediment in the bays continue to erode, the ability of marshes around the bays to accumulate sediment, and light availability to primary producers in the bays (Cloern and Jassby 2012).

Recent work by McKee et al. (2013) using updated methods to improve sediment load estimates beyond previous efforts suggests that, despite their small watershed area (5% of total area) and fluvial flow (7% of total flow), the smaller urbanized and tectonically active tributaries to San Francisco Bay are the major contributors (61% of total) of sediment load into San Francisco Bay compared to upstream sources including the Plan Area and its tributaries (the remaining 39% of total) For San Pablo Bay, which is farther upstream, the proportional contribution of sediment load from the Plan Area and its tributaries was estimated by Schoelhamer et al. (2008) to be approximately 50%.

Total sediment load reaching the Delta under alternatives would be reduced by up to approximately 9% on average as a result of the changed location of SWP/CVP diversion, which would has the potential to increase water clarity downstream of the intakes during certain times of year (Draft BDCP, Attachment 5C-D). Alternatives with greater north Delta diversions would have increased relatively high diversion of sediments, while alternatives with less north Delta diversions would have reduced relatively low diversion of sediments. However, under all alternatives with a North Delta diversion, sediment collected during north Delta intake operations, as with spoils, reusable tunnel material, and dredged material, will be reintroduced back into the Delta system in multiple ways if it meets several water quality and contaminant requirements (see Chapter 3, Conservation Strategy, Section 3.7.2.2). Therefore, the actual sediment load reduction to the Delta caused by changes in operations is expected to be lower than 9%.

Combined, the worst case scenario among alternatives is under Alternative 3 which would be a 9% reduction of the 39% to 50% of the total sediment load (from large rivers) to San Francisco Bay, or up to a 3.5% to 4.5% reduction of total sediment load. For alternatives with substantial restoration, the decrease in sediment load is estimated to range from 0 to 1.3% (see Impact AQUA-220, which was found to be less than significant/not adverse). The reintroduction of RTM, changes in hydrodynamics that promote wind and wave erosion, sea level rise, and the reintroduction of sediments collected at the NDD can all affect the sediment loading into the bays. The actual change will likely be smaller than the 3.5-4.5% reduction noted above because sediment is expected to be reintroduced into the system under BDCP, and even using a modest amount of NDD entrained sediment or RTM would eliminate this effect. As such, this potential reduction in sediment load is not likely to have detectable effects on fish and wildlife in the bays, or on ecosystem function due to the very small magnitude of change, if any such change occurs at all.

Biological Effects

Two potential biological effects were evaluated qualitatively: production and fish biomass. For alternatives including substantial habitat restoration (i.e., all except 4A, 2D, and 5A). The BDCP alternatives are expected to increase production (phytoplankton and zooplankton) in the Delta and Suisun Bay as a result of this habitat restoration (Appendix 5E, Habitat Restoration). However, as discussed above under Dissolved Oxygen, increases in production are not likely to translate into sizeable increases in production seaward of Suisun Bay. Additionally, there is uncertainty to the quantity and extent to which food would be exported into open areas of the estuary Plan Area, let alone out of the estuary into the bay and therefore even greater uncertainty over how much of this productivity would move downstream of the Plan Area into the bays.

Even under the most optimistic projections for the effects of the BDCP alternatives, the Delta's aquatic ecosystems will continue to be dominated in most areas by nonnative fishes and hatchery-origin salmonids. As a result, the increase due to alternatives in the export of wild-origin anadromous fish biomass to the Bay and the Pacific Ocean is not expected to change overall fish biomass.

NEPA Effects: Overall, the effects of operations on downstream habitat under the alternatives would not be adverse. There are no biologically meaningful adverse effects to downstream flows, water temperature, dissolved oxygen concentration, sediment inputs, biological production, or biomass of fish transported downstream.

CEQA Conclusion: Overall, the alternatives would not affect downstream habitat conditions relative to Existing Conditions.

The results of the CEQA analysis are identical to those described above for the NEPA analysis except for inflows into the bays.

The relative differences between the alternatives and the CEQA baseline differ from the relative differences between the alternatives and the NEPA baseline for various reasons, including that the Existing Conditions scenario does not include the Fall X2 requirement of the USFWS BiOp. Thus, for example, Delta outflow in July-September is similar or lower to Existing Conditions under Alternatives 1 and 3 (which do not include the fall X2 requirement) in wet and above normal years, whereas it is higher under Alternatives 2, 2D, 3, 4A, 5D, and 8, which include the requirement (Tables 11-mult-18, 11-mult-19, 11-mult-20, 11-mult-21). As with the comparison to the NEPA baseline, the overall full-year differences in Delta outflow generally are within a few percent of the CEQA baseline, except for Alternative 8, for which mean Delta outflow is 14% greater than Existing Conditions. According to CALSIM modeling, the greatest reduction in mean monthly Delta outflow compared to Existing Conditions would be 5,723 cfs during May under Alternative 3 (Appendix 11). This equates to a worst case (greatest reduction) of 0.2% and 3% of average tidal flow at the Golden Gate Bridge and Chipps Island, respectively. Mean change in mean monthly Delta outflow due to Alternative 3 would be -307 cfs increase. There would be increased Delta outflow under Alternative 3 relative to Existing Conditions in 5 months (42%) with the greatest increase of 4,759 cfs occurring during October.

These values indicate that historical average tidal flows are two to three orders of magnitude larger than the largest mean monthly change in projected flows due to the alternatives such that any project impacts on fish, wildlife, and plants in the bays would be well within the current range of daily tidal flows and there would be no effect of H3_ELT.

Table 11-mult-18. Mean Delta Outflow (Thousand Acre-Feet) for Alternatives 1 and 2 in Relation to Existing Conditions

	Oct–Dec			Jan–Mar			Apr–Jun			Jul–Sep			Full Year		
	Existing Conditions	A1_LLT	A2_LLT	Existing Conditions	A1_LLT	A2_LLT	Existing Conditions	A1_LLT	A2_LLT	Existing Conditions	A1_LLT	A2_LLT	Existing Conditions	A1_LLT	A2_LLT
Wet	4,208	4,154 (-1%)	4,269 (1%)	15,539	17,001 (9%)	16,499 (6%)	7,156	5,528 (-23%)	5,575 (-22%)	1,601	1,060 (-34%)	2,096 (31%)	28,504	27,744 (-3%)	28,438 (0%)
Above Normal	1,931	2,232 (16%)	2,418 (25%)	9,888	10,032 (1%)	9,856 (0%)	4,093	3,128 (-24%)	3,284 (-20%)	1,044	986 (-6%)	1,587 (52%)	16,956	16,378 (-3%)	17,146 (1%)
Below Normal	1,359	1,682 (24%)	1,870 (38%)	4,956	4,626 (-7%)	4,395 (-11%)	2,783	2,321 (-17%)	2,503 (-10%)	891	834 (-6%)	879 (-1%)	9,989	9,463 (-5%)	9,647 (-3%)
Dry	1,215	1,396 (15%)	1,589 (14%)	3,298	3,104 (-6%)	3,091 (0%)	1,881	1,846 (-2%)	1,899 (3%)	805	843 (5%)	852 (1%)	7,200	7,190 (0%)	7,431 (3%)
Critical	896	1,276 (42%)	1,277 (43%)	2,163	2,200 (2%)	2,255 (4%)	1,224	1,236 (1%)	1,231 (1%)	690	908 (32%)	932 (35%)	4,973	5,621 (13%)	5,694 (15%)
All	2,247	2,424 (8%)	2,563 (14%)	8,261	8,652 (5%)	8,433 (2%)	3,935	3,193 (-19%)	3,273 (-17%)	1,090	941 (-14%)	1,370 (26%)	15,533	15,210 (-2%)	15,638 (1%)

Table 11-mult-19. Mean Delta Outflow (Thousand Acre-Feet) for Alternatives 3 and 8 in Relation to Existing Conditions

	Oct–Dec			Jan–Mar			Apr–Jun			Jul–Sep			Full Year		
	Existing Conditions	A3_LLT	A8_LLT	Existing Conditions	A3_LLT	A8_LLT	Existing Conditions	A3_LLT	A8_LLT	Existing Conditions	A3_LLT	A8_LLT	Existing Conditions	A3_LLT	A8_LLT
Wet	4,208	4,190 (0%)	4,923 (17%)	15,539	17,036 (10%)	17,017 (10%)	7,156	5,537 (-23%)	6,420 (-10%)	1,601	1,073 (-33%)	2,061 (29%)	28,504	27,836 (-2%)	30,421 (7%)
Above Normal	1,931	2,291 (19%)	2,867 (48%)	9,888	10,111 (2%)	10,744 (9%)	4,093	3,124 (-24%)	4,163 (2%)	1,044	1,003 (-4%)	1,501 (44%)	16,956	16,529 (-3%)	19,276 (14%)
Below Normal	1,359	1,663 (22%)	2,388 (76%)	4,956	4,650 (-6%)	5,672 (14%)	2,783	2,324 (-17%)	3,351 (20%)	891	863 (-3%)	802 (-10%)	9,989	9,500 (-5%)	12,214 (22%)
Dry	1,215	1,426 (17%)	2,163 (52%)	3,298	3,235 (-2%)	4,357 (35%)	1,881	1,829 (-3%)	2,444 (34%)	805	836 (4%)	803 (-4%)	7,200	7,326 (2%)	9,767 (33%)
Critical	896	1,276 (42%)	1,685 (88%)	2,163	2,246 (4%)	2,901 (34%)	1,224	1,238 (1%)	1,670 (36%)	690	914 (33%)	794 (15%)	4,973	5,675 (14%)	7,050 (42%)
All	2,247	2,447 (9%)	3,110 (38%)	8,261	8,714 (5%)	9,317 (13%)	3,935	3,192 (-19%)	3,998 (2%)	1,090	952 (-13%)	1,303 (19%)	15,533	15,305 (-1%)	17,727 (14%)

Table 11-mult-20. Mean Delta Outflow (Thousand Acre-Feet) for Alternative 4A in Relation to Existing Conditions

	Oct–Dec			Jan–Mar			Apr–Jun			Jul–Sep			Full Year		
	Existing Conditions_ ELT	H3_ELT	H4_ELT	Existing Conditions_ ELT	H3_ELT	H4_ELT	Existing Conditions_ ELT	H3_ELT	H4_ELT	Existing Conditions_ ELT	H3_ELT	H4_ELT	Existing Conditions_ ELT	H3_ELT	H4_ELT
Wet	4,208	4,531 (8%)	4,597 (9%)	15,539	16,203 (4%)	16,310 (5%)	7,156	6,058 (-15%)	6,633 (-7%)	1,601	2,016 (26%)	2,006 (25%)	28,504	28,808 (1%)	29,545 (4%)
Above Normal	1,931	2,311 (20%)	2,326 (20%)	9,888	9,866 (0%)	9,924 (0%)	4,093	3,384 (-17%)	4,014 (-2%)	1,044	1,525 (46%)	1,487 (42%)	16,956	17,086 (1%)	17,752 (5%)
Below Normal	1,359	1,763 (30%)	1,790 (32%)	4,956	4,595 (-7%)	4,895 (-1%)	2,783	2,458 (-12%)	3,066 (10%)	891	883 (-1%)	876 (-2%)	9,989	9,699 (-3%)	10,627 (6%)
Dry	1,215	1,490 (23%)	1,482 (0%)	3,298	3,104 (-6%)	3,218 (4%)	1,881	1,732 (-8%)	1,853 (7%)	805	740 (-8%)	754 (2%)	7,200	7,066 (-2%)	7,307 (3%)
Critical	896	1,085 (21%)	1,089 (22%)	2,163	2,162 (0%)	2,172 (0%)	1,224	1,206 (-2%)	1,222 (0%)	690	664 (-4%)	670 (-3%)	4,973	5,117 (3%)	5,152 (4%)
All	2,247	2,562 (14%)	2,588 (15%)	8,261	8,364 (1%)	8,484 (3%)	3,935	3,392 (-14%)	3,799 (-3%)	1,090	1,273 (17%)	1,267 (16%)	15,533	15,590 (0%)	16,138 (4%)

Table 11-mult-21. Mean Delta Outflow (Thousand Acre-Feet) for Alternatives 2D and 5A in Relation to Existing Conditions

	Oct–Dec			Jan–Mar			Apr–Jun			Jul–Sep			Full Year		
	Existing Conditions_ ELT	A2D_ELT	A5A_ELT	Existing Conditions_ ELT	A2D_ELT	A5A_ELT	Existing Conditions_ ELT	A2D_ELT	A5A_ELT	Existing Conditions_ ELT	A2D_ELT	A5A_ELT	Existing Conditions_ ELT	A2D_ELT	A5A_ELT
Wet	4,208	4,497 (7%)	4,490 (7%)	15,539	16,092 (4%)	16,281 (5%)	7,156	5,960 (-17%)	6,317 (-12%)	1,601	2,010 (25%)	2,047 (28%)	28,504	28,559 (0%)	29,135 (2%)
Above Normal	1,931	2,280 (18%)	2,179 (13%)	9,888	9,763 (-1%)	9,875 (0%)	4,093	3,325 (-19%)	3,594 (-12%)	1,044	1,515 (45%)	1,570 (50%)	16,956	16,883 (0%)	17,218 (2%)
Below Normal	1,359	1,754 (29%)	1,683 (24%)	4,956	4,544 (-8%)	4,577 (-8%)	2,783	2,445 (-12%)	2,500 (-10%)	891	877 (-2%)	901 (1%)	9,989	9,620 (-4%)	9,661 (-3%)
Dry	1,215	1,485 (22%)	1,386 (-7%)	3,298	3,056 (-7%)	3,115 (2%)	1,881	1,731 (-8%)	1,745 (1%)	805	740 (-8%)	776 (5%)	7,200	7,011 (-3%)	7,022 (0%)
Critical	896	1,086 (21%)	1,012 (13%)	2,163	2,182 (1%)	2,128 (-2%)	1,224	1,207 (-1%)	1,216 (-1%)	690	669 (-3%)	663 (-4%)	4,973	5,144 (3%)	5,019 (1%)
All	2,247	2,544 (13%)	2,482 (10%)	8,261	8,297 (0%)	8,384 (1%)	3,935	3,350 (-15%)	3,517 (-11%)	1,090	1,269 (16%)	1,300 (19%)	15,533	15,460 (0%)	15,683 (1%)

Summary of CEQA Conclusion:

These results indicate that the effects of operations on effects of operations on downstream habitat under all alternatives would less than significant and no mitigation would be necessary. There are no biologically meaningful significant effects to downstream flows, water temperature, dissolved oxygen concentration, sediment inputs, biological production, or biomass of fish transported downstream.

Impact AQUA-219: Effects of Operations on Contaminants on Covered Species

This impact discussion is new and is divided by Alternatives 1-5 (Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5); Alternatives 4A, 2D, and 5A; and Alternatives 6-9 (Alternatives 6, 7, 8, and 9). Residence time changes are shown for Alternatives 1-9 in Table 8-60a of Section 8.3.1.7.

The effects of contaminants on aquatic resources associated with implementation of water operations will depend on how operations change the composition or concentration of contaminants, how contaminant bioavailability is affected, and how those changes might impact aquatic resources.

This analysis is based on the results of the water quality evaluation presented in Chapter 8 Water Quality, and the detailed technical evaluation of the potential for alternatives to mobilize contaminants into the food chain provided in *Draft BDCP Appendix 5D- Contaminants*.

Chapter 8 Water Quality presents a full analysis of changes to water quality that could result from water operations under all alternatives, and the reader is directed to that chapter for a full evaluation of those conclusions that are incorporated here by reference. The purpose of this section is to discuss the changes in water quality identified in Chapter 8 that could result in effects to aquatic species. Additional information on the contaminant occurrence, biogeochemistry, bioavailability and mechanisms by which the proposed water operations alternatives could result in changes to bioavailability of contaminants is also provided in *Draft BDCP Appendix 5D - Contaminants*.

Mercury

The operational impacts of new flows under *CM1 Water Facilities and Operation* on mercury and methylmercury concentrations were evaluated both qualitatively in the context of a conceptual model for mercury in the delta, and quantitatively using a numerical model; details on these analyses are described in Appendix 8I, *Mercury*. These two lines of analyses must be considered together, since a very high level of uncertainty is associated with both approaches, as further described below.

Based on the conceptual model, since the Sacramento River is a larger contributor of mercury loading to the Delta system relative to the San Joaquin River, a reduction of the flow from the Sacramento River entering the Delta (due to some of the flow being exported) and an increase in the flow from the San Joaquin River entering the Delta (as opposed to being exported) would be expected to result in an overall decrease in mercury loading to the Delta under CM1 water operations. However, since the concentrations of mercury in San Joaquin River are sometimes higher than the Sacramento River, there could be increases in mercury concentrations at certain locations, depending on the specific operations at any given time.

The quantitative analysis is fully described in Appendix 8I, *Mercury*. Two approaches to quantitative modeling were used – a regression-based model and a CVRWQCB TMDL model – both of which have considerable uncertainty in application. The difference between the model results and the actual fish tissue results were more variable for the CVRWQCB than the regression-based model, but similar conclusions on fish effects can be drawn from both model results. The results of the regression-based model only are discussed below, and the reader is directed to Appendix 8I, *Mercury* for further details on model approach and results.

It uses a DSM-2-based model coupled with an equation to translate water concentrations to fish tissue concentrations. Although a high level of uncertainty is associated with the model, it was deemed useful as a line of evidence to estimate the potential magnitude of BDCP effects. The level of uncertainty is unavoidable given currently available data, and is associated with uncertainties in these areas:

- The starting estimation of source water mercury concentrations;
- Using a conservative model that does not fully account for chemical transformations of mercury;
- Limited data sets (in number of samples, time, and space) used in the derivation of regression relationships; and
- Applying the results of a bioaccumulation model based on largemouth bass to other aquatic species and terrestrial species.

Largemouth bass was selected because a data set of coincident water concentrations and fish tissue concentrations is available, and is not for other species. Because of their position in the pelagic food chain, largemouth bass are a Delta species with high potential to bioaccumulate methylmercury and thus serve as a conservative bioindicator of methylmercury exposure potential for most species.

Mercury is a widespread contaminant in the Delta system due to historic mining activities in the mountains that drain into the Delta. Modeled concentrations of mercury in bass fish tissue under both Existing Conditions and the No Action Alternative exceed the TMDL guidance concentration of 0.24 mg/kg mercury (wet weight) as shown in Tables 1-7a and I-7b in Appendix 8I, *Mercury*.

To evaluate the effects on aquatic resources in terms of current concentrations of mercury in fish and the changes that may result from proposed water operations, the exceedance quotients under each of the alternatives were compared to exceedance quotients under the No Action Alternative; differences are listed in Table 11-mult-22 and 11-mult-23. The exceedance quotient represents a comparison of tissue concentrations to the TMDL guidance concentration. An exceedance quotient greater than 1 indicates that tissue concentrations exceed the applicable guidance concentration. Table 11-mult-22 and 11-mult-23 show decreases (improvements) and increases (declines) in the exceedance quotient.

Table 11-mult-22. Difference in Exceedance Quotients for Mercury in Fish Tissue for Alternatives 2D, 4A, and 5A Compared to No Action (ELT)

		Alt.2D	Alt. 4A H3	Alt. 4A H4	Alt. 5A
Delta Interior					
Mokelumne River (South Fork) at Staten Island	All	0.2	0.2	0.2	0.2
	Drought	0.1	0.1	0.1	0.1
San Joaquin River at Buckley Cove	All	0.0	0.0	-0.1	0.0
	Drought	-0.1	-0.1	-0.1	0.0
Franks Tract	All	0.1	0.1	0.1	0.1
	Drought	0.0	0.0	0.1	0.0
Old River at Rock Slough	All	0.1	0.1	0.1	0.1
	Drought	0.0	0.0	0.1	0.0
Western Delta					
Sacramento River at Emmaton	All	0.0	0.0	0.0	0.0
	Drought	0.0	0.0	0.1	0.0
SJR at Antioch	All	0.1	0.1	0.1	0.0
	Drought	0.0	0.0	0.1	0.0
Sacramento River at Mallard Island	All	0.1	0.1	0.1	0.0
	Drought	0.1	0.1	0.1	0.1
Major Diversions (Pumping Stations)					
North Bay Aqueduct at Barker Slough PP	All	-0.1	-0.1	-0.1	-0.1
	Drought	-0.1	-0.1	-0.1	-0.1
Contra Costa Pumping Plant #1	All	0.1	0.1	0.2	0.1
	Drought	0.0	0.0	0.1	0.0
Banks Pumping Plant	All	-0.2	-0.2	-0.2	-0.1
	Drought	0.0	0.0	-0.1	0.0
Jones Pumping Plant	All	-0.3	-0.2	-0.2	-0.1
	Drought	-0.1	-0.1	-0.1	-0.1
	Minimum	-0.3	-0.2	-0.2	-0.1
	Maximum	0.2	0.2	0.2	0.2

Table 11-mult-23. Difference in Exceedance Quotients for Mercury in Fish Tissue for Alternatives 1–9 Compared to No Action (LLT)

		Alt. 1	Alt. 2	Alt. 3	Alt 4H1	Alt 4H2	Alt. 4H3	Alt. 4H4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9
Delta Interior													
Mokelumne River (South Fork) at Staten Island	All	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2	-0.2
	Drought	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.1
San Joaquin River at Buckley Cove	All	0.1	-0.1	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	-0.1	-0.3
	Drought	0.1	-0.1	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.6
Franks Tract	All	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.4	0.3	0.3	0.4
	Drought	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.4	0.3	0.3	0.4
Old River at Rock Slough	All	0.1	0.2	0.1	0.1	0.1	0.2	0.2	0.1	0.6	0.4	0.5	0.6
	Drought	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.5	0.5	0.7
Western Delta													
Sacramento River at Emmaton	All	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
	Drought	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0
SJR at Antioch	All	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.3	0.2	0.2	0.1
	Drought	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.2	0.2	0.1
Sacramento River at Mallard Island	All	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.1	0.1	0.0
	Drought	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1	0.0	0.1	0.1	0.2	0.0
Major Diversions (Pumping Stations)													
North Bay Aqueduct at Barker Slough PP	All	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
	Drought	-0.2	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1
Contra Costa Pumping Plant #1	All	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.7	0.4	0.5	0.6
	Drought	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.7	0.5	0.5	0.8
Banks Pumping Plant	All	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.1	-0.6	-0.4	-0.4	-0.2
	Drought	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	-0.5	-0.4	-0.3	-0.2
Jones Pumping Plant	All	-0.2	-0.3	-0.1	-0.3	-0.3	-0.3	-0.3	-0.1	-0.7	-0.5	-0.6	-0.3
	Drought	0.0	-0.1	0.0	-0.1	-0.1	-0.1	-0.1	0.0	-0.6	-0.5	-0.5	-0.3
	Minimum	-0.2	-0.3	-0.2	-0.3	-0.3	-0.3	-0.3	-0.1	-0.7	-0.5	-0.6	-0.6
	Maximum	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.7	0.5	0.5	0.8

Alternatives 2D, 4A, and 5A (not adverse/less than significant)

For Alternatives 2D, 4A, and 5A, the change in exceedance quotient with proposed water operations ranges from a decrease (improvement) of 0.3 to an increase (decline) of 0.2. Compared to an exceedance quotient of 1, which represents the threshold at which fish are expected to be affected, these values are considered within the range of uncertainty associated with the models that are the basis of this analysis, and no substantive change is indicated. Results are similar when compared to Existing Conditions (see Appendix 8I, *Mercury*). Overall, model results do not indicate an adverse impact to largemouth bass (and therefore other fish species in the Delta) due to water operations under Alternatives 2D, 4A, and 5A.

NEPA Effects: Based on the above discussion, the effects of mercury and methylmercury in comparison to the No Action Alternative are not considered to be adverse to all fish species evaluated for Alternatives 2D, 4A, and 5A because the modeled changes are within the range of uncertainty and no substantive change is indicated.

CEQA Conclusion: Alternatives 2D, 4A, and 5A would not increase levels of mercury by frequency, magnitude, and geographic extent such that the affected environment would be expected to have measurably higher body burdens of mercury in aquatic organisms, thereby substantially increasing the health risks to wildlife (including fish). This impact is considered to be less than significant for Alternatives 2D, 4A, and 5A. No mitigation is required.

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4 and 5 (not adverse/less than significant)

For Alternatives 1 through 5, the change in exceedance quotient with proposed water operations ranges from a decrease (improvement) of 0.3 to an increase (decline) of 0.2. Compared to an exceedance quotient of 1, which represents the threshold at which fish are expected to be affected, these values are considered within the range of uncertainty associated with the models that are the basis of this analysis, and no substantive change is indicated. Results are similar when compared to Existing Conditions (see Appendix 8I, *Mercury*). Overall, model results do not indicate an adverse impact to largemouth bass (and therefore other fish species in the Delta) due to water operations under Alternatives 1 through 5 of the alternatives.

NEPA Effects: Based on the above discussion, the effects of mercury and methylmercury in comparison to the No Action Alternative are not considered to be adverse to all fish species evaluated for Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4 and 5 because the modeled changes are within the range of uncertainty and no substantive change is indicated.

CEQA Conclusion: Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4 and 5 would not increase levels of mercury by frequency, magnitude, and geographic extent such that the affected environment would be expected to have measurably higher body burdens of mercury in aquatic organisms, thereby substantially increasing the health risks to wildlife (including fish). This impact is considered to be less than significant for Alternatives 1 through 5. No mitigation is required.

Alternatives 6A, 6B, 6C, 7, 8 and 9 (adverse/significant)

For Alternatives 6A, 6B, 6C, 7, 8 and 9, the range of differences was greater, from a decrease (improvement) of 0.7 to an increase of 0.8; it is likely that this range is outside the range of uncertainty associated with the model, and therefore, there is a greater likelihood that these changes could result in adverse effects on species. Alternative 9 showed the greatest increase in exceedance quotient, with a maximum change in exceedance quotient of 0.8. Results are similar when compared to Existing Conditions (see Appendix 8I, *Mercury*).

Although the use of largemouth bass as a surrogate species is conservative, especially relative to the lower trophic feeders such as delta smelt, longfin smelt, and splittail, model results for Alternatives 6-9 show widespread increases in exceedance quotients, and the fish tissue and water concentrations from which the exceedance quotient is calculated. Results are similar relative to Existing Conditions.

NEPA Effects: Based on the consistent and relatively high increases in the exceedance quotient for Alternatives 6A, 6B, 6C, 7, 8 and 9, these alternatives could result in adverse effects on all fish species considered, with greatest concern for sturgeon, since as larger fish that spend several years in the Delta, and therefore will tend to bioaccumulate more mercury in tissues.

CEQA Conclusion: Alternatives 6A, 6B, 6C, 7, 8 and 9 may result in increased levels of mercury by frequency, magnitude, and geographic extent such that there could be measurably higher body burdens of mercury in aquatic organisms, thereby substantially increasing the health risks to wildlife (including fish). Effects under Alternatives 6 through 9 could be significant and unavoidable given a primary objective of the project is to change the CVP and SWP Delta operations.

Selenium

Currently elevated selenium concentrations in the Delta ecosystem are widely recognized as posing a threat to aquatic species. Selenium in the Delta ecosystem and potential effects of BDCP conservation measures on covered fish species are fully described in *Chapter 8, Water Quality, Section 8.1.3.15* and the *BDCP Effects Analysis – Appendix 5.D*, *Contaminants, Section 5D.4.2.1*. These effects include impaired reproduction, embryonic deformities, and bioaccumulation.

Overall, loading of selenium to the Delta aquatic system has decreased significantly (see Section 8.1.3.15). The main controllable sources of selenium in the Bay-Delta estuary are agricultural drainage (generated by irrigation of seleniferous soils in the western side of the San Joaquin basin) and discharges from North Bay refineries (in processing selenium-rich crude oil), neither of which are affected by the alternatives. Both the San Joaquin River and North Bay selenium loads have declined in the last 15 years in response to, first, a control program in the San Joaquin Grassland area, and, second, National Pollutant Discharge Elimination System (NPDES) permit requirements established for refineries in the late 1990s (see Section 8.1.3.15).

The rate of bioaccumulation and effects of selenium on fish have much to do with their feeding behavior. The overbite clam, *Potamocorbula amurensis*, accumulates selenium and is key to mobilizing it into the food chain via benthic feeders such as green sturgeon, white sturgeon, and Sacramento splittail. Delta smelt and longfin smelt, on the other hand, would be expected to have lower exposure to selenium as they are feeding on pelagic organisms that are able to excrete most of the selenium they consume (Stewart et al. 2004).

In Suisun Bay, particulate concentrations of selenium (the most bioavailable) are considered low, typically between 0.5 and 1.5 micrograms per gram (µg/g), but the bivalve *Potamocorbula amurensis* (overbite clam) contains elevated levels of selenium that range from 5 to 20 µg/g (Stewart et al. 2004). Given the fact that *Potamocorbula* may occur in abundances of up to 50,000 per m^2, the Suisun Marsh can be considered a sink for selenium because 95% of the biota in some areas are made up of this clam.

The longer the residence time of surface waters, the higher the particulate concentration resulting in higher selenium concentrations in wetlands and shallows (Presser and Luoma 2006, 2010). Aquatic systems in shallow, slow-moving water with low flushing rates are thought to accumulate selenium most efficiently (Presser and Luoma 2006; Lemly 1999). However, the ratio of selenium in particulates (which is more bioavailable) to selenium in the water column is a complex relationship that can vary across different hydrologic regimes and seasons (Presser and Luoma 2010).

An increase of residence time in areas with dense clam populations that could experience increased loading due to the alternatives' operations, (such as Suisun Bay) combined with a benthic-feeding covered fish species, such as green sturgeon, could result in increased mobilization and bioaccumulation of selenium in the food chain of benthic-feeding fish. Based on this, green sturgeon was identified as the fish species at highest risk for increased selenium exposures under water operations alternatives, since it is a high-trophic level benthic feeder that spends time feeding and spawning in the estuary including Suisun Marsh. Green sturgeon are used as the basis for determining the potential effects of selenium on other species as a result of operations.

Selenium - Quantitative Modeling

Bioaccumulation in two fish species was modeled: largemouth bass and green sturgeon. Largemouth bass was modeled primarily because it is the only species for which fish tissue data were available from representative locations throughout the Delta (including wet and dry years), so fish tissue and water data could be used to develop relationships between water and fish concentrations. Also, because largemouth bass is a voracious, high-level consumer relative to the covered fish species, it will show effects of bioaccumulation, and is a reasonable surrogate for covered species that are pelagic-based feeders. The largemouth bass model approach is fully described in Appendix 8M, *Selenium*.

As discussed above, the greatest rate of selenium bioaccumulation into the food web is through a diet based on sessile, filter feeder organisms, such as clams, that bioaccumulate selenium at very high rates. Because the greatest probability for selenium accumulation in fish was identified for benthic-feeding green sturgeon in the western Delta (Suisun Bay), bioaccumulation in green sturgeon at two western Delta locations was also modeled; the modeling approach and all results are fully described in Appendix 8M, *Selenium*.

For largemouth bass, model results for all alternatives indicate little to no changes in tissue selenium concentrations (see Appendix 8M, *Selenium*). Also, exceedance quotients are below 1 for both the No Action Alternative and project alternatives, indicating tissue concentrations below the Level of Concern for fish tissue of 4 mg/kg (dry weight) (Beckon 2008; see Appendix 8M, *Selenium* for a discussion of levels used for comparison) and Toxicity Threshold of 8.1 mg/kg dw (USEPA 2014). These results show little difference among locations throughout the Delta.

For green sturgeon, estimated tissue selenium concentrations for Existing Conditions and the No Action Alternative-ELT, when the entire modeled period (1976–1991) is considered, are close to the toxicity threshold of 5 mg/kg (dry weight), and drought period concentrations exceed the toxicity threshold (Presser and Luoma 2010; see Appendix 8M, *Selenium* for a discussion of levels used for comparison) (Table 11-mult-24). For Alternatives 2D, 4A, and 5A, model results showed some increases in selenium tissue concentrations, as shown in Table 11-mult-24.

Increases in concentrations ranged from 0.2 to 0.9 mg/kg for these alternatives; this increase should be considered relative to the toxicity threshold of 5 mg/kg (low end established by Presser and

Luoma (2013). To compare the Alternatives 2D, 4A, and 5A in terms of potential toxicity to fish, the hazard quotients were compared for the alternatives (Table 11-mult-25). Hazard quotients increased by a maximum of 0.2; this should be considered in the context that a hazard quotient less than 1 is considered below risk levels.

Table 11-mult-24. Annual average selenium concentrations in whole-body green sturgeon

Location	Period[a]	Estimated Concentrations of Selenium in Whole-body Green Sturgeon (mg/kg, dw)					
		Existing Conditions	No Action Alternative ELT	Alternative 2D ELT	Alternative 4A-H3 ELT	Alternative 4A-H4 ELT	Alternative 5A ELT
San Joaquin River at Antioch	ALL	4.71	4.73	5.64	5.54	5.59	5.05
	DROUGHT	6.82	6.87	7.31	7.30	7.35	7.14
Sacramento River at Mallard Island	ALL	4.38	4.41	4.98	4.92	4.93	4.60
	DROUGHT	6.93	6.96	7.25	7.24	7.27	7.16

dw - dry weight
ELT - Early Long Term
mg/kg - milligram per kilogram

[a] All: Water years 1975-1991 represent the 16-year period modeled using DSM2. Drought: Represents a 5-consecutive-year (Water Years 1987-1991) drought period consisting of dry and critical water-year types (as defined by the Sacramento Valley 40-30-30 water year hydrologic classification index).

Table 11-mult-25. Comparison of annual average selenium concentrations in whole-body green sturgeon to toxicity thresholds[a] for Existing Conditions, the No Action Alternative (ELT), and Alternatives 2D, 4A, and 5A ELT

Location	Period [b]	Existing Conditions		No Action Alternative ELT		Alternative 2D ELT		Alternative 4A-H3 ELT		Alternative 4A-H4 ELT		Alternative 5A ELT	
		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
San Joaquin River at Antioch	ALL	0.94	0.59	0.95	0.59	1.1	0.70	1.1	0.69	1.1	0.70	1.0	0.63
	DROUGHT	1.4	0.85	1.4	0.86	1.5	0.91	1.5	0.91	1.5	0.92	1.4	0.89
Sacramento River at Mallard Island	ALL	0.88	0.55	0.88	0.55	1.00	0.62	0.98	0.61	0.99	0.62	0.92	0.58
	DROUGHT	1.4	0.87	1.4	0.87	1.4	0.91	1.4	0.91	1.5	0.91	1.4	0.89

dw - dry weight
ELT - Early Long Term
mg/kg - milligram per kilogram

[a] Toxicity thresholds are those reported in Presser and Luoma (2013): Low = 5 mg/kg, dw and High = 8 mg/kg, dw

[b] All: Water years 1975-1991 represent the 16-year period modeled using DSM2. Drought: Represents a 5-consecutive-year (Water Years 1987-1991) drought period consisting of dry and critical water-year types (as defined by the Sacramento Valley 40-30-30 water year hydrologic classification index).

Table 11-mult-26. Summary of Annual Average Selenium Concentrations in Whole-body Green Sturgeon for Existing Conditions, No Action Alternative - Late Long Term and Alternatives 1-9

Location	Period [a]	Estimated Concentrations of Selenium in Whole-body Sturgeon (mg/kg, dw)													
		Existing Conditions	No Action Alternative	Alternative											
				1	2	3	4H1	4H2	4H3	4H4	5	6	7	8	9
San Joaquin River at Antioch	ALL	4.71	4.68	5.26	5.58	5.02	5.39	5.45	5.50	5.57	5.02	6.64	6.12	6.13	6.35
	DROUGHT	6.82	6.91	7.05	7.39	7.03	7.21	7.28	7.39	7.47	7.16	8.80	8.43	8.45	9.31
Sacramento River at Mallard Island	ALL	4.38	4.39	4.72	4.89	4.57	4.79	4.81	4.84	4.87	4.55	5.45	5.15	5.15	5.15
	DROUGHT	6.93	6.98	7.10	7.26	7.09	7.17	7.20	7.26	7.29	7.14	7.93	7.74	7.75	8.14

dw - dry weight
mg/kg - milligram per kilogram

[a] All: Water years 1975-1991 represent the 16-year period modeled using DSM2. Drought: Represents a 5-consecutive-year (Water Years 1987-1991) drought period consisting of dry and critical water-year types (as defined by the Sacramento Valley 40-30-30 water year hydrologic classification index).

Modeled concentrations of selenium in green sturgeon for Alternatives 1 through 9 are summarized in Table 11-mult-26. Estimated tissue selenium concentrations for Existing Conditions and the No Action Alternative (LLT), when the entire modeled period (1976–1991) is considered, are close to the toxicity threshold of 5 mg/kg (Presser and Luoma 2013). During the drought period, selenium concentrations exceed the lower toxicity level of 5 mg/kg (Presser and Luoma 2013) for both the Existing Conditions and No Action Alternative. Selenium concentrations show slight increases for Alternatives 1 through 5 and moderate increases for Alternatives 6 through 9. The primary mechanism for these changes is the increased proportion of San Joaquin River water entering the Delta, which has elevated loads of selenium.

However, looking across all water years, selenium concentrations in sturgeon fish tissue would be slightly to moderately increased to above the toxicity value for Alternatives 1 through 9 at the San Joaquin River at Antioch (see Table 11-mult-27). Conversely, model results for Sacramento River at Mallard Island show that selenium concentrations would be below the lower toxicity level for Alternatives 1 through 5, but above for Alternatives 6 through 9.

Exceedance quotients (concentration divided by the toxicity value) for Alternatives 1 through 9, relative to the No Action Alternative and Existing Conditions are shown in Table-11-mult-27. Following the concentration trend discussed above, changes in exceedance quotient are slight for all Alternatives 1 through 9 at the Sacramento River, and for Alternatives 1 through 5 (ranges from no change to 0.2) in the San Joaquin River. However, Alternatives 6 through 9 have greater changes in the exceedance quotient for the San Joaquin River (ranges from 0.1 to 0.5).

Table 11-mult-27. Comparison of Annual Average Selenium Concentrations in Whole-body Green Sturgeon to Toxicity Thresholds Sturgeon for Existing Conditions, No Action Alternative - Late Long Term and Alternatives 1-9

		Existing Conditions		No Action Alternative		Alternative 1		Alternative 2		Alternative 3		Alternative 4 (H1)		Alternative 4 (H2)		Alternative 4 (H3)		Alternative 4 (H4)		Alternative 5		Alternative 6		Alternative 7		Alternative 8		Alternative 9	
Location	Period [b]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]	Low [a]	High [a]
San Joaquin River at Antioch	ALL	0.94	0.59	0.94	0.59	1.1	0.66	1.1	0.70	1.0	0.63	1.1	0.67	1.1	0.68	1.1	0.69	1.1	0.70	1.0	0.63	1.3	0.83	1.2	0.76	1.2	0.77	1.3	0.79
	DROUGHT	1.4	0.85	1.4	0.86	1.4	0.88	1.5	0.92	1.4	0.88	1.4	0.90	1.5	0.91	1.5	0.92	1.5	0.93	1.4	0.89	1.8	1.1	1.7	1.1	1.7	1.1	1.9	1.2
Sacramento River at Mallard Island	ALL	0.88	0.55	0.88	0.55	0.94	0.59	0.98	0.61	0.91	0.57	0.96	0.60	0.96	0.60	0.97	0.60	0.97	0.61	0.91	0.57	1.1	0.68	1.0	0.64	1.0	0.64	1.0	0.64
	DROUGHT	1.4	0.87	1.4	0.87	1.4	0.89	1.5	0.91	1.4	0.89	1.4	0.90	1.4	0.90	1.5	0.91	1.5	0.91	1.4	0.89	1.6	0.99	1.5	0.97	1.6	0.97	1.6	1.0

[a] Toxicity thresholds are those reported in Presser and Luoma (2013): Low = 5 mg/kg, dw and High = 8 mg/kg, dw

[b] All: Water years 1975-1991 represent the 16-year period modeled using DSM2. Drought: Represents a 5-consecutive-year (Water Years 1987-1991) drought period consisting of dry and critical water-year types (as defined by the Sacramento Valley 40-30-30 water year hydrologic classification index).

Based on the above analysis, findings are as follows:

- Quantitative modeling indicates minimal effects on concentrations and no exceedance of toxicity thresholds for a largemouth bass. Largemouth bass is representative of a high trophic level fish species with a planktonic diet that spends its life in the Delta. Thus results for largemouth bass would likely overestimate effects on fish feeding lower on the food chain or that do not spend significant amounts of time in the Delta, including delta smelt, longfin smelt, Chinook salmon, steelhead and lamprey.
- Benthic feeders have a greater potential to bioaccumulate selenium. Modeling results for green sturgeon, a high trophic level benthic feeder, indicate moderate increases in selenium tissue concentrations and changes in exceedance quotient for all alternatives in the Sacramento River at Mallard Island, and Alternatives 1 through 5 in the San Joaquin River at Antioch, although the effects of this increase are highly uncertain.
- Green sturgeon model results also apply to white sturgeon and splittail. However, when applying results to splittail, the proportion of bivalves that constitute their diet, is less than that of green sturgeon.
- Overall decrease in loading of selenium into the Delta system unrelated to the alternatives is expected to continue to occur through existing and future enforcement actions. In addition, land use transitioning from agricultural use to tidal wetlands under most of the alternatives will also result in decreased selenium loading in the future.
- AMM 27 would develop a plan to evaluate site-specific restoration conditions and include design elements that minimize any conditions that could be conducive to increases of bioavailable selenium in restored areas. Before ground-breaking activities associated with site-specific restoration occurs, identify and evaluate potentially feasible actions for the purpose of minimizing conditions that promote bioaccumulation of selenium in restored areas. As such, restored areas would be less likely to promote bioaccumulation of selenium that may be increased as a result of operations.

Alternatives 2D, 4A, and 5A (not adverse/less than significant)

NEPA Conclusion: Based on the above discussion, Alternatives 2D, 4A, and 5A would not be adverse for green and white sturgeon because the increase in concentrations would cause concentrations to be only slightly above the low threshold in all years; average concentrations would still be below the high benchmark in all years. Similarly, in drought years, there would be little to no change in the long-term average exceedance of the low toxicity threshold and the high toxicity threshold would not be exceeded. Thus, overall, these alternatives would not be expected to substantially increase the frequency with which applicable threshold would be exceeded in the Delta, there being only a small increase for sturgeon exceedance relative to the low threshold for sturgeon and no exceedance of the high threshold. Therefore, effects to green and white sturgeon are considered to be not adverse.

CEQA Conclusion: Based on the above discussion, Alternatives 2D, 4A, and 5A would not be adverse for green and white sturgeon because the increase in concentrations would cause concentrations to be only slightly above the low threshold in all years; average concentrations would still be below the high benchmark in all years. Similarly, in drought years, there would be little to no change in the long-term average exceedance of the low toxicity threshold and the high toxicity threshold would not be exceeded. Thus, overall, these alternatives would not be expected to substantially increase the frequency with which applicable threshold would be exceeded in the Delta, there being only a small increase for sturgeon exceedance relative to the low threshold for sturgeon and no exceedance of the high threshold. Therefore, effects to green and white sturgeon are considered to be less than significant. No mitigation is required.

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4 and 5 (not adverse/less than significant)

NEPA Conclusion: The conclusions for Alternatives 1-5 are the same as those presented for Alternatives 4A, 2D, and 5A. The small modeled changes would not be expected to substantially increase the frequency with which applicable threshold would be exceeded in the Delta and as such, Alternatives 1 through 5 would not be adverse.

CEQA Conclusion: The conclusions for Alternatives 1-5 are the same as those presented for Alternatives 4A, 2D, and 5A. The small modeled changes would not be expected to substantially increase the frequency with which applicable threshold would be exceeded in the Delta and as such, Alternatives 1 through 5 would be less than significant. No mitigation is required.

Alternatives 6A, 6B, 6C, 7, 8 and 9 (adverse/significant)

NEPA Effect: Based on the above discussion for green sturgeon which was assumed to the species most sensitive to selenium, Alternatives 6 through 9 have the potential to exceed applicable screening levels in the western Delta and Suisun Marsh for green sturgeon, and therefore, these alternatives would be adverse for green and white sturgeon, and splittail.

CEQA Conclusion: Based on the above discussion, Alternatives 6 through 9 have the potential to exceed applicable screening levels in the western Delta and Suisun Marsh for green sturgeon, and therefore, these alternatives would be significant for green and white sturgeon, and splittail.

11.3.6 Impacts Previously with No NEPA Effects Determination

The following impacts did not include NEPA effect determinations in the Public Draft EIR/EIS for a number of reasons including conflicting modeling results and lack of data or other information to support a conclusion. As part of this REIR/EIS, these effects were re-examined and NEPA determinations have been made for each effect. Table 11-mult-28 presents a list of impacts with uncertain NEPA effect determinations in the Public Draft EIR/EIS and their respective conclusions in this document.

Table 11-mult-28: Impacts Previously with Uncertain NEPA Effect and/or CEQA Conclusion Determinations

	Public Draft EIR/EIS Determination	Final EIR/EIS Determination
Impact	NEPA Effect	NEPA Effect
Impact AQUA-5: Effects of Water Operations on Rearing Habitat for Delta Smelt	**No Determination:** Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9	**Not Adverse:** Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9
Impact AQUA-6: Effects of Water Operations on Migration Conditions for Delta Smelt	**No Determination:** Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9	**Not Adverse:** Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9
Impact AQUA-8: Effects of Contaminants Associated with Restoration Measures on Delta Smelt	**Not Adverse/No Determination:** Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9	**Not Adverse:** Alternative 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9
Impact AQUA-22: Effects of Water Operations on Spawning, Egg Incubation, and Rearing Habitat for Longfin Smelt	**No Determination:** Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9	**Not Adverse:** Alternative 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9
Impact AQUA-26: Effects of Contaminants Associated with Restoration Measures on Longfin Smelt	**Not Adverse/No Determination:** Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9	**Not Adverse:** Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9
Impact AQUA-40: Effects of Water Operations on Spawning and Egg Incubation Habitat for Chinook Salmon (Winter-Run ESU)	**No Determination:** Alternatives 3, 4 and 7	**Not Adverse:** Alternatives 4 and 7 **Adverse/Significant**: Alternative 3*
Impact AQUA-42: Effects of Water Operations on Migration Conditions for Chinook Salmon (Winter-Run ESU)	**No Determination:** Alternatives 4, 5 and 7	**Not Adverse:** Alternatives 4, 5 and 7
Impact AQUA-58: Effects of Water Operations on Spawning and Egg Incubation Habitat for Chinook Salmon (Spring-Run ESU)	**No Determination:** Alternatives 2A, 2B, 2C, 4, 5 and 7	**Not Adverse:** Alternatives 2A, 2B, 2C, 4, 5 and 7
Impact AQUA-60: Effects of Water Operations on Migration Conditions for Chinook Salmon (Spring-Run ESU)	**No Determination:** Alternatives 3, 4, 5, 6 and 7	**Not Adverse:** Alternatives 3, 4, 5 and 7
Impact AQUA-78: Effects of Water Operations on Migration Conditions for Chinook Salmon (Fall-/Late Fall–Run ESU)	**No Determination:** Alternatives 4 and 7	**Not Adverse:** Alternative 7 **Adverse/Significant** Alternative 4*
Impact AQUA-96: Effects of Water Operations on Migration Conditions for Steelhead	**No Determination:** Alternatives 3, 4, 5 and 7	**Not Adverse:** Alternatives 3, 4, 5 and 7
Impact AQUA-132: Effects of Water Operations on Migration Conditions for Green Sturgeon	**No Determination:** Alternatives 4, 5, 6A, 6B, 6C and 9	**Not Adverse:** Alternatives 4, 5, 6A, 6B, 6C and 9

* Denotes a change in CEQA conclusion due to change in NEPA effect determination.

Impact AQUA-5: Effects of Water Operations on Rearing Habitat for Delta Smelt

Within the public draft EIR/EIS, a NEPA determination was not made for any alternative for water operations effects on rearing habitat for delta smelt, except for Alternative 4. This section provides determinations for all alternatives, except for Alternative 4 (the analysis presented for Alternative 4 in the public draft EIR/EIS remains valid—it concluded that the impact was not adverse because of the Decision Trees process). Note that additional analysis of this impact is presented in the analyses of the new alternatives, i.e., Alternatives 2D, 4A, and 5A (see sections 4.3.7, 4.4.7, and 4.4.8).

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse)

NEPA Effects: As described in the public draft EIR-EIS, the principal method used to assess the potential effects on rearing habitat for delta smelt was the method based on Feyrer and coauthors (2011). The issues related to this method and the processes that it represents are discussed in the public draft EIR-EIS, as well as in more recent analyses for Alternative 4A. To reiterate the issues related to this method, and as described in the Low Salinity Zone discussion within Section 11.1.2.2, there are remaining uncertainties regarding the contribution of the survivorship of delta smelt in the fall period to interannual population variability, concerns regarding the current sampling data, and investigation of the potential application of a habitat index that applies multiple habitat characteristics. The CAMT process is investigating these and other questions to better understand how summer and fall flow conditions influence the abundance of delta smelt. However, these CAMT efforts remain incomplete and while they can and will be applied in the future, this information is currently unavailable. As such, the analysis of rearing habitat effects on delta smelt relies on a technique based on the method of Feyrer and coauthors (2011) which estimates the extent of abiotic habitat for delta smelt in the fall (September–December, the older juvenile rearing and maturation period) as a function of changes in X2 (as detailed in *BDCP Effects Analysis –Appendix 5.C, Flow, Section 5C.5.4.5.1 Delta Smelt Fall Abiotic Habitat Index hereby incorporated by reference*; see also discussion in the Low Salinity Zone discussion within Section 11.1.2.2).

As described for Alternative 4 in the public draft EIR/EIS, Feyrer and coauthors (2011) demonstrated that X2 in the fall correlates nonlinearly with an index of delta smelt abiotic habitat in the West Delta, Suisun Bay, and Suisun Marsh subregions, as well as smaller portions of the Cache Slough, South Delta, and North Delta subregions (see Figure 3 of Feyrer et al. 2011). Investigations in recent years have indicated that delta smelt occur year-round in the Cache Slough subregion, including Cache Slough, Liberty Island, and the Sacramento Deep Water Ship Channel (Baxter et al. 2010; Sommer et al. 2011). Whether the same individuals are residing in these areas for their full life cycles or different individuals are moving between upstream and downstream habitats is not known (Sommer et al. 2011). The delta smelt fall abiotic habitat index is the surface area of water in the west Delta, Suisun Bay, and Suisun Marsh (as well as smaller portions of the Cache Slough, South Delta, and North Delta subregions) weighted by the probability of presence of delta smelt based on water clarity (Secchi depth) and salinity (specific conductance) in the water. Feyrer and coauthors' (2011) method found these two variables to be significant predictors of delta smelt presence in the fall. They also concluded that water temperature was not a predictor of delta smelt presence in the fall, although it has been shown to be important during summer months (Nobriga et al. 2008). Manly et al. (2015) commented on the analysis of Feyrer et al. (2011) and found that the amount of variability in delta smelt presence explained by water clarity and salinity decreased when a region factor was included in the analysis, and suggested that inclusion of a region factor and an independent abundance term could improve the original habitat index of Feyrer et al. (2011). Based on the observations of Manly et al. (2015), the analysis of Alternative 4A presented herein based on

Feyrer et al. (2011) gives more weight to dynamic habitat effects (e.g., changes in salinity and the location of the low-salinity zone) than static habitat (geographic regions).

As noted for Alternative 4, the degree of individual movement between upstream and downstream habitats has not been confirmed (Sommer et al. 2011), although emerging evidence suggests that a substantial fraction of the fish occurring in the upstream areas are residing there throughout the year (Hobbs in prep.).

Disagreements regarding the relationship between Fall X2 and delta smelt abundance prompted the CAMT process, which is currently investigating these relationships through a multi-agency collaborative process which may yield additional or different insight regarding how fall habitat conditions affect rearing and overall success of delta smelt.

In general, and assuming that restored habitat does not contribute to abiotic rearing habitat extent for delta smelt, the index representing rearing habitat extent for delta smelt in the fall based on Feyrer et al. (2011) is lower under the alternatives that do not include Fall X2 per the 2008 USFWS BiOp than under NAA: Alternatives 1A, 1B, 1C, and 3. Should habitat restored under *CM4 Tidal Natural Communities Restoration* provide abiotic rearing habitat, the overall average abiotic habitat index would be similar to NAA, by being greater in drier years but less in wetter years. As described in the public draft BDCP EIR/EIS for Alternative 1A, the areas restored under *CM4* may also provide additional food production and export to rearing areas which would be beneficial to delta smelt, particularly from the Suisun Marsh, West Delta, and Cache Slough ROAs which are closer to the species' main range. A decrease in food resources (principally calanoid copepods) has been linked to declines in delta smelt abundance in several studies. Kimmerer (2008) demonstrated a strong positive correlation between survival of juvenile delta smelt from summer to fall and density of calanoid copepods during that period. Miller et al. (2012) found that minimum density of the calanoid copepods *Eurytemora affinis* and *Pseudodiaptomus forbesi* during the spring delta smelt larval period (April–June) and average density of *E. affinis* and *P. forbesi* during the fall (September–December) were significantly related to interannual trends in fall delta smelt relative abundance. Maunder and Deriso (2010) found that April–June minimum density of *E. affinis* and *P. forbesi* before the larval life stage and July–August average density of *E. affinis* and *P. forbesi* after the juvenile life stage (July–August) were important factors associated to changes in delta smelt abundance in their life cycle model. Mac Nally et al. (2010) found some statistical evidence that summer calanoid copepod density was associated with annual trends in abundance of delta smelt in the fall. The decrease in food resources may have been because of a factor such as a change in phytoplankton and zooplankton assemblages related to biological invasions (e.g., the invasive clam *Corbula amurensis*) (Winder and Jassby 2011) and anthropogenic factors such as nutrient balance (Dugdale et al. 2007; Glibert et al. 2011). Because of the reduction in fall abiotic habitat and the uncertainty in restoration outcomes, it is concluded that Alternatives 1A, 1B, 1C, and 3 would have an adverse effect on delta smelt rearing habitat.

The other alternatives (i.e., other than 1A, 1B, 1C, and 3) either include Fall X2 per the 2008 USFWS BiOp or some sufficient magnitude of fall Delta outflow that results in little to no difference from the NAA in abiotic habitat index, even without any assumed benefits of tidal habitat restoration. It is concluded that Alternatives 2A, 2B, 2C, 2D,4A, 5, 5A, 6, 7, 8, and 9 would not have an adverse effect on delta smelt rearing habitat.

Impact AQUA-6: Effects of Water Operations on Migration Conditions for Delta Smelt

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse)

Within the public draft EIR/EIS, there was no NEPA determination for any alternative for water operations effects on migration conditions for delta smelt. This section provides determinations for all alternatives. Note that additional analysis of this impact is presented in the analyses of the new alternatives, i.e., Alternatives 2D, 4A, and 5A (see sections 4.3.7, 4.4.7, and 4.4.8).

NEPA Effects: As described in the public draft EIR-EIS, the initiation of delta smelt upstream migration is associated with pulses of freshwater inflow, which are turbid, cool, and less saline (Grimaldo et al. 2009). Although the alternatives that include north Delta intakes (i.e., Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 2D, 3, 4A, 5, 5A, 7, and 8) may decrease sediment supply to the estuary (up to ~8-9%), with the potential for decreased habitat suitability for delta smelt in some locations, there would not be an adverse effect during the migration period because these changes are not expected to affect suspended sediment concentration during the first flush of precipitation that cues delta smelt migration. In addition, water operations would not affect water temperature to any biologically meaningful degree. The impact on migration conditions for delta smelt therefore would not be adverse for any alternative relative to NAA.

Impact AQUA-8: Effects of Contaminants Associated with Restoration Measures on Delta Smelt

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse) Effects of implementing the habitat restoration conservation measures (CM2, CM4–CM7, and CM10) on delta smelt will depend on the life stage present in the area of elevated toxins and the duration of exposure. Formation and release of toxic constituents from sediments (e.g., in restored areas) is tied to inundation, and so highest concentrations will occur during seasonal high water and to a lesser extent for short time periods on a tidal cycle in marshes.

A complete analysis can be found in the Public Draft BDCP Effects Analysis – Appendix 5D, Contaminants, hereby incorporated by reference.

Mercury

Restoration will involve inundation of soils that may contain mercury. Because insoluble mercury found in dry soils can be converted into the more toxic form of methylmercury in an aquatic system, restoration actions could result in mobilizing mercury into the food web. Many environmental and chemical factors work together to determine the rate of mercury methylation, including how often the soils are inundated, if the soils completely dry out between inundation, the amount of mercury contained in the inundated soils, and geochemical regime (oxidizing vs. reducing). Other influencing factors include vegetation, grain size, availability of binding constituents (iron, sulfur, organic matter), and factors influencing success of the microbes responsible for the methylation process (nutrients and dissolved oxygen) (Alpers et al. 2008; Wood et al. 2010;Miles and Ricca 2010).

As discussed throughout this section, the biogeochemistry and fate and transport of mercury and methylmercury are very complex. Quantification of the amount of mercury methylation that may occur from restoration actions is not possible to quantify on a regional level, and will require site specific analysis, with is included in all Alternatives as CM 12. The following analysis is based on best available science, recognizes the level of uncertainty associated with the analysis, and has included CM12 to address this uncertainty.

Research is ongoing to better understand the fate and transport of mercury in the environment, and specifically the amount mobilized by restoration actions. Substantial research is currently being undertaken to better understand the mechanisms for mercury methylation associated with wetland restoration by the DWR Mercury Monitoring and Evaluation Section and the Delta Mercury Control Program. Early results are expected starting in 2015, as outlined in Technical Memorandum for the Methylmercury Control Study Workplan (December 20, 2013) (The Open Water Workgroup et al 2013).

Mercury is transformed by reducing bacteria in flooded fine sediments subjected to periodic drying-out periods under anaerobic (oxygen-depleted), reducing environments (Alpers et al. 2008; Ackerman and Eagles-Smith 2010). The drying period between inundations appears to be an important factor. Methylmercury production is higher in high marshes that are subjected to inundation periods during only the highest monthly tidal cycles; production appears to be lower in low marshes not subjected to dry periods (Alpers et al. 2008). Floodplains, which are inundated relatively infrequently, likely support high rates of methylation, but in very short spikes restricted to flood events, which are typically very sporadic.

The presence of an electron donor is required for the reducing bacteria to accomplish methylation. Research indicates that iron and sulfur are effective donors, and the ability of manganese to interfere with the methylation process is being investigated. Thus, levels of iron, sulfate and manganese can determine if mercury is methylated, regardless of the initial mercury concentrations in inundated sediments.

These factors are all very site specific, resulting in widely varying methylation rates, regardless of the amount of inorganic mercury contained in the inundated soils. Further, once methylated, partitioning of methylmercury into the water column, sediment and biota is not a constant ratio. Thus, mercury methylation rates must be determined on a site-specific basis.

Given the factors controlling methylation, managed wetlands provide for the highest rates of methylation (Windham-Myers et al. 2010). Studies of agricultural and managed, non-agricultural wetlands in the Yolo Bypass Wildlife Area demonstrated some of the highest concentrations of methylmercury measured in wetlands and caged fish (Alpers et al 2014). The maximum concentrations were recorded in the summer growing season following harvest. However, both Alpers et al (2014) and research by Dave et al (2012) in San Francisco Bay, indicate much lower methylmercury concentrations in open water and tidal marsh plains. Thus, methylation varies significantly across different types of wetland systems, and methylmercury generation rates measured in managed wetlands cannot be used to estimate potential mercury methylation in restored tidal marsh or floodplains. Further, restoration actions that convert managed to unmanaged tidal wetlands, such as in Suisun Marsh, may decrease mercury methylation on a local scale, and total bioavailable methylmercury on a broader scale in the system.

In summary, the factors that determine mercury methylation rates are complex, resulting in a high level of uncertainty about the effects of restoration on net methylmercury production in the Study Area. A generalized conceptual model indicates that:

- Although methylation is controlled by many factors, mercury must be present in sediment for methylation.

- Mercury methylation would occur in high marsh and likely floodplains, where the sediment is allowed to dry out between inundations
- Methylation rates spike immediately following inundation, and then typically decrease.

The major sources of mercury to the delta are former mining areas located in the mountains that drain into the Sacramento River watershed, especially through Yolo Bypass, and to a lesser extent, through the Cosumnes-Mokelumne River. In general, sediment total mercury concentrations are highest in the northern tributaries near the source areas, and follow a decreasing concentration gradient to the central and southern delta (Heim et al 2008). The same trend is seen in water concentrations and loading.

Cache Creek, which discharges in the upper part of Yolo Bypass, has the highest loadings and concentrations of mercury in the delta system. However, mercury concentrations in both sediment and water in Yolo Bypass decrease substantially at the lower portion of Yolo Bypass before discharging back into the Sacramento River. Methylmercury concentrations in water decrease significantly (by 30% to 60%) downstream of Rio Vista, where concentrations were at or below 0.05 nanograms per liter (ng/L) (Foe 2003; Wood et al. 2010). Sediment concentrations of mercury are highest where Cache Creek and Putah Creek discharge into Yolo Bypass, and then generally decrease downstream within Yolo Bypass (Heim et al 2010).

The San Joaquin River is a relatively minor contributor of mercury loads to the Delta system, compared to the Sacramento River watershed. However, due to lower flows in the San Joaquin River, mercury concentrations in water are often higher than in the Sacramento River. The Cosumnes - Mokelumne River, with an average waterborne mercury concentration of 0.31 ng/L, is the largest contributor of mercury in the San Joaquin watershed, but it only accounts for 2.1% of the total methylmercury in the Delta (Wood et al. 2010). Less data for this area are available. In Suisun Marsh, mercury appears to be highest in sloughs where up to 36.62 ng/L was reported by Heim et al (2010), and in managed wetlands, which are numerous in Suisun Marsh.

Based on available information, the restoration opportunity areas of primary concern include:

- Cache Slough ROA in Yolo Bypass – Yolo Bypass contains the highest levels of mercury in the Delta, specifically where Cache Creek and Putah Creek discharge. However, the Cache Slough ROA is located south of the most of the high mercury area and data has demonstrated lower concentrations in most of the lower Yolo Bypass where the ROA is located. Restoration in this area that would allow drying out periods between inundation is of concern for methylmercury generation. However, it should be noted that the ROA is not located within the highest concentrations of mercury in sediments. Also, methylation is expected to spike immediately following inundation, with rates slowing down over time, so that exposures would be short-lived.
- Suisun Marsh ROA – mercury is elevated in certain parts of the Suisun Marsh system. However, transformation of managed agricultural wetlands to tidal wetlands would be expected to result in an overall decrease in methylmercury, and an overall benefit.
- Cosumnes-Mokelumne ROA –The Cosumnes-Mokelumne River is identified as a source of mercury from the mountains upstream of discharging to the Delta, although the amount of mercury (loading) is low compared with the Yolo Bypass and Sacramento River basin.

Mercury Mitigation/Exposure Reduction by BDCP

Due to the complex and very site-specific factors that will determine if mercury becomes mobilized into the foodweb, *CM12 Methylmercury Management,* is included to provide for site-specific evaluation for each restoration project. On a project-specific basis, where high potential for methylmercury production is identified that restoration design and adaptive management cannot fully address while also meeting restoration objectives, alternate restoration areas will be considered. CM 12 will be implemented in coordination with other similar efforts to address mercury in the Delta, and specifically with the DWR Mercury Monitoring and Analysis Section.

CM12 will be developed and implemented in coordination with the California Department of Water Resources (DWR) Mercury Monitoring and Evaluation Section which is working on DWR's compliance with the requirements of the *Sacramento–San Joaquin Delta Methylmercury Total Maximum Daily Load* (Central Valley Regional Water Quality Control Board 2011a) and *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury and Total Mercury in the Sacramento–San Joaquin Delta Estuary* (Mercury Basin Plan Amendments) (Central Valley Regional Water Quality Control Board 2011b). Under Phase I of the TMDL, the DWR Mercury Monitoring and Evaluation Section is planning control studies to research and identify effective measures to mitigate methylmercury generation and mobilization in connection with restored wetlands. The results of the Phase I control studies will be integrated into BDCP restoration planning to attempt to limit methylmercury production and keep it within acceptable bounds.

This conservation measure includes the following actions.

- Assess pre-restoration conditions to determine the risk that the project could result in increased mercury methylation and bioavailability
- Define design elements that minimize conditions conducive to generation of methylmercury in restored areas.
- Define adaptive management strategies that can be implemented to monitor and minimize actual post-restoration creation and mobilization of methylmercury.

The restoration design will always focus on the ecosystem restoration objectives. Design elements to mitigate mercury methylation that will not interfere with restoration objectives, will be integrated into site-specific restoration designs based on site conditions, community type (tidal marsh, nontidal marsh, floodplain), and potential concentrations of mercury in pre-restoration sediments. The adaptive management strategies can be applied where site conditions indicate a high probability of methylmercury generation and effects on covered species.CM12 requires that as the Phase I and Phase II TMDL programs generate information on methylmercury distribution, effects, and the performance of mitigation measures, this information be reviewed for every restoration project, and design elements and BMPs that have proven successful be incorporated into the restoration design.

Mercury – Potential Impacts

Mercury in the form of methylmercury can be taken up by organisms and concentrated in their tissues. This concentration increases up the food chain, a process called biomagnification. Again, the factors that control the rate of bioaccumulation are complex. Organisms feeding within pelagic-based (algal) food webs have been found to have higher concentrations of methylmercury than those in benthic or epibenthic food webs; this has been attributed to food chain length and dietary segregation (Grimaldo et al. 2009). That is, the pelagic food chain tends to be longer than the benthic food chain, which allows for greater biomagnification of methylmercury in top predators. Alternatively, other research has indicated that bioaccumulation is similar between different food webs (Stewart 2008).

Limited data is currently available for mercury effects associated with marsh restoration projects in the delta. Ackerman et al. (2013) found increased methylmercury concentrations in Forester's tern and American avocet eggs within three months post restoration in the South Bay Salt Pond restoration areas. However, the authors cautioned that this increase could represent a short term maximum effect given that methylmercury production and bioaccumulation often shows a short term spike immediately following perturbation. Also, risk to methylmercury exposure likely varies by species as there are taxonomic differences in hepatic (liver) detoxification rates (rate at which methylmercury is converted to a more inert form of mercury by the liver) (Eagles-Smith et al. 2009). Resultant waterborne concentrations of mercury following restoration activities in the Delta is a primary focus of current research being conducted by the DWR Mercury Monitoring and Evaluation Section, Delta Mercury Control Program.

It should be noted that the primary concern for methylmercury is its bioaccumulation into piscivorous wildlife (Melwani et al. 2009; Ackerman et al. 2012) and humans (Davis et al. 2012). Forage fishes similar to delta smelt show high spatial variability in the bioaccumulation of methylmercury (Gehrke et al. 2011; Greenfield et al. 2013) as do juvenile Chinook salmon (Henery et al. 2010). It has not been demonstrated that these accumulations impair these small fishes so similar exposures in restored habitats may not affect these species' viability, though they may be of concern for passing mercury up the food web to predator fish, birds and humans.

Mercury – Potential Effects on Delta Smelt

Delta smelt spawn in or near areas that would be restored under the BDCP alternatives and therefore have the potential for increased exposure to methylmercury. Although no specific information is available, it is potentially possible that maternal transfer could occur, (i.e., prespawned eggs could be exposed to methylmercury from adult consumption of contaminated prey). Splittail, delta smelt, and longfin smelt all spawn in or near areas that would be restored under the BDCP and therefore have the potential for increased exposure to methylmercury. For delta smelt that spawn directly downstream of the Yolo Bypass or other ROAs in the west or north Delta, exposure of prespawned eggs to increased levels of methylmercury could affect the viability of fertilized eggs. It is not known what level of mercury would be assimilated and transferred to the larvae. Mercury exposure in eggs can lead to egg failure and developmental effects, but the levels of mercury that would result in these effects are not fully understood.

Effects of increased methylmercury are expected to be minimal for fish rearing in the Delta. Larvae and juvenile delta smelt feed very low on the food chain and would bioaccumulate methylmercury at low rates. In addition, juvenile delta smelt occur primarily in the west Delta and Suisun Bay, where elevated levels of methylmercury from restoration are not likely. However, juvenile smelt remaining in the north Delta area would experience exposure from food in the Yolo Bypass and Cache Slough regions although not to levels that would have any direct effect on them.

Although adult life stages of delta smelt feed and spawn in areas with potential for elevated methylmercury levels, they feed primarily on lower trophic level food sources and therefore do not accumulate methylmercury at rates as high as if they preyed on fish. Methlymercury is generally high in the Delta, and thus all fish have significant body burdens, even those that would be expected to have low bioaccumulation rates (e.g., Delta Smelt). In addition, they are not expected to spend excessive amounts of time in these areas, so the uptake through their gills and food is expected to be minimal. Nevertheless, delta smelt have been shown to accumulate appreciable quantities of mercury: Bennett et al. (2001) found average levels of 0.18 µg/g, which is just under the 0.20 µg/g general threshold for effects on fish (Henery et al. 2010:561). There is no evidence for acute toxicity of mercury being related to recent declines of pelagic fish such as delta smelt, although mercury, selenium, and copper may have chronically affected these species (Brooks et al. 2012).

Restoration actions are not expected to result in negative effects to delta smelt for the following reasons. Delta smelt feed low on the food chain, and are likely to bioaccumulate mercury at low rates, resulting in low tissue concentrations. Additionally, the greatest potential for increased methyl mercury is expected to occur in floodplains, and although, the Cache Slough ROA in Yolo Bypass may be used by delta smelt, but this area is not identified for high mercury concentrations like the areas in the northern reaches of the Yolo Bypass, and the majority of delta smelt do not occur in this area. Further, CM12 will require more site specific pre-restoration characterization, post-restoration monitoring, and adaptive management to monitor for mercury in water, sediment and biota to further ensure no negative impact to species. No adverse effect on delta smelt is anticipated from restoration-related mercury increases.

Selenium

Elevated selenium concentrations in the Delta ecosystem is widely recognized as posing a threat to aquatic species. Selenium in the Delta ecosystem and potential effects of BDCP conservation measures on covered fish species are fully described in the *BDCP Effects Analysis – Appendix 5.D, Contaminants, Section 5D.4.2.1 Selenium-Location, Environmental Fate, and Transport, and Appendix 5D, Attachment 5D.B Bioaccumulation Model Development for Selenium Concentrations in Whole Body Fish, Bird Eggs, and Fish Filets (hereby incorporated by reference)*. These effects include impaired reproduction, embryonic deformities and bioaccumulation.

Overall, loading of selenium to the Delta aquatic system has decreased significantly. The main controllable sources of selenium in the Bay-Delta estuary are agricultural drainage (generated by irrigation of seleniferous soils in the western side of the San Joaquin basin) and discharges from North Bay refineries (in processing selenium-rich crude oil). Both the San Joaquin River and North Bay selenium loads have declined in the last 15 years in response to, first, a control program in the San Joaquin Grassland area, and, second, National Pollutant Discharge Elimination System (NPDES) permit requirements established for refineries in the late 1990s.

Because the bioavailability of selenium increases in an aquatic system, inundation of ROAs could mobilize selenium sequestered in sediments and increase exposure of covered fish species. The rate at which selenium will become mobilized as part of restoration will depend on the amount of selenium stored in the sediments, the length of inundation (residence time), and whether sufficient time allows the selenium to cycle through the aquatic system and into the food chain.

The bioaccumulation and effects of selenium on fish have much to do with their feeding behavior. The overbite clam, *Potamocorbula amurensis*, accumulates selenium and is key to mobilizing it into the food chain via benthic feeders. Delta smelt would be expected to have low exposure to selenium as they are feeding on pelagic organisms that are able to excrete most of the selenium they consume (Stewart et al. 2004).

In Suisun Bay, particulate concentrations of selenium (the most bioavailable) are considered low, typically between 0.5 and 1.5 micrograms per gram (µg/g), but the bivalve *Potamocorbula amurensis* (overbite clam) contains elevated levels of selenium that range from 5 to 20 µg/g (Stewart et al. 2004). Given the fact that *Potamocorbula* may occur in abundances of up to 50,000 per m^2, this area can be considered a sink for selenium because 95% of the biota in some areas are made up of this clam.

The longer the residence time of surface waters, the higher the particulate concentration resulting in higher selenium concentrations in wetlands and shallows (Presser and Luoma 2006, 2010). Aquatic systems in shallow, slow-moving water with low flushing rates are thought to accumulate selenium most efficiently (Presser and Luoma 2006; Lemly 1999). However, the ratio of selenium in particulates (which is more bioavailable) to selenium in the water column is a complex relationship that can vary across different hydrologic regimes and seasons (Presser and Luoma 2010).

An increase of residence time in areas with dense clam populations (such as Suisun Bay) and benthic-feeding covered fish species, could result in increased mobilization and bioaccumulation of selenium in the food chain of benthic-feeding fish. Residence time is directly related to outflow in Suisun Bay. However, CALSIM modeling results indicate that outflow and residence time will not change significantly under Alternative 4, and effects on selenium biogeochemical cycling are not anticipated. Comparison of the monthly mean residence time under Alternative 4 indicates that residence time in Suisun Bay may change from a decrease of 13 days to an increase of 5 days. For other alternatives with somewhat less Delta outflow and an equal amount of restoration (e.g., Alternatives 1A-C), residence time would increase, although as shown in section 11.3.5, the potential for increases in selenium because of water operations effects are limited (see quantitative modeling for Impact AQUA-219: Effects of Operations on Contaminants on Covered Species).

In summary, selenium currently sequestered in soils could be mobilized and become more bioavailable as a result of inundation of restoration areas. Because the magnitude of this mobilization and bioaccumulation of selenium would depend on the type of food sources (filter feeders vs. plankton), significant changes in residence time, and pre-existing concentrations of selenium in the specific area, effects on aquatic species would need to be determined on a site-specific basis.

Given the decrease in loading of selenium to the Delta (from regulation of both Grasslands in the San Joaquin River basin and oil refineries near Suisun Bay) and that the selenium would be mobilized into the food chain under a narrow set of conditions, the overall effects within the Plan Area are likely low. The potential is highest for increased mobilization of selenium in Suisun Bay where filter feeders are the food source for benthic-feeding covered fish species, and restoration actions may result in increased residence times. There is also potential near the historic source areas in and near the San Joaquin River and the South Delta ROAs, where selenium concentrations in soils are expected to be highest. Given that exposures would occur under a narrow set of circumstances, site-specific evaluation is necessary to assess the real risks of increased exposures.

Mitigation/Exposure Reduction by BDCP

AMM27 will require that all restoration areas be evaluated for the site-specific potential for restoration to result in selenium exposures. Where appropriate, pre- and post-monitoring will be put in place, along with an adaptive management framework.

Selenium – Effects on Delta Smelt

Based on the evaluation above, delta smelt are not likely to be affected by selenium under restoration actions for several reasons. The delta smelts planktonic food source tends to excrete selenium rather than bioaccumulate, and does not transfer it up the food chain. Also, because delta smelt do not consume *Potamocorbula*, they do not tend to bioaccumulate. Further, overall loading of selenium to the Delta system has and will continue to substantially decrease. Added to the benefits from BDCP habitat restoration, little effects are expected from selenium on Delta smelt. No adverse impact is expected.

Copper

Copper is expected to be present in soils where copper-containing pesticides have been applied. Although copper is relatively immobile in terrestrial soils, its mobility increases in an aquatic system and it could be mobilized by inundation of restored habitat areas within the ROAs.

In general, the copper data sets discussed in Section 5.D.4.3 of the *BDCP Effects Analysis – Appendix 5D*, *Contaminants, Section 5D.4.3 Copper (hereby incorporated by reference),* indicate low levels of copper (less than 2 μg/L) throughout the Delta waterways, and elevated concentrations in agricultural drainage sloughs and near mines. Although data were not identified, it is assumed the agricultural soils will contain some level of copper given its affinity for soils in a terrestrial environment. Formerly agricultural ROAs, which are likely to have elevated levels of copper in soils, will result in some level of increased copper in the aquatic system over an undetermined time period. Currently, information on the concentrations of copper in soils of specific ROAs is insufficient to estimate the increase in concentrations.

Additionally, restoration of agricultural land to marshes and floodplains will result in decreased application of copper-containing pesticides and decreased copper loading to the Delta. This net benefit at least partially will counter the copper introduced to the aquatic system through mobilization during inundation.

It is difficult to establish precise concentrations at which copper is acutely toxic to fish, as a large number of water chemistry parameters (including temperature, pH, DOC, and ions) can affect the bioavailability of copper to the fish population (U.S. Environmental Protection Agency 2007). As discussed in Section D.5.3 of *BDCP Effects Analysis – Appendix 5.D*, *Contaminants, Section 5.D.4.3 Copper*, copper is present in the Sacramento River at low concentrations (2 μg/L). Connon with others (2011) demonstrated that the median lethal concentration of dissolved copper at which 10% of delta smelt juveniles died after 7 days of exposure under experimental conditions (LC10) was 9.0 μg/L; 50% of juveniles died (LC50) when exposed to a median concentration of 17.8 μg/L. Although 96-hour larval delta smelt mortality indicated higher concentrations than juveniles (median LC10 = 9.3 μg/L; median LC50 = 80.4 μg/L), these results were complicated by differences in exposure duration and experimental conditions (particularly for factors such as temperature and conductivity that may affect copper toxicity) (Connon et al. 2011).

There is some evidence that larval delta smelt swimming velocity decreases as dissolved copper concentration increases, although experimental testing did not find statistical differences between test subjects and controls (Connon et al. 2011). Various delta smelt genes have been shown to have altered expression in copper-exposed larvae (Connon et al. 2011).

Conclusion – Copper – Delta Smelt

There is insufficient data to estimate the amount of copper present in soils of the potential restored areas within the ROAs, or the amount of copper that would be mobilized into the aquatic system and become bioavailable. Even with this uncertainty, given that the overall detected levels of copper are low and that applications of copper-containing pesticides at formerly agricultural ROAs will cease, which will reduce overall copper loading to the system, effects of copper on Delta Smelt due to Alternative 4 restoration activities are expected to be minimal. No adverse impact is expected.

Ammonia

Increased ammonium has been identified as a possible contributor to the POD through inhibition of primary productivity (Wilkerson et al. 2006; Dugdale et al. 2007; Glibert et al. 2011; Parker et al. 2012), and causing a shift in algal species structure to a lower quality food source for the higher trophic levels, including covered species (Baxter et al. 2010; Glibert 2010). Based on the analysis presented in *BDCP Effects Analysis – Appendix 5D, Contaminants, Section 5.D.4.4 Ammonia/um (hereby incorporated by reference)*, actions from BDCP restoration activities are not expected to result in substantial increases in ammonia concentrations in the aquatic system that could affect covered fish species. Analysis of the ability of the Sacramento River to dilute ammonia discharges from the Sacramento WWTP indicates that resultant concentrations would be within ecologically acceptable limits under the BDCP alternatives. Further, no appreciable addition or mobilization of ammonia to the aquatic system would result from restoration activities.

Pyrethroids, Organophosphate Pesticides, and Organochlorine Pesticides

Based on the analysis in *BDCP Effects Analysis – Appendix 5D, Contaminants, Sections 5D.4.5 Pyrethroids, 5D.4.6 Organochlorine Pesticides, 5D.4.7 Organophosphate Pesticides (hereby incorporated by reference)*, changes in concentrations of pyrethroids, organophosphate pesticides, and organochlorine pesticides resulting from the BDCP alternatives are expected in the vicinity of agricultural land restored to marshes and floodplains. These chemicals either have a strong affinity for sediment and will settle out of the water column, or will readily degrade in an aquatic system. Thus, it is expected that increases in concentrations due to BDCP alternatives would be of relatively short duration and localized near ROAs. Specific areas of these elevated toxins have not been identified, but they can be expected in any of the ROAs. Restoration will take these agricultural areas out of production, therefore eliminating the source and reducing these chemicals in the Delta system, providing a long-term ecological benefit. In addition, CM19 would provide for treatment of stormwater discharges, a major contributor of pyrethroids to the Delta. Thus BDCP may result in reduced loading of pyrethroids to the Delta.

Pyrethroids have been shown to be lethal as low as 1 μg/L, although there are many different chemicals in this group with varying toxicities for fish. Likewise, little is known on the effects of organophosphates on fish, but elevated concentrations of organophosphates are more likely to affect the lower trophic levels that the covered fish species prey on than the fish directly (Turner 2002). As these pesticides are neurotoxins, behavioral effects are of primary concern; however, Scholz et al. (2000) points out that the effects are not well understood. Scholz et al. (2000) found that diazinon concentrations as low as 1 μg/L resulted in significant impairment of predator-alarm responses, and slightly higher concentrations of 10 μg/L caused the impairment of homing behavior in Chinook salmon. Organochlorine pesticides are neurotoxic, are likely carcinogenic, and have been implicated as endocrine disruptors because of their estrogenic nature and effects on reproductive development (Leatherbarrow et al. 2006). These pesticides are highly persistent and lipophilic, and as such, they strongly bioaccumulate (Werner et al. 2008). Because of their persistence in the environment and biomagnification through the foodweb, the main concern with organochlorines is bioaccumulation in the higher trophic levels and implications for human consumption. However, organochlorine pesticides and degradation products can directly affect fish through toxicity to lower-level invertebrates on the food chain, and toxicity to small and early life stage fish, but there is little information specific to effects on individual species. Sublethal effects may include reproductive failure and behavioral changes. Ostrach's (2008) report indicates that largemouth bass have been experiencing reproductive failure due to organochlorine compounds in San Francisco Bay, which is likely due to concentrations accumulated through biomagnification. Because they tend to adhere to soils and particulates, organochlorine compounds may take longer to flush out than some of the more environmentally mobile constituents discussed above (e.g., copper).

In the Delta, fish in higher trophic levels are particularly vulnerable to these pesticides, as the chemicals will biomagnify and bioaccumulate in their tissues. These fish include white and green sturgeon, salmonids, and lampreys. As smaller fish at lower trophic levels, smelt can be expected to have less biomagnification of these pesticides.

Summary

Mercury. Given the widespread occurrence of mercury in Delta soils and sediment, there is potential for methylation of mercury and mobilization into the food chain in any newly inundated area restorated under BDCP, especially in floodplains and other areas that are repeatedly wetted and dried. This is particularly of concern because mercury is widely elevated in biota throughout the delta system. However, the factors that determine if methylation occurs and at what rate are complex, and require site-specific evaluation, which will be provided by CM12.

Analysis of restoration actions and mercury distribution in the Delta indicates a few important factors:

- The Cache Slough ROA in Yolo Bypass is not an identified as a high mercury area, like the upstream Cache Creek and Putah Creek areas
- Methylation in Yolo Bypass will likely occur in a short-lived spike following inundation during flood events
- Restoration of managed wetlands to tidal wetlands in Suisun Marsh is expected to result in decreased overall mercury methylation in this system
- Delta smelt feed low on the food chain, and do not bioaccumulate mercury at a high rate
- CM12 is expected to provide the site-specific analysis to support site selection, implementation of design elements, pre- and post-restoration monitoring, and an adaptive management framework that is adaptable over time and will result in no adverse effect on delta smelt from mercury associated with restoration actions.

Selenium. Based on the evaluation above, delta smelt is not likely to be affected by selenium under restoration actions for several reasons. The delta smelt planktonic food source tends to excrete selenium rather than bioaccumulate, and does not transfer it up the food chain. Also, because delta smelt feeds at the bottom of the food chain, it will not tend to bioaccumulate. Further, overall loading of selenium to the Delta system has and will continue to substantially decrease. Added to the benefits from BDCP habitat restoration, little effects are expected from selenium on Delta smelt. No adverse impacts is expected.

Copper. Localized, short-term increases in copper concentrations are possible, but not presently quantifiable near ROA areas, particularly in the eastern Delta. However, the BDCP alternatives are not expected to result in increased toxicological effects of copper on delta smelt. In addition, the removal of agricultural areas through restoration activities would eliminate some sources of copper. It is concluded for delta smelt that BDCP restoration activities will not generate adverse effects on delta smelt of copper relative to the NAA. Similarly, no appreciable addition or mobilization of ammonia to the aquatic system would result from restoration activities.

Ammonia. No mechanism for increased exposures of aquatic species to ammonia due to restoration actions is anticipated, and there would be no adverse effect.

Pesticides. The removal of agricultural areas through restoration activities would eliminate some sources of organophosphate and organochlorine pesticide contamination, potentially providing a long-term net benefit to delta smelt and their supporting food web. In addition, implementing *CM19 Urban Stormwater Treatment* would provide for treatment of stormwater discharges, a major contributor of pyrethroid pesticides to the Delta. Thus the BDCP may contribute to reduced loading of stormwater and agricultural sources of pesticides. Therefore, the effect of BDCP on pesticides would not be adverse to delta smelt.

NEPA Effects: Overall, the effects of contaminants associated with restoration measures would not be adverse for delta smelt with respect to mercury, selenium, copper, ammonia and pesticides, given the inclusion of CM 12 and the fact that they are unlikely to be exposed to elevated levels of selenium.

Impact AQUA-22: Effects of Water Operations on Spawning, Egg Incubation, and Rearing Habitat for Longfin Smelt

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse) Within the public draft EIR/EIS, there was no NEPA determination for any alternative for water operations effects on spawning, egg incubation, and rearing habitat for longfin smelt, except for Alternative 4. This section provides determinations for all alternatives, except for Alternative 4 (the analysis presented for Alternative 4 in the public draft EIR/EIS remains valid—it concluded that the impact was not adverse because of the Decision Trees process). Note that additional analysis of this impact is presented in the analyses of the new alternatives, i.e., Alternatives 2D, 4A, and 5A (see sections 4.3.7, 4.4.7, and 4.4.8).

NEPA Effects: Background on the general distribution of longfin smelt and the evidence for relationships between longfin smelt abundance with freshwater outflow is provided in detail in the discussion for Alternative 4 in the public draft EIR-EIS. The X2–longfin smelt abundance relationship provided by Kimmerer et al. (2009) was used to evaluate the effects of the alternatives on longfin smelt, following the historical observation that lower X2 (farther downstream) correlates with increased recruitment (represented by abundance indices in trawl surveys), although it is not understood if or how this would affect spawning, egg incubation, and/or rearing longfin smelt. Relationships between X2 and longfin smelt abundance developed by Kimmerer et al. (2009) were used to determine how the changes in winter-spring X2 position described above might influence longfin smelt abundance the following fall.

The results of the analyses based on Kimmerer et al. (2009) reflect differences in winter-spring (January-June) Delta outflows between the alternatives and NAA. For Alternatives 1A, 1B, 1C, 2D, and 3, the all-year mean fall midwater trawl index predicted under the alternatives was 7-8% lower than under NAA. Inclusion of extensive habitat restoration under *CM4 Tidal Natural Communities Restoration*, as well as mitigation measures AQUA-22a, AQUA-22b, and AQUA-22c to mitigate the significant CEQA impact, would result in Alternatives 1A, 1B, 1C, and 3 being not adverse. Although Alternative 2D would include the same mitigation measures, its lack of extensive tidal habitat restoration would result in the impact remaining adverse.

For Alternatives 2A, 2B, 2C, 5, and 5A there was little (5% or less) to no difference from NAA in the all-year mean fall midwater trawl index. Alternatives 2A, 2B, 2C, and 4 have extensive habitat restoration and would not be adverse. Alternative 5 also has this extensive habitat restoration, as well as mitigation measures AQUA-22a, AQUA-22b, and AQUA-22c (because of a significant CEQA impact), and as such Alternative 5 also would not be adverse. Alternative 5A does not include the extensive habitat restoration under *CM4*, but is not adverse because of the inclusion of mitigation measures AQUA-22a, AQUA-22b, and AQUA-22c (because of a significant CEQA impact).

Alternatives 6A, 6B, 6C, 7, 8, and 9 had similar or greater predicted all-year mean fall midwater trawl indices than NAA. These alternatives would not be adverse.

As described in more detail in section 4.3.7, Alternative 4A is not adverse because Delta outflows would be provided to avoid differences from NAA during spring, included in Mitigation Measure AQUA-22d.

Impact AQUA-26: Effects of Contaminants Associated with Restoration Measures on Longfin Smelt

Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9 (not adverse)

The analysis of the effects of contaminants associated with restoration measures on delta smelt is also applicable to the longfin smelt because they have similar potential for exposure and risk for the contaminants evaluated due to their similar diets, habitat uses, and physiology.

NEPA Effects: As discussed above for delta smelt, the effects of contaminants associated with restoration measures would not be adverse for longfin smelt with respect to mercury, selenium, copper, ammonia and pesticide because they have similar potential for exposure and risk for the contaminants evaluated due to their similar diets, habitat uses, and physiology.

Impact AQUA-40: Effects of Water Operations on Spawning and Egg Incubation Habitat for Chinook Salmon (Winter-Run ESU)

Alternatives 4 and 7 (not adverse)

Alternative 4

In general, the effects of Alternative 4 on spawning and egg incubation habitat for winter-run Chinook salmon relative to the NAA are not adverse.

H3/ESO

Flows in the Sacramento River between Keswick and upstream of Red Bluff Diversion Dam were examined during the May through September winter-run spawning period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Lower flows can reduce the instream area available for spawning and egg incubation. Flows under H3 would generally be greater (by up to 20%) than flows under NAA during May and June and similar during July through September. Based on these flow results, it is expected that H3 would generally provide flow-related benefits to winter-run Chinook salmon spawning and egg incubation habitat in earlier months and no effects in later months.

Shasta Reservoir storage volume at the end of May influences flow rates below the dam during the May through September winter-run spawning and egg incubation period. May Shasta storage under H3 would be similar (<5% difference) to storage under NAA for all water year types (Table 11-mult-29).

Table 11-mult-29. Difference and Percent Difference in May Water Storage Volume (thousand acre-feet) in Shasta Reservoir for Alternative 4 (Scenario H3)

Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
Wet	-59 (-1%)	-25 (-1%)
Above Normal	-156 (-3%)	-70 (-2%)
Below Normal	-330 (-8%)	-132 (-3%)
Dry	-550 (-15%)	-106 (-3%)
Critical	-622 (-25%)	-38 (-2%)

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the May through September winter-run spawning period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period at either location.

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September) and year of the 82-year modeling period (Table 11-mult-30). The combination of number of days and degrees above the 56°F threshold were further assigned a “level of concern”, as defined in Table 11-mult-31. Differences between baselines and H3 in the highest level of concern across all months and all 82 modeled years are presented in Table 11-mult-32. There would be no difference in levels of concern between NAA and H3.

Table 11-mult-30. Maximum Water Temperature Criteria for Covered Salmonids and Sturgeon Provided by NMFS and Used in the BDCP Effects Analysis

Location	Period	Maximum Water Temperature (°F)	Purpose
Upper Sacramento River			
Bend Bridge	May–Sep	56	Winter- and spring-run spawning and egg incubation
		63	Green sturgeon spawning and egg incubation
Red Bluff	Oct–Apr	56	Spring-, fall-, and late fall–run spawning and egg incubation
Hamilton City	Mar–Jun	61 (optimal), 68 (lethal)	White sturgeon spawning and egg incubation
Feather River			
Robinson Riffle (RM 61.6)	Sep–Apr	56	Spring-run and steelhead spawning and incubation
	May–Aug	63	Spring-run and steelhead rearing
Gridley Bridge	Oct–Apr	56	Fall- and late fall–run spawning and steelhead rearing
	May–Sep	64	Green sturgeon spawning, incubation, and rearing
American River			
Watt Avenue Bridge	May–Oct	65	Juvenile steelhead rearing

Table 11-mult-31. Number of Days per Month Required to Trigger Each Level of Concern for Water Temperature Exceedances in the Sacramento River for Covered Salmonids and Sturgeon Provided by NMFS and Used in the BDCP Effects Analysis

Exceedance above Water Temperature Threshold (°F)	Level of Concern			
	None	Yellow	Orange	Red
1	0–9 days	10–14 days	15–19 days	≥20 days
2	0–4 days	5–9 days	10–14 days	≥15 days
3	0 days	1–4 days	5–9 days	≥10 days

Table 11-mult-32. Differences between Baseline and H3 Scenarios in the Number of Years in Which Water Temperature Exceedances above 56°F Are within Each Level of Concern, Sacramento River at Bend Bridge, May through September

Level of Concern	EXISTING CONDITIONS vs. H3	NAA vs. H3
Red	31 (61%)	0 (0%)
Orange	-17 (-100%)	0 (NA)
Yellow	-11 (-100%)	0 (NA)
None	-3 (-100%)	0 (NA)

Note: For definitions of levels of concern, see Table 11-mult-31.

NA = could not be calculated because the denominator was 0.

Total degree-days exceeding 56°F at Bend Bridge were summed by month and water year type during May through September (Table 11-mult-33). Total degree-days under H3 would be up to 11% lower than under NAA during May and June and up to 11% higher during July through September.

Table 11-mult-33. Differences between Baseline and H3 Scenarios in Total Degree-Days (°F-Days) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Sacramento River at Bend Bridge, May through September

Month	Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
May	Wet	1,065 (282%)	-137 (-9%)
	Above Normal	228 (107%)	-127 (-22%)
	Below Normal	434 (198%)	-29 (-4%)
	Dry	246 (132%)	-168 (-28%)
	Critical	454 (205%)	44 (7%)
	All	2,427 (200%)	-417 (-10%)
June	Wet	500 (130%)	-211 (-19%)
	Above Normal	66 (45%)	-163 (-43%)
	Below Normal	276 (199%)	-76 (-15%)
	Dry	514 (273%)	-20 (-3%)
	Critical	623 (155%)	73 (8%)
	All	1,979 (157%)	-397 (-11%)
July	Wet	653 (126%)	47 (4%)
	Above Normal	347 (428%)	77 (22%)
	Below Normal	591 (402%)	135 (22%)
	Dry	1,313 (466%)	385 (32%)
	Critical	1,776 (216%)	-10 (-0.4%)
	All	4,680 (253%)	634 (11%)
August	Wet	2,091 (300%)	128 (5%)
	Above Normal	830 (203%)	171 (16%)
	Below Normal	1,246 (470%)	211 (16%)
	Dry	2,063 (308%)	453 (20%)
	Critical	2,732 (184%)	113 (3%)
	All	8,962 (254%)	1,076 (9%)
September	Wet	806 (109%)	97 (7%)
	Above Normal	586 (82%)	186 (17%)
	Below Normal	1,570 (210%)	424 (22%)
	Dry	2,425 (190%)	-171 (-4%)
	Critical	1,938 (93%)	47 (1%)
	All	7,325 (132%)	583 (5%)

The Reclamation egg mortality model predicts that winter-run Chinook salmon egg mortality in the Sacramento River under H3 would be similar to mortality under NAA (Table 11-mult-34). In below normal and dry water years, the relative increase in egg mortality under H3 over NAA would be 76% and 11% greater, respectively, although the absolute increase in these water years would be only 1%. Therefore, the increase in mortality from NAA to H3, although relatively large, would be negligible at an absolute scale to the winter-run population.

Table 11-mult-34. Difference and Percent Difference in Percent Mortality of Winter-Run Chinook Salmon Eggs in the Sacramento River (Egg Mortality Model)

Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
Wet	1 (262%)	-0.1 (-4%)
Above Normal	2 (340%)	-0.1 (-3%)
Below Normal	2 (228%)	1 (76%)
Dry	7 (436%)	1 (11%)
Critical	42 (156%)	-2 (-3%)
All	9 (185%)	0.1 (1%)

SacEFT predicts that there would be a 28% decrease in the percentage of years with good spawning availability, measured as weighted usable area, under H3 relative to NAA (Table 11-mult-35). On an absolute scale, this reduction would be small (9% lower). SacEFT predicts that the percentage of years with good (lower) redd scour risk, good (lower) redd dewatering risk, and good egg incubation conditions under H3 would be similar to the percentage of years under NAA. These results indicate that there would be a small negative effect of H3 on spawning habitat, but no effects on other modeled parameters.

The biological significance of a reduction in available suitable spawning habitat varies at the population level in response to a number of factors, including adult escapement. For those years when adult escapement is less than the carrying capacity of the spawning habitat, a reduction in area would have little or no population level effect. In years when escapement exceeds carrying capacity of the reduced habitat, competition among spawners for space (e.g., increased redd superimposition) would increase, resulting in reduced reproductive success. The reduction in the frequency of years in which spawning habitat availability is considered to be good by SacEFT could result in reduced reproductive success and abundance of winter-run Chinook salmon if the number of spawners is limited by spawning habitat quantity. However, it is unlikely that spawning habitat is limiting to winter-run Chinook salmon due to their small spawning adult population sizes in recent years relative to historical numbers.

Table 11-mult-35. Difference and Percent Difference in Percentage of Years with "Good" Conditions for Winter-Run Chinook Salmon Habitat Metrics in the Upper Sacramento River (from SacEFT)

Metric	EXISTING CONDITIONS vs. H3	NAA vs. H3
Spawning WUA	-35 (-60%)	-9 (-28%)
Redd Scour Risk	0 (0%)	0 (0%)
Egg Incubation	-25 (-26%)	-2 (-3%)
Redd Dewatering Risk	3 (12%)	-1 (-3%)
Juvenile Rearing WUA	-24 (-48%)	1 (4%)
Juvenile Stranding Risk	0 (0%)	-11 (-35%)

WUA = Weighted Usable Area.

H1/LOS

lows in the Sacramento River between Keswick and Red Bluff Diversion Dam under H1 between May and September would be greater than flows under NAA in May and June (8% to 10%), similar (>5% difference) during July and August, and lower during September (26% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis).* Flow reductions during September would occur primarily during wetter water years when flow reductions are less critical due to already high flows and, therefore, would not cause biologically meaningful effects. May storage in Shasta Reservoir under H1 would be similar to storage under NAA (Table 11-mult-36).

Table 11-mult-36. Difference and Percent Difference in May Water Storage Volume (thousand acre-feet) in Shasta Reservoir for H1 and H4 Scenarios

Water Year Type	EXISTING CONDITIONS vs. H1	NAA vs. H1	EXISTING CONDITIONS vs. H4	NAA vs. H4
Wet	-60 (-1.3%)	-26 (-0.6%)	-43 (-1%)	-9 (-0.2%)
Above Normal	-149 (-3.3%)	-62 (-1.4%)	-140 (-3.1%)	-53 (-1.2%)
Below Normal	-296 (-7.2%)	-98 (-2.5%)	-181 (-4.4%)	17 (0.4%)
Dry	-436 (-11.5%)	9 (0.3%)	-434 (-11.5%)	10 (0.3%)
Critical	-589 (-24.1%)	-6 (-0.3%)	-474 (-19.4%)	110 (5.9%)

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the May through September winter-run spawning period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period at either location.

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September) and year of the 82-year modeling period (Table 11-mult-30). The combination of number of days and degrees above the 56°F threshold were further assigned a “level of concern”, as defined in Table 11-mult-31. Differences between baselines and H1 in the highest level of concern across all months and all 82 modeled years are presented in Table 11-mult-37. There would be no difference in levels of concern between NAA and H1.

Table 11-mult-37. Differences between Baseline Scenarios and H1 and H4 Scenarios in the Number of Years in Which Water Temperature Exceedances above 56°F Are within Each Level of Concern, Sacramento River at Bend Bridge, May through September

Level of Concern	EXISTING CONDITIONS vs. H1	NAA vs. H1	EXISTING CONDITIONS vs. H4	NAA vs. H4
Red	31 (61%)	0 (0%)	30 (59%)	-1 (-1%)
Orange	-17 (-100%)	0 (NA)	-16 (-94%)	1 (NA)
Yellow	-11 (-100%)	0 (NA)	-11 (-100%)	0 (NA)
None	-3 (-100%)	0 (NA)	-3 (-100%)	0 (NA)

Note: For definitions of levels of concern, see Table 11-mult-31.
NA = could not be calculated because the denominator was 0.

Total degree-days exceeding 56°F at Bend Bridge were summed by month and water year type during May through September (Table 11-mult-38). Total degree-days under H1 would be up to 11% to 12% lower than under NAA during May and June and 8% to 16% higher during July through September.

Table 11-mult-38. Differences between Baseline Scenarios and H1 and H4 Scenarios in Total Degree-Days (°F-Days) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Sacramento River at Bend Bridge, May through September

Month	Water Year Type	EXISTING CONDITIONS vs. H1	NAA vs. H1	EXISTING CONDITIONS vs. H4	NAA vs. H4
May	Wet	1,050 (279%)	-152 (-10%)	1,109 (294%)	-93 (-6%)
	Above Normal	273 (128%)	-82 (-14%)	290 (136%)	-65 (-11%)
	Below Normal	429 (196%)	-34 (-5%)	493 (225%)	30 (4%)
	Dry	216 (116%)	-198 (-33%)	392 (211%)	-22 (-4%)
	Critical	428 (194%)	18 (3%)	392 (177%)	-18 (-3%)
	All	2,396 (197%)	-448 (-11%)	2,676 (220%)	-168 (-4%)
June	Wet	468 (122%)	-243 (-22%)	645 (168%)	-66 (-6%)
	Above Normal	91 (61%)	-138 (-37%)	247 (167%)	18 (5%)
	Below Normal	245 (176%)	-107 (-22%)	374 (269%)	22 (4%)
	Dry	458 (244%)	-76 (-11%)	576 (306%)	42 (6%)
	Critical	671 (167%)	121 (13%)	607 (151%)	57 (6%)
	All	1,933 (153%)	-443 (-12%)	2,449 (194%)	73 (2%)
July	Wet	658 (127%)	52 (5%)	633 (122%)	27 (2%)
	Above Normal	352 (435%)	82 (23%)	299 (369%)	29 (8%)
	Below Normal	621 (422%)	165 (27%)	506 (344%)	50 (8%)
	Dry	1,162 (412%)	234 (19%)	1,033 (366%)	105 (9%)
	Critical	1,731 (210%)	-55 (-2%)	1,438 (175%)	-348 (-13%)
	All	4,524 (244%)	478 (8%)	3,909 (211%)	-137 (-2%)
August	Wet	2,153 (309%)	190 (7%)	1,861 (267%)	-102 (-4%)
	Above Normal	816 (200%)	157 (15%)	593 (145%)	-66 (-6%)
	Below Normal	1,302 (491%)	267 (21%)	1,010 (381%)	-25 (-2%)
	Dry	2,003 (299%)	393 (17%)	1,577 (235%)	-33 (-1%)
	Critical	2,605 (175%)	-14 (-0.3%)	2,284 (154%)	-335 (-8%)
	All	8,879 (252%)	993 (9%)	7,325 (208%)	-561 (-5%)
September	Wet	2,321 (314%)	1,612 (111%)	681 (92%)	-28 (-2%)
	Above Normal	1,025 (144%)	625 (56%)	406 (57%)	6 (1%)
	Below Normal	1,278 (171%)	132 (7%)	1,289 (173%)	143 (8%)
	Dry	2,206 (173%)	-390 (-10%)	2,178 (171%)	-418 (-11%)
	Critical	1,843 (89%)	-48 (-1%)	1,691 (81%)	-200 (-5%)
	All	8,673 (156%)	1,931 (16%)	6,245 (112%)	-497 (-4%)

H4/HOS

Flows in the Sacramento River between Keswick and Red Bluff Diversion Dam under H4 between May and September would generally be similar to flows under NAA, except during September (7% greater under H4) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis).* May storage in Shasta Reservoir under H4 would be similar to storage under NAA, except in critical water years in which storage would be 6% greater under H4 (Table 11-mult-36).

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the May through September winter-run spawning period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period at either location.

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September) and year of the 82-year modeling period (Table 11-mult-30). The combination of number of days and degrees above the 56°F threshold were further assigned a “level of concern”, as defined in Table 11-mult-31. Differences between baselines and H4 in the highest level of concern across all months and all 82 modeled years are presented in Table 11-mult-37. There would be no difference in levels of concern between NAA and H4.

Total degree-days exceeding 56°F at Bend Bridge were summed by month and water year type during May through September (Table 11-mult-38). Total degree-days under H4 would be up to 5% lower than under NAA during August and similar during other months.

NEPA Effects: Alternative 4 does not propose any changes in Shasta Reservoir operating criteria, and CALSIM results show that Reclamation could operate Shasta in such a manner that it does not affect upstream storage or flows substantially as compared to the NAA. Mean water temperatures do not differ appreciably between Alternative 4 and NAA. However, available analytical tools show conflicting results regarding the temperature effects of relatively small changes in predicted summer and fall flows. Several models (CALSIM, SRWQM, and Reclamation Egg Mortality Model) generally show no change in upstream conditions as a result of Alternative 4. However, one model, SacEFT, shows small negative effects to spawning habitat availability. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions, which may or may not accurately predict adverse effects. Temperature and end of September storage criteria from the NMFS (2009a) BiOp for Shasta reservoir are maintained, in order to minimize adverse effects to spawning and incubating salmonids including winter-run-run Chinook salmon. It is unlikely that the reduction in spawning habitat availability predicted by SacEFT would have an appreciable effect to the winter-run Chinook salmon population given the greatly reduced population size relative to historical values and because the NMFS (2009a) BiOp RPA includes an investigation of passage upstream of Shasta Dam, which would greatly enhance spawning habitat availability. Given this information and the lack of effect seen in every analysis other than SacEFT, it is concluded that this effect is not adverse.

Alternative 7

In general, effects of Alternative 7 on spawning and egg incubation habitat conditions for winter-run Chinook salmon relative to NAA are not adverse.

Flows in the Sacramento River between Keswick and upstream of Red Bluff Diversion Dam were examined during the May through September winter-run spawning period (Appendix 11C, *CALSIM II*

Model Results utilized in the Fish Analysis). Lower flows can reduce the instream area available for spawning and egg incubation. Flows under A7_LLT during May through September would generally be similar to or greater than flows under NAA, except in above normal, and below normal years during September (7% to 8% and 18% to 20% lower, respectively). These results indicate that there would be intermittent negligible to small flow-related effects of Alternative 7 on spawning and egg incubation habitat.

Shasta Reservoir storage volume at the end of May influences flow rates below the dam during the May through September winter-run spawning and egg incubation period. May Shasta storage volume under A7_LLT would be similar to storage under NAA for all water year types (Table 11-mult-39).

These results indicate that there would be negligible (<5%) effects of Alternative 7 relative to NAA on winter-run Chinook salmon spawning and egg incubation habitat.

Table 11-mult-39. Difference and Percent Difference in May Water Storage Volume (thousand acre-feet) in Shasta Reservoir for Model Scenarios

Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wet	-42 (-1%)	-8 (0%)
Above Normal	-126 (-3%)	-40 (-1%)
Below Normal	-249 (-6%)	-51 (-1%)
Dry	-431 (-11%)	13 (0%)
Critical	-627 (-26%)	-43 (-2%)

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the May through September winter-run spawning period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period at either location.

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September) and year of the 82-year modeling period (Table 11-mult-40). The combination of number of days and degrees above the 56°F threshold were further assigned a “level of concern”, as defined in Table 11-mult-41. Differences between baselines and Alternative 7 in the highest level of concern across all months and all 82 modeled years are presented in Table 11-mult-42. There would be no difference in levels of concern between NAA and Alternative 7.

Table 11-mult-40. Maximum Water Temperature Criteria for Covered Salmonids and Sturgeon Provided by NMFS and Used in the BDCP Effects Analysis

Location	Period	Maximum Water Temperature (°F)	Purpose
Upper Sacramento River			
Bend Bridge	May–Sep	56	Winter- and spring-run spawning and egg incubation
		63	Green sturgeon spawning and egg incubation
Red Bluff	Oct–Apr	56	Spring-, fall-, and late fall–run spawning and egg incubation
Hamilton City	Mar-Jun	61 (optimal), 68 (lethal)	White sturgeon spawning and egg incubation
Feather River			
Robinson Riffle (RM 61.6)	Sep–Apr	56	Spring-run and steelhead spawning and incubation
	May–Aug	63	Spring-run and steelhead rearing
Gridley Bridge	Oct–Apr	56	Fall- and late fall–run spawning and steelhead rearing
	May–Sep	64	Green sturgeon spawning, incubation, and rearing
American River			
Watt Avenue Bridge	May–Oct	65	Juvenile steelhead rearing

Table 11-mult-41. Number of Days per Month Required to Trigger Each Level of Concern for Water Temperature Exceedances in the Sacramento River for Covered Salmonids and Sturgeon Provided by NMFS and Used in the BDCP Effects Analysis

Exceedance above Water Temperature Threshold (°F)	Level of Concern			
	None	Yellow	Orange	Red
1	0-9 days	10-14 days	15-19 days	≥20 days
2	0-4 days	5-9 days	10-14 days	≥15 days
3	0 days	1-4 days	5-9 days	≥10 days

Table 11-mult-42. Differences between Baseline and Alternative 7 Scenarios in the Number of Years in Which Water Temperature Exceedances above 56°F Are within Each Level of Concern, Sacramento River at Bend Bridge, May through September

Level of Concern[a]	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Red	33 (67%)	0 (0%)
Orange	-14 (-100%)	0 (NA)
Yellow	-16 (-100%)	0 (NA)
None	-3 (-100%)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] For definitions of levels of concern, see Table 11-mult-41.

Total degree-days exceeding 56°F at Bend Bridge were summed by month and water year type during May through September (Table 11-mult-43). Total degree-days under Alternative 7 would be similar to those under NAA during May, 2% lower than under NAA during June and July, and 7% higher during August and September.

Table 11-mult-43. Differences between Baseline and Alternative 7 Scenarios in Total Degree-Days (°F-Days) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Sacramento River at Bend Bridge, May through September

Month	Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
May	Wet	1,121 (297%)	-81 (-5%)
	Above Normal	328 (154%)	-27 (-5%)
	Below Normal	549 (251%)	86 (13%)
	Dry	444 (239%)	30 (5%)
	Critical	403 (182%)	-7 (-1%)
	All	2,845 (234%)	1 (0%)
June	Wet	472 (123%)	-239 (-22%)
	Above Normal	226 (153%)	-3 (-1%)
	Below Normal	412 (296%)	60 (12%)
	Dry	598 (318%)	64 (9%)
	Critical	601 (150%)	51 (5%)
	All	2,308 (183%)	-68 (-2%)
July	Wet	626 (121%)	20 (2%)
	Above Normal	269 (332%)	-1 (0%)
	Below Normal	372 (253%)	-84 (-14%)
	Dry	847 (300%)	-81 (-7%)
	Critical	1,805 (219%)	19 (0.7%)
	All	3,919 (212%)	-127 (-2%)
August	Wet	2,094 (300%)	131 (5%)
	Above Normal	833 (204%)	174 (16%)
	Below Normal	1,137 (429%)	102 (8%)
	Dry	1,851 (276%)	241 (11%)
	Critical	2,812 (189%)	193 (5%)
	All	8,726 (247%)	839 (7%)
September	Wet	816 (111%)	107 (7%)
	Above Normal	538 (75%)	138 (12%)
	Below Normal	1,659 (222%)	513 (27%)
	Dry	2,608 (204%)	12 (0%)
	Critical	1,975 (95%)	84 (2%)
	All	7,599 (137%)	854 (7%)

The Reclamation egg mortality model predicts that winter-run Chinook salmon egg mortality in the Sacramento River under A7_LLT would be 11%, 100%, and 45% greater than mortality under NAA in above normal, below normal, and dry water years, respectively (Table 11-mult-44). The increase in the percent of winter-run population subject to mortality would be 0.2%, 2%, and 3% in above normal, below normal, and dry years, respectively. Therefore, the increase in mortality of up to 3% from NAA to A7_LLT, although relatively large, would be negligible at an absolute scale to the winter-run population. These results indicate that climate change would cause the majority of the increase in winter-run egg mortality.

Table 11-mult-44. Difference and Percent Difference in Percent Mortality of Winter-Run Chinook Salmon Eggs in the Sacramento River (Egg Mortality Model)

Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wet	1 (269%)	-0.04 (-2%)
Above Normal	2 (404%)	0.2 (11%)
Below Normal	3 (273%)	2 (100%)
Dry	9 (596%)	3 (45%)
Critical	45 (169%)	1 (2%)
All	10 (210%)	1 (9%)

SacEFT predicts that there would be a 28% decrease in the percentage of years with good spawning availability, measured as weighted usable area, under A7_LLT relative to NAA (Table 11-mult-45). These results indicate that there may be small negative effects of Alternative 7 on spawning habitat availability. SacEFT predicts that the percentage of years with good (lower) redd scour risk under A7_LLT would be similar to the percentage of years under NAA. SacEFT predicts that the percentage of years with good egg incubation conditions under A7_LLT would be similar to (<5% difference) that under NAA. SacEFT predicts that the percentage of years with good (lower) redd dewatering risk under A7_LLT would be 17% lower (5% lower on an absolute scale) than risk under NAA.

The biological significance of a reduction in available suitable spawning habitat varies at the population level in response to a number of factors, including adult escapement. For those years when adult escapement is less than the carrying capacity of the spawning habitat, a reduction in area would have little or no population level effect. In years when escapement exceeds carrying capacity of the reduced habitat, competition among spawners for space (e.g., increased redd superimposition) would increase, resulting in reduced reproductive success. The reduction in the frequency of years in which spawning habitat availability is considered to be good by SacEFT could result in reduced reproductive success and abundance of winter-run Chinook salmon if the number of spawners is limited by spawning habitat quantity. However, it is unlikely that spawning habitat is limiting to winter-run Chinook salmon due to their small spawning adult population sizes in recent years relative to historical numbers.

Table 11-mult-45. Difference and Percent Difference in Percentage of Years with "Good" Conditions for Winter-Run Chinook Salmon Habitat Metrics in the Upper Sacramento River (from SacEFT)

Metric	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Spawning WUA	-35 (-60%)	-9 (-28%)
Redd Scour Risk	0 (0%)	0 (0%)
Egg Incubation	-22 (-23%)	1 (1%)
Redd Dewatering Risk	-1 (-4%)	-5 (-17%)
Juvenile Rearing WUA	-27 (-54%)	-2 (-8%)
Juvenile Stranding Risk	2 (10%)	-9 (-29%)

WUA = Weighted Usable Area.

NEPA Effects: Alternative 7 generally does not cause changes to Shasta Reservoir storage or mean flows and water temperatures in the Sacramento River by month and water year type. However, available analytical tools show conflicting results regarding the temperature effects of relatively small changes in predicted summer and fall flows. Several models (CALSIM, SRWQM, and Reclamation Egg Mortality Model) generally show no change in upstream conditions as a result of Alternative 7. However, one model, SacEFT, shows small negative effects to spawning habitat availability. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions, which may or may not accurately predict adverse effects. Temperature and end of September storage criteria from the NMFS (2009a) BiOp for Shasta reservoir are maintained, in order to minimize adverse effects to spawning and incubating salmonids including winter-run-run Chinook salmon. It is unlikely that the reduction in spawning habitat availability predicted by SacEFT would have an appreciable effect to the winter-run Chinook salmon population given the greatly reduced population size relative to historical values and because the NMFS (2009a) BiOp RPA includes an investigation of passage upstream of Shasta Dam, which would greatly enhance spawning habitat availability. Given this information and the lack of effect seen in every analysis other than SacEFT, it is concluded that this effect is not adverse.

Alternative 3 (adverse/significant)

In general, effects of Alternative 3 on spawning and egg incubation habitat for winter-run Chinook salmon relative to NAA are adverse.

Flows in the Sacramento River between Keswick and upstream of Red Bluff Diversion Dam were examined during the May through September winter-run Chinook salmon spawning period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Lower flows can reduce the instream area available for spawning and egg incubation. Flows under A3_LLT during May through July would generally be similar to or greater than flows under NAA except in dry years during July (9% at both locations). Flows during August and September under A3_LLT would be mostly lower than flows under NAA (up to 45% lower depending on month, location, and water year type).

Shasta Reservoir storage volume at the end of May influences flow rates below the dam during the May through September winter-run spawning and egg incubation period. May Shasta storage volume under A3_LLT would be similar to or greater than storage under NAA for all water year types except below normal (8% lower) and dry (6% lower) (Table 11-mult-46).

These results indicate that there would be small to moderate effects of Alternative 3 on storage and flows in the Sacramento River relative to NAA.

Table 11-mult-46. Difference and Percent Difference in May Water Storage Volume (thousand acre-feet) in Shasta Reservoir for Model Scenarios

Water Year Type	EXISTING CONDITIONS vs. A3_LLT	NAA vs. A3_LLT
Wet	-78 (-2%)	-44 (-1%)
Above Normal	-161 (-4%)	-75 (-2%)
Below Normal	-518 (-13%)	-320 (-8%)
Dry	-634 (-17%)	-190 (-6%)
Critical	-593 (-24%)	-9 (0%)

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the May through September winter-run spawning period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 3 in any month or water year type throughout the period at either location.

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September) and year of the 82-year modeling period (Table 11-mult-47). The combination of number of days and degrees above the 56°F threshold were further assigned a “level of concern”, as defined in Table 11-mult-48. Differences between baselines and Alternative 3 in the highest level of concern across all months and all 82 modeled years are presented in Table 11-mult-49. There would be no difference in levels of concern between NAA and A3_LLT.

Table 11-mult-47. Maximum Water Temperature Criteria for Covered Salmonids and Sturgeon Provided by NMFS and Used in the BDCP Effects Analysis

Location	Period	Maximum Water Temperature (°F)	Purpose
Upper Sacramento River			
Bend Bridge	May–Sep	56	Winter- and spring-run spawning and egg incubation
		63	Green sturgeon spawning and egg incubation
Red Bluff	Oct–Apr	56	Spring-, fall-, and late fall–run spawning and egg incubation
Hamilton City	Mar-Jun	61 (optimal), 68 (lethal)	White sturgeon spawning and egg incubation
Feather River			
Robinson Riffle (RM 61.6)	Sep–Apr	56	Spring-run and steelhead spawning and incubation
	May–Aug	63	Spring-run and steelhead rearing
Gridley Bridge	Oct–Apr	56	Fall- and late fall–run spawning and steelhead rearing
	May–Sep	64	Green sturgeon spawning, incubation, and rearing
American River			
Watt Avenue Bridge	May–Oct	65	Juvenile steelhead rearing

Table 11-mult-48. Number of Days per Month Required to Trigger Each Level of Concern for Water Temperature Exceedances in the Sacramento River for Covered Salmonids and Sturgeon Provided by NMFS and Used in the BDCP Effects Analysis

Exceedance above Water Temperature Threshold (°F)	Level of Concern			
	None	Yellow	Orange	Red
1	0-9 days	10-14 days	15-19 days	≥20 days
2	0-4 days	5-9 days	10-14 days	≥15 days
3	0 days	1-4 days	5-9 days	≥10 days

Table 11-mult-49. Differences between Baseline and Alternative 3 Scenarios in the Number of Years in Which Water Temperature Exceedances above 56°F Are within Each Level of Concern, Sacramento River at Bend Bridge, May through September

Level of Concern[a]	EXISTING CONDITIONS vs. A3_LLT	NAA vs. A3_LLT
Red	33 (67%)	0 (0%)
Orange	-14 (-100%)	0 (NA)
Yellow	-16 (-100%)	0 (NA)
None	-3 (-100%)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] For definitions of levels of concern, see Table 11-mult-48.

Total degree-days exceeding 56°F at Bend Bridge were summed by month and water year type during May through September (Table 11-mult-51). Total degree-days exceeding 56°F under A3_LLT would be 16% and 11% lower to those under NAA during May and June, respectively, and 15% to 20% higher July through September. Most of the increases during July and September under A3_LLT would occur in wetter water years. During September, the total degree-days of 2,459 would correspond to one degree increase in temperature every day over the 82 year CALSIM period. These results indicate that there is a small to moderate effect of Alternative 3 on temperatures in the Sacramento River.

Table 11-mult-50. Differences between Baseline and Alternative 3 Scenarios in Total Degree-Days (°F-Days) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Sacramento River at Bend Bridge, May through September

Month	Water Year Type	EXISTING CONDITIONS vs. A3_LLT	NAA vs. A3_LLT
May	Wet	965 (256%)	-237 (-15%)
	Above Normal	232 (109%)	-123 (-22%)
	Below Normal	412 (188%)	-51 (-7%)
	Dry	182 (98%)	-232 (-39%)
	Critical	402 (182%)	-8 (-1%)
	All	2,193 (180%)	-651 (-16%)
June	Wet	361 (94%)	-350 (-32%)
	Above Normal	107 (72%)	-122 (-32%)
	Below Normal	389 (280%)	37 (8%)
	Dry	578 (307%)	44 (6%)
	Critical	548 (137%)	-2 (0%)
	All	1,983 (157%)	-393 (-11%)
July	Wet	750 (145%)	144 (13%)
	Above Normal	372 (459%)	102 (29%)
	Below Normal	809 (550%)	353 (59%)
	Dry	1,328 (471%)	400 (33%)
	Critical	1,846 (224%)	60 (2.3%)
	All	5,104 (276%)	1,058 (18%)
August	Wet	2,207 (317%)	244 (9%)
	Above Normal	917 (225%)	258 (24%)
	Below Normal	1,420 (536%)	385 (30%)
	Dry	2,220 (331%)	610 (27%)
	Critical	2,782 (187%)	163 (4%)
	All	9,546 (271%)	1,659 (15%)
September	Wet	2,367 (321%)	1,658 (115%)
	Above Normal	947 (133%)	547 (49%)
	Below Normal	1,437 (193%)	291 (15%)
	Dry	2,581 (202%)	-15 (0%)
	Critical	1,867 (90%)	-24 (-1%)
	All	9,204 (166%)	2,459 (20%)

The Reclamation egg mortality model predicts that winter-run Chinook salmon egg mortality in the Sacramento River under A3_LLT would be similar to mortality under NAA in wet and critical years (<5% difference). Egg mortality under A3_LLT would be 12% to 97% greater than mortality under NAA in above normal, below normal, and dry water years, although these increases represent a 0.3 to 2% absolute scale change in the winter-run Chinook salmon population (Table 11-mult-51). Therefore, this effect is considered negligible to the winter-run population.

Table 11-mult-51. Difference and Percent Difference in Percent Mortality of Winter-Run Chinook Salmon Eggs in the Sacramento River (Egg Mortality Model)

Water Year Type	EXISTING CONDITIONS vs. A3_LLT	NAA vs. A3_LLT
Wet	1 (270%)	-0.03 (-2%)
Above Normal	2 (413%)	0.3 (13%)
Below Normal	3 (267%)	2 (97%)
Dry	7 (440%)	1 (12%)
Critical	43 (159%)	-1 (-2%)
All	9 (190%)	0.3 (2%)

SacEFT predicts that there would be a 22% decrease in the percentage of years with good spawning availability, measured as weighted usable area, under A3_LLT relative to NAA (Table 11-mult-52). This reduction would be 7% on an absolute scale and, therefore, is considered a small effect. SacEFT predicts that the percentage of years with good (lower) redd scour risk under A3_LLT would be identical to the percentage of years under NAA. SacEFT predicts that the percentage of years with good egg incubation conditions under A3_LLT would be similar to (<5% difference) that under NAA. SacEFT predicts that the percentage of years with good (lower) redd dewatering risk under A3_LLT would be 10% lower than risk under NAA, which is negligible (3%) on an absolute scale.

The biological significance of a reduction in available suitable spawning habitat varies at the population level in response to a number of factors, including adult escapement. For those years when adult escapement is less than the carrying capacity of the spawning habitat, a reduction in area would have little or no population level effect. In years when escapement exceeds carrying capacity of the reduced habitat, competition among spawners for space (e.g., increased redd superimposition) would increase, resulting in reduced reproductive success. The reduction in the frequency of years in which spawning habitat availability is considered to be good by SacEFT could result in reduced reproductive success and abundance of winter-run Chinook salmon if the number of spawners is limited by spawning habitat quantity

Table 11-mult-52. Difference and Percent Difference in Percentage of Years with "Good" Conditions for Winter-Run Chinook Salmon Habitat Metrics in the Upper Sacramento River (from SacEFT)

Metric	EXISTING CONDITIONS vs. A3_LLT	NAA vs. A3_LLT
Spawning WUA	-33 (-57%)	-7 (-22%)
Redd Scour Risk	0 (0%)	0 (0%)
Egg Incubation	-25 (-26%)	-2 (-3%)
Redd Dewatering Risk	1 (4%)	-3 (-10%)
Juvenile Rearing WUA	-10 (-20%)	15 (60%)
Juvenile Stranding Risk	-14 (-70%)	-25 (-81%)

WUA = Weighted Usable Area.

NEPA Effects: Considering the range of results presented here for winter-run Chinook salmon spawning and egg incubation, this effect would be adverse because it has the potential to substantially reduce suitable spawning habitat and substantially reduce the number of fish. Flows during August and September under Alternative 3 would be up to 45% lower than flows under the NEPA baseline. End of May storage would be slightly reduced in below normal and dry water years resulting in some flow reductions during August and September. The total number of degree-days exceeding 56°F would be higher under Alternative 3 relative to the NEPA point of comparison during July through September. This effect is a result of the specific reservoir operations and resulting flows associated with this alternative. Applying mitigation (e.g., changing reservoir operations in order to alter the flows) to the extent necessary to reduce this effect to a level that is not adverse would fundamentally change the alternative, thereby making it a different alternative than that which has been modeled and analyzed. As a result, this would be an unavoidable adverse effect because there is no feasible mitigation available. Even so, proposed mitigation (Mitigation Measure AQUA-40a through AQUA-40c) has the potential to reduce the severity of impact, although not necessarily to a not adverse level.

CEQA Conclusion: In general, Alternative 3 would degrade spawning and egg incubation habitat for winter-run Chinook salmon relative to the Existing Conditions.

CALSIM flows in the Sacramento River between Keswick and upstream of Red Bluff were examined during the May through September winter-run spawning and egg incubation period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT during May through July would generally be similar to or greater than flows under Existing Conditions, except in wet years during May (14% to 18% lower depending on location) and in dry and critical years during July (6% to 11% lower depending on month and location) and August (21% to 25% lower depending on location). Flows under A3_LLT during August and September would generally be lower than flows under Existing Conditions by up to 27% depending on month, water year type, and location.

Shasta Reservoir storage volume at the end of May under A3_LLT would be similar to Existing Conditions in wet and above normal water years, but lower by 13% to 24% in below normal, dry, and critical water years (Table 11-mult-46). This indicates that there would be a small to moderate effect of Alternative 3 on flows during the spawning and egg incubation period.

Water temperatures in the Sacramento River under Alternative 3 would be the same as those under Alternative 1A, Impact AQUA-40, which indicates that there would be increased exceedances of NMFS temperature thresholds in the Sacramento River relative to Existing Conditions.

The Reclamation egg mortality model predicts that winter-run Chinook salmon egg mortality in the Sacramento River under A3_LLT would be 159% to 440% greater than mortality under Existing Conditions depending on water year type (Table 11-mult-51). These increases would only affect the winter-run population during dry and critical years, in which the absolute percent increase of the winter-run population would be 7% and 43%, respectively. These results indicate that Alternative 3 would cause substantially increased winter-run Chinook salmon mortality in drier years in the Sacramento River.

SacEFT predicts that there would be a 57% decrease in the percentage of years with good spawning availability, measured as weighted usable area, under A3_LLT relative to Existing Conditions (Table 11-mult-52). SacEFT predicts that the percentage of years with good (lower) redd scour risk under A3_LLT would be identical to the percentage of years under Existing Conditions. SacEFT predicts that the percentage of years with good egg incubation conditions under A3_LLT would be 26% lower than under Existing Conditions. SacEFT predicts that the percentage of years with good (lower) redd dewatering risk under A3_LLT would be similar (<5% difference) to the percentage of years under Existing Conditions. These results indicate that Alternative 3 would cause moderate to substantial reductions in spawning WUA and egg incubation conditions.

Summary of CEQA Conclusion

Collectively, the model results of the Impact AQUA-40 CEQA analysis indicate that the difference between the CEQA baseline and Alternative 3 is significant Flows and water temperature conditions would be degraded in the Sacramento River under Alternative 3 relative to Existing Conditions. Egg mortality in drier years, during which winter-run Chinook salmon would already be stressed due to reduced flows and increased temperatures, would be up to 43% greater (on an absolute scale) due to Alternative 3 compared to the Existing Conditions (Table 11-mult-51). Further, the extent of spawning habitat would be 33% lower (absolute scale) and egg incubation would be reduced by 25% (absolute scale) under Alternative 3 compared to the Existing Conditions (Table 11-mult-52), which represent a substantial reductions spawning and egg incubation conditions for winter-run Chinook salmon.

This impact is a result of the specific reservoir operations and resulting flows associated with this alternative. Applying mitigation (e.g., changing reservoir operations in order to alter the flows) to the extent necessary to reduce this impact to a less-than-significant level would fundamentally change the alternative, thereby making it a different alternative than that which has been modeled and analyzed. As a result, this impact is significant and unavoidable because there is no feasible mitigation available. Even so, proposed below is mitigation that has the potential to reduce the severity of impact though not necessarily to a less-than-significant level.

Mitigation Measure AQUA-40a: Following Initial Operations of CM1, Conduct Additional Evaluation and Modeling of Impacts to Winter-Run Chinook Salmon to Determine Feasibility of Mitigation to Reduce Impacts to Spawning Habitat

Although analysis conducted as part of the EIR/EIS determined that Alternative 3 would have significant and unavoidable adverse effects on spawning habitat, this conclusion was based on the best available scientific information at the time and may prove to have been overstated.

Upon the commencement of operations of CM1 and continuing through the life of the permit, the BDCP proponents will monitor effects on spawning habitat in order to determine whether such effects would be as extensive as concluded at the time of preparation of this document and to determine any potentially feasible means of reducing the severity of such effects. This mitigation measure requires a series of actions to accomplish these purposes, consistent with the operational framework for Alternative 3.

The development and implementation of any mitigation actions shall be focused on those incremental effects attributable to implementation of Alternative 3 operations only. Development of mitigation actions for the incremental impact on spawning habitat attributable to climate change/sea level rise are not required because these changed conditions would occur with or without implementation of Alternative 3.

Mitigation Measure AQUA-40b: Conduct Additional Evaluation and Modeling of Impacts on Winter-Run Chinook Salmon Spawning Habitat Following Initial Operations of CM1

Following commencement of initial operations of CM1 and continuing through the life of the permit, the BDCP proponents will conduct additional evaluations to define the extent to which modified operations could reduce impacts to spawning habitat under Alternative 3. The analysis required under this measure may be conducted as a part of the Adaptive Management and Monitoring Program required by the BDCP (Chapter 3 of the BDCP, Section 3.6).

Mitigation Measure AQUA-40c: Consult with NMFS, USFWS, and CDFW to Identify and Implement Potentially Feasible Means to Minimize Effects on Winter-Run Chinook Salmon Spawning Habitat Consistent with CM1

In order to determine the feasibility of reducing the effects of CM1 operations on winter-run Chinook salmon habitat, the BDCP proponents will consult with NMFS, USFWS and CDFW to identify and implement any feasible operational means to minimize effects on spawning habitat. Any such action will be developed in conjunction with the ongoing monitoring and evaluation of habitat conditions required by Mitigation Measure AQUA-40a.

If feasible means are identified to reduce impacts on spawning habitat consistent with the overall operational framework of Alternative 3 without causing new significant adverse impacts on other covered species, such means shall be implemented. If sufficient operational flexibility to reduce effects on winter-run Chinook salmon habitat is not feasible under Alternative 2A operations, achieving further impact reduction pursuant to this mitigation measure would not be feasible under this Alternative, and the impact on winter-run Chinook salmon would remain significant and unavoidable.

Impact AQUA-42: Effects of Water Operations on Migration Conditions for Chinook Salmon (Winter-Run ESU)

Alternatives 4, 5 and 7 (not adverse)

Alternative 4

The effects of Alternative 4 on winter-run Chinook salmon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

H3/ESO

Flows in the Sacramento River upstream of Red Bluff were examined for the July through November juvenile emigration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). A reduction in flow may reduce the ability of juvenile winter-run to migrate effectively through the Sacramento River. Flows under H3 would be 5% to 18% lower than under NAA during November and generally similar to NAA during the rest of the juvenile winter-run Chinook salmon migration period (July through October).

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the July through November winter-run juvenile emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period at either location.

Flows in the Sacramento River upstream of Red Bluff during the adult winter-run Chinook salmon upstream migration period (December through August) under H3 would generally be similar to those under NAA, except during May and June in which flows would be up to 12% greater than flows under NAA.

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the December through August winter-run upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period at either location.

H1/LOS

Flows in the Sacramento River upstream of Red Bluff during the July through November juvenile emigration period under H1 would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*) with some exceptions. Flow reductions during these months would occur primarily during wetter water years when flow reductions are less critical to emigrating juveniles due to already high flows and, therefore, would not cause biologically meaningful effects.

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the July through November winter-run juvenile emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period at either location.

Flows in the Sacramento River upstream of Red Bluff during the adult winter-run Chinook salmon upstream migration period (December through August) would generally be similar to or greater than flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the December through August winter-run upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in* *the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period at either location.

H4/HOS

Flows in the Sacramento River upstream of Red Bluff during the July through November juvenile emigration period under H4 would generally be similar to or greater than flows under NAA, except in November (11% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). These flow reductions and increases would not be of sufficient frequency or magnitude to cause biologically meaningful effects on migrating juveniles.

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the July through November winter-run juvenile emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period at either location.

Flows in the Sacramento River upstream of Red Bluff during the adult winter-run Chinook salmon upstream migration period (December through August) would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the December through August winter-run upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period at either location.

Through-Delta

H3/ESO

Juveniles

Plan Area flows have considerable importance for downstream migrating juvenile salmonids (primarily for those remaining in the Sacramento River as opposed to entering the Yolo Bypass at Fremont Weir) and would be affected by the north Delta diversions, as discussed above for winter-run Chinook above (Impact AQUA-42 for Alternative 1A). Average monthly Sacramento River flows below the NDD under H3 for juvenile winter-run migrants (November through May) would be reduced 11% to 23% compared to NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Note that *CM1 Water Facilities and Operation* includes bypass flow criteria that will be managed in real time to minimize adverse effects of diversions at the north Delta intakes on downstream-migrating salmonids. As noted for Alternative 1A, juvenile salmonids migrating down the Sacramento River often do so in pulses that are triggered by increases in flows. CM1 will account for such changes in flows and the associated pulses of fish by monitoring fish presence at locations such as Knights Landing and adjusting to low-level pumping as necessary. Low-level pumping will consist of total north Delta diversions of up to 6% of river flow for flows greater than 5,000 cfs and not more than 300 cfs at any intake. Following the initial pulse flows, schedules of post-pulse flows will be applied depending on flows in the river at the time. Additional detail is provided in Chapter 3 Section 3.6.4.2.

Potential predation effects at the north Delta intakes for juvenile salmonids remaining in the Sacramento River (as opposed to entering the Yolo Bypass) could occur if predatory fish aggregated along the screens as has been observed at other long screens in the Central Valley (Vogel 2008). Baseline levels of predation are uncertain, however. Analysis by a bioenergetics model (Appendix 5.F, *Biological Stressors on Covered Fish,* Section 5.F.3.2.1) suggests that considerably less than 0.3% of winter-run juveniles could be preyed upon (Table 11-mult-53). Using another scenario of predation that assumes a 5% loss per intake (based on GCID losses, Vogel 2008) would yield a cumulative loss of about 12% of the annual production that reaches the north Delta. The three intake structures would also permanently displace approximately 12.3 acres of in-water habitat and 6,360 linear feet of shoreline along the migration route. However, there are appreciable uncertainties in these analyses, including unknown baseline levels of predation, uncertainty in the bioenergetics model parameters, and the comparability of the GCID intakes for estimating loss rates. This is discussed in detail in Alternative 1A.

Table 11-mult-53. Winter-Run Chinook Salmon Predation Loss at the Proposed North Delta Diversion Intakes (Three Intakes for Alternative 4)

Striped Bass at NDD (Three Intakes)			Winter-Run Chinook Consumed	
Density Assumption	Bass per 1,000 Feet of Intake	Total Number of Bass	Number	Percentage of Annual Juvenile Production
Low	18	86	648	0.02%
Median	119	571	4,283	0.16%
High	219	1,051	7,881	0.30%

Note: Based on bioenergetics modeling of Chinook salmon consumption by striped bass (Appendix 5F Biological Stressors).

Through-Delta survival by juvenile winter-run Chinook salmon, as estimated by the Delta Passage Model under Scenario H3, averaged 33.2% across all years, 26% in drier years, and up to 45.3% in wetter years (for further details, refer to *BDCP Appendix 5.C, Section 5C.5.3.1.3.1*). Average juvenile survival under H3 was similar or slightly lower than NAA (1% less, a 3% relative decrease) (Table 11-mult-54).

Table 11-mult-54. Through-Delta Survival (%) of Emigrating Juvenile Winter-Run Chinook Salmon under Alternative 4 (Scenarios H3, H1, and H4)

	Average Percentage Survival					Difference in Percentage Survival (Relative Difference)					
	SCENARIO					EXISTING CONDITIONS vs. Alt 4 Scenario			NAA vs. Alt 4 Scenario		
Water Year Type	EXISTING CONDITIONS	NAA	H3	H1	H4	H3	H1	H4	H3	H1	H4
Wetter Years	46.3	46.1	45.3	45.2	46.0	-1.1 (-2%)	-1.1 (-2%)	-0.3 (-1%)	-0.8 (-2%)	-0.9 (-2%)	-0.1 (0%)
Drier Years	28.0	27.1	26.0	26.1	25.7	-2.0 (-7%)	-1.9 (-7%)	-2.3 (-8%)	-1.1 (-4%)	-1.0 (-4%)	-1.4 (-5%)
All Years	34.9	34.2	33.2	33.3	33.3	-1.6 (-5%)	-1.6 (-5%)	-1.6 (-5%)	-1.0 (-3%)	-0.9 (-3%)	-0.9 (-3%)

Note: Average Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and Above Normal Water Years (6 years).
Drier = Below Normal, Dry and Critical Water Years (10 years).
H3 = ESO operations, H1 = Low Outflow, H4 = High Outflow.

Adults

Adult salmonids migrating through the delta use flow and olfactory cues for navigation to their natal streams (Marston et al. 2012), as discussed above for winter-run Chinook (Impact AQUA-42 for Alternative 1A). The importance of flow changes to currently affect these cues is rated as low but with low certainty. Attraction flows and olfactory cues in the west Delta would be altered because of shifts in exports from the south Delta to the north Delta. Flows in the Sacramento River downstream of the north Delta intake diversions would be reduced, with concomitant proportional increases in San Joaquin River flow, with differences between water-year types because of differences in the relative proportion of water being exported from the north Delta and south Delta facilities (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis)*.

These changes may slightly decrease the Sacramento River olfactory cues used by migrating adults, although the changes are within the dilution factor and the behavioral response is uncertain. Fingerprint analyses determined that attraction flow, as estimated by the percentage of Sacramento River water at Collinsville, declined from NAA to Scenario H3 operations by up to 4% during the peak migration period for winter-run adults (December through February) (Table 11-mult-55). The flow changes under Scenario H3 would slightly decrease the olfactory cues for migrating adult salmon in the Sacramento River (by 9% or less compared to NAA). Nevertheless, the Sacramento River would still represent a substantial proportion of Delta outflows. Under Scenario H4, the difference would be less due to increased spring outflows in March, April, and May. Scenario H1 results would be similar to Scenario H3. Overall, the reductions in olfactory cues resulting from all scenarios would be less than the magnitude of change in dilution (20% or more) reported to cause a significant change in migration by Fretwell (1989) and, therefore, are not expected to affect adult Chinook salmon migration. However, uncertainty remains with regard to adult salmon behavioral response to anticipated changes in lower Sacramento River flow percentages. This topic is discussed further in Impact AQUA-42 for Alternative 1A.

Table 11-mult-55. Percentage (%) of Water at Collinsville that Originated in the Sacramento River during the Adult Winter-Run Chinook Salmon Migration Period for Alternative 4 (Scenario H3)

Month	EXISTING CONDITIONS	NAA	H3	EXISTING CONDITIONS vs. H3	NAA vs. H3
December	67	66	66	-1	0
January	76	75	73	-3	-2
February	75	72	68	-7	-4
March	78	76	68	-10	-8
April	77	75	66	-11	-9
May	69	65	59	-10	-6
June	64	62	58	-6	-4
July	64	65	56	-8	-9

▨ Shading indicates 10% or greater difference.

H1/LOS

Juveniles

Plan Area flows have considerable importance for downstream migrating juvenile salmonids and would be affected by the north Delta diversions, as discussed above for winter-run Chinook above (Impact AQUA-42 for Alternative 1A). Under H1, Sacramento River flows below the NDD during the juvenile winter-run migration period (November-May) would be reduced compared to NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Note that *CM1 Water Facilities and Operation* includes bypass flow criteria that will be managed in real time to minimize adverse effects of diversions at the north Delta intakes on downstream-migrating salmonids.

Through-Delta survival by juvenile winter-run Chinook salmon under Scenario H1 averaged 33.3% across all years, 26.1% in drier years, and up to 45.2% in wetter years (for further details, refer to *BDCP Appendix 5.C, Section 5C.5.3.1.3.1*). Average survival under Scenario H1 was generally similar to NAA (Table 11-mult-54).

Overall, the similarity in through-Delta survival for these scenarios is explained by the relatively low overlap of the winter-run Delta entry distribution with the spring period that has differing outflows for the Alternative 4 operations scenarios. In addition, the DPM has less representation of intermediate-outflow years where the differences among the Alternative 4 operations scenarios are more pronounced than wetter or drier years.

Adults

Results for H1 regarding attraction flows and olfactory cues are the same as those presented as part of the corresponding discussion under H3 (above).

H4/HOS

Juveniles

Plan Area flows have considerable importance for downstream migrating juvenile salmonids and would be affected by the north Delta diversions, as discussed above for winter-run Chinook above (Impact AQUA-42 for Alternative 1A). Under H4, Sacramento River flows below the NDD during the juvenile winter-run migration period (November–May) would be reduced 5% to 23% compared to NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Note that *CM1 Water Facilities and Operation* includes bypass flow criteria that will be managed in real time to minimize adverse effects of diversions at the north Delta intakes on downstream-migrating salmonids.

Through-Delta survival by juvenile winter-run Chinook salmon under Scenario H4 averaged 33.3% across all years, 25.7% in drier years, and up to 46% in wetter years (for further details, refer to *BDCP Appendix 5.C, Section 5C.5.3.1.3.1*). Average survival under Scenario H4 was generally similar to NAA, with slightly lower survival for H4 in wetter years (0.9% less, a 3% relative decrease) (Table 11-mult-54).

Overall, the similarity in through-Delta survival for these scenarios is explained by the relatively low overlap of the winter-run Delta entry distribution with the spring period that has differing outflows for the Alternative 4 operations scenarios. In addition, the DPM has less representation of intermediate-outflow years where the differences among the Alternative 4 operations scenarios are more pronounced than wetter or drier years.

Adults

Results for H4 regarding attraction flows and olfactory cues are the same as those presented as part of the corresponding discussion under H3 (above).

NEPA Effects: Collectively, these results indicate that Alternative 4 operations would not adversely affect upstream or through-Delta migration conditions for winter-run Chinook salmon.

Due to mostly similar migration flows and water temperatures between Alternative 4 and the NAA, upstream habitat and movement conditions are not substantially reduced for juvenile or adult winter-run Chinook salmon.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 4 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 4.

Near-field effects of Alternative 4 NDD on winter-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating winter-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 3 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 12% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the three new intake structures will be implemented as part of the final NDD screen design effort. Alternative 4 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for winter-run Chinook salmon. This includes biologically-based triggers to adjust the amount of pumping at the NDD in response to likely fish presence.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 4 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 4 would be similar to or slightly lower than survival estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for Chinook salmon.

Alternative 5

The effects of Alternative 5 on winter-run Chinook salmon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Flows in the Sacramento River upstream of Red Bluff were examined for the July through November juvenile emigration period. A reduction in flow may reduce the ability of juvenile winter-run Chinook salmon to migrate effectively down the Sacramento River. Flows under A5_LLT would up to 17% lower than under NAA during November depending on water year type (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). However, except for very few water year types each month, flows under A5_LLT would be similar to or greater than flows under NAA during the rest of the juvenile winter-run Chinook salmon migration period (July through October).

Flows in the Sacramento River upstream of Red Bluff were examined during the adult winter-run Chinook salmon upstream migration period (December through August). A reduction in flows may reduce the olfactory cues needed by adult winter-run to return to natal spawning grounds in the upper Sacramento River. Flows under A5_LLT would generally be similar to or greater than those under NAA except in dry water years during January (5% lower) and August (14% lower).

Water temperatures in the Sacramento River under Alternative 5 would be the same as those under Alternative 1A, Impact AQUA-42 which indicates there would be no differences in water temperatures between NAA and Alternative 1A.

Overall, upstream conditions during winter-run Chinook salmon migration under Alternative would be similar to those under NAA.

Through-Delta

Juveniles

During the juvenile winter-run Chinook salmon emigration period (November to early May), mean monthly flows in the Sacramento River below the north Delta intake under Alternative 5 averaged across years would be lower (up to 17% lower) compared to NAA. Flows would be up to 23% lower in November of above normal years.

The north Delta export facilities would replace aquatic habitat and likely attract piscivorous fish around the intake structures. The single new intake would remove or modify habitat along that portion of the migration corridor (3.8 acres aquatic habitat and 2,050 linear feet of shoreline). Bioenergetics modeling of a single intake with a median predator density predicts a predation loss of about 0.3% of the juvenile winter-run juvenile population (Table 11-mult-56). A conservative assumption of 5% loss per intake would result in a loss of 4% of juvenile winter-run Chinook that reach the north Delta.

Table 11-mult-56. Chinook Salmon Predation Loss at the Proposed North Delta Diversion Intake (One Intake)

Striped Bass Numbers		Estimated Number of Juvenile Salmon Consumed				Percentage of Annual Juvenile Production (%) Consumed			
Per 1,000 Feet of Intake	Total	Winter	Spring	Fall	Late Fall	Winter	Spring	Fall	Late Fall
18 (Low)	20	1,005	1,407	21,571	4,082	0.04	0.03	0.04	0.09
119 (Median)	131	6,647	9,301	142,610	26,983	0.26	0.22	0.23	0.63
219 (High)	241	12,233	17,117	262,451	49,658	0.47	0.41	0.43	1.15

Through-Delta survival to Chipps Island by emigrating juvenile winter-run Chinook salmon was modeled by the DPM. Average survival under Alternative 5 would be 34% across all years, 27% in drier years, and 45% in wetter years, which is similar to survival under baseline conditions (Table 11-mult-57).

Table 11-mult-57. Through-Delta Survival (%) of Emigrating Juvenile Winter-Run Chinook Salmon under Alternative 5

	Percentage Survival			Difference in Percentage Survival (Relative Difference)	
Year Types	EXISTING CONDITIONS	NAA	A5_LLT	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Wetter Years	46.3	46.1	45.3	-1.0 (-2%)	-0.8 (-2%)
Drier Years	28.0	27.1	26.7	-1.3 (-5%)	-0.4 (-2%)
All Years	34.9	34.2	33.7	-1.2 (-3%)	-0.6 (-2%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and above normal water years (6 years).
Drier = Below normal, dry and critical water years (10 years).

Adults

The importance of attraction flows and olfactory cues to adult Chinook salmon migrating upstream through the Delta is described in detail in Impact AQUA-42 for Alternative 1A. During the adult winter-run Chinook salmon migration period in the Delta (December to February), olfactory cues, based on the proportion of Sacramento River flows, would be similar (<7% difference) compared to NAA (Table 11-mult-58).

Table 11-mult-58. Percentage (%) of Water at Collinsville that Originated in the Sacramento River and San Joaquin River during the Adult Chinook Migration Period for Alternative 5

Month	EXISTING CONDITIONS	NAA	A5_LLT	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Sacramento River					
September	60	65	67	7	2
October	60	68	66	6	-2
November	60	66	65	5	-1
December	67	66	72	5	6
January	76	75	70	-6	-5
February	75	72	71	-4	-1
March	78	76	70	-8	-6
April	77	75	62	-15	-13
May	69	65	59	-10	-6
San Joaquin River					
September	0.3	0.1	0.5	0.2	0.4
October	0.2	0.3	1.3	1.1	1.0
November	0.4	1.0	2.4	2.0	1.4
December	0.9	1.0	1.9	1.0	0.9
January	1.6	1.7	2.0	0.4	0.3
February	1.4	1.5	1.7	0.3	0.2
March	2.6	2.8	3.0	0.4	0.2
April	6.3	6.6	6.8	0.5	0.2

▨ Shading indicates 10% or greater absolute difference.

Source: DSM2-QUAL fingerprinting analysis (monthly time step, October 1976-September 1991). *BDCP Effects Analysis – Appendix 5.C, Section 5C.5.3. Passage, Movement, and Migration Results.*

NEPA Effects: Collectively, these results indicate that Alternative 5 operations would not adversely affect upstream or through-Delta migration conditions for winter-run Chinook salmon.

Upstream flows and water temperatures would generally be similar between Alternative 5 and NAA during the juvenile and adult migration periods. Although some small to moderate reductions in upstream flows would occur in November (up to 17% lower), there are generally no effects of Alternative 5 on flows or temperatures in the Sacramento River.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 5 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 5.

Near-field effects of Alternative 5 NDD on winter-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating winter-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 1 new intake would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to larger effects (~ 4% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the 1 new intake structure will be implemented as part of the final NDD screen design effort. Alternative 5 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for winter-run Chinook salmon. This includes biologically-based triggers to adjust the amount of pumping at the NDD in response to likely fish presence.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 5 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 5 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for Chinook salmon.

Alternative 7

The effects of Alternative 7 winter-run Chinook salmon migration conditions relative to NAA are not adverse.

Upstream of the Delta

Flows in the Sacramento River upstream of Red Bluff were examined for the July through November juvenile emigration period. A reduction in flow may reduce the ability of juvenile winter-run

Chinook salmon to migrate effectively down the Sacramento River. Flows under A7_LLT would be up to 14% lower than under NAA during November depending on water year type (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). However, flows under A7_LLT would generally be similar to flows under NAA during the rest of the juvenile winter-run Chinook salmon migration period (July through October).

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the July through November winter-run juvenile emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period at either location.

Flows in the Sacramento River upstream of Red Bluff were examined during the adult winter-run Chinook salmon upstream migration period (December through August). A reduction in flows may reduce the olfactory cues needed by adult winter-run Chinook salmon to return to natal spawning grounds in the upper Sacramento River. Flows under A7_LLT would generally be similar to or greater than those under NAA with few exceptions.

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the December through August winter-run upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period at either location.

These results indicate that, overall, there would be no effect of Alternative 7 to migration conditions in the Sacramento River upstream of the Delta.

Through-Delta

The effects on through-Delta migration were evaluated using the approach described in Alternative 1A, Impact AQUA-42.

Juveniles

Juvenile salmonids migrating down the Sacramento River would generally experience lower flows (up to 25% lower averaged over all water year types) below the north Delta intakes compared to baseline. Predation at the north Delta would be increased at the three new intake structures. The north Delta export facilities would replace aquatic habitat and likely attract piscivorous fish around the intake structures. The predation effects would be the same as those described for Alternative 4, which also has three proposed intakes. Three NDD intakes would remove or modify habitat along that portion of the migration corridor (22 acres aquatic habitat and 11,900 linear feet of shoreline). Potential predation losses at the north Delta intakes, as estimated by the bioenergetics model, would be less than 2% compared to the annual production estimated for the Sacramento Valley (Table 11-4-11). A conservative assumption of 5% loss per intake would yield a cumulative loss of 11.6% of juvenile winter-run Chinook that reach the north Delta. This assumption is uncertain and represents an upper bound estimate. For further discussion of this topic see Impact AQUA-42 for Alternative 1A.

Table 11-4-11. Winter-Run Chinook Salmon Predation Loss at the Proposed North Delta Diversion (NDD) Intakes (Three Intakes for Alternative 4)

Striped Bass at NDD (Three Intakes)			Winter-Run Chinook Consumed	
Density Assumption	Bass per 1,000 Feet of Intake	Total Number of Bass	Number	Percentage of Annual Juvenile Production
Low	18	86	648	0.02%
Median	119	571	4,283	0.16%
High	219	1,051	7,881	0.30%

Note: Based on bioenergetics modeling of Chinook salmon consumption by striped bass (Appendix 5F Biological Stressors).

Through-Delta survival by emigrating juvenile winter-run Chinook salmon under Alternative 7 (A7_LLT) would average 33% across all years, ranging from 26% in drier years to 45% in wetter years. Under Alternative 7, juvenile survival would increase slightly in wetter years (1% greater survival, or 2% more in relative percentage) compared to NAA (Table 11-mult-59).

Table 11-mult-59. Through-Delta Survival (%) of Emigrating Juvenile Winter-Run Chinook Salmon under Alternative 7

	Percentage Survival			Difference in Percentage Survival (Relative Difference)	
Month	EXISTING CONDITIONS	NAA	A7_LLT	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wetter Years	46.3	46.1	45.1	-1.2 (-3%)	-1.0 (-2%)
Drier Years	28.0	27.1	26.3	-1.7 (-6%)	-0.9 (-3%)
All Years	34.9	34.2	33.3	-1.6 (-4%)	-0.9 (-3%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and Above Normal WYs (6 years).
Drier = Below Normal, Dry and Critical WYs (10 years).

Adults

Attraction flow, as estimated by the percentage of Sacramento River water at Collinsville, decreased under Alternative 7A by no more than 10% during the December through June migration period for winter-run adults (Table 11-mult-60). The proportion of Sacramento River flows in the Delta would represent 56-73% of Delta outflows, and would thus still provide strong olfactory cues. This topic is discussed in further detail in Impact AQUA-42 for Alternative 1A. Therefore, it is expected that olfactory cues for adult winter-run Chinook salmon from the Sacramento River would be adequate and not substantially affected by flow operations under Alternative 7.

Table 11-mult-60. Percentage (%) of Water at Collinsville that Originated in the Sacramento River and San Joaquin River during the Adult Chinook Salmon Migration Period for Alternative 7

Month	EXISTING CONDITIONS	NAA	A7_LLT	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Sacramento River					
September	60	65	78	18	13
October	60	68	67	7	-1
November	60	66	62	2	-4
December	67	66	65	-2	-1
January	76	75	73	-3	-2
February	75	72	67	-8	-5
March	78	76	67	-11	-9
April	77	75	65	-12	-10
May	69	65	59	-10	-6
June	64	62	56	-8	-6
San Joaquin River					
September	0.3	0.1	1.1	0.8	1.0
October	0.2	0.3	4.5	4.3	4.2
November	0.4	1.0	7.9	7.5	6.9
December	0.9	1.0	6.2	5.3	5.2

▨ Shading indicates a difference of 10% or greater in flow proportion.

NEPA Effects: Collectively, these results indicate that Alternative 7 operations would not adversely affect upstream or through-Delta migration conditions for winter-run Chinook salmon.

Upstream flows and water temperatures would generally be similar between Alternative 7 and NAA during the juvenile and adult migration periods. Although some small to moderate reductions in upstream flows would occur in November (up to 14% lower), there are generally no effects of Alternative 7 on flows or temperatures in the Sacramento River.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 7 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 7.

Near-field effects of Alternative 7 NDD on winter-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating winter-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 3 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 12% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the three new intake structures will be implemented as part of the final NDD screen design effort. Alternative 7 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for winter-run Chinook. salmon. This includes biologically-based triggers to adjust the amount of pumping at the NDD in response to likely fish presence.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 7 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry(from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 7 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of, the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for Chinook salmon.

Impact AQUA-58: Effects of Water Operations on Spawning and Egg Incubation Habitat for Chinook Salmon (Spring-Run ESU)

Alternatives 2A, 4, 5 and 7 (not adverse)

Alternative 2A

In general, the effects of Alternative 2A on spawning and egg incubation habitat for spring-run Chinook salmon relative to NAA are not adverse.

Sacramento River

Flows in the Sacramento River upstream of Red Bluff during the spring-run Chinook salmon spawning and incubation period (September through January) under A2A_LLT would be greater than, similar to, and lower than those under NAA depending on month and water year type (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A2A_LLT during December and January would be greater than or similar to those under NAA regardless of water year type. Flows during September would be up to 17% greater than or similar to those under NAA in wet, dry, and critical years, up to 15% lower in above normal and below normal years, but similar when all years are combined. Flows during October would not be different from those under NAA in all water years except below normal years, when flows are 6% lower. Flows in November would be similar or lower (up to -17%) depending on water year type.

Shasta Reservoir storage volume at the end of September influences flows downstream of the dam during the spring-run spawning and egg incubation period (September through January). Storage under A2A_LLT would be similar to storage under NAA in all water year types (Table 11-mult-61).

Table 11-mult-61. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Shasta Reservoir for Model Scenarios

Water Year Type	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
Wet	-602 (-18%)	-90 (-3%)
Above Normal	-660 (-21%)	-45 (-2%)
Below Normal	-446 (-16%)	-92 (-4%)
Dry	-550 (-22%)	-39 (-2%)
Critical	-395 (-33%)	-13 (-2%)

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the September through January spring-run Chinook salmon spawning period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 2A in any month or water year type throughout the period at either location.

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September at Bend Bridge and October through April at Red Bluff) and year of the 82-year modeling period (Table 11-mult-47). The combination of number of days and degrees above the 56°F threshold were further assigned a "level of concern" as defined in Table 11-mult-48. Differences between baselines and Alternative 2A in the highest level of concern across all months and all 82 modeled years are presented in Table 11-2A-12 for Bend Bridge and in Table 11-mult-62 for Red Bluff. There would be no difference in levels of concern between NAA and Alternative 2A at Bend Bridge. At Red Bluff, there would be 1 (2%) and 4 (24%) more years with a "red" and "orange" level of concern, respectively, under Alternative 2A. There would be 5 (71%) fewer years with a "yellow" level of concern.

Table 11-2A-12. Differences between Baseline and Alternative 2A Scenarios in the Number of Years in Which Water Temperature Exceedances above 56°F Are within Each Level of Concern, Sacramento River at Bend Bridge, May through September

Level of Concern[a]	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
Red	33 (67%)	0 (0%)
Orange	-14 (-100%)	0 (NA)
Yellow	-16 (-100%)	0 (NA)
None	-3 (-100%)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] For definitions of levels of concern, see Table 11-2A-11.

Table 11-mult-62. Differences between Baseline and Alternative 2A Scenarios in the Number of Years in Which Water Temperature Exceedances above 56°F Are within Each Level of Concern, Sacramento River at Red Bluff, October through April

Level of Concern[a]	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
Red	37 (308%)	1 (2%)
Orange	11 (183%)	4 (24%)
Yellow	-6 (-46%)	-5 (-71%)
None	-42 (-82%)	0 (0%)

[a] For definitions of levels of concern, see Table 11-mult-48.

Total degree-days exceeding 56°F were summed by month and water year type at Bend Bridge during May through September and at Red Bluff during October through April. At Bend Bridge, total degree-days under Alternative 2A would be up to 12% lower than those under NAA during May and June and up to 16% higher during July through September (Table 11-2A-13). At Red Bluff, total degree-days under Alternative 2A would differ from those under NAA during October, November, and March (6%, 8%, and 9% higher, respectively), 5% lower during April, and similar during remaining months, for all years combined (Table 11-mult-63).

Table 11-2A-13. Differences between Baseline and Alternative 2A Scenarios in Total Degree-Days (°F-Days) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Sacramento River at Bend Bridge, May through September

Month	Water Year Type	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
May	Wet	987 (262%)	-215 (-14%)
	Above Normal	213 (100%)	-142 (-25%)
	Below Normal	431 (197%)	-32 (-5%)
	Dry	235 (126%)	-179 (-30%)
	Critical	477 (216%)	67 (11%)
	All	2,344 (193%)	-500 (-12%)
June	Wet	391 (102%)	-320 (-29%)
	Above Normal	48 (32%)	-181 (-48%)
	Below Normal	304 (219%)	-48 (-10%)
	Dry	554 (295%)	20 (3%)
	Critical	628 (157%)	78 (8%)
	All	1,926 (153%)	-450 (-12%)
July	Wet	757 (146%)	151 (13%)
	Above Normal	374 (462%)	104 (30%)
	Below Normal	670 (456%)	214 (35%)
	Dry	1,295 (459%)	367 (30%)
	Critical	1,873 (227%)	87 (3.3%)
	All	4,968 (268%)	922 (16%)
August	Wet	2,187 (314%)	224 (8%)
	Above Normal	901 (221%)	242 (23%)
	Below Normal	1,279 (483%)	244 (19%)
	Dry	2,098 (313%)	488 (21%)
	Critical	2,764 (186%)	145 (4%)
	All	9,229 (262%)	1,342 (12%)
September	Wet	833 (113%)	124 (9%)
	Above Normal	559 (78%)	159 (14%)
	Below Normal	1,572 (211%)	426 (23%)
	Dry	2,585 (202%)	-11 (0%)
	Critical	1,971 (95%)	80 (2%)
	All	7,523 (135%)	778 (6%)

NA = could not be calculated because the denominator was 0.

Table 11-mult-63. Differences between Baseline and Alternative 2A Scenarios in Total Degree-Days (°F-Days) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Sacramento River at Red Bluff, October through April

Month	Water Year Type	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
October	Wet	1,277 (497%)	108 (8%)
	Above Normal	526 (202%)	49 (7%)
	Below Normal	825 (395%)	119 (13%)
	Dry	1,153 (235%)	82 (5%)
	Critical	909 (152%)	-14 (-1%)
	All	4,690 (258%)	344 (6%)
November	Wet	97 (9,700%)	7 (8%)
	Above Normal	75 (NA)	14 (23%)
	Below Normal	59 (NA)	11 (23%)
	Dry	163 (2,038%)	12 (8%)
	Critical	105 (2,625%)	-5 (-4%)
	All	499 (3,838%)	39 (8%)
December	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)
January	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)
February	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)
March	Wet	9 (NA)	0 (0%)
	Above Normal	5 (NA)	1 (25%)
	Below Normal	36 (400%)	15 (50%)
	Dry	63 (450%)	-1 (-1%)
	Critical	25 (2,500%)	-2 (-7%)
	All	138 (575%)	13 (9%)
April	Wet	260 (226%)	-1 (0%)
	Above Normal	208 (149%)	-21 (-6%)
	Below Normal	228 (289%)	-2 (-1%)
	Dry	261 (140%)	-59 (-12%)
	Critical	152 (1,267%)	1 (1%)
	All	1,109 (208%)	-82 (-5%)

NA = could not be calculated because the denominator was 0.

The Reclamation egg mortality model predicts that spring-run Chinook salmon egg mortality in the Sacramento River under A2A_LLT would be similar to mortality under NAA in dry and critical years, but greater in wet (13% greater), above normal (9% greater), and below normal (28% greater) water years (Table 11-mult-64). Absolute scale increases of 3% of the spring-run population under wet and above normal water years would be negligible to the overall population. However, the 12% increase in mortality in below normal years would be a small negative effect on the spring-run population. Combining all water years, there would be no effect of Alternative 2A on egg mortality (3% absolute change).

Table 11-mult-64. Difference and Percent Difference in Percent Mortality of Spring-Run Chinook Salmon Eggs in the Sacramento River (Egg Mortality Model)

Water Year Type	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
Wet	18 (178%)	3 (13%)
Above Normal	25 (188%)	3 (9%)
Below Normal	41 (345%)	12 (28%)
Dry	56 (287%)	0 (0%)
Critical	22 (30%)	0 (0%)
All	32 (143%)	3 (7%)

SacEFT predicts that there would be a minimal (<5%) difference in the percentage of years with good spawning availability, measured as weighted useable area, between A2A_LLT and NAA (Table 11-mult-65). SacEFT predicts that there would be no difference in the percentage of years with good (lower) redd scour risk under A2A_LLT relative to NAA (Table 11-mult-65). SacEFT predicts that there would be a 26% decrease (9% decrease on absolute scale) in the percentage of years with good (lower) egg incubation conditions under A2A_LLT relative to NAA. SacEFT predicts that there would be a 6% decrease (2% decrease on absolute scale) in the percentage of years with good (lower) redd dewatering risk under A2A_LLT relative to NAA.

Table 11-mult-65. Difference and Percent Difference in Percentage of Years with "Good" Conditions for Spring-Run Chinook Salmon Habitat Metrics in the Upper Sacramento River (from SacEFT)

Metric	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
Spawning WUA	-22 (-31%)	-1 (-2%)
Redd Scour Risk	0 (0%)	0 (0%)
Egg Incubation	-61 (-71%)	-9 (-26%)
Redd Dewatering Risk	-17 (-35%)	-2 (-6%)
Juvenile Rearing WUA	1 (5%)	1 (5%)
Juvenile Stranding Risk	-8 (-42%)	-3 (-21%)

WUA = Weighted Usable Area.

There is an apparent discrepancy in results of the SacEFT model and Reclamation egg mortality model with regard to conditions for spring-run salmon eggs. SacEFT predicts that egg incubation habitat would decrease (9% absolute scale decrease) and the Reclamation egg mortality model predicts that overall egg mortality would be unaffected by Alternative 2A, except in below normal water years. The SacEFT uses mid-August through early March as the egg incubation period, based on Vogel and Marine (1991), and the reach between ACID Dam and Battle Creek for redd locations. The Reclamation egg mortality model uses the number of days after Julian week 33 (mid-August) that it takes to accumulate 750 temperature units to hatching and another 750 temperature units to emergence. Temperatures units are calculated by subtracting 32°F from daily river temperature and are computed on a daily basis. As a result, egg incubation duration is generally mid-August through January, but is dependent on river temperature. The Reclamation model uses the reach between ACID Dam and Jelly's Ferry (approximately 5 river miles downstream of Battle Creek), which includes 95% of Sacramento River spawning locations based on 2001–2004 redd survey data (Reclamation 2008). These differences in egg incubation period and location likely account for the difference between model results. Although the SacEFT model has been peer-reviewed, the Reclamation egg mortality model has been extensively reviewed and used in prior biological assessments and BiOps. Therefore, both results are considered valid and were considered in drawing conclusions about spring-run egg mortality in the Sacramento River.

Clear Creek

Flows in Clear Creek were examined during the spring-run Chinook salmon spawning and egg incubation period (September through January). Flows under A2A_LLT would be similar to or greater than flows under NAA throughout the period for all water year types (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

The potential risk of spring-run Chinook salmon redd dewatering in Clear Creek was evaluated by comparing the magnitude of flow reduction each month over the incubation period compared to the flow in September when spawning is assumed to occur. The greatest reduction in flows under A2A_LLT would be the same as that under NAA in all water year types (Table 11-mult-66).

Water temperatures were not modeled in Clear Creek.

Table 11-mult-66. Difference and Percent Difference in Greatest Monthly Reduction (Percent Change) in Instream Flow in Clear Creek below Whiskeytown Reservoir during the September through January Spawning and Egg Incubation Period[a]

Water Year Type	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
Wet	0 (NA)	0 (NA)
Above Normal	-27 (NA)	0 (0%)
Below Normal	53 (100%)	0 (NA)
Dry	-67 (NA)	0 (0%)
Critical	-33 (-50%)	0 (0%)

NA = could not be calculated because the denominator was 0.

[a] Redd dewatering risk not applicable for months when flows during the egg incubation period were at or greater than flows in September, when spawning is assumed to occur. A negative value indicates that the greatest monthly reduction would be of greater magnitude (worse) under the alternative than under the baseline.

Feather River

Flows were examined in the Feather River low-flow channel (upstream of Thermalito Afterbay) where spring-run Chinook primarily spawn during September through January (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A2A_LLT would not differ from NAA because minimum Feather River flows are included in the FERC settlement agreement and would be met for all model scenarios (California Department of Water Resources 2006).

Oroville Reservoir storage volume at the end of September influence flows downstream of the dam during the spring-run spawning and egg incubation period. Storage volume at the end of September under A2A_LLT would be similar to or up to 16% greater than storage under NAA depending on water year type (Table 11-mult-67).

Table 11-mult-67. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Oroville Reservoir for Model Scenarios

Water Year Type	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
Wet	-929 (-32%)	85 (5%)
Above Normal	-859 (-36%)	-68 (-4%)
Below Normal	-559 (-28%)	50 (4%)
Dry	-192 (-14%)	161 (16%)
Critical	-71 (-7%)	117 (15%)

The potential risk of redd dewatering in the Feather River low-flow channel was evaluated by comparing the magnitude of flow reduction each month over the egg incubation period compared to the flow in September when spawning is assumed to occur. Minimum flows in the low-flow channel during October through January were identical among A2A_LLT and NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Therefore, there would be no effect of Alternative 2A on redd dewatering in the Feather River low-flow channel.

Mean monthly water temperatures were examined in the Feather River low-flow channel (upstream of Thermalito Afterbay) during September through January (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 2A in any month or water year type throughout the period.

The percent of months exceeding the 56°F temperature threshold in the Feather River above Thermalito Afterbay (low-flow channel) was evaluated during September through January (Table 11-mult-68). The percent of months exceeding the threshold under Alternative 2A would generally be lower (up to 11% lower on an absolute scale) than the percent under NAA during September, October and November and similar during other months.

Table 11-mult-68. Differences between Baseline and Alternative 2A Scenarios in Percent of Months during the 82-Year CALSIM Modeling Period during Which Water Temperatures in the Feather River above Thermalito Afterbay Exceed the 56°F Threshold, September through January

	Degrees Above Threshold				
Month	>1.0	>2.0	>3.0	>4.0	>5.0
EXISTING CONDITIONS vs. A2A_LLT					
September	0 (0%)	0 (0%)	6 (7%)	17 (24%)	35 (85%)
October	53 (239%)	51 (683%)	48 (780%)	44 (1,800%)	31 (1,250%)
November	54 (2,200%)	47 (3,800%)	41 (3,300%)	27 (NA)	14 (NA)
December	4 (NA)	1 (NA)	0 (NA)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)
NAA vs. A2A_LLT					
September	0 (0%)	-1 (-1%)	-1 (-1%)	-6 (-6%)	-7 (-9%)
October	-11 (-13%)	-7 (-11%)	-1 (-2%)	-2 (-5%)	-6 (-16%)
November	-10 (-15%)	-11 (-19%)	-7 (-15%)	-5 (-15%)	-11 (-45%)
December	0 (0%)	0 (0%)	-1 (-100%)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

Total degree-days exceeding 56°F were summed by month and water year type above Thermalito Afterbay (low-flow channel) during September through January (Table 11-mult-69). Total degree-months would be similar between NAA and Alternative 2A during September and January, lower during October and November, and 20% higher during December.

Table 11-mult-69. Differences between Baseline and Alternative 2A Scenarios in Total Degree-Months (°F-Months) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Feather River above Thermalito Afterbay, September through January

Month	Water Year Type	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
September	Wet	29 (27%)	4 (3%)
	Above Normal	14 (33%)	4 (8%)
	Below Normal	39 (65%)	8 (9%)
	Dry	70 (101%)	-18 (-11%)
	Critical	50 (77%)	-12 (-9%)
	All	202 (59%)	-14 (-2%)
October	Wet	84 (1,680%)	-12 (-12%)
	Above Normal	31 (310%)	-4 (-9%)
	Below Normal	52 (743%)	-2 (-3%)
	Dry	83 (1,186%)	3 (3%)
	Critical	33 (413%)	-8 (-16%)
	All	282 (762%)	-24 (-7%)
November	Wet	56 (NA)	0 (0%)
	Above Normal	24 (800%)	-1 (-4%)
	Below Normal	26 (2,600%)	-8 (-23%)
	Dry	48 (NA)	-3 (-6%)
	Critical	24 (NA)	-4 (-14%)
	All	177 (4,425%)	-17 (-9%)
December	Wet	1 (NA)	0 (0%)
	Above Normal	2 (NA)	1 (100%)
	Below Normal	3 (NA)	0 (0%)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	6 (NA)	1 (20%)
January	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

NEPA Effects: There would be no effects of Alternative 2A on spawning and egg incubation conditions in Clear Creek and no or beneficial effects in the Feather River. However, available analytical tools show conflicting results regarding the temperature effects of relatively small changes in predicted summer and fall flows in the Sacramento River. Several models (CALSIM, SRWQM, and Reclamation Egg Mortality Model) generally show no change or negligible changes in upstream conditions as a result of Alternative 2A. However, one model, SacEFT, shows a 9% reduction in the percentage of years with "good" egg incubation conditions on an absolute scale. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions, which may or may not accurately predict adverse effects. Considering the lack of effects found in all other analyses for this impact, the small decrease in egg incubation conditions found by SacEFT, and the high model sensitivity of SacEFT, the weight of evidence indicates that the effects of Alternative 2A on spring-run Chinook salmon spawning and egg incubation would not be adverse.

Alternative 4

In general, the effects of Alternative 4 on spawning and egg incubation habitat for spring-run Chinook salmon relative to the NAA are not adverse.

H3/ESO

Sacramento River

There has been a small, inconsistent spawning population (<400 individuals) in the mainstem Sacramento River primarily upstream of Red Bluff Diversion Dam over the past decade (Azat 2012).

Flows in the Sacramento River between Keswick and upstream of Red Bluff were examined during the spring-run Chinook salmon spawning and incubation period (September through January) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 during all months except November would generally be similar to those under NAA with few exceptions. Flows under H3 during November would be 5% to 20% lower than flows during NAA depending on water year type and location.

Shasta Reservoir storage volume at the end of September influences flows downstream of the dam during the spring-run spawning and egg incubation period (September through January). Storage under H3 would be similar to (<5% different from) storage under NAA in all water year types (Table 11-mult-70) so there would be no biologically meaningful effects.

Table 11-mult-70. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Shasta Reservoir for Alternative 4 (Scenario H3)

Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
Wet	-605 (-18%)	-93 (-3%)
Above Normal	-677 (-21%)	-62 (-2%)
Below Normal	-443 (-15%)	-89 (-4%)
Dry	-535 (-22%)	-24 (-1%)
Critical	-392 (-33%)	-10 (-1%)

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the September through January spring-run Chinook salmon spawning period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period at either location.

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September At Bend Bridge and October through April at Red Bluff) and year of the 82-year modeling period (Table 11-mult-30). The combination of number of days and degrees above the 56°F threshold were further assigned a “level of concern”, as defined in Table 11-mult-31. Differences between baselines and H3 in the highest level of concern across all months and all 82 modeled years are presented in Table 11-mult-32 for Bend Bridge and in Table 11-mult-71 for Red Bluff. There would be no difference in levels of concern between NAA and H3 at Bend Bridge. At Red Bluff, there would be 2 (4%) and 3 (23%) more years with a "red" and "orange" level of concern, respectively, under H3 that would not be biologically meaningful to spring-run Chinook salmon spawners and eggs, as this is a small proportion of the 82 year period.

Table 11-mult-71. Differences between Baseline and H3 Scenarios in the Number of Years in Which Water Temperature Exceedances above 56°F Are within Each Level of Concern, Sacramento River at Red Bluff, October through April

Level of Concern[a]	EXISTING CONDITIONS vs. H3	NAA vs. H3
Red	38 (317%)	2 (4%)
Orange	10 (167%)	3 (23%)
Yellow	-3 (-23%)	-2 (-17%)
None	-45 (-88%)	-3 (-33%)

[a] For definitions of levels of concern, see Table 11-mult-31.

Total degree-days exceeding 56°F were summed by month and water year type at Bend Bridge during May through September and at Red Bluff during October through April. At Bend Bridge, total degree-days under H3 would be up to 11% lower than under NAA during May and June and up to 11% higher during July through September (Table 11-mult-33). At Red Bluff, total degree-days under H3 would be 5% higher than those under NAA during October, 7% lower during April, and similar during remaining months (Table 11-mult-72).

Table 11-mult-72. Differences between Baseline and H3 Scenarios in Total Degree-Days (°F-Days) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Sacramento River at Red Bluff, October through April

Month	Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
October	Wet	1,262 (491%)	93 (7%)
	Above Normal	514 (198%)	37 (5%)
	Below Normal	798 (382%)	92 (10%)
	Dry	1,164 (237%)	93 (6%)
	Critical	926 (154%)	3 (0%)
	All	4,664 (257%)	318 (5%)
November	Wet	96 (9,600%)	6 (7%)
	Above Normal	67 (NA)	6 (10%)
	Below Normal	52 (NA)	4 (8%)
	Dry	159 (1,988%)	8 (5%)
	Critical	102 (2,550%)	-8 (-7%)
	All	476 (3,662%)	16 (3%)
December	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)
January	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)
February	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)
March	Wet	9 (NA)	0 (0%)
	Above Normal	5 (NA)	1 (25%)
	Below Normal	29 (322%)	8 (27%)
	Dry	64 (457%)	0 (0%)
	Critical	24 (2,400%)	-3 (-11%)
	All	131 (546%)	6 (4%)
April	Wet	260 (226%)	-1 (0%)
	Above Normal	204 (146%)	-25 (-7%)
	Below Normal	229 (290%)	-1 (0%)
	Dry	248 (133%)	-72 (-14%)
	Critical	137 (1,142%)	-14 (-9%)
	All	1,078 (203%)	-113 (-7%)

NA = could not be calculated because the denominator was 0.

The Reclamation egg mortality model predicts that spring-run Chinook salmon egg mortality in the Sacramento River under H3 would be similar to mortality under NAA in dry and critical years, less in dry years, but greater in wet, above normal, and below normal (11% to 29% greater) water years (Table 11-mult-73). Relative increases of 11% mortality of the spring-run population under wet and above normal water years would be negligible to the overall population, particularly because this represents a 3% to 4% increase on an absolute scale. However, the 29% relative increase in mortality in below normal years would have an effect on the spring-run population. Combining all water years, there would be no effect of H3 on egg mortality (3% absolute change).

Table 11-mult-73. Difference and Percent Difference in Percent Mortality of Spring-Run Chinook Salmon Eggs in the Sacramento River (Egg Mortality Model)

Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
Wet	18 (174%)	3 (11%)
Above Normal	26 (195%)	4 (11%)
Below Normal	41 (349%)	12 (29%)
Dry	54 (275%)	-3 (-3%)
Critical	22 (30%)	0 (0%)
All	32 (141%)	3 (6%)

SacEFT predicts that there would be a 6% relative decrease (3% on an absolute scale) in the percentage of years with good spawning availability, measured as weighted usable area, under H3 relative to NAA (Table 11-mult-74). SacEFT predicts that there would be no difference in the percentage of years with good (lower) redd scour risk under H3 relative to NAA. SacEFT predicts that there would be a 12% decrease on an absolute scale (35% relative decrease) in the percentage of years with good (lower) egg incubation conditions under H3 relative to NAA. SacEFT predicts that there would be a 6% relative decrease (2% on an absolute scale) in the percentage of years with good (lower) redd dewatering risk under H3 relative to NAA.

Table 11-mult-74. Difference and Percent Difference in Percentage of Years with "Good" Conditions for Spring-Run Chinook Salmon Habitat Metrics in the Upper Sacramento River (from SacEFT)

Metric	EXISTING CONDITIONS vs. H3	NAA vs. H3
Spawning WUA	-24 (-34%)	-3 (-6%)
Redd Scour Risk	0 (0%)	0 (0%)
Egg Incubation	-64 (-74%)	-12 (-35%)
Redd Dewatering Risk	-17 (-35%)	-2 (-6%)
Juvenile Rearing WUA	4 (18%)	4 (18%)
Juvenile Stranding Risk	-7 (-37%)	-2 (-14%)

WUA = Weighted Usable Area.

There is an apparent discrepancy in results of the SacEFT model and Reclamation egg mortality model with regard to conditions for spring-run salmon eggs. SacEFT predicts that egg incubation habitat would decrease (12% absolute scale decrease) and the Reclamation egg mortality model predicts that overall egg mortality would be unaffected by the H3, except in below normal water years. The SacEFT uses mid-August through early March as the egg incubation period, based on Vogel and Marine (1991), and the reach between ACID Dam and Battle Creek for redd locations. The Reclamation egg mortality model uses the number of days after Julian week 33 (mid-August) that it takes to accumulate 750 temperature units to hatching and another 750 temperature units to emergence. Temperatures units are calculated by subtracting 32°F from daily river temperature and are computed on a daily basis. As a result, egg incubation duration is generally mid-August through January, but is dependent on river temperature. The Reclamation model uses the reach between ACID Dam and Jelly's Ferry (approximately 5 river miles downstream of Battle Creek), which includes 95% of Sacramento River spawning locations based on 2001–2004 redd survey data (Reclamation 2008). These differences in egg incubation period and location likely account for the difference between model results. The SacEFT model has been peer-reviewed, and the Reclamation egg mortality model has been extensively reviewed and used in prior biological assessments and BiOps. Therefore, both results are considered valid and were considered in drawing conclusions about spring-run egg mortality in the Sacramento River.

Clear Creek

Flows in Clear Creek during the spring-run Chinook salmon spawning and egg incubation period (September through January) under H3 would generally be similar to flows under NAA throughout the spring-run spawning and egg incubation period for all water year types (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). The potential risk of spring-run Chinook salmon redd dewatering in Clear Creek was evaluated by comparing the magnitude of flow reduction each month over the incubation period compared to the flow in September when spawning is assumed to occur. The greatest reduction in flows under H3 would be the same as that under NAA in all water year types (Table 11-mult-75).

Water temperatures were not modeled in Clear Creek.

Table 11-mult-75. Difference and Percent Difference in Greatest Monthly Reduction (Percent Change) in Instream Flow in Clear Creek below Whiskeytown Reservoir during the September through January Spawning and Egg Incubation Period[a]

Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
Wet	0 (NA)	0 (NA)
Above Normal	-27 (NA)	0 (0%)
Below Normal	53 (100%)	0 (NA)
Dry	-67 (NA)	0 (0%)
Critical	-33 (-50%)	0 (0%)

NA = could not be calculated because the denominator was 0.

[a] Redd dewatering risk not applicable for months when flows during the egg incubation period were at or greater than flows in September, when spawning is assumed to occur. A negative value indicates that the greatest monthly reduction would be of greater magnitude (worse) under the alternative than under the baseline.

Feather River

Flows were examined in the Feather River low-flow channel (upstream of Thermalito Afterbay) where spring-run Chinook salmon primarily spawn during September through January. Flows under H3 would not differ from NAA because minimum Feather River flows are included in the FERC settlement agreement (California Department of Water Resources 2006) and would be met for all model scenarios (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Oroville Reservoir storage volume at the end of September influences flows downstream of the dam during the spring-run spawning and egg incubation period. Storage volume at the end of September under H3 would be similar to storage under NAA in wet, above normal, and below normal water years and 18% and 11% greater in dry and critical water years (Table 11-mult76).

Table 11-mult-76. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Oroville Reservoir for Alternative 4 (Scenario H3)

Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
Wet	-978 (-34%)	36 (2%)
Above Normal	-823 (-35%)	-32 (-2%)
Below Normal	-571 (-28%)	38 (3%)
Dry	-170 (-12%)	183 (18%)
Critical	-100 (-10%)	88 (11%)

The potential risk of redd dewatering in the Feather River low-flow channel was evaluated by comparing the magnitude of flow reduction each month over the egg incubation period compared to the flow in September when spawning is assumed to occur. Minimum flows in the low-flow channel during October through January were identical between H3 and NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Therefore, there would be no effect of H3 on redd dewatering in the Feather River low-flow channel.

Mean monthly water temperatures in the low-flow channel would not differ between NAA and H3 (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Effects of H3 on water temperature-related spawning and egg incubation conditions for spring-run Chinook salmon in the Feather River were analyzed by comparing the percent of months between September through January over the 82-year CALSIM modeling period that exceed a 56°F temperature threshold in the low-flow channel (above Thermalito Afterbay) (Table 11-mult-77). In general, differences in the percent of months exceeding the threshold between NAA and H3 would be negligible (<5% on an absolute scale), although there would be a 6% reduction (absolute scale) in the percent of months exceeding the threshold by >3°F under H3 relative to NAA during October and in the percent of months exceeding the threshold by >5°F during October and November.

Table 11-mult-77. Differences between Baseline and H3 Scenarios in Percent of Months during the 82-Year CALSIM Modeling Period during Which Water Temperatures in the Feather River above Thermalito Afterbay Exceed the 56°F Threshold, September through January

	Degrees Above Threshold				
Month	>1.0	>2.0	>3.0	>4.0	>5.0
EXISTING CONDITIONS vs. H3					
September	0 (0%)	1 (1%)	7 (8%)	25 (34%)	44 (109%)
October	63 (283%)	59 (800%)	48 (780%)	46 (1,850%)	31 (1,250%)
November	60 (2,450%)	56 (4,500%)	42 (3,400%)	35 (NA)	19 (NA)
December	4 (NA)	2 (NA)	1 (NA)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)
NAA vs. H3					
September	0 (0%)	0 (0%)	0 (0%)	1 (1%)	2 (3%)
October	-1 (-1%)	1 (2%)	-1 (-2%)	-1 (-3%)	-6 (-16%)
November	-4 (-6%)	-2 (-4%)	-6 (-13%)	2 (8%)	-6 (-25%)
December	0 (0%)	1 (100%)	0 (0%)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

The effects of H3 on water temperature-related spawning and egg incubation conditions for spring-run Chinook salmon in the Feather River were also analyzed by comparing the total degree-months for months that exceed the 56°F NMFS threshold during the September through January spring-run Chinook salmon spawning and egg incubation period for all 82 years (Table 11-mult-78). Combining all water year types, there would be a small (5% to 7%) reduction in degree-months exceeded under H3 relative to NAA during October and November and no other differences between NAA and H3. Results are highly variable when separating out by water year type, ranging from a 9% more degree-months under H3 in below normal water years during September to a 17% fewer degree-months under H3 in dry water years during October. Overall, there would be many more water year types within each month with reductions in exceedances under H3 than increases in exceedances.

Table 11-mult-78. Differences between Baseline and H3 Scenarios in Total Degree-Months (°F-Months) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Feather River above Thermalito Afterbay, September through January

Month	Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
September	Wet	30 (28%)	5 (4%)
	Above Normal	14 (33%)	4 (8%)
	Below Normal	39 (65%)	8 (9%)
	Dry	71 (103%)	-17 (-11%)
	Critical	54 (83%)	-8 (-6%)
	All	208 (60%)	-8 (-1%)
October	Wet	79 (1,580%)	-17 (-17%)
	Above Normal	30 (300%)	-5 (-11%)
	Below Normal	50 (714%)	-4 (-7%)
	Dry	81 (1,157%)	1 (1%)
	Critical	41 (513%)	0 (0%)
	All	281 (759%)	-25 (-7%)
November	Wet	57 (NA)	1 (2%)
	Above Normal	23 (767%)	-2 (-7%)
	Below Normal	32 (3,200%)	-2 (-6%)
	Dry	46 (NA)	-5 (-10%)
	Critical	26 (NA)	-2 (-7%)
	All	184 (4,600%)	-10 (-5%)
December	Wet	1 (NA)	0 (0%)
	Above Normal	2 (NA)	1 (100%)
	Below Normal	3 (NA)	0 (0%)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	6 (NA)	1 (20%)
January	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

H1/LOS

Sacramento River

Flows in the Sacramento River between Keswick and upstream of RBDD under H1 during the September through January spring-run Chinook salmon spawning and egg incubation period would generally similar to flows under NAA except during September and November, in which flows would be 18% to 26% lower under H1, and during January, in which flows would be 5% to 9% higher, under H1. Flow reductions during these months would occur primarily during wetter water years when flow reductions are less critical due to already high flows and, therefore, would not cause biologically meaningful effects.

Shasta Reservoir storage at the end of September under H1 would be similar to storage under NAA, except for a 9% increase in wet water years (Table 11-mult-79).

Table 11-mult-79. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Shasta Reservoir between Baselines and H1 and H4 Scenarios

Water Year Type	EXISTING CONDITIONS vs. H1	NAA vs. H1	EXISTING CONDITIONS vs. H4	NAA vs. H4
Wet	-273 (-8.2%)	238 (8.5%)	-594 (-17.9%)	-83 (-3.0%)
Above Normal	-507 (-15.8%)	109 (4.2%)	-634 (-19.8%)	-18 (-0.7%)
Below Normal	-453 (-15.8%)	-99 (-3.9%)	-317 (-11%)	37 (1.5%)
Dry	-461 (-18.8%)	50 (2.6%)	-463 (-18.9%)	48 (2.5%)
Critical	-384 (-32.3%)	0 (0%)	-339 (-28.5%)	45 (5.6%)

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the September through January spring-run Chinook salmon spawning period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period at either location.

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September at Bend Bridge and October through April at Red Bluff) and year of the 82-year modeling period (Table 11-mult-30). The combination of number of days and degrees above the 56°F threshold were further assigned a "level of concern", as defined in Table 11-mult-31. Differences between baselines and H1 in the highest level of concern across all months and all 82 modeled years are presented in Table 11-mult-37 for Bend Bridge and in Table 11-mult-80 for Red Bluff. There would be no difference in levels of concern between NAA and H1 at Bend Bridge. At Red Bluff, there would be 6 (13%) fewer years with a "red" level of concern.

Table 11-,mult-80. Differences between Baseline and H3 Scenarios in the Number of Years in Which Water Temperature Exceedances above 56°F Are within Each Level of Concern, Sacramento River at Red Bluff, October through April

Level of Concern[a]	EXISTING CONDITIONS vs. H1	NAA vs. H1	EXISTING CONDITIONS vs. H4	NAA vs. H4
Red	30 (250%)	-6 (-13%)	38 (317%)	2 (4%)
Orange	15 (250%)	8 (62%)	9 (150%)	2 (15%)
Yellow	-2 (-15%)	-1 (-8%)	-5 (-38%)	-4 (-33%)
None	-43 (-84%)	-1 (-11%)	-42 (-82%)	0 (0%)

[a] For definitions of levels of concern, see Table 11-mult-31.

Total degree-days exceeding 56°F were summed by month and water year type at Bend Bridge during May through September and at Red Bluff during October through April. At Bend Bridge, total degree-days under H1would be up to 11% to 12% lower than under NAA during May and June and 8% to 16% higher during July through September (Table 11-mult-38). At Red Bluff, total degree-days under H1 would be 10% lower than those under H1 during November, 5% higher during March, and similar during remaining months (Table 11-mult-38).

Table 11-mult-81. Differences between Baseline and H3 Scenarios in Total Degree-Days (°F-Days) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Sacramento River at Red Bluff, October through April

Month	Water Year Type	EXISTING CONDITIONS vs. H1	NAA vs. H1	EXISTING CONDITIONS vs. H4	NAA vs. H4
October	Wet	1,084 (422%)	-85 (-6%)	1,261 (491%)	92 (6%)
	Above Normal	452 (174%)	-25 (-3%)	498 (192%)	21 (3%)
	Below Normal	685 (328%)	-21 (-2%)	697 (333%)	-9 (-1%)
	Dry	1,018 (207%)	-53 (-3%)	1,044 (213%)	-27 (-2%)
	Critical	859 (143%)	-64 (-4%)	827 (138%)	-96 (-6%)
	All	4,098 (226%)	-248 (-4%)	4,327 (238%)	-19 (-0.3%)
November	Wet	72 (7,200%)	-18 (-20%)	94 (9,400%)	4 (4%)
	Above Normal	64 (NA)	3 (5%)	71 (NA)	10 (16%)
	Below Normal	41 (NA)	-7 (-15%)	45 (NA)	-3 (-6%)
	Dry	139 (1,738%)	-12 (-8%)	145 (1,813%)	-6 (-4%)
	Critical	98 (2,450%)	-12 (-11%)	88 (2,200%)	-22 (-19%)
	All	414 (3,185%)	-46 (-10%)	443 (3,408%)	-17 (-4%)
December	Wet	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)	0 (NA)	0 (NA)
January	Wet	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)	0 (NA)	0 (NA)
February	Wet	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)	0 (NA)	0 (NA)
March	Wet	9 (NA)	0 (0%)	9 (NA)	0 (0%)
	Above Normal	6 (NA)	2 (50%)	5 (NA)	1 (25%)
	Below Normal	29 (322%)	8 (27%)	35 (389%)	14 (47%)
	Dry	63 (450%)	-1 (-1%)	65 (464%)	1 (1%)
	Critical	25 (2,500%)	-2 (-7%)	26 (2,600%)	-1 (-4%)
	All	132 (550%)	7 (5%)	140 (583%)	15 (10%)
April	Wet	259 (225%)	-2 (-1%)	262 (228%)	1 (0%)
	Above Normal	202 (144%)	-27 (-7%)	205 (146%)	-24 (-7%)
	Below Normal	230 (291%)	0 (0%)	255 (323%)	25 (8%)
	Dry	294 (158%)	-26 (-5%)	322 (173%)	2 (0%)
	Critical	135 (1,125%)	-16 (-10%)	131 (1,092%)	-20 (-12%)
	All	1,120 (211%)	-71 (-4%)	1,175 (221%)	-16 (-1%)

NA = could not be calculated because the denominator was 0.

Clear Creek

Flows in Clear Creek during the spring-run Chinook salmon spawning and egg incubation period (September through January) under H1 would generally be similar to those under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Also, flows would generally be similar between H1 and H3 such that results of the redd dewatering analysis would be similar between H1 and H3. Therefore, no analysis of redd dewatering risk was conducted for H1 in Clear Creek. Due to similar flows between H1 and H3, effects of H1 on spring-run Chinook salmon spawning and egg incubation habitat in Clear Creek would not be different from effects of H3. Therefore, there would be no effects of H1 on spring-run Chinook salmon spawning and egg incubation in Clear Creek relative to Existing Conditions.

Feather River

H1 flows in the Feather River low-flow channel during the spring-run Chinook salmon spawning and egg incubation period (September through January) would be similar between NAA and H1 (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Oroville Reservoir storage volume at the end of September under H1 would be 8% to 24% greater than storage under NAA depending on water year type (Table 11-mult-82). Higher storage during wetter water year types would generally benefit spring-run Chinook spawning and egg incubation habitat.

Table 11-mult-82. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Oroville Reservoir for H1 and H4 Scenarios

Water Year Type	EXISTING CONDITIONS vs. H1	NAA vs. H1	EXISTING CONDITIONS vs. H4	NAA vs. H4
Wet	-591 (-20.4%)	423 (22.5%)	-959 (-33.1%)	55 (2.9%)
Above Normal	-645 (-27.2%)	146 (9.2%)	-741 (-31.2%)	50 (3.1%)
Below Normal	-491 (-24.3%)	119 (8.4%)	-620 (-30.7%)	-10 (-0.7%)
Dry	-108 (-7.9%)	245 (24.3%)	-33 (-2.4%)	320 (31.7%)
Critical	-50 (-5.0%)	138 (17.3%)	108 (11.0%)	295 (37.1%)

Mean monthly water temperatures in the low-flow channel would not differ between NAA and H1 (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Differences in the percent of months exceeding the 56°F threshold between NAA and H1 would generally be negligible (<5% on an absolute scale) except during October and November, during which the exceedances would be between 17% and 26% (absolute scale) lower under H1 (Table 11-mult-83). This represents a moderate benefit of H1 on spring-run spawning habitat conditions in the Feather River.

Table 11-mult-83. Differences between Baselines and H1 and H4 Scenarios in Percent of Months during the 82-Year CALSIM Modeling Period during Which Water Temperatures in the Feather River above Thermalito Afterbay Exceed the 56°F Threshold, September through January

	Degrees Above Threshold				
Month	>1.0	>2.0	>3.0	>4.0	>5.0
EXISTING CONDITIONS vs. H1					
September	0 (0%)	1 (1%)	9 (9%)	21 (29%)	46 (112%)
October	40 (178%)	37 (500%)	31 (500%)	28 (1,150%)	20 (800%)
November	41 (1,650%)	35 (2,800%)	22 (1,800%)	11 (NA)	7 (NA)
December	2 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)
NAA vs. H1					
September	0 (0%)	0 (0%)	1 (1%)	-2 (-3%)	4 (4%)
October	-25 (-29%)	-21 (-32%)	-19 (-33%)	-19 (-38%)	-17 (-44%)
November	-23 (-35%)	-23 (-40%)	-26 (-53%)	-21 (-65%)	-17 (-70%)
December	-1 (-33%)	-1 (-100%)	-1 (-100%)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)
EXISTING CONDITIONS vs. H4					
September	0 (0%)	0 (0%)	6 (7%)	19 (25%)	40 (97%)
October	46 (206%)	49 (667%)	41 (660%)	37 (1,500%)	36 (1,450%)
November	46 (1,850%)	41 (3,300%)	30 (2,400%)	22 (NA)	15 (NA)
December	2 (NA)	1 (NA)	1 (NA)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)
NAA vs. H4					
September	0 (0%)	-1 (-1%)	-1 (-1%)	-5 (-5%)	-2 (-3%)
October	-19 (-21%)	-9 (-13%)	-9 (-16%)	-10 (-20%)	-1 (-3%)
November	-19 (-28%)	-17 (-29%)	-19 (-38%)	-10 (-31%)	-10 (-40%)
December	-1 (-33%)	0 (0%)	0 (0%)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

During September, exceedances above the 56°F threshold under H1 would not differ from those under NAA across all water years (Table 11-mult-84). Total degree-months above the 56°F threshold under H1 would be higher than those under NAA in wetter water years and lower in drier water year types. During October and November, exceedances above the threshold under H1 would be 76 to 112 (33% to 38%) fewer degree-months than exceedances under NAA. There would be no meaningful differences between NAA and H1 during December and January.

Table 11-mult-84. Differences between Baseline Scenarios and H1 and H4 Scenarios in Total Degree-Months (°F-Months) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Feather River above Thermalito Afterbay, September through April

Month	Water Year Type	EXISTING CONDITIONS vs. H1	NAA vs. H1	EXISTING CONDITIONS vs. H4	NAA vs. H4
September	Wet	59 (55%)	34 (26%)	56 (52%)	31 (23%)
	Above Normal	23 (53%)	13 (25%)	32 (74%)	22 (42%)
	Below Normal	37 (62%)	6 (7%)	69 (115%)	38 (42%)
	Dry	53 (77%)	-35 (-22%)	50 (72%)	-38 (-24%)
	Critical	44 (68%)	-18 (-14%)	25 (38%)	-37 (-29%)
	All	216 (63%)	0 (0%)	232 (67%)	16 (3%)
October	Wet	46 (920%)	-50 (-50%)	98 (1,960%)	2 (2%)
	Above Normal	25 (250%)	-10 (-22%)	52 (520%)	17 (38%)
	Below Normal	41 (586%)	-13 (-21%)	62 (886%)	8 (13%)
	Dry	52 (743%)	-28 (-32%)	77 (1,100%)	-3 (-3%)
	Critical	31 (388%)	-10 (-20%)	14 (175%)	-27 (-55%)
	All	194 (524%)	-112 (-33%)	303 (819%)	-3 (-1%)
November	Wet	28 (NA)	-28 (-50%)	47 (NA)	-9 (-16%)
	Above Normal	18 (600%)	-7 (-25%)	30 (1,000%)	5 (18%)
	Below Normal	18 (1,800%)	-16 (-46%)	28 (2,800%)	-6 (-17%)
	Dry	32 (NA)	-19 (-37%)	41 (NA)	-10 (-20%)
	Critical	23 (NA)	-5 (-18%)	9 (NA)	-19 (-68%)
	All	118 (2,950%)	-76 (-38%)	155 (3,875%)	-39 (-20%)
December	Wet	0 (NA)	-1 (-100%)	0 (NA)	-1 (-100%)
	Above Normal	1 (NA)	0 (0%)	1 (NA)	0 (0%)
	Below Normal	1 (NA)	-2 (-67%)	3 (NA)	0 (0%)
	Dry	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Critical	1 (NA)	1 (NA)	1 (NA)	1 (NA)
	All	3 (NA)	-2 (-40%)	5 (NA)	0 (0%)
January	Wet	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

Overall, effects of H1 on spring-run Chinook salmon spawning and egg incubation habitat in the Feather River would generally be negligible or beneficial compared to the NAA.

H4/HOS

Sacramento River

Flows in the Sacramento River between Keswick and upstream of RBDD under H4 during the September through January spring-run Chinook salmon spawning and egg incubation period would generally be similar to flows under NAA except during November (11% to 15% lower).

Shasta Reservoir storage at the end of September under H4 would be similar to storage under NAA, except in critical water years (6% lower) (Table 11-mult-79).

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September at Bend Bridge and October through April at Red Bluff) and year of the 82-year modeling period (Table 11-mult-30). The combination of number of days and degrees above the 56°F threshold were further assigned a "level of concern", as defined in Table 11-mult-31. Differences between baselines and H4 in the highest level of concern across all months and all 82 modeled years are presented in Table 11-mult-37 for Bend Bridge and in Table 11-mult-80 for Red Bluff. There would be no difference in levels of concern between NAA and H4 at Bend Bridge or at Red Bluff.

Total degree-days exceeding 56°F were summed by month and water year type at Bend Bridge during May through September and at Red Bluff during October through April. At Bend Bridge, total degree-days under H4 would be up to 5% lower than under NAA during August and similar during other months (Table 11-mult-38). At Red Bluff, exceedances above the threshold under H4 would be 15 degree-days (10%) higher than those under Existing Conditions during March, and similar during remaining months (Table 11-mult-81). On an absolute scale, the 15 degree-day increase during March, because it is the sum of the 82-year period, would not translate into a biologically meaningful effect on spring-run Chinook salmon.

Clear Creek

lows in Clear Creek during the spring-run Chinook salmon spawning and egg incubation period (September through January) under H4 would generally be similar to those under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Also, flows would generally be similar between H4 and H3 such that results of the redd dewatering analysis would be similar between H4 and H3. Therefore, no analysis of redd dewatering risk was conducted for H4 in Clear Creek. Due to similar flows between H4 and H3, effects of H4 on spring-run Chinook salmon spawning and egg incubation habitat in Clear Creek would not be different from effects of H3. Therefore, there would be no effects of H4 on spring-run Chinook salmon spawning and egg incubation in Clear Creek relative to the NAA.

Feather River

Flows in the Feather River low-flow channel during the spring-run Chinook salmon spawning and egg incubation period (September through January) would be similar between NAA and H4 (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis).*

Oroville Reservoir storage volume at the end of September under H4 would generally be similar to storage under NAA, except in dry and critical water years (32% to 37% higher under H4) (Table 11-mult-82). Higher storage in drier water year types would generally benefit spring-run Chinook salmon spawning and egg incubation habitat.

Mean monthly water temperatures in the low-flow channel would not differ between NAA and H4 (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Differences in the percent of months exceeding the threshold between NAA and H4 would generally be negligible (<5% on an absolute scale) during all months except November, in which there would be up to 19% fewer months exceeding the threshold under H4 (Table 11-mult-83).

Total degree-days of exceedance above the 56°F threshold under H4 would be similar to those under NAA in all months of the period except November, in which the total would be 20% lower. However, a reduction of 39 degree-days would not be biologically meaningful for the 82-year period.

Overall, effects of H4 on spring-run Chinook salmon spawning and egg incubation habitat in the Feather River would generally be negligible or beneficial compared to the NAA.

NEPA Effects: There would be no effects of Alternative 4 on spawning and egg incubation conditions in Clear Creek and no or beneficial effects in the Feather River. However, available analytical tools show conflicting results regarding the temperature effects of relatively small changes in predicted summer and fall flows in the Sacramento River. Several models (CALSIM, SRWQM, and Reclamation Egg Mortality Model) generally show no change or negligible changes in upstream conditions as a result of Alternative 4. However, one model, SacEFT, shows a 12% reduction in the percentage of years with "good" egg incubation conditions on an absolute scale. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions, which may or may not accurately predict adverse effects. Considering the lack of effects found in all other analyses for this impact, the small decrease in egg incubation conditions found by SacEFT, and the high model sensitivity of SacEFT, the weight of evidence indicates that the effects of Alternative 4 on spring-run Chinook salmon spawning and egg incubation would not be adverse.

Alternative 5

In general, the effects of Alternative 5 on spawning and egg incubation habitat conditions for spring-run Chinook salmon relative to NAA are not adverse.

Sacramento River

Water temperatures in the Sacramento River under Alternative 5 would be the same as those under Alternative 1A, Impact AQUA-58, which indicates that there would generally be no effects of Alternative 5 on water temperatures during the spring-run spawning and egg incubation period in the Sacramento River relative to NAA.

Flows in the Sacramento River upstream of Red Bluff were examined during the spring-run Chinook salmon spawning and incubation period (September through January). Flows under A5_LLT would generally be similar to or greater than flows under NAA during all months except November, in which flows would be up to 14% lower than under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Shasta Reservoir storage volume at the end of September influences flows downstream of the dam during the spring-run spawning and egg incubation period (September through January). Storage under A5_LLT would be similar to (<5% difference) storage under NAA in all water year types (Table 11-mult-85).

Table 11-mult-85. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Shasta Reservoir for Model Scenarios

Water Year Type	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Wet	-623 (-19%)	-111 (-4%)
Above Normal	-661 (-21%)	-46 (-2%)
Below Normal	-450 (-16%)	-96 (-4%)
Dry	-493 (-20%)	18 (1%)
Critical	-374 (-32%)	8 (1%)

The Reclamation egg mortality model predicts that spring-run Chinook salmon egg mortality in the Sacramento River under A5_LLT would be lower than or similar to mortality under NAA in above normal, dry, and critical years, but greater in wet (14% greater) and below normal (32% greater) water years. Absolute scale increases of 3% of the spring-run population in wet water years would be negligible to the overall population (Table 11-mult-86). However, the 13% increase in mortality in below normal years is considered a small effect on the spring-run population. Combining all water years, there would be no effect of Alternative 5 on egg mortality (3% absolute change).

Table 11-mult-86. Difference and Percent Difference in Percent Mortality of Spring-Run Chinook Salmon Eggs in the Sacramento River (Egg Mortality Model)

Water Year Type	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Wet	18 (180%)	3 (14%)
Above Normal	23 (171%)	1 (2%)
Below Normal	43 (359%)	13 (32%)
Dry	56 (284%)	-1 (-1%)
Critical	22 (30%)	0 (0%)
All	32 (143%)	3 (7%)

SacEFT predicts that there would be no difference in the percentage of years with good spawning availability, measured as weighted usable area, under A5_LLT relative to NAA (Table 11-mult-87). SacEFT predicts that there would be no difference in the percentage of years with good (lower) redd scour risk under A5_LLT relative to NAA. SacEFT predicts that there would be a 41% decrease (14% on an absolute scale) in the percentage of years with good (lower) egg incubation conditions under A5_LLT relative to NAA. SacEFT predicts that there would be an 18% decrease (6% on an absolute scale) in the percentage of years with good (lower) redd dewatering risk under A5_LLT relative to NAA. These results indicate that there would be a small to moderate reduction in egg incubation conditions and redd dewatering risk under Alternative 5 relative to NAA.

Table 11-mult-87. Difference and Percent Difference in Percentage of Years with "Good" Conditions for Spring-Run Chinook Salmon Habitat Metrics in the Upper Sacramento River (from SacEFT)

Metric	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Spawning WUA	-21 (-30%)	0 (0%)
Redd Scour Risk	0 (0%)	0 (0%)
Egg Incubation	-66 (-77%)	-14 (-41%)
Redd Dewatering Risk	-21 (-43%)	-6 (-18%)
Juvenile Rearing WUA	3 (14%)	3 (14%)
Juvenile Stranding Risk	-2 (-11%)	3 (21%)

WUA = Weighted Usable Area.

There is an apparent discrepancy in results of the SacEFT model and Reclamation egg mortality model with regard to conditions for spring-run salmon eggs. SacEFT predicts that egg incubation habitat would decrease (14% absolute scale decrease) and the Reclamation egg mortality model predicts that overall egg mortality would be unaffected by Alternative 5, except in below normal water years. The SacEFT uses mid-August through early March as the egg incubation period, based on Vogel and Marine (1991), and the reach between ACID Dam and Battle Creek for redd locations. The Reclamation egg mortality model uses the number of days after Julian week 33 (mid-August) that it takes to accumulate 750 temperature units to hatching and another 750 temperature units to emergence. Temperatures units are calculated by subtracting 32°F from daily river temperature and are computed on a daily basis. As a result, egg incubation duration is generally mid-August through January, but is dependent on river temperature. The Reclamation model uses the reach between ACID Dam and Jelly's Ferry (approximately 5 river miles downstream of Battle Creek), which includes 95% of Sacramento River spawning locations based on 2001–2004 redd survey data (Reclamation 2008). These differences in egg incubation period and location likely account for the difference between model results. Although the SacEFT model has been peer-reviewed, the Reclamation egg mortality model has been extensively reviewed and used in prior biological assessments and BiOps. Therefore, both results are considered valid and were considered in drawing conclusions about spring-run egg mortality in the Sacramento River.

Clear Creek

Flows in Clear Creek were examined during the spring-run Chinook salmon spawning and egg incubation period (September through January). Flows under A5_LLT would be similar to or greater than flows under NAA in all months and water years (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

The potential risk of spring-run Chinook salmon redd dewatering in Clear Creek was evaluated by comparing the magnitude of flow reduction each month over the incubation period compared to the flow in September when spawning is assumed to occur. The greatest reduction in flows under A5_LLT would be the same or of a lower magnitude as that under NAA in all water year types (Table 11-mult-88).

Water temperatures were not modeled in Clear Creek.

Table 11-mult-88. Difference and Percent Difference in Greatest Monthly Reduction (Percent Change) in Instream Flow in Clear Creek below Whiskeytown Reservoir during the September through January Spawning and Egg Incubation Period[a]

Water Year Type	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Wet	0 (NA)	0 (NA)
Above Normal	-27 (NA)	0 (0%)
Below Normal	53 (100%)	0 (NA)
Dry	-67 (NA)	0 (0%)
Critical	-33 (-50%)	0 (0%)

NA = could not be calculated because the denominator was 0.

[a] Redd dewatering risk not applicable for months when flows during the egg incubation period were at or greater than flows in September, when spawning is assumed to occur. A negative value indicates that the greatest monthly reduction would be of greater magnitude (worse) under the alternative than under the baseline.

Feather River

Flows were examined in the Feather River low-flow channel (upstream of Thermalito Afterbay) where spring-run primarily spawn during September through January (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would not differ from NAA because minimum Feather River flows are included in the FERC settlement agreement and would be met for all model scenarios.

Oroville Reservoir storage volume at the end of September influence flows downstream of the dam during the spring-run spawning and egg incubation period. Storage under A5_LLT would be similar to or greater than storage under NAA depending on water year type (Table 11-mult-89). This indicates that the majority of reduction in storage volume would be due to climate change rather than Alternative 5.

Table 11-mult-89. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Oroville Reservoir for Model Scenarios

Water Year Type	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Wet	-885 (-31%)	129 (7%)
Above Normal	-630 (-27%)	161 (10%)
Below Normal	-549 (-27%)	60 (4%)
Dry	-178 (-13%)	175 (17%)
Critical	-76 (-8%)	112 (14%)

The potential risk of redd dewatering in the Feather River low-flow channel was evaluated by comparing the magnitude of flow reduction each month over the egg incubation period compared to the flow in September when spawning is assumed to occur. Minimum flows in the low-flow channel during October through January were identical among A5_LLT and NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Therefore, there would be no effect of Alternative 5 on redd dewatering in the Feather River low-flow channel.

Water temperatures in the Feather River under Alternative 5 would be the same as those under Alternative 1A, Impact AQUA-58, which indicates that there would be no effect of Alternative 1A on water temperatures in the Feather River relative to NAA during the spring-run spawning and egg incubation period.

NEPA Effects: There would be no effects of Alternative 5 on spawning and egg incubation conditions in Clear Creek and no or beneficial effects in the Feather River. However, available analytical tools show conflicting results regarding the temperature effects of relatively small changes in predicted summer and fall flows in the Sacramento River. Several models (CALSIM, SRWQM, and Reclamation Egg Mortality Model) generally show no change or negligible changes in upstream conditions as a result of Alternative 5. However, one model, SacEFT, shows a 14% reduction in the percentage of years with "good" egg incubation conditions on an absolute scale. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions, which may or may not accurately predict adverse effects. Considering the lack of effects found in all other analyses for this impact, the small decrease in egg incubation conditions found by SacEFT, and the high model sensitivity of SacEFT, the weight of evidence indicates that the effects of Alternative 5 on spring-run Chinook salmon spawning and egg incubation would not be adverse.

Alternative 7

In general, the effects of Alternative 7 on spawning and egg incubation habitat conditions for spring-run Chinook salmon relative to NAA are not adverse.

Sacramento River

Flows in the Sacramento River upstream of Red Bluff were examined during the spring-run Chinook salmon spawning and incubation period (September through January Flows under A7_LLT would generally be similar to or greater than flows under NAA during all months except November, in which flows would be up to 14% lower (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Shasta Reservoir storage volume at the end of September influences flows downstream of the dam during the spring-run spawning and egg incubation period (September through January). Storage volume under A7_LLT would be similar to (<5% difference) storage under NAA in all water year types (Table 11-mult-90).

Table 11-mult-90. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Shasta Reservoir for Model Scenarios

Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wet	-585 (-18%)	-73 (-3%)
Above Normal	-611 (-19%)	4 (0%)
Below Normal	-383 (-13%)	-29 (-1%)
Dry	-517 (-21%)	-6 (0%)
Critical	-392 (-33%)	-10 (-1%)

Mean monthly water temperatures in the Sacramento River at Keswick and Bend Bridge were examined during the September through January spring-run Chinook salmon spawning period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results* *utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period at either location.

The number of days on which temperature exceeded 56°F by >0.5°F to >5°F in 0.5°F increments was determined for each month (May through September At Bend Bridge and October through April at Red Bluff) and year of the 82-year modeling period (Table 11-mult-40). The combination of number of days and degrees above the 56°F threshold were further assigned a "level of concern", as defined in Table 11-mult-41. Differences between baselines and Alternative 7 in the highest level of concern across all months and all 82 modeled years are presented in Table 11-mult-42 for Bend Bridge and in Table 11-mult-91 for Red Bluff. There would be no difference in levels of concern between NAA and Alternative 7 at Bend Bridge. At Red Bluff, there would be 0 (0%) and -2 (-20%) fewer years with a "red" and "yellow" level of concern, respectively, under Alternative 7. The level of concern in these years would be reduced to an "orange" level or no level.

Table 11-mult-91. Differences between Baseline and Alternative 7 Scenarios in the Number of Years in Which Water Temperature Exceedances above 56°F Are within Each Level of Concern, Sacramento River at Red Bluff, October through April

Level of Concern[a]	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Red	36 (300%)	0 (0%)
Orange	9 (150%)	2 (13%)
Yellow	-3 (-23%)	-2 (-20%)
None	-42 (-82%)	0 (0%)

[a] For definitions of levels of concern, see Table 11-mult-41.

Total degree-days exceeding 56°F were summed by month and water year type at Bend Bridge during May through September and at Red Bluff during October through April. At Bend Bridge, total degree-days under Alternative 7 would be up to 2% lower than those under NAA during May through July and up to 7% higher during August through September (Table 11-mult-43). At Red Bluff, total degree-days under Alternative 7 would be 3%, 9% 12%, and 6% higher during October, November, March and April, respectively, than those under NAA, and similar during remaining months (Table 11-mult-92).

Table 11-mult-92. Differences between Baseline and Alternative 7 Scenarios in Total Degree-Days (°F-Days) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Sacramento River at Red Bluff, October through April

Month	Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
October	Wet	1,177 (458%)	8 (1%)
	Above Normal	487 (187%)	10 (1%)
	Below Normal	839 (401%)	133 (15%)
	Dry	1,053 (214%)	-18 (-1%)
	Critical	958 (160%)	35 (2%)
	All	4,514 (248%)	168 (3%)
November	Wet	93 (9,300%)	3 (3%)
	Above Normal	68 (NA)	7 (11%)
	Below Normal	69 (NA)	21 (44%)
	Dry	165 (2,063%)	14 (9%)
	Critical	107 (2,675%)	-3 (-3%)
	All	502 (3,862%)	42 (9%)
December	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)
January	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)
February	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)
March	Wet	8 (NA)	-1 (-11%)
	Above Normal	5 (NA)	1 (25%)
	Below Normal	36 (400%)	15 (50%)
	Dry	64 (457%)	0 (0%)
	Critical	30 (3,000%)	3 (11%)
	All	143 (596%)	18 (12%)
April	Wet	261 (227%)	0 (0%)
	Above Normal	207 (148%)	-22 (-6%)
	Below Normal	289 (366%)	59 (19%)
	Dry	367 (197%)	47 (9%)
	Critical	164 (1,367%)	13 (8%)
	All	1,288 (242%)	97 (6%)

NA = could not be calculated because the denominator was 0.

The Reclamation egg mortality model predicts that spring-run Chinook salmon egg mortality in the Sacramento River under A7_LLT would be lower than or similar to mortality under NAA in above normal, dry, and critical years, but greater in wet (11% greater) and below normal (30% greater) water years (Table 11-mult-93). Increases of 3% of the spring-run population in wet water years would be negligible to the overall population. However, the 13% increase in mortality in below normal years is considered a small effect on the spring-run population. Combining all water years, there would be no effect of Alternative 7 on egg mortality (2% absolute change).

Table 11-mult-93. Difference and Percent Difference in Percent Mortality of Spring-Run Chinook Salmon Eggs in the Sacramento River (Egg Mortality Model)

Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wet	17 (173%)	3 (11%)
Above Normal	23 (170%)	1 (2%)
Below Normal	42 (353%)	13 (30%)
Dry	53 (270%)	-4 (-5%)
Critical	22 (30%)	0 (0%)
All	31 (138%)	2 (5%)

SacEFT predicts that there would be a no difference in the percentage of years with good spawning availability, measured as weighted usable area, under A7_LLT relative to NAA (Table 11-mult-94). SacEFT predicts that there would be no difference in the percentage of years with good (lower) redd scour risk under A7_LLT relative to NAA. SacEFT predicts that there would be an 8% decrease on an absolute scale (24% relative decrease) in the percentage of years with good (lower) egg incubation conditions under A7_LLT relative to NAA. SacEFT predicts that there would be a 6% decrease in the percentage of years with good (lower) redd dewatering risk under A7_LLT relative to NAA.

Table 11-mult-94. Difference and Percent Difference in Percentage of Years with “Good” Conditions for Spring-Run Chinook Salmon Habitat Metrics in the Upper Sacramento River (from SacEFT)

Metric	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Spawning WUA	-21 (-30%)	0 (0%)
Redd Scour Risk	0 (0%)	0 (0%)
Egg Incubation	-60 (-70%)	-8 (-24%)
Redd Dewatering Risk	-17 (-35%)	-2 (-6%)
Juvenile Rearing WUA	4 (18%)	4 (18%)
Juvenile Stranding Risk	-7 (-37%)	-2 (-14%)

WUA = Weighted Usable Area.

There is an apparent discrepancy in results of the SacEFT model and Reclamation egg mortality model with regard to conditions for spring-run salmon eggs. SacEFT predicts that egg incubation habitat would decrease (8% absolute scale decrease) and the Reclamation egg mortality model predicts that overall egg mortality would be unaffected by the Alternative 7, except in below normal water years. The SacEFT uses mid-August through early March as the egg incubation period, based on Vogel and Marine (1991), and the reach between ACID Dam and Battle Creek for redd locations.

The Reclamation egg mortality model uses the number of days after Julian week 33 (mid-August) that it takes to accumulate 750 temperature units to hatching and another 750 temperature units to emergence. Temperatures units are calculated by subtracting 32°F from daily river temperature and are computed on a daily basis. As a result, egg incubation duration is generally mid-August through January, but is dependent on river temperature. The Reclamation model uses the reach between ACID Dam and Jelly's Ferry (approximately 5 river miles downstream of Battle Creek), which includes 95% of Sacramento River spawning locations based on 2001–2004 redd survey data (Reclamation 2008). These differences in egg incubation period and location likely account for the difference between model results. Although the SacEFT model has been peer-reviewed, the Reclamation egg mortality model has been extensively reviewed and used in prior biological assessments and BiOps. Therefore, both results are considered valid and were considered in drawing conclusions about spring-run egg mortality in the Sacramento River.

Clear Creek

Flows in Clear Creek during the spring-run Chinook salmon spawning and egg incubation period (September through January) under A7_LLT would be similar to or greater than flows under NAA except in critical years during September (13% decrease) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

The potential risk of spring-run Chinook salmon redd dewatering in Clear Creek was evaluated by comparing the magnitude of flow reduction each month over the incubation period compared to the flow in September when spawning is assumed to occur. The greatest reduction in flows under A7_LLT would be the same or of a lower magnitude as that under NAA in all water year types (Table 11-mult-95).

Water temperatures were not modeled in Clear Creek.

Table 11-mult-95. Difference and Percent Difference in Greatest Monthly Reduction (Percent Change) in Instream Flow in Clear Creek below Whiskeytown Reservoir during the September through January Spawning and Egg Incubation Period[a]

Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wet	0 (NA)	0 (NA)
Above Normal	-27 (NA)	0 (0%)
Below Normal	53 (100%)	0 (NA)
Dry	-67 (NA)	0 (0%)
Critical	-3 (-4%)	31 (31%)

NA = could not be calculated because the denominator was 0.

[a] Redd dewatering risk not applicable for months when flows during the egg incubation period were at or greater than flows in September, when spawning is assumed to occur. A negative value indicates that the greatest monthly reduction would be of greater magnitude (worse) under the alternative than under the baseline.

Feather River

Flows were examined in the Feather River low-flow channel (upstream of Thermalito Afterbay) where spring-run primarily spawn during September through January (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would not differ from NAA because minimum Feather River flows are included in the FERC settlement agreement and would be met for all model scenarios.

Oroville Reservoir storage volume at the end of September influence flows downstream of the dam during the spring-run spawning and egg incubation period. Storage volume under A7_LLT would be similar to or greater than storage under NAA depending on water year type (Table 11-mult-96). This indicates that the majority of reduction in storage volume would be due to climate change rather than Alternative 7.

Table 11-mult-96. Difference and Percent Difference in September Water Storage Volume (thousand acre-feet) in Oroville Reservoir for Model Scenarios

Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wet	-885 (-31%)	129 (7%)
Above Normal	-675 (-28%)	116 (7%)
Below Normal	-322 (-16%)	287 (20%)
Dry	162 (12%)	515 (51%)
Critical	-90 (-9%)	98 (12%)

The potential risk of redd dewatering in the Feather River low-flow channel was evaluated by comparing the magnitude of flow reduction each month over the egg incubation period compared to the flow in September when spawning is assumed to occur. Minimum flows in the low-flow channel during October through January were identical between A7_LLT and NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Therefore, there would be no effect of Alternative 7 on redd dewatering in the Feather River low-flow channel.

Mean monthly water temperatures were examined in the Feather River low-flow channel (upstream of Thermalito Afterbay) during September through January (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

The percent of months exceeding the 56°F temperature threshold in the Feather River above Thermalito Afterbay (low-flow channel) was evaluated during September through January (Table 11-mult-97). The percent of months exceeding the threshold under Alternative 7 would generally be lower (up to 23% lower on an absolute scale) than the percent under NAA during October and November and similar during other months, except for the >4.0 and >5.0 degree categories during September when they would be slightly lower (5% and 9% absolute scale decrease).

Table 11-mult-97. Differences between Baseline and Alternative 7 Scenarios in Percent of Months during the 82-Year CALSIM Modeling Period during Which Water Temperatures in the Feather River above Thermalito Afterbay Exceed the 56°F Threshold, September through January

	Degrees Above Threshold				
Month	>1.0	>2.0	>3.0	>4.0	>5.0
EXISTING CONDITIONS vs. A7_LLT					
September	0 (0%)	0 (0%)	6 (7%)	19 (25%)	33 (82%)
October	44 (200%)	41 (550%)	30 (480%)	28 (1,150%)	16 (650%)
November	41 (1,650%)	38 (3,100%)	26 (2,100%)	17 (NA)	6 (NA)
December	2 (NA)	1 (NA)	0 (NA)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)
NAA vs. A7_LLT					
September	0 (0%)	-1 (-1%)	-1 (-1%)	-5 (-5%)	-9 (-10%)
October	-20 (-23%)	-17 (-26%)	-20 (-36%)	-19 (-38%)	-21 (-53%)
November	-23 (-35%)	-20 (-33%)	-22 (-45%)	-15 (-46%)	-19 (-75%)
December	-1 (-33%)	0 (0%)	-1 (-100%)	0 (NA)	0 (NA)
January	0 (NA)	0 (NA)	0 (NA)	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

Total degree-days exceeding 56°F were summed by month and water year type above Thermalito Afterbay (low-flow channel) during September through January (Table 11-mult-98). Total degree-months would be similar between NAA and Alternative 7 during December, and January, and 9%, 29%, and 34% lower during September, October and November, respectively.

Table 11-mult-98. Differences between Baseline and Alternative 7 Scenarios in Total Degree-Months (°F-Months) by Month and Water Year Type for Water Temperature Exceedances above 56°F in the Feather River above Thermalito Afterbay, September through January

Month	Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
September	Wet	26 (24%)	1 (1%)
	Above Normal	15 (35%)	5 (9%)
	Below Normal	26 (43%)	-5 (-5%)
	Dry	50 (72%)	-38 (-24%)
	Critical	50 (77%)	-12 (-9%)
	All	167 (48%)	-49 (-9%)
October	Wet	50 (1,000%)	-46 (-46%)
	Above Normal	30 (300%)	-5 (-11%)
	Below Normal	35 (500%)	-19 (-31%)
	Dry	64 (914%)	-16 (-18%)
	Critical	30 (375%)	-11 (-22%)
	All	208 (562%)	-98 (-29%)
November	Wet	33 (NA)	-23 (-41%)
	Above Normal	21 (700%)	-4 (-14%)
	Below Normal	18 (1,800%)	-16 (-46%)
	Dry	34 (NA)	-17 (-33%)
	Critical	21 (NA)	-7 (-25%)
	All	126 (3,150%)	-68 (-34%)
December	Wet	0 (NA)	-1 (-100%)
	Above Normal	1 (NA)	0 (0%)
	Below Normal	3 (NA)	0 (0%)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	5 (NA)	0 (0%)
January	Wet	0 (NA)	0 (NA)
	Above Normal	0 (NA)	0 (NA)
	Below Normal	0 (NA)	0 (NA)
	Dry	0 (NA)	0 (NA)
	Critical	0 (NA)	0 (NA)
	All	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

NEPA Effects: There would be no effects of Alternative 7 on spawning and egg incubation conditions in Clear Creek and no or beneficial effects in the Feather River. However, available analytical tools show conflicting results regarding the temperature effects of relatively small changes in predicted summer and fall flows in the Sacramento River. Several models (CALSIM, SRWQM, and Reclamation Egg Mortality Model) generally show no change or negligible changes in upstream conditions as a result of Alternative 7. However, one model, SacEFT, shows an 8% reduction in the percentage of years with “good” egg incubation conditions on an absolute scale. After extensive investigation of these results, they appear to be a function of high model sensitivity to relatively small changes in estimated upstream conditions, which may or may not accurately predict adverse effects. Considering the lack of effects found in all other analyses for this impact, the small decrease in egg incubation conditions found by SacEFT, and the high model sensitivity of SacEFT, the weight of evidence indicates that the effects of Alternative 7 on spring-run Chinook salmon spawning and egg incubation would not be adverse.

Impact AQUA-60: Effects of Water Operations on Migration Conditions for Chinook Salmon (Spring-Run ESU)

Alternatives 3, 4, 5 and 7 (not adverse)

Alternative 3

The effects of Alternative 3 on spring-run Chinook salmon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Sacramento River

Flows in the Sacramento River upstream of Red Bluff were evaluated during the December through May juvenile Chinook salmon spring-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would be similar to or greater than flows under NAA, except in critical years during January (8% lower).

Flows in the Sacramento River upstream of Red Bluff were evaluated during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows during April through July under A3_LLT would generally be similar to or greater than NAA except in dry water years during July (14% lower). Flows during August under A3_LLT would generally be lower than NAA by up to 18%.

Water temperatures in the Sacramento River under Alternative 3 would be the same as those under Alternative 1A Impact AQUA-60, which indicates that there would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 3.

Clear Creek

Flows in Clear Creek during the November through May juvenile Chinook salmon spring-run migration period under A3_LLT would generally be similar to or greater than flows under NAA except in critical water years during February and below normal water years during March (6% lower in both) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in Clear Creek during the April through August adult spring-run Chinook salmon upstream migration period under A3_LLT would be similar to or greater than flows under NAA in all months and water year types (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Water temperatures were not modeled in Clear Creek.

Feather River

Flows in the Feather River at the confluence with the Sacramento River were examined during the November through May juvenile Chinook salmon spring-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would generally be greater than or similar to flows under NAA, except in above normal water years during November (6% lower) and in critical water years during January (8% lower).

Flows in the Feather River at the confluence with the Sacramento River were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT during April through June would generally be similar to or greater than flows under NAA, except in critical years during June (8% lower). Flows under A3_LLT during July and August would be lower than flows under NAA by up to 48% regardless of water year type.

Water temperatures in the Feather River under Alternative 3 would be the same as those under Alternative 1A Impact AQUA-60, which indicates that there would be no differences in mean monthly water temperature between NAA and Alternative 3.

Through-Delta

The effects on through-Delta migration were evaluated using the approach described in Alternative 1A, Impact AQUA-42.

Juveniles

Juvenile salmonids migrating down the Sacramento River would generally experience lower flows below the north Delta intakes compared to baseline conditions. The two intake structures of Alternative 3 would replace aquatic habitat and likely attract piscivorous fish around the intake structures, as described above in Impact AQUA-42. Potential predation losses, as estimated by the bioenergetics model, would be 0.6% of the annual juvenile production estimated for the Sacramento Valley (Impact AQUA-42, Table 11-mult-49). A conservative assumption of 5% loss per intake would yield a cumulative loss of 8.3% of juvenile spring-run Chinook that reach the north Delta. This assumption is uncertain and represents an upper bound estimate.

Through-Delta survival to Chipps Island (DPM) by emigrating juvenile spring-run Chinook salmon under Alternative 3 would average 29.5% across all years, 24.1% in drier years, and 38.3% in wetter years (Table 11-mult-99). Compared to NAA, juvenile survival would be similar or slightly lower under Alternative 3 (up to 2.1% lower in wetter years, a 5% relative decrease).

Table 11-mult-99. Through-Delta Survival (%) of Emigrating Juvenile Spring-Run Chinook Salmon under Alternative 3

	Percentage Survival			Difference in Percentage Survival (Relative Difference)	
Month	EXISTING CONDITIONS	NAA	A3_LLT	EXISTING CONDITIONS vs. A3_LLT	NAA vs. A3_LLT
Wetter Years	42.1	40.4	38.3	-3.8 (-9%)	-2.1 (-5%)
Drier Years	24.8	24.3	24.1	-0.6 (-2%)	-0.2 (-1%)
All Years	31.3	30.3	29.5	-1.8 (-6%)	-0.9 (-3%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and Above Normal WYs (6 years).
Drier = Below Normal, Dry and Critical WYs (10 years).

Adults

During the overall spring-run upstream migration from March-June, the proportion of Sacramento River in the Delta would be similar to NAA throughout the adult migration period (Table 11-mult-31). Olfactory cues for spring-run Chinook salmon adults would be strong, as the proportion of Sacramento River under Alternative 3 would represent 61–69% of Delta outflows. This topic is discussed further in Impact AQUA-42 for Alternative 1A.

NEPA Effects: Collectively, these results indicate that Alternative 3 operations would not adversely affect upstream or through-Delta migration conditions for spring-run Chinook salmon because the alternative does not have the potential to substantially interfere with the movement of fish.

Upstream of the Delta, there would be decreases in flows during 2 of 5 months of the adult upstream migration period in the Feather River. However, there would be no other effects of Alternative 3 in the Feather River and no effects on flows or temperatures in the Sacramento River and in Clear Creek.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 3 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not be substantially affected by flow operations under Alternative 3.

Near-field effects of Alternative 3 NDD on spring-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating spring-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 2 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 8% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the 2 new intake structures will be implemented as part of the final NDD screen design effort. Alternative 3 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for spring-run Chinook salmon. This includes biologically-based triggers to adjust the amount of pumping at the NDD in response to likely fish presence.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 3 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 3 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for Chinook salmon.

Alternative 4

The effects of Alternative 4 on spring-run Chinook salmon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

H3/ESO

Sacramento River

Flows in the Sacramento River upstream of Red Bluff were evaluated during the December through May juvenile Chinook salmon spring-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would generally be up to 12% greater than flows under NAA during May and similar to flows under NAA during December through April.

Flows in the Sacramento River upstream of Red Bluff were evaluated during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 during May and June would generally be up to 12% greater than flows under NAA and similar to flows under NAA during April, July, and August.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the*

Fish Analysis). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Clear Creek

Flows in Clear Creek during the November through May juvenile Chinook salmon spring-run migration period under H3 would generally be similar to or greater than flows under NAA throughout the period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in Clear Creek during the April through August adult spring-run Chinook salmon upstream migration period under H3 would be similar to flows under NAA, except in critical water years during June (8% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Water temperatures were not modeled in Clear Creek.

Feather River

Flows in the Feather River at the confluence with the Sacramento River were examined during the November through May juvenile spring-run Chinook salmon migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 during April and May would be up to 23% greater than flows under NAA and similar to flows under NAA in the remaining months.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the November through May juvenile spring-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Flows in the Feather River at the confluence with the Sacramento River were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 during July and August would generally be up to 53% lower than flows under NAA, up to 65% greater than flows under NAA during May and June, and similar to flows under NAA during April. Although these reductions would be of moderate to large magnitude, flows under H3 during these months would generally exceed flows suggested by NMFS during the BDCP planning process at similar frequencies as those under NAA (Table 11-mult-100). Therefore, these reduced flows would not affect spring-run Chinook salmon in a biologically meaningful way.

Table 11-mult-100. Differences (Percentage Differences) in the Percentage of Years Exceeding NMFS Suggested Minimum Flows in the Feather River High-Flow Channel (at Thermalito)

	EXISTING CONDITIONS vs. H3	NAA vs. H3
Above Normal Water Year Type		
October	0 (0%)	0 (0%)
November	0 (0%)	0 (0%)
December	9.1 (50%)	-18.2 (-40%)
January	-27.3 (-60%)	0 (0%)
February	0 (0%)	0 (0%)
March	9.1 (25%)	9.1 (25%)
April	0 (NA)	0 (NA)
May	9.1 (100%)	9.1 (100%)
June	18.2 (25%)	0 (0%)
July	0 (0%)	0 (0%)
August	9.1 (10%)	0 (0%)
September	36.4 (57.2%)	0 (0%)
Below Normal Water Year Type		
October	-7.7 (-9.1%)	0 (0%)
November	-7.7 (-10%)	0 (0%)
December	0 (0%)	0 (0%)
January	-35.8 (-83.4%)	-7.2 (-50.3%)
February	-14.3 (-33.3%)	0 (0%)
March	-21.4 (-100%)	-7.1 (-100%)
April	7.1 (NA)	7.1 (NA)
May	7.1 (NA)	7.1 (NA)
June	28.6 (44.5%)	0 (0%)
July	0 (0%)	0 (0%)
August	0 (0%)	0 (0%)
September	-35.7 (-45.4%)	-50 (-53.8%)

NA = could not be calculated because the denominator was 0.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

H1/LOS

Sacramento River

Flows under H1 in the Sacramento River upstream of Red Bluff during the December through May juvenile spring-run Chinook salmon migration period would be similar to or up to 14% greater than flows under NAA depending on month and water year type (Appendix 11C, *CALSIM II Model Results* *utilized in the Fish Analysis*). Flows under H1 during the April through August adult upstream migration period would be would be similar to or up to 14% greater than flows under NAA depending on month and water year type .

September Shasta storage volume under H1 would be similar to storage volume under NAA except in wet water years (9% greater under H1) (Table 11-mult-79).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Clear Creek

Flows under H1 in Clear Creek during the November through May juvenile spring-run Chinook salmon migration period and the April through August adult upstream migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Therefore, there would be no effects of H1 on juvenile or adult spring-run Chinook salmon migration in Clear Creek relative to NAA.

Feather River

lows under H1 were evaluated in the Feather River at the confluence with the Sacramento River during the November through May juvenile spring-run Chinook salmon migration period and the April through August adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 during November through May would generally be similar to or up to 46% greater than flows under NAA depending on month and water year type. Flows under H1 during July and August would generally be up to 47% lower than flows under NAA, but similar to or up to 63% greater than flows under NAA during April through June. Although these reductions would be of moderate to large magnitude, flows under H1 during these months would generally exceed flows suggested by NMFS during the BDCP planning process at similar frequencies as those under NAA (Table 11-mult-101). Therefore, these reduced flows would not affect spring-run Chinook salmon in a biologically meaningful way.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Table 11-mult-101. Differences (Percentage Differences) in the Percentage of Years Exceeding NMFS Suggested Minimum Flows in the Feather River High-Flow Channel (at Thermalito) for H1 and H4 Model Scenarios

	EXISTING CONDITIONS vs. H1	NAA vs. H1	EXISTING CONDITIONS vs. H4	NAA vs. H4
Above Normal Water Year Type				
October	9.1 (12.5%)	9.1 (12.5%)	9.1 (12.5%)	9.1 (12.5%)
November	0 (0%)	0 (0%)	0 (0%)	0 (0%)
December	18.2 (100%)	-9.1 (-20%)	-9.1 (-50%)	-36.4 (-80%)
January	-9.1 (-20%)	18.2 (100%)	-18.2 (-40%)	9.1 (50%)
February	0 (0%)	0 (0%)	9.1 (14.3%)	9.1 (14.3%)
March	9.1 (25%)	9.1 (25%)	9.1 (25%)	9.1 (25%)
April	0 (NA)	0 (NA)	36.4 (NA)	36.4 (NA)
May	9.1 (100%)	9.1 (100%)	18.2 (200%)	18.2 (200%)
June	18.2 (25%)	0 (0%)	0 (0%)	-18.2 (-20%)
July	0 (0%)	0 (0%)	-9.1 (-9.1%)	-9.1 (-9.1%)
August	9.1 (10%)	0 (0%)	-18.2 (-20%)	-27.3 (-27.3%)
September	-45.4 (-71.4%)	-81.8 (-81.8%)	-36.3 (-57.1%)	-72.7 (-72.7%)
Below Normal Water Year Type				
October	-7.7 (-9.1%)	0 (0%)	-7.7 (-9.1%)	0 (0%)
November	-7.7 (-10%)	0 (0%)	0 (0%)	7.7 (11.1%)
December	0 (0%)	0 (0%)	0 (0%)	0 (0%)
January	-42.9 (-100%)	-14.3 (-100%)	-28.6 (-66.7%)	0 (0%)
February	-7.2 (-16.8%)	7.1 (24.8%)	-7.2 (-16.8%)	7.1 (24.8%)
March	-14.3 (-66.8%)	0 (0%)	-14.3 (-66.8%)	0 (0%)
April	0 (NA)	0 (NA)	35.7 (NA)	35.7 (NA)
May	7.1 (NA)	7.1 (NA)	14.3 (NA)	14.3 (NA)
June	28.6 (44.5%)	0 (0%)	35.7 (55.5%)	7.1 (7.6%)
July	0 (0%)	0 (0%)	-7.1 (-7.1%)	-7.1 (-7.1%)
August	0 (0%)	0 (0%)	-7.1 (-7.1%)	-7.1 (-7.1%)
September	-35.7 (-45.4%)	-50 (-53.8%)	-57.2 (-72.8%)	-71.5 (-77%)

NA = could not be calculated because the denominator was 0.

H4/HOS

Sacramento River

Flows under H4 in the Sacramento River upstream of Red Bluff during the December through May juvenile spring-run Chinook salmon migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 during the April through August adult upstream migration period would generally be similar to flows under NAA.

September Shasta storage volume under H4 would be similar to storage volume under NAA except in critical water years (6% greater under H4) (Table 11-mult-79).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Clear Creek

Flows under H4 in Clear Creek during the November through May juvenile spring-run Chinook salmon migration period and the April through August adult upstream migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*)*.* Therefore, there would be no effects of H4 on juvenile or adult spring-run Chinook salmon migration in Clear Creek relative to NAA.

Feather River

lows under H4 were evaluated in the Feather River at the confluence with the Sacramento River during the November through May juvenile spring-run Chinook salmon migration period and the April through August adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 during November through May would generally be similar to or up to 120% greater than flows under NAA depending on month and water year type. Flows during July and August would be up to 45% lower than flows under NAA, but similar to or up to 120% greater than flows under NAA during April through June. Although these reductions would be of moderate to large magnitude, flows under H4 during these months would generally exceed flows suggested by NMFS during the BDCP planning process at similar frequencies as those under NAA (Table 11-mult-101). Therefore, these reduced flows would not affect spring-run Chinook salmon in a biologically meaningful way.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Through-Delta

Juveniles

Scenario H3 operations would reduce OMR reverse flows (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*), with a corresponding increase in net positive downstream flows, during the outmigration period of Chinook salmon through the interior Delta channels. Conditions under Scenario H1 and Scenario H3 would result in slightly decreased OMR flows in April and May relative to NAA, however flows during these months would still be net positive (flowing towards the sea). OMR flows under Scenario H4 would generally be improved compared to NAA conditions during all water year types throughout the migration period. These improved net positive downstream flows would be substantial benefits of the proposed operations.

Flows downstream of the north Delta intakes would be reduced, which may increase predation potential. During the juvenile spring-run Chinook salmon emigration period (December through May), mean monthly flows under Scenario H3 in the Sacramento River below the NDD would be lower (14% to 23% reduced in monthly mean across years) compared to NAA. Flows would be up to 27% to 28% lower in April and November of above normal years. Flows below the NDD would be similar for Scenarios H3 and H1. Under the high spring outflow Scenario, H4, flows during April and May would not decrease as much (5% to 9% lower) compared to NAA.

The three North Delta intake facilities proposed on the Sacramento River under Alternative 4 would displace aquatic habitat and attract predatory fish to the structure. Potential predation at the three North Delta intakes was estimated in two ways. Bioenergetics modeling with a median predator density predicts a predation loss of about 8,200 juveniles, or 0.2% of the spring-run juvenile population under Alternative 4 (Table 11-mult-102). A conservative assumption of 5% loss per intake would yield a cumulative loss of 12% of juvenile spring-run Chinook that reach the north Delta. This assumption is uncertain and represents an upper bound estimate. In addition, the three intake structures would result in a permanent loss of 13.7 acres aquatic habitat and 7,450 linear feet of shoreline. This topic is discussed further in Impact AQUA-42 for Alternative 1A.

Table 11-mult-102. Juvenile Spring-Run Chinook Salmon Predation Loss at the proposed North Delta Diversion intakes for Alternative 4 (Three Intakes)

Striped Bass at NDD (Three Intakes)			Spring-Run Chinook Consumed	
Density Assumption	Bass per 1,000 feet of Intake	Total Number of Bass	Number	Percentage of Annual Juvenile Production
Low	18	86	1,243	0.03%
Median	119	571	8,217	0.20%
High	219	1,051	15,122	0.36%

Note: Based on bioenergetics modeling of Chinook salmon consumption by striped bass (Appendix 5F Biological Stressors).

As estimated by the Delta Passage Model, through-Delta survival under Scenario H3 by juvenile spring-run Chinook salmon Alternative 4 averaged 29% across all years, ranging from about 24% in drier years to 38% in wetter years (Table 11-mult-103). Scenario H3 survival was similar to NAA in both drier years (0.5% less survival, or 2% less in relative difference) and wetter years (2.5% reduced survival, or 6% less in relative difference) (Table 11-mult-103).

Survival under Scenario H1 (low outflow) was similar to Scenario H3 and NAA (averages around 21%) (Table 11-mult-103). Average survival under Scenario H4 (high outflow) was 30.7%, compared to 29.1% for Scenarios H1 and H3 and 30.3% for NAA. In wetter years, Scenario H4 had 2% greater survival, a 5% relative difference compared to NAA. This difference was driven by appreciably higher survival in wetter years (the above-normal year of 1980 and the wet year of 1984) as a result of greater outflow under Scenario H4.

Table 11-mult-103. Through-Delta Survival (%) of Emigrating Juvenile Spring-Run Chinook Salmon under Alternative 4 (Scenarios H3, H1 and H4)

	Average Percentage Survival					Difference in Percentage Survival (Relative Difference)					
	Scenario					EXISTING CONDITIONS vs. Alt 4 Scenario			NAA vs. Alt 4 Scenario		
Water Year Type	EXISTING CONDITIONS	NAA	H3	H1	H4	H3	H1	H4	H3	H1	H4
Wetter Years	42.1	40.4	37.9	37.9	42.4	-4.2 (-10%)	-4.2 (-10%)	0.3 (1%)	-2.5 (-6%)	-2.5 (-6%)	2.0 (5%)
Drier Years	24.8	24.3	23.7	23.8	23.7	-1.0 (-4%)	-1.0 (-4%)	-1.1 (-5%)	-0.5 (-2%)	-0.5 (-2%)	-0.6 (-3%)
All Years	31.3	30.3	29.1	29.1	30.7	-2.2 (-7%)	-2.2 (-7%)	-0.6 (-2%)	-1.3 (-4%)	-1.2 (-4%)	0.4 (1%)

Note: Average Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and Above Normal Water Years (6 years).
Drier = Below Normal, Dry and Critical Water Years (10 years).
H3 = ESO operations, H1 = Low Outflow, H4 = High Outflow.

Adults

As described for winter-run Chinook, attraction flows and olfactory cues in the west Delta would be altered because of shifts in exports from the south Delta to the north Delta. Flows in the Sacramento River downstream of the north Delta intake diversions would be reduced, with concomitant proportional increases in San Joaquin River flows. The flow changes under Scenario H3 would slightly decrease the olfactory cues for migrating adult salmon in the Sacramento River (by 9% or less compared to NAA) and slightly increase the olfactory cues for the San Joaquin River (Table 11-mult-104). Conditions under Scenario H4 are expected to reduce the magnitude of this effect because it would involve fewer exports from the north Delta compared to Scenario H3 and Scenario 1.

Table 11-mult-104. Percentage (%) of Water at Collinsville that Originated in the Sacramento during the Adult Spring-Run Chinook Salmon Migration Period for Alternative 4 (Scenario H3)

Month	EXISTING CONDITIONS	NAA	A4 (H3)	EXISTING CONDITIONS vs. A4 (H3)	NAA vs. A4 (H3)
March	78	76	68	-10	-8
April	77	75	66	-11	-9
May	69	65	59	-10	-6
June	64	62	58	-6	-4

▨ Shading indicates 10% or greater absolute difference.

NEPA Effects: Collectively, these results indicate that Alternative 4 operations would not adversely affect upstream or through-Delta migration conditions for spring-run Chinook salmon because the alternative does not have the potential to substantially interfere with the movement of fish.

Upstream of the Delta, flows in the Sacramento River and Clear Creek and water temperatures in the Sacramento and Feather Rivers would generally not be affected by Alternative 4. Flows in the Feather River would be lower during summer months, although flows would otherwise not be different from NAA.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 4 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 4.

Near-field effects of Alternative 4 NDD on spring-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating spring-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 3 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 12% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the three new intake structures will be implemented as part of the final NDD screen design effort. Alternative 4 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for spring-run Chinook salmon. This includes biologically-based triggers to adjust the amount of pumping at the NDD in response to likely fish presence.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 4 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 4 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for Chinook salmon.

Alternative 5

The effects of Alternative 5 on spring-run Chinook salmon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Sacramento River

Water temperatures in the Sacramento River under Alternative 5 would be the same as those under Alternative 1A Impact AQUA-60, which indicates that there would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 1A.

Flows in the Sacramento River upstream of Red Bluff were evaluated during the December through May juvenile Chinook salmon spring-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT during December through May would nearly always be similar to or greater than flows under NAA, except in dry years during January (5% lower).

Flows in the Sacramento River upstream of Red Bluff were evaluated during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would be similar to or greater than flows under NAA during all months except August in dry years (14% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Clear Creek

Flows in Clear Creek during the November through May juvenile Chinook salmon spring-run migration period under A5_LLT would generally be similar to or greater than flows under NAA except in critical years during March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in Clear Creek during the April through August adult spring-run Chinook salmon upstream migration period under A5_LLT would be similar to or greater than flows under NAA in all months and water year types (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Water temperatures were not modeled in Clear Creek.

Feather River

Water temperatures in the Feather River under Alternative 5 would be the same as those under Alternative 1A Impact AQUA-60, which indicates that there would be no differences in mean monthly water temperature between NAA and Alternative 1A.

Flows in the Feather River at the confluence with the Sacramento River were examined during the November through May juvenile Chinook salmon spring-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would be mostly similar to or greater than under NAA except in above normal years during November and December (6% lower for both).

Flows in the Feather River at the confluence with the Sacramento River were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT during April through July would generally be similar to or greater than flows under NAA except in dry and critical water year types during July (19% and 34% lower, respectively). Flows during August under A5_LLT would generally be lower than flows under NAA (up to 31% lower).

Through-Delta

Juveniles

During the juvenile spring-run Chinook salmon emigration period (November to May), mean monthly flows in the Sacramento River below the north Delta intake under Alternative 5 averaged across years would be 6% to 11% lower in most months, and 17% lower in November compared to NAA. Flows would be up to 23% lower in November of above normal years compared to NAA.

As described above in Impact AQUA-39, the north Delta export facilities would replace aquatic habitat and likely attract piscivorous fish around the intake structures. Estimates of potential predation losses at the single intake range from about 0.2% (bioenergetics model, Table 11-mult-56) to 4.2% (based on a fixed 5% loss per intake) of the juvenile spring-run population that reaches the Delta (Appendix 5F, *Biological Stressors*).

Through-Delta survival to Chipps Island by emigrating juvenile winter-run Chinook salmon was modeled by the DPM. Average survival under Alternative 5 would be 30% across all years, 24% in drier years, and 39% in wetter years, which is similar to modeled survival under baseline conditions (Table 11-mult-105).

Table 11-mult-105. Through-Delta Survival (%) of Emigrating Juvenile Spring-Run Chinook Salmon under Baseline and Alternative 5 Scenarios, by Year Type

	Percentage Survival			Difference in Percentage Survival (Relative Difference)	
Year Types	EXISTING CONDITIONS	NAA	A5_LLT	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Wetter Years	42.1	40.4	38.8	-3.4 (-8%)	-1.7 (-4%)
Drier Years	24.8	24.3	24.3	-0.5 (-2%)	0.0 (0%)
All Years	31.3	30.3	29.7	-1.6 (-5%)	-0.6 (-2%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and above normal water years (6 years).
Drier = Below normal, dry and critical water years (10 years).

Adults

The importance of attraction flows and olfactory cues to adult Chinook salmon migrating upstream is described in detail in Impact AQUA-42 for Alternative 1A. Olfactory cues, based on the proportion of Sacramento River flows during the spring-run adult migration, the proportion of Sacramento River flows at Collinsville would be 59% to 70% during March to May (the peak of the migration is March and April), 6% to 13% lower than NAA (Table 11-mult-58). As suggested by adult sockeye salmon, attraction due to olfactory cues could be adversely affected by dilution greater than 20%, but was not discernibly affected by dilution of 10% or less (Fretwell 1989).

NEPA Effects: Collectively, these results indicate that Alternative 5 operations would not adversely affect upstream or through-Delta migration conditions for spring-run Chinook salmon because the alternative does not have the potential to substantially interfere with the movement of fish.

Upstream of the Delta, flows under Alternative 5 would generally be similar to or greater than flows under NAA, with exceptions during some months and water year types. However, the frequency of reduced flows would not cause population level effects. Also, there would be no effects on water temperatures in the Sacramento and Feather Rivers.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 5 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 5.

Near-field effects of Alternative 5 NDD on spring-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating spring-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 1 new intake would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to larger effects (~ 4% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the 1 new intake structure will be implemented as part of the final NDD screen design effort. Alternative 5 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for spring-run Chinook salmon. This includes biologically-based triggers to adjust the amount of pumping at the NDD in response to likely fish presence.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 5 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 5 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for Chinook salmon.

Alternative 7

The effects of Alternative 7on spring-run Chinook salmon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Sacramento River

Flows in the Sacramento River upstream of Red Bluff were evaluated during the December through May juvenile Chinook salmon spring-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT during December through May would be similar to or greater than flows under NAA, except in above normal years during December (5% lower) and dry and critical years during January (7% and 11% lower, respectively).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the December through May juvenile Chinook salmon spring-run emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Flows in the Sacramento River upstream of Red Bluff were evaluated during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would be similar to or greater than flows under NAA during all months and in all water year types.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Clear Creek

Flows in Clear Creek during the November through May juvenile Chinook salmon spring-run migration period under A7_LLT would generally be similar to or greater than flows under NAA except in below normal water years during March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Flows in Clear Creek during the April through August adult spring-run Chinook salmon upstream migration period under A7_LLT would be similar to or greater than flows under NAA in all months and water year types (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Water temperatures were not modeled in Clear Creek.

Feather River

Flows in the Feather River at the confluence with the Sacramento River were examined during the November through May juvenile Chinook salmon spring-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would be mostly lower than under NAA during December. During January through May, flows under A7_LLT would generally be similar to or greater than flows under NAA except in critical years during January (10% lower) and in below normal and dry years during May (7% and 16% lower, respectively).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the November through May juvenile spring-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Flows in the Feather River at the confluence with the Sacramento River were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT during April through June would generally be similar to or greater than flows under NAA. Flows under A7_LLT during July and August would generally be lower than flows under NAA by up to 38% (monthly mean of 12% to 16% combining all water year types). These flow reductions are of too low of magnitude to affect adult spring-run Chinook salmon spawning in a biologically meaningful way.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the April through August adult spring-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Through-Delta

The effects on through-Delta migration were evaluated using the approach described in Alternative 1A, Impact AQUA-42.

Juveniles

Juvenile salmonids migrating down the Sacramento River would generally experience lower flows below the north Delta intakes compared to NAA. Predation at the north Delta would be increased at the three new intake structures, as described for Alternative 4 (Impact AQUA-60). The north Delta export facilities would replace aquatic habitat and likely attract piscivorous fish around the intake structures. The predation effects would be the same as those described for Alternative 4, which also has three proposed intakes. Potential predation losses at the north Delta intakes were estimated to range from 0.2% (bioenergetics, Table 11-mult-53) to 12.3% (fixed rate of 5% per intake), of juvenile spring-run Chinook that reach the north Delta. This assumption is uncertain and represents an upper bound estimate. For further discussion of this topic see Impact AQUA-42 for Alternative 1A.

Through-Delta survival of migrating juvenile spring-run Chinook salmon, as estimated by DPM, averaged 29% across all years, 38% in wetter years, and 24% in drier years under Alternative 7

(Table 11-mult-106). This is similar (<5% difference) to results under NAA (about 1% lower survival compared to NAA, a 5% relative decrease).

Table 11-mult-106. Through-Delta Survival (%) of Emigrating Juvenile Spring-Run Chinook Salmon under Alternative 7

	Percentage Survival			Difference in Percentage Survival (Relative Difference)	
Month	EXISTING CONDITIONS	NAA	A7_LLT	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wetter Years	42.1	40.4	38.1	-4.1 (-10%)	-2.3 (-6%)
Drier Years	24.8	24.3	23.5	-1.3 (-5%)	-0.8 (-3%)
All Years	31.3	30.3	29.0	-2.3 (-7%)	-1.4 (-5%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and Above Normal WYs (6 years).
Drier = Below Normal, Dry and Critical WYs (10 years).

Adults

During the overall spring-run upstream migration from March-June, the proportion of Sacramento River water in the Delta would decrease 11–16% in March-May relative to NAA, but would be similar to NAA in June (Table 11-mult-60).

The reductions in percentage are small in comparison with the magnitude of change in dilution reported to cause a significant change in migration by Fretwell (1989) and, therefore, are not expected to affect winter-run migration. Furthermore, olfactory cues for spring-run adults would still be strong as the proportion of Sacramento River under Alternative 7 would still represent 53–65% of Delta outflows. This topic is discussed in further detail in Impact AQUA-42 for Alternative 1A.

NEPA Effects: Collectively, these results indicate that Alternative 7 operations would not adversely affect upstream or through-Delta migration conditions for spring-run Chinook salmon because the alternative does not have the potential to substantially interfere with the movement of fish.

Upstream of the Delta, migration conditions under Alternative 7 would generally be similar to or better than those under NAA. There would be no effects of Alternative 7 on flows in the Sacramento River and Clear Creek and no effect on water temperatures in the Sacramento and Feather Rivers. Flows in the Feather River would be lower during two of five months during the adult migration period, although these reductions are not expected to be large enough or frequent enough to have a biologically meaningful effect on spring-run Chinook salmon.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 7 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 7.

Near-field effects of Alternative 7 NDD on spring-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating spring-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 3 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 12% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the three new intake structures will be implemented as part of the final NDD screen design effort. Alternative 7 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for spring-run Chinook salmon. This includes biologically-based triggers to adjust the amount of pumping at the NDD in response to likely fish presence.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 7 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 7 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for Chinook salmon.

Impact AQUA-78: Effects of Water Operations on Migration Conditions for Chinook Salmon (Fall-/Late Fall–Run ESU)

Alternative 7 (not adverse)

The effects of Alternative 7 on fall- and late fall-run Chinook salmon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Sacramento River

Fall-Run

Flows in the Sacramento River upstream of Red Bluff were examined for juvenile fall-run migrants during February through May. Flows under A7_LLT would be similar to or greater than flows under NAA throughout the juvenile fall-run migration period in all water year types (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Flows in the Sacramento River upstream of Red Bluff were examined during the adult fall-run Chinook salmon upstream migration period (August through December) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under A7_LLT would generally be similar to or slightly greater than those under NAA during August through October and December, except for lower flows in above normal or below normal years during September, October and December. Flows under A7_LLT would generally be lower during November (up to 14% lower).

Water temperatures in the Sacramento River at Red Bluff were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Late Fall-Run

Flows in the Sacramento River upstream of Red Bluff for juvenile late fall–run migrants (January through March) under A7_LLT would generally be similar to or greater than flows under NAA except in dry and critical water years during January (7% and 11% lower, respectively) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the January through March juvenile late fall-run Chinook salmon emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Flows in the Sacramento River upstream of Red Bluff during the adult late fall–run Chinook salmon upstream migration period (December through February) under A7_LLT would generally be similar to or greater than flows under NAA except in above normal water years during December (5% lower) and in dry and critical water years during January (7% and 11% lower, respectively) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the December through February adult late fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the*

Fish Analysis). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Clear Creek

Water temperature modeling was not conducted in Clear Creek.

Fall-Run

Flows in the Clear Creek below Whiskeytown Reservoir were examined for juvenile fall-run migrants during February through May. Flows under A7_LLT would generally be similar to or greater than those under NAA, except in below normal years during March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean flows in Clear Creek below Whiskeytown Reservoir during the adult fall-run Chinook salmon upstream migration period (August through December) under A7_LLT would be similar to or greater than those under NAA, except for 13% lower flow in critical water years during September (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Feather River

Fall-Run

Flows in the Feather River at the confluence with the Sacramento River were reviewed during the February through May fall-run juvenile migration period Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).Flows under A7_LLT would generally be similar to or greater than flows under NAA except in below normal and dry water years during May (7% and 16% lower, respectively).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Mean flows in the Feather River at the confluence with the Sacramento River during the August through December fall-run Chinook salmon adult migration period under A7_LLT would generally be lower by up to 33% than flows under NAA during August, September, and December, except for 74% and 15% greater flows in August and September, respectively, of critical water years (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Average flow changes across water year types from NAA to A7_LLT during August, September, and December would be -12%, -14%, and 4%, respectively. Mean flows would be up to 29% greater than flows under NAA during October and would be similar during November. These changes would not be frequent enough to cause a substantial effect to fall-run Chinook salmon adult migration.

Water temperatures in the Feather River at the confluence with the Sacramento River were examined during the August through December fall-run Chinook salmon adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

American River

Fall-Run

Flows in the American River at the confluence with the Sacramento River were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would be generally similar to or greater than flows under NAA, except for dry years during March and April (6% and 15% lower, respectively) and critical years during February, March, and April (7% to 17% lower).

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Flows in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows during September under A7_LLT would be lower by up to 15% than those under NAA, except for 15% and 27% greater flows in dry and critical years, respectively. Flows during the other four months of the migration period would generally be similar to or greater than flows under NAA, except for 50% lower flow during August of critical years and lower flows during October of above and below normal water years (13% and 12% lower, respectively).

Water temperatures in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Stanislaus River

Fall-Run

Flows in the Sacramento River at the confluence with the San Joaquin River were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would be similar to flows under NAA throughout the period. This indicates that climate change would affect juvenile migration flows in the Stanislaus River, but Alternative 7 would not.

Mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the September and October adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under A7_LLT would be similar to flows under NAA throughout the period.

Water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

San Joaquin River

Fall-Run

Flows in the San Joaquin River at Vernalis were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under Alternative 7 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the San Joaquin River at Vernalis were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under Alternative 7 would be similar to those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Fall-Run

Flows in the Mokelumne River at the Delta were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under Alternative 7 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the Mokelumne River at the Delta were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under Alternative 7 would be similar to those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the Mokelumne River.

Through-Delta

Sacramento River

The effects on through-Delta migration were evaluated using the approach described in Alternative 1A, Impact AQUA-42.

Fall-Run

Juveniles

Juvenile salmonids migrating down the Sacramento River would generally experience lower flows below the north Delta intakes compared to baseline. The north Delta export facilities would replace aquatic habitat and likely attract piscivorous fish around the three intake structures. The predation effects would be the same as those described for Alternative 4 (Impact AQUA-78). Estimates of potential predation losses at the north Delta intakes range from about 0.25% to 13% of those migrating juveniles that reach the Delta. This topic is further discussed in Impact AQUA-42 for Alternative 1A. The overall effect of the predation and habitat loss associated with the three intake structures is not considered substantial.

Through-Delta average survival by emigrating juvenile fall-run Chinook salmon under Alternative 7 (A7_LLT) would be similar for the Sacramento River, slightly greater for the Mokelumne River (1.8% greater survival, or 11% more in relative percentage), compared to NAA (Table 11-mult-107). In drier years, mean survival would be slightly greater in the Mokelumne River (1.2% more, or 7% more in relative percentage).

Table 11-mult-107. Through-Delta Survival (%) of Emigrating Juvenile Fall-Run Chinook Salmon under Alternative 7

	Percentage Survival			Difference in Percentage Survival (Relative Difference)	
Month	EXISTING CONDITIONS	NAA	A7_LLT	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Sacramento River					
Wetter Years	34.5	31.1	29.2	-5.3 (-15%)	-1.9 (-6%)
Drier Years	20.6	20.8	20.5	-0.1 (1%)	-0.3 (-1%)
All Years	25.8	24.7	23.7	-2.1 (-8%)	-0.9 (-4%)
Mokelumne River					
Wetter Years	17.2	15.7	18.5	1.3 (8%)	2.8 (18%)
Drier Years	15.6	15.9	17.1	1.5 (10%)	1.2 (7%)
All Years	16.2	15.9	17.6	1.4 (9%)	1.8 (11%)

Note: Delta Passage Model results for survival to Chipps Island.
Results for San Joaquin River runs may be anomalous when applying DPM to operations scenarios with low or no south Delta exports.
Wetter = Wet and Above Normal WYs (6 years).
Drier = Below Normal, Dry and Critical WYs (10 years).

Adults

The adult fall-run migration extends from September-December. The proportion of Sacramento River water in the Delta under Alternative 7 would be similar (<10% change) to (NAA during the adult-Fall-Run migration (Table 11-mult-60).

Flows at Rio Vista would be similar (<5% difference) between Alternative 7 and Alternative 1A in December, but substantially changed from September-November depending on year type. In Wet and above normal years Rio Vista flows would be substantially increased in September relative to Alternative 1A but would be decreased 33–46% in all years in October and November.

Late Fall-Run

Juveniles

During the late fall–run juvenile Chinook salmon migration occurs from December-May, flows at Rio Vista under Alternative 7 would be similar (<5% difference) to those predicted for Alternative 1A (Table 11-mult-108). Based on DPM results for Alternative 1A, juvenile late fall–run survival would decrease less than 0.5%.

Table 11-mult-108. Through-Delta Survival (%) of Emigrating Juvenile Late Fall–Run Chinook Salmon under Alternative 7

	Percentage Survival			Difference in Percentage Survival (Relative Difference)	
Month	EXISTING CONDITIONS	NAA	A7_LLT	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wetter Years	28.8	27.3	27.2	-1.6 (-6%)	-0.2 (-1%)
Drier Years	18.8	20.2	20.4	1.6 (9%)	0.2 (1%)
All Years	22.5	22.9	22.9	0.4 (2%)	0.0 (0%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and Above Normal WYs (6 years).
Drier = Below Normal, Dry and Critical WYs (10 years).

Adults

The adult late fall–run migration is from November through March, peaking in January through March. The proportion of Sacramento River water in the Delta would be similar to NAA from November–February, and decreased slightly in March (11%). Rio Vista flows under Alternative 7 would be similar Alternative 1A from December–March, which overlaps with the peak migration months; however Rio Vista flows would decrease 33% relative to Alternative 1A in November. Based on the similarity in Sacramento River olfactory cues and Rio Vista flows during the vast majority of the adult late fall–run migration, it is assumed that adult migration success through the Delta would be similar to those described for Alternative 1A.

San Joaquin River

Fall-Run

Juveniles

As discussed for Alternative 6A (Impact AQUA-78), the DPM can produce anomalous results for certain Alternatives and operations scenarios with highly reduced south Delta exports, such as Alternative 7. A qualitative assessment is therefore more appropriate given this modeling limitation.

There is a beneficial effect of Alternative 7 to all San Joaquin River basin fish due to positive Old and Middle River flows during migratory months resulting in San Joaquin water moving westward and contributing to Delta outflow. This is expected to decrease entrainment at South Delta facilities and reduce predation hotspots to promote greater survival to Chipps Island. Furthermore under Alternative 7, entrainment and entrainment-related mortality at the South Delta Facilities would be reduced.

Additionally, under Alternative 7, the reduction of entrainment at the South Delta Facilities would alleviate one of the primary concerns related to potential Old and Middle River corridor habitat restoration. Successful restoration in this area would be expected to enhance rearing habitat, food availability, and overall salmonid fitness and survival.

Adults

Alternative 7 would slightly increase the proportion of San Joaquin River water in the Delta in September through December by 0.8 to 7.5% compared to NAA. The proportion of San Joaquin River water would be similar or slightly more than to NAA. Therefore migration conditions under Alternative 7 would be similar to slightly improved to those described for Alternative 1A. Alternative 7 would have no effect to a slight beneficial effect on the fall-run adult migration.

NEPA Effects: Collectively, these results indicate that Alternative 7 operations would not adversely affect upstream or through-Delta migration conditions for fall-/late fall-run Chinook salmon because the alternative does not have the potential to substantially interfere with the movement of fish.

Upstream of the Delta, reservoir storage volume, instream flows, and water temperatures under Alternative 7 in all rivers in which these parameters were analyzed would generally be similar to those under the NAA.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 7 would be similar to or slightly lower than NAA, averaged across all years. Several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 7.

Near-field effects of Alternative 7 NDD on fall- and late fall-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating fall- and late fall-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 3 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 13% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the three new intake structures will be implemented as part of the final NDD screen design effort.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 7 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under

CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 7 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for Chinook salmon.

Alternative 4 (adverse/significant)

IThe effects of Alternative 4 on fall- and late fall-run Chinook salmon migration conditions relative to the NAA are adverse.

Upstream of the Delta

H3/ESO

Sacramento River

Fall-Run

Flows in the Sacramento River upstream of Red Bluff were examined for juvenile fall-run migrants during February through May (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would generally be up to 12% greater than flows under NAA during May and similar to flows under NAA during February through April.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Flows in the Sacramento River upstream of Red Bluff were examined for the adult fall-run Chinook salmon upstream migration period (August through December) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would generally be similar to or greater than those under NAA except November (5% to 18% lower, depending on water year type).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Late Fall-Run

Flows in the Sacramento River upstream of Red Bluff for juvenile late fall-run migrants (January through March) under H3 would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the January through March juvenile late fall-run Chinook salmon emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Flows in the Sacramento River upstream of Red Bluff during the adult late fall-run Chinook salmon upstream migration period (December through February) under H3 would be generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the December through February adult late fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Clear Creek

Water temperature modeling was not conducted in Clear Creek.

Fall-Run

Flows in the Clear Creek below Whiskeytown Reservoir were examined for juvenile fall-run migrants during February through May (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would generally be similar to those under NAA with few exceptions.

Flows in Clear Creek below Whiskeytown Reservoir were examined during the adult fall-run Chinook salmon upstream migration period (August through December) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would generally be similar to flows under NAA with few exceptions.

Feather River

Fall-Run

Flows in the Feather River at the confluence with the Sacramento River were reviewed for the fall-run juvenile migration period (February through May) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would generally be up to 23% greater than flows under NAA during April and May and similar to flows under NAA during February and March.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Flows in the Feather River at the confluence with the Sacramento River were reviewed for the August through December fall-run Chinook salmon adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would generally be up to 27% lower than flows under NAA in August and September but up to 22% greater than flows under NAA in October. Flows during November and December would generally be unchanged by H3.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the August through December fall-run Chinook salmon adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be negligible differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

American River

Fall-Run

Flows in the American River at the confluence with the Sacramento River were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would generally be up to 24% greater than flows under NAA during May, and similar to flows under NAA during February through April.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Flows in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows H3 would generally be up to 28% lower during August, September, and November and similar to flows under NAA during October and December. These flow reductions would cause a biologically meaningful effect to fall-run Chinook salmon migration.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be negligible differences (<5%) in mean monthly water temperature between NAA and H3 in all months and water year types throughout the period.

Stanislaus River

Fall-Run

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to those under NAA in all months and water year types throughout the period.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the September and October adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to those under NAA in all months and water year types throughout the period.

Mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

San Joaquin River

Fall-Run

Flows in the San Joaquin River at Vernalis were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the San Joaquin River at Vernalis were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Fall-Run

Flows in the Mokelumne River at the Delta were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the Mokelumne River at the Delta were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the Mokelumne River.

H1/LOS

Sacramento River

Fall-Run

Flows in the Sacramento River upstream of Red Bluff were examined for the juvenile fall-run Chinook salmon downstream migration period (February through May) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 would generally be similar to flows under NAA throughout the period.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Flows in the Sacramento River upstream of Red Bluff were examined for the adult fall-run Chinook salmon upstream migration period (August through December) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly flows under H1 would be 43 and 36% lower in wet and above normal water years, respectively, during September relative to those under NAA, and up to 29% lower during November, depending on water year type. There would be no difference in flows between NAA and H1 during August, October, and December.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Late Fall-Run

Flows in the Sacramento River upstream of Red Bluff were examined for the juvenile fall-run Chinook salmon downstream migration period (January through March) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 would generally be similar to or up to 13% higher than flows under NAA throughout the period.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the January through March juvenile late fall-run Chinook salmon emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Flows in the Sacramento River upstream of Red Bluff were examined for the adult fall-run Chinook salmon upstream migration period (December through February) (Appendix 11C, CALSIM II Model Results utilized in the Fish Analysis). Flows under H1 would generally be up to 13% greater than flows under NAA throughout the period.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the December through February adult late fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results* *utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Clear Creek

Water temperature modeling was not conducted in Clear Creek.

Fall-Run

Flows in the Clear Creek below Whiskeytown Reservoir during February through May under H1 would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows in the Clear Creek below Whiskeytown Reservoir during August through December under H1 would generally be similar to flows under NAA.

Feather River

Fall-Run

Flows in the Feather River at the confluence with the Sacramento River during the February through May juvenile fall-run Chinook salmon emigration period under H1 would be similar to or up to 17% greater than flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the February through May March juvenile fall-run Chinook salmon emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

lows in the Feather River at the confluence with the Sacramento River were examined during the August through December fall-run adult migration period. Flows under H1 would be up 69% lower during August and September relative to NAA. Flows would be up to 31% higher than flows under NAA during October and December, but similar between NAA and H1 during November. The large flow reductions are expected to have biologically meaningful effects on fall-run Chinook salmon.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the August through December fall-run Chinook salmon adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be negligible differences (<5%) in mean monthly water temperature between NAA and H1 in all months throughout the period, except for a 7% and 5% increase under H1 in wet and above normal water years during September.

American River

Fall-Run

Flows in the American River at the confluence with the Sacramento River during February through May under H1 would generally be similar to or flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model*

Results utilized in the Fish Analysis). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Flows were evaluated in the American River at the confluence with the Sacramento River during the August through December adult fall-run Chinook salmon migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 would be up to 50% lower than flows under NAA during August, September, and November, similar to those under NAA during October, and up to 12% greater during December. These frequent flow reductions would cause effects to fall-run migration.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be negligible differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Stanislaus River

Fall-Run

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 would be similar to those under NAA in all months and water year types throughout the period.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the September and October adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be negligible differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 would be similar to those under NAA in all months and water year types throughout the period.

Mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be negligible differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

San Joaquin River

Fall-Run

Flows in the San Joaquin River at Vernalis were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish*

Analysis). Flows under H1 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the San Joaquin River at Vernalis were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 would be similar to those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Fall-Run

Flows in the Mokelumne River at the Delta were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the Mokelumne River at the Delta were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 would be similar to those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the Mokelumne River.

H4/HOS

Sacramento River

Fall-Run

Flows in the Sacramento River upstream of Red Bluff were examined for the juvenile fall-run Chinook salmon downstream migration period (February through May) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would generally be similar to flows under NAA throughout the period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Flows in the Sacramento River upstream of Red Bluff were examined for the adult fall-run Chinook salmon upstream migration period (August through December) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly flows under H4 would be up to 18% higher during September relative to those under NAA, up to 18% lower during November, and similar during August, October, and December.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the*

Fish Analysis). There would be negligible differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Late Fall-Run

Flows in the Sacramento River upstream of Red Bluff were examined for the juvenile fall-run Chinook salmon downstream migration period (January through March) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would generally be similar to flows under NAA throughout the period.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the January through March juvenile late fall-run Chinook salmon emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Flows in the Sacramento River upstream of Red Bluff were examined for the adult fall-run Chinook salmon upstream migration period (December through February) (Appendix 11C, CALSIM II Model Results utilized in the Fish Analysis). Flows under H4 would generally be similar to flows under NAA throughout the period.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the December through February adult late fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Clear Creek

Water temperature modeling was not conducted in Clear Creek.

Fall-Run

Flows in the Clear Creek below Whiskeytown Reservoir during the February through May fall-run Chinook salmon juvenile migration period under H4 would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows in the Clear Creek below Whiskeytown Reservoir during the August through December fall-run Chinook salmon adult migration period under H4 would generally be similar to flows under NAA.

Feather River

Fall-Run

FFlows were evaluated in the Feather River at the confluence with the Sacramento River during the February through May juvenile late fall-run Chinook salmon emigration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would generally be similar to flows under NAA throughout the period.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the January through March juvenile late fall-run Chinook salmon emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the*

Fish Analysis). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Flows in the Feather River at the confluence with the Sacramento River were examined during August through December period. Flows during August and September under H4 would be up to 43% lower than flows under NAA depending on month and water year type. Flows in the remaining months would be variable among water year types and months but generally small. The large reductions during August and September are expected to have biologically meaningful effects on fall-run Chinook salmon.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the August through December fall-run Chinook salmon adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be negligible differences (<5%) in mean monthly water temperature between NAA and H4 in any month throughout the period.

American River

Fall-Run

Flows were evaluated in the American River at the confluence with the Sacramento River during the February through May fall-run Chinook salmon juvenile migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would be similar to flows under NAA throughout the period.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Flows were evaluated in the American River at the confluence with the Sacramento River during the August through December fall-run Chinook salmon adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would be similar to those under NAA, except during October and November, in which flows under H4 would be up to 16% lower.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be negligible differences (<5%) in mean monthly water temperature between NAA and H4 in all months and water year types throughout the period.

Stanislaus River

Fall-Run

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would be similar to those under NAA in all months and water year types throughout the period.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the September and October adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would be similar to those under NAA in all months and water year types throughout the period.

Mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

San Joaquin River

Fall-Run

Flows in the San Joaquin River at Vernalis were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the San Joaquin River at Vernalis were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would be similar to those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Fall-Run

Flows in the Mokelumne River at the Delta were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would be similar to those under NAA in all months and water year types throughout the period.

Flows in the Mokelumne River at the Delta were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would be similar to those under NAA in all months and water year types throughout the period.

Water temperature modeling was not conducted in the Mokelumne River.

Through-Delta

Sacramento River

Fall-Run

Juveniles

Alternative 4 operations would generally reduce OMR reverse flows under Scenarios H3 and H1 (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*), with a corresponding increase in net positive downstream flows, during the migration period of Chinook salmon through the interior Delta channels. Conditions under Scenario H4 would further improve overall average OMR flows compared to NAA. These improved net positive downstream flows would be substantial benefits of the proposed operations.

Predation risk at the north Delta would be increased due to the installation of the proposed SWP/CVP North Delta intake facilities on the Sacramento River. Bioenergetics modeling with a median predator density predicts a predation loss under Alternative 4 of less than 0.6% of the annual juvenile production (0.25% fall run; 0.58% late fall-run) (Table 11-4-73). A conservative assumption of 5% loss per intake would yield a cumulative loss of about 13% of juvenile fall-run and late fall-run Chinook that reach the north Delta. This assumption is uncertain and represents an upper bound estimate. For a discussion of this topic see Impact AQUA-42 for Alternative 1A.

Table 11-4-73. Fall-Run and Late Fall-Run Chinook Salmon Juvenile Predation Loss at the proposed North Delta Diversion intakes for Alternative 4 (Three Intakes)

Striped Bass at NDD (Three Intakes)			Fall-Run Chinook		Late Fall-Run Chinook	
Density	Bass per 1,000 Feet of Intake	Total Number of Bass	Number Consumed (LLT)	Percentage of Annual Production	Number Consumed (LLT)	Percentage of Annual Production
Low	18	86	23,395	0.04%	3,795	0.09%
Median	119	571	154,665	0.25%	25,089	0.58%
High	219	1,051	284,636	0.46%	46,172	1.07%

Note: Based on bioenergetics modeling of Chinook salmon consumption by striped bass (Appendix 5F Biological Stressors).

H3/ESO and H1/LOS

Flows below the north Delta intakes would be reduced during the juvenile emigration period for fall-run Chinook (February through May) and late fall-run Chinook salmon (January through March), which may increase predation potential. Mean monthly flows would decrease about 14% to 21% under H3, and decrease 15% to 27% under H1, with reductions up to 28% in April of above normal years compared to NAA.

Under Scenario H3, Through-Delta survival of Sacramento River fall-run Chinook salmon, as estimated by the Delta Passage Model, averaged 24.4% across all years, 21.7% in drier years and 29% in wetter years (Table 11-4-74). Compared to NAA, average survival under Scenario H3 would be similar across all years. Juvenile survival under Scenario H1 (low outflow) was similar to Scenario H3.

H4/HOS

Under the high outflow scenario H4, mean monthly flows would decrease by about 5% to 23% during the emigration period, with the greatest relative reduction of 28% in November of below normal years. Under H4, flow decreases in April and May would be less than 10% compared to NAA. Survival under Scenario H4 would be slightly greater than NAA (3% relative difference).

Overall, Alternative 4 would not have an adverse effect on Sacramento River fall-run Chinook salmon juvenile survival due to minor differences in survival for most operations, and slight increase in survival for the high outflow operations Scenario H4.

Table 11-4-74. Through-Delta Survival (%) of Emigrating Juvenile Fall-Run Chinook Salmon under Alternative 4 (Scenarios H3, H1 and H4)

	Average Percentage Survival					Difference in Percentage Survival (Relative Difference)					
	Scenario					EXISTING CONDITIONS vs. Alt 4 Scenario			NAA vs. Alt 4 Scenario		
Water Year Type	EXISTING CONDITIONS	NAA	H3	H1	H4	H3	H1	H4	H3	H1	H4
Sacramento											
Wetter	34.5	31.1	29.0	29.0	32.2	-5.5 (-15%)	-5.5 (-16%)	-2.3 (-7%)	-2.1 (-6%)	-2.1 (-7%)	1.1 (3%)
Drier	20.6	20.8	21.7	21.6	21.4	1.1 (7%)	1.0 (5%)	0.8 (4%)	0.9 (4%)	0.8 (4%)	0.6 (3%)
All Years	25.8	24.7	24.4	24.4	25.5	-1.4 (-1%)	-1.4 (-6%)	-0.3 (-1%)	-0.2 (-1%)	-0.3 (-1%)	0.8 (3%)
Mokelumne											
Wetter	17.2	15.7	17.2	17.2	18.0	<0.1 (<1%)	0.0 (0%)	0.8 (5%)	1.5 (9%)	1.5 (10%)	2.3 (15%)
Drier	15.6	15.9	15.8	15.8	16.1	0.2 (1%)	0.2 (1%)	0.5 (3%)	-0.1 (-1%)	-0.1 (-1%)	0.2 (1%)
All Years	16.2	15.9	16.3	16.4	16.8	0.1 (1%)	0.2 (1%)	0.6 (4%)	0.5 (3%)	0.5 (3%)	0.9 (6%)
San Joaquin											
Wetter	19.3	20.3	17.0	17.0	16.7	-2.4 (-12%)	-2.3 (-12%)	-2.6 (-13%)	-3.3 (-16%)	-3.3 (-16%)	-3.6 (-18%)
Drier	10.0	9.5	11.0	11.0	10.7	1.0 (10%)	1.0 (10%)	0.7 (7%)	1.4 (14%)	1.5 (16%)	1.2 (13%)
All Years	13.5	13.6	13.2	13.2	12.9	-0.3 (-2%)	-0.3 (-2%)	-0.6 (-4%)	-0.3 (-3%)	-0.4 (-3%)	-0.7 (-5%)

Note: Average Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and Above Normal Water Years (6 years).
Drier = Below Normal, Dry and Critical Water Years (10 years).
H3 =ESO operations, H1 = Low Outflow, H4 = High Outflow.

Adults

Attraction flows and olfactory cues in the west Delta for migrating adults would be altered because of shifts in exports from the south Delta to the North Delta under Alternative 4. Sacramento River flows downstream of the north Delta diversion would be reduced, with concomitant increase in San Joaquin River flow contribution.

Results of fingerprint simulation modeling (DSM2 modeling of percentage of water at Collinsville that originated in the Sacramento River water) for Scenario H3 predicted a minimal reduction in Sacramento River source water September–November (1–3% less) compared with NAA (Table 11-4-75). The effect would be even lower under Scenario H4 because exports from the north Delta would be lower than under Scenario H3 and H1. Studies indicate that a 10% or less reduction in source flows that provides olfactory cues would not adversely affect adult attraction (Fretwell 1989). The reduction in olfactory cues under Scenario H3 is small and is expected to be within the broad range of olfactory cues and migration conditions that currently occur within the lower reach of the Sacramento River.

Table 11-4-75. Percentage (%) of Water at Collinsville that Originated in the Sacramento River and San Joaquin River during the Adult Fall-Run and Late Fall-Run Chinook Salmon Migration Period for Alternative 4 (Scenario H3)

	Scenario			Percentage Difference	
Month	EXISTING CONDITIONS	NAA	A4 (H3)	EXISTING CONDITIONS vs. A4 (H3)	NAA vs. A4 (H3)
Fall-Run—Sacramento River					
September	60	65	63	3	-2
October	60	68	67	7	-1
November	60	66	63	3	-3
December	67	66	66	-1	0
Fall-Run—San Joaquin River					
September	0.3	0.1	1.2	0.9	1.1
October	0.2	0.3	3.3	3.1	3
November	0.4	1.0	4.9	4.5	3.9
December	0.9	1.0	2.9	2	1.9
Late Fall-Run—Sacramento River					
December	67	66	66	-1	0
January	76	75	73	-3	-2
February	75	72	68	-7	-4
March	78	76	68	-10	-8

▨ Shading indicates 10% or greater absolute difference.

Late Fall-Run

Juveniles

Alternative 4 operations would generally reduce OMR reverse flows under all flow scenarios (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*), with a corresponding increase in net positive downstream flows that would benefit juveniles migrating through the Delta. Reduced flows below the north Delta intakes may increase predation potential. Through-Delta survival by emigrating juvenile late fall-run Chinook salmon under Scenario H3 averaged 23% across all years, 20.5% in drier years, and 27.3% in wetter years (Table 11-4-76). Juvenile survival under the Scenario H3 was similar or slightly greater than under NAA for drier, wetter and all years averaged (around 1% more in relative difference) (Table 11-4-76). Overall, Alternative 4 would not have an adverse effect on late fall-run Chinook salmon juvenile survival due to similar survival between Alternative 4 and NAA during all water year types.

Table 11-4-76. Through-Delta Survival (%) of Emigrating Juvenile Late Fall-Run Chinook Salmon under Alternative 4 (Scenarios H3, H1, and H4)

Water Year Type	Average Percentage Survival					Difference in Percentage Survival (Relative Difference)					
	Scenario					EXISTING CONDITIONS vs. Alt 4 Scenario			NAA vs. Alt 4 Scenario		
	EXISTING CONDITIONS	NAA	H3	H1	H4	H3	H1	H4	H3	H1	H4
Wetter	28.8	27.3	27.3	26.9	27.2	-1.4 (-5%)	-1.9 (-7%)	-1.6 (-5%)	0.0 (0%)	-0.4 (-2%)	-0.1 (0%)
Drier	18.8	20.2	20.5	19.7	20.2	1.7 (9%)	0.9 (5%)	1.4 (7%)	0.3 (1%)	-0.5 (-2%)	0.0 (0%)
All Years	22.5	22.9	23.0	22.4	22.8	0.5 (2%)	-0.1 (0%)	0.3 (1%)	0.2 (1%)	-0.5 (-2%)	-0.1 (0%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and Above Normal Water Years (6 years).
Drier = Below Normal, Dry and Critical Water Years (10 years)

Adults

Flows in the Sacramento River downstream of the north Delta intake diversions would be reduced under Alternative 4, with concomitant proportional increases in San Joaquin River flows. Under Scenario H3, the percentage of Sacramento River water at Collinsville would be unchanged in December, and slightly reduced (2% to 8%) in January through March compared to NAA (Table 11-4-75). This effect would be less under Scenario H4 compared to Scenarios H3 and H1 because it would involve fewer exports from the north Delta. The effect on olfactory cues for migrating adults late fall-run Chinook salmon would be negligible because the change in flow proportions is less than 10%.

Mokelumne River

Fall-Run

Juveniles

Through-Delta survival of Mokelumne River fall-run Chinook salmon under Scenario H3 averaged 16% across all years and water year types (Table 11-4-58). Survival under Scenario H3 was similar to NAA averaged across all years (0.5% greater, or 3% more in relative difference) and in drier years (a 1% relative difference), and 1.5% increase in survival (an 9% relative difference) in wetter years. Juvenile survival under Scenario H1 (low outflow) and H4 (high outflow) was similar to Scenario H3 and NAA in drier years, slightly increased averaged across all years. In wetter years, survival increased 1.5% (10% relative difference) under Scenario H1 and 2.3% under Scenario H4 (a 15% relative difference). Overall, Alternative 4 would not have an adverse effect on fall-run Chinook salmon juvenile survival due to minor differences in survival for most operations, and slight increase in survival for the high outflow years or operations Scenario H4.

San Joaquin River

Fall-Run

Juveniles

Under Alternative 4 Scenario H3 operations, through-Delta survival by juvenile fall-run Chinook salmon emigrating from the San Joaquin River averaged 13% across all years, 11% in drier years, and 17% in wetter years (Table 11-4-74). Compared to NAA, average survival was similar for all years averaged for all operations scenarios (H3, H1, and H4). Survival is slightly increased in drier years (1% greater, a 13-16% relative difference). Survival is greatest in wetter years, but is slightly reduced relative to NAA by about 3% (16–18% relative difference for Scenarios H1, H3, and H4). Overall, Alternative 4 would not have an adverse effect on through-Delta migration due to minor differences in survival.

Adults

The percentage of water at Collinsville that originated from the San Joaquin River is very small (no more than 1% under NAA) during the fall-run migration period (September to December). The fingerprinting analysis showed a small increase in olfactory cues from the San Joaquin River passing downstream through the Delta under Scenario H3 (Table 11-4-75). Although the relative change is substantial (i.e., close to double the percentage of flow in the San Joaquin under Scenario H3 than under NAA), the percentage of flow attributable to San Joaquin River water under all scenarios is quite low (no more than 5%). Scenario H4 would not have as great a relative change because exports at the north Delta diversion would be lower than under Scenarios H3 and H1. Overall, Alternative 4 operations conditions would incremental increase olfactory cues associated with attraction flows in the lower San Joaquin River, but the increase would be small. This would not be an adverse effect on adult fall-run Chinook salmon migrating to the San Joaquin River.

NEPA Effects: Collectively, these results indicate that Alternative 4 operations adversely affect migration conditions for fall-/late fall-run Chinook salmon because the alternative has the potential to substantially interfere with the movement of fish in upstream habitats.

Upstream of the Delta, reductions in flows in the Sacramento, American, and Feather rivers during the fall-run Chinook salmon adult upstream migration period would be of high enough magnitude and frequency to cause biologically meaningful effect on fall- and late fall-run Chinook salmon migration. Flows reductions would generally be more severe under H1 compared to H3 and less severe under H4 compared to H3.

n the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 4 would be similar to or slightly lower than NAA, averaged across all years. Several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 4.

Near-field effects of Alternative 4 NDD on fall- and late fall-run Chinook salmon related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating fall- and late fall-run Chinook salmon, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 3 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 13% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the three new intake structures will be implemented as part of the final NDD screen design effort. Alternative 4 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for fall- and late fall-run Chinook salmon. This includes biologically-based triggers to adjust the amount of pumping at the NDD in response to likely fish presence.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 4 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 4 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for Chinook salmon.

Overall, the adverse upstream effects are a result of the specific reservoir operations and resulting flows associated with this alternative. Applying mitigation (e.g., changing reservoir operations in order to alter the flows) to the extent necessary to reduce this effect to a level that is not adverse for H1 and H2 scenarios would fundamentally change the alternative, thereby making it a different alternative than that which has been modeled and analyzed. As a result, this would be an unavoidable adverse effect because there is no feasible mitigation available. Even so, proposed mitigation (Mitigation Measure AQUA-78a through AQUA-78d) has the potential to reduce the severity of impact (including reducing the effect of H3 and H4 to a level that would not be biologically meaningful), although not necessarily to a not adverse level.

CEQA Conclusion: In general, Alternative 4 would degrade the migration conditions for fall-/late fall-run Chinook salmon relative to Existing Conditions.

Upstream of the Delta

H3/ESO

Sacramento River

Fall-Run

Flows in the Sacramento River upstream of Red Bluff were examined for juvenile fall-run migrants during February through May (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would generally be up to 14% greater than those under Existing Conditions during May, and similar to flows under Existing Conditions during February through April.

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H3 in any month throughout the period. There would be a 5% increase in water temperatures in wet water years during May.

Flows in the Sacramento River upstream of Red Bluff were examined during the adult fall-run Chinook salmon upstream migration period (August through December) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H3 would generally be lower (up to 26% lower) than those under Existing Conditions during August and November, and would be similar to or greater (by up to 55%) than those under Existing Conditions during the other three months of the migration period, with minor exceptions.

Water temperatures in the Sacramento River at Red Bluff were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H3 for all water year types combined would be 5% to 7% higher than those under Existing Conditions during August through October, and would be similar (<5% difference) to those Existing Conditions during November and December.

Late Fall-Run

Flows in the Sacramento River upstream of Red Bluff for juvenile late fall-run migrants (January through March) under H3 would generally be similar to flows under Existing Conditions, with few exceptions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the January through March juvenile late fall-run Chinook salmon emigration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H3 in any month or water year type, except in critical years during January (5% higher).

Flows in the Sacramento River upstream of Red Bluff during the adult late fall-run Chinook salmon upstream migration period (December through February) under H3 would generally be similar to flows under Existing Conditions, with few exceptions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River at Red Bluff were examined during the December through February adult late fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H3 in any month throughout the period, except in critical years during January (5% higher).

Clear Creek

Fall-Run

Flows in Clear Creek below Whiskeytown Reservoir were examined during the juvenile fall-run Chinook salmon upstream migration period (February through May). Flows under H3 would generally be greater than those under Existing Conditions during March and similar to flows under Existing Conditions during February, April, and May (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean flows in Clear Creek below Whiskeytown Reservoir during the adult fall-run Chinook salmon upstream migration period (August through December) under H3 would generally be similar to those under Existing Conditions, except for 25% and 28% lower flows during August and September of critical water years (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Water temperature modeling was not conducted in Clear Creek

Feather River

Fall-Run

Flows in the Feather River at the confluence with the Sacramento River during the fall-run juvenile migration period (February through May) under H3 would generally be similar to flows under Existing Conditions, with few exceptions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H3 in any month throughout the period.

Flows in the Feather River at the confluence with the Sacramento River were examined during the August through December fall-run Chinook salmon adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Differences in mean flows between H3 and Existing Conditions would be highly variable during the adult upstream migration period. Flows would generally be lower during August (up to 46% lower for dry water years) and would generally be higher during September and October (up to 108% higher during September of wet years). However, in some water year types during September and October, flows under H3 would be up to 28% lower than those under Existing Conditions. During November and December, flows would generally be similar between H3 and Existing Conditions, with some exceptions, including 20% lower flow during November of wet years).

Water temperatures in the Feather River at the confluence with the Sacramento River were examined during the August through December fall-run Chinook salmon adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). Mean water temperatures for all water year types combined would be 5% to 6% higher under H3 than under Existing Conditions for August, November and December, and the means for individual year types would be higher for the majority of water year types in September and October.

American River

Fall-Run

Flows in the American River at the confluence with the Sacramento River were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*)*.* Flows under H3 would generally be up to 27% greater than flows under Existing Conditions during February and March, up to 31% lower during May, and similar to flows under Existing Conditions during April.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H3 would be 5% to 7% higher than under Existing Conditions in all month except April, in which there would be no difference.

Flows in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*)*.* Mean flows under H3 would be 25% to 54% lower than flows under Existing Conditions during August, September, and November, and would be lower (up to 25% lower) than those under Existing Conditions in the majority of water year types during December. Flows would be similar to or up to 26% greater than flows under Existing Conditions during October, except for 16% lower flow in wet years

Water temperatures in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis). Mean monthly water temperatures under H3 for all water year types combined would be 6% to 11% higher than those under Existing Conditions during August through November, and would be similar during December.

Stanislaus River

Fall-Run

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 throughout this period would generally be lower than Existing Conditions (up to 36% lower), except in wet water years, in which flows would be similar or up to 8% greater than flows under Existing Conditions.

Mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model*

Results utilized in the Fish Analysis). Mean monthly water temperatures under H3 would be 6% higher than those under Existing Conditions in every month of the period.

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H3 would be lower than flows under Existing Conditions during the majority of months and water year types of the adult migration period, with flows up to 23% lower during August of wet years.

Water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H3 for all water year types combined would be 5% to 7% higher than those under Existing Conditions during August, September, November, and December. Mean temperatures for individual water year types would be 5% higher under H3 during October of wet and critical years.

San Joaquin River

Fall-Run

Flows in the San Joaquin River at Vernalis were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly flows under H3 would generally be similar to flows under Existing Conditions in all months. Wetter water years under H3 would have similar or greater flows than those under Existing Conditions, whereas drier years would have lower flows under H3.

Flows in the San Joaquin River at Vernalis were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H3 would be up to 25% lower than those under Existing Conditions during August through October, and would be largely similar during November and December.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Fall-Run

Flows in the Mokelumne River at the Delta were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to or up to 15% greater than those under Existing Conditions during February and March, but up to 18% lower than flows under Existing Conditions during April and May.

Flows in the Mokelumne River at the Delta were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H3 would be up to 51% lower than flows under Existing Conditions during August, up to 29% lower during September, and up to 14% lower during October through November. Flows during December would generally be higher under H3 than under Existing Conditions.

Water temperature modeling was not conducted in the Mokelumne River.

H1/LOS

Sacramento River

Fall-Run

Mean monthly flows and water temperatures in the Sacramento River at Red Bluff were examined during the February through May juvenile fall-run Chinook salmon migration period. Flows under H1 would generally be similar to or up to 13% higher than flows under Existing Conditions depending on month and water year type (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H1 in any month throughout the period, except in wet water years during May (5% increase) (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Mean monthly flows and water temperatures in the Sacramento River at Red Bluff were examined during the August through December adult fall-run Chinook salmon upstream migration period. Mean flows under H1 would generally be up to 20% lower than flows under Existing Conditions during August and November, and would be 23%and 12% lower during September of wet and dry years, respectively (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows during September of other water year types and during October and December would generally be similar to flows under Existing Conditions, with minor exceptions. Mean monthly water temperatures for all water year types combined under H1 would be 5% to 6% greater than those under Existing Conditions during August through October, and would be similar between H1 and Existing Conditions during November and December (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Late Fall-Run

Mean monthly flows and water temperatures in the Sacramento River at Red Bluff were examined during the January through March juvenile late fall-run Chinook salmon emigration period. Mean monthly flows under H1 would generally be similar to flows under H3 (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H1 in any month or water year type, except in critical years during January (5% higher). (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Mean monthly flows and water temperatures in the Sacramento River at Red Bluff were examined during the December through February adult late fall-run Chinook salmon migration period. Mean monthly flows under H1 would generally be similar to or up to 22% higher than flows under Existing Conditions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H1 in any month throughout the period, except in critical years during January (5% higher) (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Clear Creek

Fall-Run

Flows in the Clear Creek below Whiskeytown Reservoir during February through May under H1 would generally be similar to flows under Existing Conditions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows in the Clear Creek below Whiskeytown Reservoir during August through December under H1 would generally be similar to flows under Existing Conditions, except for 17% and 28% lower flows during August and September of critical water years..

Water temperature modeling was not conducted in Clear Creek.

Feather River

Fall-Run

Mean monthly flows and water temperatures in the Feather River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period. Flows under H1 would generally be similar to or up to 20% greater than flows under Existing Conditions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H1 in any month throughout the period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Flows and water temperatures in the Feather River at the confluence with the Sacramento River were examined during the August through December fall-run Chinook salmon adult upstream migration period. Mean flows under H1 would generally be up to 39% lower than flows under Existing Conditions during August and September, and generally up to 35% greater than flows under Existing Conditions during October (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows during November and December would generally be similar to flows under Existing Conditions, except for 16% and 22% higher flows in December of above normal and below normal years and 12% and 10% lower flows in November of wet and below normal years. Mean monthly water temperatures for all water year types combined during August, September, November, and December would be 5% to 7% higher under H1 than under Existing Conditions, but there would be no differences during October (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

American River

Fall-Run

Mean monthly flows and water temperatures in the American River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period. Flows under H1 would generally be up to 28% higher than flows under Existing Conditions during February and March, similar to flows under Existing Conditions during April, and up to 32% lower than flows under Existing Conditions during May (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H1 would be 5% to 7% higher than under Existing Conditions in all month except April, in which there would be no difference (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Flows in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H1 would be lower than flows under Existing Conditions for all water year types during August, September, and November (up to 55%, 54% and 41% lower for August, September, and November, respectively) and would be up to 20% lower than flows under Existing Conditions during December. Flows during October would be up to 11% lower than those under Existing Conditions in wet and above normal years, 31% greater than those under Existing Conditions in below normal years, and similar in dry and critical years. Mean monthly water temperatures under H1 for all water year types combined would be 6% to 11% higher than those under Existing Conditions during August through November and would be similar for December (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Stanislaus River

Fall-Run

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 throughout this period would generally be lower than Existing Conditions (up to 36% lower), except in wet water years, in which flows would be similar or up to 7% greater than flows under Existing Conditions.

Mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H1 would be 6% higher than those under Existing Conditions in every month of the period.

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H1 would be lower than flows under Existing Conditions during most months and water year types of the adult migration period, with flows up to 23% lower during August of wet years.

Mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H1 for all water year types combined would be 5% to 6% higher than those under Existing Conditions during August, September, November and December, but there would be no difference (<5%) in the mean monthly water temperatures between H1 and Existing Conditions during October.

San Joaquin River

Fall-Run

Flows in the San Joaquin River at Vernalis were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly flows under H1 would generally be similar to flows under Existing

Conditions in all months. Wetter water years under H1 would have similar or greater flows than those under Existing Conditions, whereas drier years would have lower flows under H1.

Flows in the San Joaquin River at Vernalis were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H1 would generally be 5% and 25% lower than those under Existing Conditions during August through October, and would generally be similar during November and December.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Fall-Run

Flows in the Mokelumne River at the Delta were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H1 would be similar to or up to 15% higher than those under Existing Conditions during February and March, but up to 18% lower than flows under Existing Conditions during April and May.

Flows in the Mokelumne River at the Delta were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H1 would be up to 51% lower than flows under Existing Conditions during August through September, up to 14% lower during October through November, and would be similar to or up to 15% higher than flows under Existing Conditions during December.

Water temperature modeling was not conducted in the Mokelumne River.

H4/HOS

Sacramento River

Fall-Run

Mean monthly flows and water temperatures in the Sacramento River at Red Bluff were examined during the February through May juvenile fall-run Chinook salmon migration period. Flows under H4 would generally be similar to or up to 11% higher than flows under Existing Conditions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H4 in any month throughout the period, except in wet water years during May (5% increase) (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Mean monthly flows and water temperatures in the Sacramento River at Red Bluff were examined during the August through December adult fall-run Chinook salmon upstream migration period. Mean flows under H4 would generally be similar to or up to 68% greater than flows under Existing Conditions, except during November, when flows would be up to 13% lower, and during August of critical years when the mean flow would be 16% lower than under Existing Conditions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H4 for all water year types combined would not be different from those under Existing Conditions during September, November and December, but would be 5% greater than those under Existing Conditions during August and October (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Late Fall-Run

Mean monthly flows and water temperatures in the Sacramento River at Red Bluff were examined during the January through March juvenile late fall-run Chinook salmon emigration period. Mean monthly flows under H4 would generally be similar to or up to 11% higher than flows under Existing Conditions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in water temperature between Existing Conditions and H4 in any month or water year type. (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Mean monthly flows and water temperatures in the Sacramento River at Red Bluff were examined during the December through February adult late fall-run Chinook salmon migration period. Mean monthly flows under H4 would generally be similar to or up to 11% higher than flows under Existing Conditions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H4 in any month throughout the period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Clear Creek

Fall-Run

Flows in the Clear Creek below Whiskeytown Reservoir during February through May under H4 would generally be similar to flows under H3 (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows in the Clear Creek below Whiskeytown Reservoir during August through December under H4 would generally be similar to flows under Existing Conditions, except for 17% and 28% lower flows during August and September, respectively, of critical water years.

Water temperature modeling was not conducted in Clear Creek.

Feather River

Fall-Run

Mean monthly flows and water temperatures in the Feather River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period. Flows under H4 would generally be similar to or up to 112% greater than flows under Existing Conditions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between Existing Conditions and H4 in any month throughout the period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Mean monthly flows and water temperatures in the Feather River at the confluence with the Sacramento River were examined during the August through December fall-run Chinook salmon adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H4 would generally be lower than flows under Existing Conditions during August and October through December, including flows 16% to 54% lower during August and 5% to 22% lower during October through December. During September, flows would be 43% to

95% higher than flows under Existing Conditions during wet, above normal and critical water years, but would be 22% to 30% lower during below normal and dry years. Mean monthly water temperatures under H4 for all water year types combined would be similar to those under Existing Conditions during September, but 5% to 7% higher during August and October through November (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

American River

Fall-Run

Mean monthly flows and water temperatures in the American River at the confluence with the Sacramento River were examined during the February through May juvenile fall-run Chinook salmon migration period. Flows under H4 would generally be up to 27% higher than flows under Existing Conditions during February, similar during March and April, and up to 35% lower during May (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H4 would be 5% to 7% higher than under Existing Conditions in all month except April, in which there would be no difference (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Flows and water temperatures in the American River at the confluence with the Sacramento River were examined during the August through December adult fall-run Chinook salmon upstream migration period. Mean flows under H4 would generally be up to 53% lower than flows under Existing Conditions during August through November, and would be similar to flows under Existing Conditions during December, except for 21% and 15% lower flows during December of dry and critical years (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H4 for all water year types combined would be 6% to 11% higher than those under Existing Conditions during August through November and would be similar to temperatures under Existing Conditions during December (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*).

Stanislaus River

Fall-Run

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 throughout this period would generally be lower than Existing Conditions (up to 36% lower), except in wet water years, in which flows would be similar or up to 7% greater than flows under Existing Conditions.

Mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the February through May juvenile fall-run Chinook salmon migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H4 would be 6% higher than those under Existing Conditions in every month of the period.

Flows in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H4 would be lower than flows under Existing Conditions during most months and water year types of the adult migration period (up to 23% lower, August of wet years).

Mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). Mean monthly water temperatures under H4 for all water year types combined would be 5% to 6% higher than those under Existing Conditions during all five months of the adult migration period.

San Joaquin River

Fall-Run

Flows in the San Joaquin River at Vernalis were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean monthly flows under H4 would generally be similar to flows under Existing Conditions in all months. Wetter water years under H4 would have similar or greater flows than those under Existing Conditions, whereas drier years would have lower flows under H4.

Flows in the San Joaquin River at Vernalis were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H4 would generally be up to 25% lower than those under Existing Conditions during August through October, and would generally be similar to flows under Existing Conditions during November and December.

Water temperature modeling was not conducted in the San Joaquin River. Mokelumne River

Fall-Run

Flows in the Mokelumne River at the Delta were examined during the February through May juvenile Chinook salmon fall-run migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H4 would be similar to or up to 15% higher than those under Existing Conditions during February and March, but up to 18% lower than flows under Existing Conditions during April and May.

Flows in the Mokelumne River at the Delta were examined during the August through December adult fall-run Chinook salmon upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Mean flows under H4 would be up to 51% lower than flows under Existing Conditions during August, up to 29% lower than those under Existing Conditions during September, and up to 13% lower during October through November. Flows during December would be up to 15% greater than those under Existing Conditions.

Water temperature modeling was not conducted in the Mokelumne River.

Through-Delta

Sacramento River

Fall-Run

Juveniles

As described above, Scenario H3 operations would reduce overall OMR reverse flows and reduce Sacramento River flows below the north Delta diversions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Survival of Sacramento River juveniles under Scenarios H3 and H1 averaged for all years was similar to Existing Conditions, with a slight increase in drier years (about 1% greater, or a 5% relative difference) and about 5% decrease (a 16% relative difference) in wetter years (Table 11-4-74). Under Scenario H4 average survival was similar (1% relative decrease) to Existing Conditions for all years, drier years and wetter years.

Table 11-4-74. Through-Delta Survival (%) of Emigrating Juvenile Fall-Run Chinook Salmon under Alternative 4 (Scenarios H3, H1 and H4)

Water Year Type	Average Percentage Survival					Difference in Percentage Survival (Relative Difference)					
	Scenario					EXISTING CONDITIONS vs. Alt 4 Scenario			NAA vs. Alt 4 Scenario		
	EXISTING CONDITIONS	NAA	H3	H1	H4	H3	H1	H4	H3	H1	H4
Sacramento											
Wetter	34.5	31.1	29.0	29.0	32.2	-5.5 (-15%)	-5.5 (-16%)	-2.3 (-7%)	-2.1 (-6%)	-2.1 (-7%)	1.1 (3%)
Drier	20.6	20.8	21.7	21.6	21.4	1.1 (7%)	1.0 (5%)	0.8 (4%)	0.9 (4%)	0.8 (4%)	0.6 (3%)
All Years	25.8	24.7	24.4	24.4	25.5	-1.4 (-1%)	-1.4 (-6%)	-0.3 (-1%)	-0.2 (-1%)	-0.3 (-1%)	0.8 (3%)
Mokelumne											
Wetter	17.2	15.7	17.2	17.2	18.0	<0.1 (<1%)	0.0 (0%)	0.8 (5%)	1.5 (9%)	1.5 (10%)	2.3 (15%)
Drier	15.6	15.9	15.8	15.8	16.1	0.2 (1%)	0.2 (1%)	0.5 (3%)	-0.1 (-1%)	-0.1 (-1%)	0.2 (1%)
All Years	16.2	15.9	16.3	16.4	16.8	0.1 (1%)	0.2 (1%)	0.6 (4%)	0.5 (3%)	0.5 (3%)	0.9 (6%)
San Joaquin											
Wetter	19.3	20.3	17.0	17.0	16.7	-2.4 (-12%)	-2.3 (-12%)	-2.6 (-13%)	-3.3 (-16%)	-3.3 (-16%)	-3.6 (-18%)
Drier	10.0	9.5	11.0	11.0	10.7	1.0 (10%)	1.0 (10%)	0.7 (7%)	1.4 (14%)	1.5 (16%)	1.2 (13%)
All Years	13.5	13.6	13.2	13.2	12.9	-0.3 (-2%)	-0.3 (-2%)	-0.6 (-4%)	-0.3 (-3%)	-0.4 (-3%)	-0.7 (-5%)

Note: Average Delta Passage Model results for survival to Chipps Island.

Wetter = Wet and Above Normal Water Years (6 years).

Drier = Below Normal, Dry and Critical Water Years (10 years).

H3 =ESO operations, H1 = Low Outflow, H4 = High Outflow.

Adults

The percentage of Sacramento River origin flow at Collinsville, would be slightly increased (3–7% in September to November) under Scenario H3 compared to Existing Conditions (Table 11-4-75). This would not significantly affect olfactory cues for adults migrating to the Sacramento River because the change is less than 10%.

Table 11-4-75. Percentage (%) of Water at Collinsville that Originated in the Sacramento River and San Joaquin River during the Adult Fall-Run and Late Fall-Run Chinook Salmon Migration Period for Alternative 4 (Scenario H3)

	Scenario			Percentage Difference	
Month	EXISTING CONDITIONS	NAA	A4 (H3)	EXISTING CONDITIONS vs. A4 (H3)	NAA vs. A4 (H3)
Fall-Run—Sacramento River					
September	60	65	63	3	-2
October	60	68	67	7	-1
November	60	66	63	3	-3
December	67	66	66	-1	0
Fall-Run—San Joaquin River					
September	0.3	0.1	1.2	0.9	1.1
October	0.2	0.3	3.3	3.1	3
November	0.4	1.0	4.9	4.5	3.9
December	0.9	1.0	2.9	2	1.9
Late Fall-Run—Sacramento River					
December	67	66	66	-1	0
January	76	75	73	-3	-2
February	75	72	68	-7	-4
March	78	76	68	▨ -10	-8

▨ Shading indicates 10% or greater absolute difference.

Late Fall-Run

Juveniles

As described above, Alternative 4 operations would reduce OMR reverse flows and reduce Sacramento River flows below the north Delta diversions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Conditions under Scenario H4 would further improve OMR flow conditions relative to the Scenario H3 and LOS. As estimated by DPM, through-Delta survival by emigrating juvenile late fall-run Chinook salmon under Scenario H3 was slightly increased averaged across all years (0.5% greater survival, a 2% relative difference) compared to Existing Conditions (Table 11-4-76). Survival was greater in drier years (1.7% increase, a 9% relative difference) but reduced in wetter years (1.4%, a 5% relative difference).

Table 11-4-76. Through-Delta Survival (%) of Emigrating Juvenile Late Fall-Run Chinook Salmon under Alternative 4 (Scenarios H3, H1, and H4)

Water Year Type	Average Percentage Survival					Difference in Percentage Survival (Relative Difference)					
	Scenario					EXISTING CONDITIONS vs. Alt 4 Scenario			NAA vs. Alt 4 Scenario		
	EXISTING CONDITIONS	NAA	H3	H1	H4	H3	H1	H4	H3	H1	H4
Wetter	28.8	27.3	27.3	26.9	27.2	-1.4 (-5%)	-1.9 (-7%)	-1.6 (-5%)	0.0 (0%)	-0.4 (-2%)	-0.1 (0%)
Drier	18.8	20.2	20.5	19.7	20.2	1.7 (9%)	0.9 (5%)	1.4 (7%)	0.3 (1%)	-0.5 (-2%)	0.0 (0%)
All Years	22.5	22.9	23.0	22.4	22.8	0.5 (2%)	-0.1 (0%)	0.3 (1%)	0.2 (1%)	-0.5 (-2%)	-0.1 (0%)

Note: Delta Passage Model results for survival to Chipps Island.
Wetter = Wet and Above Normal Water Years (6 years).
Drier = Below Normal, Dry and Critical Water Years (10 years)

Adults

As described above, the percentage of Sacramento River water would be slightly reduced in December and March (1% to 10% less) compared to NAA (Table 11-4-75). This effect would be less under Scenario H4 compared to Scenarios H3 and H1 due to reduced north Delta exports. Olfactory cues would be slightly decreased, but the impact would be less minor because flow changes are than 10% for the bulk of the late fall-run migration.

Overall, the impact on migration conditions from Alternative 4 operations (Scenarios H3, H1 and H4) is considered less than significant due to similar juvenile survival during all water year types and minor effect on olfactory cues.

Overall, conditions would be similar across all flow scenarios under Alternative 4. No mitigation would be required.

Mokelumne River

Fall-Run

Through-Delta survival of emigrating juveniles estimated by DPM under Alternative 4 operations (Scenarios H3, H1, and H4) was similar to Existing Conditions for all years, drier years, and wetter years (less than 1% absolute difference in survival, and no more than 5% relative difference) (Table 11-4-74).

San Joaquin River

Fall-Run

Juveniles

Under Alternative 4 (all operation Scenarios H3, H1 and H4), mean survival of juveniles migrating from the San Joaquin River averaged around 13% (Table 11-4-74). Alternative 4 survival was similar to Existing Conditions for all years (less than 1% absolute difference, a 2–4% relative difference). Survival was slightly greater in drier years (about 1 % greater survival, or 10% more in relative difference) and slightly reduced in wetter years (about 2% decrease, or 12–13% less in relative difference).

Adults

As described above, the percentage of San Joaquin River water is very small (no more than 1% under NAA) during the fall-run migration period (September to December). Under Scenario H3 operations, this would increase by 1–3% in September and October, 4.5% in November, and 2% in December (Table 11-4-75). Olfactory cues for adults migrating to the San Joaquin River would be slightly increased under all flows scenarios for Alternative 4.

Summary of CEQA Conclusion

Collectively, these modeling results indicate that the impact of Alternative 4 would be significant because movement conditions would be substantially reduced. Flows under Alternative 4 would be substantially reduced during large portions of the migration periods analyzed. In addition water temperatures would be elevated and would cause thermal stress to migrating individuals. The impact of Alternative 4 across the operational range (Scenarios H3, H1 low outflow, and H4 high outflow) on through-Delta migration conditions would be negligible due to similar juvenile survival and minor effect on olfactory cues for adults. Although this impact would be significant to fall-/late fall-run Chinook salmon migration, the impact on the Chinook salmon commercial fishery would be less than significant because the commercial fishery relies primarily on Central Valley-wide production of hatchery fish, which is not generally affected by adult return numbers.

This impact is a result of the specific reservoir operations and resulting flows associated with this alternative. Applying mitigation (e.g., changing reservoir operations in order to alter the flows) to the extent necessary to reduce this impact to a less-than-significant level would fundamentally change the alternative, thereby making it a different alternative than that which has been modeled and analyzed. As a result, this impact is significant and unavoidable because there is no feasible mitigation available. Even so, proposed below is mitigation that has the potential to reduce the severity of impact though not necessarily to a less-than-significant level.

Mitigation Measure AQUA-78a: Following Initial Operations of CM1, Conduct Additional Evaluation and Modeling of Impacts to Fall-/Late Fall–Run Chinook Salmon to Determine Feasibility of Mitigation to Reduce Impacts to Migration Conditions

Although analysis conducted as part of the EIR/EIS determined that Alternative 4 would have significant and unavoidable adverse effects on migration habitat, this conclusion was based on the best available scientific information at the time and may prove to have been over- or understated. Upon the commencement of operations of CM1 and continuing through the life of the permit, the BDCP proponents will monitor effects on migration habitat in order to determine whether such effects would be as extensive as concluded at the time of preparation of this document and to determine any potentially feasible means of reducing the severity of such effects. This mitigation measure requires a series of actions to accomplish these purposes, consistent with the operational framework for Alternative 4.

The development and implementation of any mitigation actions shall be focused on those incremental effects attributable to implementation of Alternative 4 operations only. Development of mitigation actions for the incremental impact on migration habitat attributable to climate change/sea level rise are not required because these changed conditions would occur with or without implementation of Alternative 4.

Mitigation Measure AQUA-78b: Conduct Additional Evaluation and Modeling of Impacts on Fall-/Late Fall–Run Chinook Salmon Migration Conditions Following Initial Operations of CM1

Following commencement of initial operations of CM1 and continuing through the life of the permit, the BDCP proponents will conduct additional evaluations to define the extent to which modified operations could reduce impacts to migration habitat under Alternative 4. The analysis required under this measure may be conducted as a part of the Adaptive Management and Monitoring Program required by the BDCP (Chapter 3 of the BDCP, Section 3.6).

Mitigation Measure AQUA-78c: Consult with NMFS and CDFW to Identify and Implement Potentially Feasible Means to Minimize Effects on Fall-/Late Fall–Run Chinook Salmon Migration Conditions Consistent with CM1

In order to determine the feasibility of reducing the effects of CM1 operations on fall-run/late fall-run Chinook salmon habitat, the BDCP proponents will consult with NMFS and the Department of Fish and Wildlife to identify and implement any feasible operational means to either effects on migration habitat. Any such action will be developed in conjunction with the ongoing monitoring and evaluation of habitat conditions required by Mitigation Measure AQUA-78a.

If feasible means are identified to reduce impacts on migration habitat consistent with the overall operational framework of Alternative 4 without causing new significant adverse impacts on other covered species, such means shall be implemented. If sufficient operational flexibility to reduce effects on fall-run/late fall-run Chinook salmon habitat is not feasible under Alternative 4 operations, achieving further impact reduction pursuant to this mitigation measure would not be feasible under this Alternative, and the impact on fall-run/late fall-run Chinook salmon would remain significant and unavoidable.

Impact AQUA-96: Effects of Water Operations on Migration Conditions for Steelhead

Alternatives 3, 4, 5, and 7 (not adverse)

Alternative 3

The effects of Alternative 3 on steelhead migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Sacramento River

Water temperatures in the Sacramento River under Alternative 3 would be the same as those under Alternative 1A, which indicates that temperatures would not be different during the periods evaluated relative to NAA.

Juveniles

Flows in the Sacramento River upstream of Red Bluff were evaluated during the October through May juvenile steelhead migration period. Flows under A3_LLT would be 10% to 37% lower than flows under NAA during November depending on water year type, they would be up to 22% higher during October, December, April, and May (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT in the January and February would be similar to flows under NAA with some higher and lower flows in certain water years.

Water temperatures in the Sacramento River under Alternative 3 would be the same as those under Alternative 1A, which indicates that temperatures would not be different during the periods evaluated relative to NAA.

Adults

Flows in the Sacramento River upstream of Red Bluff were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would be lower than flows under NAA during September depending on water year type, lower by 10% to 37% in November, and generally similar to flows under NAA in the remaining six months of the period.

Kelts

Flows in the Sacramento River upstream of Red Bluff were evaluated during the March and April steelhead kelt downstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows during March would be similar to NAA flows but higher in below normal, critical and above normal years (up to 13% higher) and flow would be higher during April (up to 13% higher) except for being similar to NAA in critical years.

Overall in the Sacramento River, Alternative 3 would not result in biologically meaningful effects on juvenile, adult, or kelt steelhead migration based on mean monthly flows and water temperatures.

Clear Creek

Water temperature modeling was not conducted in Clear Creek.

Juveniles

Flows in Clear Creek during the October through May juvenile steelhead migration period under A3_LLT would be similar to flows under NAA except in critical years during October, November and January (7%, 9% and 7% higher, respectively), in critical years in February (6% lower), and in below normal years in March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in Clear Creek during the September through March adult steelhead migration period under A3_LLT would similar to flows under NAA except in critical years during September, October, November and January (13%, 7%, 9% and 7% higher, respectively), in critical years in February (6% lower), and in below normal years in March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Kelts

Flows in Clear Creek during the March through April steelhead kelt downstream migration period under A3_LLT would be similar to or greater flows under NAA except for lower flows in below normal years in March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Overall in Clear Creek, Alternative 3 would not have biologically meaningful effects on juvenile, adult, or kelt steelhead migration.

Feather River

Water temperatures in the Feather River under Alternative 3 would be the same as those under Alternative 1A, which indicates that temperatures would not be different during the periods evaluated relative to NAA.

Juveniles

Flows in the Feather River at the confluence with the Sacramento River were examined during the October through May juvenile steelhead migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would be similar to or greater than flows under NAA in all months and water years except during October in above normal years (6% lower) and January in critical years (8% lower).

Adults

Flows in the Feather River at the confluence with the Sacramento River were examined during the September through March adult steelhead upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would be similar to or greater than flows under NAA in all months and water years except during September in below normal years (31% lower), October in above normal years (6% lower) and January in critical years (8% lower).

Kelts

Flows in the Feather River at the confluence with the Sacramento River were examined during the March and April steelhead kelt downstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would generally be greater than those under NAA in both months (up to 22% higher).

Overall in the Feather River, project-related effects of Alternative 3 consist of negligible changes in water temperature, and negligible effects (<5%) on mean monthly flow or increases in flow that would have a beneficial effect on migration conditions for juvenile, adult and kelt steelhead.

American River

Water temperatures in the American River under Alternative 3 would be the same as those under Alternative 1A, which indicates that temperatures would not be different during the periods evaluated relative to NAA.

Juveniles

Flows in the American River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would be similar to or greater than flows under

NAA during the entire period except for lower flows in dry and critical years in March (7% and 9% lower).

Adults

Flows in the American River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would be similar to or greater than flows under NAA during the entire period except for lower flows in dry and critical years in March (7% and 9% lower) and would be lower during September for all water year types except dry and critical years (16% to 50% lower).

Kelts

Flows in the American River at the confluence with the Sacramento River were evaluated for the March and April kelt migration period. Flows under A3_LLT would generally be similar to flows under NAA except in dry and critical years during March (7% and 9% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Overall in the American River, results indicate that project-related effects of Alternative 3 consist of negligible effects on temperature, negligible effects (<5%) on flow or increases in flow that would have beneficial effects on migration conditions, with decreases in flow that would be infrequent, of small magnitude, or would occur in wetter water years that would not have biologically meaningful effects on juvenile, adult, or kelt steelhead migration conditions in the American River.

Stanislaus River

Water temperatures in the Stanislaus River under Alternative 3 would be the same as those under Alternative 1A, which indicates that temperatures would not be different during the periods evaluated relative to NAA.

Juveniles

Flows in the Stanislaus River at the confluence with the San Joaquin River were evaluated during the October through May juvenile steelhead migration period. Flows under A3_LLT would be similar to flows under NAA during the entire period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in the Stanislaus River at the confluence with the San Joaquin River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would be similar flows under NAA during the entire period.

Kelts

Flows in the Stanislaus River at the confluence with the San Joaquin River were evaluated for the March and April kelt migration period. Flows under A3_LLT would be similar to under NAA for both months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Overall in the Stanislaus River, there would be no effects of Alternative 3 on flows or water temperatures during the juvenile, adult, or kelt steelhead migration periods.

San Joaquin River

Water temperature modeling was not conducted in the San Joaquin River.

Juveniles

Flows in the San Joaquin River at Vernalis were evaluated during the October through May juvenile steelhead migration period. Flows under A3_LLT would be similar to flows under NAA during the entire period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in the San Joaquin River at Vernalis were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would be similar flows under NAA during the entire period.

Kelts

Flows in the San Joaquin River at Vernalis were evaluated for the March and April kelt migration period. Flows under A3_LLT would be similar to under NAA for both months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mokelumne River

Water temperature modeling was not conducted in the Mokelumne River.

Juveniles

Flows in the Mokelumne River were evaluated during the October through May juvenile steelhead migration period. Flows under A3_LLT would be similar to flows under NAA during the entire period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in the Mokelumne River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A3_LLT would be similar flows under NAA during the entire period.

Kelts

Flows in the Mokelumne River were evaluated for the March and April kelt migration period. Flows under A3_LLT would be similar to under NAA for both months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

The through-Delta methodology for assessing steelhead Delta migration habitat conditions is fully described in the analysis of Alternative 1A.

Sacramento River

Juveniles

Based on DPM results for Chinook salmon (Impact AQUA-42 for Alternative 3), steelhead survival would not be expected to decrease more than 0.5% under Alternative 3.

Adults

The upstream adult steelhead migration occurs from September–March, peaking during December-February. The steelhead kelt downstream migration occurs from January–April. The proportion of Sacramento River water in the Delta under Alternative 3 would to be similar (<10% difference) to NAA during the majority (October–March) of the adult steelhead upstream migration, including during the peak migration months (Table 11-3-14). The proportion of Sacramento River water decreases in September compared to NAA (13%). Based on the overall similarity in Sacramento River flow olfactory cues, especially during the adult upstream and kelt downstream migration periods, the effects would be expected to be similar. Alternative 3 would not have an adverse effect on adult and kelt steelhead migration through the Delta.

San Joaquin River

Juveniles

The only changes to San Joaquin River flows at Vernalis would result from the modeled effects of climate change on inflows to the river downstream of Friant Dam and reduced tributary inflows. There no flow changes associated with the Alternatives. Alternative 3 would have no effect on steelhead migration success through the Delta.

Adults

Alternative 3 would slightly increase the proportion of San Joaquin River water in the Delta in September through December by 1.9% compared to NAA (Table 11-3-14). Therefore, Alternative 3 would have no effect on the adult steelhead and kelt migration because olfactory cues and flow conditions would be relatively unchanged.

Based on DPM, through-Delta juvenile steelhead survival would not be expected to decrease more than 0.5% under Alternative 3. Alternative 3 would also not have an adverse effect on Sacramento River adult and kelt steelhead migration through the Delta. Alternative 3 would also have no effect on the San Joaquin River juvenile and adult steelhead and kelt through-Delta migrations because olfactory cues and flow conditions would be relatively unchanged.

NEPA Effects: Collectively, these results indicate that Alternative 3 operations would not adversely affect upstream or through-Delta migration conditions for Central Valley steelhead because the alternative does not have the potential to substantially interfere with the movement of fish.

Upstream of the Delta, Alternative 3 would have negligible effects on water temperatures in the Sacramento, Feather, American, and Stanislaus Rivers, and effects on flow would consist of negligible effects (<5% difference), beneficial effects (increases in flow to 84%), or reductions in flow that would not have biologically meaningful effects on migration conditions based on the infrequency of occurrence throughout a relatively long migration period (to -68%), moderate magnitude (i.e., more routine reductions in flow to -16%), and/or timing of the reduction (i.e., larger reductions in wetter water years when effects on migration would not be critical).

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 3 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 3.

Near-field effects of Alternative 3 NDD on Sacramento River steelhead related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating steelhead, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 2 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 12% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the 2 new intake structures will be implemented as part of the final NDD screen design effort. Alternative 3 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for steelhead.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 3 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 3 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for steelhead.

Alternative 4

The effects of Alternative 4 on steelhead migration conditions relative to the NAA are not adverse.

Upstream of the Delta

H3/ESO

Sacramento River

Juveniles

Sacramento River flow upstream of Red Bluff during the juvenile steelhead migration period (October through May) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*) is used to represent flow conditions in the mainstem of the upper river below Keswick Dam. Flows under H3 during this period would generally be similar to flows under NAA, except during November, during which flows would be up to 18% lower than flows under NAA. These reductions would not have a biologically meaningful effect on steelhead juvenile migration because reductions occur during only one of eight months of the period.

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Overall, these results indicate that H3 would not have biologically meaningful effects on juvenile migration conditions.

Adults

Instream flows upstream of Red Bluff were compared monthly over the period from September through March under H3 and NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 during this period would generally be similar to flows under NAA, except during November, during which flows would be up to 18% lower than flows under NAA. These reductions would not have a biologically meaningful effect on steelhead adult migration because reductions occur during only one of seven months of the period.

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Kelts

Average Sacramento River flows upstream of Red Bluff under H3 during March and April (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*) would generally be similar to flows under NAA. Therefore, H3 would not affect kelt migration in the Sacramento River.

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Overall in the Sacramento River, these results indicate that H3 would not have biologically meaningful effects on juvenile, adult, or kelt steelhead migration in the Sacramento River.

Clear Creek

No water temperature modeling was conducted in Clear Creek.

Juveniles

Flows in Clear Creek at Whiskeytown were evaluated for the juvenile steelhead migration period (October through May) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to or greater than flows under NAA throughout the period. These results indicate that effects of H3 on flows would not affect juvenile steelhead migration conditions in Clear Creek.

Adults

Flows in Clear Creek at Whiskeytown were evaluated for the September through March adult steelhead migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to or greater than flows under NAA throughout the period. These results indicate that effects of Alternative 4 on flows would not affect adult steelhead migration conditions in Clear Creek.

Kelts

Flows in Clear Creek at Whiskeytown were evaluated for the March through April kelt steelhead migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under H3 would be similar to or greater than flows under NAA throughout the period. These results indicate that H3 would not affect kelt steelhead migration conditions in Clear Creek.

Overall in Clear Creek, these results indicate that effects of H3 on flows would not affect juvenile, adult, or kelt steelhead migration.

Feather River

Juveniles

Flows in the Feather River at Thermalito Afterbay (high-flow channel) and at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows in the high-flow channel under H3 would generally be similar to or greater than flows under NAA throughout the period. Increases in flow would have a beneficial effect on migration conditions, particularly in drier water years during some months (up to 54% greater flows).

Flows under H3 in the Feather River at the confluence with the Sacramento River during October through May would generally be similar to or greater than flows under NAA, except in above normal water years during November (6% lower) and December (8% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). These isolated reductions would not have biologically meaningful effects on juvenile steelhead migration conditions.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the*

Fish Analysis). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Overall, there would be no biologically meaningful effects H3 on juvenile migration conditions in the Feather River.

Adults

Flows in the Feather River at Thermalito Afterbay (high-flow channel) and at the confluence with the Sacramento River were evaluated during the September through March adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). e Flows in the high-flow channel under H3 would generally be similar to or greater than flows under NAA, except during September, in which flows would be up to 42% lower depending on water year type. These flow reductions would be isolated and would, therefore, not have a biologically meaningful effect on adult steelhead migration conditions. Flows in the Feather River at the confluence with the Sacramento River under H3 would generally be similar to or greater than flows under NAA, except during September, in which flows would be up to 27% lower depending on water year type. These flow reductions would be isolated and would, therefore, not have a biologically meaningful effect on adult steelhead migration conditions.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Kelts

Flows in the Feather River at the Thermalito Afterbay and at the confluence with the Sacramento River were evaluated during the March and April kelt migration period. Flows at Thermalito under H3 during March and April would generally be similar to or up to 54% greater than flows under NAA. Flows at the confluence with the Sacramento River would generally be similar to or up to 14% greater than flows under NAA. These results indicate that H3 would not affect kelt steelhead migration conditions in the Feather River.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Overall in the Feather River, H3 would not have biologically meaningful effects on juvenile, adult, or kelt steelhead migration.

American River

Juveniles

Flows in the American River at the confluence with the Sacramento River (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*) were evaluated for the juvenile steelhead migration period (October through May). Flows under H3 would generally be similar to flows under NAA, except during November, in which flows would be up to 8% lower depending on water year type, and during May, in which flows would be up to 24% greater depending on water year type. Increases and decreases would be too rare to have biologically meaningful effects on juvenile steelhead migration.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Based on generally negligible effects or increases in mean monthly flow and negligible effects on water temperature, effects of H3 on flows would not affect juvenile steelhead migration in the American River.

Adults

Flows in the American River at the confluence with the Sacramento River (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*) were evaluated for the September through March adult migration period. Flows would generally be similar to flows under NAA, except during September and November, in which flows would be up to 18% lower depending on month and water year type. These reductions would be too rare to cause biologically meaningful effects on adult steelhead migration.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Kelts

Flows in the American River at the confluence with the Sacramento River (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*) were evaluated for the March through April kelt migration period. Flows under H3 would generally be similar to flows under NAA during this period, except for small reductions in flows in dry and critical years during March (5% to 6% lower).

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Overall in the American River, the effects of H3 on flows would not affect juvenile, adult, or kelt migration conditions.

Stanislaus River

Flows in the Stanislaus River at the confluence with the San Joaquin River for H3 are not different from flows under NAA for any month. Therefore, there would be no effect of H3 on juvenile, adult, or kelt migration in the Stanislaus River.

Further, mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River for H3 are not different from flows under NAA for any month. Therefore, there would be no effect of H3 on juvenile, adult, or kelt migration in the Stanislaus River.

San Joaquin River

Flows in the San Joaquin River at Vernalis for H3 are not different from flows under NAA for any month. Therefore, there would be no effect of H3 on juvenile, adult, or kelt migration in the San Joaquin River.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Flows in the Mokelumne River at the Delta for H3 are not different from flows under NAA for any month. Therefore, there would be no effect of H3 on juvenile, adult, or kelt migration in the Mokelumne River.

Water temperature modeling was not conducted in the Mokelumne River.

H1/LOS

Sacramento River

Juveniles

Flows under H1 in the Sacramento River upstream of Red Bluff during the October through May juvenile steelhead migration period would generally be similar to flows under NAA, except during November, in which flows would be up to 28% lower, and during December through February and May, in which flows would be up to 14% higher (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Adults

Flows under H1 in the Sacramento River upstream of Red Bluff during the September through March adult steelhead migration period would generally be similar to flows under NAA, except during November, in which flows would be up to 28% lower, and during December through February, in which flows would be up to 13% higher (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis)*.

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Kelts

Flows under H1 in the Sacramento River upstream of Red Bluff during the March through April adult steelhead migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Clear Creek

No water temperature modeling was conducted in Clear Creek.

Juveniles

lows under H1 in Clear Creek at Whiskeytown during the October through May juvenile migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

lows under H1 in Clear Creek at Whiskeytown during the September through March adult migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Kelts

lows under H1 in Clear Creek at Whiskeytown during the March through April kelt migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Feather River

Juveniles

Flows under H1 in the Feather River at Thermalito Afterbay and the confluence with the Sacramento River during the October through May juvenile migration period would generally be similar to or up to 55% greater than flows under NAA depending on location, month, and water year type (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Adults

Flows under H1 in the Feather River at Thermalito Afterbay and the confluence with the Sacramento River during the September through March adult migration period would generally be similar to or up to 55% greater than flows under NAA, except during September, in which flows would be up to

86% lower depending on water year type and location (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Kelts

Flows under H1 in the Feather River at Thermalito Afterbay and the confluence with the Sacramento River during the March through April kelt migration period would generally be similar to or up to 47% greater than flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

American River

Juveniles

Flows under H1 in the American River at the confluence with the Sacramento River during the October through May juvenile migration period would generally be similar to flows under NAA, except during December and May, in which flows would be up to 27% higher, and during November, in which flows would be up to 11% lower (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Adults

Flows under H1 in the American River at the confluence with the Sacramento River during the September through March adult migration period would generally be similar to flows under NAA except during September and November, in which flows would be up to 49% lower than flows under NAA, and during December, in which flows would be up to 12% higher (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H3 in any month or water year type throughout the period.

Kelts

Flows under H1 in the American River at the confluence with the Sacramento River during the March through April kelt migration period would generally be similar to flows under NAA with few exceptions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H1 in any month or water year type throughout the period.

Stanislaus River

Flows in the Stanislaus River at the confluence with the San Joaquin River for H1 are not different from flows under NAA for any month. Therefore, there would be no effect of H1 on juvenile, adult, or kelt migration in the Stanislaus River.

Further, mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River for H1 are not different from flows under NAA for any month. Therefore, there would be no effect of H1 on juvenile, adult, or kelt migration in the Stanislaus River.

San Joaquin River

Flows in the San Joaquin River at Vernalis for H1 are not different from flows under NAA for any month. Therefore, there would be no effect of H1 on juvenile, adult, or kelt migration in the San Joaquin River.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Flows in the Mokelumne River at the Delta for H1 are not different from flows under NAA for any month. Therefore, there would be no effect of H1 on juvenile, adult, or kelt migration in the Mokelumne River.

Water temperature modeling was not conducted in the Mokelumne River.

H4/HOS

Sacramento River

Juveniles

Flows under H4 in the Sacramento River upstream of Red Bluff during the October through May juvenile steelhead migration period would generally be similar to flows under NAA, except during November (up to 16% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis)*.

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Adults

Flows under H4 in the Sacramento River upstream of Red Bluff during the September through March adult steelhead migration period would generally be similar to flows under NAA, except during September, in which flows would be up to 18% higher, and during November, in which flows would be up to 16% lower (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Kelts

Flows under H4 in the Sacramento River upstream of Red Bluff during the March through April adult steelhead migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Clear Creek

No water temperature modeling was conducted in Clear Creek.

Juveniles

lows under H4 in Clear Creek at Whiskeytown during the October through May juvenile migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

lows under H4 in Clear Creek at Whiskeytown during the September through March adult migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Kelts

lows under H4 in Clear Creek at Whiskeytown during the March through April kelt migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Feather River

Juveniles

lows under H4 in the Feather River at Thermalito Afterbay and the confluence with the Sacramento River during the October through May juvenile migration period would generally be similar to or up to 518% greater than flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Adults

Flows under H4 in the Feather River at Thermalito Afterbay and the confluence with the Sacramento River during the September through March adult migration period would generally be similar to flows under NAA, except during September and December, in which flows would be up to 60% lower depending on water year type and location (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Kelts

Flows under H4 in the Feather River at Thermalito Afterbay and the confluence with the Sacramento River during the March through April kelt migration period would generally be similar to or greater than flows under H3 during March and up to 518% higher during April (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

American River

Juveniles

Flows under H4 in the American River at the confluence with the Sacramento River during the October through May juvenile migration period would generally be similar to flows under NAA, except during October and November in which flows would be up to 16% lower (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). These reductions would not be large or frequent enough to have biologically meaningful effects on juvenile steelhead migration conditions.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Adults

Flows under H4 in the American River at the confluence with the Sacramento River during the September through March adult migration period would generally be similar to flows under H3, except during October and November in which flows would be up to 16% lower under H3 (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). These reductions would not be large or frequent enough to have biologically meaningful effects on adult steelhead migration conditions.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Kelts

Flows under H4 in the American River at the confluence with the Sacramento River during the March through April kelt migration period would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and H4 in any month or water year type throughout the period.

Stanislaus River

Flows in the Stanislaus River at the confluence with the San Joaquin River for H4 are not different from flows under NAA for any month. Therefore, there would be no effect of H4 on juvenile, adult, or kelt migration in the Stanislaus River.

Further, mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River for H4 are not different from flows under NAA for any month. Therefore, there would be no effect of H4 on juvenile, adult, or kelt migration in the Stanislaus River.

San Joaquin River

Flows in the San Joaquin River at Vernalis for H4 are not different from flows under NAA for any month. Therefore, there would be no effect of H4 on juvenile, adult, or kelt migration in the San Joaquin River.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Flows in the Mokelumne River at the Delta for H4 are not different from flows under NAA for any month. Therefore, there would be no effect of H4 on juvenile, adult, or kelt migration in the Mokelumne River.

Water temperature modeling was not conducted in the Mokelumne River.

Through-Delta

Sacramento River

Juveniles

Alternative 4 operations would generally reduce OMR reverse flows under all flow scenarios, with a corresponding increase in net positive downstream flows, during the outmigration period of steelhead through the interior Delta channels (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Conditions under Scenario H4 would further improve overall average OMR flows relative to other flow scenarios under Alternative 4. These improved net positive downstream flows would be substantial benefits of the proposed operations.

Predation at the north Delta would be increased due to the construction of the proposed SWP/CVP water export facilities on the Sacramento River. It is assumed that per capita steelhead predation losses would be similar to those predicted for spring-run Chinook salmon, although slightly reduced because of the larger size of steelhead outmigrants. Bioenergetics modeling with a median predator density of 0.12 predators per foot (0.39 predators per meter) of intake predicts a predation loss of about 0.2% of the juvenile spring-run population (Table 11-4-26).

Based on DPM results for Chinook salmon (Impact 42 for Alternative 4), steelhead survival would not be expected to change more than 1% under Alternative 4. Also, steelhead juveniles are larger than Chinook salmon juveniles in general, and therefore would be less vulnerable to predation during migration. Therefore the effect on juvenile steelhead outmigration success through the Delta under Alternative 4 would not be adverse.

Adults

The upstream adult steelhead migration occurs from September–March, peaking during December-February. The steelhead kelt downstream migration occurs from January–April. The proportion of Sacramento River water in the Delta under Alternative 4 would to be similar (<10% difference) to NAA throughout the adult steelhead upstream migration (Table 11-mult-109). Under Alternative 4 Scenario H3 Sacramento River flows at Rio Vista would be reduced, but the effect would similar or improved relative to Alternative 1A's effects (Impact AQUA-96) in all months of the adult upstream migration and kelt downstream migration periods, except in October. Rio Vista flows would be similar between all the flow scenarios under Alternative 4 from October–March. However, in September, average flows under Scenario H4 at Rio Vista would be 46% less compared to Scenario H3 and 67% less compared to NAA. Because the effect under Alternative 1A would not be adverse, Alternative 4 would also not have an adverse effect on adult and kelt steelhead migration through the Delta.

San Joaquin River

Juveniles

The only changes to San Joaquin River flows at Vernalis would result from the modeled effects of climate change on inflows to the river downstream of Friant Dam and reduced tributary inflows. There no flow changes associated with the Alternatives. Alternative 4 would have no effect on steelhead migration success through the Delta.

Adults

Alternative 4 Scenario H3 would slightly increase the proportion of San Joaquin River water in the Delta in September through December by 1.1 to 3.9 % (compared to NAA) (Table 11-mult-109). The proportion of San Joaquin River water under Scenario H3 would be similar or slightly more than NAA. Conditions under Scenario H4 are expected to reduce the magnitude of this effect because it would involve fewer exports from the north Delta compared to Scenario H3 and the LOS.

Table 11-mult-109. Percentage (%) of Water at Collinsville that Originated in the Sacramento River and San Joaquin River during the Adult Steelhead Migration Period for Alternative 4

Month	EXISTING CONDITIONS	NAA	A4	EXISTING CONDITIONS vs. A4	NAA vs. A4
Sacramento River					
September	60	65	63	3	-2
October	60	68	67	7	-1
November	60	66	63	3	-3
December	67	66	66	-1	0
January	76	75	73	-3	-2
February	75	72	68	-7	-4
March	78	76	68	-10	-8
San Joaquin River					
September	0.3	0.1	1.2	0.9	1.1
October	0.2	0.3	3.3	3.1	3
November	0.4	1.0	4.9	4.5	3.9
December	0.9	1.0	2.9	2	1.9
January	1.6	1.7	3.1	1.5	1.4
February	1.4	1.5	3.4	2	1.9
March	2.6	2.8	5.5	2.9	2.7
▨	Shading indicates 10% or greater absolute difference.				

NEPA Effects: Collectively, these results indicate that Alternative 4 operations would not adversely affect upstream or through-Delta migration conditions for Central Valley steelhead because the alternative does not have the potential to substantially interfere with the movement of fish.

Upstream of the Delta,. effects of Alternative 4 in all locations analyzed would consist primarily of negligible effects on mean monthly flow and water temperatures for the juvenile, adult, and kelt migration periods. Effects of Alternative 4 on upstream water temperatures would also be negligible.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 4 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 4.

Near-field effects of Alternative 4 NDD on Sacramento River steelhead related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating steelhead, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 3 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 12% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the three new intake structures will be implemented as part of the final NDD screen design effort. Alternative 4 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for steelhead.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 4 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 4 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for steelhead.

Alternative 5

The effects of Alternative 5 on steelhead migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Sacramento River

Juveniles

Flows in the Sacramento River upstream of Red Bluff were evaluated during the October through May juvenile steelhead migration period. Flows under A5_LLT would be higher than NAA in some water years in October (up to 13% higher), 8% to 21% lower than flows under NAA during November depending on water year type, lower and higher in individual water years in December and January, higher in most water years (up to 11% higher) in May and generally similar in February, March and April (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Water temperatures in the Sacramento River under Alternative 5 would be the same as those under Alternative 1A, which indicates that temperatures would not be different under Alternative 1A during the periods evaluated relative to NAA.

Adults

Flows in the Sacramento River upstream of Red Bluff were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would be higher than NAA in wet and critical water years (6% and 23%, respectively) and lower in below normal water years (15% lower) in September, higher than NAA in some water years in October (up to 13% higher), 8% to 21% lower than flows under NAA during November depending on water year type, lower and higher in individual water years in December and January, and generally similar in February and March.

Kelts

Flows in the Sacramento River upstream of Red Bluff were evaluated during the March and April steelhead kelt downstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows during these two months would be minimally different between NAA and A5_LLT with lower flows in dry years (5% lower) and higher flows in critical years (6% higher) in March and somewhat higher flows in above normal (5%) and below normal (6%) years in April.

Overall in the Sacramento River, Alternative 5 would not have biologically meaningful effects on juvenile, adult, or kelt steelhead migration based on mean monthly flows and water temperatures.

Clear Creek

Water temperatures were not modeled in Clear Creek.

Juveniles

Flows in Clear Creek during the October through May juvenile Chinook steelhead migration period under A5_LLT would generally be similar to or greater than flows under NAA except in below normal years in March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in Clear Creek during the September through March adult steelhead migration period under A5_LLT would generally be similar to or greater than flows under NAA except in below normal years in March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Kelts

Flows in Clear Creek during the March through April steelhead kelt downstream migration period under A5_LLT would generally be similar to flows under NAA except in below normal years in March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Overall, these results indicate that juvenile, adult, or kelt steelhead migration conditions in Clear Creek would not be affected by Alternative 5.

Feather River

Water temperatures in the Feather River under Alternative 5 would be the same as those under Alternative 1A, which indicates that temperatures would not be different under Alternative 1A during the periods evaluated relative to NAA.

Juveniles

Flows in the Feather River at the confluence with the Sacramento River were examined during the October through May juvenile steelhead migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would generally be similar to or greater than flows under NAA in all months and water years except during November in above normal years (6% lower).

Adults

Flows in the Feather River at the confluence with the Sacramento River were examined during the September through March adult steelhead upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would be up to 47% lower than flows under NAA during September, up to 39% higher than flows under NAA during October, and generally similar to flows under NAA in the remaining five months of the period.

Kelts

Flows in the Feather River at the confluence with the Sacramento River were examined during the March and April steelhead kelt downstream migration period (Appendix 11C, CALSIM II Model *Results utilized in the Fish Analysis*). Flows under A5_LLT would be similar to those under NAA in March and up to 12% greater than flows under NAA in April.

Overall, these results indicate that there would be negligible effects of Alternative 5 on steelhead juvenile, adult, and kelt migration conditions. There would be some flow-based beneficial effects in some months.

American River

Water temperatures in the American River under Alternative 5 would be the same as those under Alternative 1A, which indicates that temperatures would not be different between NAA and Alternative 1A during the periods evaluated.

Juveniles

Flows in the American River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period. Flows under A5_LLT would generally be similar to flows under NAA except in wet, above normal and critical water years during October (10%, 15% and 12% lower, respectively), above normal and below normal water years during November (9% lower for each), and dry water years during January (8% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in the American River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would generally be similar to flows under NAA except in wet and below normal years during September (8% and 16% lower, respectively), in wet, above normal and critical water years during October (10%, 15% and 12% lower, respectively), above normal and below normal water years during November (9% lower for each), and dry water years during January (8% lower).

Kelts

Flows in the American River at the confluence with the Sacramento River were evaluated for the March and April kelt migration period. Flows under A5_LLT would generally be similar to flows under NAA (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Overall in the American River, Alternative 5 would have negligible effects on water temperatures and effects on flow consist of negligible effects (<5%), increases in flow (to 33%) that would have a beneficial effect on migration conditions, or infrequent and small-magnitude decreases in flow that would not have biologically meaningful effects on juvenile, adult, or kelt steelhead migration in the American River.

Stanislaus River

Water temperatures in the Stanislaus River under Alternative 5 would be the same as those under Alternative 1A, which indicates that temperatures would not be different between NAA and Alternative 1A during the periods evaluated.

Juveniles

Flows in the Stanislaus River at the confluence with the San Joaquin River were evaluated during the October through May juvenile steelhead migration period. Flows under A5_LLT would be similar to flows under NAA during the entire period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in the Stanislaus River at the confluence with the San Joaquin River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would be similar flows under NAA during the entire period.

Kelts

Flows in the Stanislaus River at the confluence with the San Joaquin River were evaluated for the March and April kelt migration period. Flows under A5_LLT would be similar to under NAA for both months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

San Joaquin River

Water temperature modeling was not conducted in the San Joaquin River.

Juveniles

Flows in the San Joaquin River at Vernalis were evaluated during the October through May juvenile steelhead migration period. Flows under A5_LLT would be similar to flows under NAA during the entire period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in the San Joaquin River at Vernalis were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would be similar flows under NAA during the entire period.

Kelts

Flows in the San Joaquin River at Vernalis were evaluated for the March and April kelt migration period. Flows under A5_LLT would be similar to under NAA for both months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mokelumne River

Water temperature modeling was not conducted in the Mokelumne River.

Juveniles

Flows in the Mokelumne River were evaluated during the October through May juvenile steelhead migration period. Flows under A5_LLT would be similar to flows under NAA during the entire period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in the Mokelumne River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A5_LLT would be similar flows under NAA during the entire period.

Kelts

Flows in the Mokelumne River were evaluated for the March and April kelt migration period. Flows under A5_LLT would be similar to under NAA for both months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Through-Delta

Sacramento River

Juveniles

Based on DPM results for winter-run Chinook salmon (migration period November to May) (Impact AQUA-42), survival of migrating juvenile steelhead under Alternative 5 would be expected to be similar to baseline (Table 11-5-14).

The new north Delta intake structure of Alternative 5 would increase potential predation loss of migrating juvenile salmonids and would displace 3.8 acres of aquatic habitat. Losses of juvenile winter-run Chinook salmon were estimated ranging from 2% to 4% of juveniles reaching the Delta (Impact AQUA-42 for Alternative 5). However, juvenile steelhead would be less vulnerable than winter-run Chinook salmon to predation associated with the intake facilities because of their greater size and strong swimming ability.

Adults

As assessed by DSM2 fingerprinting analysis, the average percentage of Sacramento River–origin water at Collinsville under Alternative 5 was within 6% of proportions for NAA during the

September-March steelhead upstream migration period (Table 11-mult-58). For a discussion of the topic see the analysis for Alternative 1A.

Alternative 5 would not have an adverse effect on adult and kelt steelhead migration through the Delta.

San Joaquin River

Juveniles

The only changes to San Joaquin River flows at Vernalis would result from the modeled effects of climate change on inflows to the river downstream of Friant Dam and reduced tributary inflows. There no flow changes associated with the Alternatives. Alternative 5 would have no effect on steelhead migration success through the Delta.

Adults

The percentage of water at Collinsville that originated from the San Joaquin River during the fall-run migration period (September to December) is small, typically 0.1% to less than 3% under NAA. Alternative 1A operations conditions would incrementally increase olfactory cues associated with the San Joaquin River, which would benefit adult steelhead migrating to the San Joaquin River. For a discussion of the topic see the analysis for Alternative 1A.

NEPA Effects: Collectively, these results indicate that Alternative 5 operations would not adversely affect upstream or through-Delta migration conditions for Central Valley steelhead because the alternative does not have the potential to substantially interfere with the movement of fish.

Upstream of the Delta, effects would range from negligible effects on water temperature, and negligible effects (<5%) on flow, substantial increases in flow (to 47%) that would have beneficial effects on migration conditions, isolated occurrences of small to modest decreases (to -17%) that would not have biologically meaningful effects on migration conditions, and more substantial decreases in mean monthly flow in the Feather River (to -61%) that would only occur during September (the start of the adult migration period) in some water years and would not be prevalent enough to have biologically meaningful effects on adult migration conditions. There would be no effects of Alternative 5 on water temperatures in the Sacramento or Feather Rivers.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 5 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 5.

Near-field effects of Alternative 5 NDD on Sacramento River steelhead related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating steelhead, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 1 new intake would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~

4% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the 1 new intake structure will be implemented as part of the final NDD screen design effort. Alternative 5 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for steelhead.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 5 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 5 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for steelhead.

Alternative 7

The effects of Alternative 7 on steelhead migration conditions relative to the NAA are not adverse.

Sacramento River

Juveniles

Flows in the Sacramento River upstream of Red Bluff were evaluated during the October through May juvenile steelhead migration period. Flows under A7_LLT would be higher than NAA in some water years during February and May (up to 11% higher), similar to NAA during October through January, March, and April, and lower than NAA (up to 14% lower) during November (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Adults

Flows in the Sacramento River upstream of Red Bluff were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would be higher than NAA in some water years during February (up to 11% higher), similar to NAA during September through January, and March, and lower than NAA (up to 14% lower) during, November.

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Kelt

Flows in the Sacramento River upstream of Red Bluff were evaluated during the March and April steelhead kelt downstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows during these two months would be minimally different between NAA and A7_LLT.

Mean monthly water temperatures in the Sacramento River upstream of Red Bluff were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Overall in the Sacramento River, these results indicate that Alternative 7 would not have biologically meaningful effects on steelhead kelt migration, but would have biologically meaningful effects on juvenile and adult steelhead migration.

Clear Creek

Water temperatures were not modeled in Clear Creek.

Juveniles

Flows in Clear Creek during the October through May juvenile Chinook steelhead migration period under A7_LLT would generally be similar to or greater than flows under NAA except in below normal years in March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Adults

Flows in Clear Creek during the September through March adult steelhead migration period under A7_LLT would generally be similar to or greater than flows under NAA except in critical years in September (13% lower) and below normal years in March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Kelt

Flows in Clear Creek during the March through April steelhead kelt downstream migration period under A7_LLT would generally be similar to flows under NAA except in below normal years in March (6% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Overall in Clear Creek, these results indicate that effects of Alternative 7 on flows would not affect juvenile, adult, or kelt steelhead migration.

Feather River

Juveniles

Flows in the Feather River at the confluence with the Sacramento River were examined during the October through May juvenile steelhead migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would generally be similar to or greater than flows under NAA in all months and water years except during November in above normal years (8% lower) and dry years during December (17% lower) while flows during May would be mixed with similar flows, lower flows during below normal and critical years (7% and 16% lower, respectively) but higher in critical years (13% higher).

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Adults

Flows in the Feather River at the confluence with the Sacramento River were examined during the September through March adult steelhead upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would generally be similar to or greater than flows under NAA in all months and water years except during November in above normal years (8% lower) and dry years during December (17% lower) while flows in September would generally be lower (13%, 25% and 17%, lower in wet, above normal, and below normal water years) and 15% higher in critical water years.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Kelt

Flows in the Feather River at the confluence with the Sacramento River were examined during the March and April steelhead kelt downstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would be similar to those under NAA in March although 8% greater in below normal water years and similar to flows under NAA in April.

Mean monthly water temperatures in the Feather River at the confluence with the Sacramento River were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Overall in the Feather River, the effects of Alternative 7 on flows would not have biologically meaningful effects on juvenile, adult, or kelt steelhead migration.

American River

Juveniles

Flows in the American River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period. Flows under A7_LLT would be lower than under NAA during October (12% lower in below normal years although 8% higher in dry years), March (up to 17% lower in critical years) and April (up to 15% lower in dry years), generally similar to flows under NAA during November, December, January and February, and higher than under NAA during May (20% higher in critical years) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the October through May juvenile steelhead migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Adults

Flows in the American River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A7_LLT would be variable in September (up to 15% lower in below normal years but up to 27% higher in critical years), lower than under NAA during October (12% lower in below normal years although 8% higher in dry years) and March (up to 17% lower in critical years), generally similar to flows under NAA during November, December, January and February.

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the September through March steelhead adult upstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period

Kelt

Flows in the American River at the confluence with the Sacramento River were evaluated for the March and April kelt migration period. Flows under A7_LLT would generally be lower during March (up to 17% lower in critical years) and April (up to 15% lower in dry years and 9% lower in critical years (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Mean monthly water temperatures in the American River at the confluence with the Sacramento River were evaluated during the March through April steelhead kelt downstream migration period (Appendix 11D, *Sacramento River Water Quality Model and Reclamation Temperature Model Results utilized in the Fish Analysis*). There would be no differences (<5%) in mean monthly water temperature between NAA and Alternative 7 in any month or water year type throughout the period.

Overall in the American River, the effects of Alternative 7 on flows would affect kelt migration in dry and critical years but would not affect juvenile and adult migration.

Stanislaus River

Flows in the Stanislaus River at the confluence with the San Joaquin River for Alternative 7 are not different from flows under NAA for any month except for higher flows in below normal, dry and critical water years during June. Therefore, there would be no effect of Alternative 7 on juvenile, adult, or kelt migration in the Stanislaus River.

Further, mean monthly water temperatures in the Stanislaus River at the confluence with the San Joaquin River for Alternative 7 are not different from flows under NAA for any month. Therefore, there would be no effect of Alternative 7 on juvenile, adult, or kelt migration in the Stanislaus River.

San Joaquin River

Flows in the San Joaquin River at Vernalis for Alternative 7 are not different from flows under NAA for any month. Therefore, there would be no effect of Alternative 7 on juvenile, adult, or kelt migration in the San Joaquin River.

Water temperature modeling was not conducted in the San Joaquin River.

Mokelumne River

Flows in the Mokelumne River at the Delta for Alternative 7 are not different from flows under NAA for any month. Therefore, there would be no effect of Alternative 7 on juvenile, adult, or kelt migration in the Mokelumne River.

Water temperature modeling was not conducted in the Mokelumne River.

Through-Delta

The methodology for assessing steelhead Delta migration habitat conditions is fully described in the analysis of Alternative 1A.

Sacramento River

Juveniles

DPM results for Alternative 7 for fall-run Chinook salmon from the Sacramento River (Impact AQUA-78 for Alternative 7) predict decreases in survival of less than 0.5%. Juvenile steelhead are not expected to be negatively affected by predation at the three NDD intakes because of their size and strong swimming ability.

Adults

The upstream adult steelhead migration occurs from September-March, peaking during December-February. The steelhead kelt downstream migration occurs from January-April. For Sacramento River steelhead, straying rates of adult hatchery-origin Chinook salmon that were released upstream of the Delta are low (Marston et al. 2012). Although straying rates for hatchery-origin steelhead apparently have not been examined in detail, for this analysis of effects, it was assumed with high certainty (based on Chinook salmon rates), that Plan Area flows in relation to straying have low importance under Existing Conditions for adult Sacramento River region steelhead.

The proportion of Sacramento River water in the Delta under Alternative 7 during the adult migration period would be increased 13% in September and slightly reduced (1% to 9% decrease) during October to March compared to NAA (Table 11-mult-110). The proportion of Sacramento River flow would still comprise 62% to 78% of flows, which would maintain strong olfactory cues for migrating adults under Alternative 7.

Table 11-mult-110. Percentage (%) of Water at Collinsville that Originated in the Sacramento River and San Joaquin River during the Steelhead Migration Period for Alternative 7

Month	EXISTING CONDITIONS	NAA	A7_LLT	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Sacramento River					
September	60	65	78	18	13
October	60	68	67	7	-1
November	60	66	62	2	-4
December	67	66	65	-2	-1
January	76	75	73	-3	-2
February	75	72	67	-8	-5
March	78	76	67	-11	-9
April	77	75	65	-12	-10
May	69	65	59	-10	-6
June	64	62	56	-8	-6
San Joaquin River					
September	0.3	0.1	1.1	0.8	1.0
October	0.2	0.3	4.5	4.3	4.2
November	0.4	1.0	7.9	7.5	6.9
December	0.9	1.0	6.2	5.3	5.2
January	1.6	1.7	7.0	5.4	5.3
February	1.4	1.5	7.1	5.7	5.6
March	2.6	2.8	8.8	6.2	6.0
April	6.3	6.6	14.0	7.7	7.4
▨	Shading indicates a difference of 10% of greater in flow proportion.				

San Joaquin River

Juveniles

The only changes on San Joaquin River flows at Vernalis would result from the modeled effects of climate change on inflows to the river downstream of Friant Dam and reduced tributary inflows. As discussed for fall-run Chinook (Impact AQUA-78), there is a beneficial effect of Alternative 7 to all San Joaquin River basin fish due to positive Old and Middle River flows during migratory months resulting in San Joaquin water moving westward and contributing to Delta outflow. This is expected to decrease entrainment at South Delta facilities and reduce predation hotspots to promote greater survival to Chipps Island. Furthermore under Alternative 7, entrainment and entrainment-related mortality at the South Delta Facilities would be reduced.

Additionally, under Alternative 7, the reduction of entrainment at the South Delta Facilities would alleviate one of the primary concerns related to potential Old and Middle River corridor habitat restoration. Successful restoration in this area would be expected to enhance rearing habitat, food availability, and overall salmonid fitness and survival.

Adults

The proportion of San Joaquin River water in the Delta in September through December under Alternative 7 (1.1% to 7.9%) would increase appreciably by 1% to 6.9% compared to NAA (Table 11-mult-110). Little information apparently currently exists as to the importance of Plan Area flows on the straying of adult San Joaquin River region steelhead, in contrast to San Joaquin River fall-run Chinook salmon (Marston et al. 2012). It was assumed with moderate certainty that the attribute of Plan Area flows (including olfactory cues associated with such flows) is of high importance to adult San Joaquin River region steelhead adults as well. Therefore migration conditions would be improved, and Alternative 7 would have a slight beneficial effect on the adult steelhead and kelt migration.

NEPA Effects: Collectively, these results indicate that Alternative 7 operations would not adversely affect upstream or through-Delta migration conditions for Central Valley steelhead because the alternative does not have the potential to substantially interfere with the movement of fish.

Upstream of the Delta, effects of Alternative 7 in all locations analyzed would consist primarily of negligible effects on mean monthly flow and water temperatures for the juvenile, adult, and kelt migration periods.

On the basis of changes in flow and migration routing, through-Delta juvenile survival under Alternative 7 would be similar to or slightly lower than NAA, averaged across all years. In addition to biologically-based triggers to inform real-time operations of the NDD, several key conservation measures (CM6, CM15, and CM16) would minimize adverse effects. Near-field predation losses would be managed with CM15. Despite a minor reduction in through-Delta flows during the adult migration period, the olfactory cues would be adequate and not substantially affected by flow operations under Alternative 7.

Near-field effects of Alternative 7 NDD on Sacramento River steelhead related to impingement and predation associated with three new intake structures could result in negative effects on juvenile migrating steelhead, although there is high uncertainty regarding the overall effects. It is expected that the level of near-field impacts would be directly correlated to the number of new intake structures in the river and thus the level of impacts associated with 3 new intakes would be considerably lower than those expected from having 5 new intakes in the river. Estimates within the effects analysis range from very low levels of effects (<1% mortality) to more significant effects (~ 12% mortality above current baseline levels). CM15 would be implemented with the intent of providing localized and temporary reductions in predation pressure at the NDD. Additionally, several pre-construction studies to better understand how to minimize losses associated with the three new intake structures will be implemented as part of the final NDD screen design effort. Alternative 7 also includes an Adaptive Management Program and Real-Time Operational Decision-Making Process to evaluate and make limited adjustments intended to provide adequate migration conditions for steelhead.

Two recent studies (Newman 2003 and Perry 2010) indicate that far-field effects associated with the new intakes could cause a reduction in smolt survival in the Sacramento River downstream of the NDD intakes due to reduced flows in this area. The analyses of other elements of Alternative 7 predict improvements in smolt condition and survival associated with increased access to the Yolo Bypass (CM2), enhanced channel margin habitat along 15 miles of juvenile salmonid migration routes (under CM6), reduced interior Delta entry (from the action of nonphysical barriers under CM16), and reduced south Delta entrainment (under CM1). The overall magnitude of each of these factors and how they might interact and/or offset each other in affecting salmonid survival through the Plan Area remains an area of active investigation.

The DPM is a flow-based model that incorporates flow-survival and junction routing relationships with flow modeling of operations to estimate relative differences between scenarios in smolt migration survival throughout the entire Plan Area. The DPM predicted that smolt migration survival under Alternative 7 would be similar to or slightly lower than survival those estimated for NAA. Several ongoing and planned studies related to salmonid survival at and downstream of the NDD are expected to be completed in the foreseeable future. These efforts are expected to improve understanding of the relationships and interactions among the various factors affecting salmonid survival, and reduce the uncertainty around the potential effects of Project implementation on migration conditions for steelhead.

Impact AQUA-132: Effects of Water Operations on Migration Conditions for Green Sturgeon

Alternatives 4, 5, 6A and 9 (not adverse)

Alternative 4

The effects of Alternative 4 on green sturgeon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

H3/ESO

Analyses for green sturgeon migration conditions focused on flows in the Sacramento River between Keswick and Wilkins Slough and in the Feather River between Thermalito and the confluence with the Sacramento River during the April through October larval migration period, the August through March juvenile migration period, and the November through June adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Because these periods encompass the entire year, flows during all months were compared. Reduced flows could slow or inhibit downstream migration of larvae and juveniles and reduce the ability to sense upstream migration cues and pass impediments by adults.

Sacramento River flows at Keswick under H3 would generally be lower than flows under NAA during November, greater during May and June, and similar to flows under NAA in the remaining nine months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Sacramento River flows at Wilkins Slough under H3 would generally be lower than flows under NAA during November, greater during May and June, and similar to flows under NAA in the remaining nine months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Feather River flows at Thermalito under H3 would generally be lower than flows under NAA during July through September, greater during March through June and October, and similar to flows under NAA in the remaining four months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). However, given the benthic nature of green sturgeon and that flows in the Feather River would be consistent with the flow schedule provided by NMFS during the BDCP planning process, these reductions in summer flows are not expected to have a substantial effect on green sturgeon in the Feather River.

Feather River flows at the confluence with the Sacramento River under H3 would generally be lower than flows under NAA during July through September, greater during April through June and October, and similar to flows under NAA in the remaining five months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). However, given the benthic nature of green sturgeon and that flows in the Feather River would be consistent with the flow schedule provided by NMFS during the BDCP planning process, these reductions in summer flows are not expected to have a substantial effect on green sturgeon in the Feather River.

Larval transport flows were also examined by utilizing the positive correlation between white sturgeon year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved green sturgeon larval transport that results in improved year class strength. However, there are temporal and spatial differences between green and white sturgeon larval presence that make this analysis highly uncertain and potentially not applicable (Murphy et al. 2011). In particular, during April and May, green sturgeon would be spawning in the upper Sacramento River and Feather River; young-of-the year would not be found in the Delta until the subsequent fall and winter. This mismatch in timing and location limits the confidence in using this as a surrogate for green sturgeon and suggests that year-class strength correlated with flow at another location within the Sacramento River or during a different period, if at all. Regardless, for lack of a known relationship for green sturgeon year-class strength, the results using white sturgeon as a surrogate for green sturgeon were examined here. Results for white sturgeon presented in Impact AQUA-150 below suggest that, using the positive correlation between Delta outflow and year class strength, green sturgeon year class strength would be lower under H3 than those under NAA (up to 50% lower).

H1/LOS

Year-round flows under H1 in the Sacramento River at Keswick and Wilkins Slough would generally be similar to flows under NAA, except during September and November, during which flows would be up to 36% lower (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). These isolated reductions would not have biologically meaningful effects on green sturgeon migration habitat.

Year-round flows in the Feather River below Thermalito Afterbay (high-flow channel) and at the confluence with the Sacramento River under H1 would generally be similar to or up to 78% greater than flows under NAA, except during July through September during which flows would be up to 86% lower. However, given the benthic nature of green sturgeon and that flows in the Feather River would be consistent with the flow schedule provided by NMFS during the BDCP planning process, these reductions in summer flows are not expected to have a substantial effect on green sturgeon in the Feather River

H4/HOS

Year-round flows in the Sacramento River at Keswick and Wilkins Slough under H4 would generally be similar to or up to 20% higher than flows under NAA, except during January and June at Keswick and during January at Wilkins Slough, during which flows would be up to 21% lower (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Year-round flows in the Feather River below Thermalito Afterbay (high-flow channel) and at the confluence with the Sacramento River under H4 would generally be similar to or greater than flows under NAA except during July through September at both locations and during December at the confluence, in which flows would be up to 60% lower under H4. However, given the benthic nature of green sturgeon and that flows in the Feather River would be consistent with the flow schedule provided by NMFS during the BDCP planning process, these reductions in summer flows are not expected to have a substantial effect on green sturgeon in the Feather River

Through-Delta

The impact of Alternative 4 on in-Delta conditions for green sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that green sturgeon year class strength could be lower under Alternative 4, but due to a lack of understanding and potentially inapplicable use of white sturgeon as a surrogate for green sturgeon, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 4 and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 4 and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 4 was appreciably lower than that under NAA_ELT. Analysis of white sturgeon year-class strength (USFWS 1995), used here as a surrogate for green sturgeon, found a positive correlation between year class strength and Delta outflow during April and May. However, this correlation was found in the absence of north Delta intakes and the exact mechanism that causes this correlation is not known at this time. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

Determining whether a relationship exists between green sturgeon year class strength and river/Delta outflow and addressing the scientific uncertainty regarding which mechanisms are responsible for the positive correlation between white sturgeon year class strength and river/Delta flow will occur through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 4 operations such that the effect on green sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 4 and NAA_ELT and a lack of confidence in using white sturgeon as a surrogate for green sturgeon given the differences in timing and location of the two species, indicate that Alternative 4 would not be adverse to migration conditions for green sturgeon.

Alternative 5

The effects of Alternative 5 on green sturgeon migration conditions relative to NAA are not adverse.

Upstream of the Delta

Analyses for green sturgeon migration conditions focused on flows in the Sacramento River between Keswick and Wilkins Slough and in the Feather River between Thermalito and the confluence with the Sacramento River during the April through October larval migration period, the August through March juvenile migration period, and the November through June adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Because these periods encompass the entire year, flows during all months were compared. Reduced flows could slow or inhibit downstream migration of larvae and juveniles and reduce the ability to sense upstream migration cues and pass impediments by adults.

Sacramento River flows under A5_LLT would generally be similar to or greater than flows under NAA in all months except September, during which flows would be up to 21% lower depending on location and water year type (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis)*.

Larval transport flows were also examined by utilizing the positive correlation between white sturgeon year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved green sturgeon larval transport that results in improved year class strength. However, there are temporal and spatial differences between green and white sturgeon larval presence that make this analysis highly uncertain and potentially not applicable (Murphy et al. 2011). In particular, during April and May, green sturgeon would be spawning in the upper Sacramento River and Feather River; young-of-the year would not be found in the Delta until the subsequent fall and winter. This mismatch in timing and location limits the confidence in using this as a surrogate for green sturgeon and suggests that year-class strength correlated with flow at another location within the Sacramento River or during a different period, if at all. Regardless, for lack of a known relationship for green sturgeon year-class strength, the results using white sturgeon as a surrogate for green sturgeon were examined here. Results for white sturgeon presented in Impact AQUA-150 below suggest that, using the positive correlation between Delta outflow and year class strength, green sturgeon year class strength would be lower under Alternative 5.

Feather River flows under A5_LLT would generally be lower by up to 61% than those under NAA during August and September. Flows during other months under A5_LLT would generally be similar to or greater than flows under NAA with some exceptions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis)*.

Through-Delta

The impact of Alternative 5 on in-Delta conditions for green sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that green sturgeon year class strength could be lower under Alternative 5, but due to a lack of understanding and potentially inapplicable use of white sturgeon as a surrogate for green sturgeon, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 4 and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 5 and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 5 was appreciably lower than that under NAA_ELT. Analysis of white sturgeon year-class strength (USFWS 1995), used here as a surrogate for green sturgeon, found a positive correlation between year class strength and Delta outflow during April and May. However, this correlation was found in the absence of north Delta intakes and the exact mechanism that causes this correlation is not known at this time. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

Determining whether a relationship exists between green sturgeon year class strength and river/Delta outflow and addressing the scientific uncertainty regarding which mechanisms are responsible for the positive correlation between white sturgeon year class strength and river/Delta flow will occur through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 5 operations such that the effect on green sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 5 and NAA_ELT and a lack of confidence in using white sturgeon as a surrogate for green sturgeon given the differences in timing and location of the two species, indicate that Alternative 5 would not be adverse to migration conditions for green sturgeon.

Alternative 6A

The effects of Alternative 6A on green sturgeon migration conditions relative to NAA are not adverse.

Upstream of the Delta

Analyses for green sturgeon migration conditions focused on flows in the Sacramento River between Keswick and Wilkins Slough and in the Feather River between Thermalito and the confluence with the Sacramento River during the April through October larval migration period, the August through March juvenile migration period, and the November through June adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Because these periods encompass the entire year, flows during all months were compared. Reduced flows could slow or inhibit downstream migration of larvae and juveniles and reduce the ability to sense upstream migration cues and pass impediments by adults.

Sacramento River flows under A6A_LLT would nearly always be similar to or greater than flows under NAA in all months, except during August, September, and November, in which flows would be up to 18% lower depending on location, month, and water year type (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis)*.

Larval transport flows were also examined by utilizing the positive correlation between white sturgeon year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved green sturgeon larval transport that results in improved year class strength. However, there are temporal and spatial differences between green and white sturgeon larval presence that make this analysis highly uncertain and potentially not applicable (Murphy et al. 2011). In particular, during April and May, green sturgeon would be spawning in the upper Sacramento River and Feather River; young-of-the year would not be found in the Delta until the subsequent fall and winter. This mismatch in timing and location limits the confidence in using this as a surrogate for green sturgeon and suggests that year-class strength correlated with flow at another location within the Sacramento River or during a different period, if at all. Regardless, for lack of a known relationship for green sturgeon year-class strength, the results using white sturgeon as a surrogate for green sturgeon were examined here. Results for white sturgeon presented in Impact AQUA-150 below suggest that, using the positive correlation between Delta outflow and year class strength, green sturgeon year class strength would be lower under Alternative 6A than those under NAA (up to 67% lower).

Relative to NAA, flows in the Feather River at Thermalito under A6A_LLT would generally be similar in all but two months (July and December) (up to 43% lower). Flows at the confluence with the Sacramento River would generally be similar in all but three months (July, August, and December) (up to 49% lower) (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis)*.

Through-Delta

The impact of Alternative 6 on in-Delta conditions for green sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that green sturgeon year class strength could be lower under Alternative 6, but due to a lack of understanding and potentially inapplicable use of white sturgeon as a surrogate for green sturgeon, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 6A and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 6A and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 6A was appreciably lower than that under NAA_ELT. Analysis of white sturgeon year-class strength (USFWS 1995), used here as a surrogate for green sturgeon, found a positive correlation between year class strength and Delta outflow during April and May. However, this correlation was found in the absence of north Delta intakes and the exact mechanism that causes this correlation is not known at this time. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

Determining whether a relationship exists between green sturgeon year class strength and river/Delta outflow and addressing the scientific uncertainty regarding which mechanisms are responsible for the positive correlation between white sturgeon year class strength and river/Delta flow will occur through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 6A operations such that the effect on green sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 6A and NAA_ELT and a lack of confidence in using white sturgeon as a surrogate for green sturgeon given the differences in timing and location of the two species, indicate that Alternative 6A would not be adverse to migration conditions for green sturgeon.

Alternative 9

The effects of Alternative 9 on green sturgeon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Analyses for green sturgeon migration conditions focused on flows in the Sacramento River between Keswick and Wilkins Slough and in the Feather River between Thermalito and the confluence with the Sacramento River during the April through October larval migration period, the August through March juvenile migration period, and the November through June adult migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Because these periods encompass the entire year, flows during all months were compared. Reduced flows could slow or inhibit downstream migration of larvae and juveniles and reduce the ability to sense upstream migration cues and pass impediments by adults.

Sacramento River flows under A9_LLT would nearly always be similar to or greater than flows under NAA in all months, except during October at Keswick (up to 14% lower) and during August and October at Wilkins Slough (up to 15% lower).

Flows under A9_LLT would generally be lower by up to 14% than those under NAA in the Feather River during October depending on location and water year type. Flows during other months under A9_LLT would generally be similar to or greater than flows under NAA, with few exceptions (up to 22% lower) depending on month, location, and water year type.

Larval transport flows were also examined by utilizing the positive correlation between white sturgeon year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved green sturgeon larval transport that results in improved year class strength. However, there are temporal and spatial differences between green and white sturgeon larval presence that make this analysis highly uncertain and potentially not applicable (Murphy et al. 2011). In particular, during April and May, green sturgeon would be spawning in the upper Sacramento River and Feather River; young-of-the year would not be found in the Delta until the subsequent fall and winter. This mismatch in timing and location limits the confidence in using this as a surrogate for green sturgeon and suggests that year-class strength correlated with flow at another location within the Sacramento River or during a different period, if at all. Regardless, for lack of a known relationship for green sturgeon year-class strength, the results using white sturgeon as a surrogate for green sturgeon were examined here. Results for white sturgeon presented in Impact AQUA-150 below suggest that, using the positive correlation between Delta outflow and year class strength, green sturgeon year class strength would be lower under Alternative 9.

Through-Delta

The impact of Alternative 9 on in-Delta conditions for green sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that green sturgeon year class strength could be lower under Alternative 9, but due to a lack of understanding and potentially inapplicable use of white sturgeon as a surrogate for green sturgeon, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 9 and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 9 and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 9 was appreciably lower than that under NAA_ELT. Analysis of white sturgeon year-class strength (USFWS 1995), used here as a surrogate for green sturgeon, found a positive correlation between year class strength and Delta outflow during April and May. However, this correlation was found in the absence of north Delta intakes and the exact mechanism that causes this correlation is not known at this time. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

Determining whether a relationship exists between green sturgeon year class strength and river/Delta outflow and addressing the scientific uncertainty regarding which mechanisms are responsible for the positive correlation between white sturgeon year class strength and river/Delta flow will occur through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 9 operations such that the effect on green sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 9 and NAA_ELT and a lack of confidence in using white sturgeon as a surrogate for green sturgeon given the differences in timing and location of the two species, indicate that Alternative 9 would not be adverse to migration conditions for green sturgeon.

Impact AQUA-150: Effects of Water Operations on Migration Conditions for White Sturgeon

Alternatives 1A, 2A, 3, 4, 5, 6A, 7 and 9 (not adverse)

Alternative 1A

The effects of Alternative 1A on white sturgeon migration conditions relative to NAA are not adverse.

Upstream of the Delta

Analyses for white sturgeon focused on the Sacramento River (North Delta to RM 143—i.e., Wilkins Slough and Verona CALSIM nodes). Larval transport flows were represented by the average number of months per year that exceeded thresholds of 17,700 cfs (Wilkins Slough) and 31,000 cfs (Verona) during February through May (Table 11-mult-111). Exceedances of the 17,700 cfs threshold for Wilkins Slough under A1A_LLT were similar to those under NAA. The number of months per year above 31,000 cfs at Verona would be lower for all water year types (up to 50% lower) relative to NAA depending on water year type, except above normal years (6% increase). However, on an absolute scale, none of these differences would be biologically meaningful to white sturgeon (up to 0.2 months). Overall, there is no consistent difference between Alternative 1A and NAA.

Table 11-mult-111. Difference and Percent Difference in Number of Months between February and May in Which Flow Rates Exceed 17,700 and 5,300 Cubic Feet per Second (cfs) in the Sacramento River at Wilkins Slough and 31,000 cfs at Verona

	EXISTING CONDITIONS vs. A1A_LLT	NAA vs. A1A_LLT
Wilkins Slough, 17,700 cfs[a]		
Wet	-0.04 (-2%)	0 (0%)
Above Normal	0.3 (18%)	0.1 (5%)
Below Normal	-0.1 (-25%)	0 (0%)
Dry	0 (0%)	0 (0%)
Critical	0 (0%)	0 (0%)
Wilkins Slough, 5,300 cfs[b]		
Wet	-0.1 (-1%)	0.1 (2%)
Above Normal	-0.1 (-1%)	0.3 (4%)
Below Normal	0.1 (3%)	0.4 (9%)
Dry	0.6 (13%)	0.3 (6%)
Critical	0.3 (10%)	0.3 (7%)
Verona, 31,000 cfs[a]		
Wet	-0.5 (-21%)	-0.2 (-9%)
Above Normal	-0.1 (-5%)	0.1 (6%)
Below Normal	-0.2 (-43%)	-0.1 (-33%)
Dry	-0.2 (-60%)	-0.1 (-50%)
Critical	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] Months analyzed: February through May.

[b] Months analyzed: November through May.

The effects of changes in flow for white sturgeon under Alternative 4A were also examined by utilizing the positive correlation between year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved transport (e.g., for white sturgeon larvae or other early life stages). The percent of months exceeding flow thresholds under A1A_LLT would be lower than those under NAA (up to 67%) (Table 11-mult-112). These results indicate that, using the positive correlation between Delta outflow and year class strength, year class strength would be lower under Alternative 1A.

Table 11-mult-112. Difference and Percent Difference in Percentage of Months in Which Average Delta Outflow is Predicted to Exceed 15,000, 20,000, and 25,000 Cubic Feet per Second (cfs) in April and May of Wet and Above-Normal Water Years

Flow	Water Year Type	EXISTING CONDITIONS vs. A1A_LLT	NAA vs. A1A_LLT
April			
15,000 cfs	Wet	-15 (-16%)	-15 (-16%)
	Above Normal	-25 (-27%)	-25 (-27%)
20,000 cfs	Wet	-12 (-14%)	-12 (-14%)
	Above Normal	-33 (-44%)	-25 (-38%)
25,000 cfs	Wet	-15 (-19%)	-12 (-15%)
	Above Normal	-17 (-29%)	-8 (-17%)
May			
15,000 cfs	Wet	-15 (-17%)	-8 (-10%)
	Above Normal	-33 (-40%)	-8 (-14%)
20,000 cfs	Wet	-38 (-45%)	-15 (-25%)
	Above Normal	-25 (-60%)	-17 (-50%)
25,000 cfs	Wet	-31 (-44%)	-19 (-33%)
	Above Normal	-25 (-75%)	-17 (-67%)
April/May Average			
15,000 cfs	Wet	-15 (-16%)	-8 (-9%)
	Above Normal	-33 (-33%)	-25 (-27%)
20,000 cfs	Wet	-23 (-26%)	-19 (-23%)
	Above Normal	-17 (-25%)	0 (0%)
25,000 cfs	Wet	-19 (-24%)	-8 (-11%)
	Above Normal	-25 (-50%)	-25 (-50%)

For juveniles, year-round migration flows at Verona were up to 55% lower under A1A_LLT relative to NAA during July through September and November (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Migration flows during other months were typically similar of greater than NAA, with few exceptions in some months or water years.

For adults, the average number of months per year during the November through May adult migration period in which flows in the Sacramento River at Wilkins Slough exceed 5,300 cfs was determined (Table 11-mult-111). The average number of months exceeding 5,300 cfs under A1A_LLT would be similar to the number of months under NAA in wet and above normal years and higher in remaining water year types (6% to 9% higher). These increase in exceedances are considered small (<15%) and would not likely affect white sturgeon adult migration.

Through-Delta

The impact of Alternative 1A on in-Delta conditions for white sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that white sturgeon year class strength could be lower under Alternative 1A, but due to a lack of understanding of the mechanism responsible for the correlation and because it was found in the absence of north Delta intakes, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 1A and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 1A and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 1A was appreciably lower than that under NAA_ELT. The exact mechanism for the correlation between white sturgeon year-class strength and Delta outflow is not known at this time and was found in the absence of north Delta intakes. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

The scientific uncertainty regarding which mechanisms are responsible for the positive correlation between year class strength and river/Delta flow will be addressed through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 1A operations such that the effect on white sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 1A and NAA_ELT, indicate that Alternative 1A would not be adverse to migration conditions for white sturgeon.

Alternative 2A

The effects of Alternative 2A on white sturgeon migration conditions relative to NAA are not adverse.

Upstream of the Delta

Analyses for white sturgeon focused on the Sacramento River (North Delta to RM 143—i.e., Wilkins Slough and Verona CALSIM nodes). Larval transport flows were represented by the average number of months per year that exceeded thresholds of 17,700 cfs (Wilkins Slough) and 31,000 cfs (Verona) (Table 11-mult-113). Exceedances of the 17,700 cfs threshold for Wilkins Slough under A2A_LLT were similar to those under NAA. The number of months per year above 31,000 cfs at Verona would range from a reduction of 1.5 months (67% lower in wet years) to an increase of 0.8 months (350% higher in dry years) relative to NAA depending on water year type. Overall, there is no consistent difference between Alternative 2A and the baselines.

Table 11-mult-113. Difference and Percent Difference in Number of Months between February and May in Which Flow Rates Exceed 17,700 and 5,300 cfs in the Sacramento River at Wilkins Slough and 31,000 cfs at Verona

	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
Wilkins Slough, 17,700 cfs[a]		
Wet	-0.04 (-2%)	0 (0%)
Above Normal	0.3 (18%)	0.1 (5%)
Below Normal	-0.1 (-25%)	0 (0%)
Dry	0 (0%)	0 (0%)
Critical	0 (0%)	0 (0%)
Wilkins Slough, 5,300 cfs[b]		
Wet	-0.2 (-2%)	0.04 (1%)
Above Normal	-0.3 (-4%)	0.1 (1%)
Below Normal	0.3 (5%)	0.6 (12%)
Dry	0.5 (10%)	0.2 (4%)
Critical	0.3 (10%)	0.3 (7%)
Verona, 31,000 cfs[a]		
Wet	-1.8 (-72%)	-1.5 (-67%)
Above Normal	-0.5 (-30%)	-0.3 (-22%)
Below Normal	0.4 (71%)	0.4 (100%)
Dry	0.7 (260%)	0.8 (350%)
Critical	0 (0%)	0 (0%)

[a] Months analyzed: February through May.

[b] Months analyzed: November through May.

Larval transport flows were also examined by utilizing the positive correlation between year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved larval transport that results in improved year class strength. The percent of months exceeding flow thresholds under A2A_LLT generally be lower than those under NAA (up to 67%) with few exceptions (Table 11-mult-114). These results suggest that, using the positive correlation between Delta outflow and year class strength, year class strength would be lower under Alternative 2A.

Table 11-mult-114. Difference and Percent Difference in Percentage of Months in Which Average Delta Outflow is Predicted to Exceed 15,000, 20,000, and 25,000 Cubic Feet per Second in April and May of Wet and Above-Normal Water Years

Flow	Water Year Type	EXISTING CONDITIONS vs. A2A_LLT	NAA vs. A2A_LLT
April			
15,000 cfs	Wet	-8 (-8%)	-8 (-8%)
	Above Normal	-17 (-18%)	-17 (-18%)
20,000 cfs	Wet	-8 (-9%)	-8 (-9%)
	Above Normal	-25 (-33%)	-17 (-25%)
25,000 cfs	Wet	-19 (-24%)	-15 (-20%)
	Above Normal	-25 (-43%)	-17 (-33%)
May			
15,000 cfs	Wet	-12 (-13%)	-4 (-5%)
	Above Normal	-25 (-30%)	0 (0%)
20,000 cfs	Wet	-38 (-45%)	-15 (-25%)
	Above Normal	-8 (-20%)	0 (0%)
25,000 cfs	Wet	-31 (-44%)	-19 (-33%)
	Above Normal	-25 (-75%)	-17 (-67%)
April/May Average			
15,000 cfs	Wet	-12 (-12%)	-4 (-4%)
	Above Normal	-25 (-25%)	-17 (-18%)
20,000 cfs	Wet	-23 (-26%)	-19 (-23%)
	Above Normal	-17 (-25%)	0 (0%)
25,000 cfs	Wet	-19 (-24%)	-8 (-11%)
	Above Normal	-25 (-50%)	-25 (-50%)

For juveniles, year-round migration flows at Verona were more than 5% lower under A2A_LLT relative to NAA throughout much of the year under each water year type (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

For adults, the average number of months per year during the November through May adult migration period in which flows in the Sacramento River at Wilkins Slough exceed 5,300 cfs was determined (Table 11-mult-113). The average number of months exceeding 5,300 cfs under A2A_LLT would generally be similar to the number of months under NAA, except in below normal (12% higher), dry (9% higher), and critical (10% higher) water year types. These increase in exceedances are considered small (<15%) and would not affect white sturgeon adult migration.

These results suggest that, using the positive correlation between Delta outflow and year class strength, year class strength would be lower under Alternative 2A. However, there is high uncertainty that year class strength is due to Delta outflow or if both year class strength and Delta outflows are caused by another unknown factor. There is no difference in the ability of Alternative 2A to meet flow targets in the Sacramento River relative to NAA (Table 11-mult-113).

Through-Delta

The impact of Alternative 2A on in-Delta conditions for white sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that white sturgeon year class strength could be lower under Alternative 2A, but due to a lack of understanding of the mechanism responsible for the correlation and because it was found in the absence of north Delta intakes, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 2A and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 2A and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 2A was appreciably lower than that under NAA_ELT. The exact mechanism for the correlation between white sturgeon year-class strength and Delta outflow is not known at this time and was found in the absence of north Delta intakes. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

The scientific uncertainty regarding which mechanisms are responsible for the positive correlation between year class strength and river/Delta flow will be addressed through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 2A operations such that the effect on white sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 2A and NAA_ELT, indicate that Alternative 2A would not be adverse to migration conditions for white sturgeon.

Alternative 3

The effects of Alternative 3 on white sturgeon migration conditions relative to NAA are not adverse.

Upstream of the Delta

Analyses for white sturgeon focused on the Sacramento River (north Delta to RM 143—i.e., Wilkins Slough and Verona CALSIM nodes). Larval transport flows were represented by the average number of months per year that exceeded thresholds of 17,700 cfs (Wilkins Slough) and 31,000 cfs (Verona) (Table 11-mult-115). Exceedances of the 17,700 cfs threshold for Wilkins Slough under A3_LLT were generally similar to those under NAA. The number of months per year above 31,000 cfs at Verona under A3_LLT would be up to 50% lower than under NAA. On an absolute scale, all of these changes would be negligible (up to 0.2 months).

Table 11-mult-115. Difference and Percent Difference in Number of Months in Which Flow Rates Exceed 17,700 and 5,300 cfs in the Sacramento River at Wilkins Slough and 31,000 cfs at Verona

	EXISTING CONDITIONS vs. A3_LLT	NAA vs. A3_LLT
Wilkins Slough, 17,700 cfs[a]		
Wet	-0.04 (-2%)	0 (0%)
Above Normal	0.3 (18%)	0.1 (5%)
Below Normal	-0.1 (-25%)	0 (0%)
Dry	0 (0%)	0 (0%)
Critical	0 (0%)	0 (0%)
Wilkins Slough, 5,300 cfs[b]		
Wet	-0.1 (-2%)	0.1 (1%)
Above Normal	0 (0%)	0.3 (5%)
Below Normal	0.2 (4%)	0.5 (10%)
Dry	0.6 (11%)	0.3 (5%)
Critical	0.3 (10%)	0.3 (7%)
Verona, 31,000 cfs[a]		
Wet	-0.5 (-21%)	-0.2 (-9%)
Above Normal	-0.1 (-5%)	0.1 (6%)
Below Normal	-0.2 (-43%)	-0.1 (-33%)
Dry	-0.2 (-60%)	-0.1 (-50%)
Critical	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] Months analyzed: February through May.

[b] Months analyzed: November through May.

Larval transport flows were also examined by utilizing the positive correlation between year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved larval transport that results in improved year class strength. The percentage of months exceeding flow thresholds under A3_LLT would generally be lower than those under NAA (up to 50% lower) (Table 11-mult-116). These results suggest that, using the positive correlation between Delta outflow and year class strength, year class strength would be lower under Alternative 3.

Table 11-mult-46. Difference and Percent Difference in Percentage of Months in Which Average Delta Outflow is Predicted to Exceed 15,000, 20,000, and 25,000 Cubic Feet per Second in April and May of Wet and Above-Normal Water Years

Flow	Water Year Type	EXISTING CONDITIONS vs. A3_LLT	NAA vs. A3_LLT
April			
15,000 cfs	Wet	-15 (-16%)	-15 (-16%)
	Above Normal	-25 (-27%)	-25 (-27%)
20,000 cfs	Wet	-12 (-14%)	-12 (-14%)
	Above Normal	-33 (-44%)	-25 (-38%)
25,000 cfs	Wet	-15 (-19%)	-12 (-15%)
	Above Normal	-17 (-29%)	-8 (-17%)
May			
15,000 cfs	Wet	-15 (-17%)	-8 (-10%)
	Above Normal	-33 (-40%)	-8 (-14%)
20,000 cfs	Wet	-35 (-41%)	-12 (-19%)
	Above Normal	-25 (-60%)	-17 (-50%)
25,000 cfs	Wet	-31 (-44%)	-19 (-33%)
	Above Normal	-17 (-50%)	-8 (-33%)
April/May Average			
15,000 cfs	Wet	-15 (-16%)	-8 (-9%)
	Above Normal	-33 (-33%)	-25 (-27%)
20,000 cfs	Wet	-23 (-26%)	-19 (-23%)
	Above Normal	-17 (-25%)	0 (0%)
25,000 cfs	Wet	-19 (-24%)	-8 (-11%)
	Above Normal	-25 (-50%)	-25 (-50%)

For juveniles, year-round migration flows at Verona would be up to 54% lower under A3_LLT relative to NAA during four of 12 months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

For adults, the average number of months per year during the November through May adult migration period in which flows in the Sacramento River at Wilkins Slough exceed 5,300 cfs was determined (Table 11-mult-115). The average number of months exceeding 5,300 cfs under A3_LLT would always be similar to greater than the number of months under NAA.

Through-Delta

The impact of Alternative 3 on in-Delta conditions for white sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that white sturgeon year class strength could be lower under Alternative 3, but due to a lack of understanding of the mechanism responsible for the correlation and because it was found in the absence of north Delta intakes, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 3 and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 3 and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 3 was appreciably lower than that under NAA_ELT. The exact mechanism for the correlation between white sturgeon year-class strength and Delta outflow is not known at this time and was found in the absence of north Delta intakes. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

The scientific uncertainty regarding which mechanisms are responsible for the positive correlation between year class strength and river/Delta flow will be addressed through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 3 operations such that the effect on white sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 3 and NAA_ELT, indicate that Alternative 3 would not be adverse to migration conditions for white sturgeon.

Alternative 4

The effects of Alternative 4 on white sturgeon migration conditions relative to NAA are not adverse.

Upstream of the Delta

H3/ESO

Analyses for white sturgeon focused on the Sacramento River (North Delta to RM 143—i.e., Wilkins Slough and Verona CALSIM nodes). Larval transport flows were represented by the average number of months per year that exceeded thresholds of 17,700 cfs (Wilkins Slough) and 31,000 cfs (Verona) (Table 11-mult-117). Exceedances of the 17,700 cfs threshold for Wilkins Slough and the 31,000 cfs threshold at Verona under H3 would generally be similar to those under NAA. Despite some large relative difference (up to 50%), these changes would be negligible on an absolute scale.

Table 11-mult-117. Difference and Percent Difference in Number of Months in Which Flow Rates Exceed 17,700 and 5,300 cfs in the Sacramento River at Wilkins Slough and 31,000 cfs at Verona

	EXISTING CONDITIONS vs. H3	NAA vs. H3
Wilkins Slough, 17,700 cfs[a]		
Wet	0 (-2%)	0 (0%)
Above Normal	0.3 (18%)	0.1 (5%)
Below Normal	-0.1 (-25%)	0 (0%)
Dry	0 (0%)	0 (0%)
Critical	0 (0%)	0 (0%)
Wilkins Slough, 5,300 cfs[b]		
Wet	-0.2 (-3%)	0 (0%)
Above Normal	-0.3 (-4%)	0.1 (1%)
Below Normal	0.3 (5%)	0.6 (12%)
Dry	0.4 (9%)	0.2 (3%)
Critical	0.2 (5%)	0.1 (2%)
Verona, 31,000 cfs[a]		
Wet	-0.5 (-21%)	-0.2 (-9%)
Above Normal	-0.2 (-10%)	0 (0%)
Below Normal	-0.2 (-43%)	-0.1 (-33%)
Dry	-0.2 (-60%)	-0.1 (-50%)
Critical	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] Months analyzed: February through May.

[b] Months analyzed: November through May.

Larval transport flows were also examined by utilizing the positive correlation between year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved larval transport that results in improved year class strength. The percentage of months exceeding flow thresholds under H3 would generally be lower than those under NAA (up to 50% lower) (Table 11-mult-118). These results indicate that, using the positive correlation between Delta outflow and year class strength, year class strength generally would be lower under H3.

Table 11-mult-118. Difference and Percent Difference in Percentage of Months in Which Average Delta Outflow is Predicted to Exceed 15,000, 20,000, and 25,000 Cubic Feet per Second (cfs) in April and May of Wet and Above-Normal Water Years

Flow	Water Year Type	EXISTING CONDITIONS vs. H3	NAA vs. H3
April			
15,000 cfs	Wet	-8 (-8%)	-8 (-8%)
	Above Normal	-17 (-18%)	-17 (-18%)
20,000 cfs	Wet	-8 (-9%)	-8 (-9%)
	Above Normal	-25 (-33%)	-17 (-25%)
25,000 cfs	Wet	-15 (-19%)	-12 (-15%)
	Above Normal	-17 (-29%)	-8 (-17%)
May			
15,000 cfs	Wet	-8 (-9%)	0 (0%)
	Above Normal	-17 (-20%)	8 (14%)
20,000 cfs	Wet	-35 (-41%)	-12 (-19%)
	Above Normal	-17 (-40%)	-8 (-25%)
25,000 cfs	Wet	-27 (-39%)	-15 (-27%)
	Above Normal	-17 (-50%)	-8 (-33%)
April/May Average			
15,000 cfs	Wet	-8 (-8%)	0 (0%)
	Above Normal	-25 (-25%)	-17 (-18%)
20,000 cfs	Wet	-19 (-22%)	-15 (-18%)
	Above Normal	-17 (-25%)	0 (0%)
25,000 cfs	Wet	-19 (-24%)	-8 (-11%)
	Above Normal	-25 (-50%)	-25 (-50%)

For juveniles, flows in the Sacramento River at Verona were examined during the year-round migration period (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows at Verona under H3 would be lower by up to 25% relative to NAA during January, July, August, and November, greater by up to 32% greater during May and June, and similar in the remaining six months (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

For adults, the average number of months per year during the November through May adult migration period in which flows in the Sacramento River at Wilkins Slough exceed 5,300 cfs was determined (Table 11-mult-117). The average number of months exceeding 5,300 cfs under H3 would be similar to or greater than the number of months under NAA (up to 12% greater).

H1/LOS

Year-round flows under H1 in the Sacramento River at Wilkins Slough and Verona would be similar to those under NAA, except during July through September at Verona and at both locations during November, in which flows would be up to 55% lower (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

H4/HOS

Year-round flows under H4 in the Sacramento River at Wilkins Slough and Verona would be similar to those under NAA, except during January, March, and July through September at Verona and at both locations during November, in which flows would be up to 26% lower (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

Through-Delta

The impact of Alternative 4 on in-Delta conditions for white sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that white sturgeon year class strength could be lower under Alternative 4, but due to a lack of understanding of the mechanism responsible for the correlation and because it was found in the absence of north Delta intakes, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 4 and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 4 and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 4 was appreciably lower than that under NAA_ELT. The exact mechanism for the correlation between white sturgeon year-class strength and Delta outflow is not known at this time and was found in the absence of north Delta intakes. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

The scientific uncertainty regarding which mechanisms are responsible for the positive correlation between year class strength and river/Delta flow will be addressed through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 4 operations such that the effect on white sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 4 and NAA_ELT, indicate that Alternative 4 would not be adverse to migration conditions for white sturgeon.

Alternative 5

The effects of Alternative 5 on white sturgeon migration conditions relative to NAA are not adverse.

Upstream of the Delta

Analyses for white sturgeon focused on the Sacramento River (north Delta to RM 143—i.e., Wilkins Slough and Verona CALSIM nodes). Larval transport flows were represented by the average number of months per year that exceeded thresholds of 17,700 cfs (Wilkins Slough) and 31,000 cfs (Verona) (Table 11-mult-119). Exceedances of the 17,700 cfs threshold for Wilkins Slough under A5_LLT were generally similar to those under NAA (Table 11-mult-119). The number of months per year above 31,000 cfs at Verona would range from small increases to a reduction of 0.5 months (21% lower in wet years) relative to NAA. Overall, there is no consistent difference between Alternative 5 and the NAA. On an absolute scale, none of these values would be biologically meaningful (up to 0.2 months).

Table 11-mult-119. Difference and Percent Difference in Number of Months in Which Flow Rates Exceed 17,700 and 5,300 Cubic Feet per Second (cfs) in the Sacramento River at Wilkins Slough, and 31,000 cfs at Verona

Water Year Types	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
Wilkins Slough, 17,700 cfs[a]		
Wet	-0.04 (-2%)	0 (0%)
Above Normal	0.3 (18%)	0.1 (5%)
Below Normal	-0.1 (-25%)	0 (0%)
Dry	0 (0%)	0 (0%)
Critical	0 (0%)	0 (0%)
Wilkins Slough, 5,300 cfs[b]		
Wet	-0.2 (-2%)	0 (1%)
Above Normal	-0.1 (-1%)	0.3 (4%)
Below Normal	0.2 (4%)	0.5 (10%)
Dry	0.6 (11%)	0.3 (5%)
Critical	0.3 (10%)	0.3 (7%)
Verona, 31,000 cfs[a]		
Wet	-0.5 (-21%)	-0.2 (-9%)
Above Normal	-0.2 (-10%)	0 (0%)
Below Normal	-0.2 (-43%)	-0.1 (-33%)
Dry	-0.2 (-60%)	-0.1 (-50%)
Critical	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] Months analyzed: February through May.

[b] Months analyzed: November through May.

Larval transport flows were also examined by utilizing the positive correlation between year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved larval transport that results in improved year class strength. The percent of months exceeding flow thresholds under A5_LLT would generally be lower than those under NAA (up to 33% lower) (Table 11-mult-120). These results indicate that, using the positive correlation between Delta outflow and year class strength, year class strength would be lower under Alternative 5.

Table 11-mult-120. Difference and Percent Difference in the Percentage of Months in Which Average Delta Outflow is Predicted to Exceed 15,000, 20,000, and 25,000 Cubic Feet per Second (cfs) in April and in May of Wet and Above-Normal Water Years

Flow	Water Year Type	EXISTING CONDITIONS vs. A5_LLT	NAA vs. A5_LLT
April			
15,000 cfs	Wet	-4 (-4%)	-4 (-4%)
	Above Normal	-8 (-9%)	-8 (-9%)
20,000 cfs	Wet	-4 (-5%)	-4 (-5%)
	Above Normal	-17 (-22%)	-8 (-13%)
25,000 cfs	Wet	-8 (-10%)	-4 (-5%)
	Above Normal	-17 (-29%)	-8 (-17%)
May			
15,000 cfs	Wet	-12 (-13%)	-4 (-5%)
	Above Normal	-17 (-20%)	8 (14%)
20,000 cfs	Wet	-27 (-32%)	-4 (-6%)
	Above Normal	-8 (-20%)	0 (0%)
25,000 cfs	Wet	-19 (-28%)	-8 (-13%)
	Above Normal	-17 (-50%)	-8 (-33%)
April/May Average			
15,000 cfs	Wet	-8 (-8%)	0 (0%)
	Above Normal	-25 (-25%)	-17 (-18%)
20,000 cfs	Wet	-8 (-9%)	-4 (-5%)
	Above Normal	-17 (-25%)	0 (0%)
25,000 cfs	Wet	-19 (-24%)	-8 (-11%)
	Above Normal	0 (0%)	0 (0%)

For juveniles, year-round migration flows at Verona would be up to 30% under A5_LLT relative to NAA throughout much of the year and under almost all water year types (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Although the differences would be generally small, they would occur throughout the year (in all but two months).

For adults, the average number of months per year during the November through May adult migration period in which flows in the Sacramento River at Wilkins Slough exceed 5,300 cfs was determined (Table 11-mult-119). The average number of months exceeding 5,300 cfs under A5_LLT would always be similar to or up to 10% greater than the number of months under NAA.

Through-Delta

The impact of Alternative 5 on in-Delta conditions for white sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that white sturgeon year class strength could be lower under Alternative 5, but due to a lack of understanding of the mechanism responsible for the correlation and because it was found in the absence of north Delta intakes, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 5 and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 5 and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 5 was appreciably lower than that under NAA_ELT. The exact mechanism for the correlation between white sturgeon year-class strength and Delta outflow is not known at this time and was found in the absence of north Delta intakes. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

The scientific uncertainty regarding which mechanisms are responsible for the positive correlation between year class strength and river/Delta flow will be addressed through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 5 operations such that the effect on white sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 5 and NAA_ELT, indicate that Alternative 5 would not be adverse to migration conditions for white sturgeon.

Alternative 6A

The effects of Alternative 6A on white sturgeon migration conditions relative to NAA are not adverse.

Upstream of the Delta

Analyses for white sturgeon focused on the Sacramento River (North Delta to RM 143—i.e., Wilkins Slough and Verona CALSIM nodes). Larval transport flows were represented by the average number of months per year that exceeded thresholds of 17,700 cfs (Wilkins Slough) and 31,000 cfs (Verona) (Table 11-mult-121). Exceedances of the 17,700 cfs threshold for Wilkins Slough under A6A_LLT were generally similar to those under NAA. The number of months per year above 31,000 cfs at Verona under A6A_LLT would be up to 6% higher and up to 50% lower than under NAA. On an absolute scale, all of these changes would be negligible (up to 0.2 months).

Table 11-mult-121. Difference and Percent Difference in Number of Months in Which Flow Rates Exceed 17,700 and 5,300 cfs in the Sacramento River at Wilkins Slough and 31,000 cfs at Verona

	EXISTING CONDITIONS vs. A6A_LLT	NAA vs. A6A_LLT
Wilkins Slough, 17,700 cfs[a]		
Wet	-0.04 (-2%)	0 (0%)
Above Normal	0.3 (18%)	0.1 (5%)
Below Normal	-0.1 (-25%)	0 (0%)
Dry	0 (0%)	0 (0%)
Critical	0 (0%)	0 (0%)
Wilkins Slough, 5,300 cfs[b]		
Wet	-0.2 (-3%)	0 (0%)
Above Normal	-0.4 (-6%)	-0.1 (-1%)
Below Normal	-0.1 (-1%)	0.2 (4%)
Dry	0.3 (7%)	0.1 (1%)
Critical	0.1 (2%)	0 (0%)
Verona, 31,000 cfs[a]		
Wet	-0.5 (-21%)	-0.2 (-9%)
Above Normal	-0.1 (-5%)	0.1 (6%)
Below Normal	-0.2 (-43%)	-0.1 (-33%)
Dry	-0.2 (-60%)	-0.1 (-50%)
Critical	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] Months analyzed: February through May.

[b] Months analyzed: November through May.

Larval transport flows were also examined by utilizing the positive correlation between year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved larval transport that results in improved year class strength. The percentage of months exceeding flow thresholds under A6A_LLT would generally be lower than those under NAA (up to 67% lower) with few exceptions (Table 11-mult-122). These results suggest that, using the positive correlation between Delta outflow and year class strength, year class strength would generally be lower under Alternative 6A.

Table 11-mult-122. Difference and Percent Difference in Percentage of Months in Which Average Delta Outflow is Predicted to Exceed 15,000, 20,000, and 25,000 Cubic Feet per Second (cfs) in April and May of Wet and Above-Normal Water Years

Flow	Water Year Type	EXISTING CONDITIONS vs. A6A_LLT	NAA vs. A6A_LLT
April			
15,000 cfs	Wet	0 (0%)	0 (0%)
	Above Normal	0 (0%)	0 (0%)
20,000 cfs	Wet	-8 (-9%)	-8 (-9%)
	Above Normal	-17 (-22%)	-8 (-13%)
25,000 cfs	Wet	-15 (-19%)	-12 (-15%)
	Above Normal	-25 (-43%)	-17 (-33%)
May			
15,000 cfs	Wet	-4 (-4%)	4 (5%)
	Above Normal	-17 (-20%)	8 (14%)
20,000 cfs	Wet	-38 (-45%)	-15 (-25%)
	Above Normal	-8 (-20%)	0 (0%)
25,000 cfs	Wet	-27 (-39%)	-15 (-27%)
	Above Normal	-25 (-75%)	-17 (-67%)
April/May Average			
15,000 cfs	Wet	-8 (-8%)	0 (0%)
	Above Normal	-25 (-25%)	-17 (-18%)
20,000 cfs	Wet	-19 (-22%)	-15 (-18%)
	Above Normal	-17 (-25%)	0 (0%)
25,000 cfs	Wet	-19 (-24%)	-8 (-11%)
	Above Normal	-25 (-50%)	-25 (-50%)

For juveniles, year-round migration flows at Verona would be up to 21% lower under A6A_LLT relative to NAA in most water year types during January, March, April, July, August, November, and December, although differences would rarely exceed ~15% (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*). Flows under A6A_LLT during other months would generally be similar to flows under NAA with some exceptions.

For adults, the average number of months per year during the November through May adult migration period in which flows in the Sacramento River at Wilkins Slough exceed 5,300 cfs was determined (Table 11-mult-121). The average number of months exceeding 5,300 cfs under A6A_LLT would always be similar to or greater than the number of months under NAA.

Through-Delta

The impact of Alternative 6A on in-Delta conditions for white sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that white sturgeon year class strength could be lower under Alternative 6A, but due to a lack of understanding of the mechanism responsible for the correlation and because it was found in the absence of north Delta intakes, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 6A and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 6A and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 6A was appreciably lower than that under NAA_ELT. The exact mechanism for the correlation between white sturgeon year-class strength and Delta outflow is not known at this time and was found in the absence of north Delta intakes. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

The scientific uncertainty regarding which mechanisms are responsible for the positive correlation between year class strength and river/Delta flow will be addressed through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 6A operations such that the effect on white sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 6A and NAA_ELT, indicate that Alternative 6A would not be adverse to migration conditions for white sturgeon.

Alternative 7

The effects of Alternative 7 on white sturgeon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Analyses for white sturgeon focused on the Sacramento River (North Delta to RM 143—i.e., Wilkins Slough and Verona). Larval transport flows were represented by the average number of months per year during the February through May larval transport period that exceeded thresholds of 17,700 cfs (Wilkins Slough) and 31,000 cfs (Verona) (Table 11-mult-123). Exceedances of the 17,700 cfs threshold for Wilkins Slough under A7_LLT were similar to those under NAA, except in above normal water years (6% higher). The number of months per year above 31,000 cfs at Verona would be similar to or lower than the number under NAA in all water year types. On an absolute scale, all these changes would be negligible (up to 0.3 months).

Table 11-mult-123. Difference and Percent Difference in Number of Months in Which Flow Rates Exceed 17,700 and 5,300 cfs in the Sacramento River at Wilkins Slough and 31,000 cfs at Verona

	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
Wilkins Slough, 17,700 cfs[a]		
Wet	0 (-2%)	0 (0%)
Above Normal	0.3 (18%)	0.1 (6%)
Below Normal	-0.1 (-25%)	0 (0%)
Dry	0 (0%)	0 (0%)
Critical	0 (0%)	0 (0%)
Wilkins Slough, 5,300 cfs[b]		
Wet	-0.1 (-2%)	0.1 (1%)
Above Normal	-0.4 (-6%)	-0.1 (-1%)
Below Normal	0 (0%)	0.3 (6%)
Dry	0.2 (4%)	-0.1 (-1%)
Critical	0.3 (7%)	0.2 (5%)
Verona, 31,000 cfs[a]		
Wet	-0.5 (-21%)	-0.2 (-9%)
Above Normal	-0.2 (-10%)	0 (0%)
Below Normal	-0.2 (-42%)	-0.1 (-33%)
Dry	-0.2 (-61%)	-0.1 (-50%)
Critical	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] Months analyzed: February through May.

[b] Months analyzed: November through May.

Larval transport flows were also examined by utilizing the positive correlation between year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved larval transport that results in improved year class strength. The percent of months exceeding flow thresholds under A7_LLT would generally be lower than those under NAA (up to 33%) (Table 11-mult-124). These results suggest that, using the positive correlation between Delta outflow and year class strength, year class strength would be lower under Alternative 7.

Table 11-mult-124. Difference and Percent Difference in Percentage of Months in Which Average Delta Outflow is Predicted to Exceed 15,000, 20,000, and 25,000 Cubic Feet per Second in April and May of Wet and Above-Normal Water Years

Flow	Water Year Type	EXISTING CONDITIONS vs. A7_LLT	NAA vs. A7_LLT
April			
15,000 cfs	Wet	0 (0%)	0 (0%)
	Above Normal	0 (0%)	0 (0%)
20,000 cfs	Wet	-8 (-9%)	-8 (-9%)
	Above Normal	-8 (-11%)	0 (0%)
25,000 cfs	Wet	-8 (-10%)	-4 (-5%)
	Above Normal	-17 (-29%)	-8 (-17%)
May			
15,000 cfs	Wet	-4 (-4%)	4 (5%)
	Above Normal	-17 (-20%)	8 (14%)
20,000 cfs	Wet	-31 (-36%)	-8 (-13%)
	Above Normal	-17 (-40%)	-8 (-25%)
25,000 cfs	Wet	-27 (-39%)	-15 (-27%)
	Above Normal	-17 (-50%)	-8 (-33%)
April/May Average			
15,000 cfs	Wet	-8 (-8%)	0 (0%)
	Above Normal	-17 (-17%)	-8 (-9%)
20,000 cfs	Wet	-12 (-13%)	-8 (-9%)
	Above Normal	-17 (-25%)	0 (0%)
25,000 cfs	Wet	-19 (-24%)	-8 (-11%)
	Above Normal	-8 (-17%)	-8 (-17%)

For juveniles, year-round migration flows at Verona would be more than 5% lower under A7_LLT relative to NAA throughout much of the year under each water year, although differences would rarely exceed ~15% (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

For adults, the average number of months per year during the November through May adult migration period in which flows in the Sacramento River at Wilkins Slough exceed 5,300 cfs was determined (Table 11-mult-123). The average number of months exceeding 5,300 cfs under A7_LLT would generally be similar to the number of months under NAA, except in below normal (6% higher) and critical (5% higher) water year types (Table 11-mult-123). These increases in exceedances are considered small (<15%) and would not affect white sturgeon adult migration.

Through-Delta

The impact of Alternative 7 on in-Delta conditions for white sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that white sturgeon year class strength could be lower under Alternative 7, but due to a lack of understanding of the mechanism responsible for the correlation and because it was found in the absence of north Delta intakes, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 7 and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 7 and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 7 was appreciably lower than that under NAA_ELT. The exact mechanism for the correlation between white sturgeon year-class strength and Delta outflow is not known at this time and was found in the absence of north Delta intakes. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

The scientific uncertainty regarding which mechanisms are responsible for the positive correlation between year class strength and river/Delta flow will be addressed through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 7 operations such that the effect on white sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 7 and NAA_ELT, indicate that Alternative 7 would not be adverse to migration conditions for white sturgeon.

Alternative 9

The effects of Alternative 9 on white sturgeon migration conditions relative to the NAA are not adverse.

Upstream of the Delta

Analyses for white sturgeon focused on the Sacramento River (North Delta to RM 143—i.e., Wilkins Slough and Verona CALSIM nodes). Larval transport flows were represented by the average number of months per year that exceeded thresholds of 17,700 cfs (Wilkins Slough) and 31,000 cfs (Verona) (Table 11-mult-125). Exceedances of the 17,700 cfs threshold for Wilkins Slough under A9_LLT were identical to those under NAA. The number of months per year above 31,000 cfs at Verona under A9_LLT would be up to 33% lower than under NAA. Overall, there is no consistent difference between Alternative 9 and NAA.

Table 11-mult-125. Difference and Percent Difference in Number of Months in Which Flow Rates Exceed 17,700 and 5,300 cfs in the Sacramento River at Wilkins Slough and 31,000 cfs at Verona

	EXISTING CONDITIONS vs. A9_LLT	NAA vs. A9_LLT
Wilkins Slough, 17,700 cfs[a]		
Wet	-0.04 (-2%)	0 (0%)
Above Normal	0.2 (12%)	0 (0%)
Below Normal	-0.1 (-25%)	0 (0%)
Dry	0 (0%)	0 (0%)
Critical	0 (0%)	0 (0%)
Wilkins Slough, 5,300 cfs[b]		
Wet	-0.1 (-1%)	0.1 (2%)
Above Normal	-0.3 (-4%)	0.1 (1%)
Below Normal	0.4 (7%)	0.6 (13%)
Dry	0.8 (17%)	0.6 (11%)
Critical	0.2 (5%)	0.1 (2%)
Verona, 31,000 cfs[a]		
Wet	-0.5 (-21%)	-0.2 (-9%)
Above Normal	-0.2 (-10%)	0 (0%)
Below Normal	-0.2 (-43%)	-0.1 (-33%)
Dry	-0.1 (-40%)	-0.1 (-25%)
Critical	0 (NA)	0 (NA)

NA = could not be calculated because the denominator was 0.

[a] Months analyzed: February through May.

[b] Months analyzed: November through May.

Larval transport flows were also examined by utilizing the positive correlation between year class strength and Delta outflow during April and May (USFWS 1995) under the assumption that the mechanism responsible for the relationship is that Delta outflow provides improved larval transport that results in improved year class strength. The percentage of months exceeding flow thresholds under A9_LLT would generally be lower by up to 50% than those under NAA for each flow threshold, water year type, and month (Table 11-mult-126). These results indicate that, using the positive correlation between Delta outflow and year class strength, year class strength would generally be lower under Alternative 9.

Table 11-mult-126. Difference and Percent Difference in Percentage of Months in Which Average Delta Outflow is Predicted to Exceed 15,000, 20,000, and 25,000 Cubic Feet per Second (cfs) in April and May of Wet and Above-Normal Water Years

Flow	Water Year Type	EXISTING CONDITIONS vs. A9_LLT	NAA vs. A9_LLT
April			
15,000 cfs	Wet	-8 (-8%)	-8 (-8%)
	Above Normal	-17 (-18%)	-17 (-18%)
20,000 cfs	Wet	-4 (-5%)	-4 (-5%)
	Above Normal	-17 (-22%)	-8 (-13%)
25,000 cfs	Wet	-8 (-10%)	-4 (-5%)
	Above Normal	-17 (-29%)	-8 (-17%)
May			
15,000 cfs	Wet	-15 (-17%)	-8 (-10%)
	Above Normal	-42 (-50%)	-17 (-29%)
20,000 cfs	Wet	-27 (-32%)	-4 (-6%)
	Above Normal	-8 (-20%)	0 (0%)
25,000 cfs	Wet	-19 (-28%)	-8 (-13%)
	Above Normal	-17 (-50%)	-8 (-33%)
April/May Average			
15,000 cfs	Wet	-8 (-8%)	0 (0%)
	Above Normal	-33 (-33%)	-25 (-27%)
20,000 cfs	Wet	-15 (-17%)	-12 (-14%)
	Above Normal	-17 (-25%)	0 (0%)
25,000 cfs	Wet	-19 (-24%)	-8 (-11%)
	Above Normal	0 (0%)	0 (0%)

For juveniles, year-round migration flows at Verona would generally be up to 13% lower under A9_LLT relative to NAA during January, March, and October and similar to or greater than flows under NAA during the rest of the year, with some exceptions (Appendix 11C, *CALSIM II Model Results utilized in the Fish Analysis*).

For adults, the average number of months per year during the November through May adult migration period in which flows in the Sacramento River at Wilkins Slough exceed 5,300 cfs was determined (Table 11-mult-125). The average number of months exceeding 5,300 cfs under A9_LLT would generally be similar to or greater than the number of months under NAA, except in below normal and dry years (11% to 13% lower).

Through-Delta

The impact of Alternative 9 on in-Delta conditions for white sturgeon is described above with respect to Delta outflow and its potential effects to larval transport. The analysis indicates that white sturgeon year class strength could be lower under Alternative 9, but due to a lack of understanding of the mechanism responsible for the correlation and because it was found in the absence of north Delta intakes, the analysis is deemed unreliable.

NEPA Effects: Upstream flows (above north Delta intakes) would generally be similar between Alternative 9 and NAA. Due to the removal of water at the North Delta intakes, there are substantial differences in through-Delta flows between Alternative 9 and NAA_ELT. The percentage of months exceeding the USFWS (1995) Delta outflow thresholds in April and May of wet and above normal years under Alternative 9 was appreciably lower than that under NAA_ELT. The exact mechanism for the correlation between white sturgeon year-class strength and Delta outflow is not known at this time and was found in the absence of north Delta intakes. One hypothesis suggests that the correlation is caused by high flows in the upper river resulting in improved migration, spawning, and rearing conditions in the upper river. In this case, there would be no causal link between Delta outflow and white sturgeon year-class strength. Another hypothesis suggests that the positive correlation is a result of higher flows through the Delta triggering more adult sturgeon to move up into the river to spawn. It is also possible that some combination of these factors are working together to produce the positive correlation between high flows and sturgeon year-class strength.

The scientific uncertainty regarding which mechanisms are responsible for the positive correlation between year class strength and river/Delta flow will be addressed through targeted research and monitoring to be conducted in the years leading up to the initiation of north Delta facilities operations. Given the outcome of these investigations, Delta outflow would be appropriately set for Alternative 9 operations such that the effect on white sturgeon Delta flow conditions would not be adverse. This, combined with similarities in upstream flow conditions between Alternative 9 and NAA_ELT, indicate that Alternative 9 would not be adverse to migration conditions for white sturgeon.

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11.4.2 Personal Communications

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Kirkland, M. Senior Engineer. California Department of Water Resources Division of Environmental Services. September 12, 2011—email response to Sophie Unger regarding potential effects of diverting Sacramento River flow at the Fremont Weir on Sutter Bypass inundation.

Kurth, Ryon. Staff Environmental Scientist. California Department of Water Resources. July 6, 2010—email to Rick Wilder about spawning location of Pacific and river lamprey in the Feather River.

Lindberg, Joan, PhD, Director, Fish Conservation and Culture Lab, Byron, Biological and Ag Engineering, University of California, Davis. December 15, 2011—Email communication with Willis (Chip) McConnaha, PhD, Ecosystem Biometrics Practice Leader, ICF International, Portland, OR.

Munévar, Armin. Engineer. CH2M Hill. April 2009—technical memorandum to BDCP Integration Team regarding an evaluation of operations of the Fremont Weir to increase the frequency and duration of inundation of the Yolo Bypass.

Sommer, T. Senior Environmental Scientist. California Department of Water Resources. June 28 and 29, 2010—Telephone communications with S. Unger, Owner, Waterwise Consulting, about splittail spawning timing and conditions.