Appendix 6D

Selenium Model Documentation

This appendix provides information about the methods, modeling tools, and assumptions used for the Coordinated Long Term Operation of the Central Valley Project (CVP) and State Water Project (SWP) Environmental Impact Statement (EIS) analysis. This appendix also provides information pertaining to the development of the analytical tools and the use of input data as well as model result processing and interpretation methods used for the impacts analysis and descriptions.

This appendix is organized into three main sections:

- Section 6D.1: Modeling Methodology
  - The selenium impacts analysis uses CalSim II, the Delta Simulation Model II (DSM2), and Delta-specific selenium bioaccumulation modeling to assess and quantify effects of the alternatives on the long-term operation and the environment. This section provides information about the development and calibration of a Delta-wide bioaccumulation model for selenium in fish, use of outputs from that model to estimate bioaccumulation in bird eggs and fish fillets, and modeling of selenium bioaccumulation in sturgeon living in the western Delta using inputs from other models.
- Section 6D.2: Modeling Simulations and Assumptions
  - This section provides a brief description of the assumptions for the selenium model simulations of the No Action Alternative, Second Basis of Comparison, and Alternatives 1 through 5.
- Section 6D.3: Modeling Results
  - This section provides a description of the model simulation output formats used in the analysis and interpretation of modeling results for the alternatives impacts assessment.

6D.1 Modeling Methodology

This section summarizes the selenium modeling methodology used for the No Action Alternative, Second Basis of Comparison, and Alternatives 1 through 5. It describes the overall analytical framework and development and use of bioaccumulation models. This section also contains descriptions of the key analytical and numerical tools and approaches used in the quantitative evaluation of the alternatives. The project alternatives include changes to CVP and SWP operation that would cause subsequent effects on the water quality of the system relative to selenium. Those changes in waterborne selenium concentrations would propagate to changes in selenium concentrations in fish and bird eggs throughout the Delta.

6D.1.1 Overview of the Modeling Approach and Objectives

Modeling of flows, hydrodynamics, and selenium bioaccumulation in the Delta is necessary to support the selenium impact analysis of alternatives. Impact analysis focuses on evaluation of changes to selenium concentrations in tissues that affect the health of fish as well as wildlife and humans consuming fish in the Delta.

CalSim II, DSM2, and bioaccumulation modeling were used in sequence to estimate the effects of CVP and SWP operations on water quality relative to selenium in the Delta. CalSim II, which simulates flow in California's waterways, and DSM2, which simulates one-dimensional hydrodynamics in California's Delta, are discussed in detail in Appendix 5A. One of the three DSM2 modules, QUAL, simulates one-dimensional source tracking in the Delta. Results from DSM2 were multiplied by source concentrations (shown in Table 6D.1) to determine annual average waterborne selenium concentrations in the Delta for all year types and drought years.

Operations-related changes in waterborne selenium concentrations in the Delta may result in increased selenium bioaccumulation or toxicity (or both) to aquatic and semi-aquatic receptors using the Delta. Historical fish tissue data from 2000, 2005, and 2007 (Foe 2010a) and measured (for Sacramento River below Knights Landing and for San Joaquin River at Vernalis) or DSM2-modeled (other locations) waterborne selenium concentrations for selected locations in 2000, 2005, and 2007 were used to model water-to-tissue relationships. This modeling generally followed procedures described by Presser and Luoma (2010a, 2010b). Implementation of the Grassland Bypass Project (GBP) has led to a 60 percent decrease in selenium loads from the Grassland Drainage Area compared to pre-project conditions (San Francisco Bay Regional Water Quality Control Board 2008). These changes are reflected in data for the San Joaquin River at Vernalis, where water quality is monitored frequently because the river is a primary source of selenium to the Delta. Vernalis water data for 2 years (1999-2000, 2004-2005, and 2006-2007) were used for each year when fish data were available because of the GBP-related changes and because the lag time for selenium bioaccumulation in the piscivorous Largemouth Bass (*Micropterus salmoides*, the species for which the Delta-wide bioaccumulation model was calibrated) may be more than 1 year (Beckon 2014).

Output from the DSM2-QUAL model (expressed as percentage of inflow from different sources) was used in combination with the available measured waterborne selenium concentrations (Table 6D.1) to model concentrations of selenium at locations throughout the Delta. These modeled waterborne selenium concentrations were used in the relationship model to estimate bioaccumulation of selenium in whole-body fish and in bird eggs. Selenium concentrations in fish fillets were then estimated from those in whole-body fish. The following sections provide detailed information about the modeling approach for selenium.

Table 6D.1 Selenium Concentrations in Water at Inflow Sources to the Delta

Delta Sources	Representative Inflow Site	GM Se Concentration in Water (µg/L)[a]	Years	Source
Delta Agriculture	Mildred Island, Center	0.11	2000	Lucas and Stewart 2007
East Delta Tributaries	Mokelumne, Calaveras, and Cosumnes Rivers	0.10[b]	None	None
Martinez/Suisun Bay	San Joaquin River near Mallard Island	0.10	02/2000–08/2008	SFEI 2014
Sacramento River	Sacramento River at Freeport	0.09	11/2007–07/2014	USGS 2014
San Joaquin River	San Joaquin River at Vernalis (Airport Way)	0.45 [c]	11/2007-08/2014	USGS 2014
San Joaquin River	San Joaquin River at Vernalis (Airport Way)	0.83 [d]	1999-2000	SWAMP 2009
		0.85	2004-2005	SWAMP 2009
		0.58	2006-2007	SWAMP 2009
Yolo Bypass	Sacramento River below Knights Landing	0.23[e]	2004, 2007, 2008	DWR 2009

Notes:
a. Selenium concentrations are in dissolved fraction unless otherwise noted.
b. Dissolved selenium concentration is assumed to be 0.1 µg/L due to lack of available data and lack of sources that would be expected to result in concentrations greater than 0.1 µg/L.
c. Data used to represent conditions for comparison of alternatives.
d. Not specified whether total or dissolved selenium; data for 1999-2000 used for bioaccumulation by bass in 2000; data for 2004-2005 for bass in 2005; and data for 2006-2007 for bass in 2007.
e. Total selenium concentration in water.

µg/L = microgram(s) per liter
GM = geometric mean
Se = selenium

In addition to the Delta-wide modeling for fish and birds (calibrated with data for Largemouth Bass), selenium uptake and food-chain transfer information from the ecosystem-scale selenium model for the San Francisco Bay-Delta Regional Ecosystem Restoration Implementation Plan (Presser and Luoma 2013) informed the selenium bioaccumulation model for the western Delta. The Largemouth Bass has lower selenium bioaccumulation rates than those observed for sturgeon (Green Sturgeon [*Acipenser medirostris]* and White Sturgeon, [*A. transmontanus]*) and is not an appropriate model species that would be protective of sturgeon. Sturgeon differ by feeding, in part, on Overbite Clams (*Corbula* [*Potamocorbula*] *amurensis*) in Suisun Bay and may do so in the western portion of the Delta under future conditions. Therefore, DSM2-modeled waterborne selenium concentrations from three western-most locations in the Delta (Sacramento River at Emmaton, San Joaquin River at Antioch, and Montezuma

Slough at Hunter Cut/Beldon's Landing) were used to model selenium bioaccumulation for sturgeon at those three locations to supplement the modeling done for Largemouth Bass.

The results from this suite of physical and biological models are used to inform the understanding of effects of each alternative considered in this EIS on selenium. Modeling objectives included evaluation of the following:

- Percent changes in waterborne selenium concentrations under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison
- Exceedances of fish, wildlife, or human thresholds for selenium effects

6D.1.2 Key Components of the Selenium Modeling

To fulfill the objectives of the selenium modeling effort, DSM2 output data were used in combination with source water concentrations to estimate waterborne selenium concentrations at representative locations throughout the Delta (Tables 6D.2 through 6D.4, located at end of this appendix). Waterborne selenium concentrations were then used to estimate tissue selenium concentrations in Largemouth Bass (as a representative higher trophic-level fish) throughout the Delta and in sturgeon in the western Delta. Estimation of concentrations in Largemouth Bass throughout the Delta included the development and calibration of a bioaccumulation model using measured concentrations in bass (Foe 2010a). In contrast, modeling for sturgeon in the western Delta relied on literature-based model parameters (Presser and Luoma 2013), because data were not available to further calibrate the model.

6D.1.2.1 DSM2 Post-processing

Dissolved or total selenium data were available for six inflow locations to the Delta (Table 6D.1):

- Sacramento River below Knights Landing (just upstream of Yolo Bypass, representing the Bypass source)
- Sacramento River at Freeport (mainstem flow to Delta)
- San Joaquin River at Vernalis (Airport Way) (mainstem flow to Delta)
- Mokelumne, Calaveras, and Cosumnes Rivers (for East Delta tributaries)
- Mildred Island, Center (for Delta Agriculture)
- San Joaquin River near Mallard Island (for Martinez/Suisun Bay)

Both dissolved and total selenium data were considered suitable for purposes of the modeling conducted for the Delta, because they typically do not differ greatly. Statements related to waterborne selenium concentrations in this appendix would be applicable to either dissolved or total concentrations.

Whole-body Largemouth Bass data for selenium were available from the following DSM2 output locations:

- Big Break
- Cache Slough Ryer
- Franks Tract
- Middle River Bullfrog
- Old River Near Paradise Cut
- Sacramento River Mile (RM) 44
- San Joaquin River Potato Slough

Largemouth Bass data also were available from the Veterans Bridge on the Sacramento River and from Vernalis on the San Joaquin River, but DSM2 data were not available for those locations; therefore, historical data for selenium concentrations in water collected nearby (Table 6D.1) were used to represent quarterly averages. The geometric mean of total selenium concentrations in water collected from the Sacramento River below Knights Landing in 2004, 2007, and 2008 (DWR 2009) were used to represent quarterly averages of selenium concentrations in water for Veterans Bridge in all years. The geometric means of selenium concentrations (total or dissolved was not specified) in water collected from 1999–2000, 2004-2005, and 2006-2007 (SWAMP 2009) were used to represent quarterly averages for selenium concentrations in water at Vernalis during 2000, 2005, and 2007, respectively.

For DSM2 output locations, the geometric mean selenium concentrations from the inflow locations were combined with the modeled quarterly average percent inflow for each DSM2 output location to estimate waterborne selenium concentrations at those locations. The quarterly average mix of water from the six inflow sources (Table 6D.1) was calculated from daily percent inflows provided by the DSM2 model output for the DSM2 output locations for which fish data were available. The quarterly waterborne selenium concentrations at DSM2 locations were calculated using Equation 1:

$$C_{water\ quarterly} = ([I_1 * C_1] + [I_2 * C_2] + [I_3 * C_3] + [I_4 * C_4] + [I_5 * C_5] + [I_6 * C_6])/100$$

Where:

- $C_{water\ quarterly}$ = quarterly average selenium concentration in water (micrograms/liter [µg/L]) at a DSM2 output location
- I_{1-6} = modeled quarterly inflow from each of the six sources of water to the Delta for each DSM2 output location (percentage)
- C_{1-6} = selenium concentration in water (µg/L) from each of the six inflow sources to the Delta (1-6)

Example Calculation: Modeled Selenium Concentration at Franks Tract Year 2000, First Quarter:

(43.94 [% inflow from Sacramento River water source at Franks Tract] × 0.09 µg/L [selenium concentration at Sacramento River at Freeport]) + (11.56 [% inflow from East Delta Tributaries water source at Franks Tract] × 0.10 µg/L [selenium concentration at Mokelumne, Calaveras, and Cosumnes Rivers]) + (15.79 [% inflow from San Joaquin River water source at Franks Tract] × 0.83 µg/L [selenium concentration at San Joaquin River at Vernalis]) + (0.02 [% inflow from Martinez/Suisun Bay water source at Franks Tract] × 0.10 µg/L [selenium concentration at San Joaquin River near Mallard Island]) + (0.32 [% inflow from Yolo Bypass water source at Franks Tract] × 0.23 µg/L [selenium concentration at Sacramento River below Knights Landing]) + (5.06 [% inflow from Delta Agriculture water source at Franks Tract] × 0.11 µg/L [selenium concentration at Mildred Island, Center])/100 = 0.19 µg/L

The quarterly and average annual waterborne selenium concentrations for the DSM2 output locations are shown in Table 6D.2 (Year 2000), Table 6D.3 (Year 2005), and Table 6D.4 (Year 2007).

6D.1.2.2 Delta-wide Selenium Model Development

Selenium concentrations in whole-body fish and in bird eggs were calculated using ecosystem-scale models developed by Presser and Luoma (2010a, 2010b, 2013). The models were based on biogeochemical and physiological factors from laboratory and field studies; loading rates, chemical speciation, and transformation to particulate material; bioavailability; bioaccumulation in invertebrates; and trophic transfer to predators. Important components of the methodology included (1) empirically determined environmental partitioning factors between water and particulate material that quantify the effects of dissolved speciation and phase transformation; (2) concentrations of selenium in living and non-living particulates at the base of the food web that determine selenium bioavailability to invertebrates; and (3) selenium biodynamic food web transfer factors that quantify the physiological potential for bioaccumulation from particulate matter to consumer organisms and from prey to their predators.

6D.1.2.2.1 Selenium Concentration in Particulates

Phase transformation reactions from dissolved to particulate selenium are the primary form by which selenium enters the food web. Presser and Luoma (2010a, 2010b, 2013) used field observations to quantify the relationship between particulate material and dissolved selenium as indicated in Equation 2.

$$C_{particulate} = K_d * C_{water\ column}$$

Where:

- $C_{particulate}$ = selenium concentration in particulate material (micrograms/kilogram, dry weight [µg/kg dw])
- K_d = particulate/water ratio

- $C_{water\ column}$ = selenium concentration in water column (µg/L)

The K_d (also called an "enrichment factor") describes the particulate/water ratio at the moment the sample was taken and should not be interpreted as an equilibrium constant (as it sometimes is mistaken to be). It can vary widely among hydrologic environments and potentially among seasons (Presser and Luoma 2010a, 2010b, 2013; Young et al. 2010). In addition, other factors such as selenium speciation, water residence time, and particle type affect K_d. Selenium typically enters a stream primarily as selenate. If the stream flows into a wetland and the water is retained there with sufficient residence time, recycling of selenium may occur. This results in generation of particulate selenium and conversion to more bioaccumulative selenite and organo-selenium from the less-bioaccumulative dissolved selenate. Residence time of water containing selenium is usually the most influential factor on the conditions in the receiving aquatic environment. Short water residence times (such as in streams and rivers) limit partitioning of selenium into particulate material. Conversely, longer residence times (such as in sloughs, lakes, and estuaries) allow greater uptake by plants, algae, and microorganisms. Furthermore, environments in downstream portions of a watershed can receive cumulative contributions of upstream recycling in a hydrologic system. Because of its high variability, K_d is a large source of uncertainty in any selenium model where extrapolations from selenium concentrations in the water column to those in aquatic organism tissues, or from tissue to waterborne concentrations, are necessary.

In developing the Delta-wide bioaccumulation model for bass, the particulate selenium concentration initially was estimated using Equation 2 and a default K_d of 1,000 (Presser and Luoma 2010a). Because the K_d is typically much more variable than other steps in the bioaccumulation model, the K_d was then adjusted to calibrate the model so that the modeled concentrations for fish approximated the measured concentrations in bass for normal and wet years (2000 and 2005) and for drought years (2007), as described in more detail in Section 6D.1.2.3.

6D.1.2.2.2 Selenium Concentrations in Invertebrates

Trophic transfer factors (TTFs) for transfer of selenium from particulates to prey and to predators were developed using data from laboratory experiments and field studies (Presser and Luoma 2010a, 2010b, 2013). TTFs are species-specific, but the range of TTFs for freshwater invertebrates was found to be similar to TTFs for marine invertebrates determined in laboratory experiments.

TTFs for estimating selenium concentrations in invertebrates were calculated using Equation 3:

$$TTF_{invertebrate} = (C_{invertebrate})/(C_{particulate})$$

Where:

- $TTF_{invertebrate}$ = trophic transfer factor from particulate material to invertebrate
- $C_{invertebrate}$ = concentration of selenium in invertebrate (µg/g dw)
- $C_{particulate}$ = concentration of selenium in particulate material (µg/g dw)

An average aquatic insect TTF was calculated from TTFs for aquatic insect species with similar bioaccumulative potential, including Mayfly (*Baetidae; Heptageniidae; Ephemerellidae*), Caddisfly (*Rhyacophilidae; Hydropsychidae*), Crane Fly (*Tipulidae*), Stonefly (*Perlodidae*/*Perlidae*; *Chloroperlidae*), Damselfly (*Coenagrionidae*), Corixid (*Cenocorixa* sp.), and Chironomid (*Chironomus* sp.) aquatic life stages. Species-specific TTFs ranged from 2.1 to 3.2; the average TTF of 2.8 was used in the Delta-wide model.

6D.1.2.2.3 Selenium Concentrations in Whole-body Fish

The mechanistic equation for modeling of selenium bioaccumulation in fish tissue is similar to that for invertebrates if whole-body concentrations are the endpoint (Presser and Luoma 2010a, 2010b, 2013), as shown in Equation 4:

$$TTF_{fish} = C_{fish} / C_{invertebrate}$$

where:

$$C_{invertebrate} = C_{particulate} * TTF_{invertebrate}$$

therefore:

$$C_{fish} = C_{particulate} * TTF_{invertebrate} * TTF_{fish}$$

Where:

- C_{fish} = concentration of selenium in fish (µg/g dw)
- $C_{particulate}$ = concentration of selenium in particulate material (µg/g dw)
- $C_{invertebrate}$ = *concentration of selenium in invertebrate (µg/g dw)*
- $TTF_{invertebrate}$ = trophic transfer factor from particulate material to invertebrate
- TTF_{fish} = trophic transfer factor from invertebrate to fish

Modeling selenium bioaccumulation into a particular fish species considers organism physiology and its preferred foods. However, variability in fish tissue selenium concentrations for present modeling purposes is driven more by dietary choices and their respective levels of bioaccumulation (that is, TTFinvertebrate) than by differences in fish physiology or the dietary transfer to the fish (TTFfish). A diet of mixed prey (including invertebrates or other fish) can be modeled as shown in Equation 5:

$$C_{fish} = TTF_{fish} * ([C_1 * F_1] + [C_2 * F_2] + [C_3 * F_3])$$

Where:

- C_{fish} = concentration of selenium in fish (µg/g dw)
- TTF_{fish} = trophic transfer factor for fish species
- $C_{1\text{-}3}$ = concentration of selenium in invertebrate or fish prey items 1, 2, and 3 (µg/g dw)
- $F_{1\text{-}3}$ = fraction of diet composed of prey items 1, 2, and 3

Modeling of selenium concentrations in longer food webs with higher trophic levels (for example, predator fish such as bass consuming forage fish) can be completed by incorporating additional TTFs, as shown in Equation 6:

$$C_{predatorfish} = C_{particulate} * TTF_{invertebrate} * TTF_{foragefish} * TTF_{predatorfish}$$

Where:

- $C_{predatorfish}$ = concentration of selenium in fish (µg/g dw)
- $C_{particulate}$ = concentration of selenium in particulate material (µg/g dw)
- $TTF_{invertebrate}$ = trophic transfer factor from particulate material to invertebrate
- $TTF_{foragefish}$ = trophic transfer factor for invertebrates to foraging fish species
- $TTF_{predatorfish}$ = trophic transfer factor for forage fish to predator species

The fish TTFs reported in Presser and Luoma (2010a) ranged from 0.5 to 1.6, so the average fish TTF of 1.1 was used for all trophic levels of fish in the Delta-wide model.

Modeled selenium concentrations in whole-body fish were used to estimate selenium concentrations in fish fillets, as described in Section 6D.1.2.2.5.

6D.1.2.2.4 Selenium Concentrations in Bird Eggs

Selenium concentrations in bird tissues can be estimated, but the transfer of selenium into bird eggs is more meaningful for evaluating reproductive endpoints (Presser and Luoma 2010a; Ohlendorf and Heinz 2011). Examples of models for selenium transfer to bird eggs are as shown in Equations 7 and 8:

$$C_{birdegg} = C_{particulate} * TTF_{invertebrate} * TTF_{birdegg}$$

(this equation is based on birds, such as shorebirds, eating invertebrates)

or:

$$C_{birdegg} = C_{particulate} * TTF_{invertebrate} * TTF_{fish} * TTF_{birdegg}$$

(this equation is based on birds, such as herons or terns, feeding on small fish)

Where:

- $C_{birdegg}$ = concentration of selenium in bird egg (µg/g dw)
- $C_{particulate}$ = concentration of selenium in particulate material (µg/g dw)
- $TTF_{invertebrate}$ = trophic transfer factor from particulate material to invertebrate
- TTF_{fish} = trophic transfer factor from invertebrate to fish
- $TTF_{birdegg}$ = trophic transfer factor from invertebrate or fish (depending on diet) to bird egg

Presser and Luoma (2010b, 2013) reviewed the available data for selenium bioaccumulation from diet to bird eggs and concluded that the mean $TTF_{birdegg}$ = 2.6 was most appropriate for modeling. This TTF was based on laboratory studies in which Mallards (*Anas platyrhynchos*) were fed selenium-fortified diets to evaluate reproductive effects. Mallards are considered a sensitive species to selenium based on reproductive endpoints. In their previous evaluation of those data, Presser and Luoma (2010a) concluded that a $TTF_{birdegg}$ = 1.8 was appropriate. The form of selenium included in the Mallard diet (selenomethionine) has been used as a surrogate in many laboratory studies to represent exposure of fish and birds under field conditions. Other laboratory studies were conducted with Black-crowned Night-herons (*Nycticorax*

nycticorax) by Smith et al (1988), for Eastern Screech-owls (*Otus asio)* by Wiemeyer and Hoffman (1996), and for American Kestrels (*Falco sparverius)* by Santolo et al. (1999). In each of these studies, the experimental groups also received supplemental selenium in the form of selenomethionine. Transfer factors for the selenium-supplemented birds varied from approximately 1.0 to 2.2, with a mean of 1.5.

In field studies conducted at Kesterson Reservoir and the Volta Wildlife Area reference site, extensive sampling of food-chain biota and bird eggs was conducted from 1983 through 1985, and birds were collected to determine qualitatively the kinds of aquatic organisms they had eaten (Saiki and Lowe 1987; Hothem and Ohlendorf 1989; Schuler et al. 1990; Ohlendorf and Hothem 1995). Based on the kinds of food items found in each of the sampled species and the mean selenium concentrations in those kinds of organisms, a mean selenium concentration was estimated for each species at each site during each nesting season. In contrast to the findings with selenomethionine-supplemented diets in the laboratory, TTFs from diet to eggs were almost always less than 2.0. At the Volta Wildlife Area, where diet and egg selenium concentrations were representative of "background" conditions, transfer factors ranged from 0.63 to 2.0, with a mean of 1.35. At Kesterson, the transfer factors ranged from less than 0.2 to 0.48.

Because selenomethionine in the Mallard diet is probably more readily transferred to eggs than are the selenium forms in field-collected food-chain biota, the $TTF_{birdegg}$ = 1.8 value from Presser and Luoma (2010a) was used in the bioaccumulation model.

6D.1.2.2.5 Selenium Concentrations in Fish Fillets

Selenium concentrations in whole-body fish from the bioaccumulation model were converted to selenium concentrations in skinless fish fillets for evaluation of potential human health effects. The regression equation provided in Saiki et al. (1991) for Largemouth Bass from the San Joaquin River system was considered to be the most representative of fish in the Delta and was used for the conversion of these selenium concentrations as shown in Equation 9:

$$SF = (-0.388) + (1.322 * WB)$$

Where:

- *SF* = selenium concentration in skinless fish fillet (µg/g dw)
- *WB* = selenium concentration in whole-body fish (µg/g dw)

For the impact assessment in this EIS, fish fillet data were compared to the Advisory Tissue Level (2.5 micrograms per gram [µg/g]) in wet weight (ww) (OEHHA 2008); therefore, wet-weight concentrations were estimated from dry-weight concentrations using the equation provided by Saiki et al. (1991) as shown in Equation 10:

$$WW = DW * (100 – Moist)/100$$

Where:

- *WW* = selenium concentration in wet weight (µg/g ww)
- *DW* = selenium concentration in dry weight (µg/g dw)
- *Moist* = mean moisture content of the species

Because moisture content in fish varies among species, sample handling, and locations, the mean moisture content of 70 percent used by Foe (2010b) was used as an assumed approximation for fish in the Delta. The final equation used to estimate selenium concentration in skinless fish fillets (wet weight) from selenium concentration in whole-body fish (dry weight) is as shown in Equation 11:

$$SF = ([-0.388] + [1.322 * WB]) * 0.3$$

Where:

- *SF* = selenium concentrations in skinless fish fillet (µg/g ww)
- *WB* = selenium concentration in whole-body fish (µg/g dw)

6D.1.2.3 Delta-wide Selenium Model Calibration

Several models were evaluated and refined to estimate selenium uptake in fish and in bird eggs from waters in the Delta. Input parameters to the model (K_ds and the number of trophic levels) were varied among the models as refinements were made. Data for Largemouth Bass collected in the Delta from areas near DSM2 output locations were used to calculate the geometric mean selenium concentration in whole-body fish (Foe 2010a). The ratio of the estimated (modeled) selenium concentration in fish to measured selenium in whole-body bass was used to evaluate each fish model and to focus refinements of the model. These Delta-wide models are presented in the following subsections.

Characteristics of water flow in the Delta affect selenium bioaccumulation and the model refinements, because longer residence time for the water can be expected to increase bioaccumulation by increasing K_d. Foe (2010a) reported the water year type for 2000 as "above normal" for both the Sacramento River and San Joaquin River watersheds. It came after "wet" water years and was followed by "dry" water years. Year 2005 was wetter than 2000, was reported as "above normal" for the Sacramento River watershed and "wet" for the San Joaquin River watershed. Year 2005 occurred between periods of wet water years. Water Year 2007 was reported as "dry" (Sacramento River watershed) and "critically dry" (San Joaquin River watershed). It came after wet water years and was followed by critically dry water years.

There was no difference in bass selenium concentrations in the Sacramento River at Rio Vista in comparison to the San Joaquin River at Vernalis in 2000, 2005, and 2007 (Foe 2010a). The lack of a difference in bioaccumulated selenium between the two river systems was unexpected because the San Joaquin River is considered a significant source of selenium to the Delta. There were differences among years, however, that were related to hydrology and water flow through the Delta. Year 2005 selenium concentrations in bass were comparatively lower than those estimated for Year 2000. As expected in a wet water year, the water residence time was shorter, resulting in less selenium recycling, lower K_d values, and lower concentrations of selenium entering the food web. The dry water year (2007) resulted in a longer water residence time, higher K_d values, greater selenium recycling, and higher concentrations of bioavailable selenium entering the food web. These differences among years were considered when refining the selenium bioaccumulation model.

6D.1.2.3.1 Bioaccumulation in Whole-body Fish

Models estimating whole-body selenium concentrations in fish were refined by modifying dietary composition and input parameters to closely represent measured conditions in the Delta. Each model is described in this section.

Model 1 was a basic representative of uptake by a forage fish, while Model 2 calculated sequential bioaccumulation in a more complex food web that included predatory fish eating forage fish, as shown below:

Model 1: Trophic level 3 (TL-3) fish eating invertebrates (Equation 12):

$$C_{fish} = C_{particulate} * TTF_{invertebrate} * TTF_{fish}$$

Model 2: Trophic level 4 (TL-4) fish eating TL-3 fish (Equation 13):

$$C_{predatorfish} = C_{particulate} * TTF_{invertebrate} * TTF_{foragefish} * TTF_{predatorfish}$$

Where:

- C_{fish} = concentration of selenium in fish (µg/g dw)
- $C_{particulate}$ = concentration of selenium in particulate material (µg/g dw)
- $TTF_{invertebrate}$ = Trophic transfer factor from particulate material to invertebrate
- TTF_{fish} = Trophic transfer factor from invertebrate to forage fish or forage fish to predator fish

Equation 12 is the same as Equation 4 and Equation 13 is the same as Equation 6 that were described previously for the generalized model. In both Models 1 and 2, the particulate selenium concentration was estimated using Equation 2 and a default K_d of 1,000. The average TTFs for invertebrates (2.8) and fish (1.1) were used in each model. The outputs of estimated selenium concentrations and the ratios of predicted-to-observed bass selenium concentrations for Models 1 and 2 are presented in Table 6D.5 and Figure 6D.1 (all figures are provided at the end of this appendix).

Models 1 and 2 tended to substantially underestimate the whole-body selenium concentrations in fish compared to bass data reported in Foe (2010a). This was partly because Model 1 was estimating selenium concentration in a forage fish (TL-3), whereas bass are a predatory fish with expected higher dietary exposure. Consequently, Model 1 was not further developed as the selenium bioaccumulation model to represent fish in the Delta.

Model 2 is representative of predatory fish, but Model 2 was very similar to Model 1 in distribution of data and in underestimating bass data, even though an additional trophic-level transfer was included in the model. As noted in Section 6D.1.2.2.1 and described in much greater detail by Presser and Luoma (2010a, 2010b, 2013), the K_d values for uptake from water are far more variable than the

TTFs for invertebrates or fish. Models 1 and 2 also apparently reflect the tendency of selenium (as an essential nutrient) to be more bioaccumulative when waterborne concentrations are low (as described by Stewart et al. [2010]), which they were for the DSM2-modeled concentrations (that is, 0.09 to 0.85 µg/L). Available K_d values from various sampling efforts in the Delta provided by Presser and Luoma (2010b) were reviewed for potential applicability in the modeling effort. Those values varied on the basis of locations within the Delta and Suisun Bay and also by water year and flow characteristics (often greater than 5,000 and sometimes exceeding 10,000). However, efforts to incorporate various selected K_d values (for example, 2,000 or 3,000) into the model uniformly for different DSM2 locations failed to produce ratios of modeled-to-measured fish selenium concentrations that approximated 1 (they either over- or underestimated fish selenium concentrations because of variability in site conditions).

The available bass data and the assumed TTFs for invertebrates (2.8) and fish (1.1) were used to back-calculate a location and sample-specific K_d. It is recognized that some of the variability in bioaccumulation may be associated with the TTFs, but there were no reasonable assumptions for selection of alternative values to plug into the model.

When TTFs were held constant, back-calculation of K_d values revealed a concentration-related influence on the values. For waterborne selenium concentrations in the range of 0.09 to 0.13 µg/L (N = 50), the median was 5,575; when waterborne selenium concentrations were in the range of 0.14 to 0.40 µg/L (N = 19), the median K_d was 2,431; for waterborne selenium concentrations in the range of 0.41 to 0.85 µg/L (N = 19), the median K_d was 748. These observations are consistent with an inverse relationship between waterborne selenium concentrations and bioaccumulation in aquatic organisms (Stewart et al. 2010).

Figure 6D.2 shows the log-log regression relation of K_d to waterborne selenium concentration when all years are included and the TTFs are held constant, while Figure 6D.3 shows the relationship for normal/wet years (2000 and 2005) and Figure 6D.4 shows the regression for dry years (2007), when the K_ds were generally higher.

Model 3 is based on Model 2 (with TTFs as described previously) but includes the K_d estimated from the log-log regression relation for all years (Figure 6D.2). This produced a median ratio of predicted-to-observed whole-body selenium in bass that slightly exceeded 1 (Figure 6D.1); details are provided in Table 6D.6. Because of the noticeable differences between 2007 (the dry year) and the other 2 years, the next step in modeling was to evaluate 2007 separately from 2000 and 2005.

Model 4 was developed using the log-log relationship between K_d and water selenium concentrations for 2000 and 2005 (Figure 6D.3). Model 5 was developed using log-log relationship between K_d and water selenium concentrations for 2007 (Figure 6D.4 and Table 6D.7). These two models produced ratios of predicted-to-observed whole-body selenium in bass approximating 1, as shown in Figure 6D.1.

As expected in a large, complex, and diverse ecological habitat such as the Delta, variations in the data distribution and in the outputs of the models are not surprising. However, it should be noted that the estimated K_d values for Model 3 (674-6,060; Table 6D.6), Model 4 (651-4,997; Table 6D.7), and Model 5 (1,206-8,064; Table 6D.7) are consistent with those summarized by Presser and Luoma (2010b) for the Delta.

Figures 6D.5 and 6D.6 illustrate the distribution of data for selenium concentrations in Largemouth Bass (Foe 2010a) relative to the measured or DSM2-modeled waterborne selenium concentrations (Tables 6D.1 through 6D.4) and Models 3, 4, and 5 to complement the boxplots shown in Figure 6D.1. There is notably more variability in selenium concentrations in bass between 0.09 and 0.13 μg/L than at higher waterborne selenium concentrations (as shown in both Figures 6D.5 and 6D.6); most of the higher values are from 2007 and most of the lower ones are from 2005.

Figure 6D.5 shows the available data for 2000, 2005, and 2007 plotted with the Model 3 prediction of selenium concentrations. As noted previously in text and in Figure 6D.1, the model slightly over-predicts the median concentrations in fish on the basis of waterborne selenium concentrations. This effect is reflected in Figure 6D.1 by the outliers above the 90^{th} percentile bar (that is, the higher over-predictions for fish, which are those from 2000 and 2005). However, overall, the model is within 1 μg/g for all values less than the prediction, and within approximately 1.2 μg/g for the values greater than the prediction (Figure 6D.5).

Because of the notable differences between data for 2007 compared to combined 2000 and 2005 data, Model 4 was developed for 2000 and 2005 and Model 5 was developed for 2007, Figure 6D.6 shows those model predictions compared to the data. These two models improved the predictions; although the figure shows more differences between data and the models at the lower waterborne concentrations (that is, less than 0.30 μg/L) than at higher ones, the divergence is generally less than 0.5 μg/g at the higher waterborne concentrations. The outliers for Model 4 are mostly above the 90^{th} percentile (that is, over-predicting concentrations in fish), rather than below, as shown in Figure 6D.1. For Model 5, the predictions are "tighter" with just a few outliers above or below the 90^{th} percentile.

Evaluation of water-year effects on selenium concentration in bass concluded that Model 4 was relatively predictive of selenium concentration in whole-body bass during normal to wet water years. Model 5 was considered predictive for dry water years (such as 2007). Model 3 incorporates the varying bioaccumulation when all years are considered (that is, 2000, 2005, and 2007). Although Model 3 tends to slightly overestimate selenium bioaccumulation (Table 6D.6 and Figure 6D.1), it was used for estimating selenium concentrations in whole-body fish in the impact assessment for "All" years, and Model 5 was used for "Drought" years.

6D.1.2.3.2 Selenium Bioaccumulation in Bird Eggs

The K_d, invertebrate TTF, and fish TTFs developed for use in fish bioaccumulation Models 4 and 5 were also used to estimate selenium uptake into bird eggs using the following two bird egg models (Table 6D.8):

Bird Egg: Uptake from invertebrates (Equation 14):

$$C_{birdegg} = C_{particulate} * TTF_{invertebrate} * TTF_{birdegg}$$

where:

$$C_{particulate} = K_d * C_{water}$$

Bird Egg: Uptake from fish (Equation 15):

$$C_{birdegg} = C_{particulate} * TTF_{invertebrate} * TTF_{fish} * TTF_{fish} * TTF_{birdegg}$$

where:

$$C_{particulate} = K_d * C_{water}$$

Where:

- $C_{birdegg}$ = concentration of selenium in bird egg (µg/g dw)
- $C_{particulate}$ = concentration of selenium in particulate material (µg/g dw)
- C_{water} = selenium concentration in water column (µg/L)
- K_d = particulate/water ratio
- $TTF_{invertebrate}$ = trophic transfer factor from particulate material to invertebrate
- TTF_{fish} = trophic transfer factor from invertebrate or fish to fish
- $TTF_{birdegg}$ = trophic transfer factor from invertebrate or fish (depending on diet) to bird egg

Equation 14 is the same as Equation 7, but Equation 15 differs from Equation 8 in that it assumes birds are eating larger predatory fish such as bass.

6D.1.2.4 Western Delta Sturgeon Model

Presser and Luoma (2013) determined K_d values for San Francisco Bay (including Carquinez Strait – Suisun Bay) during "low flow" conditions (5,986) and "average" conditions (3,317). These values were used to model selenium concentrations in particulates in bioaccumulation modeling for sturgeon under "Drought" and "All" year conditions at the three locations in the western Delta. (By comparison, calibration of the Delta-wide model for two western-most location from which bass had been collected [Big Break] resulted in an average K_d = 3,736 for 2000/2005 [Model 4, normal/wet years] and average K_d = 7,166 for 2007 [Model 5, dry year].)

Sturgeon in the western Delta, Carquinez Strait, and Suisun Bay typically prey on a mix of clams including *Corbula amurensis*, which is known to be an efficient bioaccumulator of selenium (Stewart et al. 2010) and crustaceans. Presser and Luoma (2013) assumed a sturgeon diet of 50 percent clams and 50 percent amphipods and other crustaceans in their model. Based on this diet, the authors reported a TTF of 9.2 (identified as TTF_{prey} in Table 1 of Presser and Luoma [2013]). This TTF was used to calculate concentrations in sturgeon invertebrate prey for the Sacramento River at Emmaton, San Joaquin River at Antioch, and Montezuma Slough at Hunter Cut/Beldon's Landing locations under the No Action Alternative, Second Basis of Comparison, and Alternatives 1 through 5.

A TTF of 1.3 from diet to fish (identified as $TTF_{predator}$) was reported for sturgeon in Presser and Luoma (2013) and was used to calculate concentrations of selenium in sturgeon for the three western Delta locations.

Modeling for sturgeon at the three western Delta locations did not require refinement because it relied on recent data provided by Presser and Luoma [2013]) and because data to refine the model were not available.

6D.2 Modeling Simulations and Assumptions

As described in Section 6D.1, selenium modeling was performed for evaluation of the alternatives. This section describes the assumptions for the selenium model simulations of the No Action Alternative, Second Basis of Comparison, and other alternatives. A description of DSM2 model assumptions is in Appendix 5A.

The following model simulations were used as the basis of evaluating the impacts of the other alternatives:

- No Action Alternative
- Second Basis of Comparison

The following selenium model simulations of other alternatives were performed:

- Alternative 1 – for selenium simulation purposes, considered the same as Second Basis of Comparison
- Alternative 2 – for selenium simulation purposes, considered the same as No Action Alternative
- Alternative 3
- Alternative 4 – for selenium simulation purposes, considered the same as Second Basis of Comparison.
- Alternative 5

The general selenium modeling assumptions described in the following subsection pertain to all the model runs.

6D.2.1 Delta-wide Assumptions

The calibrated Delta-wide selenium bioaccumulation models (Models 3, 4, and 5) are considered representative of conditions in the Delta under current and likely future conditions, because they incorporate realistic concentrations of waterborne selenium and they predict selenium concentrations in predatory fish that approximate measured concentrations in Largemouth Bass. The calibrated models take into account the variable nature of selenium bioaccumulation in relation to waterborne concentrations, which is reflected in the generally inverse relationship between the K_d and waterborne selenium concentration.

Models are not available to quantitatively estimate the level of changes in selenium bioaccumulation as related to residence time, but the effects of residence time are incorporated in the bioaccumulation modeling for selenium that was based on higher K_d values for drought years in comparison to wet, normal, or all years. If increases in fish tissue or bird egg selenium were to occur, the increases would likely be of concern only where fish tissues or bird eggs are already elevated in selenium to near or above thresholds of concern. That is, where biota concentrations are currently low and not approaching thresholds of concern (which is the case throughout the Delta, except for sturgeon in the western Delta), changes in residence time alone would not be expected to cause them to then approach or exceed thresholds of concern. In consideration of this factor, although the Delta as a whole is a Clean Water Act (CWA) Section 303(d)-listed waterbody for selenium (SWRCB 2011), and although monitoring data of fish tissue or bird eggs in the Delta are sparse, the most likely areas in which biota tissue selenium concentrations would be high enough that additional bioaccumulation due to increased residence time from restoration areas would be a concern are the western Delta and Suisun Bay (discussed below for sturgeon), and the south Delta in areas that receive San Joaquin River water.

The South Delta receives elevated selenium loads from the San Joaquin River. In contrast to Suisun Bay and possibly the western Delta in the future, the south Delta lacks the Overbite Clam (*Corbula* [*Potamocorbula*] *amurensis*), which is considered a key driver of selenium bioaccumulation in Suisun Bay because of its high bioaccumulation of selenium and its role in the benthic food web that includes long-lived sturgeon. The south Delta does have *Corbicula fluminea*, another bivalve that bioaccumulates selenium, but it is not as invasive as the Overbite Clam and thus likely makes up a smaller fraction of sturgeon diet. Also, nonpoint sources of selenium in the San Joaquin Valley that contribute selenium to the Delta will be controlled through a Total Maximum Daily Load (TMDL) developed by the Central Valley Regional Water Quality Control Board (Central ValleyRWQCB) for the lower San Joaquin River, established limits for the Grassland Bypass Project, and Basin Plan objectives (Central Valley RWQCB 2001, 2010; SWRCB 2010a, 2010b) that are expected to result in decreasing discharges of selenium from the San Joaquin River to the Delta. Further, if selenium levels in the San Joaquin River are not sufficiently reduced by these efforts, it is expected that the SWRCB and Central Valley RWQCB would initiate additional TMDLs to further control nonpoint sources of selenium.

6D.2.2 Western Delta Sturgeon Assumptions

Modeling for selenium bioaccumulation by sturgeon in the western Delta is considered to be based on the most appropriate uptake factors available, which were published recently by Presser and Luoma (2013) specifically for sturgeon in northern San Francisco Bay estuary. The disparity between larger estimated changes for sturgeon and smaller changes for other biota (that is, whole-body fish, bird eggs, and fish fillets) is attributable largely to differences in modeling approaches, as described previously. The model for most biota was calibrated to encompass the varying concentration-dependent uptake from waterborne selenium concentrations (expressed as the K_d, which is the ratio of selenium concentrations in particulates [as the lowest level of the food chain] relative to the waterborne concentration) that was exhibited in data for Largemouth Bass in 2000, 2005, and 2007 at various locations across the Delta. In contrast, the modeling for sturgeon could not be similarly calibrated at the three western Delta locations and used literature-derived uptake factors and TTFs for the estuary from Presser and Luoma (2013). There was a significant negative log-log relationship of K_d to waterborne selenium concentration that reflected the greater bioaccumulation rates for bass at low waterborne selenium than at higher concentrations. There was no difference in bass selenium concentrations in the Sacramento River at Rio Vista compared to the San Joaquin River at Vernalis in 2000, 2005, and 2007 (Foe 2010a), despite a nearly 10-fold difference in waterborne selenium concentrations. It is unknown whether this might also occur in the sturgeon food web. Thus, there is more confidence in the site-specific modeling based on the Delta-wide model that was calibrated for bass data than in the estimates for sturgeon based on "fixed" K_d values for all years and for drought years without regard to waterborne selenium concentration at the three locations in different time periods.

The western Delta and Suisun Bay receive elevated selenium loads from North San Francisco Bay (including San Pablo Bay, Carquinez Strait, and Suisun Bay) and from the San Joaquin River. Point sources of selenium in North San Francisco Bay (that is, refineries) that contribute selenium to Suisun Bay are expected to be reduced through a TMDL under development by the San Francisco Bay Regional Water Quality Control Board (San Francisco Bay RWQCB 2012) that is expected to result in decreasing discharges of selenium. Nonpoint sources of selenium in the San Joaquin Valley that contribute selenium to the San Joaquin River, and thus the Delta and Suisun Bay, will be controlled through a TMDL developed by the Central Valley RWQCB (2001) for the lower San Joaquin River, established limits for the GBP, and Basin Plan objectives (Central Valley RWQCB 2010; SWRCB 2010a, 2010b) that are expected to result in decreasing discharges of selenium from the San Joaquin River to the Delta. If selenium levels are not sufficiently reduced via these efforts, it is expected that the SWRCB and the San Francisco Bay and Central Valley regional Water Quality Control Boards would initiate additional actions to further control sources of selenium.

6D.2.3 Model Application Methodology

To evaluate differences in the impact assessment, modeled whole-body fish, bird egg or fish fillet data were compared directly (for percent change) and to the following threshold effect benchmarks:

- Whole-body fish for the Delta-wide model were compared to the Level of Concern (4 milligrams per kilogram [mg/kg] dw; Beckon et al. 2008) and the Toxicity Level (8.1 mg/kg dw; USEPA 2014) for fish tissue.

- Modeled bird egg selenium concentrations were compared to Level of Concern (6 mg/kg dw) and Toxicity Level (10 mg/kg dw) values from Beckon et al. (2008).
- Fish fillet data were compared to the Advisory Tissue Level (2.5 µg/g ww) for human consumption of fish (OEHHA 2008).
- Whole-body selenium concentrations in sturgeon were compared to Low Effect (5 mg/kg dw) and High Effect (8 mg/kg dw) guidelines from Presser and Luoma (2013).

Results of comparisons to these benchmarks are expressed as Exceedance Quotients (EQs) in some of the tables and figures. Annual average selenium concentrations in water did not exceed the 5.0 µg/L(4-day average) or 20 µg/L (1-hour average) criterion, so no EQs were calculated.

6D.2.3.1 No Action Alternative and Second Basis of Comparison Models

The purpose of the No Action Alternative and the Second Basis of Comparison for comparison with the forecasts of the alternative models was to determine whether the implementation of the proposed alternatives is likely to result in substantial impacts to selenium, thereby affecting biological resources. The No Action Alternative and the Second Basis of Comparison models were completed for five Delta interior, three western Delta, and four major Delta diversion locations. DSM2 post-processing output provided estimates of the waterborne selenium concentration at each of those 12 locations (Table 6D.9). The Delta-specific selenium bioaccumulation model that was calibrated using Largemouth Bass data from the Delta was then used to estimate selenium concentrations in whole-body fish and then in bird eggs and fish fillets. Selenium concentrations in sturgeon inhabiting the western Delta (represented by three locations) were estimated using recently published literature parameters. Modeled selenium concentrations in whole-body fish (predatory fish throughout the Delta or sturgeon in the western Delta), bird egg or fish fillet data were compared to the threshold effect benchmarks listed previously. The modeled tissue selenium concentrations themselves and the EQs (based on comparisons to thresholds) both served as a basis for comparison of other alternatives to identify potential impacts.

6D.2.3.2 Alternative Models

For each of the alternative model simulations, the same procedure as described for the No Action Alternative and the Second Basis of Comparison models was used, with similar assumptions, to estimate waterborne selenium concentrations and selenium concentrations in fish and bird eggs. Each alternative model simulation for each type of biota (whole-body fish [either using the Delta-wide model for bass or the western Delta sturgeon model], bird eggs, or fish fillets) was compared to both the No Action Alternative and the Second Basis of Comparison to determine potentially significant impacts.

6D.3 Modeling Results

The post-processing tool is Excel-based. The general pre-processing and input files development are described in the modeling data assumptions sections above. This section focuses on data analysis and results interpretation for the impact assessment.

6D.3.1 Post-processing and Results Analysis: Delta-wide Model

Output data resulting from the model simulations for each alternative are processed to provide a tabular depiction of potential impacts to fish and wildlife (Tables 6D.13 through 6D.15). As discussed previously, outputs from the post-processing model used in this analysis are annual average selenium fish tissue concentrations for all year types and separately presented for the subset of drought years.

The variation in concentrations between the No Action Alternative, Second Basis of Comparison, and Alternatives 1 through 5 was less than 5 percent (Tables 6D.13 through 6D.15). Annual average concentrations do not exceed the selenium thresholds at all locations modeled in the Delta for all years and drought years both as measured and as modeled. Results are shown in Tables 6D.9 through 6D.15 and Figures 6D.7 through 6D.10. Table 6D.9 presents the period-average waterborne selenium concentrations by location and water year type that were used to model fish tissue (whole-body and fillet) and bird egg concentrations (Tables 6D.10 through 6D.12).

All estimated selenium concentrations in water and biota (whole-body fish, bird eggs, and fish fillets) were below the benchmarks used for evaluation (presented in Section 6D.2.4). The highest estimated selenium concentrations were for Alternative 1 in the San Joaquin River at San Andreas Landing and Sacramento River at Emmaton, and Alternative 3 in the North Bay Aqueduct at Barker Slough in drought years (Tables 6D.10 through 6D.12). Changes in estimated selenium concentrations for Alternatives 3 and 5 compared to the No Action Alternative and Alternative 1 were less than 4 percent (Tables 6D.14 and 6D.15).

6D.3.2 Post-processing and Results Analysis: Western Delta Sturgeon Model

Output data resulting from the sturgeon model simulations for each alternative at the three western Delta locations were processed to provide a tabular depiction of potential impacts to sturgeon. Table 6D.16 presents the period-average waterborne selenium concentrations by location and water year type that were used to model fish tissue concentrations (Table 6D.17). As discussed previously, outputs from the post-processing model used in this analysis are annual average selenium concentrations in whole-body sturgeon for all year types and separately presented for the subset of drought years.

The expected variations in whole-body sturgeon selenium concentrations between the No Action Alternative, the Second Basis of Comparison, and Alternatives 1 through 5 were less than 1 mg/kg dw (Table 6D.17). The highest estimated selenium concentrations were for drought years at all three locations with little difference among alternatives. Annual average sturgeon concentrations slightly exceeded the low selenium thresholds for all locations and alternatives for drought years, but not for all years. Results of comparisons to the thresholds are shown in Table 6D.18 and Figure 6D.11. Estimated selenium concentrations did not exceed high thresholds.

Changes in estimated selenium concentrations compared to the No Action Alternative and Alternative 1 are less than 5 percent for all years and for drought years (Table 6D.19). The largest predicted changes were a small decrease under Alternative 3 relative to the No Action Alternative for the San Joaquin River at Antioch in all years and a small increase predicted for Alternative 5 relative to Second Basis of Comparison at that location in all years. Both of these predicted changes were less than 5 percent. However, as noted previously, even the expected changes for the San Joaquin River at Antioch for Alternatives 3 and 5 as compared to the No Action Alternative or the Second Basis of Comparison were less than 1 mg/kg dw. It is not likely that such small changes in whole-body selenium concentrations would be detectable under field conditions.

6D.3.3 Model Limitations and Applicability

Although it is impossible to predict future hydrology, land use, and water use with certainty, the selenium model and DSM2 were used to forecast impacts to fish and wildlife that could result from implementation of the alternatives. The selenium model for sturgeon has greater uncertainty than the selenium model for bass because the sturgeon model was not as finely calibrated for varying K_d relative to waterborne selenium concentrations throughout the Delta, as discussed in Section 6D.2.2. Mathematical models like DSM2 can only approximate processes of physical systems. Models are inherently inexact because the mathematical description of the physical system is imperfect and the understanding of interrelated physical processes is incomplete. However, the selenium models are powerful tools that, when used carefully, can provide useful insight into processes of the physical system. Selenium concentrations for inflow sources to the Delta (for example, agriculture in the Delta, Yolo Bypass, Eastside Tributaries) also caused uncertainty in the modeling because of limited data. For the Sacramento River and the San Joaquin River, approximately 90 data points (Chapter 6, Table 6.58; Table 6D.1) were used to estimate the mean selenium concentrations for these inflow sources, whereas the mean selenium concentrations for other inflow sources to the Delta had many fewer (0 to 14) data points (concentrations for the Eastside Tributaries were assumed).

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Table 6D.2 Calculation of Quarterly Average Selenium Concentrations for DSM2 Output Locations Based on Percentage of Flow at Each Location from Different Sources: Year 2000

DSM2 Output Water Location	Location ID	First Quarter Inflow Percentage						Second Quarter Inflow Percentage						Third Quarter Inflow Percentage						Fourth Quarter Inflow Percentage						Estimated Waterborne Selenium Concentrations (µg/L)				
	Inflow Source →	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
	Inflow Location →	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*					
	Selenium (µg/L) →	0.11	0.10	0.09	0.83	0.10	0.23	0.11	0.10	0.09	0.83	0.10	0.23	0.11	0.10	0.09	0.83	0.10	0.23	0.11	0.10	0.09	0.83	0.10	0.23					
Big Break	BIGBRK_MID	2.94	6.88	53.15	6.59	0.18	5.70	2.95	6.37	73.59	13.55	0.27	3.12	3.13	0.45	85.63	0.44	4.15	6.12	2.13	0.20	84.85	0.02	8.76	3.96	0.13	0.20	0.10	0.10	0.13
Cache Slough	CACHS_LEN	1.46	0	53.38	0	0	31.91	1.24	1.5E-05	85.07	2.5E-05	0	13.25	1.66	4.7E-07	85.95	4.3E-07	5.9E-07	12.23	1.32	2.8E-06	89.83	1.1E-07	2.3E-05	8.67	0.12	0.11	0.11	0.10	0.11
Cache Slough Ryer	CACHSR_MID	2.88	0	54.86	0	0	20.48	3.36	9.8E-07	79.75	1.9E-06	0	16.25	1.90	9.3E-08	84.53	1.8E-07	9.2E-12	13.38	1.81	1.0E-07	89.45	6.2E-10	3.0E-06	8.54	0.10	0.11	0.11	0.10	0.11
Cosumnes R.	COSR_LEN	8.1E-06	98.82	0	0	0	0	0	100.00	0	0	0	0	0	100.00	0	0	0	0	0	100.00	0	0	0	0	0.10	0.10	0.10	0.10	0.10
Franks Tract	FRANKST_MID	5.06	11.56	43.94	15.79	0.02	0.32	4.17	9.42	61.16	23.89	0.01	1.22	4.04	0.57	90.34	0.41	0.80	3.78	2.76	0.62	91.38	0.12	2.42	2.64	0.19	0.27	0.10	0.10	0.16
Little Holland Tract	LHOLND_L0	72.35	0	5.06	0	0	6.50	23.38	8.2E-07	63.10	1.6E-06	0	13.03	18.48	2.2E-07	68.67	4.2E-07	7.2E-13	12.68	19.63	2.6E-09	72.79	0	0	7.42	0.10	0.11	0.11	0.10	0.11
Middle R Bullfrog	MIDRBULFRG_LEN	10.54	13.07	18.37	32.20	1.9E-03	3.2E-03	5.49	9.19	14.96	70.17	4.2E-04	0.10	7.81	6.43	69.63	14.94	0.12	1.02	4.86	6.31	59.79	27.84	1	0.68	0.31	0.61	0.20	0.30	0.36
Mildred Island	MILDDRISL_MID	7.47	14.31	22.79	30.23	2.4E-03	1.8E-03	4.77	10.05	18.48	66.48	6.7E-04	0.13	6.57	4.57	83.28	4.14	0.15	1.25	4.50	6.63	71.28	16.13	0.61	0.82	0.29	0.58	0.12	0.21	0.30
Mok. R. below Cosum.	MOKBCOS_LEN	2.07	96.19	0	0	0	0	1.65	98.35	0	0	0	0	7.23	92.77	4.7E-09	0	0	0	2.47	97.53	0	0	0	0	0.10	0.10	0.10	0.10	0.10
Mok. R. downstream Cosum.	MOKDCOS_MID	2.07	96.43	0	0	0	0	1.68	98.32	0	0	0	0	7.08	92.92	0	0	0	0	2.34	97.66	0	0	0	0	0.10	0.10	0.10	0.10	0.10
Old R near Paradise Cut	OLDRNPARADSEC_MID	6.24	0	0	87.26	0	0	14.40	1.67	5.21	78.66	1.2E-05	0.04	10.56	3.9E-05	1.3E-04	89.44	8.8E-28	3.0E-07	2.50	1.1E-04	3.5E-04	97.50	2.8E-20	1.7E-07	0.73	0.68	0.75	0.81	0.74
Paradise Cut	PARADSECUT_LEN	4.69	0	0	91.37	0	0	2.62	0.06	0.15	97.16	1.5E-07	1.1E-03	3.43	0	0	96.57	0	0	0.96	0	0	99.04	0	0	0.76	0.81	0.81	0.82	0.80
Port of Stockton	PORTOSTOCK_L0	1.67	0	0	18.85	0	0	2.22	0	0	60.73	0	0	3.09	0	0	81.32	0	0	2.70	0	0	89.89	0	0	0.16	0.51	0.68	0.75	0.52
Sac. R. at Isleton	SACRISLTON_L0	0.33	0	95.77	0	0	0	0.31	0.00	99.60	0	0	5.5E-05	0.44	0	99.55	0	0	1.3E-05	0.28	0	99.72	0	0	1.1E-03	0.09	0.09	0.09	0.09	0.09
Sac River RM 44	SACR44_L0	0.14	0	97.93	0	0	0	0.11	0	99.81	0	0	0	0.13	0	99.86	0	0	0	0.05	0	99.94	0	0	0	0.09	0.09	0.09	0.09	0.09
Sandmound Sl.	SANDMND_MID	6.36	10.51	43.82	12.90	0.03	0.57	5.22	8.81	63.78	20.40	0.03	1.63	5.24	0.61	87.78	0.49	1.22	4.59	3.31	0.43	89.58	0.06	3.44	3.11	0.17	0.25	0.10	0.10	0.15
Sherman Island	SHERMNILND_L0	1.64	3.45	52.71	3.93	0.60	12.10	2.48	4.95	76.80	10.96	0.96	3.67	2.60	0.40	81.69	0.46	8.21	6.56	1.77	0.11	77.64	0.01	16.46	3.94	0.11	0.18	0.10	0.10	0.12
SJR Bowman	SJRBOWMN_MID	1.40	0	0	94.03	0	0	1.52	0	0	98.48	0	0	3.00	0	0	97.00	0	0	0.33	0	0	99.67	0	0	0.78	0.82	0.81	0.83	0.81
SJR N Hwy4	SJRNHWY4_MID	3.49	0	0	89.96	0	0	1.87	0	0	98.13	0	0	3.91	0	0	96.09	0	0	0.72	0	0	99.28	0	0	0.75	0.82	0.80	0.82	0.80
SJR Naval st	SJRNAVLST_L0	8.89	12.70	0.00	65.44	0	0	2.69	6.26	0	90.94	0	0	5.98	10.89	0	83.00	0	0	2.02	3.10	0.00	94.84	0	0	0.57	0.76	0.71	0.79	0.71
SJR Potato Slough	SJRPOTSL_MID	3.15	12.62	55.38	12.40	0.01	0.06	3.05	10.32	65.93	19.73	0.01	0.86	2.63	0.35	93.54	0.20	0.45	2.79	2.06	0.80	93.46	0.06	1.47	2.11	0.17	0.24	0.10	0.09	0.15
SJR Turner	SJRTURNR_MID	8.81	9.28	2.55	56.31	5.3E-05	1.0E-05	3.33	5.77	0.41	90.39	6.3E-06	2.4E-03	8.69	13.75	17.87	59.41	0.01	0.16	3.23	4.83	7.34	84.49	0.03	0.05	0.49	0.76	0.53	0.72	0.62
SJR/Pt. Antioch/fish pier	ASRANTFSH_MID	1.92	4.35	55.13	4.50	0.44	10.23	2.45	4.72	77.70	10.28	0.76	3.91	2.64	0.35	83.38	0.38	6.66	6.52	1.82	0.12	80.54	0.01	13.33	4.11	0.12	0.17	0.10	0.10	0.12
Suisun Bay	SUISNB_LEN	0.81	1.22	45.93	1.24	16.49	15.94	0.92	1.66	49.51	3.61	41.10	2.95	0.80	0.23	27.56	0.40	68.55	2.42	0.60	0.03	28.62	0.01	69.16	1.54	0.11	0.13	0.10	0.10	0.11
Sycamore Slough	SYCAMOR_MID	6.50	50.69	15.18	0	0	0	5.89	76.86	16.89	2.8E-07	0	0	5.04	14.29	80.66	1.2E-31	0	0	4.23	31.10	64.66	0	0	0	0.07	0.10	0.09	0.09	0.09
White Slough	WHITESL_L0	22.32	11.88	17.97	25.51	1.7E-08	6.0E-11	16.54	12.10	16.87	54.46	3.7E-09	6.1E-05	9.89	7.76	82.34	3.8E-03	3.0E-05	5.3E-04	11.19	12.92	75.64	0.24	4.2E-04	6.4E-04	0.26	0.50	0.09	0.10	0.24
White Slough DS Disappointment Sl.	WHTSLDISPONT_LEN	14.83	22.63	29.02	22.45	5.4E-08	0	12.45	13.97	21.21	52.32	2.2E-09	2.3E-04	8.74	7.78	83.47	2.4E-03	4.0E-05	5.6E-04	5.28	14.84	79.82	0.05	5.0E-04	7.3E-04	0.25	0.48	0.09	0.09	0.23

Table 6D.3 Calculation of Quarterly Average Selenium Concentrations for DSM2 Output Locations Based on Percentage of Flow at Each Location from Different Sources: Year 2005

DSM2 Output Water Location	Location ID	First Quarter Inflow Percentage						Second Quarter Inflow Percentage					
	Inflow Source →	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass
	Inflow Location →	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*
	Selenium (μg/L) →	0.11	0.10	0.09	0.85	0.10	0.23	0.11	0.10	0.09	0.85	0.10	0.23
Big Break	BIGBRK_MID	5.87	7.57	83.73	2.41	0.24	0.18	2.90	17.21	52.77	26.69	1.6E-03	0.43
Cache Slough	CACHS_LEN	4.89	2.2E-07	93.64	8.E-07	3.8E-07	1.47	1.48	7.1E-07	94.13	8.0E-07	1.1E-08	4.38
Cache Slough Ryer	CACHSR_MID	8.13	3.0E-07	91.14	1.2E-06	1.3E-06	0.73	3.74	2.5E-08	91.89	1.0E-07	2.9E-08	4.38
Cosumnes R.	COSR_LEN	0	100.00	0	0	0	0	0.00	100.00	0.00	0	0	0
Franks Tract	FRANKST_MID	8.65	11.65	72.50	7.E+00	0.19	0.05	4.63	16.63	26.97	51.74	1.1E-04	0.03
Little Holland Tract	LHOLND_L0	97.11	3.2E-09	2.88	9.E-09	3.9E-09	0.01	44.12	6.5E-09	53.25	2E-08	1.2E-08	2.63
Middle R Bullfrog	MIDRBULFRG_LEN	13.67	9.76	28.26	48.24	0.08	0.01	5.55	5.64	2.70	86.11	7.1E-05	8.4E-04
Mildred Island	MILDDRISL_MID	12.36	11.39	32.28	43.87	8.4E-02	0.01	4.81	6.98	2.78	85.43	3.6E-05	6.7E-04
Mok. R. below Cosum.	MOKBCOS_LEN	2.18	97.82	0	0.00	0	0	0.53	99.47	0	0	0	0
Mok. R. downstream Cosum.	MOKDCOS_MID	2.22	97.78	0	0.00	0	0	0.53	99.47	0	0	0	0
Old R near Paradise Cut	OLDRNPARADSEC_MID	8.95	4.7E-05	1.5E-03	91.05	1.4E-05	1.4E-06	1.43	1.7E-07	1.6E-05	98.57	1.7E-08	3.5E-10
Paradise Cut	PARADSECUT_LEN	10.28	1.6E-07	6.8E-07	89.72	1.6E-11	1.7E-08	0.82	0	0	99.18	0	0
Port of Stockton	PORTOSTOCK_L0	4.70	0	0	95.30	0	0	2.83	0	0	97.16	0	0
Sac. R. at Isleton	SACRISLTON_L0	0.55	0	99.45	0.00	0	0	0.18	0	99.82	0.00	0	0
Sac River RM 44	SACR44_L0	0.21	0	99.79	0.00	0	0	0.07	0	99.93	0.00	0	0
Sandmound Sl.	SANDMND_MID	10.51	10.17	74.35	4.65	0.25	0.07	5.35	18.03	32.15	44.41	1.5E-04	0.06
Sherman Island	SHERMNILND_L0	4.89	5.04	87.74	1.52	0.56	0.23	2.43	14.17	61.17	21.31	0.03	0.89
SJR Bowman	SJRBOWMN_MID	1.10	0	0.00	98.90	0	0	0.45	0	0	99.55	0	0
SJR N Hwy4	SJRNHWY4_MID	1.89	0	0.00	98.11	0	0	0.59	0	0	99.41	0	0
SJR Naval st	SJRNAVLST_L0	4.70	5.45	0.00	89.85	0	0	1.06	5.10	0	93.84	0	0
SJR Potato Slough	SJRPOTSL_MID	6.24	16.03	71.18	6.45	0.07	0.03	2.65	23.15	38.61	35.59	1.1E-05	0.01
SJR Turner	SJRTURNR_MID	6.75	4.55	1.37	87.31	0.01	0	1.49	3.20	0.00	95.31	0	0
SJR/Pt. Antioch/fish pier	ASRANTFSH_MID	4.87	5.29	87.53	1.67	0.37	0.27	2.37	13.56	62.61	20.61	0.02	0.84
Suisun Bay	SUISNB_LEN	2.63	1.36	66.87	0.33	28.58	0.23	1.35	6.21	59.91	8.33	22.38	1.82
Sycamore Slough	SYCAMOR_MID	14.41	68.02	17.57	8.8E-17	0	3.5E-29	3.66	95.02	1.31	1.E-18	0	3.9E-33
White Slough	WHITESL_L0	47.62	12.39	33.06	6.93	8.2E-04	2.7E-06	15.95	8.06	2.95	73.04	1.4E-05	1.5E-07
White Slough DS Disappointment Sl.	WHTSLDISPONT_LEN	20.77	29.09	44.03	6.11	2.4E-04	3.6E-06	14.40	8.89	3.00	73.72	7.9E-06	0

DSM2 Output Water Location	Location ID	Third Quarter Inflow Percentage						Fourth Quarter Inflow Percentage						Estimated Waterborne Selenium Concentrations (μg/L)				
	Inflow Source →	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass					
	Inflow Location →	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*					
	Selenium (μg/L) →	0.11	0.10	0.09	0.85	0.10	0.23	0.11	0.10	0.09	0.85	0.10	0.23	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
Big Break	BIGBRK_MID	3.31	2.21	88.77	1.70	3.98	0.03	2.39	0.24	90.17	0.01	6.48	0.70	0.11	0.30	0.10	0.09	0.15
Cache Slough	CACHS_LEN	1.94	1.7E-05	98.02	1.0E-05	1.6E-06	0.05	2.30	1.2E-05	92.72	4.6E-07	0.00	4.98	0.09	0.10	0.09	0.10	0.09
Cache Slough Ryer	CACHSR_MID	2.15	5.6E-07	97.77	2.6E-07	4.5E-09	0.08	2.66	8.8E-07	96.37	1.9E-08	7.6E-06	0.97	0.09	0.10	0.09	0.09	0.09
Cosumnes R.	COSR_LEN	0	100	0	0	0	0	1.2E-04	100.00	0	0	0	0	0.10	0.10	0.10	0.10	0.10
Franks Tract	FRANKST_MID	4.27	3.20	89.93	1.81	0.77	0.02	3.17	0.81	94.16	0.06	1.74	0.05	0.15	0.49	0.11	0.09	0.21
Little Holland Tract	LHOLND_L0	18.61	5.6E-07	81.24	0.00	0.00	0.16	46.22	6.1E-08	53.77	2.8E-08	2.6E-09	0.01	0.11	0.10	0.09	0.10	0.10
Middle R Bullfrog	MIDRBULFRG_LEN	7.43	12.50	53.07	26.88	0.12	3.1E-03	5.54	8.75	65.65	19.67	0.39	1.1E-03	0.46	0.75	0.30	0.24	0.44
Mildred Island	MILDDRISL_MID	6.73	12.68	65.46	14.98	0.15	3.9E-03	4.81	7.16	77.85	9.71	0.47	1.8E-03	0.43	0.74	0.21	0.17	0.38
Mok. R. below Cosum.	MOKBCOS_LEN	3.05	96.95	0	0	0	0	3.00	97.00	0	0	0	0	0.10	0.10	0.10	0.10	0.10
Mok. R. downstream Cosum.	MOKDCOS_MID	3.05	96.95	0	0	0	0	2.93	97.07	0	0	0	0	0.10	0.10	0.10	0.10	0.10
Old R near Paradise Cut	OLDRNPARADSEC_MID	6.64	0	5.E-09	93.36	0	0	14.49	0.24	3.16	82.09	0.02	8.1E-05	0.78	0.84	0.80	0.72	0.79
Paradise Cut	PARADSECUT_LEN	2.39	0	0	97.61	0	0	1.08	0	0	98.92	0	0	0.77	0.84	0.83	0.84	0.82
Port of Stockton	PORTOSTOCK_L0	2.20	0	0	97.80	0	0	2.20	0	0	97.79	0	0	0.82	0.83	0.83	0.83	0.83
Sac. R. at Isleton	SACRISLTON_L0	0.45	0	99.55	0.00	0	0	0.41	0	99.59	0	0	8.2E-08	0.09	0.09	0.09	0.09	0.09
Sac River RM 44	SACR44_L0	0.14	0	99.86	0.00	0	0	0.17	0	99.83	0	0	0	0.09	0.09	0.09	0.09	0.09
Sandmound Sl.	SANDMND_MID	5.61	3.13	87.97	2.10	1.17	0.02	3.93	0.55	92.97	0.03	2.45	0.07	0.13	0.43	0.11	0.09	0.19
Sherman Island	SHERMNILND_L0	2.76	1.84	86.03	1.72	7.62	0.04	1.95	0.11	84.69	0.01	11.76	1.48	0.10	0.26	0.10	0.09	0.14
SJR Bowman	SJRBOWMN_MID	2.06	0	0	97.94	0	0	0.80	0	0	99.20	0	0	0.84	0.85	0.83	0.84	0.84
SJR N Hwy4	SJRNHWY4_MID	2.64	0	0	97.36	0	0	1.94	0.00	0	98.06	0	0	0.84	0.85	0.83	0.84	0.84
SJR Naval st	SJRNAVLST_L0	4.11	9.43	0	86.46	0	0	4.97	12.46	0	82.57	0	0	0.77	0.80	0.75	0.72	0.76
SJR Potato Slough	SJRPOTSL_MID	2.75	2.58	93.40	0.83	0.42	0.01	2.16	1.30	95.35	0.02	1.04	0.13	0.14	0.36	0.10	0.09	0.17
SJR Turner	SJRTURNR_MID	6.05	11.77	4.90	77.27	0.01	8.4E-05	5.55	16.96	10.99	66.44	0.06	7.4E-05	0.76	0.81	0.68	0.60	0.71
SJR/Pt. Antioch/fish pier	ASRANTFSH_MID	2.82	1.68	87.76	1.46	6.24	0.03	2.05	0.14	86.70	0.01	9.68	1.42	0.10	0.25	0.10	0.09	0.14
Suisun Bay	SUISNB_LEN	0.83	0.82	31.47	1.16	65.65	0.07	0.68	0.05	32.01	0.03	66.56	0.68	0.10	0.16	0.11	0.10	0.11
Sycamore Slough	SYCAMOR_MID	4.79	40.41	54.81	2.9E-20	0	1.1E-32	5.24	32.04	62.72	2.6E-18	7.7E-14	1.0E-30	0.10	0.10	0.09	0.09	0.10
White Slough	WHITESL_L0	10.03	26.20	63.17	0.61	3.0E-05	8.1E-08	9.32	12.33	78.34	0.01	4.6E-04	4.6E-08	0.15	0.65	0.10	0.09	0.25
White Slough DS Disappointment Sl.	WHTSLDISPONT_LEN	9.10	26.19	64.27	0.45	3.1E-05	0	6.26	14.39	79.35	1.9E-03	6.8E-04	0	0.14	0.65	0.10	0.09	0.25

Table 6D.4 Calculation of Quarterly Average Selenium Concentrations for DSM2 Output Locations Based on Percentage of Flow at Each Location from Different Sources: Year 2007

		First Quarter Inflow Percentage						Second Quarter Inflow Percentage						Third Quarter Inflow Percentage						Fourth Quarter Inflow Percentage						Estimated Waterborne Selenium Concentrations (µg/L)				
	Inflow Source →	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass	Delta Ag.	East Delta Tributaries	Sac. R.	San Joaq. R.	Martinez/ Suisun Bay	Yolo Bypass					
	Inflow Location →	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*	*Mildred Island, Center*	*Mokelumne Calaveras Cosumnes Rivers*	*Freeport*	*Vernalis*	*San Joaq. R. near Mallard Island*	*Sac. R. below Knights Landing*	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
DSM2 Output Water Location	Selenium (µg/L) → **Location ID**	0.11	0.10	0.09	0.58	0.10	0.23	0.11	0.10	0.09	0.58	0.10	0.23	0.11	0.10	0.09	0.58	0.10	0.23	0.11	0.10	0.09	0.58	0.10	0.23					
Big Break	BIGBRK_MID	2.66	1.75	93.01	0.07	2.30	0.21	4.40	3.10	84.13	4.24	1.24	2.89	3.58	0.32	81.60	0.79	9.45	4.27	2.60	0.11	84.06	0.04	8.53	4.65	0.09	0.12	0.10	0.10	0.10
Cache Slough	CACHS_LEN	1.86	1.4E-05	97.14	2.2E-07	2.8E-05	1.01	1.99	5.1E-04	88.84	8.8E-04	1.6E-05	9.17	1.92	9.1E-06	89.20	1.9E-05	1.6E-06	8.88	1.64	1.9E-05	91.73	8.5E-06	5.1E-04	6.62	0.09	0.10	0.10	0.10	0.10
Cache Slough Ryer	CACHSR_MID	2.85	1.8E-06	96.46	4.7E-08	1.5E-05	0.68	2.66	1.2E-04	88.76	1.8E-04	1.4E-06	8.58	2.16	1.5E-05	88.35	3.1E-05	3.1E-07	9.49	1.96	4.5E-06	90.83	2.8E-06	1.9E-04	7.21	0.09	0.10	0.10	0.10	0.10
Cosumnes R.	COSR_LEN	0.00	100.00	0	0	0	0.00	0.01	99.99	0	0	0	0	0.09	99.91	0	0	0	0	0	100.00	0	0	0	0.00	0.10	0.10	0.10	0.10	0.10
Franks Tract	FRANKST_MID	3.85	4.08	90.69	0.32	0.94	0.11	6.16	5.35	77.86	9.10	0.16	1.38	4.86	0.34	88.03	0.84	2.96	2.98	3.19	0.32	91.15	0.17	2.23	2.95	0.09	0.14	0.10	0.10	0.11
Little Holland Tract	LHOLND_L0	29.80	0.00	69.38	1.2E-07	5.3E-05	0.81	22.80	8.0E-05	71.18	1.1E-04	5.2E-06	6.02	18.52	2.4E-05	73.18	0.00	4.9E-07	8.30	21.64	5.2E-07	71.72	1.4E-06	4.9E-05	6.64	0.10	0.10	0.11	0.10	0.10
Middle R Bullfrog	MIDRBULFRG_LEN	8.32	10.69	59.08	21.39	0.48	0.04	9.69	10.67	38.75	40.64	0.03	0.22	8.41	3.92	81.16	4.51	0.87	1.14	5.81	4.90	72.42	15.36	0.57	0.94	0.20	0.29	0.12	0.17	0.19
Mildred Island	MILDDRISL_MID	7.42	11.13	68.24	12.63	0.54	0.04	8.53	10.39	42.57	38.23	0.03	0.25	6.49	1.12	88.25	1.83	1.00	1.30	4.91	4.55	80.81	7.99	0.66	1.08	0.15	0.28	0.10	0.13	0.17
Mok. R. below Cosum.	MOKBCOS_LEN	1.46	98.54	0	0	0	0	6.32	93.68	6.5E-04	0	0	0	15.09	84.81	0.10	6.2E-35	0	0	2.30	97.70	0	0	0	0	0.10	0.10	0.10	0.10	0.10
Mok. R. downstream Cosum.	MOKDCOS_MID	1.46	98.54	0	0	0	0	6.42	93.58	0	0	0	0	15.19	84.81	3.2E-04	0	0	0	2.27	97.73	0	0	0	0	0.10	0.10	0.10	0.10	0.10
Old R near Paradise Cut	OLDRNPARADSEC_MID	3.95	5E-12	3E-06	96.05	1.7E-16	2.5E-17	15.73	1.81	12.66	69.68	0.02	0.10	10.18	1.9E-05	1.6E-04	89.82	6.9E-08	6.5E-07	2.31	9.2E-04	0.01	97.68	0	9.7E-05	0.56	0.43	0.53	0.57	0.52
Paradise Cut	PARADSECUT_LEN	1.91	0	0	98.09	0	0	4.98	0.11	0.61	94.29	6.7E-04	3.7E-03	7.14	0	0	92.86	0	0	1.24	4.1E-03	0.05	98.71	4.1E-04	4.5E-04	0.57	0.55	0.55	0.57	0.56
Port of Stockton	PORTOSTOCK_L0	1.48	0	0	98.52	0	0	2.29	0	0	97.71	0	0	6.32	0.04	0	93.64	0	0	7.16	0.05	0	92.78	0	0	0.57	0.57	0.55	0.55	0.56
Sac. R. at Isleton	SACRISLTON_L0	0.45	0	99.55	0	0	2.1E-06	0.63	8.8E-05	99.36	5.7E-08	0	0.01	0.49	0	99.51	0	0	2.9E-04	0.39	1.0E-08	99.61	0	6.7E-07	0.01	0.09	0.09	0.09	0.09	0.09
Sac River RM 44	SACR44_L0	0.20	0	99.80	0	0	0	0.30	0	99.70	0	0	0	0.15	0	99.85	0	0	0	0.11	0	99.89	0	0	0	0.09	0.09	0.09	0.09	0.09
Sandmound Sl.	SANDMND_MID	4.47	3.23	90.83	0.17	1.17	0.13	7.20	4.64	79.23	6.98	0.23	1.71	6.15	0.39	84.96	0.98	4.06	3.46	3.79	0.22	89.26	0.10	3.11	3.51	0.09	0.13	0.10	0.10	0.10
Sherman Island	SHERMNILND_L0	2.14	0.95	92.16	0.04	4.49	0.23	3.69	2.31	83.94	2.94	4.01	3.11	2.99	0.32	77.36	0.77	14.22	4.34	2.22	0.06	75.89	0.03	17.11	4.68	0.09	0.11	0.10	0.10	0.10
SJR Bowman	SJRBOWMN_MID	0.88	0	0	99.12	0	0	3.52	0	0	96.48	0	0	8.49	2.5E-04	0	91.51	0	0	0.91	0	0	99.09	0	0	0.58	0.56	0.54	0.58	0.56
SJR N Hwy4	SJRNHWY4_MID	1.82	2.8E-08	0	98.18	0	0	4.35	1.4E-07	0	95.65	0	0	12.54	0.08	4.0E-26	87.39	0	0	1.89	1.3E-04	0	98.11	0	0	0.57	0.56	0.52	0.57	0.56
SJR Naval st	SJRNAVLST_L0	4.83	6.83	0	88.35	0	0	5.86	11.12	1.3E-06	83.02	0	0	12.06	40.15	3.4E-03	47.78	6.2E-07	6.3E-06	4.73	6.37	2.5E-04	88.90	5.4E-09	7.0E-09	0.52	0.50	0.33	0.53	0.47
SJR Potato Slough	SJRPOTSL_MID	2.91	5.22	91.00	0.15	0.61	0.10	4.89	5.67	79.70	8.49	0.10	1.16	3.16	0.19	91.86	0.46	1.88	2.44	2.37	0.33	93.43	0.10	1.44	2.33	0.09	0.13	0.10	0.09	0.10
SJR Turner	SJRTURNR_MID	7.22	10.11	10.82	71.76	0.08	0.01	7.49	11.95	7.23	73.31	2.9E-03	0.02	11.09	11.29	65.50	11.02	0.46	0.63	6.16	6.57	36.18	50.55	0.19	0.35	0.44	0.45	0.15	0.34	0.35
SJR/Pt. Antioch/fish pier	ASRANTFSH_MID	2.17	1.01	92.90	0.04	3.62	0.26	3.74	2.30	84.37	3.04	3.24	3.31	3.00	0.27	79.62	0.65	12.05	4.40	2.27	0.07	78.73	0.03	14.08	4.82	0.09	0.11	0.10	0.10	0.10
Suisun Bay	SUISNB_LEN	0.87	0.23	46.77	0.01	51.97	0.14	0.94	0.51	31.58	0.43	65.55	0.98	0.84	0.16	21.30	0.36	76.08	1.25	0.59	0.02	21.39	0.01	76.63	1.36	0.10	0.10	0.10	0.10	0.10
Sycamore Slough	SYCAMOR_MID	10.20	72.58	17.22	5.1E-10	9.7E-14	4.3E-29	13.62	50.90	35.47	0.01	4.0E-09	1.1E-07	5.33	3.90	90.77	1.9E-16	3.8E-25	1.1E-22	3.69	20.36	75.95	6.0E-19	1.1E-37	2.4E-31	0.10	0.10	0.09	0.09	0.10
White Slough	WHITESL_L0	20.35	16.73	61.67	1.25	4.8E-03	2.4E-04	33.31	13.41	23.49	29.78	3.9E-04	3.2E-03	15.53	1.33	83.05	0.09	1.2E-03	2.0E-03	9.35	8.62	81.98	0.04	3.7E-04	7.1E-04	0.10	0.24	0.09	0.09	0.13
White Slough DS Disappointment Sl.	WHTSLDISPONT_LEN	10.09	24.12	65.07	0.71	4.1E-03	1.9E-04	17.00	13.60	32.29	37.10	1.4E-03	0.01	7.70	1.46	90.83	1.5E-03	1.3E-03	2.2E-03	5.21	9.69	85.06	0.03	9.7E-04	2.1E-03	0.10	0.28	0.09	0.09	0.14

Table 6D.5 Selenium Bioaccumulation from Water (µg/L) to Particulates and Fish (µg/g, dw) Using Models 1 and 2

DSM2 Delta Water Location	Year 2000								Year 2005								Year 2007							
	Concentration					Whole-body Bass[a]	Fish-to-Bass Ratio		Concentration					Whole-body Bass[a]	Fish-to-Bass Ratio		Concentration					Whole-body Bass[a]	Fish-to-Bass Ratio	
	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 1 Fish	Model 2 Fish		Model 1	Model 2	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 1 Fish	Model 2 Fish		Model 1	Model 2	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 1 Fish	Model 2 Fish		Model 1	Model 2
	First Quarter								**First Quarter**								**First Quarter**							
Sacramento River RM 44	0.09	0.09	0.25	0.27	0.30	2.6	0.10	0.11	0.09	0.09	0.25	0.28	0.31	1.5	0.19	0.21	0.09	0.09	0.25	0.28	0.31	1.8	0.15	0.17
Cache Slough Ryer[b]	0.10	0.10	0.28	0.31	0.34	1.5	0.21	0.23	0.09	0.09	0.26	0.29	0.31	1.7	0.17	0.18	0.09	0.09	0.26	0.28	0.31	2.5	0.11	0.12
San Joaquin River Potato Slough	0.17	0.17	0.47	0.52	0.57	1.4	0.38	0.42	0.14	0.14	0.40	0.44	0.48	1.3	0.33	0.37	0.09	0.09	0.26	0.28	0.31	2.5	0.11	0.13
Franks Tract	0.19	0.19	0.53	0.58	0.64	1.6	0.35	0.39	0.15	0.15	0.41	0.45	0.49	1.1	0.39	0.43	0.09	0.09	0.26	0.29	0.32	3.0	0.10	0.11
Big Break	0.13	0.13	0.35	0.39	0.43	1.6	0.25	0.28	0.11	0.11	0.31	0.34	0.37	1.0	0.33	0.37	0.09	0.09	0.26	0.28	0.31	2.8	0.10	0.11
Middle River Bullfrog	0.31	0.31	0.86	0.95	1.05	NA	NA	NA	0.46	0.46	1.29	1.42	1.56	1.9	0.7	0.8	0.20	0.20	0.55	0.61	0.67	2.1	0.3	0.3
Old River near Paradise Cut[c]	0.73	0.73	2.05	2.25	2.48	NA	NA	NA	0.78	0.78	2.19	2.41	2.66	2.4	1.0	1.1	0.56	0.56	1.57	1.73	1.90	NA	NA	NA
Knights Landing[d]	0.23	0.23	0.64	0.71	0.78	NA	NA	NA	0.23	0.23	0.64	0.71	0.78	2.2	0.3	0.4	0.23	0.23	0.64	0.71	0.78	NA	NA	NA
Vernalis[e]	0.83	0.83	2.32	2.56	2.81	1.7	1.50	1.65	0.85	0.85	2.38	2.62	2.88	1.9	1.38	1.52	0.58	0.58	1.62	1.79	1.97	2.4	0.74	0.82
	Second Quarter								**Second Quarter**								**Second Quarter**							
Sacramento River RM 44	0.09	0.09	0.25	0.28	0.30	2.6	0.11	0.12	0.09	0.09	0.25	0.28	0.30	1.5	0.19	0.21	0.09	0.09	0.25	0.28	0.31	1.8	0.15	0.17
Cache Slough Ryer[b]	0.11	0.11	0.32	0.35	0.38	1.5	0.23	0.26	0.10	0.10	0.27	0.30	0.33	1.7	0.17	0.19	0.10	0.10	0.29	0.32	0.35	2.5	0.12	0.14
San Joaquin River Potato Slough	0.24	0.24	0.67	0.74	0.81	1.4	0.54	0.60	0.36	0.36	1.02	1.12	1.23	1.3	0.86	0.94	0.13	0.13	0.38	0.42	0.46	2.5	0.17	0.18
Franks Tract	0.27	0.27	0.76	0.83	0.92	1.6	0.51	0.56	0.49	0.49	1.36	1.50	1.65	1.1	1.31	1.44	0.14	0.14	0.39	0.43	0.47	3.0	0.14	0.16
Big Break	0.20	0.20	0.55	0.60	0.66	1.6	0.39	0.43	0.30	0.30	0.83	0.91	1.00	1.0	0.89	0.98	0.12	0.12	0.33	0.36	0.39	2.8	0.13	0.14
Middle River Bullfrog	0.61	0.61	1.71	1.88	2.07	NA	NA	NA	0.75	0.75	2.09	2.30	2.53	1.9	1.2	1.3	0.29	0.29	0.82	0.90	0.99	2.1	0.4	0.5
Old River near Paradise Cut[c]	0.68	0.68	1.89	2.08	2.29	NA	NA	NA	0.84	0.84	2.35	2.59	2.84	2.4	1.1	1.2	0.43	0.43	1.22	1.34	1.47	NA	NA	NA
Knights Landing[d]	0.23	0.23	0.64	0.71	0.78	NA	NA	NA	0.23	0.23	0.64	0.71	0.78	2.2	0.3	0.4	0.23	0.23	0.64	0.71	0.78	NA	NA	NA
Vernalis[e]	0.83	0.83	2.32	2.56	2.81	1.7	1.50	1.65	0.85	0.85	2.38	2.62	2.88	1.9	1.38	1.52	0.58	0.58	1.62	1.79	1.97	2.4	0.74	0.82
	Third Quarter								**Third Quarter**								**Third Quarter**							
Sacramento River RM 44	0.09	0.09	0.25	0.28	0.30	2.6	0.11	0.12	0.09	0.09	0.25	0.28	0.31	1.5	0.19	0.21	0.09	0.09	0.25	0.28	0.31	1.8	0.15	0.17
Cache Slough Ryer[b]	0.11	0.11	0.31	0.34	0.37	1.5	0.22	0.25	0.09	0.09	0.25	0.28	0.31	1.7	0.16	0.18	0.10	0.10	0.29	0.32	0.35	2.5	0.13	0.14
San Joaquin River Potato Slough	0.10	0.10	0.27	0.30	0.32	1.4	0.22	0.24	0.10	0.10	0.27	0.30	0.33	1.3	0.23	0.25	0.10	0.10	0.27	0.30	0.33	2.5	0.12	0.13
Franks Tract	0.10	0.10	0.28	0.31	0.34	1.6	0.19	0.20	0.11	0.11	0.29	0.32	0.36	1.1	0.28	0.31	0.10	0.10	0.28	0.31	0.34	3.0	0.10	0.11
Big Break	0.10	0.10	0.29	0.32	0.35	1.6	0.20	0.22	0.10	0.10	0.29	0.32	0.35	1.0	0.31	0.35	0.10	0.10	0.28	0.31	0.34	2.8	0.11	0.12
Middle River Bullfrog	0.20	0.20	0.57	0.63	0.69	NA	NA	NA	0.30	0.30	0.83	0.91	1.01	1.9	0.5	0.5	0.12	0.12	0.32	0.36	0.39	2.1	0.2	0.2
Old River near Paradise Cut[c]	0.75	0.75	2.11	2.32	2.55	NA	NA	NA	0.80	0.80	2.24	2.47	2.71	2.4	1.0	1.1	0.53	0.53	1.49	1.64	1.80	NA	NA	NA
Knights Landing[d]	0.23	0.23	0.64	0.71	0.78	NA	NA	NA	0.23	0.23	0.64	0.71	0.78	2.2	0.3	0.4	0.23	0.23	0.64	0.71	0.78	NA	NA	NA
Vernalis[e]	0.83	0.83	2.32	2.56	2.81	1.7	1.50	1.65	0.85	0.85	2.38	2.62	2.88	1.9	1.38	1.52	0.58	0.58	1.62	1.79	1.97	2.4	0.74	0.82

DSM2 Delta Water Location	Year 2000								Year 2005								Year 2007							
	Concentration					Whole-body Bass[a]	Fish-to-Bass Ratio		Concentration					Whole-body Bass[a]	Fish-to-Bass Ratio		Concentration					Whole-body Bass[a]	Fish-to-Bass Ratio	
	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 1 Fish	Model 2 Fish		Model 1	Model 2	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 1 Fish	Model 2 Fish		Model 1	Model 2	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 1 Fish	Model 2 Fish		Model 1	Model 2
	Fourth Quarter								Fourth Quarter								Fourth Quarter							
Sacramento River RM 44	0.09	0.09	0.25	0.28	0.30	2.6	0.11	0.12	0.09	0.09	0.25	0.28	0.31	1.5	0.19	0.21	0.09	0.09	0.25	0.28	0.30	1.8	0.15	0.17
Cache Slough Ryer[b]	0.10	0.10	0.29	0.31	0.35	1.5	0.21	0.23	0.09	0.09	0.26	0.28	0.31	1.7	0.16	0.18	0.10	0.10	0.28	0.31	0.34	2.5	0.12	0.13
San Joaquin River Potato Slough	0.09	0.09	0.26	0.29	0.32	1.4	0.21	0.23	0.09	0.09	0.25	0.28	0.31	1.3	0.21	0.24	0.09	0.09	0.26	0.29	0.32	2.5	0.12	0.13
Franks Tract	0.10	0.10	0.27	0.29	0.32	1.6	0.18	0.20	0.09	0.09	0.26	0.28	0.31	1.1	0.25	0.27	0.10	0.10	0.27	0.30	0.32	3.0	0.10	0.11
Big Break	0.10	0.10	0.27	0.30	0.33	1.6	0.19	0.21	0.09	0.09	0.26	0.28	0.31	1.0	0.28	0.31	0.10	0.10	0.27	0.30	0.33	2.8	0.11	0.12
Middle River Bullfrog	0.30	0.30	0.84	0.92	1.01	NA	NA	NA	0.24	0.24	0.68	0.74	0.82	1.9	0.4	0.4	0.17	0.17	0.47	0.52	0.57	2.1	0.2	0.3
Old River near Paradise Cut[c]	0.81	0.81	2.27	2.50	2.75	NA	NA	NA	0.72	0.72	2.01	2.21	2.43	2.4	0.9	1.0	0.57	0.57	1.59	1.75	1.93	NA	NA	NA
Knights Landing[d]	0.23	0.23	0.64	0.71	0.78	NA	NA	NA	0.23	0.23	0.64	0.71	0.78	2.2	0.3	0.4	0.23	0.23	0.64	0.71	0.78	NA	NA	NA
Vernalis[e]	0.83	0.83	2.32	2.56	2.81	1.7	1.50	1.65	0.85	0.85	2.38	2.62	2.88	1.9	1.38	1.52	0.58	0.58	1.62	1.79	1.97	2.4	0.74	0.82

Notes:

Equations from Presser and Luoma (2010a, 2010b) were used to calculate selenium concentrations for fish. Models 1 and 2 used the default K_d (1.00) and the average selenium trophic transfer factors to aquatic insects (2.8) and fish (1.1 for all trophic levels).

Model 1 = TL-3 Fish Eating Invertebrates

Model 2 = TL-4 Fish Eating TL-3 Fish

Invert. = invertebrate

K_d = particulate concentration/water concentration ratio

µg/g, dw = micrograms per gram, dry weight

NA = not available; bass not collected here

RM = river mile

TL = trophic level

a. Geometric mean calculated from whole-body largemouth bass data presented in Foe (2010a).

b. Fish data collected at Rio Vista (Foe 2010a) were used to calculate geometric mean whole-body largemouth bass and ratios.

c. Fish data collected at Old River near Tracy (Foe 2010a) were used to calculate geometric mean whole-body largemouth bass and ratios.

d. Geometric mean of total selenium concentrations in water collected from years 2004, 2007, and 2008 (DWR Website 2009) was used to estimate selenium concentrations in particulates and biota (DSM2 data were not available). Fish data collected from Sacramento River at Veterans Bridge (Foe 2010a) were used to calcula mean whole-body largemouth bass and ratios.

e. Geometric mean of selenium concentrations (total or dissolved was not specified) in water collected from years 1999–2000 (SWAMP Website 2009) was used to estimate Year 2000 selenium concentrations in particulates and biota (DSM2 data were not available); years 2004-2005 were used for Year 2005 estimates; and ye 2007 were used for Year 2007 estimates.

Table 6D.6 Selenium Bioaccumulation from Water (µg/L) to Particulates and Fish (µg/g, dw) Using Model 2 with Estimated K_d from All Years Regression for Model 3

Year 2000

DSM2 Delta Water Location	Concentration: DSM2 Water	Concentration: Particulate from Water	Concentration: Invert. from Particulate	Concentration: Model 3 Fish	K_d	Whole-body Bass[a]	Fish-to-Bass Ratio: Model 3
First Quarter							
Sacramento River RM 44	0.09	0.54	1.50	1.81	6060	2.6	0.69
Cache Slough Ryer[b]	0.10	0.54	1.50	1.82	5389	1.5	1.22
San Joaquin River Potato Slough	0.17	0.55	1.53	1.85	3229	1.4	1.36
Franks Tract	0.19	0.55	1.53	1.85	2904	1.6	1.13
Big Break	0.13	0.54	1.51	1.83	4295	1.6	1.18
Middle River Bullfrog	0.31	0.56	1.56	1.88	1801	NA	NA
Old River near Paradise Cut[c]	0.73	0.57	1.60	1.93	780	NA	NA
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	NA	NA
Vernalis[e]	0.83	0.57	1.60	1.94	689	1.7	1.14
Second Quarter							
Sacramento River RM 44	0.09	0.54	1.50	1.81	5952	2.6	0.69
Cache Slough Ryer[b]	0.11	0.54	1.51	1.83	4777	1.5	1.22
San Joaquin River Potato Slough	0.24	0.55	1.54	1.87	2309	1.4	1.38
Franks Tract	0.27	0.55	1.55	1.87	2048	1.6	1.14
Big Break	0.20	0.55	1.53	1.86	2800	1.6	1.20
Middle River Bullfrog	0.61	0.57	1.59	1.92	928	NA	NA
Old River near Paradise Cut[c]	0.68	0.57	1.59	1.93	842	NA	NA
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	NA	NA
Vernalis[e]	0.83	0.57	1.60	1.94	689	1.7	1.14
Third Quarter							
Sacramento River RM 44	0.09	0.54	1.50	1.81	5947	2.6	0.69
Cache Slough Ryer[b]	0.11	0.54	1.51	1.82	4942	1.5	1.22
San Joaquin River Potato Slough	0.10	0.54	1.50	1.82	5592	1.4	1.34
Franks Tract	0.10	0.54	1.50	1.82	5412	1.6	1.10
Big Break	0.10	0.54	1.50	1.82	5227	1.6	1.17
Middle River Bullfrog	0.20	0.55	1.54	1.86	2688	NA	NA
Old River near Paradise Cut[c]	0.75	0.57	1.60	1.93	757	NA	NA
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	NA	NA
Vernalis[e]	0.83	0.57	1.60	1.94	689	1.7	1.14

Year 2005

DSM2 Delta Water Location	Concentration: DSM2 Water	Concentration: Particulate from Water	Concentration: Invert. from Particulate	Concentration: Model 3 Fish	K_d	Whole-body Bass[a]	Fish-to-Bass Ratio: Model 3
First Quarter							
Sacramento River RM 44	0.09	0.54	1.50	1.81	5945	1.5	1.25
Cache Slough Ryer[b]	0.09	0.54	1.50	1.82	5783	1.7	1.05
San Joaquin River Potato Slough	0.14	0.54	1.52	1.84	3824	1.3	1.41
Franks Tract	0.15	0.54	1.52	1.84	3724	1.1	1.61
Big Break	0.11	0.54	1.51	1.82	4873	1.0	1.79
Middle River Bullfrog	0.46	0.56	1.57	1.90	1221	1.9	1.0
Old River near Paradise Cut[c]	0.78	0.57	1.60	1.94	729	2.4	0.8
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	2.2	0.8
Vernalis[e]	0.85	0.57	1.60	1.94	674	1.9	1.02
Second Quarter							
Sacramento River RM 44	0.09	0.54	1.50	1.81	5947	1.5	1.25
Cache Slough Ryer[b]	0.10	0.54	1.50	1.82	5538	1.7	1.05
San Joaquin River Potato Slough	0.36	0.56	1.56	1.89	1537	1.3	1.45
Franks Tract	0.49	0.56	1.58	1.91	1159	1.1	1.67
Big Break	0.30	0.55	1.55	1.88	1876	1.0	1.84
Middle River Bullfrog	0.75	0.57	1.60	1.93	764	1.9	1.0
Old River near Paradise Cut[c]	0.84	0.57	1.60	1.94	682	2.4	0.8
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	2.2	0.8
Vernalis[e]	0.85	0.57	1.60	1.94	674	1.9	1.02
Third Quarter							
Sacramento River RM 44	0.09	0.54	1.50	1.81	5946	1.5	1.25
Cache Slough Ryer[b]	0.09	0.54	1.50	1.81	5914	1.7	1.05
San Joaquin River Potato Slough	0.10	0.54	1.50	1.82	5523	1.3	1.39
Franks Tract	0.11	0.54	1.51	1.82	5121	1.1	1.59
Big Break	0.10	0.54	1.51	1.82	5159	1.0	1.79
Middle River Bullfrog	0.30	0.55	1.55	1.88	1868	1.9	1.0
Old River near Paradise Cut[c]	0.80	0.57	1.60	1.94	714	2.4	0.8
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	2.2	0.8
Vernalis[e]	0.85	0.57	1.60	1.94	674	1.9	1.02

Year 2007

DSM2 Delta Water Location	Concentration: DSM2 Water	Concentration: Particulate from Water	Concentration: Invert. from Particulate	Concentration: Model 3 Fish	K_d	Whole-body Bass[a]	Fish-to-Bass Ratio: Model 3
First Quarter							
Sacramento River RM 44	0.09	0.54	1.50	1.81	5946	1.8	0.98
Cache Slough Ryer[b]	0.09	0.54	1.50	1.81	5852	2.5	0.71
San Joaquin River Potato Slough	0.09	0.54	1.50	1.81	5819	2.5	0.73
Franks Tract	0.09	0.54	1.50	1.82	5762	3.0	0.61
Big Break	0.09	0.54	1.50	1.81	5850	2.8	0.64
Middle River Bullfrog	0.20	0.55	1.53	1.86	2773	2.1	0.87
Old River near Paradise Cut[c]	0.56	0.57	1.58	1.92	1007	NA	NA
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	NA	NA
Vernalis[e]	0.58	0.57	1.59	1.92	976	2.4	0.80
Second Quarter							
Sacramento River RM 44	0.09	0.54	1.50	1.81	5944	1.8	0.98
Cache Slough Ryer[b]	0.10	0.54	1.50	1.82	5241	2.5	0.72
San Joaquin River Potato Slough	0.13	0.54	1.52	1.84	4020	2.5	0.74
Franks Tract	0.14	0.54	1.52	1.84	3921	3.0	0.61
Big Break	0.12	0.54	1.51	1.83	4645	2.8	0.64
Middle River Bullfrog	0.29	0.55	1.55	1.88	1896	2.1	0.9
Old River near Paradise Cut[c]	0.43	0.56	1.57	1.90	1291	NA	NA
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	NA	NA
Vernalis[e]	0.58	0.57	1.59	1.92	976	2.4	0.80
Third Quarter							
Sacramento River RM 44	0.09	0.54	1.50	1.81	5946	1.8	0.98
Cache Slough Ryer[b]	0.10	0.54	1.51	1.82	5184	2.5	0.72
San Joaquin River Potato Slough	0.10	0.54	1.50	1.82	5557	2.5	0.73
Franks Tract	0.10	0.54	1.50	1.82	5393	3.0	0.61
Big Break	0.10	0.54	1.50	1.82	5291	2.8	0.64
Middle River Bullfrog	0.12	0.54	1.51	1.83	4656	2.1	0.86
Old River near Paradise Cut[c]	0.53	0.56	1.58	1.91	1061	NA	NA
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	NA	NA
Vernalis[e]	0.58	0.57	1.59	1.92	976	2.4	0.80

DSM2 Delta Water Location	Year 2000							Year 2005							Year 2007						
	Concentration						Fish-to-Bass Ratio	Concentration						Fish-to-Bass Ratio	Concentration						Fish-to-Bass Ratio
	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 3 Fish	K_d	Whole-body Bass[a]	Model 3	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 3 Fish	K_d	Whole-body Bass[a]	Model 3	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 3 Fish	K_d	Whole-body Bass[a]	Model 3
	Fourth Quarter							Fourth Quarter							Fourth Quarter						
Sacramento River RM 44	0.09	0.54	1.50	1.81	5948	2.6	0.69	0.09	0.54	1.50	1.81	5946	1.5	1.25	0.09	0.54	1.50	1.81	5947	1.8	0.98
Cache Slough Ryer[b]	0.10	0.54	1.50	1.82	5261	1.5	1.22	0.09	0.54	1.50	1.81	5830	1.7	1.05	0.10	0.54	1.50	1.82	5345	2.5	0.71
San Joaquin River Potato Slough	0.09	0.54	1.50	1.82	5704	1.4	1.34	0.09	0.54	1.50	1.81	5885	1.3	1.39	0.09	0.54	1.50	1.82	5678	2.5	0.73
Franks Tract	0.10	0.54	1.50	1.82	5621	1.6	1.10	0.09	0.54	1.50	1.81	5859	1.1	1.59	0.10	0.54	1.50	1.82	5596	3.0	0.61
Big Break	0.10	0.54	1.50	1.82	5534	1.6	1.17	0.09	0.54	1.50	1.82	5809	1.0	1.78	0.10	0.54	1.50	1.82	5470	2.8	0.64
Middle River Bullfrog	0.30	0.55	1.55	1.88	1859	NA	NA	0.24	0.55	1.54	1.87	2283	1.9	1.0	0.17	0.55	1.53	1.85	3241	2.1	0.87
Old River near Paradise Cut[c]	0.81	0.57	1.60	1.94	704	NA	NA	0.72	0.57	1.60	1.93	795	2.4	0.8	0.57	0.57	1.58	1.92	994	NA	NA
Knights Landing[d]	0.23	0.55	1.54	1.87	2394	NA	NA	0.23	0.55	1.54	1.87	2394	2.2	0.8	0.23	0.55	1.54	1.87	2394	NA	NA
Vernalis[e]	0.83	0.57	1.60	1.94	689	1.7	1.14	0.85	0.57	1.60	1.94	674	1.9	1.02	0.58	0.57	1.59	1.92	976	2.4	0.80

Notes:

Equations from Presser and Luoma (2010a, 2010b) were used to calculate selenium concentrations for fish. Model 3 used the average selenium trophic transfer factors to aquatic insects (2.8) and fish (1.1 for all trophic levels).

Model 3 = Model 2 (TL-4 Fish Eating TL-3 Fish) with K_d estimated using all years regression (log K_d = 2.76-0.97(logDSM2))

Invert. = invertebrate

K_d = particulate concentration/water concentration ratio

µg/g, dw = micrograms per gram, dry weight

NA = not available; bass not collected here

RM = river mile

TL = trophic level

a. Geometric mean calculated from whole-body largemouth bass data presented in Foe (2010a).

b. Fish data collected at Rio Vista (Foe 2010a) were used to calculate geometric mean whole-body largemouth bass and ratios.

c. Fish data collected at Old River near Tracy (Foe 2010a) were used to calculate geometric mean whole-body largemouth bass and ratios.

d. Geometric mean of total selenium concentrations in water collected from years 2004, 2007, and 2008 (DWR Website 2009) was used to estimate selenium concentrations in particulates and biota (DSM2 data were not available). Fish data collected from Sacramento River at Veterans Bridge (Foe 2010a) were used to calc geometric mean whole-body largemouth bass and ratios.

e. Geometric mean of selenium concentrations (total or dissolved was not specified) in water collected from years 1999-2000 (SWAMP Website 2009) was used to estimate Year 2000 selenium concentrations in particulates and biota (DSM2 data were not available); years 2004-2005 were used for Year 2005 estimates; and years 200 2007 were used for Year 2007 estimates.

Table 6D.7 Selenium Bioaccumulation from Water (µg/L) to Particulates and Fish (µg/g, dw) Using Model 2 with Estimated K_d from Normal/Wet Years Regression for Model 4 and Dry Years Regression for Model 5

DSM2 Delta Water Location	Year 2000 Concentration: DSM2 Water	Year 2000 Concentration: Particulate from Water	Year 2000 Concentration: Invert. from Particulate	Year 2000 Concentration: Model 4 Fish	Year 2000 K_d	Year 2000 Whole-body Bass[a]	Year 2000 Fish-to-Bass Ratio: Model 4	Year 2005 Concentration: DSM2 Water	Year 2005 Concentration: Particulate from Water	Year 2005 Concentration: Invert. from Particulate	Year 2005 Concentration: Model 4 Fish	Year 2005 K_d	Year 2005 Whole-body Bass[a]	Year 2005 Fish-to-Bass Ratio: Model 4	Year 2007 Concentration: DSM2 Water	Year 2007 Concentration: Particulate from Water	Year 2007 Concentration: Invert. from Particulate	Year 2007 Concentration: Model 5 Fish	Year 2007 K_d	Year 2007 Whole-body Bass[a]	Year 2007 Fish-to-Bass Ratio: Model 5
First Quarter								First Quarter							First Quarter						
Sacramento River RM 44	0.09	0.44	1.24	1.49	4997	2.6	0.57	0.09	0.44	1.24	1.50	4909	1.5	1.03	0.09	0.73	2.03	2.46	8063	1.8	1.33
Cache Slough Ryer[b]	0.10	0.45	1.25	1.51	4481	1.5	1.01	0.09	0.44	1.24	1.50	4784	1.7	0.87	0.09	0.73	2.03	2.46	7929	2.5	0.97
San Joaquin River Potato Slough	0.17	0.47	1.32	1.59	2786	1.4	1.17	0.14	0.46	1.30	1.57	3260	1.3	1.20	0.09	0.73	2.03	2.46	7883	2.5	0.99
Franks Tract	0.19	0.48	1.33	1.61	2525	1.6	0.98	0.15	0.46	1.30	1.57	3181	1.1	1.37	0.09	0.73	2.03	2.46	7802	3.0	0.82
Big Break	0.13	0.46	1.28	1.55	3630	1.6	1.00	0.11	0.45	1.26	1.53	4082	1.0	1.50	0.09	0.73	2.03	2.46	7926	2.8	0.87
Middle River Bullfrog	0.31	0.50	1.40	1.69	1621	NA	NA	0.46	0.52	1.46	1.76	1130	1.9	0.9	0.20	0.71	2.00	2.42	3616	2.1	1.14
Old River near Paradise Cut[c]	0.73	0.55	1.53	1.85	745	NA	NA	0.78	0.55	1.54	1.86	700	2.4	0.8	0.56	0.70	1.96	2.37	1247	NA	NA
Knights Landing[d]	0.23	0.49	1.36	1.64	2111	NA	NA	0.23	0.49	1.36	1.64	2111	2.2	0.7	0.23	0.71	1.99	2.41	3098	NA	NA
Vernalis[e]	0.83	0.55	1.55	1.87	665	1.7	1.10	0.85	0.55	1.55	1.87	651	1.9	0.99	0.58	0.70	1.96	2.37	1206	2.4	0.99
Second Quarter								Second Quarter							Second Quarter						
Sacramento River RM 44	0.09	0.44	1.24	1.50	4914	2.6	0.57	0.09	0.44	1.24	1.50	4910	1.5	1.03	0.09	0.73	2.03	2.46	8061	1.8	1.33
Cache Slough Ryer[b]	0.11	0.45	1.27	1.53	4007	1.5	1.03	0.10	0.45	1.25	1.51	4596	1.7	0.87	0.10	0.72	2.03	2.45	7061	2.5	0.96
San Joaquin River Potato Slough	0.24	0.49	1.36	1.65	2041	1.4	1.22	0.36	0.51	1.42	1.72	1399	1.3	1.32	0.13	0.72	2.02	2.44	5343	2.5	0.98
Franks Tract	0.27	0.49	1.38	1.67	1826	1.6	1.02	0.49	0.52	1.46	1.77	1077	1.1	1.55	0.14	0.72	2.02	2.44	5204	3.0	0.82
Big Break	0.20	0.48	1.34	1.62	2441	1.6	1.04	0.30	0.50	1.39	1.69	1683	1.0	1.65	0.12	0.72	2.02	2.45	6220	2.8	0.86
Middle River Bullfrog	0.61	0.54	1.50	1.81	876	NA	NA	0.75	0.55	1.53	1.85	732	1.9	1.0	0.29	0.71	1.99	2.40	2424	2.1	1.1
Old River near Paradise Cut[c]	0.68	0.54	1.51	1.83	801	NA	NA	0.84	0.55	1.55	1.87	658	2.4	0.8	0.43	0.70	1.97	2.38	1617	NA	NA
Knights Landing[d]	0.23	0.49	1.36	1.64	2111	NA	NA	0.23	0.49	1.36	1.64	2111	2.2	0.7	0.23	0.71	1.99	2.41	3098	NA	NA
Vernalis[e]	0.83	0.55	1.55	1.87	665	1.7	1.10	0.85	0.55	1.55	1.87	651	1.9	0.99	0.58	0.70	1.96	2.37	1206	2.4	0.99
Third Quarter								Third Quarter							Third Quarter						
Sacramento River RM 44	0.09	0.44	1.24	1.50	4910	2.6	0.57	0.09	0.44	1.24	1.50	4910	1.5	1.03	0.09	0.73	2.03	2.46	8064	1.8	1.33
Cache Slough Ryer[b]	0.11	0.45	1.26	1.53	4135	1.5	1.02	0.09	0.44	1.24	1.50	4885	1.7	0.87	0.10	0.72	2.03	2.45	6980	2.5	0.96
San Joaquin River Potato Slough	0.10	0.44	1.25	1.51	4637	1.4	1.11	0.10	0.45	1.25	1.51	4584	1.3	1.15	0.10	0.72	2.03	2.46	7510	2.5	0.99
Franks Tract	0.10	0.45	1.25	1.51	4499	1.6	0.92	0.11	0.45	1.26	1.52	4274	1.1	1.33	0.10	0.72	2.03	2.45	7276	3.0	0.82
Big Break	0.10	0.45	1.25	1.52	4356	1.6	0.98	0.10	0.45	1.26	1.52	4304	1.0	1.49	0.10	0.72	2.03	2.45	7131	2.8	0.87
Middle River Bullfrog	0.20	0.48	1.34	1.63	2350	NA	NA	0.30	0.50	1.39	1.69	1677	1.9	0.9	0.12	0.72	2.02	2.45	6235	2.1	1.15
Old River near Paradise Cut[c]	0.75	0.55	1.53	1.85	725	NA	NA	0.80	0.55	1.54	1.86	687	2.4	0.8	0.53	0.70	1.96	2.37	1317	NA	NA
Knights Landing[d]	0.23	0.49	1.36	1.64	2111	NA	NA	0.23	0.49	1.36	1.64	2111	2.2	0.7	0.23	0.71	1.99	2.41	3098	NA	NA
Vernalis[e]	0.83	0.55	1.55	1.87	665	1.7	1.10	0.85	0.55	1.55	1.87	651	1.9	0.99	0.58	0.70	1.96	2.37	1206	2.4	0.99

DSM2 Delta Water Location	Year 2000							Year 2005							Year 2007						
	Concentration				K_d	Whole-body Bass[a]	Fish-to-Bass Ratio	Concentration				K_d	Whole-body Bass[a]	Fish-to-Bass Ratio	Concentration				K_d	Whole-body Bass[a]	Fish-to-Bass Ratio
	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 4 Fish			Model 4	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 4 Fish			Model 4	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 5 Fish			Model 5
	Fourth Quarter							Fourth Quarter							Fourth Quarter						
Sacramento River RM 44	0.09	0.44	1.24	1.50	4911	2.6	0.57	0.09	0.44	1.24	1.50	4909	1.5	1.03	0.09	0.73	2.03	2.46	8064	1.8	1.33
Cache Slough Ryer[b]	0.10	0.45	1.25	1.52	4383	1.5	1.02	0.09	0.44	1.24	1.50	4820	1.7	0.87	0.10	0.72	2.03	2.45	7209	2.5	0.96
San Joaquin River Potato Slough	0.09	0.44	1.24	1.50	4723	1.4	1.11	0.09	0.44	1.24	1.50	4862	1.3	1.15	0.09	0.73	2.03	2.46	7682	2.5	0.99
Franks Tract	0.10	0.44	1.24	1.51	4660	1.6	0.91	0.09	0.44	1.24	1.50	4843	1.1	1.31	0.10	0.73	2.03	2.46	7564	3.0	0.82
Big Break	0.10	0.45	1.25	1.51	4593	1.6	0.97	0.09	0.44	1.24	1.50	4804	1.0	1.47	0.10	0.72	2.03	2.46	7386	2.8	0.87
Middle River Bullfrog	0.30	0.50	1.40	1.69	1669	NA	NA	0.24	0.49	1.37	1.65	2020	1.9	0.9	0.17	0.72	2.01	2.43	4260	2.1	1.14
Old River near Paradise Cut[c]	0.81	0.55	1.54	1.87	678	NA	NA	0.72	0.54	1.52	1.84	759	2.4	0.8	0.57	0.70	1.96	2.37	1229	NA	NA
Knights Landing[d]	0.23	0.49	1.36	1.64	2111	NA	NA	0.23	0.49	1.36	1.64	2111	2.2	0.7	0.23	0.71	1.99	2.41	3098	NA	NA
Vernalis[e]	0.83	0.55	1.55	1.87	665	1.7	1.10	0.85	0.55	1.55	1.87	651	1.9	0.99	0.58	0.70	1.96	2.37	1206	2.4	0.99

Notes:

Equations from Presser and Luoma (2010a, 2010b) were used to calculate selenium concentrations for fish. Models 4 and 5 used the average selenium trophic transfer factors to aquatic insects (2.8) and fish (1.1 for all trophic levels).

Model 4 = Model 2 (TL-4 Fish Eating TL-3 Fish) with K_d estimated using normal/wet years regression (log K_d= 2.75-0.90(logDSM2))

Model 5 = Model 2 (TL-4 Fish Eating TL-3 Fish) with K_d estimated using dry years (2007) regression (log K_d= 2.84-1.02(logDSM2))

Invert. = invertebrate

K_d = particulate concentration/water concentration ratio

µg/g, dw = micrograms per gram, dry weight

NA = not available; bass not collected here

RM = river mile

TL = trophic level

a. Geometric mean calculated from whole-body largemouth bass data presented in Foe (2010a).

b. Fish data collected at Rio Vista (Foe 2010a) were used to calculate geometric mean whole-body largemouth bass and ratios.

c. Fish data collected at Old River near Tracy (Foe 2010a) were used to calculate geometric mean whole-body largemouth bass and ratios.

d. Geometric mean of total selenium concentrations in water collected from years 2004, 2007, and 2008 (DWR Website 2009) was used to estimate selenium concentrations in particulates and biota (DSM2 data were not available). Fish data collected from Sacramento River at Veterans Bridge (Foe 2010a) were used to calc geometric mean whole-body largemouth bass and ratios.

e. Geometric mean of selenium concentrations (total or dissolved was not specified) in water collected from years 1999-2000 (SWAMP Website 2009) was used to estimate Year 2000 selenium concentrations in particulates and biota (DSM2 data were not available); years 2004-2005 were used for Year 2005 estimates; and years 200 2007 were used for Year 2007 estimates.

Table 6D.8 Selenium Bioaccumulation from Water (µg/L) to Particulates, Whole-body Fish (µg/g, dw), and Bird Eggs (µg/g, dw) Using Model 2 with Estimated K_d from Normal/Wet Years Regression for Model 4 and Dry Years Regression for Model 5

	Year 2000									Year 2005									Year 2007								
	Concentration					Whole-body	Fish-to-Bass Ratio	Bird Eggs		Concentration					Whole-body	Fish-to-Bass Ratio	Bird Eggs		Concentration					Whole-body	Fish-to-Bass Ratio	Bird Eggs	
DSM2 Delta Water Location	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 4 Fish	K_d	Bass[a]	Model 4	From Invert.	From Fish	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 4 Fish	K_d	Bass[a]	Model 4	From Invert.	From Fish	DSM2 Water	Particulate from Water	Invert. from Particulate	Model 5 Fish	K_d	Bass[a]	Model 5	From Invert.	From Fish
	First Quarter									First Quarter									First Quarter								
Sacramento River RM 44	0.09	0.44	1.24	1.49	4997	2.6	0.57	2.22	2.69	0.09	0.44	1.24	1.50	4909	1.5	1.03	2.23	2.70	0.09	0.73	2.03	2.46	8063	1.8	1.33	3.66	4.43
Cache Slough Ryer[b]	0.10	0.45	1.25	1.51	4481	1.5	1.01	2.25	2.72	0.09	0.44	1.24	1.50	4784	1.7	0.87	2.23	2.70	0.09	0.73	2.03	2.46	7929	2.5	0.97	3.66	4.43
San Joaquin River Potato Slough	0.17	0.47	1.32	1.59	2786	1.4	1.17	2.37	2.87	0.14	0.46	1.30	1.57	3260	1.3	1.20	2.33	2.82	0.09	0.73	2.03	2.46	7883	2.5	0.99	3.66	4.43
Franks Tract	0.19	0.48	1.33	1.61	2525	1.6	0.98	2.40	2.90	0.15	0.46	1.30	1.57	3181	1.1	1.37	2.34	2.83	0.09	0.73	2.03	2.46	7802	3.0	0.82	3.66	4.42
Big Break	0.13	0.46	1.28	1.55	3630	1.6	1.00	2.30	2.79	0.11	0.45	1.26	1.53	4082	1.0	1.50	2.27	2.75	0.09	0.73	2.03	2.46	7926	2.8	0.87	3.66	4.43
Middle River Bullfrog	0.31	0.50	1.40	1.69	1621	NA	NA	2.52	3.05	0.46	0.52	1.46	1.76	1130	1.9	0.9	2.62	3.17	0.20	0.71	2.00	2.42	3616	2.1	1.14	3.60	4.36
Old River near Paradise Cut[c]	0.73	0.55	1.53	1.85	745	NA	NA	2.75	3.32	0.78	0.55	1.54	1.86	700	2.4	0.8	2.77	3.35	0.56	0.70	1.96	2.37	1247	NA	NA	3.53	4.27
Knights Landing[d]	0.23	0.49	1.36	1.64	2111	NA	NA	2.45	2.96	0.23	0.49	1.36	1.64	2111	2.2	0.7	2.45	2.96	0.23	0.71	1.99	2.41	3098	NA	NA	3.59	4.34
Vernalis[e]	0.83	0.55	1.55	1.87	665	1.7	1.10	2.78	3.37	0.85	0.55	1.55	1.87	651	1.9	0.99	2.79	3.37	0.58	0.70	1.96	2.37	1206	2.4	0.99	3.53	4.27
	Second Quarter									Second Quarter									Second Quarter								
Sacramento River RM 44	0.09	0.44	1.24	1.50	4914	2.6	0.57	2.23	2.70	0.09	0.44	1.24	1.50	4910	1.5	1.03	2.23	2.70	0.09	0.73	2.03	2.46	8061	1.8	1.33	3.66	4.43
Cache Slough Ryer[b]	0.11	0.45	1.27	1.53	4007	1.5	1.03	2.28	2.76	0.10	0.45	1.25	1.51	4596	1.7	0.87	2.24	2.72	0.10	0.72	2.03	2.45	7061	2.5	0.96	3.65	4.42
San Joaquin River Potato Slough	0.24	0.49	1.36	1.65	2041	1.4	1.22	2.46	2.97	0.36	0.51	1.42	1.72	1399	1.3	1.32	2.56	3.10	0.13	0.72	2.02	2.44	5343	2.5	0.98	3.63	4.39
Franks Tract	0.27	0.49	1.38	1.67	1826	1.6	1.02	2.49	3.01	0.49	0.52	1.46	1.77	1077	1.1	1.55	2.64	3.19	0.14	0.72	2.02	2.44	5204	3.0	0.82	3.63	4.39
Big Break	0.20	0.48	1.34	1.62	2441	1.6	1.04	2.41	2.91	0.30	0.50	1.39	1.69	1683	1.0	1.65	2.51	3.04	0.12	0.72	2.02	2.45	6220	2.8	0.86	3.64	4.40
Middle River Bullfrog	0.61	0.54	1.50	1.81	876	NA	NA	2.70	3.26	0.75	0.55	1.53	1.85	732	1.9	1.0	2.75	3.33	0.29	0.71	1.99	2.40	2424	2.1	1.1	3.57	4.32
Old River near Paradise Cut[c]	0.68	0.54	1.51	1.83	801	NA	NA	2.73	3.30	0.84	0.55	1.55	1.87	658	2.4	0.8	2.79	3.37	0.43	0.70	1.97	2.38	1617	NA	NA	3.55	4.29
Knights Landing[d]	0.23	0.49	1.36	1.64	2111	NA	NA	2.45	2.96	0.23	0.49	1.36	1.64	2111	2.2	0.7	2.45	2.96	0.23	0.71	1.99	2.41	3098	NA	NA	3.59	4.34
Vernalis[e]	0.83	0.55	1.55	1.87	665	1.7	1.10	2.78	3.37	0.85	0.55	1.55	1.87	651	1.9	0.99	2.79	3.37	0.58	0.70	1.96	2.37	1206	2.4	0.99	3.53	4.27
	Third Quarter									Third Quarter									Third Quarter								
Sacramento River RM 44	0.09	0.44	1.24	1.50	4910	2.6	0.57	2.23	2.70	0.09	0.44	1.24	1.50	4910	1.5	1.03	2.23	2.70	0.09	0.73	2.03	2.46	8064	1.8	1.33	3.66	4.43
Cache Slough Ryer[b]	0.11	0.45	1.26	1.53	4135	1.5	1.02	2.27	2.75	0.09	0.44	1.24	1.50	4885	1.7	0.87	2.23	2.70	0.10	0.72	2.03	2.45	6980	2.5	0.96	3.65	4.41
San Joaquin River Potato Slough	0.10	0.44	1.25	1.51	4637	1.4	1.11	2.24	2.71	0.10	0.45	1.25	1.51	4584	1.3	1.15	2.24	2.72	0.10	0.72	2.03	2.46	7510	2.5	0.99	3.65	4.42
Franks Tract	0.10	0.45	1.25	1.51	4499	1.6	0.92	2.25	2.72	0.11	0.45	1.26	1.52	4274	1.1	1.33	2.26	2.74	0.10	0.72	2.03	2.45	7276	3.0	0.82	3.65	4.42
Big Break	0.10	0.45	1.25	1.52	4356	1.6	0.98	2.26	2.73	0.10	0.45	1.26	1.52	4304	1.0	1.49	2.26	2.74	0.10	0.72	2.03	2.45	7131	2.8	0.87	3.65	4.42
Middle River Bullfrog	0.20	0.48	1.34	1.63	2350	NA	NA	2.42	2.93	0.30	0.50	1.39	1.69	1677	1.9	0.9	2.51	3.04	0.12	0.72	2.02	2.45	6235	2.1	1.15	3.64	4.40
Old River near Paradise Cut[c]	0.75	0.55	1.53	1.85	725	NA	NA	2.76	3.33	0.80	0.55	1.54	1.86	687	2.4	0.8	2.77	3.35	0.53	0.70	1.96	2.37	1317	NA	NA	3.53	4.27
Knights Landing[d]	0.23	0.49	1.36	1.64	2111	NA	NA	2.45	2.96	0.23	0.49	1.36	1.64	2111	2.2	0.7	2.45	2.96	0.23	0.71	1.99	2.41	3098	NA	NA	3.59	4.34
Vernalis[e]	0.83	0.55	1.55	1.87	665	1.7	1.10	2.78	3.37	0.85	0.55	1.55	1.87	651	1.9	0.99	2.79	3.37	0.58	0.70	1.96	2.37	1206	2.4	0.99	3.53	4.27

Year 2000 — Fourth Quarter

DSM2 Delta Water Location	Concentration: DSM2 Water	Concentration: Particulate from Water	Concentration: Invert. from Particulate	Concentration: Model 4 Fish	K_d	Whole-body Bass[a]	Fish-to-Bass Ratio: Model 4	Bird Eggs: From Invert.	Bird Eggs: From Fish
Sacramento River RM 44	0.09	0.44	1.24	1.50	4911	2.6	0.57	2.23	2.70
Cache Slough Ryer[b]	0.10	0.45	1.25	1.52	4383	1.5	1.02	2.26	2.73
San Joaquin River Potato Slough	0.09	0.44	1.24	1.50	4723	1.4	1.11	2.24	2.71
Franks Tract	0.10	0.44	1.24	1.51	4660	1.6	0.91	2.24	2.71
Big Break	0.10	0.45	1.25	1.51	4593	1.6	0.97	2.24	2.72
Middle River Bullfrog	0.30	0.50	1.40	1.69	1669	NA	NA	2.51	3.04
Old River near Paradise Cut[c]	0.81	0.55	1.54	1.87	678	NA	NA	2.78	3.36
Knights Landing[d]	0.23	0.49	1.36	1.64	2111	NA	NA	2.45	2.96
Vernalis[e]	0.83	0.55	1.55	1.87	665	1.7	1.10	2.78	3.37

Year 2005 — Fourth Quarter

DSM2 Delta Water Location	Concentration: DSM2 Water	Concentration: Particulate from Water	Concentration: Invert. from Particulate	Concentration: Model 4 Fish	K_d	Whole-body Bass[a]	Fish-to-Bass Ratio: Model 4	Bird Eggs: From Invert.	Bird Eggs: From Fish
Sacramento River RM 44	0.09	0.44	1.24	1.50	4909	1.5	1.03	2.23	2.70
Cache Slough Ryer[b]	0.09	0.44	1.24	1.50	4820	1.7	0.87	2.23	2.70
San Joaquin River Potato Slough	0.09	0.44	1.24	1.50	4862	1.3	1.15	2.23	2.70
Franks Tract	0.09	0.44	1.24	1.50	4843	1.1	1.31	2.23	2.70
Big Break	0.09	0.44	1.24	1.50	4804	1.0	1.47	2.23	2.70
Middle River Bullfrog	0.24	0.49	1.37	1.65	2020	1.9	0.9	2.46	2.98
Old River near Paradise Cut[c]	0.72	0.54	1.52	1.84	759	2.4	0.8	2.74	3.32
Knights Landing[d]	0.23	0.49	1.36	1.64	2111	2.2	0.7	2.45	2.96
Vernalis[e]	0.85	0.55	1.55	1.87	651	1.9	0.99	2.79	3.37

Year 2007 — Fourth Quarter

DSM2 Delta Water Location	Concentration: DSM2 Water	Concentration: Particulate from Water	Concentration: Invert. from Particulate	Concentration: Model 5 Fish	K_d	Whole-body Bass[a]	Fish-to-Bass Ratio: Model 5	Bird Eggs: From Invert.	Bird Eggs: From Fish
Sacramento River RM 44	0.09	0.73	2.03	2.46	8064	1.8	1.33	3.66	4.43
Cache Slough Ryer[b]	0.10	0.72	2.03	2.45	7209	2.5	0.96	3.65	4.42
San Joaquin River Potato Slough	0.09	0.73	2.03	2.46	7682	2.5	0.99	3.66	4.42
Franks Tract	0.10	0.73	2.03	2.46	7564	3.0	0.82	3.65	4.42
Big Break	0.10	0.72	2.03	2.46	7386	2.8	0.87	3.65	4.42
Middle River Bullfrog	0.17	0.72	2.01	2.43	4260	2.1	1.14	3.61	4.37
Old River near Paradise Cut[c]	0.57	0.70	1.96	2.37	1229	NA	NA	3.53	4.27
Knights Landing[d]	0.23	0.71	1.99	2.41	3098	NA	NA	3.59	4.34
Vernalis[e]	0.58	0.70	1.96	2.37	1206	2.4	0.99	3.53	4.27

Notes:
Equations from Presser and Luoma (2010a, 2010b) were used to calculate selenium concentrations for fish. Models 4 and 5 used the average selenium trophic transfer factors to aquatic insects (2.8), fish (1.1 for all trophic levels) and bird eggs (1.8).
Model 4 = Model 2 (TL-4 Fish Eating TL-3 Fish) with K_d estimated using normal/wet years regression (log K_d = 2.75-0.90(logDSM2))
Model 5 = Model 2 (TL-4 Fish Eating TL-3 Fish) with K_d estimated using dry years (2007) regression (log K_d = 2.84-1.02(logDSM2))
Invert. = invertebrate
K_d = particulate concentration/water concentration ratio
μg/g, dw = micrograms per gram, dry weight
NA = not available; bass not collected here
RM = river mile
TL = trophic level
a. Geometric mean calculated from whole-body largemouth bass data presented in Foe (2010a).
b. Fish data collected at Rio Vista (Foe 2010a) were used to calculate geometric mean whole-body largemouth bass and ratios.
c. Fish data collected at Old River near Tracy (Foe 2010a) were used to calculate geometric mean whole-body largemouth bass and ratios.
d. Geometric mean of total selenium concentrations in water collected from years 2004, 2007, and 2008 (DWR Website 2009) was used to estimate selenium concentrations in particulates and biota (DSM2 data were not available). Fish data collected from Sacramento River at Veterans Bridge (Foe 2010a) were used to calculate geometric mean whole-body largemouth bass and ratios.
e. Geometric mean of selenium concentrations (total or dissolved was not specified) in water collected from years 1999-2000 (SWAMP Website 2009) was used to estimate Year 2000 selenium concentrations in particulates and biota (DSM2 data were not available); years 2004-2005 were used for Year 2005 estimates; and years 2006-2007 were used for Year 2007 estimates.

Table 6D.9 Modeled Annual Average Selenium Concentrations in Water for No Action Alternative and Alternatives 1 (Second Basis of Comparison), 3, and 5

Location	Period *	Period Average Concentration (µg/L) No Action Alternative	Period Average Concentration (µg/L) Second Basis of Comparison	Period Average Concentration (µg/L) Alternative 3	Period Average Concentration (µg/L) Alternative 5
Delta Interior					
San Joaquin River at Stockton	ALL	0.42	0.42	0.42	0.42
	DROUGHT	0.40	0.40	0.39	0.39
Turner Cut	ALL	0.28	0.27	0.27	0.29
	DROUGHT	0.22	0.21	0.21	0.24
San Joaquin River at San Andreas Landing	ALL	0.11	0.10	0.10	0.11
	DROUGHT	0.10	0.09	0.09	0.10
San Joaquin River at Jersey Point	ALL	0.12	0.11	0.11	0.12
	DROUGHT	0.10	0.10	0.10	0.10
Victoria Canal	ALL	0.23	0.22	0.21	0.24
	DROUGHT	0.17	0.16	0.16	0.21
Western Delta					
Sacramento River at Emmaton	ALL	0.10	0.10	0.10	0.11
	DROUGHT	0.10	0.10	0.10	0.10
San Joaquin River at Antioch	ALL	0.11	0.11	0.11	0.12
	DROUGHT	0.10	0.10	0.10	0.10
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	0.11	0.11	0.11	0.11
	DROUGHT	0.10	0.10	0.10	0.10
Major Diversions (Pumping Stations)					
North Bay Aqueduct at Barker Slough Pumping Plant	ALL	0.11	0.11	0.11	0.11
	DROUGHT	0.10	0.10	0.10	0.10
Contra Costa Pumping Plant #1	ALL	0.14	0.13	0.13	0.15
	DROUGHT	0.11	0.10	0.10	0.13
Banks Pumping Plant	ALL	0.21	0.19	0.19	0.22
	DROUGHT	0.16	0.14	0.15	0.18
Jones Pumping Plant	ALL	0.28	0.25	0.27	0.29
	DROUGHT	0.26	0.21	0.24	0.26

Notes:
* All: Water years 1922-2003 represent the 82-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)
µg/L = microgram per liter

1 **Table 6D.10 Summary Table for Annual Average Selenium Concentrations in Biota for No Action Alternative and Second Basis of Comparison**

Location	Period [a]	Estimated Concentrations of Selenium (mg/kg, dw[b])							
		Whole-body Fish NAA	Whole-body Fish Alt. 1 (SBC)	Bird Eggs (Invertebrate Diet) NAA	Bird Eggs (Invertebrate Diet) Alt. 1 (SBC)	Bird Eggs (Fish Diet) NAA	Bird Eggs (Fish Diet) Alt. 1 (SBC)	Fish Fillets (ww) NAA	Fish Fillets (ww) Alt. 1 (SBC)
Delta Interior									
San Joaquin River at Stockton	ALL	1.90	1.90	2.83	2.83	3.42	3.42	0.64	0.64
	DROUGHT	2.39	2.39	3.55	3.55	4.30	4.30	0.83	0.83
Turner Cut	ALL	1.88	1.87	2.79	2.79	3.38	3.37	0.63	0.63
	DROUGHT	2.42	2.42	3.59	3.60	4.35	4.35	0.84	0.84
San Joaquin River at San Andreas Landing	ALL	1.82	1.82	2.71	2.71	3.28	3.28	0.61	0.61
	DROUGHT	2.46	2.46	3.65	3.66	4.42	4.42	0.86	0.86
San Joaquin River at Jersey Point	ALL	1.83	1.83	2.72	2.72	3.29	3.29	0.61	0.61
	DROUGHT	2.46	2.46	3.65	3.65	4.42	4.42	0.86	0.86
Victoria Canal	ALL	1.87	1.86	2.78	2.77	3.36	3.35	0.62	0.62
	DROUGHT	2.43	2.43	3.61	3.62	4.37	4.38	0.85	0.85
Western Delta									
Sacramento River at Emmaton	ALL	1.82	1.82	2.71	2.71	3.28	3.28	0.61	0.61
	DROUGHT	2.46	2.46	3.65	3.65	4.42	4.42	0.86	0.86
San Joaquin River at Antioch	ALL	1.83	1.83	2.72	2.72	3.29	3.29	0.61	0.61
	DROUGHT	2.46	2.46	3.65	3.65	4.42	4.42	0.86	0.86
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	1.82	1.82	2.71	2.71	3.28	3.28	0.61	0.61
	DROUGHT	2.45	2.45	3.65	3.65	4.42	4.42	0.86	0.86
Major Diversions (Pumping Stations)									
North Bay Aqueduct at Barker Slough Pumping Plant	ALL	1.82	1.82	2.71	2.71	3.28	3.28	0.61	0.61
	DROUGHT	2.45	2.45	3.65	3.65	4.42	4.42	0.86	0.86
Contra Costa Pumping Plant #1	ALL	1.84	1.83	2.74	2.73	3.31	3.30	0.61	0.61
	DROUGHT	2.45	2.45	3.64	3.65	4.41	4.42	0.85	0.86
Banks Pumping Plant	ALL	1.86	1.86	2.77	2.76	3.35	3.34	0.62	0.62
	DROUGHT	2.43	2.44	3.62	3.63	4.38	4.39	0.85	0.85

Location	Period [a]	Estimated Concentrations of Selenium (mg/kg, dw[b])							
		Whole-body Fish NAA	Whole-body Fish Alt. 1 (SBC)	Bird Eggs (Invertebrate Diet) NAA	Bird Eggs (Invertebrate Diet) Alt. 1 (SBC)	Bird Eggs (Fish Diet) NAA	Bird Eggs (Fish Diet) Alt. 1 (SBC)	Fish Fillets (ww) NAA	Fish Fillets (ww) Alt. 1 (SBC)
Jones Pumping Plant	ALL	1.88	1.87	2.79	2.78	3.38	3.37	0.63	0.63
	DROUGHT	2.41	2.42	3.58	3.60	4.33	4.35	0.84	0.84

Notes:

a. All: Water years 1922-2003 represent the 82-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)

b. Dry weight, except as noted for fish fillets

Alt. = alternative
dw = dry weight
mg/kg = milligram per kilogram
NAA = No Action Alternative
SBC = Second Basis of Comparison
ww = wet weight

Table 6D.11 Summary Table for Annual Average Selenium Concentrations in Biota for No Action Alternative, Second Basis of Comparison, and Alternative 3

Location	Period [a]	Estimated Concentrations of Selenium (mg/kg, dw[b])											
		Whole-body Fish NAA	Whole-body Fish Alt. 1 (SBC)	Whole-body Fish Alt. 3	Bird Eggs (Invertebrate Diet) NAA	Bird Eggs (Invertebrate Diet) Alt. 1 (SBC)	Bird Eggs (Invertebrate Diet) Alt. 3	Bird Eggs (Fish Diet) NAA	Bird Eggs (Fish Diet) Alt. 1 (SBC)	Bird Eggs (Fish Diet) Alt. 3	Fish Fillets (ww) NAA	Fish Fillets (ww) Alt. 1 (SBC)	Fish Fillets (ww) Alt. 3
Delta Interior													
San Joaquin River at Stockton	ALL	1.90	1.90	1.90	2.83	2.83	2.83	3.42	3.42	3.42	0.64	0.64	0.64
	DROUGHT	2.39	2.39	2.39	3.55	3.55	3.55	4.30	4.30	4.30	0.83	0.83	0.83
Turner Cut	ALL	1.88	1.87	1.87	2.79	2.79	2.79	3.38	3.37	3.37	0.63	0.63	0.63
	DROUGHT	2.42	2.42	2.42	3.59	3.60	3.60	4.35	4.35	4.35	0.84	0.84	0.84
San Joaquin River at San Andreas Landing	ALL	1.82	1.82	1.82	2.71	2.71	2.71	3.28	3.28	3.28	0.61	0.61	0.61
	DROUGHT	2.46	2.46	2.46	3.65	3.66	3.66	4.42	4.42	4.42	0.86	0.86	0.86
San Joaquin River at Jersey Point	ALL	1.83	1.83	1.82	2.72	2.72	2.77	3.29	3.29	3.35	0.61	0.61	0.62
	DROUGHT	2.46	2.46	2.46	3.65	3.65	3.62	4.42	4.42	4.38	0.86	0.86	0.85
Victoria Canal	ALL	1.87	1.86	1.86	2.78	2.77	2.77	3.36	3.35	3.35	0.62	0.62	0.62
	DROUGHT	2.43	2.43	2.43	3.61	3.62	3.62	4.37	4.38	4.38	0.85	0.85	0.85
Western Delta													
Sacramento River at Emmaton	ALL	1.82	1.82	1.82	2.71	2.71	2.71	3.28	3.28	3.28	0.61	0.61	0.61
	DROUGHT	2.46	2.46	2.46	3.65	3.65	3.65	4.42	4.42	4.42	0.86	0.86	0.86
San Joaquin River at Antioch	ALL	1.83	1.83	1.82	2.72	2.72	2.71	3.29	3.29	3.28	0.61	0.61	0.61
	DROUGHT	2.46	2.46	2.46	3.65	3.65	3.65	4.42	4.42	4.42	0.86	0.86	0.86
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	1.82	1.82	1.82	2.71	2.71	2.71	3.28	3.28	3.28	0.61	0.61	0.61
	DROUGHT	2.45	2.45	2.46	3.65	3.65	3.65	4.42	4.42	4.42	0.86	0.86	0.86
Major Diversions (Pumping Stations)													
North Bay Aqueduct at Barker Slough Pumping Plant	ALL	1.82	1.82	1.82	2.71	2.71	2.71	3.28	3.28	3.28	0.61	0.61	0.61
	DROUGHT	2.45	2.45	2.45	3.65	3.65	3.65	4.42	4.42	4.42	0.86	0.86	0.86
Contra Costa Pumping Plant #1	ALL	1.84	1.83	1.83	2.74	2.73	2.72	3.31	3.30	3.30	0.61	0.61	0.61
	DROUGHT	2.45	2.45	2.45	3.64	3.65	3.65	4.41	4.42	4.41	0.85	0.86	0.86

Location	Period [a]	Estimated Concentrations of Selenium (mg/kg, dw[b])											
		Whole-body Fish NAA	Whole-body Fish Alt. 1 (SBC)	Whole-body Fish Alt. 3	Bird Eggs (Invertebrate Diet) NAA	Bird Eggs (Invertebrate Diet) Alt. 1 (SBC)	Bird Eggs (Invertebrate Diet) Alt. 3	Bird Eggs (Fish Diet) NAA	Bird Eggs (Fish Diet) Alt. 1 (SBC)	Bird Eggs (Fish Diet) Alt. 3	Fish Fillets (ww) NAA	Fish Fillets (ww) Alt. 1 (SBC)	Fish Fillets (ww) Alt. 3
Banks Pumping Plant	ALL	1.86	1.86	1.86	2.77	2.76	2.76	3.35	3.34	3.34	0.62	0.62	0.62
	DROUGHT	2.43	2.44	2.44	3.62	3.63	3.62	4.38	4.39	4.39	0.85	0.85	0.85
Jones Pumping Plant	ALL	1.88	1.87	1.87	2.79	2.78	2.79	3.38	3.37	3.37	0.63	0.63	0.63
	DROUGHT	2.41	2.42	2.41	3.58	3.60	3.59	4.33	4.35	4.34	0.84	0.84	0.84

Notes:
a. All: Water years 1922-2003 represent the 82-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)
b. Dry weight, except as noted for fish fillets
Alt. = alternative
dw = dry weight
mg/kg = milligram per kilogram
NAA = No Action Alternative
SBC = Second Basis of Comparison
ww = wet weight

Table 6D.12 Summary Table for Annual Average Selenium Concentrations in Biota for No Action Alternative, Second Basis of Comparison, and Alternative 5

Location	Period [a]	Estimated Concentrations of Selenium (mg/kg, dw[b])											
		Whole-body Fish NAA	Whole-body Fish Alt. 1 (SBC)	Whole-body Fish Alt. 5	Bird Eggs (Invertebrate Diet) NAA	Bird Eggs (Invertebrate Diet) Alt. 1 (SBC)	Bird Eggs (Invertebrate Diet) Alt. 5	Bird Eggs (Fish Diet) NAA	Bird Eggs (Fish Diet) Alt. 1 (SBC)	Bird Eggs (Fish Diet) Alt. 5	Fish Fillets (ww) NAA	Fish Fillets (ww) Alt. 1 (SBC)	Fish Fillets (ww) Alt. 5
Delta Interior													
San Joaquin River at Stockton	ALL	1.90	1.90	1.90	2.83	2.83	2.83	3.42	3.42	3.42	0.64	0.64	0.64
	DROUGHT	2.39	2.39	2.39	3.55	3.55	3.55	4.30	4.30	4.30	0.83	0.83	0.83
Turner Cut	ALL	1.88	1.87	1.88	2.79	2.79	2.79	3.38	3.37	3.38	0.63	0.63	0.63
	DROUGHT	2.42	2.42	2.41	3.59	3.60	3.59	4.35	4.35	4.34	0.84	0.84	0.84
San Joaquin River at San Andreas Landing	ALL	1.82	1.82	1.82	2.71	2.71	2.71	3.28	3.28	3.28	0.61	0.61	0.61
	DROUGHT	2.46	2.46	2.45	3.65	3.66	3.65	4.42	4.42	4.42	0.86	0.86	0.86
San Joaquin River at Jersey Point	ALL	1.83	1.83	1.83	2.72	2.72	2.78	3.29	3.29	3.36	0.61	0.61	0.62
	DROUGHT	2.46	2.46	2.45	3.65	3.65	3.60	4.42	4.42	4.35	0.86	0.86	0.84
Victoria Canal	ALL	1.87	1.86	1.87	2.78	2.77	2.78	3.36	3.35	3.36	0.62	0.62	0.62
	DROUGHT	2.43	2.43	2.42	3.61	3.62	3.60	4.37	4.38	4.35	0.85	0.85	0.84
Western Delta													
Sacramento River at Emmaton	ALL	1.82	1.82	1.82	2.71	2.71	2.71	3.28	3.28	3.28	0.61	0.61	0.61
	DROUGHT	2.46	2.46	2.45	3.65	3.65	3.65	4.42	4.42	4.42	0.86	0.86	0.86
San Joaquin River at Antioch	ALL	1.83	1.83	1.83	2.72	2.72	2.72	3.29	3.29	3.29	0.61	0.61	0.61
	DROUGHT	2.46	2.46	2.45	3.65	3.65	3.65	4.42	4.42	4.42	0.86	0.86	0.86
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	1.82	1.82	1.82	2.71	2.71	2.71	3.28	3.28	3.28	0.61	0.61	0.61
	DROUGHT	2.45	2.45	2.45	3.65	3.65	3.65	4.42	4.42	4.42	0.86	0.86	0.86
Major Diversions (Pumping Stations)													
North Bay Aqueduct at Barker Slough Pumping Plant	ALL	1.82	1.82	1.82	2.71	2.71	2.71	3.28	3.28	3.28	0.61	0.61	0.61
	DROUGHT	2.45	2.45	2.45	3.65	3.65	3.65	4.42	4.42	4.42	0.86	0.86	0.86
Contra Costa Pumping Plant #1	ALL	1.84	1.83	1.84	2.74	2.73	2.74	3.31	3.30	3.32	0.61	0.61	0.61
	DROUGHT	2.45	2.45	2.44	3.64	3.65	3.63	4.41	4.42	4.39	0.85	0.86	0.85
Banks Pumping Plant	ALL	1.86	1.86	1.86	2.77	2.76	2.77	3.35	3.34	3.35	0.62	0.62	0.62
	DROUGHT	2.43	2.44	2.43	3.62	3.63	3.61	4.38	4.39	4.37	0.85	0.85	0.85

Location	Period [a]	Estimated Concentrations of Selenium (mg/kg, dw[b])											
		Whole-body Fish NAA	Whole-body Fish Alt. 1 (SBC)	Whole-body Fish Alt. 5	Bird Eggs (Invertebrate Diet) NAA	Bird Eggs (Invertebrate Diet) Alt. 1 (SBC)	Bird Eggs (Invertebrate Diet) Alt. 5	Bird Eggs (Fish Diet) NAA	Bird Eggs (Fish Diet) Alt. 1 (SBC)	Bird Eggs (Fish Diet) Alt. 5	Fish Fillets (ww) NAA	Fish Fillets (ww) Alt. 1 (SBC)	Fish Fillets (ww) Alt. 5
Jones Pumping Plant	ALL	1.88	1.87	1.88	2.79	2.78	2.79	3.38	3.37	3.38	0.63	0.63	0.63
	DROUGHT	2.41	2.42	2.41	3.58	3.60	3.58	4.33	4.35	4.33	0.84	0.84	0.84

Notes:

a. All: Water years 1922-2003 represent the 82-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)

b. Dry weight, except as noted for fish fillets

Alt. = alternative
dw = dry weight
mg/kg = milligram per kilogram
NAA = No Action Alternative
SBC = Second Basis of Comparison
ww = wet weight

Table 6D.13 Summary Table for Selenium Concentrations in Biota, and Comparisons for No Action Alternative and Second Basis of Comparison to Benchmarks

Location	Period [a]	Estimated Concentrations of Selenium (mg/kg, dw[b])								Exceedance Quotients[c]													
		Whole-body Fish		Bird Eggs (Invertebrate Diet)		Bird Eggs (Fish Diet)		Fish Fillets (ww)		Whole-body Fish				Bird Eggs (Invertebrate Diet)				Bird Eggs (Fish Diet)				Fish Fillets (ww)	
										Level of Concern[d]		Toxicity Level[e]		Level of Concern[f]		Toxicity Level[g]		Level of Concern[f]		Toxicity Level[g]		Advisory Tissue Level[h]	
		NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)
Delta Interior																							
San Joaquin River at Stockton	ALL	1.90	1.90	2.83	2.83	3.42	3.42	0.64	0.64	0.47	0.47	0.23	0.23	0.47	0.47	0.28	0.28	0.57	0.57	0.34	0.34	0.25	0.25
	DROUGHT	2.39	2.39	3.55	3.55	4.30	4.30	0.83	0.83	0.60	0.60	0.29	0.29	0.59	0.59	0.36	0.36	0.72	0.72	0.43	0.43	0.33	0.33
Turner Cut	ALL	1.88	1.87	2.79	2.79	3.38	3.37	0.63	0.63	0.47	0.47	0.23	0.23	0.47	0.46	0.28	0.28	0.56	0.56	0.34	0.34	0.25	0.25
	DROUGHT	2.42	2.42	3.59	3.60	4.35	4.35	0.84	0.84	0.60	0.60	0.30	0.30	0.60	0.60	0.36	0.36	0.72	0.73	0.43	0.44	0.34	0.34
San Joaquin River at San Andreas Landing	ALL	1.82	1.82	2.71	2.71	3.28	3.28	0.61	0.61	0.46	0.46	0.23	0.22	0.45	0.45	0.27	0.27	0.55	0.55	0.33	0.33	0.24	0.24
	DROUGHT	2.46	2.46	3.65	3.66	4.42	4.42	0.86	0.86	0.61	0.61	0.30	0.30	0.61	0.61	0.37	0.37	0.74	0.74	0.44	0.44	0.34	0.34
San Joaquin River at Jersey Point	ALL	1.83	1.83	2.72	2.72	3.29	3.29	0.61	0.61	0.46	0.46	0.23	0.23	0.45	0.45	0.27	0.27	0.55	0.55	0.33	0.33	0.24	0.24
	DROUGHT	2.46	2.46	3.65	3.65	4.42	4.42	0.86	0.86	0.61	0.61	0.30	0.30	0.61	0.61	0.37	0.37	0.74	0.74	0.44	0.44	0.34	0.34
Victoria Canal	ALL	1.87	1.86	2.78	2.77	3.36	3.35	0.62	0.62	0.47	0.47	0.23	0.23	0.46	0.46	0.28	0.28	0.56	0.56	0.34	0.34	0.25	0.25
	DROUGHT	2.43	2.43	3.61	3.62	4.37	4.38	0.85	0.85	0.61	0.61	0.30	0.30	0.60	0.60	0.36	0.36	0.73	0.73	0.44	0.44	0.34	0.34
Western Delta																							
Sacramento River at Emmaton	ALL	1.82	1.82	2.71	2.71	3.28	3.28	0.61	0.61	0.46	0.46	0.22	0.22	0.45	0.45	0.27	0.27	0.55	0.55	0.33	0.33	0.24	0.24
	DROUGHT	2.46	2.46	3.65	3.65	4.42	4.42	0.86	0.86	0.61	0.61	0.30	0.30	0.61	0.61	0.37	0.37	0.74	0.74	0.44	0.44	0.34	0.34
San Joaquin River at Antioch	ALL	1.83	1.83	2.72	2.72	3.29	3.29	0.61	0.61	0.46	0.46	0.23	0.23	0.45	0.45	0.27	0.27	0.55	0.55	0.33	0.33	0.24	0.24
	DROUGHT	2.46	2.46	3.65	3.65	4.42	4.42	0.86	0.86	0.61	0.61	0.30	0.30	0.61	0.61	0.37	0.37	0.74	0.74	0.44	0.44	0.34	0.34
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	1.82	1.82	2.71	2.71	3.28	3.28	0.61	0.61	0.46	0.46	0.23	0.23	0.45	0.45	0.27	0.27	0.55	0.55	0.33	0.33	0.24	0.24
	DROUGHT	2.45	2.45	3.65	3.65	4.42	4.42	0.86	0.86	0.61	0.61	0.30	0.30	0.61	0.61	0.37	0.37	0.74	0.74	0.44	0.44	0.34	0.34
Major Diversions (Pumping Stations)																							
North Bay Aqueduct at Barker Slough Pumping Plant	ALL	1.82	1.82	2.71	2.71	3.28	3.28	0.61	0.61	0.46	0.46	0.23	0.23	0.45	0.45	0.27	0.27	0.55	0.55	0.33	0.33	0.24	0.24
	DROUGHT	2.45	2.45	3.65	3.65	4.42	4.42	0.86	0.86	0.61	0.61	0.30	0.30	0.61	0.61	0.37	0.37	0.74	0.74	0.44	0.44	0.34	0.34
Contra Costa Pumping Plant #1	ALL	1.84	1.83	2.74	2.73	3.31	3.30	0.61	0.61	0.46	0.46	0.23	0.23	0.46	0.45	0.27	0.27	0.55	0.55	0.33	0.33	0.25	0.24
	DROUGHT	2.45	2.45	3.64	3.65	4.41	4.42	0.85	0.86	0.61	0.61	0.30	0.30	0.61	0.61	0.36	0.36	0.73	0.74	0.44	0.44	0.34	0.34
Banks Pumping Plant	ALL	1.86	1.86	2.77	2.76	3.35	3.34	0.62	0.62	0.47	0.46	0.23	0.23	0.46	0.46	0.28	0.28	0.56	0.56	0.33	0.33	0.25	0.25
	DROUGHT	2.43	2.44	3.62	3.63	4.38	4.39	0.85	0.85	0.61	0.61	0.30	0.30	0.60	0.60	0.36	0.36	0.73	0.73	0.44	0.44	0.34	0.34
Jones Pumping Plant	ALL	1.88	1.87	2.79	2.78	3.38	3.37	0.63	0.63	0.47	0.47	0.23	0.23	0.47	0.46	0.28	0.28	0.56	0.56	0.34	0.34	0.25	0.25
	DROUGHT	2.41	2.42	3.58	3.60	4.33	4.35	0.84	0.84	0.60	0.60	0.30	0.30	0.60	0.60	0.36	0.36	0.72	0.73	0.43	0.44	0.34	0.34

Notes:
a. All: Water years 1922-2003 represent the 82-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).
b. Dry weight, except as noted for fish fillets.
c. Exceedance Quotient = tissue concentration/benchmark
d. Level of Concern for fish tissue (lower end of range) = 4 mg/kg dw (Beckon et al. 2008)
e. Toxicity Level for fish tissue = 8.1 mg/kg dw (USEPA 2014)
f. Level of Concern for bird eggs (lower end of range) = 6 mg/kg dw (Beckon et al. 2008)
g. Toxicity Level for bird eggs = 10 mg/kg dw (Beckon et al. 2008)
h. Advisory Tissue Level = 2.5 mg/kg ww (OEHHA 2008)

Alt. = Alternative
dw = dry weight
mg/kg = milligram per kilogram
NAA = No Action Alternative
SBC = Second Basis of Comparison
ww = wet weight

Table 6D.14 Summary Table for Selenium Concentrations in Biota, and Comparisons for Alternative 3 to No Action Altenative and Second Basis of Comparison Conditions and Benchmarks

Location	Period [a]	Estimated Concentrations of Selenium (mg/kg, dw[b])				% Change In Selenium Concentrations Compared to NAA and Alternative 1 (Second Basis of Comparison)[c]								Exceedance Quotients[d]						
		Whole-body Fish	Bird Eggs (Invert. Diet)	Bird Eggs (Fish Diet)	Fish Fillets (ww)	Whole-body Fish		Bird Eggs (Invert. Diet)		Bird Eggs (Fish Diet)		Fish Fillets (ww)		Whole-body Fish		Bird Eggs (Invert. Diet)		Bird Eggs (Fish Diet)		Fish Fillets (ww)
		Alt. 3	Alt. 3	Alt. 3	Alt. 3	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	LOC[e]	TL[f]	LOC[g]	TL[h]	LOC[g]	TL[h]	ATL[i]
Delta Interior																				
San Joaquin River at Stockton	ALL	1.90	2.83	3.42	0.64	0	0	0	0	0	0	0	0	0.47	0.23	0.47	0.28	0.57	0.34	0.25
	DROUGHT	2.39	3.55	4.30	0.83	0	0	0	0	0	0	0	0	0.60	0.29	0.59	0.36	0.72	0.43	0.33
Turner Cut	ALL	1.87	2.79	3.37	0.63	0	0	0	0	0	0	0	0	0.47	0.23	0.46	0.28	0.56	0.34	0.25
	DROUGHT	2.42	3.60	4.35	0.84	0	0	0	0	0	0	0	0	0.60	0.30	0.60	0.36	0.73	0.44	0.34
San Joaquin River at San Andreas Landing	ALL	1.82	2.71	3.28	0.61	0	0	0	0	0	0	0	0	0.46	0.22	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.46	3.66	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
San Joaquin River at Jersey Point	ALL	1.82	2.77	3.35	0.62	0	0	2	2	2	2	2	2	0.46	0.23	0.46	0.28	0.56	0.34	0.25
	DROUGHT	2.46	3.62	4.38	0.85	0	0	-1	-1	-1	-1	-1	-1	0.61	0.30	0.60	0.36	0.73	0.44	0.34
Victoria Canal	ALL	1.86	2.77	3.35	0.62	0	0	0	0	0	0	0	0	0.47	0.23	0.46	0.28	0.56	0.34	0.25
	DROUGHT	2.43	3.62	4.38	0.85	0	0	0	0	0	0	0	0	0.61	0.30	0.60	0.36	0.73	0.44	0.34
Western Delta																				
Sacramento River at Emmaton	ALL	1.82	2.71	3.28	0.61	0	0	0	0	0	0	0	0	0.46	0.22	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.46	3.65	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
San Joaquin River at Antioch	ALL	1.82	2.71	3.28	0.61	0	0	0	0	0	0	0	0	0.46	0.23	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.46	3.65	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	1.82	2.71	3.28	0.61	0	0	0	0	0	0	0	0	0.46	0.23	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.46	3.65	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
Major Diversions (Pumping Stations)																				
North Bay Aqueduct at Barker Slough Pumping Plant	ALL	1.82	2.71	3.28	0.61	0	0	0	0	0	0	0	0	0.46	0.23	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.45	3.65	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
Contra Costa Pumping Plant #1	ALL	1.83	2.72	3.30	0.61	0	0	0	0	0	0	0	0	0.46	0.23	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.45	3.65	4.41	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.36	0.74	0.44	0.34
Banks Pumping Plant	ALL	1.86	2.76	3.34	0.62	0	0	0	0	0	0	0	0	0.46	0.23	0.46	0.28	0.56	0.33	0.25
	DROUGHT	2.44	3.62	4.39	0.85	0	0	0	0	0	0	0	0	0.61	0.30	0.60	0.36	0.73	0.44	0.34
Jones Pumping Plant	ALL	1.87	2.79	3.37	0.63	0	0	0	0	0	0	0	0	0.47	0.23	0.46	0.28	0.56	0.34	0.25
	DROUGHT	2.41	3.59	4.34	0.84	0	0	0	0	0	0	0	0	0.60	0.30	0.60	0.36	0.72	0.43	0.34

Notes:

a. All: Water years 1922-2003 represent the 82-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).

b. Dry weight, except as noted for fish fillets.

c. % change indicates a negative change (increased concentrations) relative to the No Action Alternative and Second Basis of Comparison when values are positive and a positive change (lowered concentrations) relative to the No Action Alternative and Second Basis of Comparison when values are negative.

d. Exceedance Quotient = tissue concentration/benchmark

e. Level of Concern for fish tissue (lower end of range) = 4 mg/kg dw (Beckon et al. 2008)

f. Toxicity Level for fish tissue = 8.1 mg/kg dw (USEPA 2014)

g. Level of Concern for bird eggs (lower end of range) = 6 mg/kg dw (Beckon et al. 2008)

h. Toxicity Level for bird eggs = 10 mg/kg dw (Beckon et al. 2008)

i. Advisory Tissue Level = 2.5 mg/kg ww (OEHHA 2008)

Notes (continued):
Alt. = alternative
dw = dry weight
Invert. = invertebrate
mg/kg = milligram per kilogram
NAA = No Action Alternative
SBC = Second Basis of Comparison
ww = wet weight

Table 6D.15 Summary Table for Selenium Concentrations in Biota, and Comparisons for Alternative 5 to No Action Alternative and Second Basis of Comparison Conditions and Benchmarks

Location	Period [a]	Estimated Concentrations of Selenium (mg/kg, dw[b])				% Change In Selenium Concentrations Compared to NAA and Alternative 1 (Second Basis of Comparison)[c]								Exceedance Quotients[d]						
		Whole-body Fish	Bird Eggs (Invert. Diet)	Bird Eggs (Fish Diet)	Fish Fillets (ww)	Whole-body Fish		Bird Eggs (Invert. Diet)		Bird Eggs (Fish Diet)		Fish Fillets (ww)		Whole-body Fish		Bird Eggs (Invert. Diet)		Bird Eggs (Fish Diet)		Fish Fillets (ww)
		Alt. 5	Alt. 5	Alt. 5	Alt. 5	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	NAA	Alt. 1 (SBC)	LOC[e]	TL[f]	LOC[g]	TL[h]	LOC[g]	TL[h]	ATL[i]
Delta Interior																				
San Joaquin River at Stockton	ALL	1.90	2.83	3.42	0.64	0	0	0	0	0	0	0	0	0.47	0.23	0.47	0.28	0.57	0.34	0.25
	DROUGHT	2.39	3.55	4.30	0.83	0	0	0	0	0	0	0	0	0.60	0.29	0.59	0.36	0.72	0.43	0.33
Turner Cut	ALL	1.88	2.79	3.38	0.63	0	0	0	0	0	0	0	0	0.47	0.23	0.47	0.28	0.56	0.34	0.25
	DROUGHT	2.41	3.59	4.34	0.84	0	0	0	0	0	0	0	0	0.60	0.30	0.60	0.36	0.72	0.43	0.34
San Joaquin River at San Andreas Landing	ALL	1.82	2.71	3.28	0.61	0	0	0	0	0	0	0	0	0.46	0.23	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.45	3.65	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
San Joaquin River at Jersey Point	ALL	1.83	2.78	3.36	0.62	0	0	2	2	2	2	3	3	0.46	0.23	0.46	0.28	0.56	0.34	0.25
	DROUGHT	2.45	3.60	4.35	0.84	0	0	-1	-2	-1	-2	-2	-2	0.61	0.30	0.60	0.36	0.73	0.44	0.34
Victoria Canal	ALL	1.87	2.78	3.36	0.62	0	0	0	0	0	0	0	0	0.47	0.23	0.46	0.28	0.56	0.34	0.25
	DROUGHT	2.42	3.60	4.35	0.84	0	0	0	0	0	0	0	-1	0.60	0.30	0.60	0.36	0.73	0.44	0.34
Western Delta																				
Sacramento River at Emmaton	ALL	1.82	2.71	3.28	0.61	0	0	0	0	0	0	0	0	0.46	0.23	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.45	3.65	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
San Joaquin River at Antioch	ALL	1.83	2.72	3.29	0.61	0	0	0	0	0	0	0	0	0.46	0.23	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.45	3.65	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	1.82	2.71	3.28	0.61	0	0	0	0	0	0	0	0	0.46	0.23	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.45	3.65	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
Major Diversions (Pumping Stations)																				
North Bay Aqueduct at Barker Slough Pumping Plant	ALL	1.82	2.71	3.28	0.61	0	0	0	0	0	0	0	0	0.46	0.23	0.45	0.27	0.55	0.33	0.24
	DROUGHT	2.45	3.65	4.42	0.86	0	0	0	0	0	0	0	0	0.61	0.30	0.61	0.37	0.74	0.44	0.34
Contra Costa Pumping Plant #1	ALL	1.84	2.74	3.32	0.61	0	1	0	1	0	1	0	1	0.46	0.23	0.46	0.27	0.55	0.33	0.25
	DROUGHT	2.44	3.63	4.39	0.85	0	-1	0	-1	0	-1	0	-1	0.61	0.30	0.61	0.36	0.73	0.44	0.34
Banks Pumping Plant	ALL	1.86	2.77	3.35	0.62	0	0	0	0	0	0	0	0	0.47	0.23	0.46	0.28	0.56	0.34	0.25
	DROUGHT	2.43	3.61	4.37	0.85	0	0	0	0	0	0	0	-1	0.61	0.30	0.60	0.36	0.73	0.44	0.34
Jones Pumping Plant	ALL	1.88	2.79	3.38	0.63	0	0	0	0	0	0	0	0	0.47	0.23	0.47	0.28	0.56	0.34	0.25
	DROUGHT	2.41	3.58	4.33	0.84	0	0	0	0	0	0	0	-1	0.60	0.30	0.60	0.36	0.72	0.43	0.34

Notes:

a. All: Water years 1922-2003 represent the 82-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).

b. Dry weight, except as noted for fish fillets.

c. % change indicates a negative change (increased concentrations) relative to the No Action Alternative and Second Basis of Comparison when values are positive and a positive change (lowered concentrations) relative to the No Action Alternative and Second Basis of Comparison when values are negative.

d. Exceedance Quotient = tissue concentration/benchmark

e. Level of Concern for fish tissue (lower end of range) = 4 mg/kg dw (Beckon et al. 2008)

f. Toxicity Level for fish tissue = 8.1 mg/kg dw (USEPA 2014)

g. Level of Concern for bird eggs (lower end of range) = 6 mg/kg dw (Beckon et al. 2008)

h. Toxicity Level for bird eggs = 10 mg/kg dw (Beckon et al. 2008)

i. Advisory Tissue Level = 2.5 mg/kg ww (OEHHA 2008)

Notes (continued):
Alt. = alternative
dw = dry weight
Invert. = invertebrate
mg/kg = milligram per kilogram
NAA = No Action Alternative
SBC = Second Basis of Comparison
ww = wet weight

Table 6D.16 Modeled Selenium Concentrations in Water for No Action Alternative and Alternatives 1 (Second Basis of Comparison), 3, and 5

Location	Period *	Period Average Concentration (µg/L) No Action Alternative	Period Average Concentration (µg/L) Alternative 1 (SBC)	Period Average Concentration (µg/L) Alternative 3	Period Average Concentration (µg/L) Alternative 5
Sacramento River at Emmaton	ALL	0.10	0.10	0.10	0.11
	DROUGHT	0.10	0.10	0.10	0.10
San Joaquin River at Antioch	ALL	0.11	0.11	0.11	0.12
	DROUGHT	0.10	0.10	0.10	0.10
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	0.11	0.11	0.11	0.11
	DROUGHT	0.10	0.10	0.10	0.10

Notes:
* All: Water years 1922-2003 represent the 82-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).

µg/L = microgram per liter
SBC = Second Basis of Comparison

Table 6D.17 Summary of Annual Average Selenium Concentrations in Whole-body Sturgeon

Location	Period *	Estimated Concentrations of Selenium in Whole-body Sturgeon (mg/kg, dw) No Action Alternative	Estimated Concentrations of Selenium in Whole-body Sturgeon (mg/kg, dw) Alternative 1 (SBC)	Estimated Concentrations of Selenium in Whole-body Sturgeon (mg/kg, dw) Alternative 3	Estimated Concentrations of Selenium in Whole-body Sturgeon (mg/kg, dw) Alternative 5
Sacramento River at Emmaton	ALL	4.16	4.11	4.08	4.20
	DROUGHT	6.96	6.92	6.91	7.09
San Joaquin River at Antioch	ALL	4.56	4.40	4.34	4.61
	DROUGHT	7.06	6.99	6.97	7.23
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	4.33	4.27	4.24	4.35
	DROUGHT	7.10	7.07	7.06	7.16

Notes:
* All: Water years 1922-2003 represent the 82-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).

dw = dry weight
mg/kg = milligram per kilogram
SBC = Second Basis of Comparison

Table 6D.18 Comparison of Annual Average Selenium Concentrations in Whole-body Sturgeon to Toxicity Thresholds[a]

Location	Period [b]	No Action Alternative Low	No Action Alternative High	Second Basis of Comparison Low	Second Basis of Comparison High	Alternative 3 Low	Alternative 3 High	Alternative 5 Low	Alternative 5 High
Sacramento River at Emmaton	ALL	0.83	0.52	0.8	0.51	0.8	0.51	0.8	0.52
	DROUGHT	1.4	0.87	1.4	0.86	1.4	0.86	1.4	0.9
San Joaquin River at Antioch	ALL	0.9	0.57	0.9	0.55	0.9	0.54	0.9	0.6
	DROUGHT	1.4	0.88	1.4	0.87	1.4	0.87	1.4	0.9
Montezuma Slough at Hunter Cut/ Beldon's Landing	ALL	0.87	0.54	0.85	0.53	0.85	0.53	0.9	0.54
	DROUGHT	1.4	0.89	1.4	0.88	1.4	0.88	1.4	0.9

Notes:
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 1922-2003 represent the 82-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).

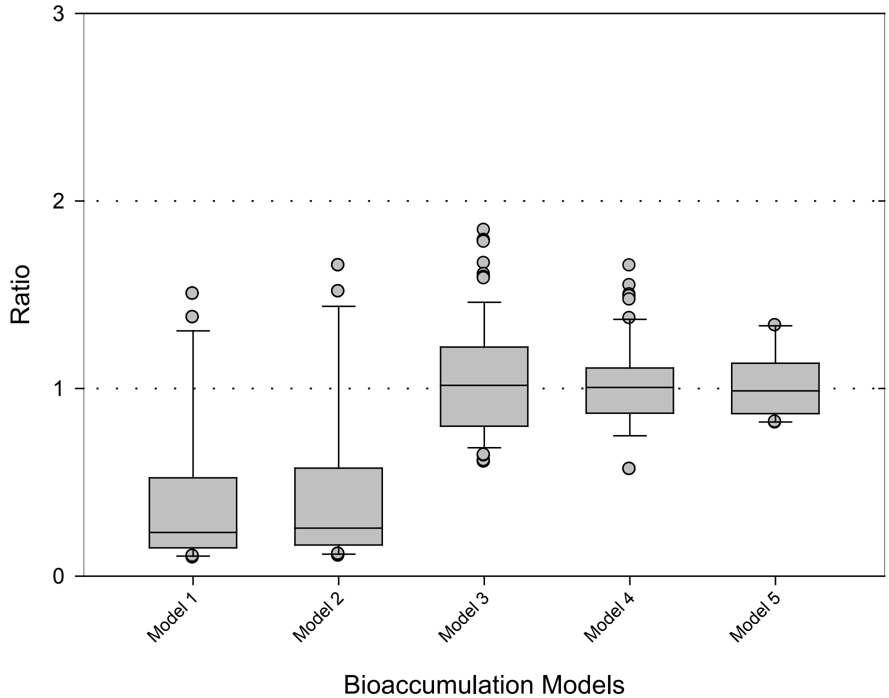
dw = dry weight
mg/kg = milligram per kilogram
SBC = Second Basis of Comparison

Table 6D.19 Percent Change in Selenium Concentrations Relative to No Action Alternative and Second Basis of Comparison

Location	Period *	Alternative 3 NAA	Alternative 3 Alt1 (SBC)	Alternative 5 NAA	Alternative 5 Alt 1 (SBC)
Sacramento River at Emmaton	ALL	-2.0	-0.7	0.9	2.2
	DROUGHT	-0.8	-0.1	1.8	2.5
San Joaquin River at Antioch	ALL	-4.7	-1.3	1.2	4.8
	DROUGHT	-1.2	-0.2	2.5	3.5
Montezuma Slough at Hunter Cut/Beldon's Landing	ALL	-2.2	-0.7	0.5	2.1
	DROUGHT	-0.5	-0.1	0.8	1.2

Notes:
* All: Water years 1922-2003 represent the 82-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).

dw = dry weight
mg/kg = milligram per kilogram
SBC = Second Basis of Comparison



For Models 1 and 2, default values (K_d = 1000, TTF_{invert} = 2.8, TTF_{fish} = 1.1) were used in calculations as follows:

Model 1=Trophic level 3 (TL-3) fish eating invertebrates

Model 2= TL-4 fish eating TL-3 fish

Model 3=Model 2 with K_d estimated using all years regression (log Kd = 2.76-0.97(logDSM2))

Model 4=Model 2 with K_d estimated using normal/wet years (2000/2005) regression (log Kd = 2.75-0.90(logDSM2))

Model 5=Model 2 with K_d estimated using dry years (2007) regression (logKd = 2.84-1.02(logDSM2))

Figure 6D.1 Ratios of Predicted Selenium Concentrations in Fish Models 1 through 5 to Observed Selenium Concentrations in Largemouth Bass

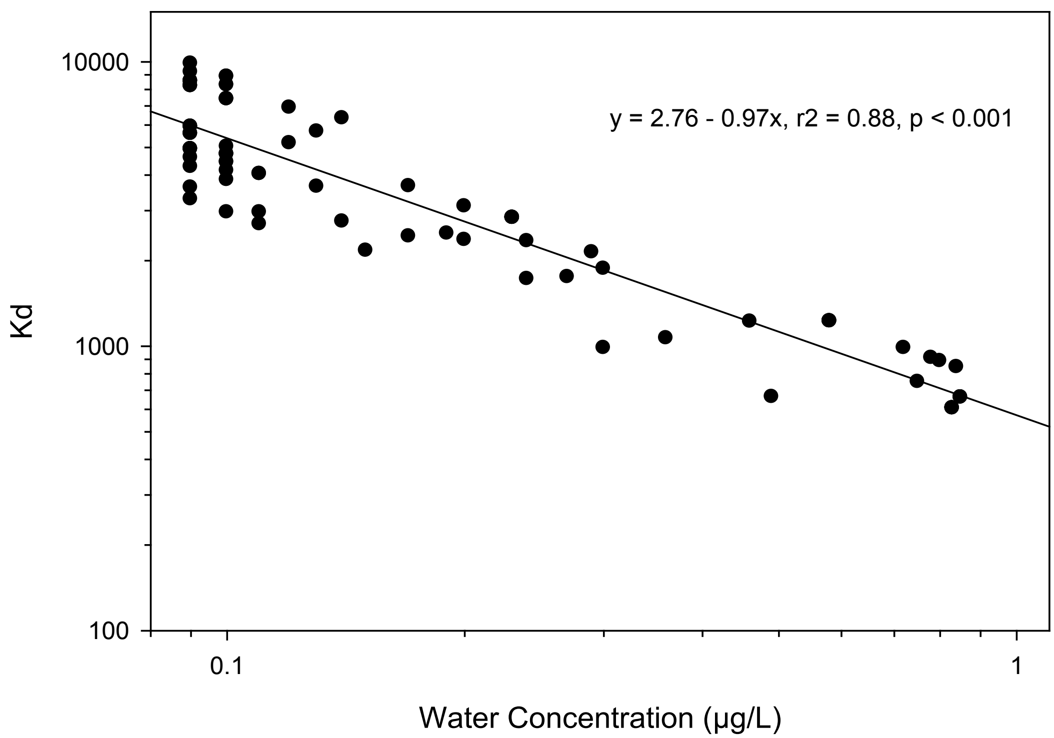


Figure 6D.2 Log-log Regression Relation of Estimated K_d to Waterborne Selenium Concentration for Model 3 in All Years (Based on Years 2000, 2005, and 2007)

To predict the K_d (y) from water concentrations using the regression equation, take the log of the water concentration (x), multiply it by the slope (-0.97), which gives a positive number for x<1 (i.e., waterborne selenium concentrations less than 1 µg/L); then add this number to the intercept (2.76) and take the antilog.

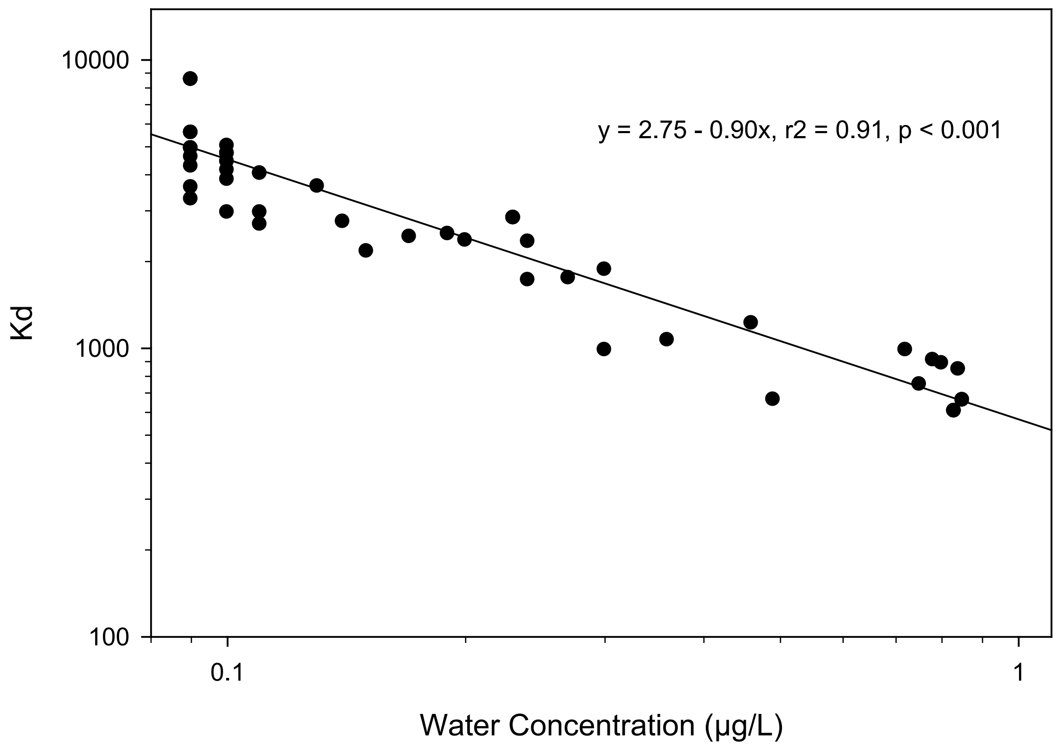


Figure 6D.3 Log-log Regression Relation of Estimated K_d to Waterborne Selenium Concentration for Model 4 in Normal/Wet Years (Based on Years 2000 and 2005)

To predict the K_d (y) from water concentrations using the regression equation, take the log of the water concentration (x), multiply it by the slope (-0.90), which gives a positive number for x<1 (i.e., waterborne selenium concentrations less than 1 µg/L); then add this number to the intercept (2.75) and take the antilog.

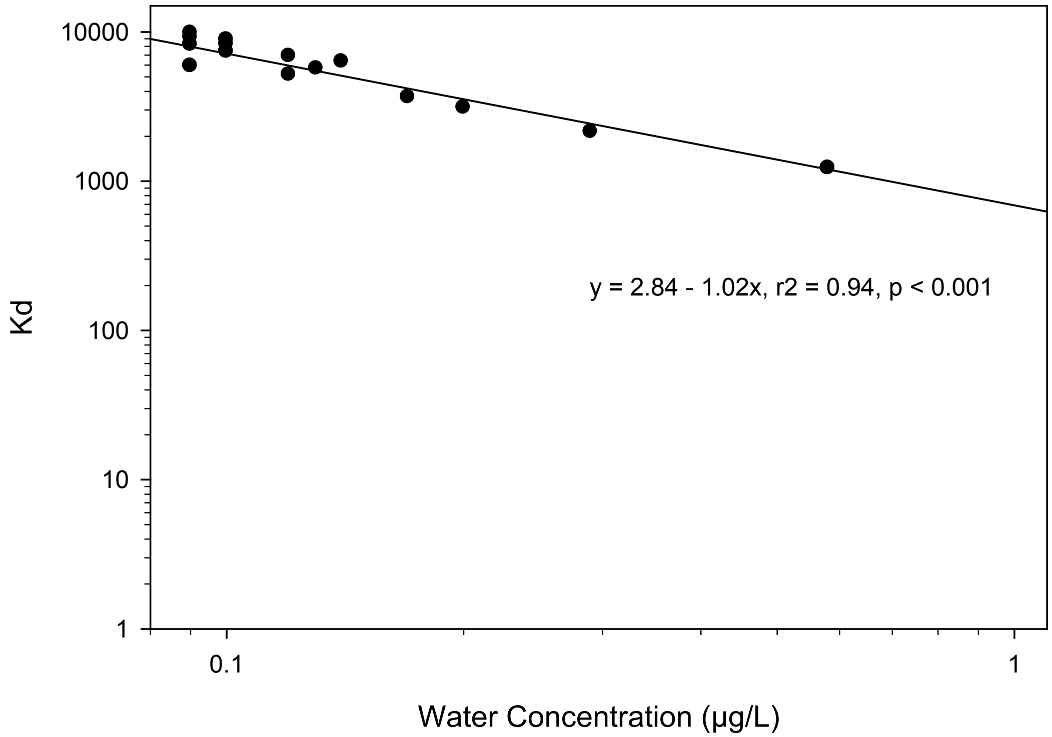


Figure 6D.4 Log-log Regression Relation of Estimated K_d to Waterborne Selenium Concentration for Model 5 in Dry Years (Based on Year 2007)

To predict the K_d (y) from water concentrations using the regression equation, take the log of the water concentration (x), multiply it by the slope (-1.02), which gives a positive number for x<1 (i.e., waterborne selenium concentrations less than 1 µg/L); then add this number to the intercept (2.84) and take the antilog.

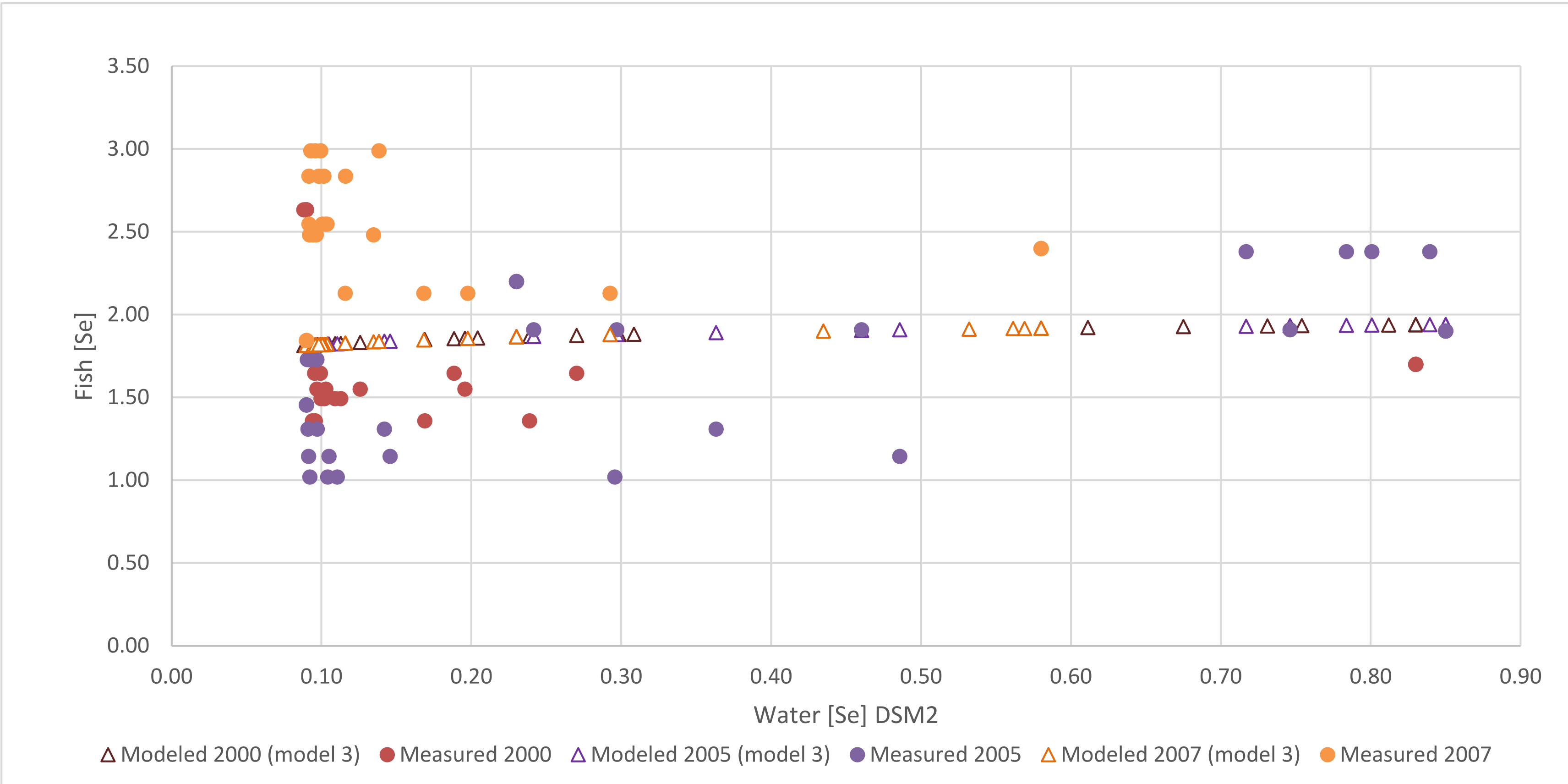


Figure 6D.5 Distribution of Data for Selenium Concentrations in Largemouth Bass Relative to Waterborne Selenium for Model 3

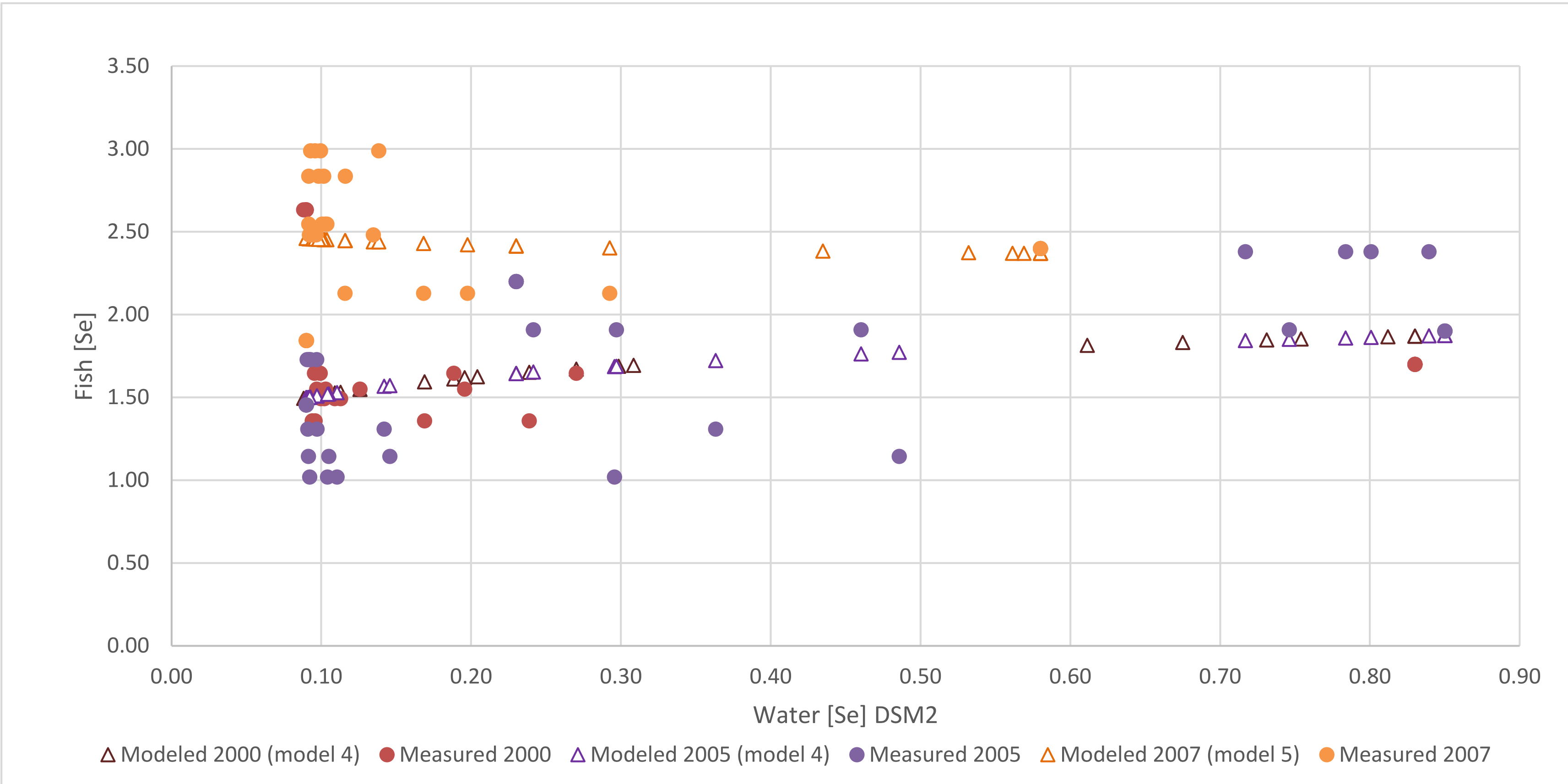


Figure 6D.6 Distribution of Data for Selenium Concentrations in Largemouth Bass Relative to Waterborne Selenium for Model 4 and Model 5

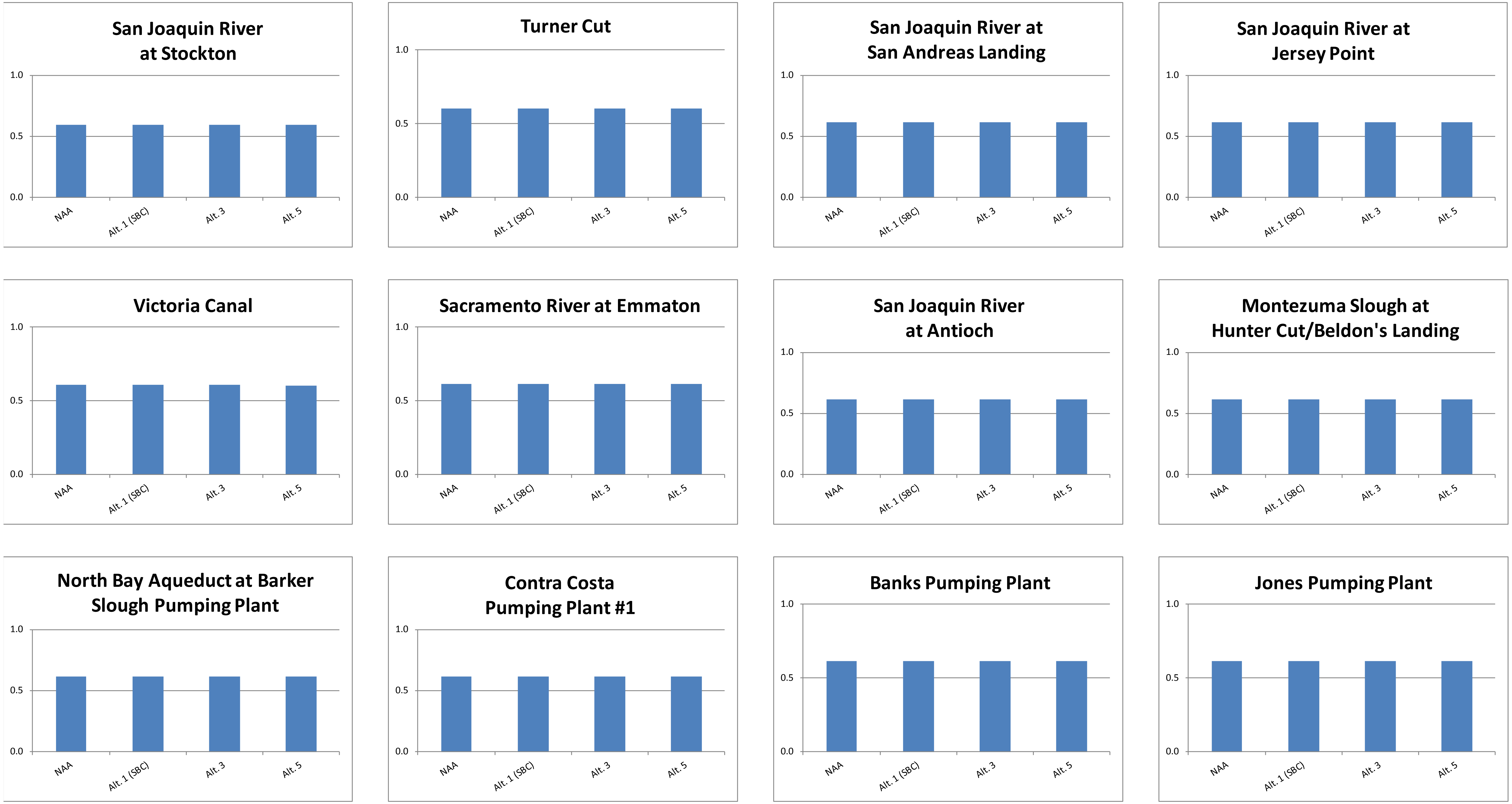


Figure 6D.7 Level of Concern Exceedance Quotients for Selenium Concentrations in Whole-Body Fish for Drought Years

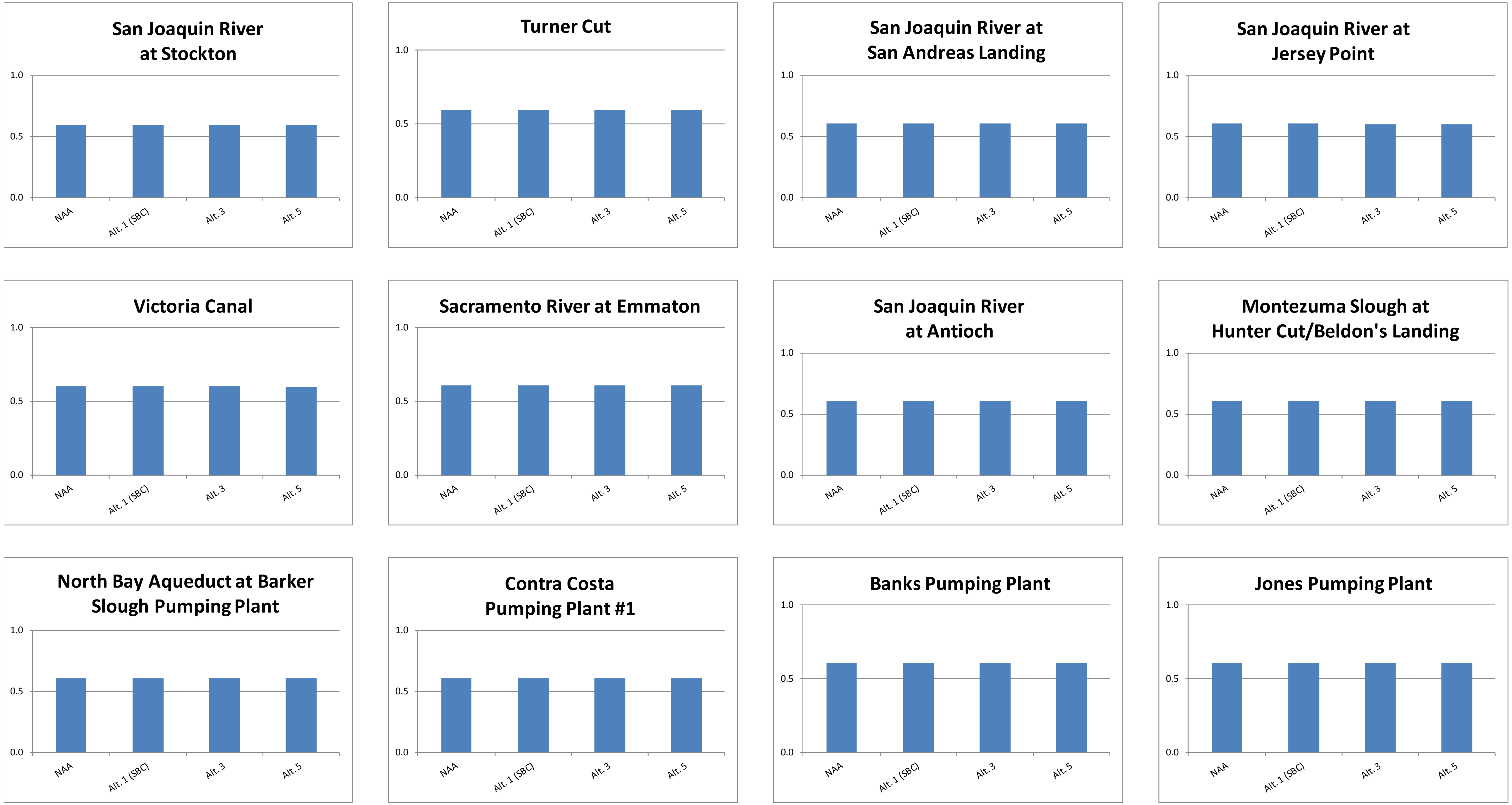


Figure 6D.8 Level of Concern Exceedance Quotients for Selenium Concentrations in Bird Eggs (Invertebrate Diet) for Drought Years

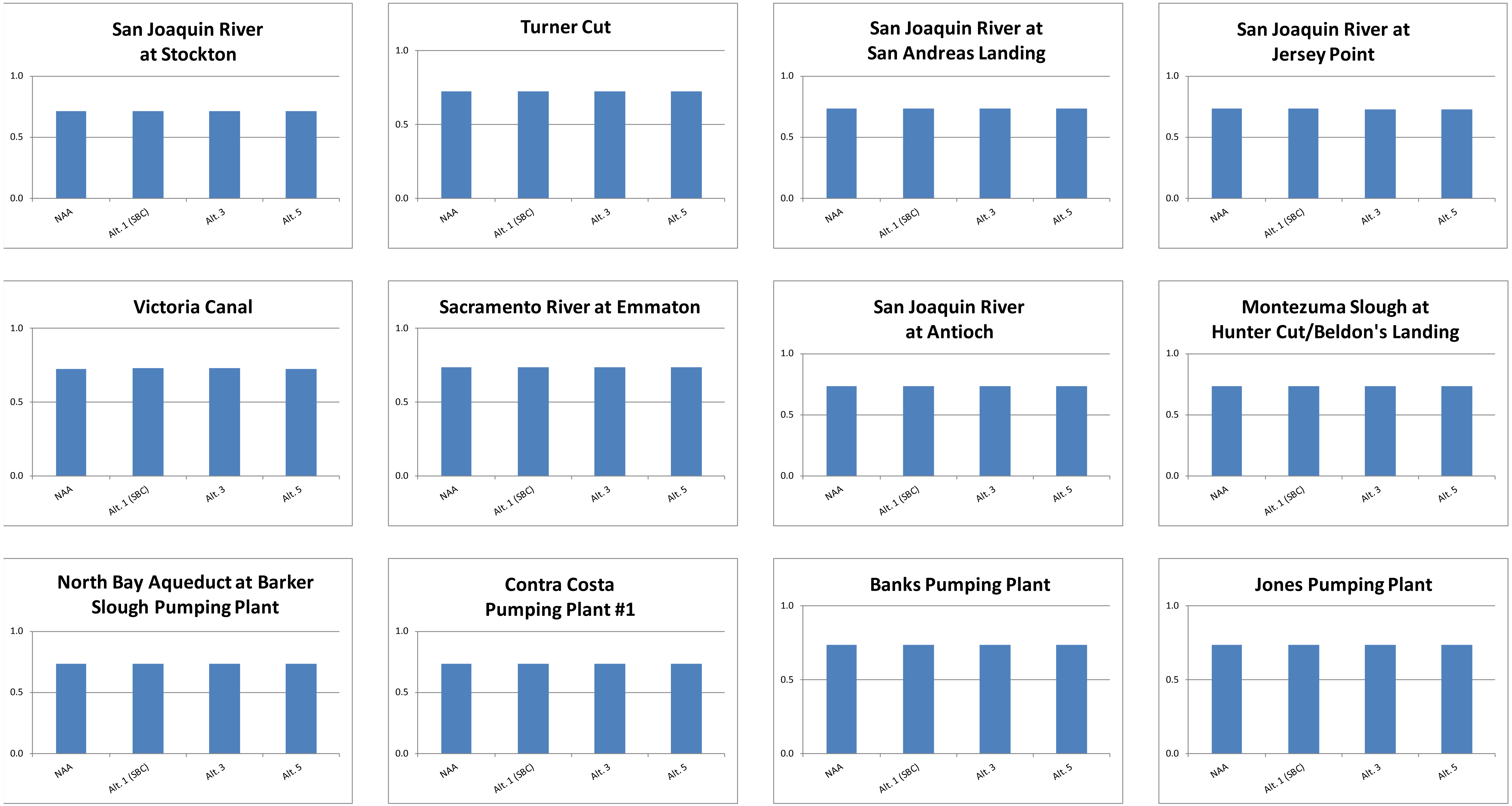


Figure 6D.9 Level of Concern Exceedance Quotients for Selenium Concentrations in Bird Eggs (Fish Diet) for Drought Years

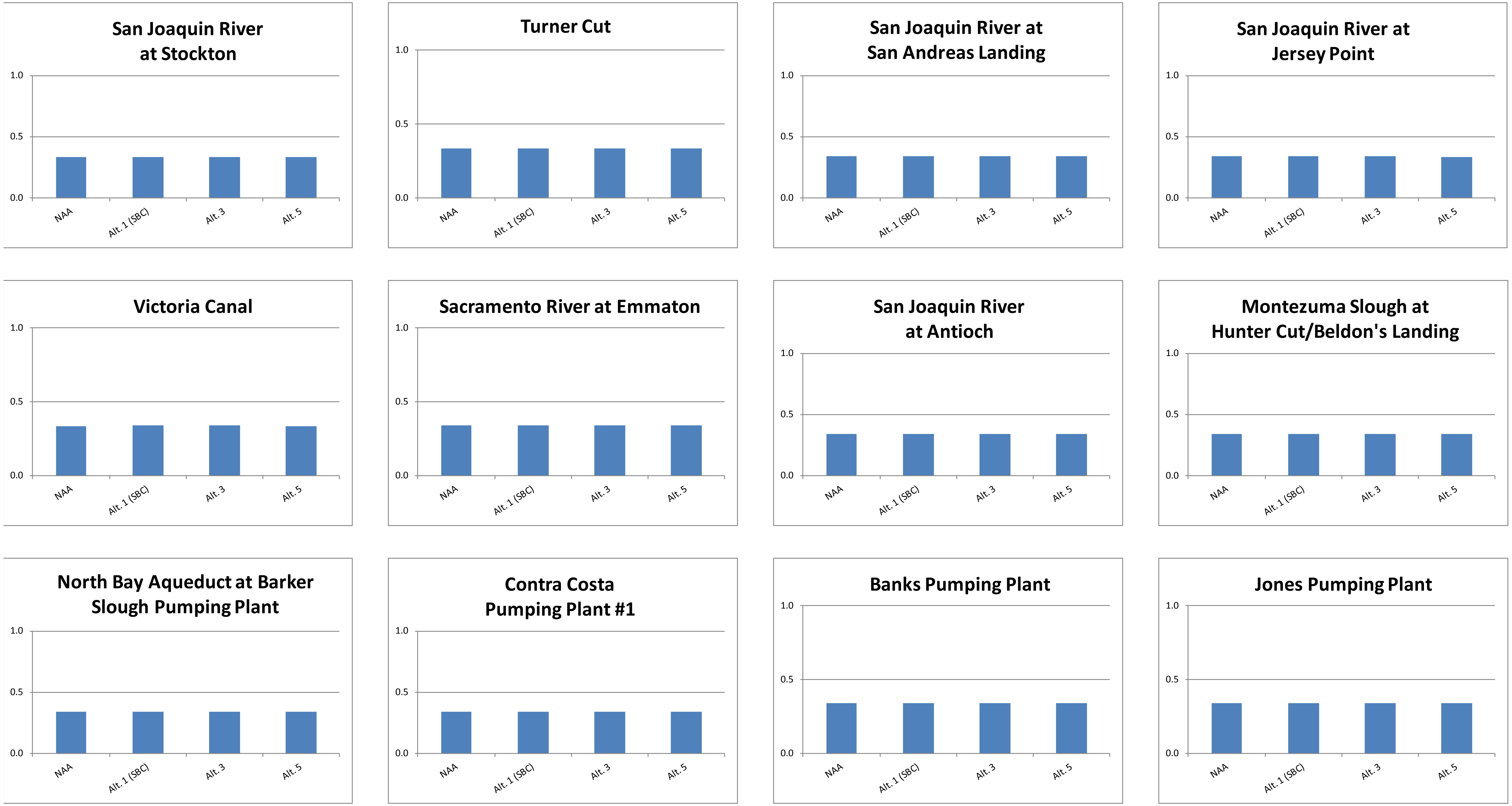


Figure 6D.10 Level of Concern Exceedance Quotients for Selenium Concentrations in Fish Fillets (wet weight) for Drought Years

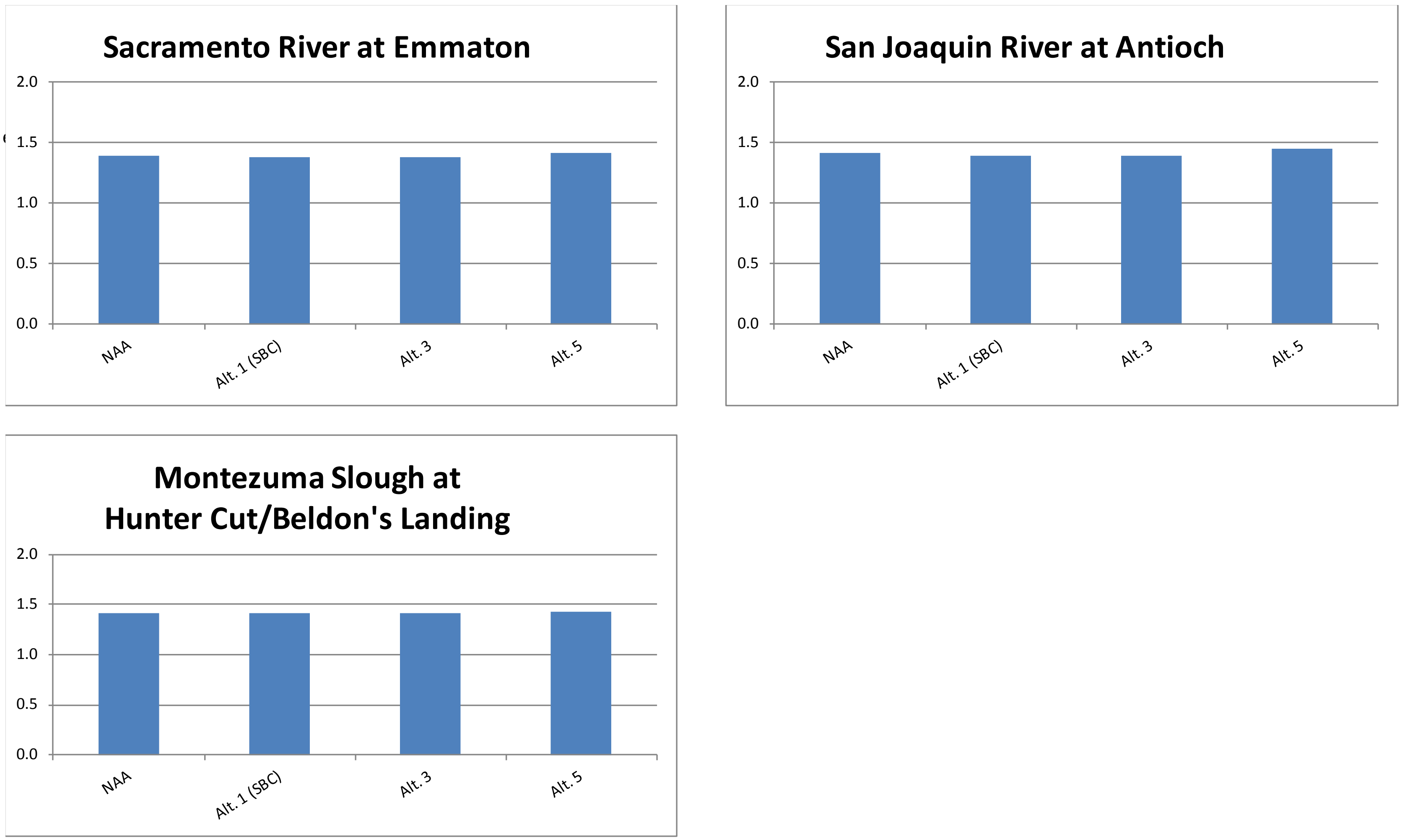


Figure 6D.11 Low Toxicity Threshold Exceedance Quotients for Selenium Concentrations in Whole-body Sturgeon for Drought Years

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