SECTIONEIGHT

SELENIUM BIOACCUMULATION

This section presents the results of evaluations conducted to determine the potential effects on regional selenium (Se) bioaccumulation due to operation of each of the action alternatives. A detailed ecological risk assessment for Se was conducted for the In-Valley Disposal Alternative, and methods and results for the risk assessment are presented in Appendix G.

8.1 AFFECTED ENVIRONMENT

Se can exist in several oxidation states (IV, VI, 0, -II) as well as in organic and inorganic form, and can exist as a dissolved species, or can be attached to suspended particulate matter (SPM) in the water column, or to bedded sediment and detritus. The following oxidation states can occur in the dissolved phase:

- Selenide or organo-selenium (-II), substituting for S (-II) in proteins seleno-methionine, or seleno-cysteine
- Selenite, SeO_3^{-2} (IV), an analog to sulfite
- Selenate (VI), an analog to sulfate
- Elemental Se, which has low solubility although it may exist as a suspended colloidal species

The reduced organic, elemental, or selenite forms of inorganic Se are converted to the selenite or selenate forms through the oxidation process. Methylation is the process by which inorganic or organic Se is converted to an organic form that contains one or more methyl groups (usually resulting in a volatile form). Assimilative reduction is the process in which oxidized forms are taken into cells and reduced to organic species such as seleno-methionine and seleno-cysteine. These organo-Se forms can then be released to the water column following death or depuration. These processes are responsible for converting relatively less bioavailable inorganic forms of Se to highly bioavailable organic forms.

Four oxidation and methylation processes also contribute to Se bioavailability in aquatic systems:

- Oxidation and methylation of inorganic and organic Se by plant roots and microorganisms
- Biological mixing and associated oxidation of sediments that results from burrowing of benthic invertebrates and foraging activities of wildlife
- Physical agitation and chemical oxidation associated with water circulation and mixing (e.g., wind, current, stratification)
- Oxidation of sediments through plant photosynthesis (Lemly 1999)

Once Se enters the aquatic environment, it has the potential to bioaccumulate in primary and secondary consumers (e.g., zooplankton and benthic invertebrates), and biomagnify as it reaches top-level predators (e.g., predatory fish, birds, and mammals). Biomagnification is a form of bioaccumulation in which the concentration of a chemical in a higher-trophic-level organism is greater than the concentration in the food that this organism consumes.

Se is an essential element necessary for proper enzyme formation and function (Eisler 1985). However, chronic exposure to significantly elevated Se levels in the diet or water can also cause severe toxicological effects, including death. The concentration range separating effects of Se deficiency from those of toxicity (i.e., selenosis) is very narrow (Luoma and Presser 2000). With the exception of mortality, the two major toxicological effects to aquatic organisms from chronic exposure are reproductive effects and teratogenesis (i.e., malformations in developing fetus). Excessive Se contamination is often associated with localized extinction of certain species and reduction in biodiversity. Based on field and laboratory studies with fish and wildlife, it is apparent that elevated Se concentrations in environmental media, including dietary components, can cause reproductive abnormalities. These abnormalities include congenital malformations, selective bioaccumulation by the organism, and growth retardation (Eisler 1985).

The following sections summarize existing data on Se speciation, bioavailability, and bioaccumulation in the areas that would be affected by each action alternative.

8.1.1 In-Valley Disposal Alternative Area

The proposed evaporation basins to be created under this alternative would be located on land where waterbodies do not currently exist. However, waterbodies do exist in adjacent areas within the Grasslands area, including the San Luis NWR complex and the Mendota NWR. Se concentrations in these areas have been measured in eggs of aquatic birds (Ohlendorf and Hothem 1995; Paveglio et al. 1992). Mean Se concentrations in duck and shorebird eggs randomly collected in 1987 were consistently low, ranging from 1.34 mg/kg in mallard eggs to 1.86 mg/kg in pintail eggs, and from 1.77 mg/kg in killdeer eggs to 1.86 mg/kg in avocet eggs (Ohlendorf and Hothem 1995). These concentrations are well below egg tissue concentrations associated with adverse reproductive effects. In addition, no deformities were observed in shorebird embryos (Ohlendorf and Hothem 1995).

In the Grasslands area, 14 of 189 duck eggs collected in 1986 and 1987 contained more than 20 mg/kg of Se. In shorebirds, the geometric mean Se concentration ranged from 3.72 mg/kg in stilt eggs to 15.3 mg/kg in killdeer eggs. The highest Se concentration in stilt eggs was 8.3 mg/kg and the highest in avocet eggs was 12.8 mg/kg. These concentrations are high enough to potentially cause adverse reproductive effects (Ohlendorf and Hothem 1995).

Se concentrations in aquatic bird eggs in the Grasslands area were found to decrease after 1986, when the water in the wetlands was switched from direct use of agricultural drainwater to predominantly freshwater (Paveglio et al. 1992). However, concentrations in 1994 were still elevated, and it is likely that Se deposited in sediments during the period of agricultural drainwater use continue to present a source of bioavailable Se in the wetland system (Paveglio et al. 1992).

8.1.2 In-Valley/Land Retirement Alternatives Area

The information described in Section 8.1.1 also applies to the In-Valley/Land Retirement Alternatives area.

8.1.3 Ocean Disposal Alternative Area

As Se is not considered to be a water quality problem in Morro Bay, limited data are available on existing Se concentrations in biota in the area. The California State Mussel Water Program was initiated in 1977 as a program to help identify water quality impairment of California's estuaries, bays, and other coastal waters. Rather than direct analysis of water samples, the program measures water quality through the analysis of clam and mussel tissues. Since many water contaminants are attached to suspended particles, and because contamination can be transitory or too low to be measured, sessile organisms such as clams and mussels that accumulate high levels of contaminants in their tissues allow for a better picture of water quality over an extended time period.

At each sampling location, three analytical replicates of 15 mussels (*Mytilus californianus*) each are analyzed for trace elements. Mussels collected from Bodega Head are transplanted to the sampling location if a suitable resident population does not exist. The mussel transplant system consists of a bottom-anchored float buoy in water up to a 40-meter depth. A 4- to 6-month transplant interval is used to allow adequate contaminant uptake.

The State Mussel Water Program sampled Se concentrations in mussel tissue collected or deployed at several stations in the Morro Bay area between 1987 and 1991. The Cayucos Pier station is located at the northern end of Morro Bay, and transplanted California mussels were sampled in 1991. The Morro Bay Boat Works station, located in inner Morro Bay, had transplanted California mussels sampled in 1987. Finally, Montana de Oro State Park at the southern end of Morro Bay contained resident California mussels, which were sampled five times from 1990 to 1992. At two other locations in Montana de Oro State Park (Montana de Oro 1 and 2), transplanted California mussels were sampled once each in 1990. Another sample from transplanted mussels was analyzed from Montana de Oro 1 in 1991. Mean Se concentrations measured in mussels at these locations are presented in Table 8-1, and ranged from 0.18 to 2.5 mg/kg dry weight. These concentrations are below thresholds associated with adverse effects to birds feeding on invertebrates.

Table 8-1
Morro Bay Area Selenium Concentrations in Mussel (*Mytilus californianus*) Tissue

Station Name	Date	Mussel Type	Wet Weight Se (mg/kg)	Dry Weight Se (mg/kg)
Cayucos Pier	2/25/1991	Transplanted	0.35	1.8
Morro Bay Boat Works	1/26/1987	Transplanted	0.49	3.1
Montana De Oro	11/14/1990	Resident	0.18	0.90
Montana De Oro	2/25/1991	Resident	0.20	1.3
Montana De Oro	9/9/1991	Resident	0.34	1.6
Montana De Oro	12/3/1991	Resident	0.45	2.3
Montana De Oro	2/25/1992	Resident	0.51	2.1
Montana De Oro 1	11/14/1990	Transplanted	0.19	1.1
Montana De Oro 1	12/4/1991	Transplanted	0.43	2.5
Montana De Oro 2	11/14/1990	Transplanted	0.20	1.1

8.1.4 Delta Disposal Alternatives Area

Se speciation and fate in the Bay-Delta Estuary are not well established; however, several studies have investigated the matter. Cutter (1989) measured and analyzed several species of Se in the Bay, Delta, and San Joaquin and Sacramento rivers between 1984 and 1987. The study measured total dissolved Se, selenate, and selenite. Concentrations of elemental Se plus selenide (-II + 0) were calculated from the measured data. Total dissolved Se concentrations were higher in the San Joaquin River than in the Sacramento River. However, because of diversions in the San Joaquin River, its flow only reached the Delta during April and May 1986. Selenate was the dominant dissolved Se species in the San Joaquin River (74±13%), while dissolved Se in Sacramento River was evenly split between selenate (48±15%) and elemental Se plus selenide (-II + 0) (40±15%). Further analysis revealed that higher concentrations of total dissolved Se and selenate were correlated with higher flows from the rivers to the Delta, implying that higher selenate and total dissolved Se concentrations are expected during winter months. Contrary to total dissolved Se and selenate concentrations, higher Se (-II and 0) concentration was found to correlate with decreased flows. No correlation was found between flow and selenite (Cutter 1989). In the North Bay, industrial effluent discharges near Carquinez Strait were found to be significant sources of anthropogenic Se, particularly during the dry season when river discharges are low (Cutter 1989).

Another study of Se speciation in San Francisco Bay (Cutter and San Diego-McGlone 1990) analyzed Se measurements from October (low flow) and December 1987 (high flow) and arrived at similar conclusions. The study found that the primary Se loadings to the Bay were Delta flows, industrial effluent near Carquinez Strait, and municipal discharges in the South Bay. The highest riverine loading of Se to the Bay occurred at times of high river discharge. Anthropogenic sources were relatively constant and, therefore, become more significant during the dry season when river discharge was small. Industrial discharges near Carquinez Strait contained up to three orders of magnitude more total dissolved Se than river discharges and, unlike river discharges, were dominated by selenite (62 percent of total dissolved Se) (Cutter and San Diego-McGlone 1990). While the municipal discharges in the South Bay were higher in total Se than river discharges, the speciation of Se was similar (60 percent selenate, 25 percent selenite, 15 percent selenide + elemental Se) (Cutter and San Diego-McGlone 1990).

More recent data presented by Cutter et al. (2000) indicated that while total Se concentrations have not increased since the mid 1980s, the percentage of selenite has diminished substantially, perhaps due to changes in industrial effluents. Particulate Se concentrations ranged from 0.2 to 1.1 micrograms per gram, with the highest concentrations seen in the Delta and more than 75 percent of particulate Se was the most bioavailable form, organic selenide. Sedimentary Se was dominated by the elemental species, making it less bioavailable than the Se suspended in the water column (Cutter et al. 2000).

In San Francisco Bay, one of the primary mechanisms of entry into the food chain is through assimilation by phytoplankton. Different algal species accumulate Se to varying degrees and in such a way that selenite and organic selenides are taken up in higher concentrations than selenate (Baines, Fisher, and Stewart 2002). Bivalves represent a significant source of dietary Se for wildlife in comparison to other benthic invertebrates and have also been shown to preferentially bioaccumulate selenite over selenate (Eisler 1985). Stewart et al. (2004) found that Se concentrations in the filter-feeding bivalve *Potamocorbula amurensis* collected from San Pablo Bay and Suisun Bay in 1999 were roughly 5 times higher than other invertebrate species (*Ampelisca abdita*, mysids, isopods, *Corophium* spp., and *Crongon fransiscorum*) collected in the same areas during the same time frame. Therefore, species composition of phytoplankton and benthic invertebrate communities are expected to have a substantial influence on Se accumulation and transfer through the food chain. Dietary preference, foraging strategy, and feeding rate significantly influence the rate of bioaccumulation in the food chain, which may ultimately lead to adverse effects in wildlife species (Luoma et al. 1992).

Bioaccumulation of Se may differ substantially between different species of bivalves. For example, Linville et al. (2002) found that Se concentrations in resident Asian clams (*Potamocorbula amurensis*) collected at three Regional Monitoring Program (RMP) sampling locations were often 2 to 3 times higher than Se concentrations in the deployed bivalve species. Since the Asian clam was introduced to the Bay-Delta Estuary in 1986, it has rapidly invaded and displaced native species. As a result, it is likely that this clam now composes a large percentage of the prey of some upper trophic level receptors.

Species that experience the highest level of chemical exposure are those most likely to suffer adverse effects, potentially at the population level. Due to the biomagnification potential of Se, species at the highest risk of toxicology effects are those found at the top of the food chain. In the *Selenium Verification Study* (Urquhart and Regalado 1991) the highest concentrations of Se in aquatic organisms were found in white sturgeon, a long-lived benthic predator of the Bay-Delta. The highest Se concentrations in aquatic birds in the Bay-Delta were found in surf scoter from Suisun and San Pablo bays. A surf scoter's diet is almost entirely comprised of benthic invertebrates, as opposed to other birds evaluated in the *Selenium Verification Study*, which include mallards, double-crested cormorants, American bitterns, northern shoveler, and scaups. The diets of these birds are comprised of higher proportions of plant material, aquatic insects, or fish.

Hunt et al. (2003) reported that in 2002, Se concentrations in surf scoter and greater scaup breast muscle tissue collected in Suisun Bay were significantly higher than Se concentrations in tissue from the same species collected in San Pablo Bay and South Bay. The authors hypothesized that the difference in concentrations may be due to a diet higher in Asian clams in Suisun Bay. Gut content analysis showed that 100 percent of the diet of surf scoters wintering in Suisun Bay was composed of the Asian clam, while only 25 percent of the diet of surf scoters wintering in San Pablo Bay and 0 percent of the diet of surf scoters wintering in South Bay was composed of the Asian clam (Hunt 2004). Studies conducted by the USGS have also found that lesser scaup consume Asian clams almost exclusively in some parts of San Francisco Bay, and greater scaup and canvasback also consume Asian clams as part of their diet (USGS 2004). Greater scaup and lesser scaup comprise about 43 to 46 percent of the total number of waterfowl on San Francisco Bay during winter, and data indicate that up to 92 percent of scaup in the Pacific Flyway may be found in San Francisco Bay at any one time (Poulton et al. 2002). Hunt (2004) reported that Se concentrations measured in surf scoter in 2002 were significantly lower than peak concentrations measured during the *Selenium Verification Study* in 1989 and 1990.

Data indicate that the Asian clam is a dominant food item found in the digestive tracts of the white sturgeon and Sacramento splittail (Stewart et al. 2004). Se concentrations in the tissue of white sturgeon collected from Suisun Bay and San Pablo Bay in January 2000 ranged from approximately 5 to 42 mg/kg dry weight, and Se concentrations in the tissue of Sacramento splittail collected from Suisun Bay and San Pablo Bay in Fall 1999/Winter 2000 ranged from approximately 7 to 20 mg/kg dry weight (Stewart et al. 2004). These concentrations exceeded the fish tissue toxicity threshold of 15 mg/kg Se dry weight, which was identified by the authors based on a literature review. The concentrations in these species were also substantially higher than concentrations in other fish species studied (yellowfin goby, starry flounder, leopard shark, and striped bass).

Studies conducted in the Bay-Delta have shown that predators with the highest tissue residues of Se are those that consume benthic invertebrates, with a high proportion consisting of bivalves (Luoma and Presser 2000). Predatory fish that primarily feed on water-column species are likely to be less exposed and accumulate less Se in their tissues than dimersal fish that consume benthic invertebrates, especially bivalves. In addition, studies on rates of accumulation revealed higher Se concentrations in smaller mussels and freshwater fish than larger individuals (i.e., older). The reverse was reported for marine mammals and fish (Eisler 1985).

8.1.5 Reuse Facilities (All Action Alternatives)

As described in Section 2.3.2.3, all of the action alternatives will include regional reuse facilities. The biological resources expected to be present within the reuse areas are described in Section 7.1.1. Little quantitative information on terrestrial Se concentrations in these areas is available.

8.2 ENVIRONMENTAL CONSEQUENCES

The discussion of evaluation criteria and modeling methods and assumptions is followed by the analysis of the environmental consequences associated with each alternative.

8.2.1 Evaluation Criteria

The criteria for determination of significant effects to wildlife resulting from increases in Se bioaccumulation due to the action alternatives include the following:

- Adverse effects such as reduced reproduction or development, or increased mortality to populations or communities of birds, mammals, or fish
- Adverse effects such as reduced reproduction or development, or increased mortality to individuals of special-status birds, mammals, or fish

To determine whether the predicted increases in Se concentrations in prey tissues are likely to result in significant effects to upper-trophic-level ecological receptors such as invertebrate-feeding birds and fish, a literature search was conducted to identify prey tissue concentrations of Se that are associated with adverse effects to predators.

Luoma et al. (1992) state that Se concentrations of 9 to 10 mg/kg (dry weight) occur in the most contaminated individuals of the clam *Corbicula fluminea* in Suisun Bay, and that at this concentration dietary toxicity is observed in fish in laboratory studies. Lemly (1996) reviewed data on Se toxicity and assigned a hazard ranking for dietary toxicity and reproductive failure in fish and aquatic birds from ingestion of Se-contaminated macroinvertebrates. A Se concentration of 2 to 3 mg/kg (dry weight) was assigned a hazard ranking of minimal toxicity, 3 to 4 mg/kg was assigned a hazard ranking of low toxicity, 4 to 5 mg/kg was assigned a hazard ranking of moderate toxicity, and greater than 5 mg/kg was assigned a hazard ranking of high toxicity. Peterson and Nebeker (1992) described the results of several comprehensive reviews on the effects of Se on animals. They concluded that it is widely agreed that chronic exposure to Se dietary concentrations greater than 5 mg/kg can result in adverse effects to birds and mammals.

Based on the studies discussed above, the significance threshold used to determine potential for adverse effects in this evaluation is a predicted average invertebrate tissue concentration exceeding 4 mg/kg Se (dry weight). To evaluate potential effects to populations, the average tissue concentration over the habitat is considered.

For this evaluation, the term "baseline conditions" for the Delta Disposal Alternatives refers to Se loading conditions for the year 2001 (existing conditions for this EIS), which incorporates changes in Se discharges from refineries as compared to previous years. Because it is not possible to quantitatively predict changes in Se bioaccumulation for the No Action Alternative, results for the action alternatives are compared to the baseline conditions to determine whether significant effects are likely. The baseline conditions are used to represent both existing conditions and No Action. In some cases, the methods used in this evaluation to assess the potential for adverse effects may predict that adverse effects would occur even under baseline conditions. In this case, a decrease of at least 10 percent in reproductive success, or any increase in adult mortality, would be considered a significant effect to a population. For special-status species, any decrease in reproductive success or increase in mortality would be considered a significant effect to individuals.

8.2.2 Modeling Methods and Assumptions

Se bioaccumulation rates are highly dependent on local environmental factors. Therefore, site-specific data were used to model aquatic Se bioaccumulation in benthic and/or aquatic invertebrates for each of the alternatives considered. This section describes the modeling methods used and the data used to develop modeling parameters. Appendix G provides a detailed risk assessment for the In-Valley Disposal Alternative.

8.2.2.1 In-Valley Disposal Alternative

As currently proposed, operation of the evaporation basin facilities, totaling 3,290 acres, would not create attractive habitat for common terrestrial seed-eating, predatory, or scavenging species. Under normal basin operation, terrestrial and shoreline vegetation that could provide forage, prey habitat, cover, and nesting substrates for terrestrial species would be systematically sprayed or mechanically removed. The high water temperatures, high salinity, and generally poor aquatic conditions would restrict development of fish, amphibian, and crustacean prey populations. Dead waterbirds (potential prey for scavengers) would be collected and removed. Seasonal hazing would reduce avian use numbers and nesting attempts, further reducing potential prey (eggs, hatchlings). The limited prey base and relative absence of terrestrial and emergent vegetation would limit attraction to the basin sites and significantly reduce the risk of dietary Se exposure for most terrestrial wildlife species. Therefore, this evaluation focuses on potential effects to waterbirds likely to forage on Se-contaminated plants and invertebrates in evaporation basins.

It is possible to predict concentrations in invertebrate prey in the evaporation basins based on Se concentrations predicted in the water and sediments of the evaporation basins. However, a large amount of uncertainty may be related to these predictions, due to various factors including:

- Limited information on Se speciation expected to be present in influent water
- Limited information on Se speciation expected to be present in water and sediments throughout the evaporation basin
- Spatial and temporal variation in factors that affect bioavailability, such as salinity, dissolved oxygen, sulfides, etc.
- Fluctuations in Se concentrations and bioavailability over time
- Chemical interactions with other constituents
- Highly variable Se bioaccumulation in different prey species
- Differences in primary production and algal biomass in various systems
- Length of exposure duration for prey species

Monitoring reports available for existing evaporation basins are based on untreated effluent, which may have very different speciation compositions than the treated influent to the proposed evaporation basins. Even if the Se speciation in the treated influent to the basins could be predicted with a reasonable amount of certainty, it is difficult to predict what will happen to the Se speciation when the water flows through the basin. Because speciation is dependent on various chemical and physical parameters that are characteristic of conditions in the evaporation basins, the speciation would eventually change if the residence time were long enough. Alaimo et al. (1994) measured Se speciation in four evaporation basins, and found that speciation varied considerably. In the Westlake Farms basins (where the total Se concentration in water was 4.3 µg/L), Se was measured as 100 percent selenate (the least bioavailable form). In contrast, Se in the Bowman Farms evaporation basins was found to be 78 percent organic selenide (the most bioavailable form), even though the total Se concentration (10.8 µg/L) was in the same range of that in the Westlake Farms basins. Total Se concentrations in the Lost Hills Water District and Sumner Peck Ranch basins were substantially higher (320 and 679 µg/L, respectively). The Lost Hills basin contained all three forms of Se (selenate, selenite, and organic selenide), while only selenate and selenite were measured in the Sumner Peck Ranch basin water. These data demonstrate that no typical Se speciation distribution can be assumed for conditions in evaporation basins. See Appendix B, Section B4, for a discussion of the Se bioaccumulation pilot study to address the lack of information currently available on Se speciation.

Historical and recent data on Se bioaccumulation in Central Valley evaporation basins are described in Appendix G. Moore et al. (1990) compiled historical data on Se concentrations in water, plants, and invertebrates of evaporation basins in the San Joaquin Valley. These data, as well as the more recent data collected by Fan et al. (2002), were used in this evaluation to develop regression equations to predict bioaccumulation for each of the dietary components (plant matter, nektonic invertebrates, and benthic invertebrates). Data for widgeongrass were used to represent Se uptake in plants, data for waterboatmen were used to represent Se uptake in nektonic invertebrates, and data for fly larvae (all available species) were used to represent Se uptake in benthic invertebrates. The regression equations are presented below and are discussed in more detail in Appendix G.

$$\text{Veg [Se]} = 10^{1.8985 + 0.7350 \text{ Log}_{10} \text{ Water [Se]}}$$

$$\text{Nektos [Se]} = 10^{2.0804 + 0.5711 \text{ Log}_{10} \text{ Water [Se]}}$$

$$\text{Benthos [Se]} = 10^{2.8625 + 0.8345 \text{ Log}_{10} \text{ Water [Se]}}$$

Where:

Veg [Se]	=	Vegetation tissue Se concentration in mg/kg dry weight
Nektos [Se]	=	Nektos tissue Se concentration in mg/kg dry weight
Benthos [Se]	=	Benthos tissue Se concentration in mg/kg dry weight
Water [Se]	=	Total recoverable waterborne Se concentration in mg/L

Dietary composition percentages used for this evaluation are presented in Table 8-2, and discussed in detail in Appendix G. The following equation is used to calculate the average dietary Se concentration for each bird category:

$$BX_{group} = (P_v * \text{Veg [Se]}) + (P_n * \text{Nektos [Se]}) + (P_b * \text{Benthos [Se]})$$

Where:

BX_{group}	=	Average dietary concentration for birds within the category being considered (mg Se/kg tissue [dry weight])
P_v	=	Proportion of diet from vegetation
P_n	=	Proportion of diet from nektonic inverts
P_b	=	Proportion of diet from benthic invertebrates

Table 8-2
Estimated Dietary Composition for Bird Categories

Bird Category	Dietary Composition (Percent)							
	Breeding Season				Nonbreeding Seasons			
	Benthic Invertebrates	Nektonic Invertebrates	Plants	Source	Benthic Invertebrates	Nektonic Invertebrates	Plants	Source
Dabblers (except for Northern Shoveler)	77	8	15	Estimated from data presented in Appendix G, Table G-4 (no Central Valley data)	42	9	49	Euliss et al. (1991) (Central Valley data on northern pintail)
Northern Shoveler	0	100	0	Estimated from data presented in Appendix G, Table G-4 and Euliss et al. (1991)	5	88	7	Euliss et al. (1991) (Central Valley data)
Divers	85	0	15	Brua (2002) (Ruddy duck at Tulare Basin)	53	37	10	Euliss et al. (1991) (Central Valley data on ruddy duck)
Shorebirds ("Breeding" and "Nonbreeding")	96	4	0	Cooper et al. (unpublished) (Central Valley stilts and avocets)	96	4	0	Cooper et al. (unpublished) (Central Valley stilts and avocets)

(Note: Post-treatment Se concentrations at final project buildout were used in this analysis. For the Public Draft EIS, an additional analysis should be conducted to evaluate initial effluent conditions.)

8.2.2.2 In-Valley/Land Retirement Alternatives

The methods described in Section 8.2.2.1 are also applied to the In-Valley/Land Retirement Alternatives. No additional quantitative analysis was performed for these alternatives, as results are expected to be comparable to the In-Valley Disposal Alternative (but potential effects would be lower in magnitude due to less evaporation basin acreage required).

8.2.2.3 Ocean Disposal Alternative

As discussed in Section 5.2.8, no significant increases in Se concentrations in surface water or sediments are predicted under this alternative. Therefore, no significant increases in Se bioaccumulation would be expected, and no quantitative bioaccumulation modeling was conducted.

8.2.2.4 Delta Disposal Alternatives

Approximately 90 percent of the Se present in drainwater is found as the selenate form. Prior to discharge to the Bay-Delta, a biological treatment process would be used to remove most of the Se from solution. It is not known what forms of Se would be discharged after treatment. Recent data from pilot Se treatment plants indicate a mix of Se species can be found in the effluent with approximately equal percentages of the total Se found as selenate and selenite, and organic species (Amweg et al. 2003).

To model bioaccumulation throughout trophic levels in the affected area, a review of published data was conducted on Se concentrations in bivalve tissue, sediment, and water at various sampling locations in San Francisco Bay and the Delta. The RMP has been monitoring various stations throughout the greater Bay ecosystem several times a year since 1993 (SFEI 2002b). Although the Mussel Watch program implemented by the National Oceanographic and Atmospheric Administration measured Se concentrations in mussels in the Bay before the RMP began, this program did not include measurements in sediment or water. To develop site-specific bioconcentration factors (BCFs), it is necessary to obtain co-located samples in both tissue and water (or sediment) collected during the same time period. Because the RMP provides co-located water, sediment, and bivalve tissue data, these data sets have been used to evaluate correlations between environmental concentrations and tissue concentrations of Se in the Bay.

For this evaluation, various groupings of the RMP data were experimented with to identify the strongest correlations between Se concentrations in tissue versus Se concentrations in water and sediment. Correlation plots were run on data for individual sampling locations, grouped sampling locations, and the entire data sets. Correlation plots of Se concentration in tissue versus Se concentration in sediment, dissolved Se concentration in water, and total Se concentration in water did not display any significant trends. However, bivalve exposure to Se primarily occurs through filtering of particulate matter in their environment. Therefore, the dissolved Se concentration was subtracted from the total Se concentration in water (to estimate the Se concentration associated with the particulate phase), and this result was divided by the total suspended solids concentration to obtain the Se concentration on SPM. For each RMP North Bay and Delta station, this SPM Se concentration was plotted against measured bivalve tissue concentrations. In some cases, the SPM Se concentration was negative due to analytical error; these data points were excluded from the analysis. In addition, a data point from the Sacramento River station was excluded from analysis due to the fact that the tissue concentration recorded was anomalously high (4 times higher than the next largest value in the data set). Linear regressions were then applied.

Most sites (six of eight total) displayed the expected increasing bivalve tissue Se concentrations with increasing SPM Se concentrations. However, correlations were generally weak ($r^2 < 0.15$). The Point Pinole and Napa River mouth stations showed relatively strong correlations between SPM and tissue Se concentrations ($r^2 = 0.50$ and 0.52, respectively). The Petaluma River station data contained too few points to establish a correlation, but when grouped with the Napa River station (both stations are in the North Bay at the mouths of freshwater creeks), a better correlation between SPM and tissue Se concentrations than either station alone was observed ($r^2 =0.53$). In the South Bay, the Coyote Creek station displayed a correlation as well ($r^2 =0.62$).

The RMP deploys three different bivalve species due to varying salinities in different areas of the Bay. With the exception of the Point Pinole station, at which the mussel *Mytilus californicus* was deployed, all stations with acceptable correlations contained the oyster *Crassostrea gigas*. All data from the North Bay and Delta were also grouped and analyzed by species (*C. gigas, M. californicus*) or by location (rivers, open-water Bay-Delta); no significant correlations were observed. The third bivalve deployed in the RMP study was the clam *Corbicula fluminea*. Available Se tissue concentrations in *C. fluminea* deployed at the Sacramento River and Grizzly Bay stations displayed no significant correlations with SPM Se concentrations.

Many reasons may contribute to explaining why the RMP data may not always exhibit good correlations among Se concentrations in corresponding water, sediment, and tissue samples. Some of the main factors are suspected to be the following:

- The RMP sediment and water data consist of instantaneous point concentrations collected one to three times per year. Bivalves from uncontaminated waters are deployed at stations in the Bay for 90 days, after which they are sampled for Se and other trace elements. Sampling dates and station locations for water and bivalve tissue do not always match; therefore, the data set used for the correlations was not very large. In addition, the water quality at one point in time during a 3-month bivalve deployment period may not be representative of the average concentration over that 3-month period. If more frequent water analyses were conducted, temporally averaged concentrations could be calculated, and these average concentrations would most likely be a better predictor of concentrations in tissue.
- As discussed earlier, bioaccumulation potential varies dramatically between different species of Se. No data are available on Se species present in the samples collected.
- The deployment period may not correspond to a period of abundant phytoplankton food. Therefore, the bivalves may have very low ingestion rates during the deployment period, resulting in low assimilation of Se.

Biota-Sediment Accumulation Factor

The RMP data were used to develop a Baywide biota-sediment accumulation factor (BSAF) based on the ratio of Se concentration in bivalve tissue to Se concentration on SPM. For development of the BSAF, the SPM concentration was selected over water or bedded sediment concentration because this media was the only one for which a reasonable correlation with tissue concentrations was exhibited, as discussed above. In addition, the available data indicate that food-web uptake of Se is much more important than uptake of Se dissolved in the water column. Bivalves feed on both SPM in the water column and detrital matter in bedded sediment, depending on species and availability of food. Because the RMP data exhibited no good correlations between Se concentrations in bedded sediment and tissue, the BSAF developed with SPM data was used to predict tissue concentrations from both the SPM Se concentration and the bedded sediment Se concentration.

The initial goal was to identify separate BSAFs for several different regions of the Bay, based on habitat types and differences in Se speciation. However, because strong correlations were only exhibited at a few sampling locations throughout the Bay, not enough data were available to assign BSAFs to specific regions. Therefore, the BSAFs calculated for each of these locations were averaged to calculate a BSAF for the entire Bay-Delta Estuary.

The BSAF for each location was calculated as the unitless ratio of the average Se concentration in SPM (mg/kg dry weight) to the average Se concentration in bivalve tissue (mg/kg dry weight). Therefore, the Se concentration in SPM can be multiplied by the BSAF to predict the Se concentration in bivalve tissue. BSAFs were calculated based on concentrations in *C. gigas*, because the best correlations were observed for this species, as discussed above. BSAFs calculated for each location are summarized as follows:

- Napa River mouth BSAF = 4.5
- San Pablo Bay BSAF = 4.7
- Coyote Creek mouth BSAF = 3.4

The average of the above BSAFs is 4.2, and this number was used as the Baywide BSAF for this evaluation. This BSAF is similar to the predictions made by Luoma and Presser (2000), using a kinetic bioaccumulation model. They predicted that Se concentrations in bivalve tissue (mg/kg dry weight) would be 8 times greater than Se concentrations in particulate matter for organo-Se, the most bioavailable form, and 2 times greater for elemental Se, the least bioavailable form. The BSAF of 4.2 used for this evaluation falls in between these values, as would be expected.

M. californicus exhibited a fairly strong correlation at Point Pinole, and the BSAF calculated for this species at this location was very low (1.0). To determine whether the difference was likely to be due to differences in Se speciation and bioavailability at this location, the average ratio of *M. californicus* tissue concentration to SPM concentration for the entire RMP data set was compared to the average ratio for *C. gigas.* The average ratio for *M. californicus* was 0.63, while the average ratio for *C. gigas* was 4.0. Therefore, it is likely that the large difference is due to the difference in bivalve species. *M. californicus* is a detrital feeder on bottom sediments, while *C. gigas* is expected to obtain much of its food from particulate matter in the water column.

Evidence indicates that *Potamocorbula amurensis*, an introduced species of clam that has aggressively invaded the San Francisco Bay-Delta, may accumulate Se at higher concentrations than the species deployed by the RMP (Linville et al. 2002). Three locations where resident *P. amurensis* tissue samples were collected in 1995 were near RMP sampling locations. At these three sites, Se concentrations in resident *P. amurensis* ranged from 11.6 to 15.4 mg/kg dry weight, while Se concentrations in the bivalves deployed by the RMP ranged from 2.5 to 4.8 mg/kg dry weight (Linville et al. 2002). While the differences may be due to some degree to variation in accumulation between species, differences in tissue concentrations may also be affected by other factors such as period of deployment (less uptake than occurs in resident organisms), and differences in Se concentrations in sediments and/or water at specific locations. If Se tissue concentrations in *P. amurensis* are consistently higher than those in other benthic organisms, and if this species comprises a substantial fraction of the food of upper-trophic-level receptors, it is possible that the toxicity threshold of 4 mg/kg may be exceeded even under baseline conditions.

Because data discussed in Section 8.1.4 indicate that *P. amurensis* does compose a large part of the diet of certain species of birds such as the surf scoter, particularly in Suisun Bay, this evaluation also includes a BSAF based on bioaccumulation in this species. Although it was not feasible to develop an empirical *P. amurensis* BSAF due to limited published data on water or sediment Se concentrations colocated with tissue samples of this species, a BSAF was estimated for *P. amurensis* by multiplying the BSAF developed based on *C. gigas* by a factor of 3. The factor of 3 was identified based on evidence presented by Linville et al. (2002) for the three sites discussed above where Se concentrations in resident *P. amurensis* ranged from 11.6 to 15.4 mg/kg dry weight, approximately 3 times the Se concentrations in the bivalves deployed by the RMP, which ranged from 2.5 to 4.8 mg/kg dry weight. Se concentrations in *P. amurensis* averaged 2.6 times greater than concentrations in the deployed bivalves. However, it should be noted that the deployed bivalves included three species (M. *californicus*, *C. gigas*, and *C. fluminea*), while the BSAF of 4.2 was developed based only on concentrations in *C. gigas.* Se concentrations in *P. amurensis* averaged 2.1 times greater than concentrations in *C. gigas*, but only 4 data points were available for comparison. In one case, the Se concentration in *P. amurensis* was 5.3 times greater than the concentrations in *C. gigas* deployed at the same location. Therefore, a factor of 3 was chosen to conservatively represent the limited data available, and the BSAF used in this evaluation to predict Se concentrations in *P. amurensis* is 12.6.

Bioconcentration Factor

Literature was reviewed to attempt to identify BCFs that could be used to predict how much Se is expected to be bioaccumulated directly from the water column. The BCF is the ratio of the average Se concentration in bivalve tissue (mg/kg dry weight) to the average dissolved Se concentration in water (mg/L). Therefore, the units of the BCF ratio are liter per kilogram, and the concentration of dissolved Se in water can be multiplied by the BCF to obtain the Se concentration in tissue at a given location.

A literature search was conducted to obtain information on studies that investigated BCFs in various organisms. Although a substantial number of studies were identified, the vast majority of these studies were conducted on freshwater species. To compare uptake routes (Se absorbed to particulate matter versus dissolved in water), it was desirable to identify BCF studies conducted on estuarine bivalves similar to those used in the RMP monitoring. Two such studies were identified.

Zhang, Hu, and Huang (1990) conducted a laboratory experiment to investigate Se uptake in the clam *Puditapes philippnarum*. However, they measured Se concentrations in the shell and in the whole body (including the shell), but not in the soft tissue alone. Because the RMP measured Se concentrations in the soft tissue alone, it is not appropriate to compare the results of these studies.

A study by Fowler and Benayoun (1976) investigated uptake of selenite (IV) and selenate (VI) by the mussel *Mytilus galloprovincialis*. Groups of mussels were placed in water containing 1, 10, and 100 ppb of either form of Se, and during a period of 21 days, Se was allowed to accumulate. Selenite tended to accumulate almost an order of magnitude more than selenate. Absorbed Se appeared to vary approximately linearly with water concentration. Se concentrations in soft tissue were given on a wet-weight basis, and no information on moisture content was provided. To calculate a BCF that could be used to predict tissue concentrations on a dry-weight basis, it was necessary to assume a moisture content. The average moisture content of *M. californicus* (a similar species of mussel) measured by the RMP was 88 percent, and this value was used for conversion to dry weight. The average ratio of soft tissue Se concentration (mg/kg dry weight) to water selenite concentration (mg/L) was 1,750. Because this value significantly underpredicts Se bioaccumulation as compared to the BSAF discussed above, the BCF approach was not used quantitatively in this evaluation.

Temporal and Spatial Averaging

Based on the water quality modeling results (see Sections 5.2.9 and 5.2.10), the summer and fall months are expected to exhibit the highest Se concentrations. Therefore, the 6-month period of June–November was used to calculate temporal averages of Se concentrations in bivalves for each scenario (No Action Alternative, Delta Disposal Alternatives). Model conditions are based on a dry year, as calibrated with Se data from 1997. Se loads for baseline conditions were updated to reflect 2001 conditions, which incorporate reductions in Se discharges from refineries.

Spatial averages of 6-month average Se concentrations in bivalve tissue were calculated for four regions of the Bay-Delta Estuary as shown on Figure 8-1: the Delta, San Pablo Bay, Central Bay, and South Bay. In addition, to evaluate a "reasonable worst case" in terms of Se bioaccumulation close to discharge points and during the time periods of highest concentrations, a shorter time averaging period (30 days) and spatial averages for locations close to the discharge points were also calculated (see Figures 8-2 and 8-3). Although Se concentrations in the water column do fluctuate during the tidal cycles, bioaccumulation typically does not fluctuate on this short of a time scale.

8.2.2.5 Reuse Facilities (All Action Alternatives)

The up to 19,000 acres of proposed reuse areas would be designed and operated to sustain long-term production and maintenance of selected salt-tolerant crops. Irrigation would be strictly controlled to maintain the productivity of the sites and to prevent standing water. No new permanent, seasonal, or intermittent wetland or aquatic habitat would intentionally be permitted to develop at the sites. All fields would be leveled and low spots identified and managed. Application of drainwater would not be permitted until subsurface drains are operational and planned tailwater management capabilities have been installed. Every reuse site would have clean ditchwater or groundwater available on a limited basis for mixing with applied drainwater to better establish newly seeded crops or for field-specific salt management. Under normal conditions, these standard operating procedures would be expected to control shallow groundwater elevations at the sites and limit occurrences of leaching, temporary ponding, and surface evaporation. Strict prevention of ponded irrigation water would reduce potential use of the sites by shorebirds and waterfowl.

During abnormal storm events and prolonged wet periods, leaching of Se from the shallow stored drainwater and temporary ponding of rainwater and surface runoff could occur for short periods of time. Surface evaporation could concentrate Se in the exposed water. These intermittent occurrences could result in short-term Se exposure risks to opportunistic shorebirds and waterfowl foraging at the temporarily inundated sites. The Se risks would be minimized with field leveling, surface drainage management, a program of surface and groundwater monitoring, and with appropriate operating modifications to limit the occurrences or durations of the hazardous conditions. Under unusual prolonged wet conditions, bypass pipelines at the reuse facilities could temporarily redirect influent drainwater, if needed, directly to the treatment plants or evaporation facilities.

It is anticipated that significant effects to aquatic and wetland-dependent species from operation of the reuse areas could be effectively minimized with (1) responsive operating rules including seasonal or incident-based actions directed at at-risk species, (2) implementation of a reuse area monitoring program (including surface and groundwater, soil, vegetation, bird use, dietary items, and bird eggs/tissues), and (3) adequate contingency strategies cooperatively developed by the Service, CDFG, and Regional Board. No quantitative modeling is necessary.

Due to elevated Se concentrations in soil, operation of these reuse areas could increase the risk of Se exposure for some terrestrial species (e.g., seed- and insect-eating species and the larger species that prey on them), potentially resulting in significant effects. No quantitative modeling has been performed at this time. Further evaluation and/or prevention measures or other mitigation would be necessary to ensure that no significant effects occur.

8.2.2.6 Uncertainties

Any evaluation of ecological effects has a number of limitations, including the degree of success in meeting objectives, range of conditions over which conclusions can be applied, and certainty with which conclusions can be drawn (USEPA 1989). The conclusions of an effects assessment are useful once they have been placed into perspective relative to the uncertainties associated with the evaluation. The major sources of uncertainty pertinent to this evaluation are discussed below.

General Sources of Uncertainty

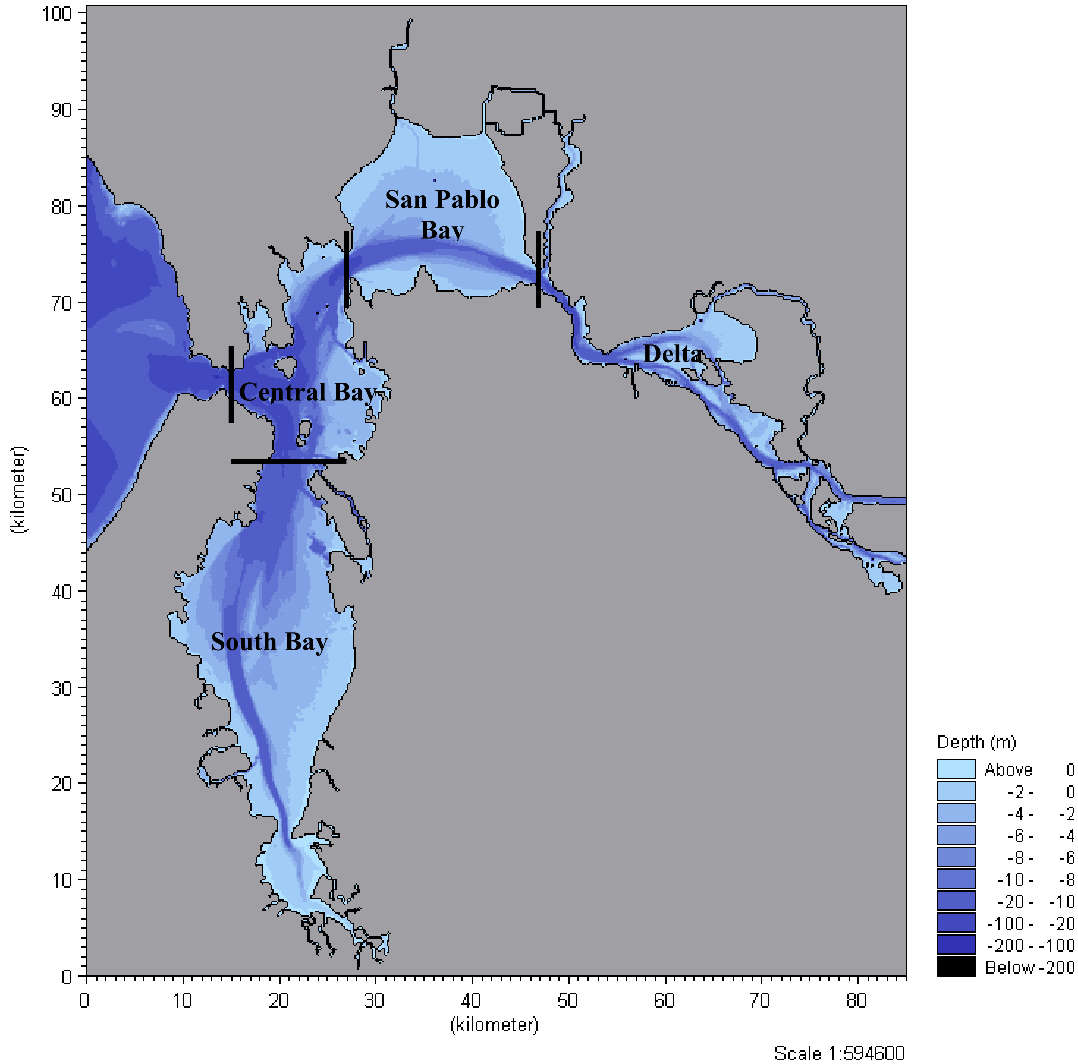
Due to the multiplicity of potential receptor species and general lack of knowledge regarding their life cycles, feeding habits, and relative toxicological sensitivity, the uncertainty surrounding estimates of ecological effects may be substantial. Most of the criteria and parameters used in this assessment are intended to provide a conservative (high end) evaluation of potential effects. The measurement endpoints utilized are chemical-specific and, as such, cannot address the additive, antagonistic, or synergistic effects of the mixtures of chemicals typically found in the environment. Furthermore, they do not account for many site-specific conditions regulating chemical contact and bioavailability, the potential toxicity of other constituents that were not quantified, or the pervasive influence of physical stressors associated with short-term and long-term disruption by human activities.

Specific Sources of Uncertainty

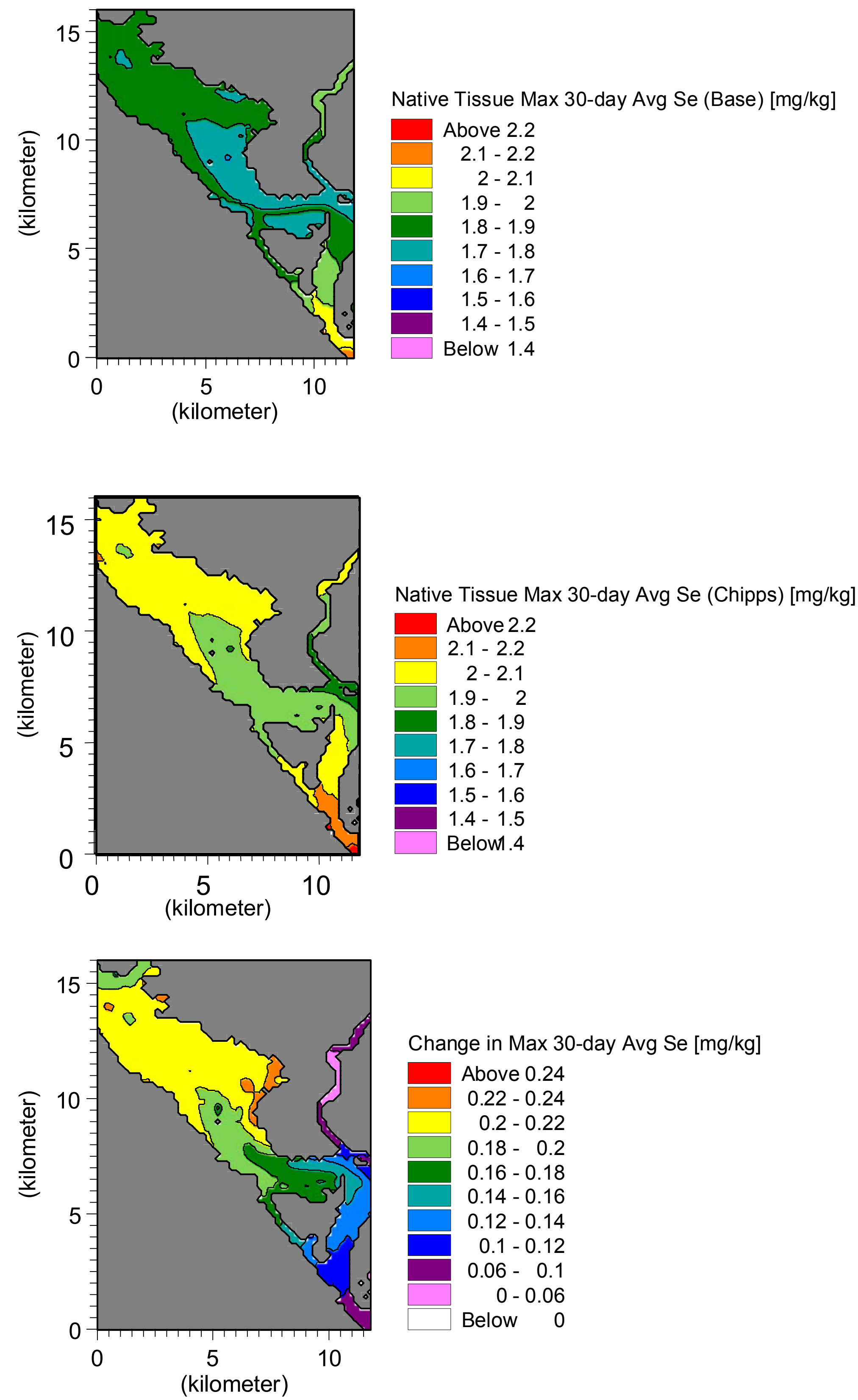
In addition to the broadly influential general sources discussed above, several discrete sources of uncertainty are described below.

Temporal and Spatial Distribution of Selenium Concentrations in Water. Because this ecological evaluation is based on predicted concentrations of Se in water, all results are based on the accuracy of the water quality modeling results. Assumptions and uncertainties in the water quality modeling of influent Se concentrations are described in detail in Appendix C. In addition, it was assumed that the influent Se concentrations would be representative of Se concentrations in water throughout the evaporation basins. Se concentrations in water are likely to change as the water flows through the system, due to factors such as partitioning and bioaccumulation. However, it is difficult to quantitatively predict changes in concentrations.

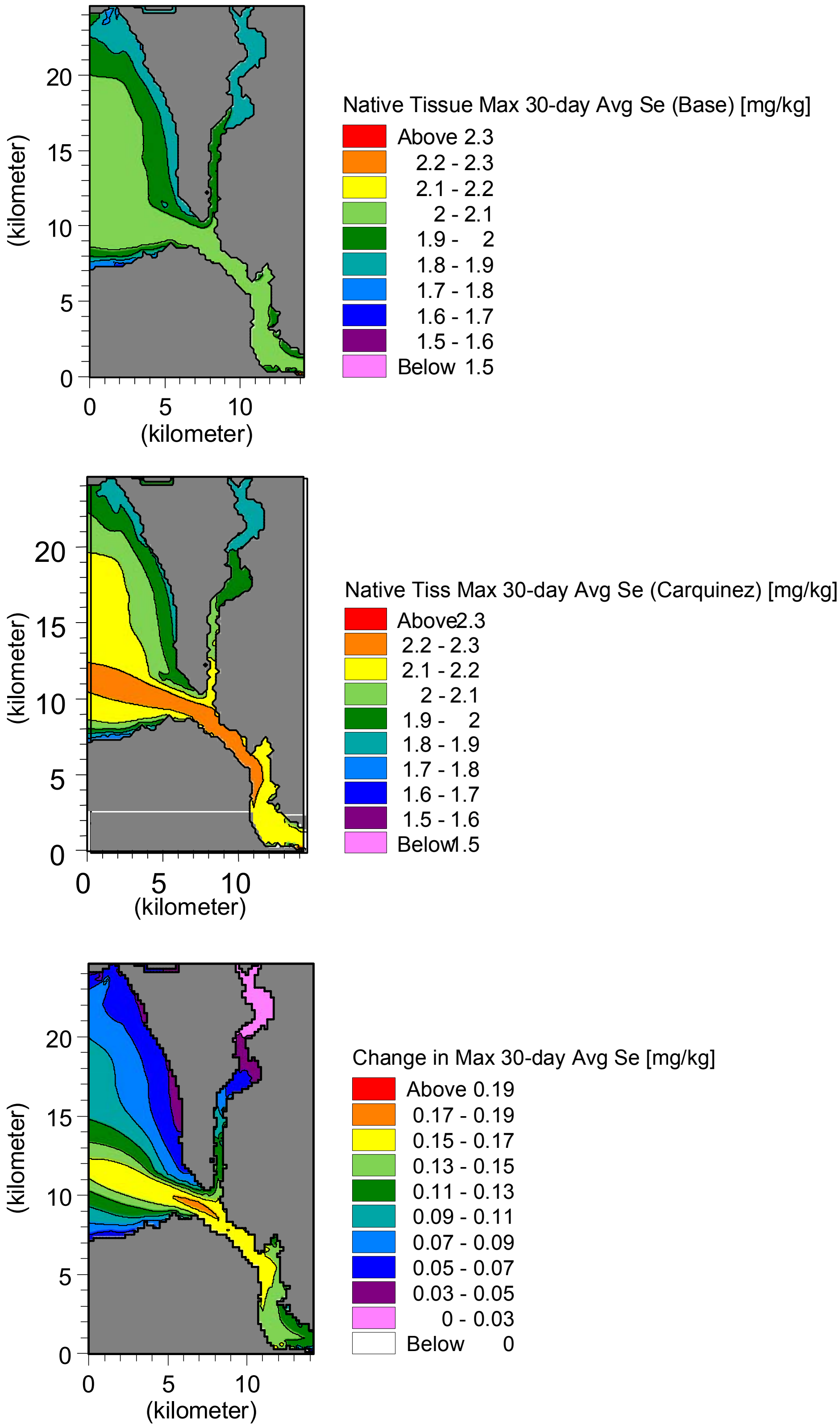
Selenium Speciation and Bioavailability. Limited information is available to predict what forms of Se will exist in the proposed evaporation basins and the San Francisco Bay -Delta. Even if the speciation of Se in the treated effluent could be predicted with a reasonable amount of certainty, it is difficult to predict what will happen to the Se speciation when the water is transported. Because speciation is dependent on various chemical and physical parameters that are characteristic of environmental conditions, the speciation is likely to eventually change.



San Luis Drainage Feature Re-evaluation	Bathymetry and Areas Selected for Average Tissue Concentration Calculations	Figure 8-1
17324004		



San Luis Drainage Feature Re-evaluation	MIKE 21 Chipps Discharge (June-November 1997) Maximum 30-Day Average Native Bivalve Tissue Selenium Concentration Near Discharge and Difference from Baseline Conditions	Figure 8-2
17324004		



San Luis Drainage Feature Re-evaluation	MIKE 21 Carquinez Discharge (June-November 1997) Maximum 30-Day Average Native Bivalve Tissue Selenium Concentration Near Discharge and Difference from Baseline Conditions	Figure 8-3
17324004		

Species Sensitivity. No data could be found that relate dietary Se concentrations to effects to the birds species most likely to nest and breed at evaporation basins (recurvirostrids such as stilts and avocets). However, available egg tissue effects data do include results of studies conducted on recurvorostrids, which indicates that birds in this family may be less sensitive to Se than some other species such as mallards (Ohlendorf 2003). Sensitivity to Se exposure can vary substantially even in closely related species, like stilts and avocets. The EC50 for overt teratogenesis was estimated to be 31 mg Se/kg egg tissue of dabbling ducks, whereas, the respective EC50s for stilts and avocets are 58 and 105 mg Se/kg egg tissue. These results indicate that ducks may be twice as sensitive to Se exposure as recurvirostrids, and avocets are relatively insensitive to selenosis (Skorupa 1998). The species examined in this study can be summarized as "sensitive" (duck), "average" (stilt), and "tolerant" (avocet) (Ohlendorf 2003).

Exposure Assessment. This evaluation assumed that birds would be ingesting food obtained from the area of concern only. If adjacent foraging habitat is available, it is likely that birds would obtain a portion of their food from areas with lower Se concentration, and exposure would be lower than predicted in this assessment.

In addition, a significant amount of uncertainty exists regarding the duration of time that migrating and wintering birds would spend at one location.

This evaluation also assumed that the dietary compositions of all bird species and all individuals within each bird category would be identical. However, dietary composition is likely to vary considerably, depending on numerous factors such as species, food availability, and time of year. In general, this evaluation assumed dietary composition that would predict Se exposure at the high end of the range (i.e., more consumption of benthic invertebrates, which accumulate higher Se levels).

Se exposure in birds is a function of two main factors: Se concentration in dietary items and food ingestion rates. Ingestion rates may vary substantially among species and at different times of the year. However, ingestion rates were not considered in this evaluation.

8.2.3 No Action Alternative

The No Action Alternative evaluates the effect of not conveying drainwater out of the drainage study area for disposal. This alternative is defined as what could be expected to occur in the 50-year planning period if drainage service is not provided to the Unit and related areas. It represents existing conditions for drainage management plus changes in management reasonably expected to be implemented by individual farmers and districts in the absence of Federal drainage services and not of a magnitude to require CEQA/NEPA documentation. The No Action Alternative includes only regional conveyance, treatment, or disposal facilities that existed in 2001 or that are authorized, funded projects. No use of the San Luis Drain would be planned after 2009, as it would require a new action and CEQA/NEPA documentation.

As discussed in Section 5.2.3, it is anticipated that adverse effects to surface water quality in the San Joaquin Valley wetlands would occur under the No Action Alternative, because some subsurface drainage is expected to migrate uncontrollably and laterally into wetland channels. Refuge waterways would be adversely affected because they have benefited in recent years from declining contaminant levels. Therefore, because Se bioaccumulation is primarily dependent on water quality, adverse effects to aquatic receptors related to changes in Se bioaccumulation are anticipated under the No Action Alternative. Special-status species affected may include the giant garter snake and California red-legged frog.

8.2.4 In-Valley Disposal Alternative

8.2.4.1 Terrestrial Resources

As currently proposed, operation of the evaporation basin facilities, totaling 3,290 acres, would not create attractive habitat for common terrestrial seed-eating, predatory, or scavenging species. Under normal basin operation, terrestrial and shoreline vegetation that could provide forage, prey habitat, cover, and nesting substrates for terrestrial species would be systematically sprayed or mechanically removed. The high water temperatures, high salinity, and generally poor aquatic conditions would restrict development of fish, amphibian, and crustacean prey populations. Dead waterbirds (potential prey for scavengers) would be collected and removed. Seasonal hazing would reduce avian use numbers and nesting attempts, further reducing potential prey (eggs, hatchlings). The limited prey base and relative absence of terrestrial and emergent vegetation would limit attraction to the basin sites and significantly reduce the risk of dietary Se exposure for most terrestrial wildlife species.

Due to elevated Se concentrations in soil, operation of these reuse areas could increase the risk of Se exposure for some terrestrial species (e.g., seed- and insect-eating species and the larger species that prey on them), potentially resulting in significant effects.

8.2.4.2 Aquatic Resources

During abnormal storm events and prolonged wet periods at reuse areas, Se leaching from the shallow stored drainwater and temporary ponding of rainwater and surface runoff could occur for short periods of time. Surface evaporation could concentrate Se in the exposed water. These intermittent occurrences could result in short-term Se exposure risks to opportunistic shorebirds and waterfowl foraging at the temporarily inundated sites. The Se risks would be minimized with field leveling, surface drainage management, a program of surface and groundwater monitoring, and with appropriate operating modifications to limit the occurrences or durations of the hazardous conditions. Under unusual prolonged wet conditions, bypass pipelines at the reuse facilities could temporarily redirect influent drainwater, if needed, directly to the treatment plants or evaporation facilities.

It is anticipated that significant effects to aquatic and wetland-dependent species from operation of the reuse areas could be effectively minimized with (1) responsive operating rules including seasonal or incident-based actions directed at at-risk species, (2) implementation of a reuse area monitoring program (including surface and groundwater, soil, vegetation, bird use, dietary items, and bird eggs/tissues), and (3) adequate contingency strategies cooperatively developed by the Service, CDFG, and Regional Board.

Table 8-3 presents the predicted Se concentrations in influent water and plant, nektonic invertebrate, and benthic invertebrate tissue for the proposed evaporation basins.

Table 8-3
Predicted Selenium Concentrations in Influent Water and Dietary Tissue

[Se] in Influent Water (µg/L)	[Se] in Plant Tissue (mg/kg dry weight)	[Se] in Nektonic Invertebrate Tissue (mg/kg dry weight)	[Se] in Benthic Invertebrate Tissue (mg/kg dry weight)
10	2.7	8.7	15.6

Table 8-4 presents the average predicted Se concentrations in the dietary items of each bird category. These estimates were calculated based on the estimated dietary composition of each bird category, as described in Appendix G, Section G5.3.

Table 8-4
Predicted Average Selenium Concentration in Diet of Each Bird Category

Bird Category	Average Dietary [Se] (mg/kg dry weight)	
	Breeding Season	Nonbreeding Seasons
Dabblers (except for Northern Shoveler)	13.1	8.7
Northern Shoveler	8.7	8.6
Divers	13.7	11.8
Shorebirds (“Breeding” and “Nonbreeding”)	15.3	15.3

Predicted mean Se concentrations in dietary tissue exceed the effects threshold of 4 mg/kg for all four evaporation basins during the breeding season. Therefore, significant effects would be expected to occur under the unmitigated alternative. These results are based on water quality modeled based on long-term irrigation with drainwater after project completion. The time needed to reach final water quality projections would be approximately 20 to 25 years after project completion. Results of the detailed ecological risk assessment conducted for this alternative are presented in Appendix G.

If not prevented or fully compensated by mitigation, effects such as reproductive impairment, embryonic deformities, sublethal reductions in health and vigor, and other Se-related effects that result in mortality or reduced reproductive success to protected migratory birds would be considered “takings” in violation of the Migratory Bird Treaty Act and, subsequently, would be considered a significant effect, and consultations with the Service are required.

To reduce the adverse effects to waterbirds, a number of design and management strategies would be implemented to modify habitat characteristics known to attract waterbirds to evaporation basins. Mitigation would be developed in consultation with the Service, CDFG, Regional Board, and others and would include a yet-to-be-determined number of development, enhancement, and restoration options as described in Section 20. With successful mitigation, the effects to waterbirds would be reduced to not significant.

8.2.4.3 Special-Status Species

Table 7-2 in Section 7.2.4.3 identifies the 16 listed special-status species that may be present, or that could occasionally utilize suitable habitat, in areas potentially affected by this alternative.

This section identifies those special-status species that may be exposed to elevated Se concentrations due to implementation of the In-Valley Disposal Alternative.

Predatory birds may feed on aquatic birds that forage on invertebrates in the evaporation basins. Aquatic birds that obtain a large amount of their diet from evaporation basins are likely to contain elevated Se levels in their tissue. Therefore, predatory birds are likely to receive Se exposure by feeding on these birds. **American peregrine falcons** (a state-listed endangered species) have been observed feeding on shorebirds at the Tulare Lake Drainage District evaporation basins. Two sick American peregrine falcons were recovered during mid-summer 1992, and blood and feather samples collected from these birds contained elevated Se levels. One birds was too weak to fly. Both birds experienced full recovery after being fed a diet containing a normal Se concentration (Hanson Environmental 2003). Evidence presented in Appendix G indicates that this species may experience significant adverse effects due to Se bioaccumulation in waterbird prey.

Operation of In-Valley facilities would be unlikely to affect the **bald eagle**, which has not been observed at evaporation basins and would favor riparian and reservoir foraging areas with suitable hunting and roosting perches.

The **San Joaquin kit fox** could forage at several of the proposed reuse areas located nearest the eastern edges of the drainage areas, but would be less likely to utilize project sites that are more isolated within the surrounding agricultural landscape. Retirement of large contiguous tracts of cropland in the vicinity of the reuse areas, however, could create travel corridors to the interior sites, expanding potential kit fox foraging areas to include all reuse areas. Portions of the reuse facilities that would be planted in salt-tolerant grasses, grain crops, or permanent pasture could develop a substantial prey base and expose foraging kit fox to elevated Se in common dietary items such as insects, ground-nesting birds, and small mammals. The more intensively cropped portions of the reuse facilities would likely support less abundant prey than the areas planted in cover or pasture crops, or nearby nonirrigated parcels and refuge lands.

Kit fox use of evaporation facilities would likely be limited. The removal of ground cover and emergent vegetation at the evaporation basins and intensive hazing of nesting shorebirds would limit development of an attractive prey base. Without an abundance of prey to attract kit fox to the evaporation facilities, the potential for significant adverse effects would be limited.

Operation of In-Valley reuse facilities also could adversely affect the **Swainson's hawk** and **greater sandhill crane**. While both species would also be attracted to grasslands, irrigated pasture, and other suitable croplands (including retired lands converted to dryland farming or grazing land), this alternative's reuse areas also would provide attractive foraging habitat, exposing foraging individuals to elevated Se in seeds, grains, worms, insects, and small mammals.

The **California black rail** and the **western yellow-billed cuckoo** would not be affected. Habitat types (emergent marshlands and riparian forest, respectively) utilized by these species would not be affected by operation of any In-Valley Disposal Alternative facility.

Burrowing owl colonies occupying the existing San Luis Drain would not be affected by operation of portions of the collection system located within the Drain's ROW if appropriate operating rules and conservation measures are included in a proposed burrowing owl management plan that would be developed for the Drain. This species typically does not nest in areas of heavy vegetation, so it is unlikely to nest in the reuse areas.

The **giant garter snake** and **California red-legged frog** would not be adversely affected by operation of any In-Valley facilities. These species, however, could indirectly benefit from a general improvement in water quality in Mud Slough and other Grasslands area waterways.

The listed **Chinook salmon** or **steelhead ESUs**, **Delta smelt**, or **green sturgeon** may benefit from implementation of the In-Valley Disposal Alternative. A reduction in the Se load entering the San Joaquin River as a direct result of the project would improve water quality in the Bay-Delta habitats used by these species. Although no evidence indicates that **Chinook salmon** or **steelhead ESUs**, **Delta smelt** would be affected by Se concentrations, sturgeon are known to accumulate Se at higher concentrations than other fish.

8.2.5 In-Valley/Groundwater Quality Land Retirement Alternative

Environmental consequences of this alternative are expected to be comparable to those discussed in Section 8.2.4, but may be lower in magnitude because evaporation basins are not required to be as large. The maximum acreage of the evaporation basin is estimated to be 2,890.

8.2.6 In-Valley/Water Needs Land Retirement Alternative

Environmental consequences of this alternative are expected to be comparable to those discussed in Section 8.2.4, but would be lower in magnitude because evaporation basins are not required to be as large (2,150 acres).

8.2.7 In-Valley/Drainage-Impaired Area Land Retirement Alternative

Environmental consequences of this alternative are expected to be comparable to those discussed in Section 8.2.4, but would be lower in magnitude with only 1,270 acres of evaporation basins.

8.2.8 Ocean Disposal Alternative

8.2.8.1 Terrestrial Resources

Due to elevated Se concentrations in soil, operation of these reuse areas could increase the risk of Se exposure for some terrestrial species (e.g., seed- and insect-eating species and the larger species that prey on them), potentially resulting in significant effects.

8.2.8.2 Aquatic Resources

As discussed in Section 5.2.8, no significant increases in Se concentrations in surface water or sediments are predicted under this alternative. Therefore, no significant increases in Se bioaccumulation would be expected, and no quantitative bioaccumulation modeling was conducted.

8.2.8.3 Special-Status Species

Table 7-3 identifies the listed special-status species that may be present, or that could occasionally utilize suitable habitat, in areas potentially affected by this alternative. This section identifies those special-status species that may be exposed to elevated Se concentrations due to implementation of the Ocean Disposal Alternative.

Operation of this alternative would be unlikely to affect the **bald eagle**, which would favor riparian and reservoir foraging areas with suitable hunting and roosting perches.

The **San Joaquin kit fox** could forage at several of the proposed reuse areas located nearest the eastern edges of the drainage areas, but would be less likely to utilize project sites that are more isolated within the surrounding agricultural landscape. Retirement of large contiguous tracts of cropland in the vicinity of the reuse areas, however, could create travel corridors to the interior sites, expanding potential kit fox foraging areas to include all reuse areas. Portions of the reuse facilities that would be planted in salt-tolerant grasses, grain crops, or permanent pasture could develop a substantial prey base and expose foraging kit fox to elevated Se in common dietary items such as insects, ground-nesting birds, and small mammals. The more intensively cropped portions of the reuse facilities would likely support less abundant prey than the areas planted in cover or pasture crops, or nearby nonirrigated parcels and refuge lands.

Operation of reuse facilities also could adversely affect the **Swainson's hawk** and **greater sandhill crane**. While both species would also be attracted to grasslands, irrigated pasture, and other suitable croplands (including retired lands converted to dryland farming or grazing land), this alternative's reuse areas also would provide attractive foraging habitat, exposing foraging individuals to elevated Se in seeds, grains, worms, insects, and small mammals.

The **California black rail** and the **western yellow-billed cuckoo** would not be affected. Habitat types (emergent marshlands and riparian forest, respectively) utilized by these species would not be affected by operation of any Ocean Disposal Alternative facility.

Burrowing owl colonies occupying the existing San Luis Drain would not be affected by operation of portions of the collection system located within the Drain's ROW if appropriate operating rules and conservation measures are included in a proposed burrowing owl management plan that would be developed for the Drain. This species typically does not nest in areas of heavy vegetation, so it is unlikely to nest in the reuse areas.

The **giant garter snake** and **California red-legged frog** would not be adversely affected by operation of any Ocean Disposal Alternative facilities. These species, however, could indirectly benefit from a general improvement in water quality in Mud Slough and other Grasslands area waterways.

The listed **Chinook salmon** or **steelhead ESUs**, **Delta smelt**, or **green sturgeon** may benefit from implementation of the Ocean Disposal Alternative. A reduction in the Se load entering the San Joaquin River as a direct result of the project would improve water quality in the Bay-Delta habitats used by these species. Although no evidence indicates that **Chinook salmon** or **steelhead ESUs**, **Delta smelt** would be affected by Se concentrations, sturgeon are known to accumulate Se at higher concentrations than other fish.

8.2.9 Delta-Chipps Island Disposal Alternative

8.2.9.1 Terrestrial Resources

The aqueduct's approximately 73 miles of open canal segments between the biotreatment plant and the discharge at Chipps Island could create a small risk of Se exposure for some species; however, the relatively small concrete-lined structure (normal capacity of 29.1 cfs) would not be particularly attractive to wildlife and would carry only treated drainwater (Se concentration of 10 ppb or less). Furthermore, at least 45.6 miles of the 73 miles of open canal segments that would convey treated drainwater would be located in developed urban and agricultural areas where wildlife exposure would be limited and natural habitat would not be bisected. Therefore, no significant effects to terrestrial resources are expected to occur due to Se exposure at the aqueduct.

The remaining open canal segments, comprised of the southern 56 miles of the existing San Luis Drain and the valley collection canal, would convey untreated drainwater collected from the reuse areas. Se concentrations in the conveyed drainwater would vary. A portion of this open canal segment passes near or through Federal and State refuges and wildlife areas, presenting additional exposure risk.

Due to elevated Se concentrations in soil, operation of the reuse areas could increase the risk of Se exposure for some terrestrial species (e.g., seed- and insect-eating species and the larger species that prey on them), potentially resulting in significant effects.

8.2.9.2 Aquatic Resources

Predicted 6-month average bivalve tissue concentrations throughout the Bay-Delta Estuary for the Delta-Chipps Island Disposal Alternative are presented on Figures 8-4 (native species) and 8-5 (exotic species–Asian clam). In addition to predicted concentrations, the incremental change from baseline conditions is also shown on these figures. Predictions for all scenarios are shown based on bioaccumulation from Se adsorbed to SPM using a BSAF of 4.2 for native species and a BSAF of 12.6 for the Asian clam.

SPM Se concentrations are believed to be the best predictor of bivalve tissue Se concentrations. As would be expected, the most highly affected area under the Delta-Chipps Island Disposal Alternative discharge scenario is the North Bay, where average Se concentrations in tissue are predicted to be approximately 9 percent higher than the concentrations under baseline conditions (Tables 8-5 and 8-6).

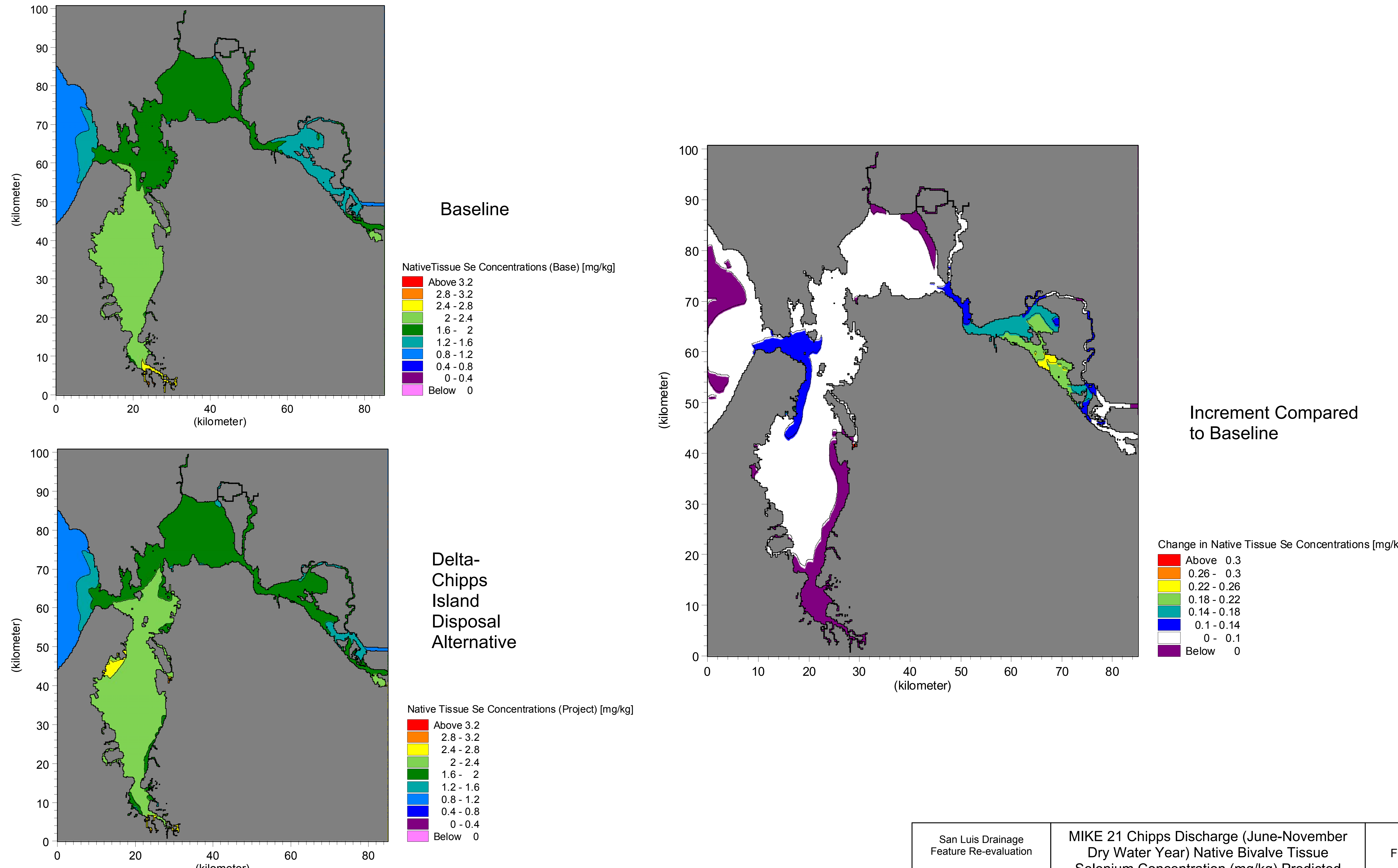
Table 8-5
Mean Predicted Native Bivalve Tissue Selenium Concentration (June-November)

Area Name	Bioaccumulation (mg/kg)		
	Baseline Conditions	Chipps Island Discharge Predictions	Carquinez Strait Discharge Predictions
North Bay	1.57	1.71	1.61
San Pablo Bay	1.83	1.88	1.92
Central Bay	1.93	2.01	2.04
South Bay	2.20	2.22	2.23

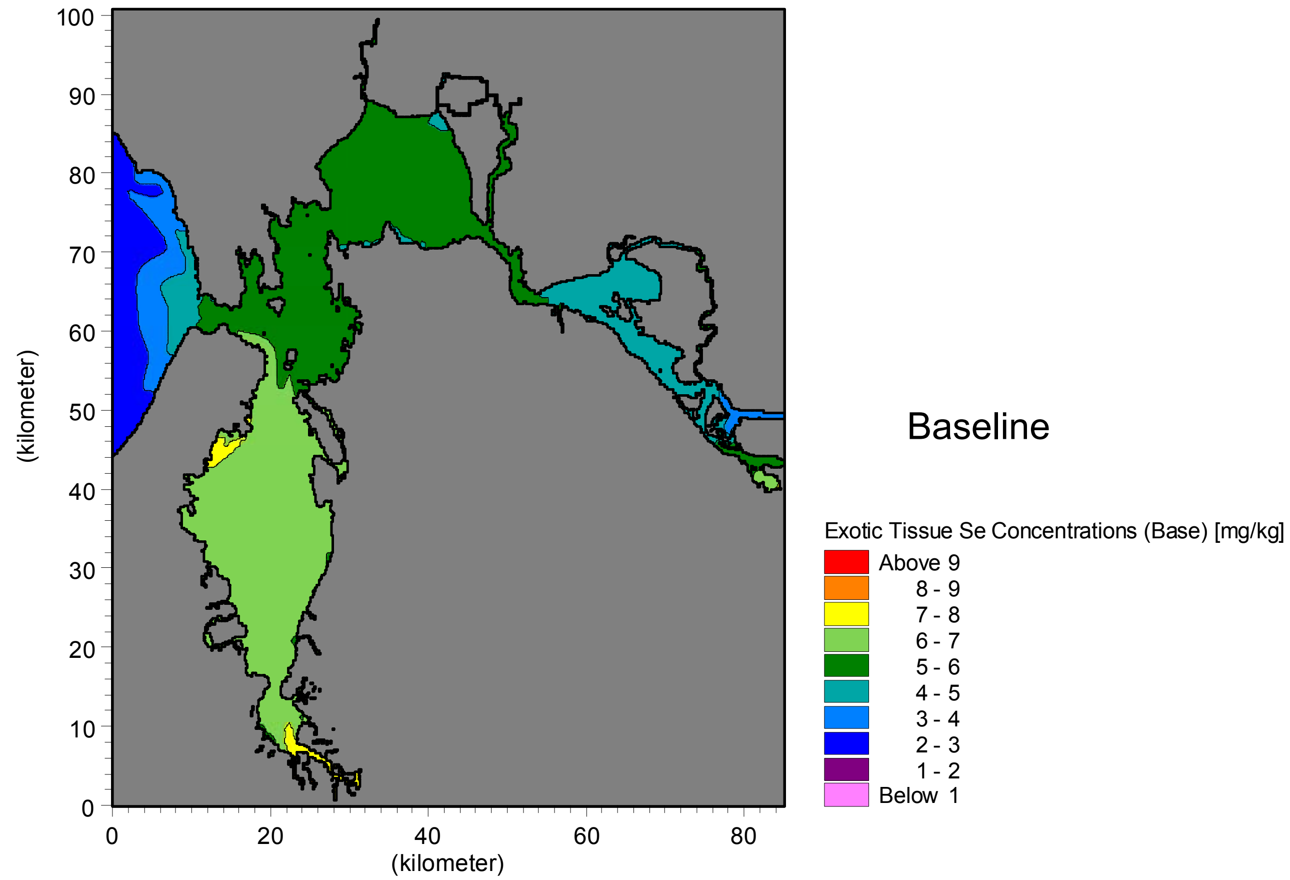
Table 8-6
Mean Predicted Exotic Bivalve Tissue Selenium Concentration (June-November)

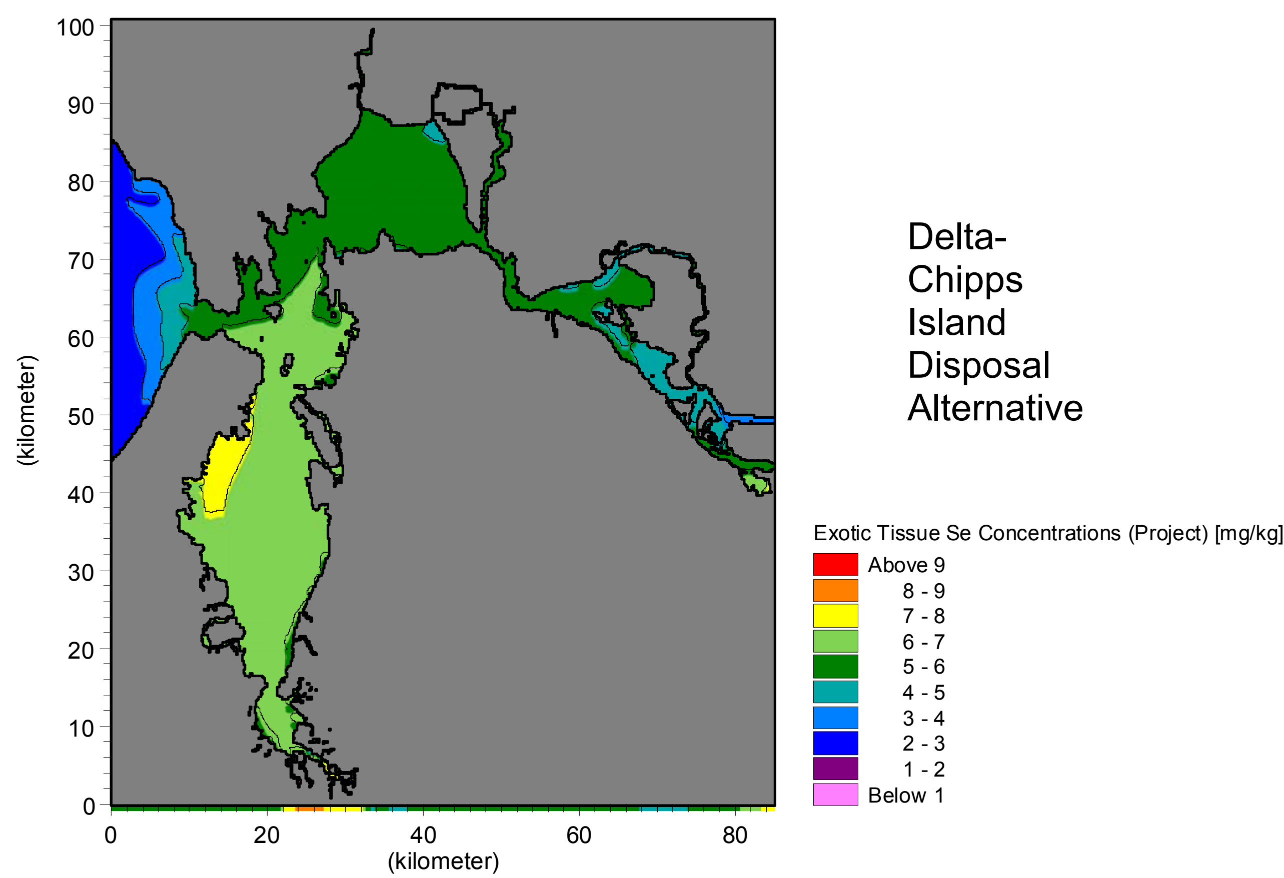
Area Name	Bioaccumulation (mg/kg)		
	Baseline Conditions	Chipps Island Discharge Predictions	Carquinez Strait Discharge Predictions
North Bay	4.71	5.12	4.82
San Pablo Bay	5.50	5.64	5.76
Central Bay	5.78	6.02	6.11
South Bay	6.60	6.65	6.69

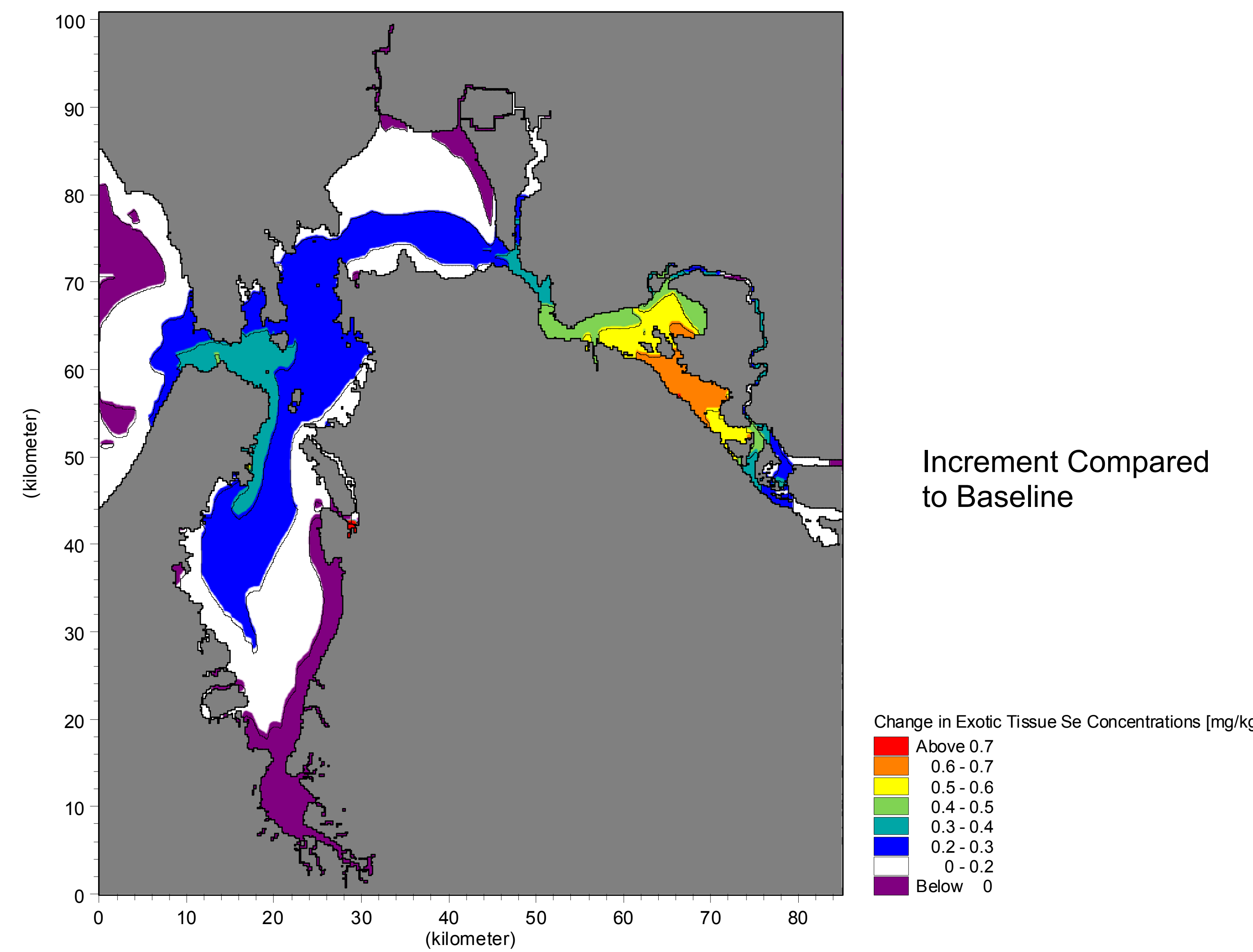
Under the Delta-Chipps Island Disposal Alternative, the highest predicted average native bivalve concentrations are well under 4 mg/kg. These concentrations are not expected to result in significant toxicity to upper trophic level receptors. However, it should be noted that these comparisons are general and that localized effects have the potential to occur at areas with the highest Se concentrations, especially if the more bioavailable forms of Se are present. As shown on Figure 8-4, the largest increment in Se tissue concentrations occurs closest to the discharge point, where average Se concentrations in native species over the 6-month period are predicted to increase by approximately 0.18 to 0.26 mg/kg. To determine the worst-case increase in Se tissue concentrations in native species at this location, the maximum 30-day average was calculated, as shown on Figure 8-6. The maximum predicted 30-day average Se concentration is less than 2.2



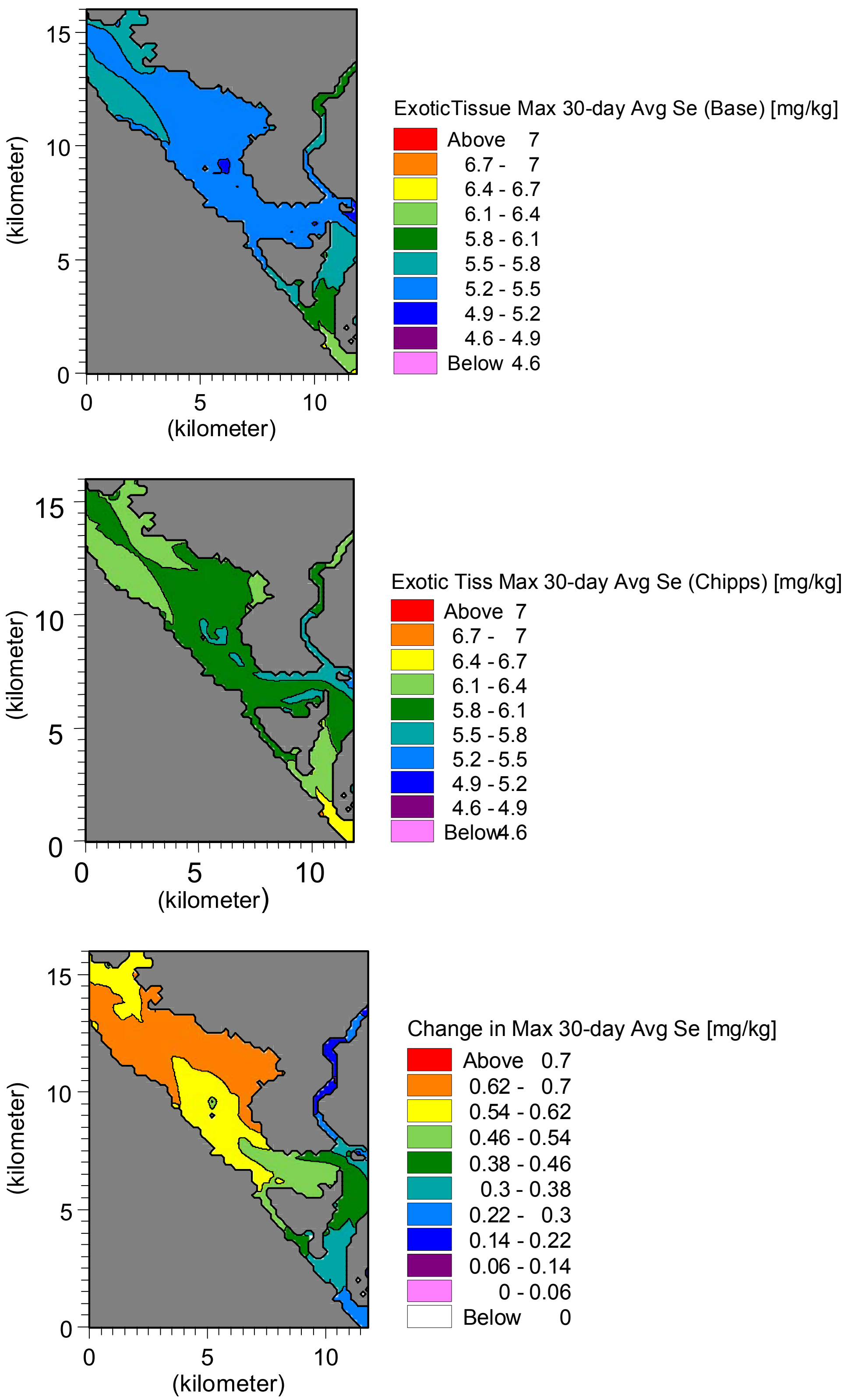
San Luis Drainage Feature Re-evaluation	MIKE 21 Chipps Discharge (June-November Dry Water Year) Native Bivalve Tissue Selenium Concentration (mg/kg) Predicted Based on BSAF and Adsorbed Selenium	Figure 8-4
17324004		







San Luis Drainage Feature Re-evaluation	MIKE 21 Chipps Discharge (June-November Dry Water Year) Exotic Bivalve Tissue Selenium Concentration (mg/kg) Predicted Based on BSAF and Adsorbed Selenium	Figure 8-5
17324004		



San Luis Drainage Feature Re-evaluation	MIKE 21 Chipps Discharge (June-November 1997) Maximum 30-Day Average Exotic Bivalve Tissue Selenium Concentration Near Discharge and Difference from Baseline Conditions	Figure 8-6
17324004		

mg/kg, with a maximum increase of 0.24 mg/kg as compared to baseline conditions. The 30-day spatial average over the discharge area (as shown on Figure 8-2) is 2.01 mg/kg (see Table 8-7).

Table 8-7
Mean Predicted Native Bivalve Tissue Selenium Concentration (Maximum 30-day Average)

Area Name	Bioaccumulation (mg/kg) Baseline Conditions	Chipps Island Discharge Predictions	Carquinez Strait Discharge Predictions
Chipps Discharge Area (See Figure 8-2)	1.83	2.01	---
Carquinez Discharge Area (See Figure 8-3)	1.97	---	2.07

A BSAF of 12.6 was used to predict Se tissue concentrations in the Asian clam over the same areas and same time frame. Results for the 6-month period indicate that Se concentrations in Asian clams in the South Bay could reach as high as 8 mg/kg in the South Bay and 7 mg/kg in the North Bay. As shown on Figure 8-5, the largest increase in Se tissue concentrations occurs closest to the discharge point, where average Se concentrations in exotic species over the 6-month period are predicted to increase by approximately 0.5 to 0.7 mg/kg. To determine the worst-case increase in Se tissue concentrations in exotic species at this location, the maximum 30-day average was calculated, as shown on Figure 8-2. The maximum predicted 30-day average Se concentration is 6.4 to 6.7 mg/kg, with a maximum increase of 0.7 mg/kg as compared to baseline conditions. The 30-day spatial average over the discharge area (as shown on Figure 8-2) is 6.04 mg/kg (see Table 8-8).

Table 8-8
Mean Predicted Exotic Bivalve Tissue Selenium Concentration (Maximum 30-day Average)

Area Name	Bioaccumulation (mg/kg) Baseline Conditions	Chipps Island Discharge Predictions	Carquinez Strait Discharge Predictions
Chipps Discharge Area (See Figure 8-2)	5.50	6.04	---
Carquinez Discharge Area (See Figure 8-3)	5.92	---	6.22

If Se tissue concentrations in *P. amurensis* are consistently higher than those in other benthic organisms, and if this species comprises a substantial fraction of the food of upper-trophic-level receptors, it is possible that the toxicity threshold of 4 mg/kg may be exceeded even under baseline conditions. As discussed in Section 8.1.4, data indicate that Asian clams do compose a large part of the diet of certain species of birds such as the surf scoter, lesser scaup, and greater scaup, in the North Bay, as well as some species of fish such as white sturgeon and Sacramento splittail. The predicted invertebrate concentrations exceed the threshold for adverse reproductive effects (4 mg/kg) for baseline conditions as well as for the Delta-Chipps Island Disposal Alternative. The threshold for increased adult mortality (10 mg/kg Se; see Appendix G) is not predicted to be exceeded under the modeled conditions, although considerable variation in concentrations occurs under existing conditions, and some exceedances of this threshold are likely to occur under baseline conditions as well as project conditions.

To evaluate the significance of potential effects to shorebirds and fish that may feed primarily on the Asian clam in the most highly affected area near the discharge location, the decrease in projected reproductive success was estimated using toxicity data presented in Appendix G, Section G7.2.1.1. Assuming that the worst-case increase in dietary Se concentration would be from 6.0 to 6.7 mg/kg, the projected decrease in percent eggs hatched was calculated based on the following equation:

$$\text{Percent Eggs Hatched} = 150.2 - 84.06 * \exp(0.03547*[\text{Se}])$$

The percentage of eggs hatched is projected to decrease from approximately 46.2 to 43.6 percent, representing a decrease of approximately 5.7 percent, less than the 10 percent change that would be deemed a significant effect.

Similarly, the projected decrease in percentage survival of ducklings to 6 days of age was calculated based on the following equation:

$$\text{Percent Survival} = 105.8 - 5.058 * \exp(0.1901*[\text{Se}])$$

The survival of ducklings to 6 days of age is projected to decrease from approximately 90.0 to 87.7 percent, representing a decrease of approximately 2.6 percent from baseline conditions, less than the 10 percent change that would be deemed a significant effect.

The projected decrease in number of surviving 6-day-old ducklings produced per hen was calculated based on the following equation:

$$\text{Number of Ducklings} = 17.32 - 8.634 * \exp(0.04374*[\text{Se}])$$

The number of surviving 6-day-old ducklings produced per hen is projected to decrease from approximately 6.1 to 5.7 percent, representing a decrease of approximately 6.6 percent, less than the 10 percent change that would be deemed a significant effect.

Based on the above analysis, no significant effects are expected to occur to populations of shorebirds or fish feeding on the Asian clam or native invertebrates in the Bay-Delta Estuary. It should be noted that the toxicity data used to estimate reproductive effects to the potentially affected species of birds and fish are based on Se toxicity to mallard ducks. As discussed in Appendix G, available toxicity data indicate that mallards are more sensitive to Se than shorebirds are. In addition, uncertainty exists regarding the threshold of 10 percent reduction in reproduction as it relates to actual effects on the population of a given species. The true threshold for effects to the population of a given species would require considerable research to determine, and is dependent on multiple factors such as population size, reproduction rates, predation rates, and lifespan.

8.2.9.3 Special-Status Species

Table 7-4 identifies the listed special-status species that may be present, or that could occasionally utilize suitable habitat, in areas potentially affected by this alternative. This section identifies those special-status species that may be exposed to elevated Se concentrations due to implementation of the Delta-Chipps Island Disposal Alternative.

Operation of this alternative would be unlikely to affect the **bald eagle**, which would favor riparian and reservoir foraging areas with suitable hunting and roosting perches.

The **San Joaquin kit fox** could forage at several of the proposed reuse areas located nearest the eastern edges of the drainage areas, but would be less likely to utilize project sites that are more isolated within the surrounding agricultural landscape. Retirement of large contiguous tracts of cropland in the vicinity of the reuse areas, however, could create travel corridors to the interior sites, expanding potential kit fox foraging areas to include all reuse areas. Portions of the reuse facilities that would be planted in salt-tolerant grasses, grain crops, or permanent pasture could develop a substantial prey base and expose foraging kit fox to elevated Se in common dietary items such as insects, ground-nesting birds, and small mammals. The more intensively cropped portions of the reuse facilities would likely support less abundant prey than the areas planted in cover or pasture crops, or nearby nonirrigated parcels and refuge lands.

Operation of reuse facilities also could adversely affect the **Swainson's hawk** and **greater sandhill crane**. While both species would also be attracted to grasslands, irrigated pasture, and other suitable croplands (including retired lands converted to dryland farming or grazing land), this alternative's reuse areas also would provide attractive foraging habitat, exposing foraging individuals to elevated Se in seeds, grains, worms, insects, and small mammals.

The **California black rail** and the **western yellow-billed cuckoo** would not be affected. Habitat types (emergent marshlands and riparian forest, respectively) utilized by these species would not be affected by operation of any Delta-Chipps Island Disposal Alternative facility.

Burrowing owl colonies occupying the existing San Luis Drain would not be affected by operation of portions of the collection system located within the Drain's ROW if appropriate operating rules and conservation measures are included in a proposed burrowing owl management plan that would be developed for the Drain. This species typically does not nest in areas of heavy vegetation, so it is unlikely to nest in the reuse areas.

The **giant garter snake** and **California red-legged frog** would not be adversely affected by Se bioaccumulation under this alternative. These species, however, could indirectly benefit from a general improvement in water quality in Mud Slough and other Grasslands area waterways.

The **Delta smelt** is known to breed in or migrate through the Delta in the vicinity of the Chipps Island outfall. Presumably, the species could forage near the outfall where elevated Se in the discharge could contaminate or bioaccumulate in prey species or other dietary items. For the Delta smelt, portions of the Bay-Delta in the vicinity of the proposed outfall location have been formally designated by the Service and National Marine Fisheries Service as Critical Habitat, thus requiring special consideration in avoiding any adverse modifications to the species' habitat. However, this species feeds primarily on zooplankton and is unlikely to forage significantly on Asian clams. Juvenile Chinook salmon and steelhead feed primarily on plankton and aquatic invertebrates, while adults feed primarily on fish. Individuals of these species are unlikely to spend long periods of time near the discharge location, but would migrate through the area. No significant effects to this species are expected to occur due to Se bioaccumulation.

Although no evidence indicates that **Chinook salmon** or **steelhead ESUs**, **Delta smelt** would be affected by Se concentrations, white sturgeon are known to accumulate Se at higher concentrations than other fish. There is little information to indicate whether **green sturgeon** would be likely to feed on Asian clams in the vicinity of the discharge location for extended periods of time. In the absence of better information, it is assumed that this species may experience significant adverse effects due to Se bioaccumulation.

8.2.10 Delta-Carquinez Strait Disposal Alternative

8.2.10.1 Terrestrial Resources

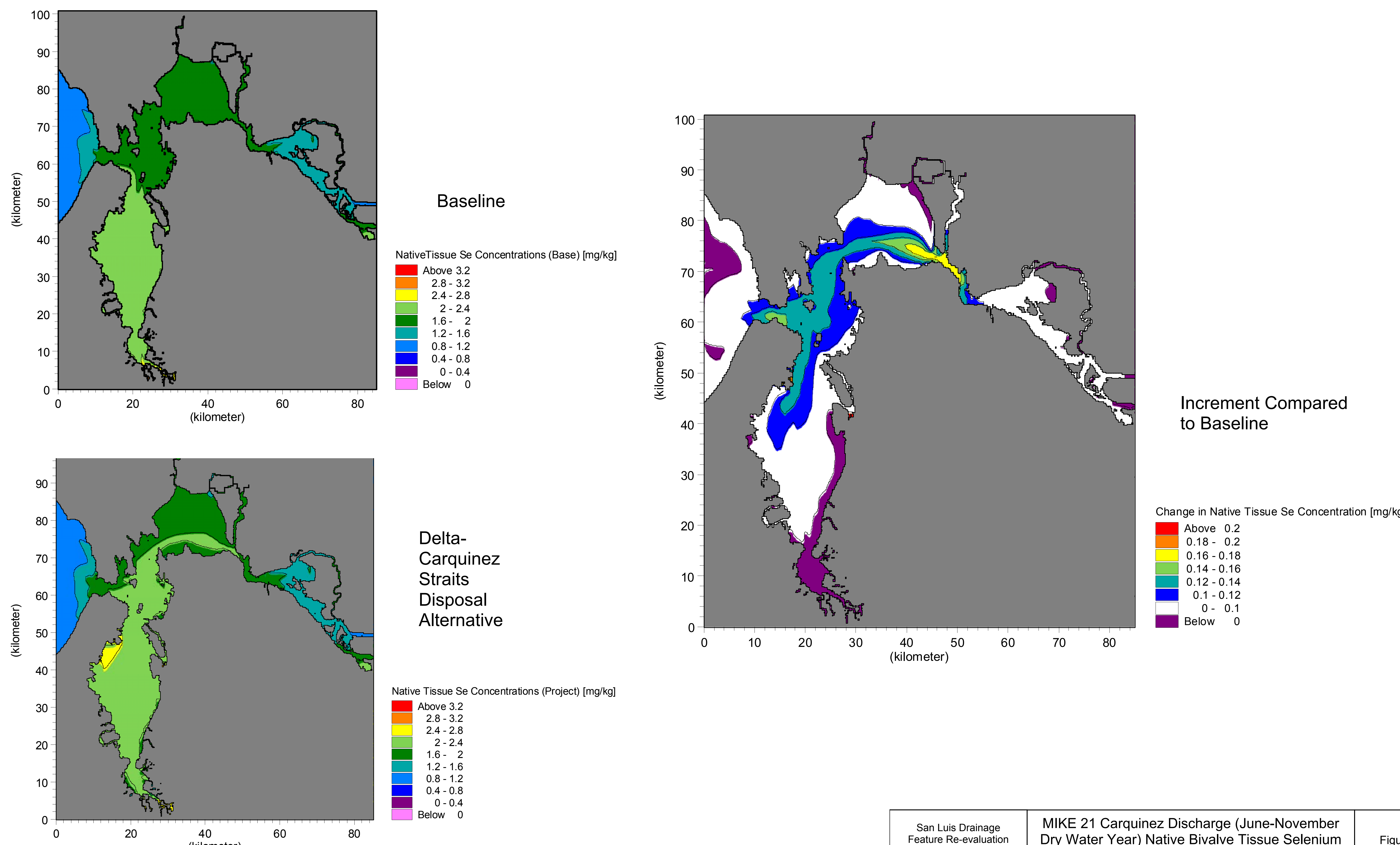
Operation of the Delta-Carquinez Strait aqueduct and buried collection system would not significantly affect terrestrial resources. Buried collection pipelines and aqueduct segments would not expose wildlife to Se-contaminated drainwater. The aqueduct's approximately 73 miles of open canal segments between the biotreatment plant and the discharge at the Carquinez Strait could create a small risk of Se exposure for some species; however, the relatively small concrete-lined structure (normal capacity of 29.1 cfs) would not be particularly attractive to wildlife and would carry only treated drainwater (Se concentration of 10 ppb or less). Furthermore, at least 45.6 miles of the 73 miles of open canal segments that would convey treated drainwater would be located in developed urban and agricultural areas where wildlife exposure would be limited and natural habitat would not be bisected.

The remaining open canal segments, comprised of the southern 56 miles of the existing San Luis Drain and the valley collection canal, would convey untreated drainwater collected from the reuse areas to the treatment facility. Se concentrations in the conveyed drainwater would vary. A portion of this open canal segment passes near or through Federal and State refuges and wildlife areas, presenting additional exposure risk. The potential risk of Se exposure associated with use of the existing Drain segments in these areas would be evaluated and strategies devised to reduce or eliminate identified hazards.

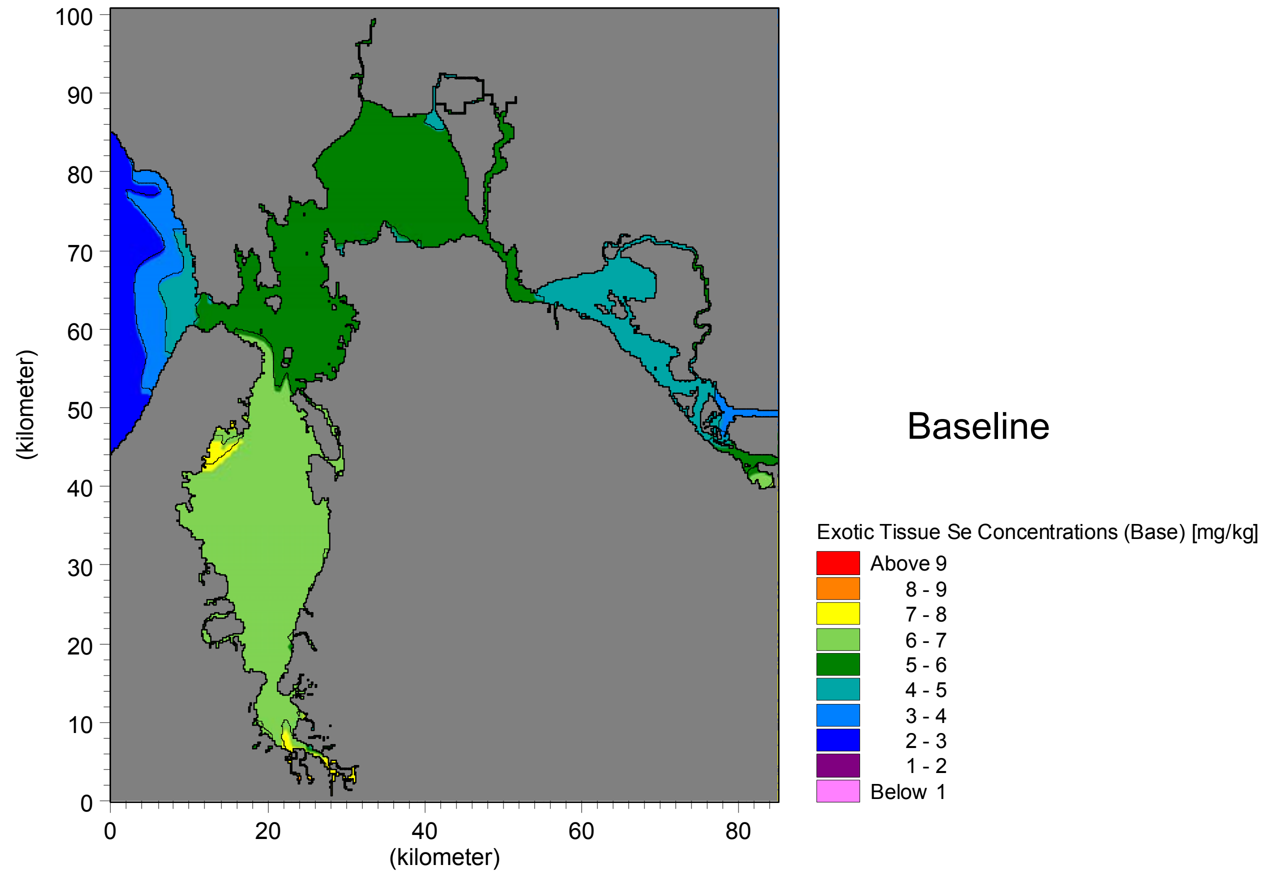
Due to elevated Se concentrations in soil, operation of these reuse areas could increase the risk of Se exposure for some terrestrial species (e.g., seed- and insect-eating species and the larger species that prey on them), potentially resulting in significant effects.

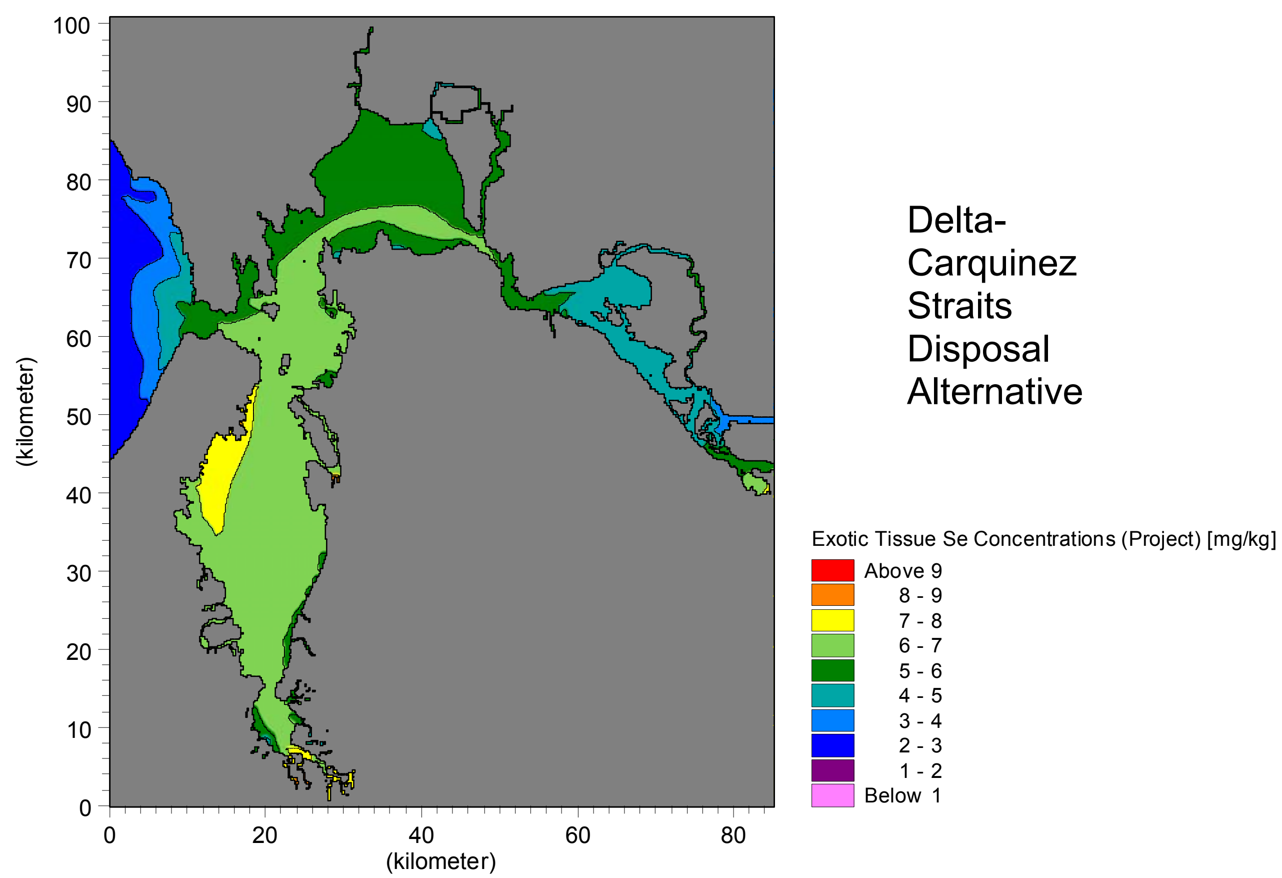
8.2.10.2 Aquatic Resources

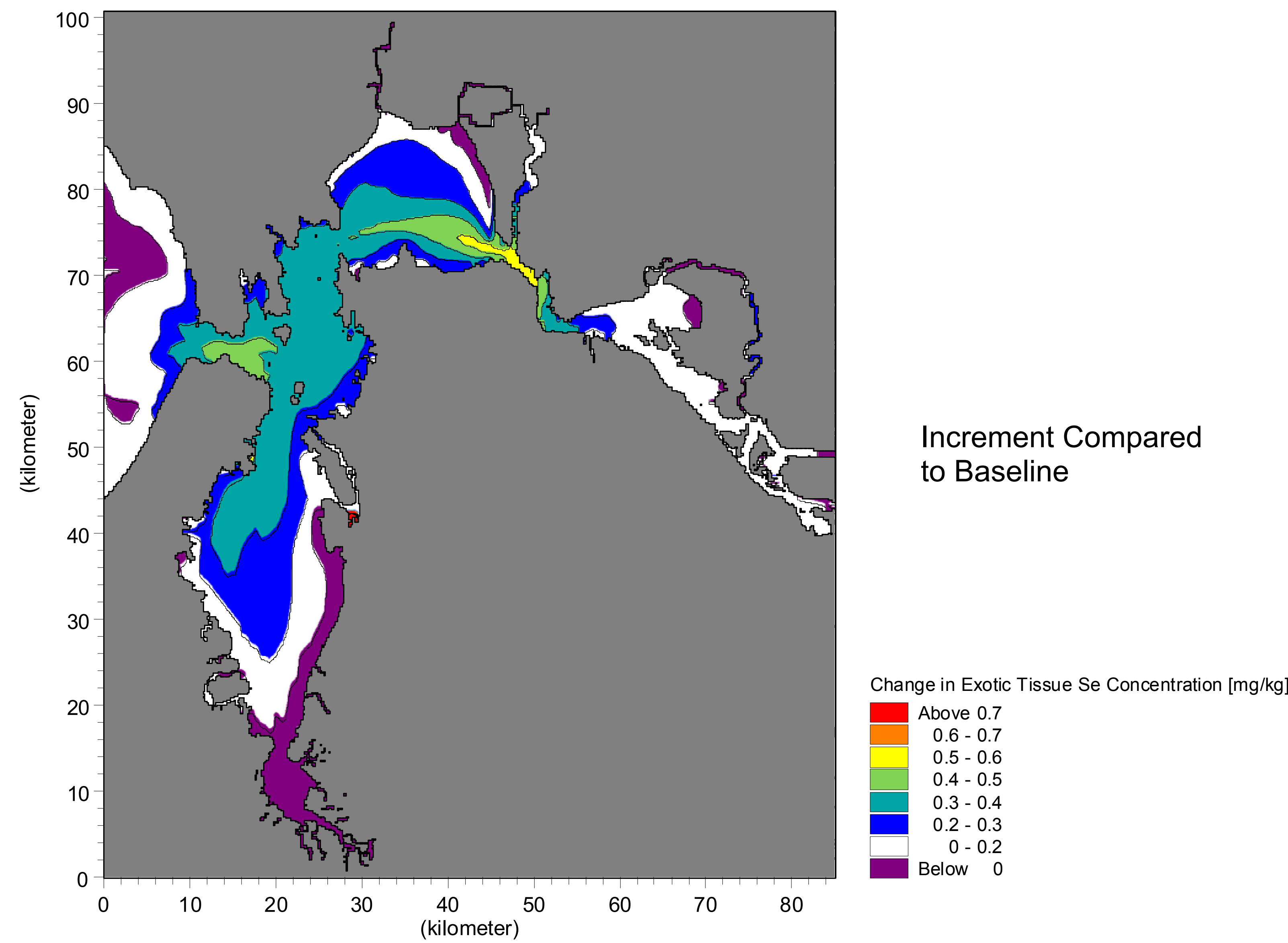
Predicted 6-month average bivalve tissue concentrations throughout the Bay-Delta Estuary for the Delta-Carquinez Strait Disposal Alternative are presented on Figures 8-7 (native species) and 8-8 (exotic species–Asian clam). In addition to predicted concentrations, the incremental change from No Action Alternative conditions is also shown on these figures. Predicted spatial averages of 6-month average Se concentrations in bivalve tissue are presented in Tables 8-5 (native species) and 8-6 (exotic species–Asian clam). Predictions for all scenarios are shown based on bioaccumulation from Se adsorbed to SPM using a BSAF of 4.2 for native species and a BSAF of 12.6 for the Asian clam.



San Luis Drainage Feature Re-evaluation	MIKE 21 Carquinez Discharge (June-November Dry Water Year) Native Bivalve Tissue Selenium Concentration (mg/kg) Predicted Based on BSAF and Adsorbed Selenium	Figure 8-7
17324004		







San Luis Drainage Feature Re-evaluation	MIKE 21 Carquinez Discharge (June-November Dry Water Year) Exotic Bivalve Tissue Selenium Concentration (mg/kg) Predicted Based on BSAF and Adsorbed Selenium	Figure 8-8
17324004		

The most highly affected area under the Delta-Carquinez Strait Disposal Alternative discharge scenario is the North Bay, where average Se concentrations in tissue are predicted to be approximately 6 percent higher than the concentrations under baseline conditions (Tables 8-5 and 8-6).

Under the Delta-Carquinez Strait Disposal Alternative, the highest predicted average native bivalve concentrations are well under 4 mg/kg. These concentrations are not expected to result in significant toxicity to upper trophic level receptors. However, it should be noted that these comparisons are general and that localized effects have the potential to occur at areas with the highest Se concentrations, especially if the more bioavailable forms of Se are present. As shown on Figure 8-7, the largest increment in Se tissue concentrations occurs closest to the discharge point, where average Se concentrations in native species over the 6-month period are predicted to increase by up to 0.18 mg/kg. To determine the worst-case increase in Se tissue concentrations in native species at this location, the maximum 30-day average was calculated, as shown on Figure 8-3. The maximum predicted 30-day average Se concentration is less than 2.3 mg/kg, with a maximum increase of 0.19 mg/kg as compared to baseline conditions. The 30-day spatial average over the discharge area (as shown on Figure 8-3) is 2.07 mg/kg (see Table 8-7).

A BSAF of 12.6 was used to predict Se tissue concentrations in the Asian clam over the same areas and same time frame. Results for the 6-month period indicate that Se concentrations in Asian clams in the South Bay could reach as high as 8 mg/kg in the South Bay and 7 mg/kg in the North Bay. As shown on Figure 8-8, the largest increase in Se tissue concentrations occurs closest to the discharge point, where average Se concentrations in native species over the 6-month period are predicted to increase by up to 0.6 mg/kg. To determine the worst-case increase in Se tissue concentrations in exotic species at this location, the maximum 30-day average was calculated, as shown on Figure 8-9. The maximum predicted 30-day average Se concentration is 6.7 to 7 mg/kg, with a maximum increase of 0.55 mg/kg as compared to baseline conditions. The 30-day spatial average over the discharge area (as shown on Figure 8-9) is 6.22 mg/kg (see Table 8-8).

If Se tissue concentrations in *P. amurensis* are consistently higher than those in other benthic organisms, and if this species comprises a substantial fraction of the food of upper-trophic-level receptors, it is possible that the toxicity threshold of 4 mg/kg may be exceeded even under baseline conditions. As discussed in Section 8.1.4, data indicate that Asian clams do compose a large part of the diet of certain species of birds such as the surf scoter, lesser scaup, and greater scaup in the North Bay, as well as some species of fish such as white sturgeon and Sacramento splittail. The predicted invertebrate concentrations exceed the threshold for adverse reproductive effects (4 mg/kg) for baseline conditions as well as for the Delta-Carquinez Strait Disposal Alternative. The threshold for increased adult mortality (10 mg/kg Se; see Appendix G) is not predicted to be exceeded under the modeled conditions, although considerable variation in concentrations occurs under existing conditions, and some exceedances of this threshold are likely to occur under baseline conditions as well as project alternative conditions.

To evaluate the significance of potential effects to the shorebirds and fish that may feed primarily on the Asian clam in the most highly affected area near the discharge location, the decrease in projected reproductive success was estimated using toxicity data presented in Appendix G, Section G7.2.1.1. Assuming that the worst-case increase in dietary Se concentration would be from 6.45 to 7.0 mg/kg, the projected decrease in percent eggs hatched was calculated based on the following equation:

Percent Eggs Hatched = 150.2 - 84.06 * exp(0.03547*[Se])

The percentage of eggs hatched is projected to decrease from approximately 44.5 to 42.4 percent, representing a decrease of approximately 4.8 percent, less than the 10 percent change that would be deemed a significant effect.

Similarly, the projected decrease in percentage survival of ducklings to 6 days of age was calculated based on the following equation:

Percent Survival = 105.8 - 5.058 * exp(0.1901*[Se])

The survival of ducklings to 6 days of age is projected to decrease from approximately 88.6 to 86.7 percent, representing a decrease of approximately 2.2 percent from baseline conditions, less than the 10 percent change that would be deemed a significant effect.

The projected decrease in number of surviving 6-day-old ducklings produced per hen was calculated based on the following equation:

Number of Ducklings = 17.32 - 8.634 * exp(0.04374*[Se])

The number of surviving 6-day-old ducklings produced per hen is projected to decrease from approximately 5.9 to 5.6 percent, representing a decrease of approximately 5.1 percent, less than the 10 percent change that would be deemed a significant effect.

Based on the above analysis, no significant effects are expected to occur to populations of shorebirds or fish feeding on the Asian clam or native invertebrates in the Bay-Delta Estuary.

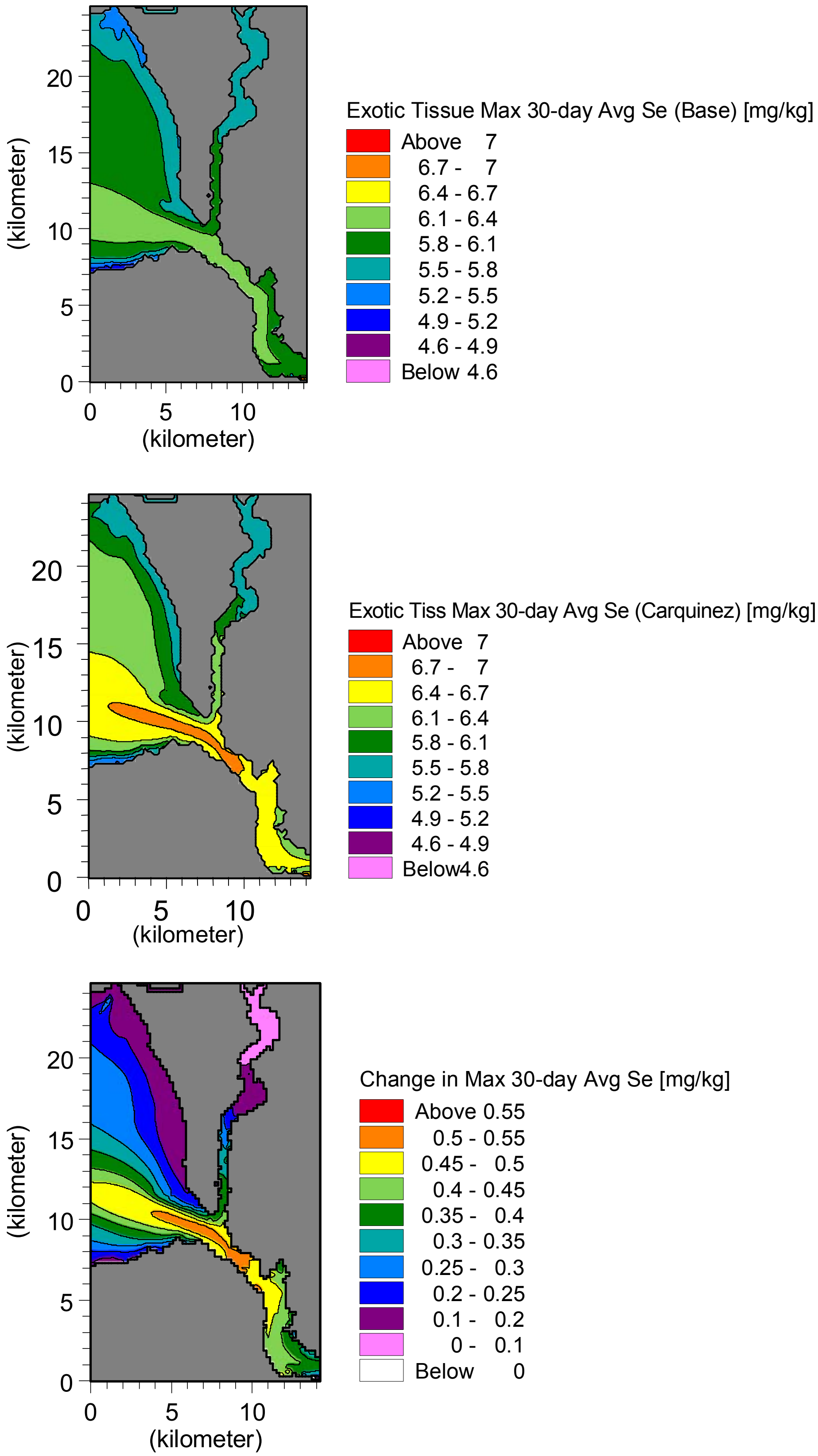
It should be noted that the toxicity data used to estimate reproductive effects to the potentially affected species of birds and fish are based on Se toxicity to mallard ducks. As discussed in Appendix G, available toxicity data indicate that mallards are more sensitive to Se than shorebirds are. In addition, uncertainty exists regarding the threshold of 10 percent reduction in reproduction as it relates to actual effects on the population of a given species. The true threshold for effects to the population of a given species would require considerable research to determine, and is dependent on multiple factors such as population size, reproduction rates, predation rates, and lifespan.

8.2.10.3 Special-Status Species

Table 7-5 identifies the listed special-status species that may be present, or that could occasionally utilize suitable habitat, in areas potentially affected by this alternative. This section identifies those special-status species that may be exposed to elevated Se concentrations due to implementation of the Delta-Carquinez Strait Disposal Alternative.

Operation of this alternative would be unlikely to affect the **bald eagle**, which would favor riparian and reservoir foraging areas with suitable hunting and roosting perches.

The **San Joaquin kit fox** could forage at several of the proposed reuse areas located nearest the eastern edges of the drainage areas, but would be less likely to utilize project sites that are more isolated within the surrounding agricultural landscape. Retirement of large contiguous tracts of cropland in the vicinity of the reuse areas, however, could create travel corridors to the interior



San Luis Drainage Feature Re-evaluation	MIKE 21 Carquinez Discharge (June-November 1997) Maximum 30-Day Average Exotic Bivalve Tissue Selenium Concentration Near Discharge and Difference from Baseline Conditions	Figure 8-9
17324004		

sites, expanding potential kit fox foraging areas to include all reuse areas. Portions of the reuse facilities that would be planted in salt-tolerant grasses, grain crops, or permanent pasture could develop a substantial prey base and expose foraging kit fox to elevated Se in common dietary items such as insects, ground-nesting birds, and small mammals. The more intensively cropped portions of the reuse facilities would likely support less abundant prey than the areas planted in cover or pasture crops, or nearby nonirrigated parcels and refuge lands.

Operation of reuse facilities also could adversely affect the **Swainson's hawk** and **greater sandhill crane**. While both species would also be attracted to grasslands, irrigated pasture, and other suitable croplands (including retired lands converted to dryland farming or grazing land), this alternative's reuse areas also would provide attractive foraging habitat, exposing foraging individuals to elevated Se in seeds, grains, worms, insects, and small mammals.

The **California black rail** and the **western yellow-billed cuckoo** would not be affected. Habitat types (emergent marshlands and riparian forest, respectively) utilized by these species would not be affected by operation of any Delta-Carquinez Strait Disposal Alternative facility.

Burrowing owl colonies occupying the existing San Luis Drain would not be affected by operation of portions of the collection system located within the Drain's ROW if appropriate operating rules and conservation measures are included in a proposed burrowing owl management plan that would be developed for the Drain. This species typically does not nest in areas of heavy vegetation, so it is unlikely to nest in the reuse areas.

The **giant garter snake** and **California red-legged frog** would not be adversely affected by Se bioaccumulation under this alternative. These species, however, could indirectly benefit from a general improvement in water quality in Mud Slough and other Grasslands area waterways.

The **Delta smelt** is known to breed in or migrate through the Delta in the vicinity of the Carquinez Strait outfall. Presumably, the species could forage near the outfall where elevated Se in the discharge could contaminate or bioaccumulate in prey species or other dietary items. For the Delta smelt, portions of the Bay-Delta in the vicinity of the proposed outfall location have been formally designated by the Service and National Marine Fisheries Service as Critical Habitat, thus requiring special consideration in avoiding any adverse modifications to the species' habitat. However, this species feeds primarily on zooplankton and is unlikely to forage significantly on Asian clams. Juvenile Chinook salmon and steelhead feed primarily on plankton and aquatic invertebrates, while adults feed primarily on fish. Individuals of these species are unlikely to spend long periods of time near the discharge location, but would migrate through the area. No significant effects to this species are expected to occur due to Se bioaccumulation.

Although no evidence indicates that **Chinook salmon** or **steelhead ESUs**, **Delta smelt** would be affected by Se concentrations, white sturgeon are known to accumulate Se at higher concentrations than other fish. There is little information to indicate whether **green sturgeon** would be likely to feed on Asian clams in the vicinity of the discharge location for extended periods of time. In the absence of better information, it is assumed that this species may experience significant adverse effects due to Se bioaccumulation.

8.2.11 Cumulative Effects

The In-Valley Alternatives that include evaporation basins would likely contribute to Se bioaccumulation by birds within the San Joaquin Valley. When this contribution of up to 3,300 acres (not significant by itself with mitigation) is combined with the effects of other existing evaporation basins (4,000 acres) within the San Joaquin Valley, these incremental effects could contribute to a significant cumulative adverse effect to birds within the valley from approximately 7,300 total acres of evaporation basins.

For both of the Delta Disposal Alternatives, changes in Se bioaccumulation are primarily dependent on changes in surface water quality. As discussed in Section 5.2.12, cumulative effects on water quality from other ongoing projects were included in the evaluation of the action alternatives. For future projects, such as implementation of TMDLs for Se in the San Joaquin River Basin, it was assumed that required actions needed to comply with discharge requirements would be taken. Therefore, the cumulative effects of future projects to comply with TMDLs were included in the analysis. In addition, flows planned under the VAMP were included in the analysis. Other programs relevant to water quality in the Bay-Delta include the CALFED Bay-Delta Program, Interim South Delta Program, SJVDIP, and CVPIA. Implementation of these programs is expected to reduce Se concentrations in surface waters of the Bay-Delta. Therefore, no additional Se bioaccumulation is expected to occur in combination with the increased Se bioaccumulation due to the Delta-Chipps Island Disposal Alternative or the Delta-Carquinez Straits Disposal Alternative. No significant cumulative Se bioaccumulation effects are expected to occur if either of these alternatives is implemented.

For the Ocean Disposal Alternative, existing discharges in the Point Estero vicinity are described in Section 5.1.4. No new sources of Se discharges are currently proposed in this vicinity. Cumulative effects are not expected to occur, because mixing zones for the Ocean Disposal Alternative discharge location and existing discharge locations are not expected to overlap and Se is not known to be a compliance or environmental issue with these discharges.

Due to elevated Se concentrations in soil, operation of the reuse areas could increase the risk of Se exposure for some terrestrial species (e.g., seed- and insect-eating species and the larger species that prey on them), potentially resulting in significant effects under operation of any of the action alternatives. Therefore, significant cumulative effects to terrestrial resources would be expected to occur under any of the alternatives.

8.2.12 Environmental Effects Summary

The following sections and tables summarize the evaluation of effects relative to baseline conditions which are used to represent both existing conditions and the No Action Alternative.

8.2.12.1 No Action Alternative

- It is anticipated that adverse effects to surface water quality in the San Joaquin Valley wetlands would occur under the No Action Alternative relative to existing conditions due to seepage into wetland channels. Therefore, because Se bioaccumulation is primarily dependent on water quality, potentially adverse effects to aquatic receptors related to changes in Se bioaccumulation are anticipated to occur in the San Joaquin Valley and the Bay-Delta under the No Action Alternative. Special-status species affected may include the giant garter snake and California red-legged frog.

8.2.12.2 In-Valley Disposal Alternative

- Predicted mean Se concentrations in dietary tissue exceed the effects threshold of 4 mg/kg for all four evaporation basins during the breeding season. Therefore, significant effects to birds using the evaporation basins would be expected to occur under the unmitigated alternative. Potential adverse effects include decreased reproduction and development, as well as direct mortality. With successful mitigation, the effect would be reduced to not significant.
- Operation of the In-Valley Disposal facilities may adversely affect San Joaquin kit fox, Swainson's hawks, and wintering greater sandhill cranes (at proposed reuse areas) and American peregrine falcons (at evaporation basins) by increasing potential exposure to elevated Se in preferred dietary items. Any taking under ESA/CESA would be considered a significant effect. Avoidance and mitigation measures for these upland species would reduce, but may not entirely eliminate, the potential for Se bioaccumulation. Additional studies and monitoring would be needed, and Section 7 consultation with the Service is required.
- The In-Valley Disposal Alternative would continue to reduce uncontrolled seepage of Se-contaminated drainwater into the San Joaquin River, as well as into drainage ditches, canals (including the Delta-Mendota Canal), and other waterways (e.g., Mud Slough), thus improving the water quality in habitats potentially used by the giant garter snake and California red-legged frog. The incremental reduction in Se load in the lower San Joaquin River and the Bay-Delta resulting from implementation of the In-Valley Disposal Alternative may benefit Chinook salmon, Central Valley steelhead, Delta smelt, and green sturgeon.

8.2.12.3 In-Valley/Groundwater Quality Land Retirement Alternative

- Although predicted mean Se concentrations in migratory bird dietary tissue in evaporation basins were not quantitatively evaluated, they are expected to be similar to those predicted under the In-Valley Disposal Alternative, and would exceed the effects threshold of 4 mg/kg for all four evaporation basins during the breeding season. Therefore, significant effects to birds using the evaporation basins would be expected to occur under the unmitigated alternative.
- Operation of the In-Valley/Groundwater Quality Land Retirement Disposal facilities may adversely affect San Joaquin kit fox, Swainson's hawks, and wintering greater sandhill cranes (at proposed reuse areas) and American peregrine falcons (at evaporation basins) by increasing potential exposure to elevated Se in preferred dietary items. Any taking under ESA/CESA would be considered a significant effect. Avoidance and mitigation measures for these upland species would reduce, but may not entirely eliminate, the potential for Se bioaccumulation. Additional studies and monitoring would be needed, and Section 7 consultation with the Service is required.
- This alternative would continue to reduce uncontrolled seepage of Se-contaminated drainwater into the San Joaquin River, as well as into drainage ditches, canals (including the Delta-Mendota Canal), and other waterways (e.g., Mud Slough), thus improving the water quality in habitats potentially used by the giant garter snake and California red-legged frog. The incremental reduction in Se load in the lower San Joaquin River and the Bay-Delta resulting from implementation of the In-Valley/Groundwater Quality Land Retirement

Alternative may benefit Chinook salmon, Central Valley steelhead, Delta smelt, and green sturgeon.

8.2.12.4 In-Valley/Water Needs Land Retirement Alternative

- Although predicted mean Se concentrations in migratory bird dietary tissue in evaporation basins were not quantitatively evaluated, they are expected to be similar to those predicted under the In-Valley Disposal Alternative, and would exceed the effects threshold of 4 mg/kg for all four evaporation basins during the breeding season. Therefore, significant effects to birds using the evaporation basins would be expected to occur under the unmitigated alternative.
- Operation of the In-Valley/Water Needs Land Retirement Disposal facilities may adversely affect San Joaquin kit fox, Swainson's hawks, and wintering greater sandhill cranes (at proposed reuse areas) and American peregrine falcons (at evaporation basins) by increasing potential exposure to elevated Se in preferred dietary items. Any taking under ESA/CESA would be considered a significant effect. Avoidance and mitigation measures for these upland species would reduce, but may not entirely eliminate, the potential for Se bioaccumulation. Additional studies and monitoring would be needed, and Section 7 consultation with the Service is required.
- This alternative would continue to reduce uncontrolled seepage of Se-contaminated drainwater into the San Joaquin River, as well as into drainage ditches, canals (including the Delta-Mendota Canal), and other waterways (e.g., Mud Slough), thus improving the water quality in habitats potentially used by the giant garter snake and California red-legged frog. The incremental reduction in Se load in the lower San Joaquin River and the Bay-Delta resulting from implementation of the In-Valley/Water Needs Land Retirement Alternative may benefit Chinook salmon, Central Valley steelhead, Delta smelt, and green sturgeon.

8.2.12.5 In-Valley/Drainage-Impaired Area Land Retirement Alternative

- Although predicted mean Se concentrations in migratory bird dietary tissue in evaporation basins were not quantitatively evaluated, they are expected to be similar to those predicted under the In-Valley Disposal Alternative, and would exceed the effects threshold of 4 mg/kg for all four evaporation basins during the breeding season. Therefore, significant effects to birds using the evaporation basins would be expected to occur under the unmitigated alternative.
- Operation of the In-Valley/Drainage-Impaired Land Retirement Disposal facilities may adversely affect San Joaquin kit fox, Swainson's hawks, and wintering greater sandhill cranes (at proposed reuse areas) and American peregrine falcons (at evaporation basins) by increasing potential exposure to elevated Se in preferred dietary items. Any taking under ESA/CESA would be considered a significant effect. Avoidance and mitigation measures for these upland species would reduce, but may not entirely eliminate, the potential for Se bioaccumulation. Additional studies and monitoring would be needed, and Section 7 consultation with the Service is required.
- This alternative would continue to reduce uncontrolled seepage of Se-contaminated drainwater into the San Joaquin River, as well as into drainage ditches, canals (including the

Delta-Mendota Canal), and other waterways (e.g., Mud Slough), thus improving the water quality in habitats potentially used by the giant garter snake and California red-legged frog. The incremental reduction in Se load in the lower San Joaquin River and the Bay-Delta resulting from implementation of the In-Valley/Drainage-Impaired Land Retirement Alternative may benefit Chinook salmon, Central Valley steelhead, Delta smelt, and green sturgeon.

8.2.12.6 Ocean Disposal Alternative

- No significant increases in Se concentrations in surface water, sediments, or invertebrate tissue are predicted under this alternative. Therefore, no significant effects to aquatic resources due to Se bioaccumulation would be expected. Compared to both the No Action Alternative and baseline conditions, operation of the Ocean Disposal Alternative's Point Estero discharge would result in a minor increase the risk of Se bioaccumulation in the general vicinity of the ocean outfall. However, the depth and offshore location of the diffuser would limit the exposure risk to not significant levels.
- Operation of the Ocean Disposal facilities may adversely affect San Joaquin kit fox, Swainson's hawks, and wintering greater sandhill cranes at proposed reuse areas by increasing potential exposure to elevated Se in preferred dietary items. Any taking under ESA/CESA would be considered a significant effect. Avoidance and mitigation measures for these upland species would reduce, but may not entirely eliminate, the potential for Se bioaccumulation. Additional studies and monitoring would be needed, and Section 7 consultation with the Service is required.
- This alternative would continue to reduce uncontrolled seepage of Se-contaminated drainwater into the San Joaquin River, as well as into drainage ditches, canals (including the Delta-Mendota Canal), and other waterways (e.g., Mud Slough), thus improving the water quality in habitats potentially used by the giant garter snake and California red-legged frog. The incremental reduction in Se load in the lower San Joaquin River and the Bay-Delta resulting from implementation of the Ocean Disposal Alternative may benefit Chinook salmon, Central Valley steelhead, Delta smelt, and green sturgeon.

8.2.12.7 Delta-Chipps Island Disposal Alternative

- Under this alternative, the highest predicted average bivalve concentrations are well below 4 mg/kg. These concentrations are not expected to result in significant toxicity to upper trophic level aquatic receptors, including waterbirds. However, it should be noted that these comparisons are general, that localized effects have the potential to occur at areas with the highest Se concentrations, and that accumulation in certain species such as P. amurensis may be higher than indicated in this evaluation. If the green sturgeon is present in the affected area, this special-status species may experience significant adverse effects.
- Operation of the Delta-Chipps Island Disposal facilities may adversely affect San Joaquin kit fox, Swainson's hawks, and wintering greater sandhill cranes at proposed reuse areas by increasing potential exposure to elevated Se in preferred dietary items. Any taking under ESA/CESA would be considered a significant effect. Avoidance and mitigation measures for these upland species would reduce, but may not entirely eliminate, the potential for Se

bioaccumulation. Additional studies and monitoring would be needed, and Section 7 consultation with the Service is required.

- This alternative would continue to reduce uncontrolled seepage of Se-contaminated drainwater into the San Joaquin River, as well as into drainage ditches, canals (including the Delta-Mendota Canal), and other waterways (e.g., Mud Slough), thus improving the water quality in habitats potentially used by the giant garter snake and California red-legged frog. The incremental reduction in Se load in the lower San Joaquin River and the Bay-Delta resulting from implementation of the Delta-Chipps Island Disposal Alternative may benefit Chinook salmon, Central Valley steelhead, Delta smelt, and green sturgeon.

8.2.12.8 Delta-Carquinez Strait Disposal Alternative

- Under this alternative, the highest predicted average bivalve concentrations are well below 4 mg/kg. These concentrations are not expected to result in significant toxicity to upper trophic level receptors. However, it should be noted that these comparisons are general, that localized effects have the potential to occur at areas with the highest Se concentrations, and that accumulation in certain species such as *P. amurensis* may be higher than indicated in this evaluation. If the green sturgeon is present in the affected area, this special-status species may experience significant adverse effects.
- Operation of the Delta-Carquinez Strait Disposal facilities may adversely affect San Joaquin kit fox, Swainson’s hawks, and wintering greater sandhill cranes at proposed reuse areas by increasing potential exposure to elevated Se in preferred dietary items. Any taking under ESA/CESA would be considered a significant effect. Avoidance and mitigation measures for these upland species would reduce, but may not entirely eliminate, the potential for Se bioaccumulation. Additional studies and monitoring would be needed, and Section 7 consultation with the Service is required.
- This alternative would continue to reduce uncontrolled seepage of Se-contaminated drainwater into the San Joaquin River, as well as into drainage ditches, canals (including the Delta-Mendota Canal), and other waterways (e.g., Mud Slough), thus improving the water quality in habitats potentially used by the giant garter snake and California red-legged frog. The incremental reduction in Se load in the lower San Joaquin River and the Bay-Delta resulting from implementation of the Delta-Carquinez Strait Disposal Alternative may benefit Chinook salmon, Central Valley steelhead, Delta smelt, and green sturgeon.

Tables 8-9 through 8-16 summarize the results of the bioaccumulation analysis.

Table 8-9
Summary Comparison of Effects of No Action Alternative

Affected Resource and Area of Potential Effect	No Action Alternative Compared to Existing Conditions
Terrestrial Resources	
Population-level effects to terrestrial resources in the San Joaquin Valley	No effect.
Aquatic and Wetland Resources	
Population-level effects to aquatic resources (including waterbirds) in the Bay-Delta	Adverse effect.
Population-level effects to aquatic resources (including waterbirds) in the San Joaquin Valley	Potential adverse effect.
Population-level effects to aquatic resources (including waterbirds) in Morro Bay	No effect.
Federally Listed Special-Status Species	
Individual-level effects to Federally listed special-status species in the Bay Delta	No effect.
Individual-level effects to Federally listed special-status species in the San Joaquin Valley	Potential effects to the giant garter snake and California red-legged frog.
Individual-level effects to Federally listed special-status species in Morro Bay	No effect.
State-Listed Special-Status Species	
Individual-level effects to State-listed special-status species in the Bay Delta	No effect.
Individual-level effects to State-listed special-status species in the San Joaquin Valley	Potential effects to the giant garter snake and California red-legged frog.
Individual-level effects to State-listed special-status species in Morro Bay	No effect.

Table 8-10
Summary Comparison of Effects of In-Valley Disposal Alternative

Affected Resource and Area of Potential Effect	In-Valley Disposal Compared to No Action	In-Valley Disposal Compared to Existing Conditions
Terrestrial Resources		
Population-level effects to terrestrial resources in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Aquatic and Wetland Resources		
Population-level effects to aquatic resources (including waterbirds) in the Bay-Delta	No significant effect.	No effect.
Population-level effects to aquatic resources (including waterbirds) in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Population-level effects to aquatic resources (including waterbirds) in Morro Bay	No significant effect.	No effect.
Federally Listed Special-Status Species		
Individual-level effects to Federally listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to Federally listed special-status species in the San Joaquin Valley	Significant adverse effects to the San Joaquin kit fox. Section 7 consultation would be initiated.	Potential effects to the San Joaquin kit fox.
Individual-level effects to Federally listed special-status species in Morro Bay	No significant effect.	No effect.
State-Listed Special-Status Species		
Individual-level effects to State-listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to State-listed special-status species in the San Joaquin Valley	Significant adverse effects to the American peregrine falcon, Swainson's hawk, greater sandhill crane, and San Joaquin kit fox. Potentially unavoidable.	Potential effects to the American peregrine falcon, Swainson's hawk, greater sandhill crane, and San Joaquin kit fox.
Individual-level effects to State-listed special-status species in Morro Bay	No significant effect.	No effect.

Table 8-11
Summary Comparison of Effects of
In-Valley/Groundwater Quality Land Retirement Alternative

Affected Resource and Area of Potential Effect	In-Valley Groundwater Quality Land Retirement Compared to No Action	In-Valley Groundwater Quality Land Retirement Compared to Existing Conditions
Terrestrial Resources		
Population-level effects to terrestrial resources in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Aquatic and Wetland Resources		
Population-level effects to aquatic resources (including waterbirds) in the Bay-Delta	No significant effect.	No effect.
Population-level effects to aquatic resources (including waterbirds) in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Population-level effects to aquatic resources (including waterbirds) in Morro Bay	No significant effect.	No effect.
Federally Listed Special-Status Species		
Individual-level effects to Federally listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to Federally listed special-status species in the San Joaquin Valley	Significant adverse effects to the San Joaquin kit fox. Section 7 consultation would be initiated.	Potential effects to the San Joaquin kit fox.
Individual-level effects to Federally listed special-status species in Morro Bay	No significant effect.	No effect.
State-Listed Special-Status Species		
Individual-level effects to State-listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to State-listed special-status species in the San Joaquin Valley	Significant adverse effects to the American peregrine falcon, Swainson’s hawk, greater sandhill crane, and San Joaquin kit fox. Potentially unavoidable.	Potential effects to the American peregrine falcon, Swainson’s hawk, greater sandhill crane, and San Joaquin kit fox.
Individual-level effects to State-listed special-status species in Morro Bay	No significant effect.	No effect.

Table 8-12
Summary Comparison of Effects of
In-Valley/Water Needs Land Retirement Alternative

Affected Resource and Area of Potential Effect	In-Valley/Water Needs Land Retirement Compared to No Action	In-Valley/Water Needs Land Retirement Compared to Existing Conditions
Terrestrial Resources		
Population-level effects to terrestrial resources in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Aquatic and Wetland Resources		
Population-level effects to aquatic resources (including waterbirds) in the Bay-Delta	No significant effect.	No effect.
Population-level effects to aquatic resources (including waterbirds) in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Population-level effects to aquatic resources (including waterbirds) in Morro Bay	No significant effect.	No effect.
Federally Listed Special-Status Species		
Individual-level effects to Federally listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to Federally listed special-status species in the San Joaquin Valley	Significant adverse effects to the San Joaquin kit fox. Section 7 consultation would be initiated.	Potential effects to the San Joaquin kit fox.
Individual-level effects to Federally listed special-status species in Morro Bay	No significant effect.	No effect.
State-Listed Special-Status Species		
Individual-level effects to State-listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to State-listed special-status species in the San Joaquin Valley	Significant adverse effects to the American peregrine falcon, Swainson’s hawk, greater sandhill crane, and San Joaquin kit fox. Potentially unavoidable.	Potential effects to the American peregrine falcon, Swainson’s hawk, greater sandhill crane, and San Joaquin kit fox.
Individual-level effects to State-listed special-status species in Morro Bay	No significant effect.	No effect.

Table 8-13
Summary Comparison of Effects of
In-Valley/Drainage-Impaired Area Land Retirement Alternative

Affected Resource and Area of Potential Effect	In-Valley/Drainage-Impaired Area Land Retirement Compared to No Action	In-Valley/Drainage-Impaired Area Land Retirement Compared to Existing Conditions
Terrestrial Resources		
Population-level effects to terrestrial resources in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Aquatic and Wetland Resources		
Population-level effects to aquatic resources (including waterbirds) in the Bay-Delta	No significant effect.	No effect.
Population-level effects to aquatic resources (including waterbirds) in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Population-level effects to aquatic resources (including waterbirds) in Morro Bay	No significant effect.	No effect.
Federally Listed Special-Status Species		
Individual-level effects to Federally listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to Federally listed special-status species in the San Joaquin Valley	Significant adverse effects to the San Joaquin kit fox. Section 7 consultation would be initiated.	Potential effects to the San Joaquin kit fox.
Individual-level effects to Federally listed special-status species in Morro Bay	No significant effect.	No effect.
State-Listed Special-Status Species		
Individual-level effects to State-listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to State-listed special-status species in the San Joaquin Valley	Significant adverse effects to the American peregrine falcon, Swainson's hawk, greater sandhill crane, and San Joaquin kit fox. Potentially unavoidable.	Potential effects to the American peregrine falcon, Swainson's hawk, greater sandhill crane, and San Joaquin kit fox.
Individual-level effects to State-listed special-status species in Morro Bay	No significant effect.	No effect.

Table 8-14
Summary Comparison of Effects of Ocean Disposal Alternative

Affected Resource and Area of Potential Effect	Ocean Disposal Compared to No Action	Ocean Disposal Compared to Existing Conditions
Terrestrial Resources		
Population-level effects to terrestrial resources in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Aquatic and Wetland Resources		
Population-level effects to aquatic resources (including waterbirds) in the Bay-Delta	No significant effect.	No effect.
Population-level effects to aquatic resources (including waterbirds) in the San Joaquin Valley	No significant effect.	No effect.
Population-level effects to aquatic resources (including waterbirds) in Morro Bay	No significant effect.	No effect.
Federally Listed Special-Status Species		
Individual-level effects to Federally listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to Federally listed special-status species in the San Joaquin Valley	Significant adverse effects to the San Joaquin kit fox. Section 7 consultation would be initiated.	Potential effects to the San Joaquin kit fox.
Individual-level effects to Federally listed special-status species in Morro Bay	No significant effect.	No effect.
State-Listed Special-Status Species		
Individual-level effects to State-listed special-status species in the Bay Delta	No significant effect.	No effect.
Individual-level effects to State-listed special-status species in the San Joaquin Valley	Significant adverse effects to the Swainson's hawk, greater sandhill crane, and San Joaquin kit fox. Potentially unavoidable.	Potential effects to the Swainson's hawk, greater sandhill crane, and San Joaquin kit fox.
Individual-level effects to State-listed special-status species in Morro Bay	No significant effect.	No effect.

Table 8-15
Summary Comparison of Effects of Delta-Chipps Island Disposal Alternative

Affected Resource and Area of Potential Effect	Delta-Chipps Island Disposal Compared to No Action	Delta-Chipps Island Disposal Compared to Existing Conditions
Population-level effects to terrestrial resources in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Aquatic and Wetland Resources		
Population-level effects to aquatic resources (including waterbirds) in the Bay-Delta	No significant effect.	No adverse effect.
Population-level effects to aquatic resources (including waterbirds) in the San Joaquin Valley	No significant effect.	No effect.
Population-level effects to aquatic resources (including waterbirds) in Morro Bay	No significant effect.	No effect.
Federally Listed Special-Status Species		
Individual-level effects to Federally listed special-status species in the Bay Delta	Significant adverse effects to the green sturgeon (currently a Federal candidate species). Section 7 consultation would be initiated.	Potential effects to the green sturgeon (currently a Federal candidate species) and the San Joaquin kit fox.
Individual-level effects to Federally listed special-status species in the San Joaquin Valley	Significant adverse effects to the San Joaquin kit fox. Section 7 consultation would be initiated.	Potential effects to the San Joaquin kit fox.
Individual-level effects to Federally listed special-status species in Morro Bay	No significant effect.	No effect.
State-Listed Special-Status Species		
Individual-level effects to State-listed special-status species in the Bay Delta	Significant adverse effects to the green sturgeon. Potentially unavoidable.	No effect.
Individual-level effects to State-listed special-status species in the San Joaquin Valley	Significant effects Swainson’s hawk, greater sandhill crane, and San Joaquin kit fox. Potentially unavoidable.	Potential effects to the Swainson’s hawk, greater sandhill crane, green sturgeon, and San Joaquin kit fox.
Individual-level effects to State-listed special-status species in Morro Bay	No significant effect.	No effect.

Table 8-16
Summary Comparison of Effects of Delta-Carquinez Strait Disposal Alternative

Affected Resource and Area of Potential Effect	Delta-Carquinez Strait Disposal Compared to No Action	Delta-Carquinez Strait Disposal Compared to Existing Conditions
Population-level effects to terrestrial resources in the San Joaquin Valley	Significant adverse effect; with mitigation = not significant.	Adverse effect; mitigation feasible.
Aquatic and Wetland Resources		
Population-level effects to aquatic resources (including waterbirds) in the Bay-Delta	No significant effect.	No adverse effect.
Population-level effects to aquatic resources (including waterbirds) in the San Joaquin Valley	No significant effect.	No effect.
Population-level effects to aquatic resources (including waterbirds) in Morro Bay	No significant effect.	No effect.
Federally Listed Special-Status Species		
Individual-level effects to Federally listed special-status species in the Bay Delta	Significant adverse effects to the green sturgeon (currently a Federal candidate species). Section 7 consultation would be initiated.	Potential effects to the green sturgeon (currently a Federal candidate species) and the San Joaquin kit fox.
Individual-level effects to Federally listed special-status species in the San Joaquin Valley	Significant effects to the San Joaquin kit fox. Section 7 consultation would be initiated.	Potential effects to the San Joaquin kit fox.
Individual-level effects to Federally listed special-status species in Morro Bay	No significant effect.	No effect.
State-Listed Special-Status Species		
Individual-level effects to State-listed special-status species in the Bay Delta	Significant adverse effects to the green sturgeon. Section 7 consultation would be initiated.	No effect.
Individual-level effects to State-listed special-status species in the San Joaquin Valley	Significant adverse effects to the Swainson's hawk, greater sandhill crane, and San Joaquin kit fox. Potentially unavoidable.	Potential effects to the Swainson's hawk, greater sandhill crane, green sturgeon, and San Joaquin kit fox.
Individual-level effects to State-listed special-status species in Morro Bay	No significant effect.	No effect.

8.2.13 Mitigation Recommendations

Design and management of the evaporation basins proposed under the In-Valley Disposal Alternative should incorporate measures that minimize wildlife exposure to Se. These measures would include, but not be limited to:

- Maintaining basin depths greater than 4 feet
- Vegetation control to minimize nesting and roosting habitat
- No islands or windbreaks
- Side slopes at least 3:1
- Hazing

In addition, mitigation habitat would be created to attract birds away from the evaporation basins, dilute the average Se concentration in the diet of birds foraging at the evaporation basins, and compensate for affected bird populations. Recommendations for mitigation are presented in Section 20, Conceptual Mitigation and Monitoring Program.