B.F. Sisk Dam Safety of Dam Modification Project Environmental Impact Statement / Environmental Impact Report

Appendix A: Water Quality Technical Appendix

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Appendix A
Water Quality Technical Appendix

The Water Quality Technical Appendix supplements Chapter 4, Water Quality, in the B.F. Sisk Dam Safety of Dams (SOD) Modification Project (Project) Environmental Impact Statement/Environmental Impact Report (EIS/EIR). The sections below provide detailed information about constituents of concern listed in the Clean Water Act (CWA) and beneficial uses of California waters defined in the California Water Code. This section also discusses water quality in the San Joaquin-Sacramento Delta, and general water quality characteristics of reservoirs.

A.1 Constituents of Concern of 303(d) Listed Water bodies

Various water bodies within the B.F. Sisk Dam SOD Project area of analysis have been identified as impaired for certain constituents of concern, as listed on the 2012 303(d) list under the CWA. Table A-1 presents the 303(d) listed water bodies within the B.F. Sisk Dam SOD Project area and the constituents of concern contributing to their impairment. Sections A.1.1 through A.1.8 provide information on the constituents concern listed in Table A-1.

Table A-1. 303(d) Listed Water Bodies Within the B.F. Sisk Dam SOD Project Area of Analysis and Associated Constituents of Concern

Name	Constituent	Potential Sources	Estimated Area Affected [1]	Proposed TMDL Completion Year	Region
O'Neill Forebay	Mercury	Source Unknown	2,254 Acres	2012	Merced County
Sacramento-San Joaquin River Delta	Chlordane	Nonpoint Source	9,204 acres	2013	Contra Costa, Sacramento, San Joaquin, Solano and Yolo Counties
	DDT	Nonpoint Source	9,204 acres	2013	
	Dieldrin	Nonpoint Source	9,204 acres	2013	
	Dioxin Compounds (2,3,7,8-TCDD)	Atmospheric Deposition	9,204 acres	2019	
	Invasive Species	Ballast Water	9,204 acres	2019	
	Furan Compounds	Atmospheric Deposition	9,204 acres	2019	
	Mercury	Industrial Point Sources Municipal Point Sources Resource Extraction Atmospheric Deposition Natural Sources Nonpoint Source	9,204 acres	2008	
	PCBs	Unknown Nonpoint Source	9,204 acres	2008	
	PCBs (dioxin-like)	Unknown Nonpoint Source	9,204 acres	2008	
	Selenium	Domestic Use of Ground Water	9,204 acres	2019	
San Luis Reservoir	Mercury	Source Unknown	13, 007 Acres	2021	Merced County

Source: Regional Water Quality Control Board, Central Valley Region (CVRWQCB) 2012.

[1] Estimated area affected is given as the surface area (acres) of lakes or estuaries or length (river miles) for river systems.

A.1.1 Chlordane

Chlordane is a manufactured chemical that was used as a pesticide in the United States from 1948 to 1988. Technically, chlordane is not a single chemical, but is actually a mixture of pure chlordane mixed with many related chemicals. It does not occur naturally in the environment. It is a thick liquid whose color ranges from colorless to amber. Chlordane has a mild, irritating smell. Some of its trade names are Octachlor and Velsicol 1068. Until 1983, chlordane was used as a pesticide on crops like corn and citrus and on home lawns and gardens. Because of concern about damage to the environment and harm to human health, the USEPA banned all uses of chlordane in 1983 except to control termites. In 1988, The United States Environmental Protection Agency (USEPA) banned all uses (Agency for Toxic Substances and Disease Registry [ATSDR] 1995).

Chlordane entered the environment through its use as a pesticide on and as termite control. Chlordane sticks strongly to soil particles at the surface and is not likely to enter groundwater. It can stay in the soil for over 20 years. Most chlordane leaves soil by evaporation to the air, where it breaks down very slowly. Chlordane doesn’t dissolve easily in water. It builds up in the tissues of fish, birds, and mammals. Exposure to chlordane could occur by eating crops grown in soil that contains chlordane; eating fish or shellfish caught in water that is contaminated by chlordane; breathing air or touching soil near homes treated for termites with chlordane; and by breathing air or by touching soil near waste sites or landfills.

Chlordane affects the nervous system, the digestive system, and the liver in people and animals. Headaches, irritability, confusion, weakness, vision problems, vomiting, stomach cramps, diarrhea, and jaundice have occurred in people who breathed air containing high concentrations of chlordane or accidentally swallowed small amounts of chlordane. Large amounts of chlordane taken by mouth can cause convulsions and death in people. Federal agencies have made several recommendations to protect human health, including:

- The USEPA recommends that a child should not drink water with more than 60 parts of chlordane per billion parts of drinking water (60 parts per billion [ppb]) for longer than 1 day. The USEPA has set a limit in drinking water of 2 ppb.

- The USEPA requires spills or releases of chlordane into the environment of 1 pound or more to be reported to the USEPA (ATSDR 1995).

- The United States Food and Drug Administration (FDA) limits the amount of chlordane and its breakdown products in most fruits and vegetables to less than 300 ppb and in animal fat and fish to less than 100 ppb (ATSDR 1995).

- The Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienists (ACGIH) set a maximum level of 0.5 milligrams of chlordane per cubic meter (mg/m^3) in workplace air for an 8-hour workday, 40-hour workweek. These agencies have advised that eye and skin contact should be avoided because this may be a significant route of exposure (ATSDR 1995).

The USEPA has established the following freshwater and saltwater aquatic life criteria for chlordane:

- 2.4 micrograms per liter (µg/L) maximum concentration; 0.0043 µg/L continuous concentration for freshwater aquatic life (USEPA 2010b).

- 0.09 µg/L maximum concentration; 0.004 µg/L continuous concentration for saltwater aquatic life (USEPA 2010b).

A.1.2 DDT

Dichlorodiphenyltrichloroethane (DDT) is a pesticide once widely used to control insects in agriculture and insects that carry diseases such as malaria. DDT is a white, crystalline solid with no odor or taste. Its use in the U.S. was banned in 1972 because of damage to wildlife, but is still used in some countries. Dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyldichloroethane (DDD) are chemicals similar to DDT that contaminate commercial DDT preparations (ATSDR 2002b).

DDT entered the environment when it was used as a pesticide; it still enters the environment due to current use in other countries. DDT sticks strongly to soil; most DDT in soil is broken down slowly to DDE and DDD by microorganisms. Half the DDT in soil will break down in 2-15 years, depending on the type of soil. Only a small amount will go through the soil into groundwater; DDT does not dissolve easily in water. Exposure to DDT occurs through eating contaminated foods, such as root and leafy vegetable, fatty meat, fish, and poultry, but levels are very low; eating contaminated imported foods from countries that still allow the use of DDT to control pests; breathing contaminated air or drinking contaminated water near waste sites and landfills that may contain higher levels of these chemicals; infants fed on breast milk from mothers who have been exposed; and breathing or swallowing soil particles near waste sites or landfills that contain these chemicals.

DDT affects the nervous system. People who accidentally swallowed large amounts of DDT became excitable and had tremors and seizures. These effects went away after the exposure stopped. No effects were seen in people who took small daily doses of DDT by capsule for 18 months. A study in humans showed that women who had high amounts of a form of DDE in their breast milk were unable to breast feed their babies for as long as women who had little DDE in the breast milk. Another study in humans showed that women who had high amounts of DDE in breast milk had an increased chance of having premature babies. Federal agencies have made several recommendations to protect human health, including:

- OSHA sets a limit of 1 milligram of DDT per cubic meter of air (1 mg/m^3) in the workplace for an 8-hour shift, 40-hour workweek (ATSDR 2002b).
- The FDA has set limits for DDT, DDE, and DDD in foodstuff at or above which the agency will take legal action to remove the products from the market (ATSDR 2002b).

DDT, and especially DDE, builds up in plants and in fatty tissues of fish, birds, and other animals. In animals, short-term exposure to large amounts of DDT in food affected the nervous system, while long-term exposure to smaller amounts affected the liver. Short-term oral exposure to small amounts of DDT or its breakdown products may also have harmful effects on animal reproduction. The

USEPA has established the following freshwater and saltwater aquatic life criteria for DDT:

- 1.1 µg/L maximum concentration; 0.001 µg/L continuous concentration for freshwater aquatic life (USEPA 2010b).
- 0.13 µg/L maximum concentration; 0.001 µg/L continuous concentration for saltwater aquatic life (USEPA 2010b).

A.1.3 Dieldrin

Pure dieldrin is a white powder with a mild chemical odor. The less pure commercial powders have a tan color. Neither substance occurs naturally in the environment. From the 1950s until 1970, dieldrin was a widely used pesticide for crops like corn and cotton. Because of concerns about damage to the environment and potentially to human health, the USEPA banned all uses of dieldrin in 1974, except to control termites. In 1987, the USEPA banned all uses (ATSDR 2002a).

Sunlight and bacteria change aldrin to dieldrin so that dieldrin is the compound more likely to be found in the environment. They bind tightly to soil and slowly evaporate to the air. Dieldrin in soil and water breaks down very slowly. Plants take in and store aldrin and dieldrin from the soil. Aldrin also rapidly changes to dieldrin in plants and animals. Dieldrin is stored in the fat and leaves the body very slowly. Dieldrin is everywhere in the environment, but at very low levels. Exposure could occur through eating food like fish or shellfish from lakes or streams contaminated with either chemical or contaminated root crops, dairy products, or meats. Air, surface water, or soil near waste sites may contain higher levels.

People who have ingested large amounts of aldrin or dieldrin suffered convulsions and some died. Health effects may also occur after a longer period of exposure to smaller amounts because these chemicals build up in the body. Some workers exposed to moderate levels in the air for a long time had headaches, dizziness, irritability, vomiting, and uncontrolled muscle movements. Workers removed from the source of exposure rapidly recovered from most of these effects. Animals exposed to high amounts of aldrin or dieldrin also had nervous system effects. In animals, oral exposure to lower levels for a long period also affected the liver and decreased their ability to fight infections. Federal agencies have made several recommendations to protect human health, including:

- The USEPA limits the amount of aldrin and dieldrin that may be present in drinking water to 0.001 and 0.002 milligrams per liter (mg/L) of water, respectively, for protection against health effects other than cancer. The USEPA has determined that a maximum concentration of aldrin and dieldrin of 0.0002 mg/L in drinking water limits the lifetime risk of developing cancer from exposure to each compound to 1 in 10,000 (ATSDR 2002a).

- OSHA sets a maximum average of 0.25 milligrams of aldrin and dieldrin per cubic meter of air (0.25 mg/m^3) in the workplace during an 8-hour shift, 40-hour workweek. NIOSH also recommends a limit of 0.25 mg/m^3 for both compounds for up to a 10-hour work day, 40-hour week (ATSDR 2002a).

- The FDA regulates the residues of aldrin and dieldrin in raw foods. The allowable range is from 0 to 0.1 parts per million (ppm), depending on the type of food product (ATSDR 2002a).

The USEPA has established the following freshwater and saltwater aquatic life criteria for aldrin and dieldrin:

- Dieldrin – 2.5 µg/L maximum concentration; 0.0019 µg/L continuous concentration for freshwater aquatic life (USEPA 2010b).

- Dieldrin – 0.71 µg/L maximum concentration; 0.0019 µg/L continuous concentration for saltwater aquatic life (USEPA 2010b).

A.1.4 Dioxin and Furan Compounds

Dioxins and furans is the abbreviated or short name for a family of toxic substances that all share a similar chemical structure. Most dioxins and furans are not man-made or produced intentionally, but are created when other chemicals or products are made

The chlorinated dibenzo-p-dioxins (CDDs) are a class of compounds that are loosely referred to as dioxins. There are 75 possible dioxins. One of these compounds is called 2,3,7,8-TCDD. It is one of the most toxic of the CDDs and is the one most studied. In the pure form, CDDs are crystals or colorless solids. CDDs enter the environment as mixtures containing a number of individual components. 2,3,7,8-TCDD is odorless and the odors of the other CDDs are not known. CDDs are not intentionally manufactured by industry except for research purposes or as by-products. They (mainly 2,3,7,8-TCDD) may be formed during the chlorine bleaching process at pulp and paper mills. CDDs are also formed during chlorination by waste and drinking water treatment plants. They can occur as contaminants in the manufacture of certain organic chemicals. CDDs are released into the air in emissions from municipal solid waste and industrial incinerators (ATSDR 1999a).

When released into the air, some CDDs may be transported long distances, even around the globe. When released in waste waters, some CDDs are broken down by sunlight, some evaporate to air, but most attach to soil and settle to the bottom sediment in water. CDD concentrations may build up in the food chain, resulting in measurable levels in animals. Eating food, primarily meat, dairy products, and fish makes up more than 90 percent of the intake of CDDs for the general population. Exposure could also occur by breathing low levels in air and drinking low levels in water; skin contact with certain pesticides and herbicides; living near an uncontrolled hazardous waste site containing CDDs or incinerators releasing CDDs; and working in industries involved in producing certain pesticides containing CDDs as impurities, working at paper and pulp mills, or operating incinerators.

The most noted health effect in people exposed to large amounts of 2,3,7,8-TCDD is chloracne. Chloracne is a severe skin disease with acne-like lesions that occur mainly on the face and upper body. Other skin effects noted in people exposed to high doses of 2,3,7,8-TCDD include skin rashes, discoloration, and excessive body hair. Changes in blood and urine that may indicate liver damage also are seen in people. Exposure to high concentrations of CDDs may induce long-term alterations in glucose metabolism and subtle changes in hormonal levels. In certain animal species, 2,3,7,8-TCDD is especially harmful and can cause death after a single exposure. Exposure to lower levels can cause a variety of effects in animals, such as weight loss, liver damage, and disruption of the endocrine system. In many species of animals, 2,3,7,8-TCDD weakens the immune system and causes a decrease in the system’s ability to fight bacteria and viruses. In other animal studies, exposure to 2,3,7,8-TCDD has caused reproductive damage and birth defects.

- The USEPA has set a limit of 0.00003 µg/L of 2,3,7,8-TCDD in drinking water (ATSDR 1999a).
- Discharges, spills, or accidental releases of 1 pound or more of 2,3,7,8-TCDD must be reported to the USEPA.
- The FDA recommends against eating fish and shellfish with levels of 2,3,7,8-TCDD greater than 50 parts per trillion (ppt) (ATSDR 1999a).

A.1.5 Invasive Species

The introduction of invasive species is the leading cause of biodiversity loss in aquatic systems. Non-native plants or animals existing within a habitat are considered exotic species and can either be deliberately or accidentally introduced. Exotic species include plants, fishes, algae, mollusks, crustaceans, bacteria and viruses. These species do or are likely to cause harm to the economy, environment, or human health in their non-native environment.

There are several different ways of introducing invasive species into freshwater sources including ballast water, hull fouling, aquaculture escapes, and accidental and/or intentional introductions, among others (USEPA 2010a). Vessels can be a significant pathway for the introduction or spread of invasive species through the discharge of ballast water containing invasive species or the transport of invasive species that have accumulated on ships' hulls. The USEPA and its federal partners, such as the United States Coast Guard, are working together and using their authorities to help address the environmental and economic threats associated with ship-related introductions of invasive species (USEPA 2012).

Invasive species can affect aquatic ecosystems directly or by affecting the land in ways that harm aquatic ecosystems. Invasive species represent the second leading cause of species extinction and loss of biodiversity in aquatic environments worldwide. They also result in considerable economic effects through direct economic losses and management/control costs, while dramatically altering ecosystems supporting commercial and recreational activities. Effects on aquatic ecosystems result in decreased native populations, modified water tables, changes in run-off dynamics and fire frequency, among other alterations. These ecological changes in turn impact many recreational and commercial activities dependent on aquatic ecosystems (USEPA 2012).

A.1.6 Mercury

Mercury is a naturally occurring metal that has several forms. The metallic mercury is a shiny, silver-white, odorless liquid. If heated, it is a colorless, odorless gas. Mercury combines with other elements, such as chlorine, sulfur, or oxygen, to form inorganic mercury compounds or “salts,” which are usually white powders or crystals. Mercury also combines with carbon to make organic mercury compounds. The most common one, methylmercury, is produced mainly by microscopic organisms in the water and soil. More mercury in the environment can increase the amounts of methylmercury that these small organisms make. Metallic mercury is used to produce chlorine gas and caustic soda, and is also used in thermometers, dental fillings, and batteries. Mercury salts are sometimes used in skin lightening creams and as antiseptic creams and ointments (ATSDR 1999b).

Inorganic mercury (metallic mercury and inorganic mercury compounds) enters the air from mining ore deposits, burning coal and waste, and from manufacturing plants. It enters the water or soil from natural deposits, disposal of wastes, and volcanic activity. Methylmercury may be formed in water and soil by bacteria. Exposure to mercury can occur through eating fish or shellfish contaminated with methylmercury; breathing vapors in air from spills, incinerators, and industries that burn mercury-containing fuels, release of mercury from dental work and medical treatments; and breathing contaminated workplace air or skin contact during use in the workplace (from businesses and industries that use mercury).

The nervous system is very sensitive to all forms of mercury. Methylmercury and metallic mercury vapors are more harmful than other forms, because more mercury in these forms reaches the brain. Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing fetus. Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems. Short-term exposure to high levels of metallic mercury vapors may cause effects including lung damage, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation. Federal agencies have made several recommendations to protect human health, including:

- The USEPA has set a limit of 2 ppb of mercury in drinking water (2 ppb) (ATSDR 1999b).
- The FDA has set a maximum permissible level of 1 ppm of methylmercury in seafood (ATSDR 1999b).
- OSHA has set limits of 0.1 mg/m^3 of organic mercury in workplace air (0.1 mg/m^3) and 0.05 mg/m^3 of metallic mercury vapor for 8-hour shifts and 40-hour workweeks (ATSDR 1999b).

Various studies have shown that mercury is a mutagen, teratogen, and carcinogen. It bioaccumulates and biomagnifies in food chains. The inorganic forms of mercury are not as toxic as the organic forms (Eisler 1987). Mammalian species tend to absorb organic forms of mercury through the respiratory tract, gastrointestinal tract, and skin. The organic forms can cross placental barriers.

Methylmercury builds up in the tissues of fish. Larger and older fish tend to have the highest levels of mercury. Chronic mercury poisoning in fish can cause emaciation due to appetite loss, brain lesions, diminished response to light intensity, inability to capture food, and abnormal muscle coordination (Eisler 1987). In general, aquatic species accumulate mercury rapidly and excretion is slow.

In mammals, subchronic exposure to mercury can cause deleterious effects on reproduction, growth and development, behavior, blood and serum chemistry, histology, and metabolism. Methylmercury irreversibly destroys neurons of the central nervous system. Symptoms to mercury exposure may not be evident for years after initial exposure (Eisler 1987). Smaller mammals are more sensitive to mercury exposure. Also, carnivorous mammals have been found to have greater concentrations of mercury within the liver and kidney than herbivorous species. The USEPA has established the following freshwater and saltwater aquatic life criteria for mercury:

- 2.1 µg/L maximum concentration; 0.012 µg/L continuous concentration for freshwater aquatic life (USEPA 2010b).
- 1.8 µg/L maximum concentration; 0.025 µg/L continuous concentration for saltwater aquatic life (USEPA 2010b).

A.1.7 Polychlorinated Biphenyls

Polychlorinated Biphenyls (PCBs) are made up of up to 209 individual chlorinated compounds known as congeners. No known natural sources of PCBs exist. They are in the form of either oily liquids or solids that may be colorless to light yellow or as vapor in air. No known smell or taste is associated with PCBs. In the United States, some commercial PCB mixtures are known by the trade name of Aroclor. They are used as coolants and lubricants in transformers, capacitors, and other electrical equipment since they do not burn easily and are good insulators. In 1977 manufacturing of PCBs was stopped in the United States because of links to harmful effects. Products older than 1977 containing PCBs include old florescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils (ATSDR 2001).

During their manufacture, use and disposal, PCBs entered the air, water and soil caused from accidental spills and leaks during their transport, and from leaks or fires in products containing PCBs. PCBs are also released from hazardous waste sites, illegal or improper disposal of industrial wastes and consumer products; leaks from old electrical transformers containing PCBs; and burning of some wastes incinerators. Since PCBs do not break down easily they may remain in the environment for long periods of time. PCBs in air can travel long distances and deposited in areas far away from the source. Most PCBs in water stick to organic particles and bottom sediments, however, a few may remain dissolved. They will bind strongly with soil. Small organisms and fish will take up PCBs in water as well as other animals who ingest them. PCBs accumulate in fish and marine mammals and may reach levels many thousands of times higher than in water (ATSDR 2001).

PCBs exposure to humans is through the use of things that leak PCBs into the air when they get hot including fluorescent lighting fixtures and electrical devices and appliances such as television sets and refrigerators that were made 30 or more years ago. They could also be a source of skin exposure. Ingesting contaminated food especially fish, meat or dairy products. Air near hazardous waste sites and contaminated well water are also sources of PCB contamination. Workplace exposure is prevalent during repair and maintenance of PCB transformers; accidents, fires or spills involving transformers, fluorescent lights, and other old electrical devices; and disposal of PCB materials (ATSDR 2001).

Harmful health effects from PCB exposure to humans includes skin conditions such as acne and rashes. In other studies of workers exposed to PCBs changes in blood and urine occurred that may indicate liver damage, however PCB exposure in the general population are not likely to cause skin and liver effects. The Department of Health and Human Services has concluded that PCBs may reasonably be anticipated to be carcinogens and the USEPA and the International Agency for Research on Cancer have determined that PCBs are probably carcinogenic to humans (ATSDR 2001).

Federal and state agencies have made several recommendations to protect human health, including:

- The USEPA limits PCBs in drinking water to 0.5 ppb (ATSDR 2006).
- The USEPA requires that discharges, spills or accidental releases of 1 pound or more into the environment must be reported (ATSDR 2006).
- The USEPA standard for eating the fish or shellfish and/or drinking the water from lakes or streams contaminated with PCBs is 0.17 ppt due to bioaccumulation (ATSDR 2006).
- The FDA requires that infant and junior foods, eggs, milk, other dairy products, fish and shellfish, poultry, and red meat contain no more than 0.2-3 ppm (ATSDR 2006).
- OSHA limits worker inhalation over a period of 8 hours for 5 days per week of 42 percent chlorine PCBs to 1 mg/m^3 of air, and for 54 percent chlorine PCBs to 0.5 mg/m^3 of air (ATSDR 2006).
- Fish and wildlife consumption advisories for PCBs have been established my many states (ATSDR 2001).

A.1.8 Selenium

Selenium is a metal commonly found in rocks and soil. In the environment, selenium is not often found in the pure form. Much of the selenium in rocks is combined with sulfide minerals or with silver, copper, lead, and nickel minerals. Selenium and oxygen combine to form several compounds. Selenium sulfide is a bright red-yellow powder used in anti-dandruff shampoo. Processed selenium is used in the electronics industry; as a nutritional supplement, in the glass industry; as a component of pigments in plastics, paints, enamels, inks and rubber; in the preparation of pharmaceuticals; as a nutritional feed additive for poultry and livestock; in pesticide formulations; in rubber production; and as a constituent of fungicides (ATSDR 2003).

Small selenium particles in the air settle to the ground or are taken out of the air in rain. Selenium dust can enter the air from burning coal and oil. Soluble selenium compounds in agricultural fields can leave the field in irrigation drainage water and can also enter water from rocks, soil and industrial waste. Some compounds dissolve in water and some will settle to the bottom as particles. Selenium can collect in animals that live in water containing high levels of it. It can accumulate up the food chain. Exposure to selenium occurs by breathing air that contains it and by eating food, drinking water, or taking dietary supplements that contain it (ATSDR 2003).

People exposed to very high levels of selenium orally over the short-term have reported nausea, vomiting, and diarrhea. Chronic oral exposure to high concentrations have been known to cause a disease called selenosis which include hair loss, nail brittleness and neurological abnormalities (such as numbness and other odd sensations in the extremities). Respiratory tract irritation, bronchitis, difficulty breathing, and stomach pains can be experiences with brief exposures to high levels of elemental selenium or selenium dioxide in air (ATSDR 2003). Federal agencies have made several recommendations to protect human health, including:

- The USEPA maximum contaminant level (MCL) for selenium in drinking water is 50 parts of selenium per billion parts of water (50 ppb) (ATSDR 2003).
- OSHA exposure limit for selenium compounds in workplace air is 0.2 mg/m^3 of selenium in air for an 8-hour day over a 40-hour workweek (ATSDR 2003).
- ATSDR and USEPA have determined that 5 micrograms of selenium per kilogram of body weight taken daily would not be expected to cause any adverse health effects over the lifetime of such intake (ATSDR 2003).

Selenium bioaccumulates in aquatic food chains and causes toxic effects on fish and bird embryos (Lemly 1998). In aquatic organisms, selenium can result in loss of equilibrium and other neurological disorders, liver damage, reproductive failure, reduced growth, reduced movement rate, chromosomal aberrations, reduced hemoglobin and increased white blood cell count, and necrosis of the ovaries (USEPA 2006). The USEPA has established the following freshwater and saltwater aquatic life criteria for selenium:

- 20 µg/L maximum concentration; 5 µg/L continuous concentration for freshwater aquatic life (USEPA 2010b).
- 290 µg/L maximum concentration; 71 µg/L continuous concentration for saltwater aquatic life (USEPA 2010b).

A.1.9 Unknown Toxicity

An unknown toxicity is defined as a toxicity that has been found within a waterbody, but further testing has not been done to discover what the toxicity specifically is (Richard 2002). Unknown toxicities are found within waterbodies that have been monitored, tested, and sampled for toxicity in general and during testing, organism within the tested water have died.

A.2 Beneficial Uses

State law defines beneficial uses of California's waters that may be protected against quality degradation to include (but not limited to) "...domestic; municipal; agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves" (Water Code Section 13050[f]).

Beneficial use designation (and water quality objectives) must be reviewed at least once during each three-year period for the purpose of modification as appropriate (40 CFR 131.20). The beneficial uses, and abbreviations, listed below are standard basin plan designations (Central Valley Regional Water Quality Control Board [CVRWQCB] 1998).

Municipal and Domestic Supply (MUN) - Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

Agricultural Supply (AGR) - Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing.

Industrial Service Supply (IND) - Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.

Industrial Process Supply (PRO) - Uses of water for industrial activities that depend primarily on water quality.

Ground Water Recharge (GWR) - Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.

Freshwater Replenishment (FRSH) - Uses of water for natural or artificial maintenance of surface water quantity or quality.

Navigation (NAV) - Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

Hydropower Generation (POW) - Uses of water for hydropower generation.

Water Contact Recreation (REC-1) - Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, canoeing, white water activities, fishing, or use of natural hot springs.

Non-contact Water Recreation (REC-2) - Uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Commercial and Sport Fishing (COMM) - Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

Aquaculture (AQUA) - Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.

Warm Freshwater Habitat (WARM) - Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Cold Freshwater Habitat (COLD) - Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Estuarine Habitat (EST) - Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).

Wildlife Habitat (WILD) - Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Preservation of Biological Habitats of Special Significance (BIOL) - Uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance, where the preservation or enhancement of natural resources requires special protection.

Rare, Threatened, or Endangered Species (RARE) - Uses of water that support aquatic habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under State or Federal law as rare, threatened or endangered.

Migration of Aquatic Organisms (MIGR) - Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

Spawning, Reproduction, and/or Early Development (SPWN) - Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Shellfish Harvesting (SHELL) - Uses of water that support habitats suitable for the collection of filter feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.

A.3 Reservoir Water Quality

This section describes how lakes and reservoirs function, and the limnological processes that occur within them to provide a better understanding of water quality.

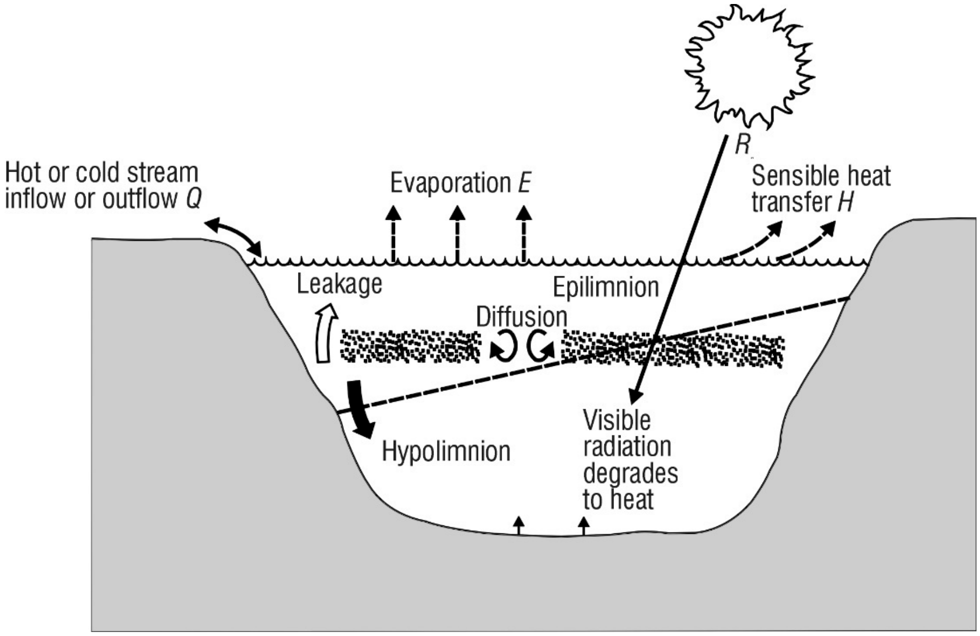
A.3.1 Physiochemical Reservoir Processes

Certain physiochemical parameters (water temperature and dissolved oxygen) associated with lakes and reservoirs typically exhibit direct relationships to depth. Because water density changes with water temperature, most water bodies have a temperature gradient that decreases with depth. In reservoirs, warmer water generally is found near the surface and the volume of warm water tends to gradually decrease down through the water column. Conversely, a greater volume of cold water is found near the bottom of the reservoir, and this is often known as the coldwater pool (Horne and Goldman 1994, Wetzel 1983, and Moss 1998).

Because the solubility of dissolved oxygen in water is related to changes in pressure and temperature, cold water generally contains a greater percentage of dissolved oxygen as compared to warm water. However, in most systems there are additional demands that may affect this relationship. Plant and animal respiration can consume large amounts of dissolved oxygen but the major consumption of oxygen in lakes and reservoirs is attributed to bacterial respiration associated with the decomposition of organic matter settling out of the water column. Additionally, wind action across the surface of lakes promotes mixing, which generally results in greater dissolved oxygen concentrations near the surface (Horne and Goldman 1994, Wetzel 1983, and Moss 1998).

A.3.2 Summer/Winter - Stratification/Mixing

In the spring and early summer, water near the lake surface begins to warm as it absorbs energy from increased solar radiation associated with longer daylight hours (Figure A-1). Because of the thermal properties associated with water, the warmer layers of water remain near the surface while denser, colder water sinks deeper into the water column. Over time, this creates distinct thermal layers (known as the epilimnion, metalimnion/thermocline and hypolimnion) within the water column. Once the spring thermocline is established, it is thermodynamically stable and usually can be destroyed only by cooling of the epilimnion. At this point, the hypolimnion is effectively isolated from the surface and dissolved oxygen cannot be replenished except by diffusion from the metalimnion, which is very slow (Horne and Goldman 1994, Wetzel 1983, and Moss 1998).



Source: Horne and Goldman 1994.

Figure A-1. Horizontal Cross-Sectional View of the Physiochemical Processes and Stratification Layers Occurring in Lakes and Reservoirs

In the fall, less solar radiation reaches the lake surface during the day, while heat losses at the surface of the water are greater at night than they are deeper in the water column. Cooling water at the surface is denser than warmer water below and so it sinks, causing the warmer water to rise up to the surface. These convective currents and wind-induced mixing begin to weaken the thermocline. The epilimnion increases in depth as water temperature decreases. Eventually the water temperature and density differences between adjacent water layers are so slight that a strong wind can overcome the remaining resistance to mixing in the water column and the lake undergoes fall overturn, mixing from top to bottom. Fall overturn causes oxygen-saturated water at the surface to be distributed throughout the various depths of the epilimnetic and hypolimnetic layers. When circulation is complete, dissolved oxygen continues at saturation in accordance with solubility at existing temperatures. These mixing events are important because they enable low or depleted oxygen stores in the hypolimnion and near the lakebed to be replenished. This also ensures that aerobic activities associated with bacterial decomposition in and above the lake sediments continue to occur. Additionally, mixing distributes organic nutrients (e.g., nitrogen and phosphorous) which are accumulated at the bottom of the lake throughout the summer, through the water column (Horne and Goldman 1994, Wetzel 1983, and Moss 1998).

A.3.3 Potential Lake Pollutants: Nutrients/Metals/Sedimentation

Healthy lake ecosystems contain small quantities of nutrients from natural sources. An increased or accelerated input of nutrients (primarily nitrogen and phosphorous) may disrupt the balance of lake ecosystems by altering physical, chemical and biological processes within the system. Excessive nutrients can stimulate increased productivity, which can lead to short-term population explosions of algae and aquatic macrophytes. Eventually the algae and other vegetation die off and sink to the bottom of the lake where it undergoes bacterial decomposition. As the bacteria continue to break down the organic matter, the decomposition process elicits a high biochemical oxygen demand, which can deplete dissolved oxygen in the water. At a substantial level, this may deprive fish and other aquatic organisms of oxygen, which in turn can lead to fish kills or produce foul odors in the water (Horne and Goldman 1994, Wetzel 1983, and Moss 1998).

After nutrient loading, metals are typically the second most common lake pollutant of concern and are often found to accumulate in lake sediments. These substances are a concern because many of them are harmful to humans and aquatic organisms. While many metals become concentrated in the sediment, they generally remain there unless disturbed and re-suspended in the water column. Reservoir drawdown has the potential to alter the concentration and mobility of metals found in the sediment within and around the reservoir by reducing the volume of the storage pool. Additionally, exposing a greater amount of the shoreline acreage surrounding the waterbody could potentially lead to increased shoreline erosion, which may increase the amount of sediment loading and suspended solids within the reservoir. In addition to concerns associated with metals, increased sedimentation may reduce water clarity or impair physiological mechanisms associated with aquatic organisms (Horne and Goldman 1994, Wetzel 1983, and Moss 1998).

Reservoir and river management objectives may have conflicting resource goals, which require management coordination to ensure that the needs of both resources are being adequately met. In some situations, trade-offs may need to occur between the upstream reservoir and river reaches downstream. Management actions may call for increased reservoir releases to provide for downstream requirements. Providing downstream benefits (e.g., flow and habitat improvements for fish and wildlife, power generation, agricultural and municipal water diversions) from increases in reservoir flow releases may lead to reductions to reservoir storage and could negatively affect reservoir-related water quality parameters by resulting in: 1) lower surface water elevations within the reservoir; 2) reductions in the volume of the cold water pool; and 3) alteration of pollutant concentrations. Such changes to reservoir water quality could also result in direct and indirect affects to reservoir-dependent aquatic and human uses such as fisheries and primary and secondary contact recreational use.

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