San Luis Low Point Improvement Project Environmental Impact Statement / Environmental Impact Report

Appendix D: Water Quality Technical Appendix

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Appendix D
Water Quality Technical Appendix

The Water Quality Technical Appendix supplements Section 4.1 Water Quality in the San Luis Low Point Improvement Project (SLLPIP) 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. Water quality monitoring and water quality modeling results are also included.

D.1 Clean Water Act Section 303(d) Listed Water Bodies

Various water bodies within the SLLPIP area of analysis have been identified as impaired for certain constituents of concern, as listed on the 2016 303(d) list under the CWA. CWA Section 303(d) requires States to identify water bodies that do not meet applicable water quality standards after the application of certain technology-based controls on point source discharges. As defined in the CWA and Federal regulations, water quality standards include the designated beneficial uses of a water body, the adopted water quality criteria necessary to protect those uses, and an anti-degradation policy. As defined in the Porter-Cologne Act, water quality standards are associated with designated beneficial uses of a water body, the established water quality objectives (both narrative and numeric), and California's non-degradation policy (State Water Resources Control Board [SWRCB] Resolution No. 68-16). Appendix C, Regulatory Setting, contains a description of the CWA and the 303(d) listing process.

Certain water bodies in the area of analysis are listed as water quality limited (impaired) for one or more of the constituents of concern. Table D-1 presents the 2016 303(d) listed water bodies within the SLLPIP area of analysis and information about the constituents of concern contributing to their impairment. Some water quality constituents are also of concern with respect to drinking water. Section D.2 provides information on the constituents concern listed in Table D-1.

Table D-1. 303(d) Listed Water Bodies Within the SLLPIP Area of Analysis and Associated Constituents of Concern

Name	Constituent	Potential Sources	Estimated Area Affected [1]	Proposed TMDL Completion Year	Region
Guadalupe Creek	Mercury	Source Unknown	8.1 miles	2008[2]	Santa Clara County
Guadalupe Reservoir	Mercury	Source Unknown	63 acres	2008[2]	Santa Clara County
Guadalupe River	Diazinon Mercury	Source Unknown Source Unknown	18 miles 18 miles	2007[3] 2008	Santa Clara County
O'Neill Forebay	Mercury	Source Unknown	2,254 acres	2012	Merced County
Pacheco Creek	Dissolved Oxygen Turbidity	Source Unknown Source Unknown	26 miles 26 miles	2005 2005	Santa Clara and San Benito Counties
Sacramento-San Joaquin River Delta	Chlordane	Nonpoint Source	41,736 acres	2013	Contra Costa, Sacramento, San Joaquin, Solano and Yolo Counties
	DDT	Nonpoint Source	41,736 acres	2013	
	Dieldrin	Nonpoint Source	41,736 acres	2013	
	Dioxin compounds (including 2,3,7,8-TCDD)	Atmospheric Deposition	41,736 acres	2019	
	Furan Compounds	Atmospheric Deposition	41,736 acres	2019	
	Invasive Species	Ballast Water	41,736 acres	2019	
	Mercury	Industrial Point Sources, Unknown Nonpoint Source, Municipal Point Sources, Resource Extraction	41,736 acres	2008	
	PCBs	Nonpoint Source	41,736 acres	2008	
	PCBs (dioxin-like)	Municipal Point Sources	41,736 acres	2008	
	Selenium	Resource Extraction, Atmospheric Deposition, Unknown Nonpoint Source	41,736 acres	2008	
San Francisco Bay, South	Chlordane	Source Unknown	9,204 acres	2013	Santa Clara County
	DDT	Source Unknown	9,204 acres	2013	
	Dieldrin	Source Unknown	9,204 acres	2013	
	Dioxin Compounds (2,3,7,8-TCDD)	Source Unknown	9,204 acres	2019	
	Furan Compounds	Source Unknown	9,204 acres	2019	
	Invasive Species	Source Unknown	9,204 acres	2019	
	Mercury	Gold mining sediments Mercury mining	9,204 acres	2008[3]	
	PCBs	Source Unknown	9,204 acres	2008	
	PCBs (dioxin-like)	Source Unknown	9,204 acres	2008	
	Selenium	Source Unknown	9,204 acres	2019	

Table D-1. 303(d) Listed Water Bodies Within the SLLPIP Area of Analysis and Associated Constituents of Concern

Name	Constituent	Potential Sources	Estimated Area Affected [1]	Proposed TMDL Completion Year	Region
San Luis Reservoir	Mercury	Source Unknown	13,007 acres	2021	Merced County
Saratoga Creek	Diazinon	Source Unknown	18 miles	2007[2]	Santa Clara County

Source: SWRCB 2018

DDT = dichlorodiphenyltrichloroethane; PCB = polychlorinated biphenyl

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

[2] USEPA TMDL was approved 6/1/2010.

[3] USEPA TMDL was approved 5/16/2007. For 2006, diazinon was moved by USEPA from the 303(d) list to the being addressed list because of a completed USEPA approved TMDL.

[4] USEPA TMDL was approved 2/29/2008

D.2 Constitutes of Concern

D.2.1 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 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 2010a).

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

D.2.2 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 2002a).

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 2002a).

- 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 2002a).

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

D.2.3 Diazinon

Diazinon is the common name of an organophosphorus insecticide used to control pest insects in soil, on ornamental plants, and on fruit and vegetable field crops. It is also used to control household pests such as flies, fleas, and cockroaches. This chemical is manufactured and does not occur naturally in the environment. The pure chemical is colorless and practically odorless oil. Most of the diazinon used is in liquid form, but it is possible to be exposed to the chemical in a solid form. Diazinon does not burn easily and does not dissolve easily in water (ATSDR 2008).

Most environmental diazinon contamination comes from agricultural and household application to control insects. Sales of home and garden products ceased in the United States in 2004 for products containing Diazinon, however, some people may still have these products stored at their homes. Diazinon may also enter the environment during the manufacturing process. It is often sprayed on crops and plants, so small particles of the chemical may be carried away from the field or yard before falling to the ground. After diazinon has been applied, it may be present in the soil, surface waters, and on the surface of the plants. Diazinon on soil and plant surfaces may be washed into surface waters by rain. In the environment, diazinon is rapidly broken down into a variety of other chemicals. It can move through the soil and contaminate ground water. Diazinon is not likely to build up to high or dangerous levels in animal or plant foods. Exposure to diazinon occurs through contact with contaminated soils or contaminated runoff water or groundwater. People who work in the manufacture and professional application of diazinon have the most significant exposure to this insecticide.

Most cases of unintentional diazinon poisoning in people have resulted from short exposures to very high concentrations of the material. Diazinon affects the nervous system. Some mild symptoms include headache, dizziness, weakness, feelings of anxiety, constriction of the pupils of the eye, and not being able to see clearly. More severe symptoms include nausea and vomiting, abdominal cramps, slow pulse, diarrhea, pinpoint pupils, difficulty breathing, and coma. The USEPA has developed the following recommendations to protect human health.

- No harmful effects in a child are expected with exposure to Diazinon in drinking water at a concentration of 20 µg/L for up to 10 days.
- Lifetime exposure to 1 µg/L Diazinon in drinking water is not expected to cause harmful effects.

D.2.4 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 2002b).

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 2002b).

- 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 2002b).

- 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 2002b).

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 2010a).

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

D.2.5 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).

D.2.6 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 2010b). 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).

D.2.7 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 2010a).
- 1.8 µg/L maximum concentration; 0.025 µg/L continuous concentration for saltwater aquatic life (USEPA 2010a).

D.2.8 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).

D.2.9 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 2010a).
- 290 µg/L maximum concentration; 71 µg/L continuous concentration for saltwater aquatic life (USEPA 2010a).

D.2.10 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.

D.3 Beneficial Uses

Application of water quality objectives (i.e. standards) to protect designated beneficial uses is critical to water quality management in California. State law defines beneficial uses to include (but not be 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)). Protection and enhancement of existing and potential beneficial uses are primary goals of water quality planning. Significant points concerning the concept of beneficial uses are:

1. All water quality problems can generally be stated in terms of whether there is water of sufficient quantity or quality to protect or enhance beneficial uses (Central Valley Regional Water Quality Control Board [RWQCB] 2018).

2. Beneficial uses do not include all of the reasonable uses of water. For example, disposal of wastewaters is not included as a beneficial use. This is not to say that disposal of wastewaters is a prohibited use; it is merely a use that cannot be satisfied to the detriment of beneficial uses. Similarly, the use of water for the dilution of salts is not a beneficial use although it may, in some cases, be a reasonable and desirable use of water (Central Valley RWQCB 2018).

3. The protection and enhancement of beneficial uses require that certain quality and quantity objectives be met for surface and ground waters (Central Valley RWQCB 2018).

4. Fish, plants, and other wildlife, as well as humans, use water beneficially.

The Porter Cologne Water Quality Control Act defines water quality objectives as, "…the limits or levels of water quality constituents or characteristics which are established for the reasonable protections of the beneficial uses of water or the preventions of nuisance within a specified area" (Water Code 13050(H)). The Basin Plans present water quality objectives in numerical or narrative format for specified water bodies or for protection of specified beneficial uses throughout a specific basin or region.

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 RWQCB 2018).

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.

The beneficial uses designated for waters within the area of analysis are presented in Table D-2 (San Luis Region), Table D-3 (San Felipe Division Region), Table D-4 (Pacheco Region) and in Table D-5 (Sacramento-San Joaquin River Delta Region). The beneficial uses designated for any specifically-identified water body generally also apply to its tributary streams. In some cases, a beneficial use may not be applicable to the entire body of water. In these cases, RWQCB judgment is applied. Water bodies within the basins that do not have beneficial uses designated are assigned municipal and domestic supply designations in accordance with the provisions of SWRCB Resolution No. 88-63. These municipal and domestic supply designations in no way affect the presence or absence of other beneficial uses in these water bodies.

Table D-2. Beneficial Uses of Water Bodies in the San Luis Region

Beneficial Use Designation	San Luis Reservoir	O'Neill Forebay
Municipal and Domestic Supply (MUN)	X	X
Agricultural Supply - Irrigation (AGR)	X	X
Agricultural Supply – Stock Watering (AGR)	X	X
Industrial Process Supply (PROC)		
Industrial Service Supply (IND)	X	
Industrial Power (POW)	X	
Water Contact Recreation (REC-1)	X	X
Canoeing and Rafting Recreation (REC-1)		
Non-contact Water Recreation (REC-2)	X	X
Wildlife Habitat (WILD)	X	X
Navigation (NAV)		
Cold Freshwater Habitat (COLD)		
Warm Freshwater Habitat (WARM)	X	X
Cold Migration (MIGR)		
Warm Migration (MIGR)		
Cold Spawning (SPWN)		
Warm Spawning (SPWN)		

Source: Central Valley RWQCB 2014.

Table D-3. Beneficial Uses of Water Bodies in the San Felipe Division Region

Beneficial Use Designation	Guadalupe River	Coyote Creek	Upper Penitencia Creek	Lower Penitencia Creek	Saratoga Creek
Municipal and Domestic Supply (MUN)					
Agricultural Supply (AGR)					X
Industrial Process Supply (PROC)					
Industrial Service Supply (IND)					
Groundwater Recharge (GWR)	X	X	X		X
Water Contact Recreation (REC-1)	X	X	X	X	X
Non-contact Water Recreation (REC-2)	X	X	X	X	X
Wildlife Habitat (WILD)	X	X	X	X	X
Cold Freshwater Habitat (COLD)	X	X	X		X
Warm Freshwater Habitat (WARM)	X	X	X	X	X
Marine and Aquatic Organisms (MIGR)	X	X	X		

Table D-3. Beneficial Uses of Water Bodies in the San Felipe Division Region

Beneficial Use Designation	Guadalupe River	Coyote Creek	Upper Penitencia Creek	Lower Penitencia Creek	Saratoga Creek
Spawning, Reproduction, and/or Early Development (SPWN)	X	X	X		
Preservation of biological Habitats of Special Significance (BIOL)					
Preservation of Rare and Endangered Species (RARE)	X	X	X		
Estuarine Habitat (EST)					
Freshwater Replenishment (FRSH)			X		X
Navigation (NAV)					
Hydropower Generation (POW)					
Commercial and Sport Fishing (COMM)		X			
Aquaculture (AQUA)					
Inland Saline Water Habitat (SAL)					
Shellfish Harvesting (SHELL)					

Source: San Francisco Bay Regional Water Quality Control Board 2015.

Table D-4. Beneficial Uses of Water Bodies in the Pacheco Region

Beneficial Use Designation	Pacheco Creek	Pacheco Lake
Municipal and Domestic Supply (MUN)	X	X
Agricultural Supply (AGR)	X	X
Industrial Process Supply (PROC)		
Industrial Service Supply (IND)		
Groundwater Recharge (GWR)	X	
Fresh Water Replenishment (FRSH)	X	
Navigation (NAV)		X
Hydropower Generation (POW)		
Water Contact Recreation (REC-1)	X	X
Non-contact Water Recreation (REC-2)	X	X
Commercial and Sport Fishing (COMM)	X	X
Aquaculture (AQUA)		
Warm Freshwater Habitat (WARM)	X	X
Cold Freshwater Habitat (COLD)	X	X
Inland Saline Water Habitat (SAL)		
Estuarine Habitat (EST)		
Marine Habitat (MAR)		
Wildlife Habitat (WILD)	X	X
Preservation of Biological Habitats of Special Significance (BIOL)	X	
Rare, Threatened, or Endangered Species (RARE)		

Table D-4. Beneficial Uses of Water Bodies in the Pacheco Region

Beneficial Use Designation	Pacheco Creek	Pacheco Lake
Migration of Aquatic Organisms (MIGR)	X	
Spawning, Reproduction, and/or Early Development (SPWN)	X	X
Shellfish Harvesting (SHELL)		

Source: Central Coast Region RWQCB 2017.

Table D-5. Beneficial Uses of Water Bodies in the Sacramento-San Joaquin River Delta

Beneficial Use Designation	Sacramento-San Joaquin River Delta
Municipal and Domestic Supply (MUN)	X
Agricultural Supply - Irrigation (AGR)	X
Industrial Process Supply (PRO)	X
Industrial Service Supply (IND)	X
Agricultural Supply (AGR)	X
Groundwater Recharge (GWR)	X
Navigation (NAV)	X
Water Contact Recreation (REC-1)	X
Non-contact Water Recreation (REC-2)	X
Shellfish Harvesting (SHELL)	X
Commercial and Sport Fishing (COMM)	X
Warm Freshwater Habitat (WARM)	X
Cold Freshwater Habitat (COLD)	X
Migration of aquatic organisms (MIGR)	X
Spawning, Reproduction, and/or Early Development (SPWN)	X
Estuarine Habitat (EST)	X
Wildlife Habitat (WILD)	X
Rare, Threatened, or Endangered Species (RARE)	X

Source: SWRCB 2006.

D.4 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.

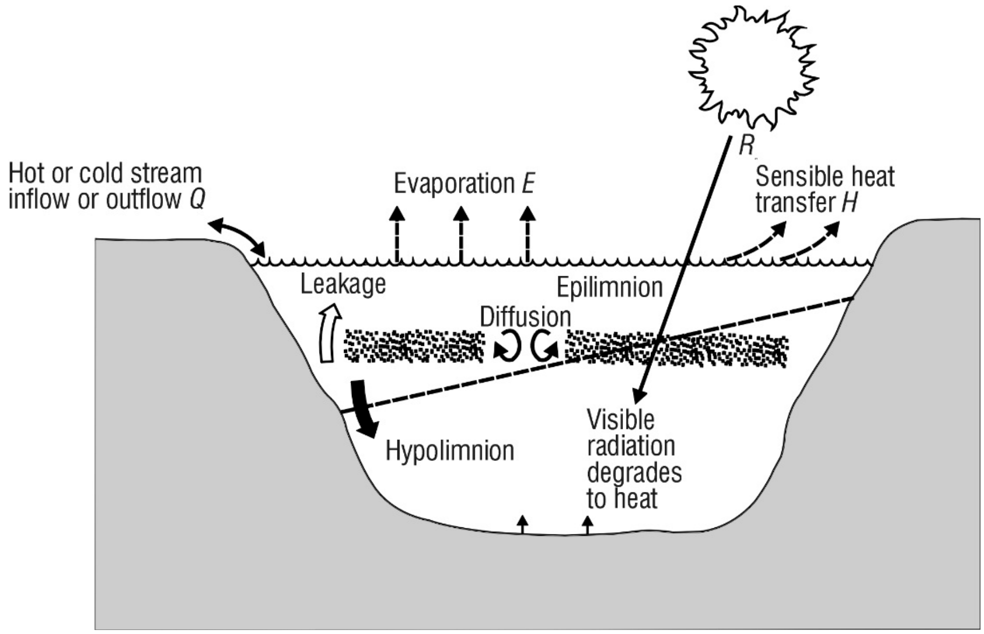
D.4.1 Physiochemical Reservoir Processes

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).

D.4.2 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 E-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 D-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).

D.4.3 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).

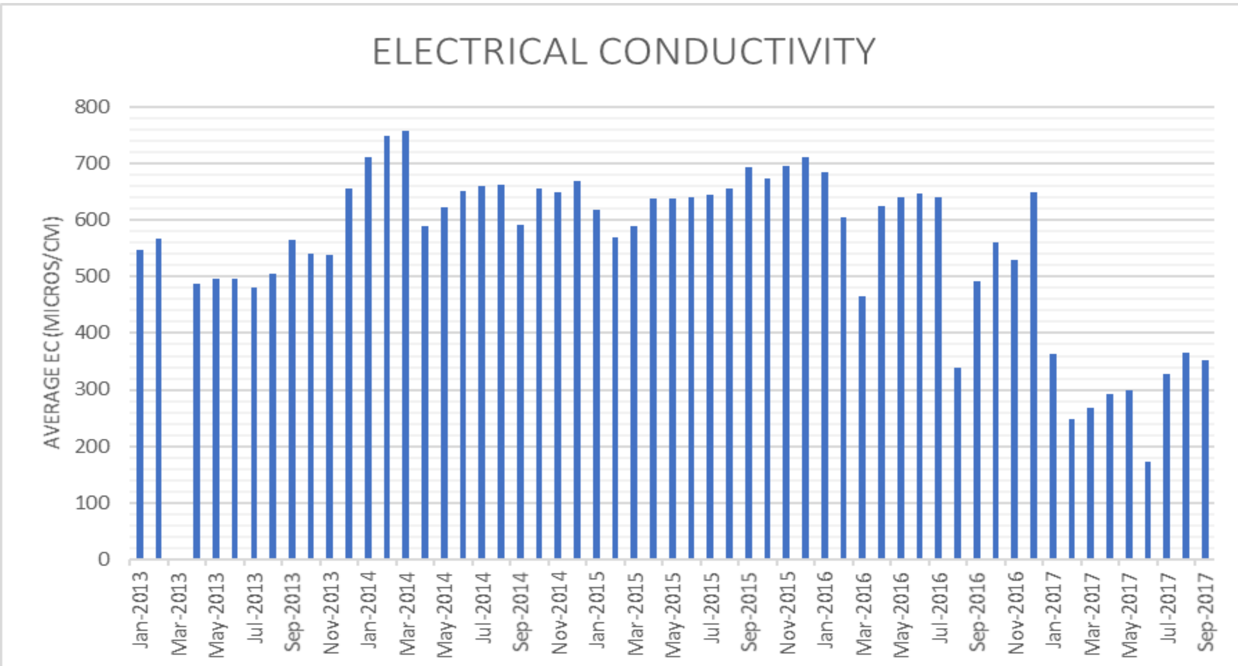
After nutrient loading, metals are typically the second most common lake pollutant of concern and are often found to accumulate in lake sediments. These substances are a concern because many of them are harmful to humans and aquatic organisms. While many metals become concentrated in the sediment, they 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.

D.5 Water Quality Monitoring

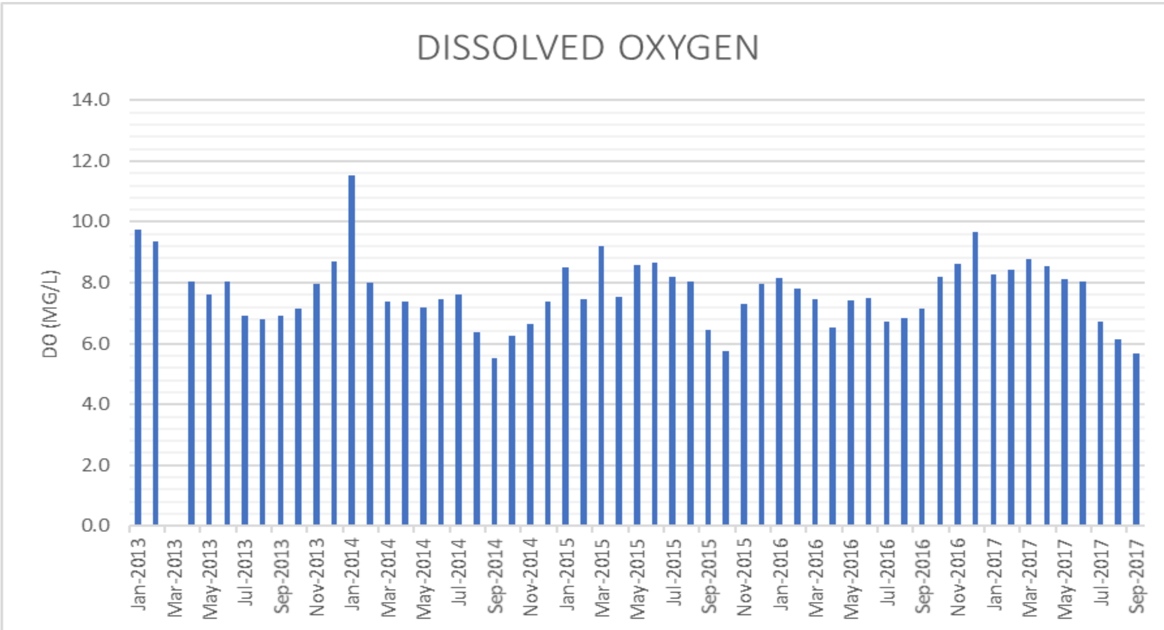
Water quality samples are routinely collected through automated monitoring at O'Neill Forebay at Gianelli Pumping Plant. Electrical Conductivity (EC), Dissolved Oxygen (DO) and Dissolved Nitrate data from this sampling location is presented in Figures D-2 through D-4. Periodic boat-based in lake sampling also occurs at multiple locations on San Luis Reservoir. Historic algae count data collected at Pacheco Pumping Plant indicates greatest algae cell counts during mid- to late-summer months, peaking in some years above 70,000 algae cell counts.

EC is directly related to the concentration of dissolved solids in the water. Salinity is related to EC in that dissolved ions that increase conductivity also increase salinity. Historic water quality data at O'Neill Forebay from 2013 thru 2017 is within the typical range of EC values for tap water in the United States.



Source: DWR California Data Exchange Center (CDEC) 2017

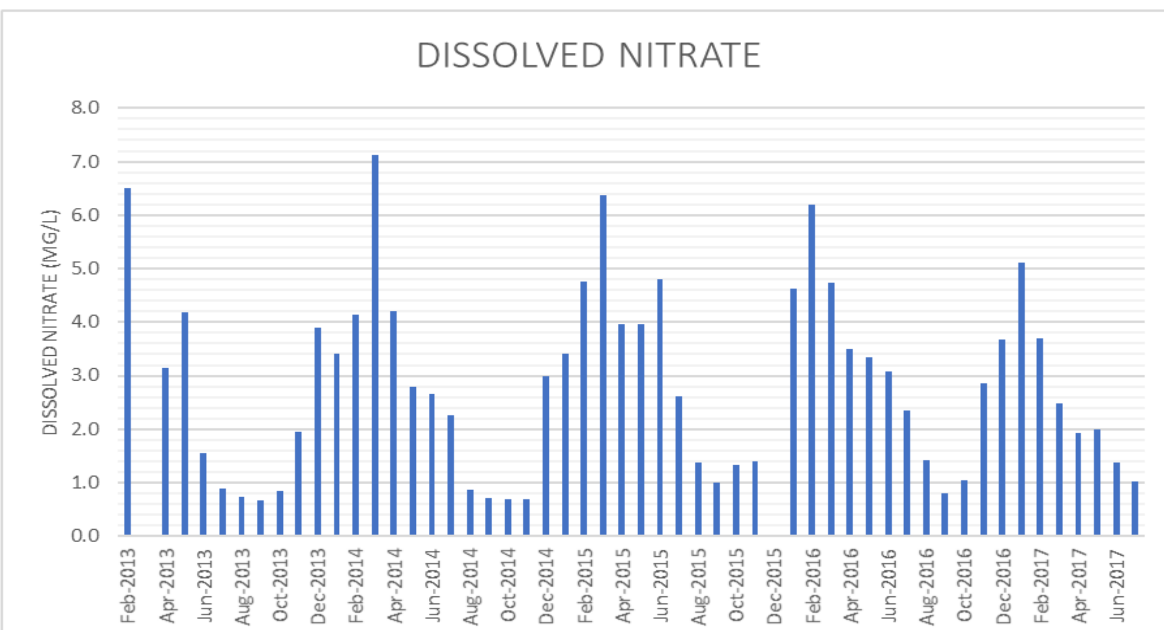
Figure D-2. Electrical Conductivity in O'Neill Forebay as Measured at Gianelli Pumping Plant



Source: DWR CDEC 2017

Figure D-3. Dissolved Oxygen in O'Neill Forebay as Measured at Gianelli Pumping Plant

As seen in Figure D-3, DO concentrations in O'Neil Forebay vary between 5 and 10 milligrams per liter (mg/L) from 2013 through 2017. DO is often lowest in the late summer and fall following excessive algae growth. As algae dies and creates decomposing organic matter the process consumes dissolved oxygen, indicated by the low late summer DO levels in O'Neill Forebay.



Source: DWR CDEC 2017

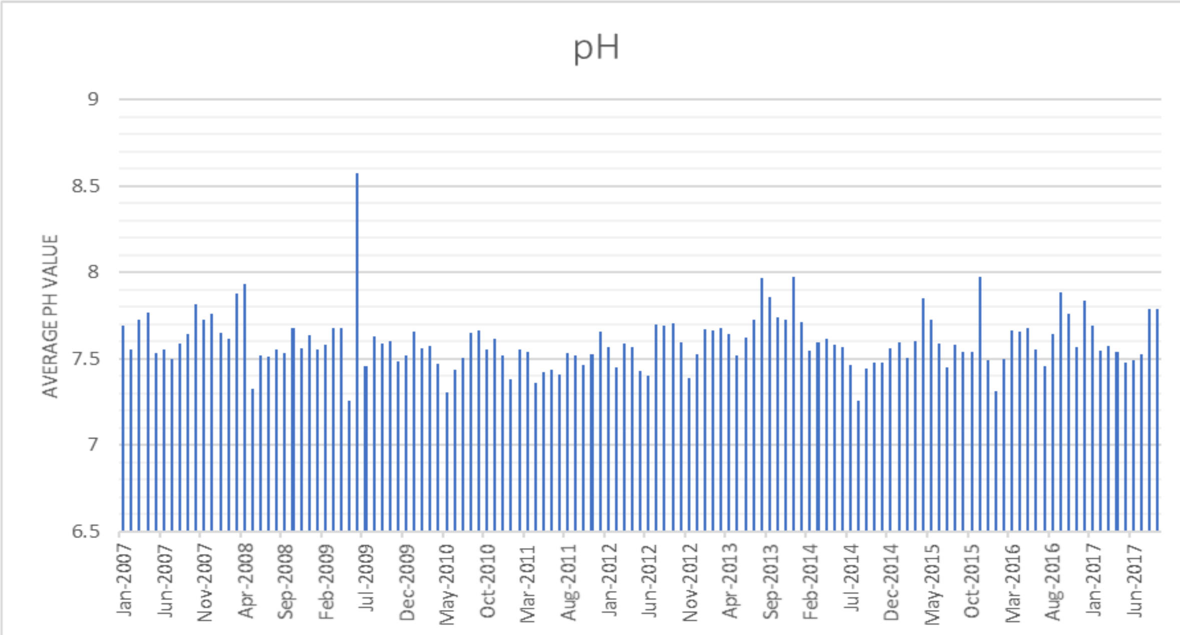
Figure D-4. Dissolved Nitrate in O'Neill Forebay as Measured at Gianelli Pumping Plant

Nitrate levels in O'Neill Forebay from 2013 through 2017 indicate late winter/Early spring peaks when algae growth is limited due to low temperatures. Nitrate levels drop beginning in late spring as algae begins to form and depletes nitrate levels through late fall. Despite annual fluctuations of approximately 5 mg/L, nitrate levels remain below the USEPA National Primary Drinking Water Regulations of 10 mg/L even in its raw water form (USEPA 2016).

The existing water quality constituents of concern in the Delta can be categorized broadly as metals, pesticides, nutrient enrichment and associated eutrophication, constituents associated with suspended sediments and turbidity, salinity, bromide, and organic carbon. The relative concentrations of these constituents over time is closely related to the hydrodynamic conditions, including the position of X2, described above. Other physical parameters (including pH, temperature, and EC), monitored daily at Clifton Court Forebay (where Banks Pumping Plant diverts from the Delta and near the Jones Pumping Plant diversion), can provide a demonstration of how change in these hydrodynamic conditions can affect water quality conditions in the Delta over time. Figures D-5 through D-7 present historical data from 2007-2017 for pH, temperature, and EC.

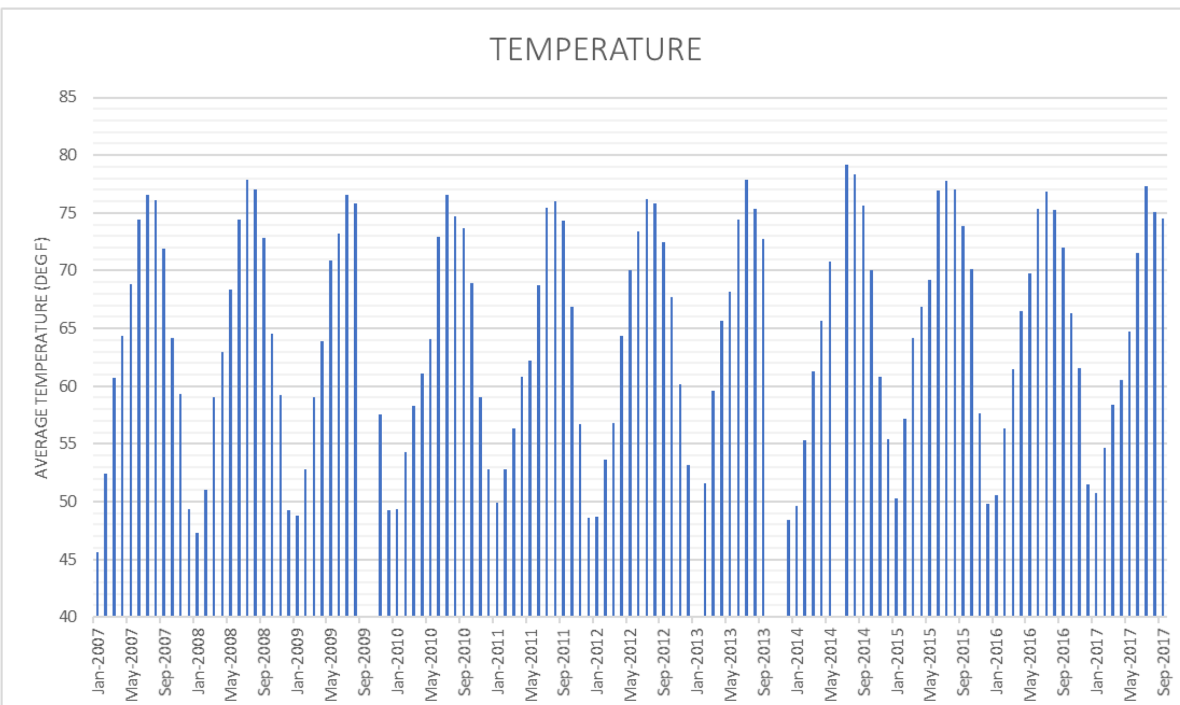
The Jones Pumping Plant diverts water from the Delta into the Delta-Mendota Canal that conveys Central Valley Project (CVP) water to users in the Central Valley and includes San Luis Reservoir as a storage feature. The influence of hydrodynamic conditions in the Delta described above for Clifton Court Forebay and indicated in Figures D-5 through D-7, is similar at the Jones Pumping Plant. Similar to the Delta Region water quality constituents of concern in the Delta-Mendota Canal can be categorized broadly as metals, pesticides, constituents associated with suspended sediments and turbidity, salinity, bromide, and organic carbon.

The Banks Pumping Plant diverts water from the Delta into Bethany Reservoir and then the California Aqueduct. Water diverted to the California Aqueduct is conveyed south to State Water Project (SWP) water users via the O'Neill Forebay and San Luis Reservoir. Water quality constituents of concern in the south-of-Delta SWP, similar to the Delta Region and Delta-Mendota Canal, include metals, pesticides, constituents associated with suspended sediments and turbidity, salinity, bromide, and organic carbon.



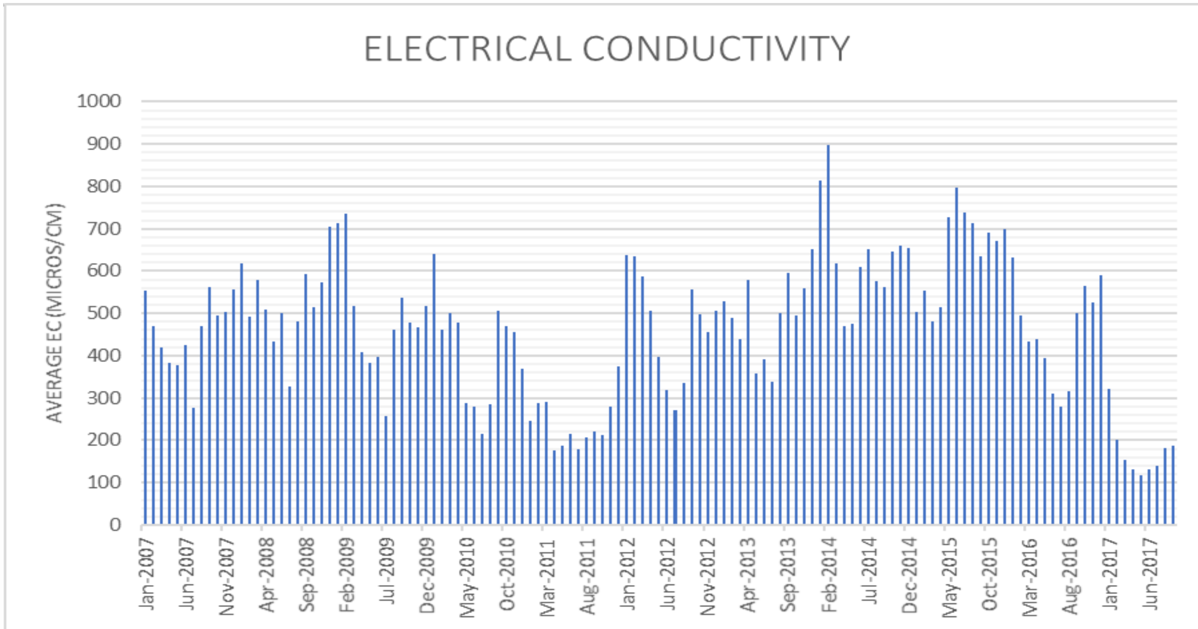
Source: DWR CDEC 2017

Figure D-5. pH in Clifton Court Forebay



Source: DWR CDEC 2017

Figure D-6. Temperature in Clifton Court Forebay



Source: DWR CDEC 2017

Figure D-7. Electrical Conductivity in Clifton Court Forebay

D.6 Water Quality Modeling Results

Water quality monitoring data and computer modeling were used to aid in evaluating potential impacts. Both temporary, construction-related effects and long-term operational effects were considered as part of this evaluation. Temporary construction impacts were evaluated qualitatively based on anticipated construction practices, materials, locations, and duration of construction and related activities. Long-term effects were evaluated using results from computer modeling tools. Specifically, the California Simulation Model II (CalSim II) was used to estimate both existing (short term) and future (long term) changes in reservoir storage and stream flow within the area of analysis.

Hydrodynamic and water quality modeling of the Delta was performed using the Delta Simulation Model-2 (DSM2). Where modeling is not available, effects are evaluated based on changes in CVP deliveries, anticipated changes in flow through the Delta (increases or decreases), and the timing of the changes.

D.6.1 X2 Results

X2 calculations were completed to determine the movement of salinity throughout the Delta. The “X2” water quality parameter represents the distance from the Golden Gate to the location of 2 parts per thousand (ppt) salinity concentration in the Delta. Larger values indicate that the salinity concentrations are increasing in the Delta as a result of reductions in outflow in the movement of the salinity zone further into the Delta, and smaller values indicate lower salinity concentrations as the salinity zone is pushed out of the Delta.

Under the Lower San Felipe Intake Alternative, X2 results indicate that on average there are very slight changes to Delta water quality resulting from changes in Delta outflows. Table D-5 summarizes X2 results which modeled potential changes in salinity in comparison to the No Action/No Project Alternative. Positive values indicate movement of the salinity zone into the Delta while negative values indicate the zones movement out of the Delta.

Under the Treatment Alternative, changes to X2 would be similar to effects under the Lower San Felipe Intake Alternative.

Under the San Luis Reservoir Expansion Alternative, although monthly minimum and maximum impacts over the 82-year modeling period of record indicate a slightly larger range of changes in X2, on average there are immeasurable changes to Delta water quality resulting from changes in Delta outflows compared to the No Action Alternative. Table D-6 summarizes X2 results which modeled potential changes in salinity in comparison to the No Action/No Project Alternative.

Under the Pacheco Reservoir Expansion Alternative, changes to X2 would be similar to effects under the Lower San Felipe Intake Alternative.

Table D-5. Modeled Difference in Delta X2 between the No Action/No Project Conditions and the Lower San Felipe Intake Alternative (km change)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
W	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AN	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Table D-6. Modeled Difference in Delta X2 between the No Action/No Project Conditions and the San Luis Reservoir Expansion Alternative (km change)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
W	0.01	0.01	-0.01	0.00	0.00	0.00	0.04	0.01	0.01	0.00	-0.01	-0.01
AN	-0.01	-0.01	0.04	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00
BN	0.00	0.00	0.02	0.01	-0.02	-0.01	-0.01	-0.02	0.00	0.00	0.00	0.00
D	0.00	0.00	-0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

D.6.2 South-of-Delta Export Results

As noted above, water quality in the Delta and the south-of-Delta CVP and SWP is closely related to changes in hydrodynamics. Changes in south-of-Delta exports are directly linked to changes in Delta outflow, which can impact water quality conditions (e.g. salinity and TDS levels) in the south Delta and south-of-Delta CVP and SWP.

As shown in Tables D-7, the changes in south-of-Delta export of CVP and SWP water under the Lower San Felipe Intake Alternative would be minimal. Under the Treatment Alternative, changes to Delta exports would be similar to effects under the Lower San Felipe Intake Alternative.

Under the San Luis Reservoir Expansion Alternative, south-of-Delta exports are expected to increase during wet and above normal year types as increased San Luis Reservoir storage will require greater exports to fill the reservoir. Exports are expected to increase by as much as 26,000 acre-feet (AF) annually under wet water year types. On the other hand, exports will decrease slightly during below normal and dry water year types by as much as 4,000 AF annually. Table D-8 shows the change in south-of-Delta exports under this alternative.

Under the Pacheco Reservoir Expansion Alternative, south-of-Delta exports are expected to increase slightly during all water years, as shown in Table D-9.

Table D-7. Modeled Difference in Total South-of-Delta Exports between the No Action/No Project Conditions and Lower San Felipe Intake Alternative (1,000 acre-feet)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	1	0	0	0	0	0	0	0	0	0	0	0	2
AN	-1	0	0	1	0	0	0	0	0	0	0	1	1
BN	0	-1	0	0	1	0	0	0	0	0	1	0	2
D	0	0	1	0	0	0	0	0	0	0	0	2	1
C	0	0	0	0	0	0	0	0	0	0	-1	2	1
All	0	0	0	0	0	0	0	0	0	0	0	1	1

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Table D-8. Modeled Difference in Total South-of-Delta Exports between the No Action/No Project Conditions and San Luis Reservoir Expansion Alternative (1,000 acre-feet)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	1	-1	0	2	6	15	1	0	0	1	1	0	26
AN	7	0	-3	6	10	1	0	0	0	0	0	-1	21
BN	1	-4	1	0	-4	0	0	0	0	0	0	2	-4
D	4	-5	0	0	0	0	0	0	0	2	-1	-1	-1
C	0	0	0	0	0	0	0	0	0	0	0	0	0
All	2	-2	0	2	3	5	0	0	0	1	0	0	10

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Table D-9. Modeled Difference in Total South-of-Delta Exports between the No Action/No Project Conditions and the Pacheco Reservoir Expansion Alternative (1,000 acre-feet)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	1	0	0	0	0	0	0	0	0	0	0	0	2
AN	-1	0	0	1	0	0	0	0	0	0	0	1	1
BN	0	-1	0	0	1	0	0	0	0	0	1	0	1
D	0	0	0	0	0	0	0	0	0	0	0	2	1
C	0	0	0	0	0	0	0	0	0	0	-1	2	1
All	0	0	0	0	0	0	0	0	0	0	0	1	1

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

D.6.3 Delta Outflow Results

As shown in Tables D-10 and D-11, the changes in Delta outflow under the Lower San Felipe Intake Alternative would be minimal. Under the Treatment Alternative, changes to Delta outflow would be similar to effects under the Lower San Felipe Intake Alternative.

Under the San Luis Reservoir Expansion Alternative, Delta outflows generally decrease, especially during wet and above normal year types due to increased storage capacity in San Luis Reservoir. During wet and above normal water year types, exports would increase in months when surplus flows are available in the Delta to fill this new available San Luis Reservoir capacity, resulting in decreases in Delta outflows as high as 434 cubic feet per second (cfs) annually in some water year types. On the contrary, during below normal and dry year types Delta outflow will increase by as much as 99 cfs annually in certain water year types, when some CVP deliveries that would be supported directly by Delta exports are instead supplied from the expanded San Luis Reservoir. Tables D-12 and D-13 summarizes the change in Delta outflow as a result of this alternative.

Under the Pacheco Reservoir Expansion Alternative, Delta outflows generally decrease under all water years, except during critical water years when Delta outflows would increase slightly, as shown in Table D-14 and D-15.

Table D-10. Modeled Difference in Delta Outflow between the No Action/No Project Conditions and Lower San Felipe Intake Alternative (cubic feet per second)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	3	1	6	-18	-17	-3	0	0	0	0	0	0	-28
AN	5	11	-1	-6	-9	-7	1	0	0	-2	0	0	-8
BN	4	0	-1	0	-13	1	-24	1	0	-1	0	2	-32
D	1	-1	-1	-1	-8	-2	1	0	0	0	-1	5	-7
C	0	0	0	0	-1	0	0	0	0	0	5	0	5
All	3	2	1	-7	-11	-2	-4	0	0	0	0	1	-16

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Table D-11. Modeled Difference in Delta Outflow between the No Action/No Project Conditions and Lower San Felipe Intake Alternative (% change)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
AN	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BN	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
D	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%
C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
All	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Table D-12. Modeled Difference in Delta Outflow between the No Action/No Project Conditions and San Luis Reservoir Expansion Alternative (cfs)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	0	10	-24	-44	-111	-242	-22	1	-3	12	0	-12	-434
AN	0	-82	-2	-130	-197	-19	0	3	-1	-3	0	0	-431
BN	0	-14	30	32	5	12	30	-2	0	1	0	5	99
D	2	4	-13	0	0	14	0	0	0	0	-2	-1	4
C	0	0	-3	3	0	0	0	0	0	0	0	0	1
All	0	-10	-6	-27	-63	-74	-2	0	-1	3	0	-3	-183

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W - Wet

Table D-13. Modeled Difference in Delta Outflow between the No Action/No Project Conditions and San Luis Reservoir Expansion Alternative (% change)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	0.0%	0.1%	-0.1%	-0.1%	-0.1%	-0.3%	0.0%	0.0%	0.0%	0.1%	0.0%	-0.1%	-0.1%
AN	0.0%	-0.7%	0.0%	-0.3%	-0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%
BN	0.0%	-0.2%	0.3%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
D	0.0%	0.0%	-0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%
C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
All	0.0%	-0.1%	0.0%	-0.1%	-0.1%	-0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W - Wet

Table D-14. Modeled Difference in Delta Outflow between the No Action/No Project Conditions and the Pacheco Reservoir Expansion Alternative (cfs)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	3	1	3	-18	-17	-4	0	0	0	0	0	0	-31
AN	5	11	-1	-5	-7	-7	1	0	0	-2	0	0	-5
BN	4	0	-2	0	-14	-1	-24	1	0	-1	0	2	-35
D	1	-1	-1	-1	-8	-2	1	0	0	0	-1	5	-6
C	0	0	0	0	-1	0	0	0	0	0	5	0	5
All	3	2	0	-7	-11	-3	-4	0	0	0	1	1	-17

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Table D-15. Modeled Difference in Delta Outflow between the No Action/No Project Conditions and the Pacheco Reservoir Expansion Alternative (cfs)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
AN	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BN	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
D	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%
C	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
All	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

D.6.4 San Luis Reservoir Storage Results

Under the Lower San Felipe Intake Alternative, Santa Clara Valley Water District (SCVWD) would be able to fully divert its CVP allocation and would not have to leave water in San Luis storage as it does in the No Action/No Project Alternative; therefore, reservoir levels would be lower.

Based on the CalSim II modeling results detailed in Appendix B, annual average reservoir storage levels would decrease by less than 17,000 AF or less than one percent of the water that is typically in storage. Additionally, reservoir levels are expected to refill to levels similar to existing conditions during the late winter and early spring months. Based on the small changes in overall reservoir storage, as well as the regular refill during fall and winter, neither water quality nor beneficial uses are expected to be substantially changed as a result of the lower intake. Table D-16 summarizes the charge in total San Luis Reservoir storage as a result of this alternative.

Table D-16. Modeled Difference in Total San Luis Reservoir Storage between the No Action/No Project Conditions and Lower San Felipe Intake Alternative (1,000 AF)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1	-1	-15
AN	-3	-5	-5	-5	-4	-4	-4	-3	-2	-1	-2	-1	-39
BN	-1	-3	-3	-3	-2	-2	-2	-2	-1	-1	-2	-3	-23
D	-1	-1	-1	-1	-1	-1	-1	0	0	0	0	0	-7
C	0	-1	-1	0	0	0	0	0	0	0	-1	-3	-8
All	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-1	-17

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Under the Treatment Alternative, SCVWD would be able to fully divert its CVP allocation and would not have to leave water in San Luis storage as it does in the No Action/No Project Alternative; therefore, reservoir levels would be lower. The change in reservoir levels would be the same as described for the

Lower San Felipe Intake Alternative in Table D-16; the changes in reservoir levels would be minor.

Under the San Luis Reservoir Expansion Alternative, additional storage would be available for treatment without concerns regarding water quality impacts resulting from algae laden water reaching the treatment system. The ten-foot maximum reservoir surface raise under this alternative would increase the water storage capacity at San Luis Reservoir by approximately 120,000 AF.

Based on CalSim II modeling results, the San Luis Reservoir Expansion Alternative would lead to monthly increases in storage of an average one percent throughout the year. Increased storage would be most apparent during spring months of wet water year types, when storage would increase by approximately 28,000 AF, or 2-percent of total storage. Table D-17 summarizes the charge in total San Luis Reservoir storage as a result of this alternative.

Table D-17. Modeled Difference in Total San Luis Reservoir Storage between the No Action/No Project Conditions and San Luis Reservoir Expansion Alternative (1,000 AF)

Sac Yr Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
W	11	9	9	9	14	28	28	26	22	18	15	15	203
AN	6	5	2	8	17	17	16	14	11	7	5	3	111
BN	4	0	1	1	7	12	10	9	6	2	-1	2	53
D	9	4	4	3	2	2	3	3	2	4	2	1	39
C	0	0	0	0	0	0	0	0	0	0	0	0	1
All	7	5	4	5	9	14	14	12	10	8	6	6	98

Notes: AN – Above Normal; BN – Below Normal; C – Critical; D – Dry; Sac Yr Type – Sacramento River Water Year Type; W – Wet

Under the Pacheco Reservoir Expansion Alternative, the new reservoir would be filled partially by CVP water allocated to SCVWD through its CVP contract with deliveries being routed through San Luis Reservoir. Under the Pacheco Reservoir Expansion Alternative, SCVWD would be able to fully divert its CVP allocation and would not have to leave water in San Luis storage as it does in the No Action/No Project Alternative; therefore, reservoir levels would be lower. The change in reservoir levels would be the same as described for the Lower San Felipe Intake Alternative in Table D-16; the changes in reservoir levels would be minor.

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