GUADALUPE RIVER WATERSHED MERCURY TMDL: 2024-2025 PROGRESS REPORT ON METHYLMERCURY CONTROL MEASURES IN RESERVOIRS

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Environmental Planning Unit
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EXECUTIVE SUMMARY

Reservoirs in the New Almaden Mining District contain fish with the highest mercury (Hg) concentrations in California (Davis et al. 2025), a direct result of legacy mining pollution from what was once the largest Hg-producing mines in North America. Most of the Hg remaining in the watershed exists as relatively insoluble Hg sulfides in mine wastes that have accumulated in reservoir deposits and sediments and in stream bottoms, banks and flood plains. Hg remaining in the system continues to dissolve and bioaccumulate in the biota present in the watershed.

In 2008, reservoirs within the watershed were listed on the 303(d) list of impaired water bodies in CA for Hg, in accordance with the Clean Water Act. A TMDL was developed and approved by the EPA in 2010, which set reduction targets for methylmercury (MeHg) in both water and fish tissue. In the water column, the MeHg target was set at 1.5 ng/L. The fish targets are 0.05 mg Hg/kg (wet weight) for fish 50-150 mm in length at trophic level 3 (TL3A) and 0.1 mg Hg/kg (wet weight) for fish 150-350 mm in length at trophic level 3(TL3B).

For several years, Valley Water has employed line diffuser hypolimnetic oxygenation treatment systems (HOSs) to suppress MeHg production in the hypolimnion, with the aim of reducing its bioavailability to the food web. Prior to this and concurrently, Valley Water implemented a monitoring program to track progress toward achieving the TMDL targets and measure Hg and MeHg loads from reservoirs.

In the years since the TMDL was implemented, Valley Water has studied MeHg cycling in reservoirs and the effectiveness of HOSs to control MeHg production and reduce fish Hg concentrations. Although the systems have successfully reduced MeHg in the hypolimnion of all reservoirs, reductions in fish tissue Hg concentrations have been statistically significant but small and remain well above TMDL targets. In 2021, the HOSs at Guadalupe and Stevens Creek Reservoirs were turned off in an attempt to preserve cold water for releases in support of downstream salmonid fishes. In 2025, both Almaden and Calero Reservoirs were also turned off in a new effort to collect more recent baseline data, as we consider alternative remediation tools, such as supersaturated oxygenation and/or carbon-based sorbents, to cap contaminated sediments.

In this study period, we focused on collecting data from Remediation Effectiveness Indicator (REI) fish, which are age-1 Largemouth bass measuring 55 to 102 mm, also known as biosentinel fish, that help track recent changes in MeHg accumulation. With four years of non-operational data from Guadalupe and Stevens Creek Reservoirs, we include initial analysis of REI fish, including pre-oxygenation data and initial comparisons. In addition to comparing water quality data to test the effectiveness of the treatment systems when turned on and off, we analyzed water quality data from before the systems were activated and after they were deactivated to compare these two time periods. When evaluating the effectiveness of the treatment systems, the additional two years of data follow previous patterns, such as increases in MeHg concentrations in reservoir hypolimnia after the treatment systems are turned off.

As in the last report, fish Hg concentrations, fitted to a multiple linear regression model, showed a small statistically significant decrease in fish tissue Hg concentrations in Almaden and Guadalupe Reservoirs. The fact that declining trends persisted in Guadalupe and Almaden reservoirs despite the nonoperation of the HOSs suggests that fish Hg trends may be dependent on factors other than HOS operation, such as source control.

During this two-year cycle, Valley Water continued its partnership agreements with the University of California at Merced, Santa Cruz, and Davis to gain a broader understanding of how Hg behaves in our reservoirs and to continue studying sorbents for potential use in remediation.

1. INTRODUCTION

The Guadalupe River watershed, located in Santa Clara County, CA, spans 171 square miles. Its headwaters originate in the eastern Santa Cruz Mountains and drain into three major tributaries that ultimately flow into the Guadalupe River (Figure 1-1). The river flows 19 miles north through a portion of heavily urbanized San Jose before discharging into the South San Francisco Bay. The watershed includes six reservoirs, approximately 253 miles of natural and engineered streams and rivers, and the historic New Almaden Quicksilver mining district, which was the largest and most productive Hg mining region in North America, producing nearly 40 million kilograms of Hg during its operations (1845–1975). Much of the Hg mined in New Almaden was used to extract gold during California's Gold Rush. The mines left a legacy of Hg contamination in the watershed, primarily in the form of calcine wastes generated during the extraction of Hg from cinnabar. Over time, these wastes have accumulated in the watershed's reservoirs, lakes, creeks, floodplains, rivers, and the San Francisco Bay. Under low oxygen conditions, certain bacteria, primarily sulfate-reducing bacteria (SRB) but also iron-reducing bacteria (IRB), archaea including methanogens, fermentative bacteria, and several unclassified strains are capable of converting relatively inert and insoluble Hg sulfides into MeHg, a potent neurotoxin that bioaccumulates and becomes increasingly concentrated in higher trophic levels of the food web (Peng et al., 2023, Peterson et al., 2025). As of 2023, the Hg concentrations in black bass (*Micropterus sp*.) measured in Guadalupe and Almaden Reservoirs were the highest of the 158 priority bass lakes in California sampled by the California State Water Resources Control Board's (State Water Board) Surface Water Ambient Monitoring Program (SWAMP) Statewide Bioaccumulation Monitoring Program (Program). (Davis et al., 2025).

In 1998, several reservoirs within the watershed were added to the California State 303(d) list of impaired water bodies, in accordance with the Clean Water Act, due to Hg impairments. These listings required the development of a Total Maximum Daily Load (TMDL) Program. From 2003 to 2005, the San Francisco Bay Regional Water Quality Control Board (Regional Water Board), Valley Water, and other stakeholders contracted Tetra Tech, Inc. to collect data and prepare technical reports on Hg contamination, fate, and transport in the Guadalupe River Watershed. After review by a panel of recognized Hg experts, these studies were used to draft the TMDL. Valley Water also initiated a voluntary monitoring program in 3 reservoirs and one lake at this time. On October 8, 2008, the State Water Board adopted a TMDL for Hg in the Guadalupe River Watershed, which was approved by the U.S. Environmental Protection Agency (USEPA) on June 1, 2010. TMDL implementation was planned in two 10-year phases: Phase 1 (2009–2018) and Phase 2 (2019–2028), with a review scheduled after Phase 1. The goal was to meet fish Hg targets by the 20-year mark. In their recent ten-year review, the Water Board acknowledged that TMDL implementation was proceeding at a slower rate than anticipated and recommended that no changes be made to targets, but that Phase 2 would be delayed to start in 2029. The goal for Phase 2 remains the same (attainment of the watershed fish tissue targets), but the deadline has been extended by 10 years to December 31, 2038 (Austin, 2022).

As part of the TMDL, the following numeric targets were developed for water and fish.

Table 1-1
Numeric targets for methylmercury in the water column.

Waters	TMDL Target
Reservoirs and lakes: • Guadalupe Reservoir • Almaden Reservoir • Calero Reservoir • Lake Almaden	1.5 ng total methylmercury per liter water (seasonal maximum, hypolimnion)

Table 1-2
Numeric targets for methylmercury in Fish.

Fish	TMDL Targets
Whole trophic level 3 fish, 5 to 15 cm in length	Average wet weight concentration 0.05 mg methylmercury per kg fish
Whole trophic level 3 fish, 15 to 35 cm in length	Average wet weight concentration 0.1 mg methylmercury per kg fish

To address MeHg production in reservoirs and lakes, the Water Board recommended that Valley Water adapt nutrient controls developed for reservoirs, such as hypolimnion oxygenation for controlling MeHg, and deploy these controls in Guadalupe, Almaden, and Calero reservoirs, as well as Almaden Lake. Along with these controls, Hg loads, concentrations, and bioaccumulation are monitored to ensure that total Hg and MeHg concentrations have declined adequately. Biannual fish monitoring is conducted in all impaired water bodies to assess progress toward reaching fish tissue targets. Studies involving hypolimnetic aeration and oxygenation began in 2006 to determine whether mechanical influences on hypolimnion anoxia can reduce MeHg production and if this approach translates to the fish. Starting in 2006, a solar-powered circulator was piloted in Lake Almaden. Over subsequent years, additional circulators were installed and tested in Lake Almaden, as well as in Almaden and Guadalupe Reservoirs. Hypolimnetic circulation significantly lowered seasonal maximum MeHg concentrations in the metalimnion at Lake Almaden, but not in the reservoirs. From 2012 to 2015, Valley Water tested more effective line diffuser hypolimnetic oxygenation systems (HOS) in Almaden, Guadalupe, and Calero Reservoirs, as well as in Stevens Creek Reservoir, which serves as a control unaffected by mining; however, fish in this reservoir still show elevated Hg concentrations like those in many other water bodies in CA. During the initial years, HOS operations were limited due to power and mechanical issues. From 2016 to 2020, they operated consistently during the dry season in all reservoirs. Starting in 2021, Guadalupe and Stevens Creek Reservoirs were turned off due to concerns about elevated temperatures in discharged water affecting downstream salmonid fisheries, as well as algal blooms within the reservoir. In 2023, only Calero remained operational due to mechanical problems in Almaden. In 2024, both Calero and Almaden were operational. Due to concerns regarding the effectiveness of HOS on fish Hg tissue concentration and the unintended water quality impacts (increased water temperature and algae blooms), Valley Water decided not to run the HOS in 2025. Instead, Valley Water continued to monitor water quality and fish tissue to evaluate post-HOS data. This also serves as an opportunity to establish new baseline conditions against which to compare the effects of potential pilot treatment methods with fewer negative water quality effects.

Calero Reservoir data indicate that even at maximum output, line diffuser oxygenation cannot overcome oxygen demand and may in fact induce it. Valley Water has partnered with Water Quality Solutions to conduct preliminary 3D modeling to better understand what is needed to effectively oxygenate Calero's hypolimnion. Additionally, after discovering the invasive golden mussel, *Limnoperna fortunei*, in San Luis Reservoir, which supplies Calero with imported water, it was determined that maintaining anoxia near the reservoir's outlet during stratification may help mitigate mussel proliferation.

HOS operation was shown to significantly decrease MeHg in the hypolimnion of some reservoirs, but concentrations remained the same or increased in surface waters. It was hypothesized that the HOSs transported profundal compounds into the photic zone and that continued Hg methylation may have occurred in the water column and littoral sediments. Despite little change in the overall water column MeHg concentrations, modest but statistically significant declining trends were observed in fish tissue Hg in Guadalupe and Stevens Creek reservoirs. This may have occurred because nutrients transported into surface waters by the HOSs may have enhanced primary productivity and indirectly impacted Hg bioaccumulation by diluting concentrations in phytoplankton—a phenomenon known as bloom dilution (Seelos, 2021). Additionally, Valley Water cleaned up Hg mining waste in Jacques Gulch, which was likely a primary factor contributing to a significant reduction in Hg concentrations in Almaden and Calero Reservoirs (Austin, 2021). Water column mixing, rather than suppression of methylation from HOSs, significantly reduced MeHg discharges downstream. After over a decade of TMDL implementation, fish Hg concentrations remain highly elevated and greatly exceed the TMDL targets in all TMDL waters. Previous studies by Valley Water and the Water Board have concluded that other types of oxygenation systems, such as saturation systems and sediment amendments using sorbents, may be more effective remediation

tools in these shallow, bottom-discharge reservoirs. (Seelos, 2021, Austin, 2021, McCord et al 2016).
In this biennial update, we continue analyzing reservoir water quality and fish data, following the approach used in previous biennial reports, with modifications to assess changes in HOS operation and an additional review of REI fish Hg data.

Valley Water continues to voluntarily test the assumptions of the TMDL and provide data to refine the plan by addressing questions raised by special studies that enhance understanding of Hg cycling and potential treatment measures. Part of this effort involves partnering with and supporting studies by several universities to expand our knowledge. Because little is known about atmospheric sources of Hg in the watershed, Valley Water collaborated with UC Santa Cruz to investigate the atmospheric origins of Hg in the New Almaden Mining district. Fieldwork was conducted in 2024, and a manuscript was published in 2025. This research led to the production of a heatmap showing areas with hotspots of high atmospheric Hg concentrations. Valley Water continues to collaborate with UC Merced and UC Davis. UC Merced is developing sorbents and application methods for Hg cleanup in Guadalupe Reservoir, while UC Davis is studying the formation and pathways of MeHg in Guadalupe Reservoir. Progress on these projects is summarized in this report. Data generated from these studies could inform a future field trial remediation study in Guadalupe Reservoir.

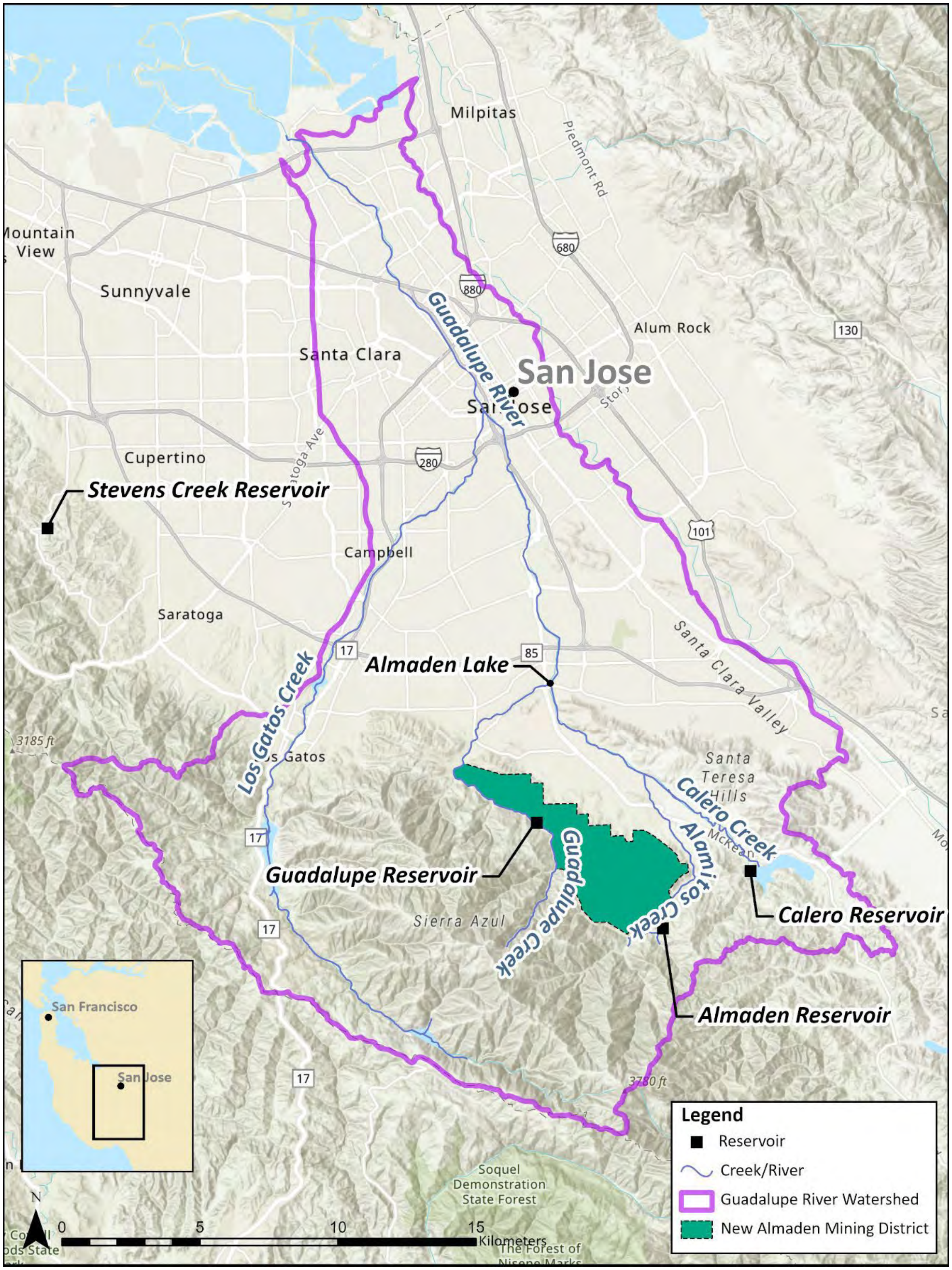

Figure 1-1 *Guadalupe River watershed, including the location of the four study reservoirs and Almaden Lake, as well as the New Almaden Mining District. Stevens Creek Reservoir lies outside the Guadalupe River watershed and is not affected by the historic mining district.*

2. STUDY PERIOD AND HYPOLIMNETIC OXYGENATION SYSTEM OPERATION

Data described in this report have been collected from 2005-2025. During this time, changes in annual hydrology, reservoir operation, and HOS operation may have affected Hg cycling and bioaccumulation.

The San Jose region experienced a prolonged drought from 2011 to 2017, peaking in 2014. Drought conditions reoccurred from 2020 to 2022. Wet periods in late 2010 and during 2019-2020 temporarily eased drought effects in the years immediately following. Two consecutive wet seasons in 2022-2023 helped refill reservoirs, providing some relief through 2025 despite drier conditions in 2024-2025.

Water levels in reservoirs varied significantly due to these changes in rainfall and hydrology. This is evident from 2014 to 2015, when reservoirs were drawn down and average storage levels were low. Conversely, in 2017-2018 and 2023-2024, reservoirs exceeded their average storage levels and were at or near full capacity (Figure 2-1). Reservoir storage levels were also reduced in some reservoirs to maintain capacity limits set by the State’s Division of Safety Dams due to seismic concerns. Releases to maintain these levels were dependent on the amount of water the outlet valves could release.

Beginning in 2006, a hypolimnetic solar-powered circulator was piloted in Lake Almaden. From 2007 to 2009, additional circulators were installed and tested in Lake Almaden, as well as in Almaden and Guadalupe Reservoirs. From 2012 to 2015, Valley Water began testing more powerful line diffuser hypolimnetic oxygenation systems (HOS) in Almaden, Guadalupe, and Calero Reservoirs, as well as Stevens Creek Reservoir. During the initial years, these systems operated on a limited basis due to issues with power and mechanical failures. From 2016 to 2019, they operated consistently during the dry season in all reservoirs. Starting in 2021, Guadalupe and Stevens Creek Reservoirs were shut off due to concerns about elevated temperatures in releases which could negatively affect downstream cold-water fisheries, and nutrient mixing that could promote reservoir algal blooms. In 2023, only Calero operated due to mechanical failures at Almaden, and in 2024, Calero and Almaden operated. All systems remained off in 2025.

During HOS operation, DO supersaturation was observed in Almaden and Guadalupe Reservoirs, and to a lesser degree at Stevens Creek Reservoir (Figure 2-2). HOSs were able to keep DO saturation levels in the bottom water above 100% throughout the oxygenation period. Supersaturation did not occur in Almaden Lake or Calero Reservoir because the DO supply to the hypolimnion was insufficient to overcome the oxygen demand. After HOS operations ended in Guadalupe and Stevens Creek Reservoirs, the oxygen pattern returned to a cycle similar to what was observed before the systems were installed, with values seasonally ranging from near zero to 100% saturation, occasionally exceeding saturation (Figure 2-2).

Effective oxygenation keeps dissolved oxygen concentrations above 3 mg/L in the bottom water. Dissolved oxygen in deep water was maintained near or above saturation in Almaden and Guadalupe Reservoirs but could not raise dissolved oxygen above hypoxia (2 mg/L) in Calero Reservoir. Calero Reservoir is larger than Almaden, Guadalupe or Stevens Creek with a higher sediment surface area to hypolimnion ratio and a greater oxygen demand

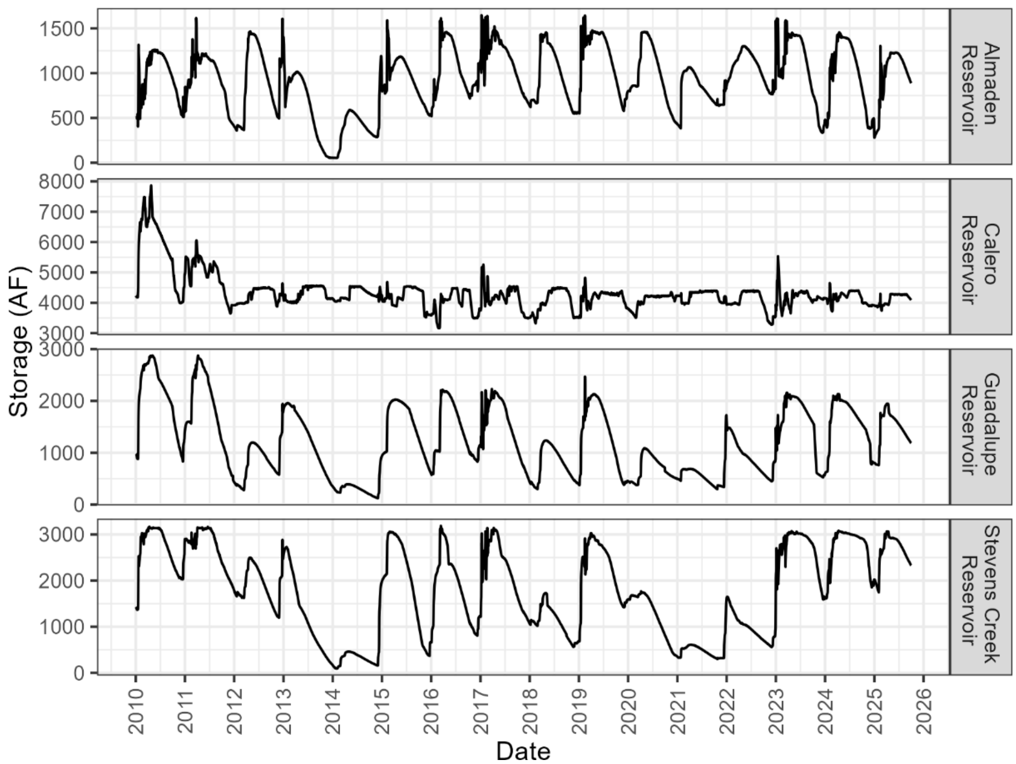

Figure 2-1 Reservoir storage (AF) over time.

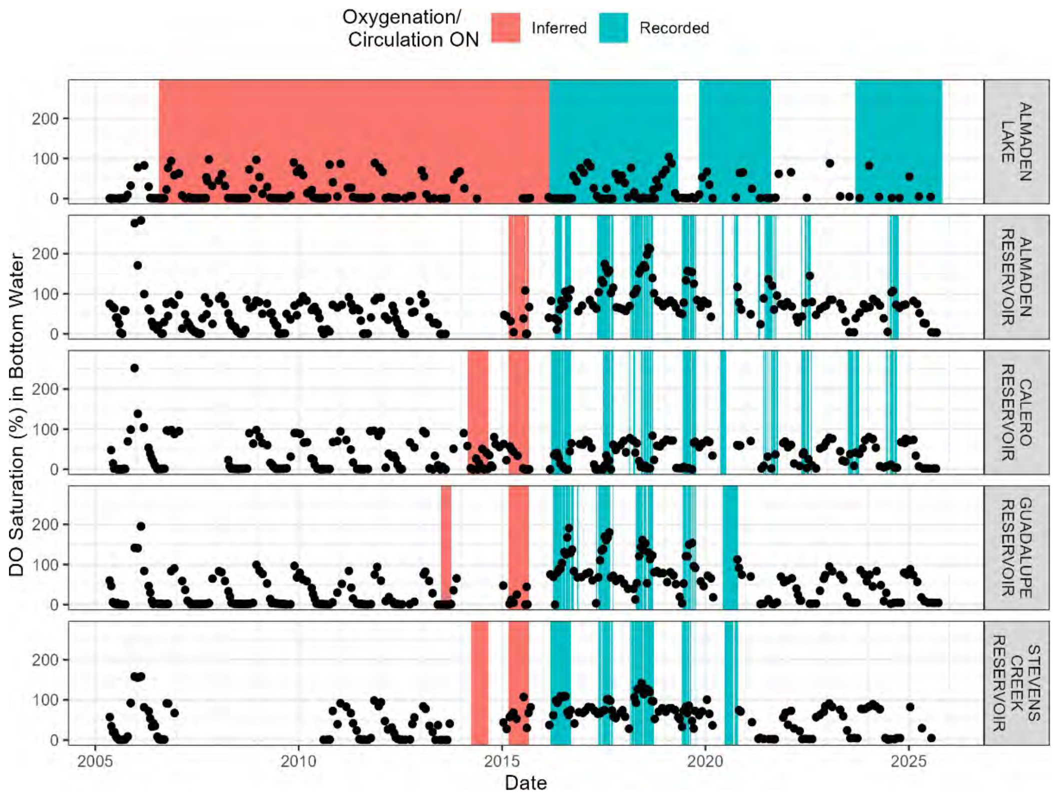

Figure 2-2 Hypolimnetic dissolved oxygen saturation in reservoirs and Almaden Lake.

3. WATER QUALITY AND FISH MONITORING

Water quality and fish Hg concentration data have been monitored in the Guadalupe River watershed reservoirs in accordance with the TMDL Implementation Plan since 2012; limited data exist from before this period. This chapter provides an overview of the monitoring program and describes data on water quality, fish assemblages, and fish Hg concentrations in Almaden Lake, as well as Almaden, Calero, Guadalupe, and Stevens Creek Reservoirs. Almaden Lake only includes water quality data; no fish data were collected. Calculated reservoir Hg and MeHg loads to downstream creeks are also reported.

3.1 METHODS

3.1.1 WATER QUALITY

Water quality depth profiles and samples were collected at the deepest portions of Almaden, Calero, Guadalupe, and Stevens Creek Reservoirs. At all reservoirs besides Guadalupe, the deepest sample from the reservoir is representative of water released downstream and can be used to calculate Hg loads. At Guadalupe Reservoir, additional samples and water quality data were collected at the outlet structure to calculate Hg loads to downstream waters.

Water quality profiles and samples were also collected within Almaden Lake and at the lake’s inlet and outlet. Water quality depth profiles were collected at all reservoirs and Almaden Lake using Hydrolab DS5 multiparameter sondes. Parameters included pH, temperature, oxidation-reduction potential, specific conductivity, dissolved oxygen, chlorophyll a, and phycocyanin. Profile data were logged at 0.25- to 1-meter intervals throughout the water column. At Guadalupe Reservoir outlet, a multiparameter handheld YSI sonde or a Hydrolab DS5 multiparameter sonde was used to collect pH, specific conductivity, turbidity, dissolved oxygen, and temperature data.

Water samples were collected using a Wildco Alpha-type Van Dorn sampling device at discrete depths. Epilimnion samples were collected two meters from the surface, and hypolimnion samples were collected one meter above the bottom. During mixed conditions, mid-depth samples were taken at three equal intervals between the epilimnion and hypolimnion samples. In stratified conditions, mid-depth samples were taken at the top, middle, and bottom of the thermocline, as indicated by the temperature-depth profile. Samples were dispensed into sample collection bottles using EPA Method 1669 “Clean Hands-Dirty Hands” procedures. Sample collection bottles and laboratory analysis methods are described in Table 3-1 and Table 3-2, respectively.

Water quality monitoring occurred monthly at each reservoir station and quarterly at Almaden Lake stations.

Table 3-1
Sample Collection Bottles and Preservatives

Analyte	Container Material	Volume	Preservative
Ammonia (as N)	HDPE	500mL	Sulfuric Acid
Chloride, Sulfate	HDPE	500mL	Unpreserved
Total Hg	Glass	250mL, double bagged	Unpreserved
Total MeHg	Amber Glass	250mL, double bagged	Hydrochloric Acid

Table 3-2
Laboratory Analysis Methods

Analyte	Method	Reporting Limit
Ammonia (as N)	EPA 350.1	0.1 mg/L
Chloride, Sulfate	EPA 300	1 mg/L
Total Hg	EPA 1631 E	0.5 ng/L
Total MeHg	EPA 1630	0.05 ng/L

3.1.2 FISH MONITORING

Fish were collected from Almaden, Calero, Guadalupe, and Stevens Creek Reservoirs twice annually in spring and summer from 2015 to 2025, except for some disruptions due to COVID-19 in 2020 and in the spring of 2021. Fish monitoring resumed in summer 2021, but due to exceptionally low water levels that year, Calero was the only reservoir where an electrofishing boat could be used. In all other reservoirs, fish were instead captured using hook-and-line methods. In the summer of 2024, fish were not collected from Almaden Reservoir. In the summer of 2025, Almaden Reservoir was sampled using a hook-and-line method due to low water levels, while the other reservoirs were sampled using electrofishing.

When boat electrofishing was used, fish were captured using a Smith-Root Model H electrofishing boat. This method can capture fish up to 4.5 meters deep, depending on conductivity and settings. Turbidity, aquatic vegetation, and water level limit the area that can be sampled by electrofishing. Boat electrofishing also introduces biases associated with species catchability and netting efficiency. The pelagic tendency of forage fish, for example, makes them more susceptible to capture using boat electrofishing, which may result in overestimating the prey populations relative to those of predatory fish. Hook-and-line sampling was conducted from a 14-foot aluminum Jon Boat. Methods included open water trolling along transects and stationary angling along shorelines. Hook-and-line sampling may present a bias toward larger fish, as gape size can limit the catchability of smaller fish. Additionally, the sampling location and the angler's ability may confound the collection results.

3.2 MONITORING RESULTS

An overview of the water quality and fish monitoring results is presented in the following sections. Data were evaluated using the statistical modeling framework in the R language as used in previous biennial reports. Notably, to interpret longer-term patterns, the data plots are shown from the inception of the monitoring program, not just the most recent two-year period. As needed, we built on or contrasted results presented in previous work, such as Valley Water (2021), Seelos et al. (2021), and McCord et al. (2016). We also refer to older data collected in the system as part of the TMDL development process (Tetra Tech, 2013, 2005a, b).

3.2.1 WATER QUALITY

Building on the recommendations from the last two biennial reports (Valley Water, 2021, and Tetra Tech, 2023), modifications were made to the operation of the HOSs. The HOSs ceased operation at Guadalupe and Stevens Creek Reservoirs in 2021. They continued operating at Almaden and Calero Reservoirs; however, the HOS at Almaden Reservoir was not operational in 2023 due to mechanical problems (Figure 2-2). None of the systems were operated in 2025. The solar hypolimnetic circulators in Almaden Lake remained operational and were in use during the sampling period.

Water quality results are shown as paired box plots for each reservoir and Almaden Lake, comparing the averages of each parameter during the stratification period (May-September) between years when HOSs were active (2016-2021) and when they were not (2005-2016 and 2021-2025). Separate plots distinguish between the epilimnion and hypolimnion. We included the entire dataset in the analysis, as in the last biennial report (Tetra Tech, 2023) and in Seelos (2021). Table A-1 in the Appendix shows these results with statistically significant findings highlighted. Water quality data in time series graphs are also provided for all parameters in Appendix B.

Similar to earlier results (Valley Water, 2021, Tetra Tech, 2023, and Seelos et al. 2021), the HOSs effectively oxygenated the hypolimnion in all reservoirs except Calero. Hypolimnion dissolved oxygen concentrations increased significantly during HOS operation in Almaden, Guadalupe, and Stevens Creek Reservoirs, and remained above or close to 100% saturation throughout the treatment periods (Figures 2-2 and 3-1). High dissolved oxygen concentrations also persisted throughout the water column of these reservoirs, as indicated by significant differences in the epilimnion when the systems were active. As previously documented, the HOS in Calero Reservoir, despite showing a significant difference in DO concentration in the hypolimnion when activated, was ineffective at raising dissolved oxygen concentrations above hypoxic conditions (DO >

3 mg/L) and failed to meet biochemical oxygen demand. Calero is larger than the other reservoirs, with a higher sediment surface area-to-hypolimnion ratio and thus has a higher oxygen demand. Therefore, the system may be undersized for these conditions (Seelos, 2021; Gantzer et al., 2009). The solar circulators had no significant effect on the hypolimnion DO concentration in Lake Almaden. A notable drop in DO concentrations in the epilimnion of Lake Almaden when the system is active is believed to result from vertical transfer of anoxic bottom water to the surface via the circulators (Valley Water 2021).

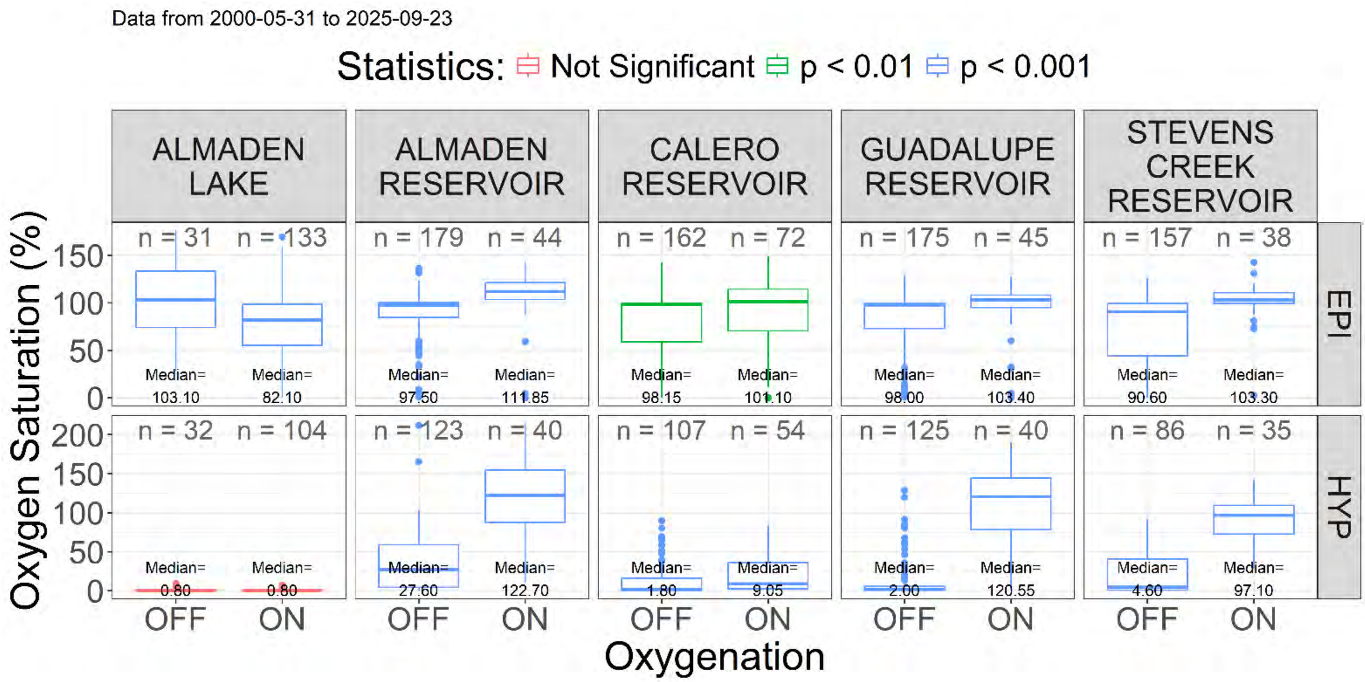

Figure 3-1 Epilimnetic and hypolimnetic dissolved oxygen when treatment systems are off and on.

Similar to results in the 2021 and 2023 reports, the oxidation-reduction potential significantly decreased in the epilimnion of all reservoirs and Almaden Lake when the treatment systems were activated (Figure 3-2). Since ORP is expected to increase oxidizing conditions, this result indicates that the HOS systems were likely transporting reduced compounds upward. No statistically significant differences were observed in ORP concentrations in the hypolimnion, except in Almaden Lake, where a higher but still relatively low ORP was recorded when the circulators were operational.

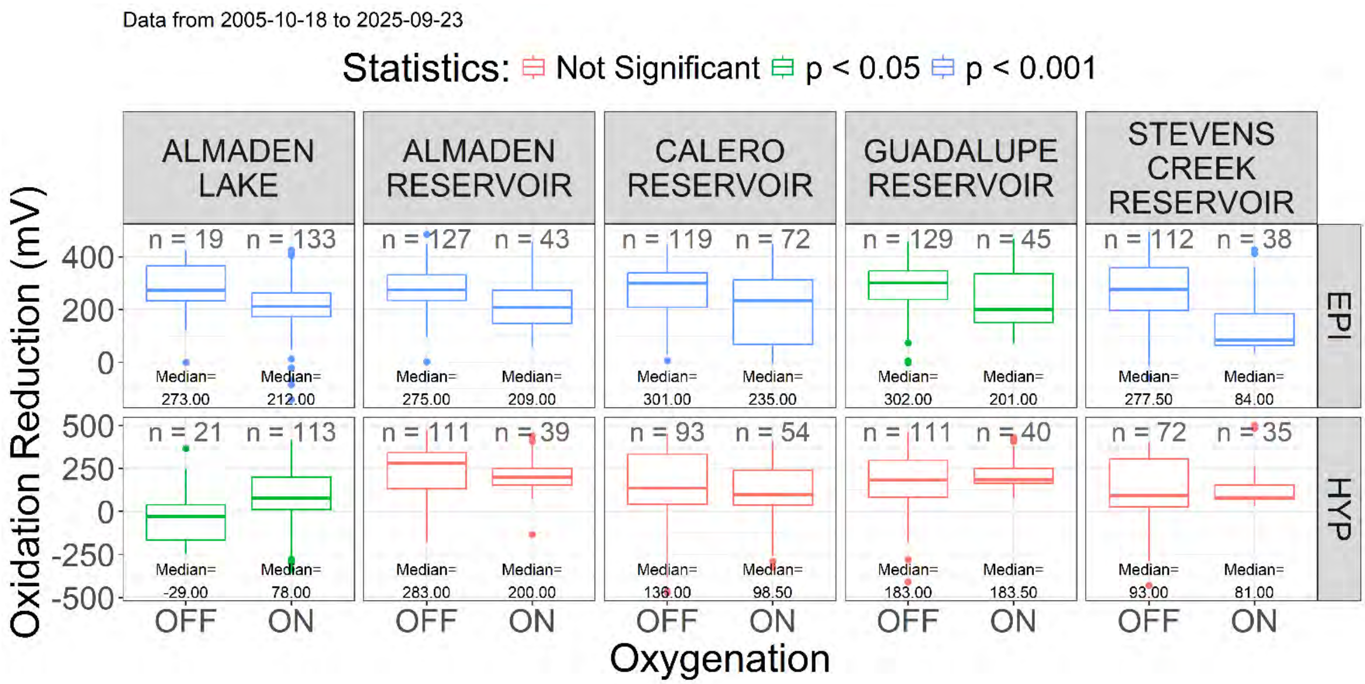

Figure 3-2 Epilimnetic and hypolimnetic oxidation-reduction potential when treatment systems are off and on.

Total Hg concentrations are shown in Figure 3-3. As in other years, the highest total Hg concentrations were seen in Almaden Lake, and the lowest in Calero Reservoir. Although Calero Reservoir has a Hg mine source through water transfer from Almaden Reservoir, the total Hg concentrations were lower than those in Stevens Creek Reservoir, a non-mine-affected reservoir. Across all reservoirs, total Hg concentrations were higher in the hypolimnia than the epilimnia, likely related to sediment resuspension. The HOS and circulators had a small effect on the distribution of total Hg. Mercury concentrations in the epilimnion and hypolimnion of all reservoirs were lower during HOS operation, except for the hypolimnion of Stevens Creek Reservoir, where concentrations were higher however in previous years Stevens Creek Reservoir also showed the pattern of lower Hg in the hypolimnion while HOS was in operation. Total Hg decreases were statistically significant in the hypolimnion of Almaden and Calero Reservoirs and the epilimnion of Guadalupe Reservoir. The result in Stevens Creek Reservoir is likely due to sediment resuspension. The lower Total Hg result is surprising and counterintuitive, as one would expect that sediment disturbance by the HOS would lead to higher total Hg concentrations in the hypolimnion. Hg has been shown to drop in hypolimnetic water during oxygenation due to co-precipitation with Fe(III) and subsequent sedimentation (Dent et al. 2014). Many studies have implicated Fe and Mn oxides as sinks for water column Hg. Precipitation of Fe(III) and Mn(IV) as metal oxides can provide a surface for adsorbing a number of metals, including Hg, arsenic, copper, zinc, and nickel (Davidson 1993).

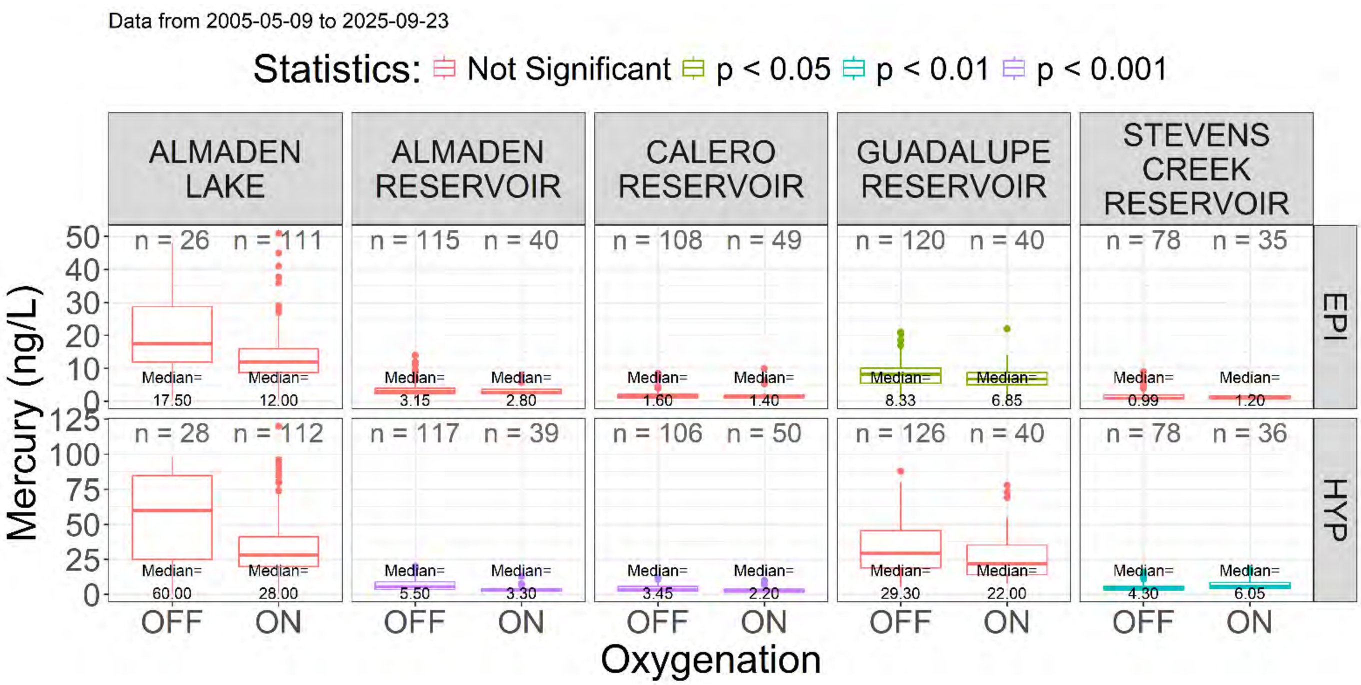

Figure 3-3 Epilimnetic and hypolimnetic Total Hg concentrations when treatment systems are off and on.

Similar to previous years, MeHg concentrations were highest in the hypolimnion of all reservoirs and lakes, with the highest concentrations observed in Lake Almaden and Guadalupe Reservoir, the two most Hg contaminated water bodies in the watershed. MeHg concentrations significantly declined in the hypolimnion and remained unchanged in the epilimnion of all reservoirs when HOSs were operational (Figure 3-4) (Valley Water, 2021; Tetra Tech, 2023; Seelos et al., 2021). This reduction was greatest in the most contaminated water bodies and followed the same trends seen in previous years. Although the solar circulators had no significant effect on hypolimnion DO concentrations in Lake Almaden, they significantly reduced MeHg concentrations from 28 ng/L to 9 ng/L while operating.

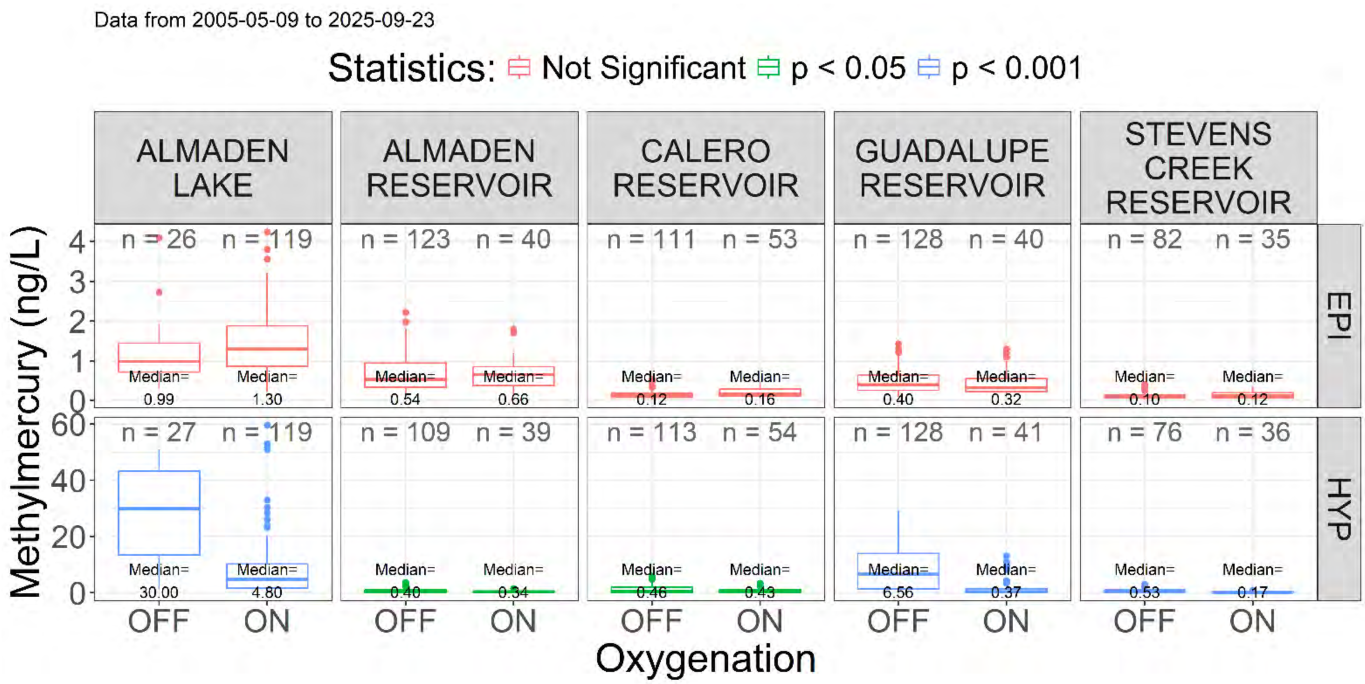

Figure 3-4 *Epilimnetic and hypolimnetic MeHg concentrations when treatment systems are off and on.*

Total Hg and MeHg data for all five water bodies are also included here as time series graphs to better understand the effects of operating the HOSs. MeHg decreased at Almaden Lake over time and increased in the hypolimnion when the circulators were turned off (Figure 3-5).

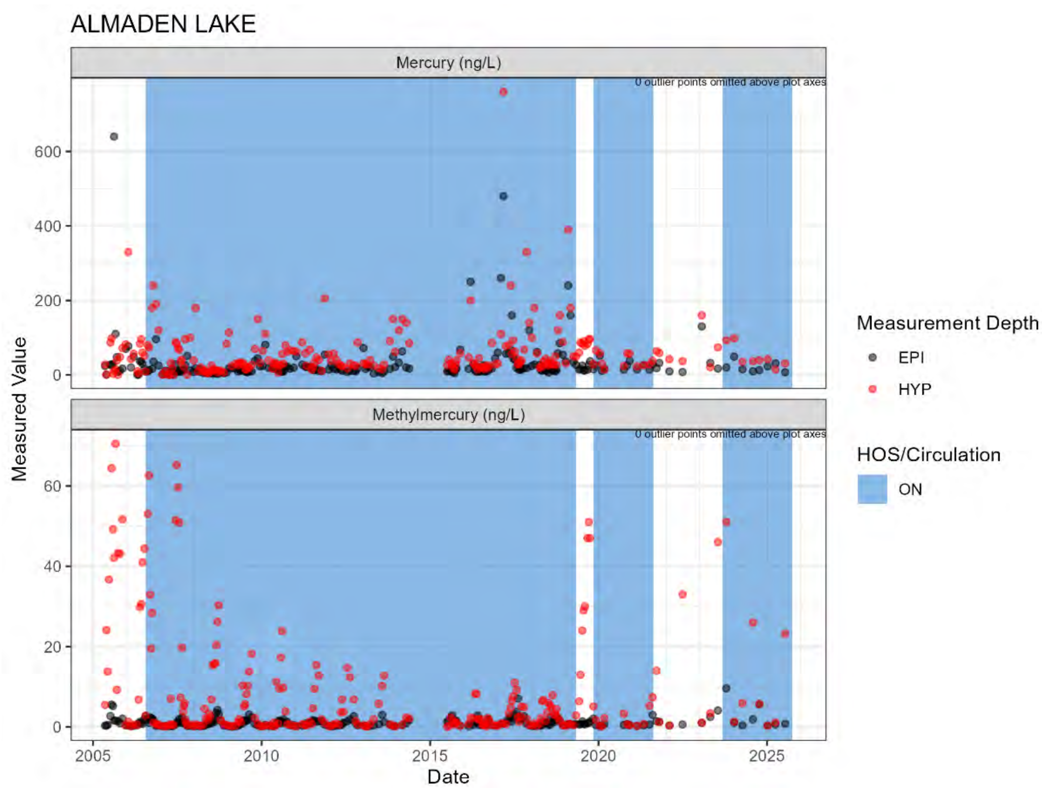

Figure 3-5 Time series of Hg and MeHg concentrations in the epilimnion and hypolimnion in Almaden Lake and showing the operation of the HOS.

In Almaden Reservoir, MeHg concentrations were lower in the hypolimnion when the HOS was operational. Similarly, Total Hg concentrations decreased in the hypolimnion when the HOS was operational (Figure 3-6).

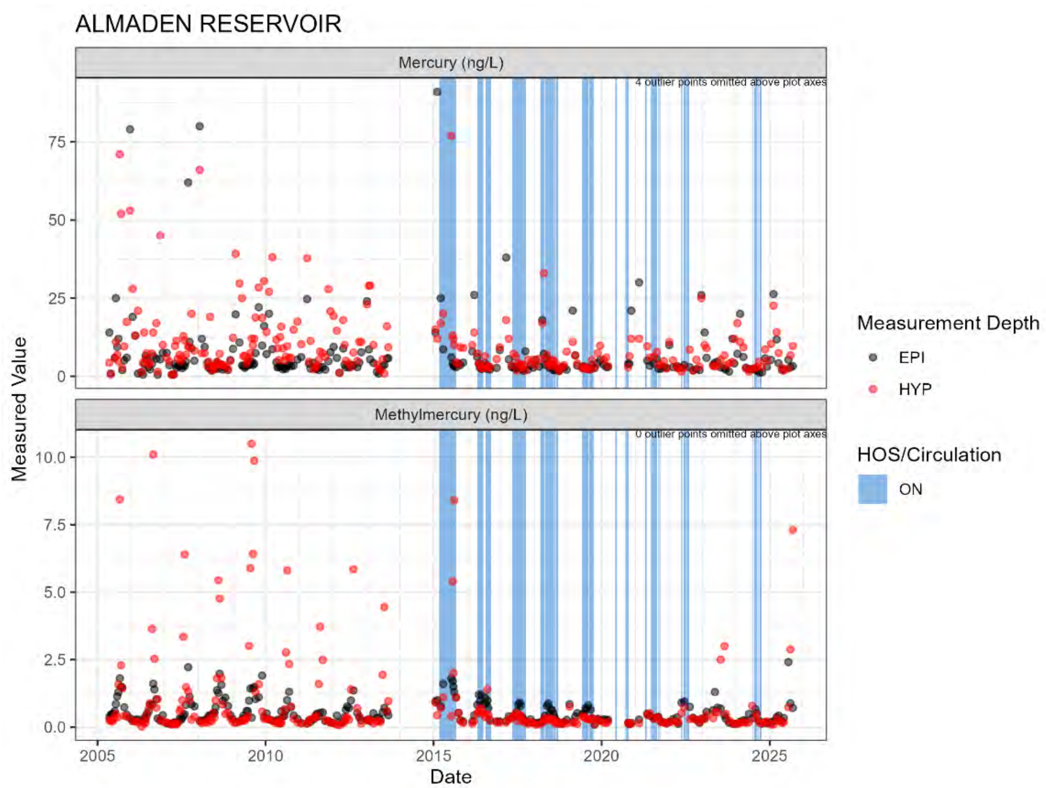

Figure 3-6 Time series of Hg and MeHg concentrations in the epilimnion and hypolimnion in Almaden Reservoir, showing the operation of the HOS

In Calero Reservoir, MeHg concentrations were lower in the hypolimnion during HOS operation, with a minimal effect on total Hg (Figure 3-7).

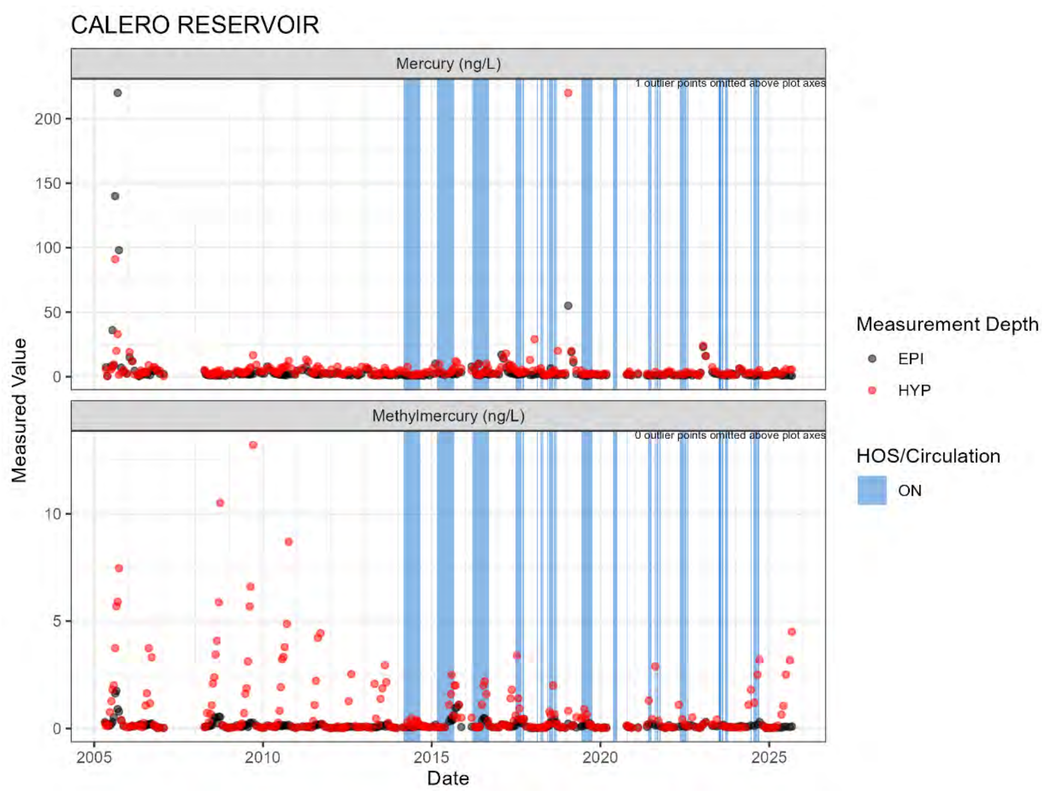

Figure 3-7 Time series of Hg and MeHg concentrations in the epilimnion and hypolimnion in Calero Reservoir, showing the operation of the HOS.

In Guadalupe Reservoir, MeHg concentrations were significantly lower in the hypolimnion when the HOS was operational and increased when HOS operations ceased (Figure 3-8). HOS operation also had a small effect on total Hg.

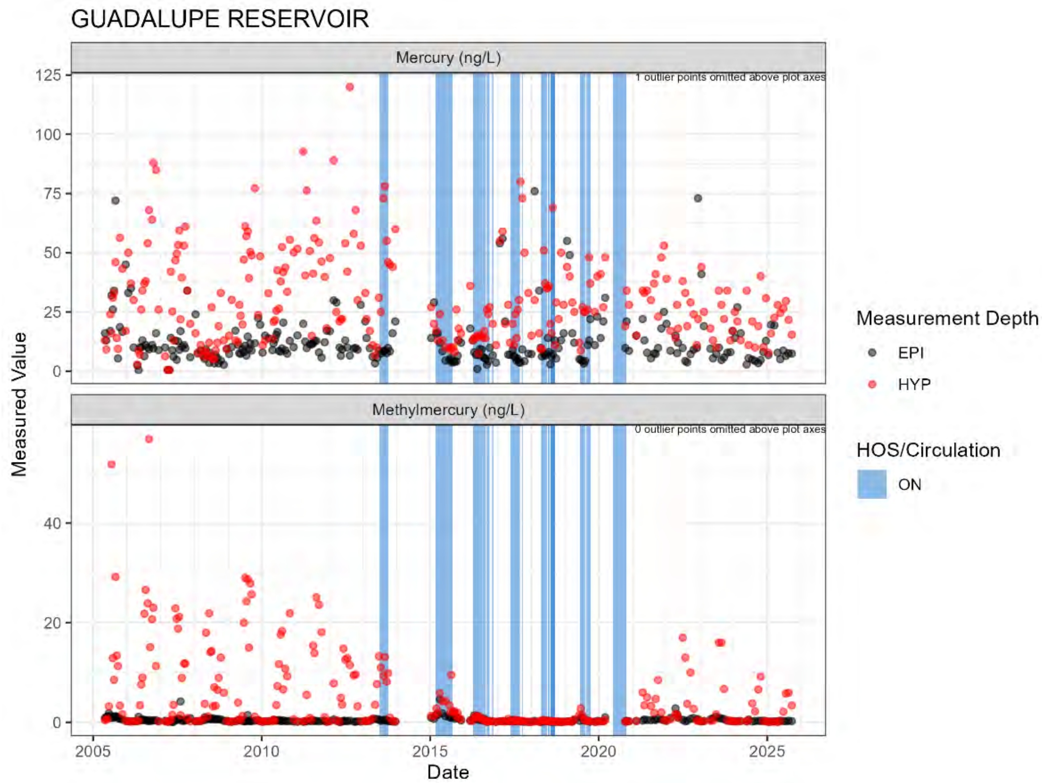

Figure 3-8 Time series of Hg and MeHg concentrations in the epilimnion and hypolimnion in Guadalupe Reservoir, showing the operation of the HOS

Stevens Creek Reservoir had lower MeHg concentrations in the hypolimnion when the HOS was operational, and higher concentrations when HOS operations ceased (Figure 3-9).

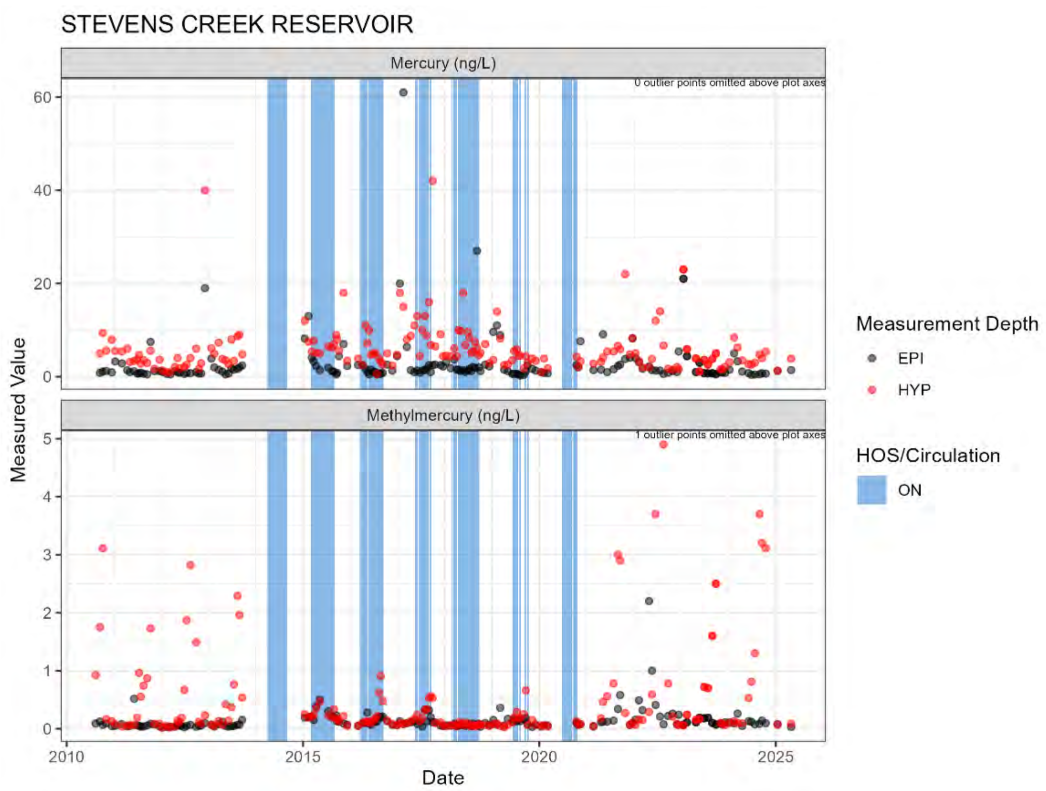

Figure 3-9 Time series of Hg and MeHg concentrations in the epilimnion and hypolimnion in Stevens Creek Reservoir, showing the operation of the HOS

The highest sulfate concentrations were measured in the epilimnia of Stevens Creek, Lake Almaden, and Calero Reservoir. As reported earlier, sulfate concentrations were significantly higher in the hypolimnia of all reservoirs and lakes when treatment systems were active, and in the epilimnion of Calero. The epilimnion of all other water bodies remained unchanged. The greatest increase in sulfate concentrations occurred in Lake Almaden. The increase in sulfate concentrations in the hypolimnion is believed to result from sulfide oxidation and the reduced activity of sulfate-reducing bacteria during operational periods of the treatment systems (Tetra Tech, 2023, Seelos 2021).

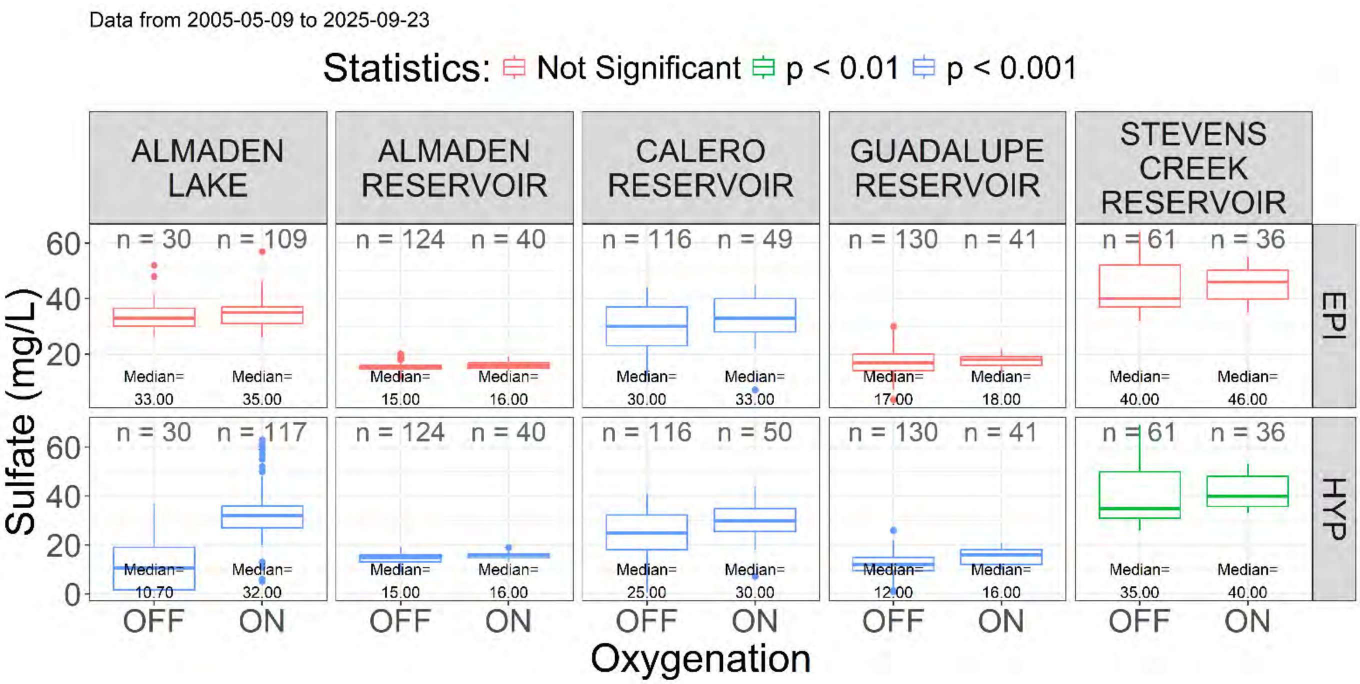

Figure 3-10 Comparison of epilimnetic and hypolimnetic sulfate concentrations when treatment systems are off and on.

Temperatures in the epilimnia and hypolimnia were generally higher during HOS and circulator operation (Figure 3-11). Differences were greater in some water bodies: bottom water temperatures in Almaden, Calero, and Stevens Creek reservoirs increased by an average of 2°C, Almaden Lake rose by an average of 3.8°C, and Guadalupe Reservoir saw an average increase of 5.5°C during system operation. As previously noted, the HOS and circulators significantly increased the temperature in the epilimnion of all water bodies, except Almaden Lake. Temperature increases in the hypolimnion during treatment system operations are attributed to mixing induced by rising bubble plumes. This process draws warmer water from the upper hypolimnion or metalimnion downward, increasing the temperature of the near-bottom water.

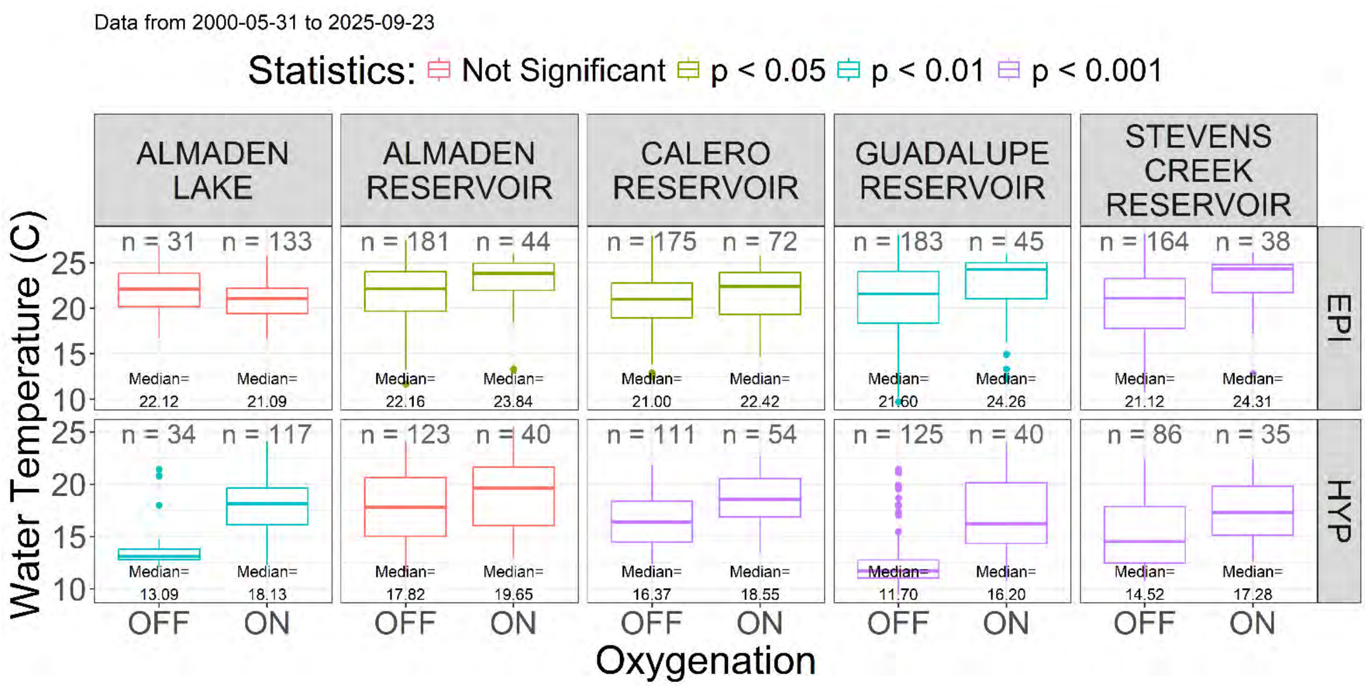

Figure 3-11 Epilimnetic and hypolimnetic water temperature when treatment systems are off and on.

Hypolimnetic ammonia concentrations were lower and statistically significant during treatment system operation in all water bodies (Figure 3-12). Changes in the epilimnia of Almaden Lake and Almaden Reservoir were not significant. Decreases in hypolimnetic ammonia concentrations were likely due to enhanced nitrification under aerobic conditions and dilution of hypolimnetic ammonia throughout the water column.

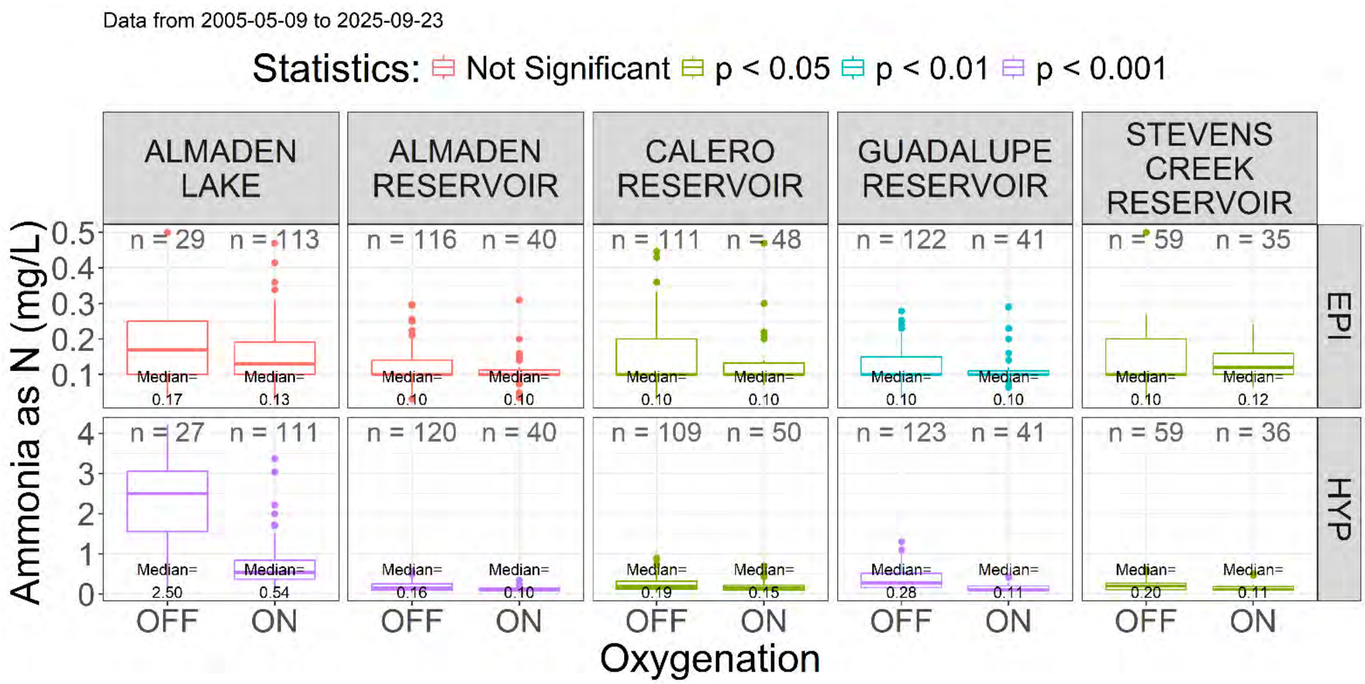

Figure 3-12 Epilimnetic and hypolimnetic ammonia concentrations when treatment systems are off and on.

The operation of the HOS and circulators generally increased chlorophyll *a* concentrations in the epilimnion, with statistically significant increases in all water bodies except Guadalupe Reservoir (Figure 3-13). Almaden Lake and Calero Reservoir exhibited the most pronounced increases in chlorophyll *a*. Increases in primary productivity were likely due to warming effects and transport of nutrient-rich profundal water into the photic zone (Seelos et al., 2021).

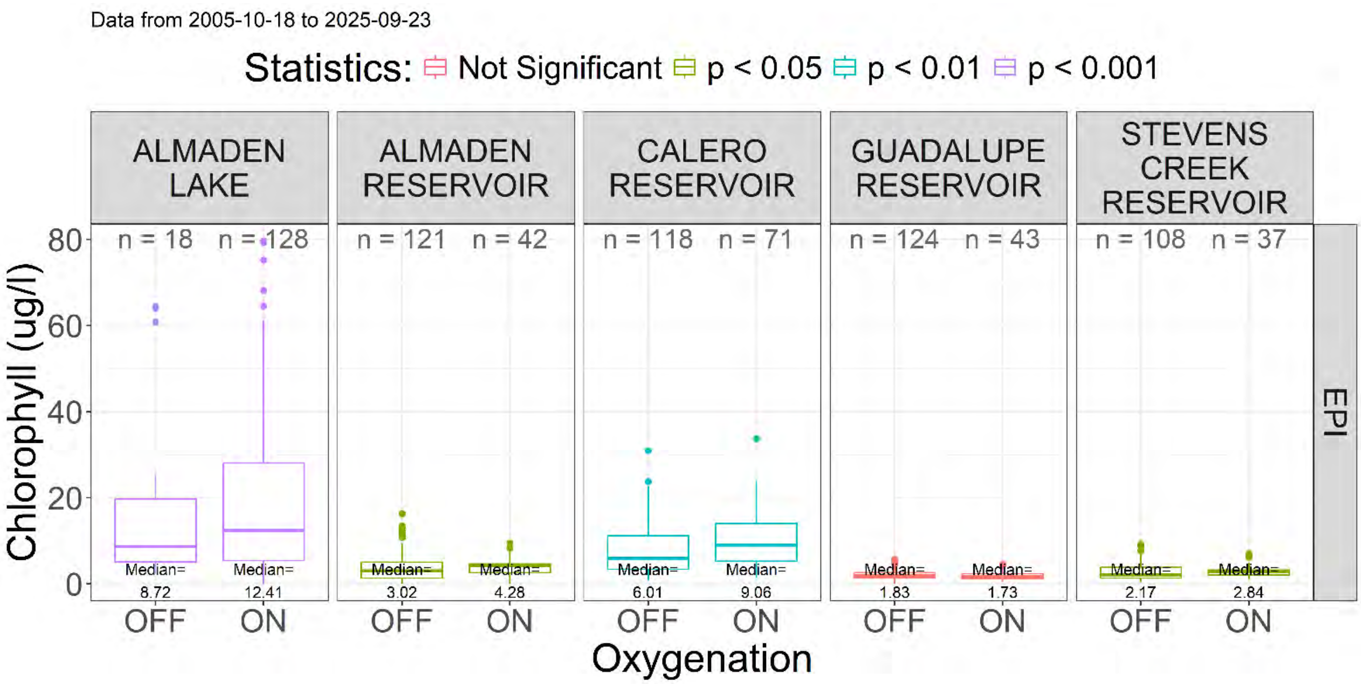

Figure 3-13   Epilimnetic chlorophyll a concentration when treatment systems are off and on.

3.2.2 PRE-HOS/POST-HOS WATER QUALITY COMPARISONS

In addition to our previous analysis, the following similar paired box plots compare water quality parameters between the years before HOSs were activated and the years after they were deactivated for each reservoir (approximately a decade gap). All statistical tests were computed using the R programming language. If the data were normally or nearly normally distributed or could be transformed into a normal or nearly normal distribution, mean comparisons were performed using Analysis of Variance (ANOVA). If the data could not be normalized, the Kruskal-Wallis One-Way Analysis of Variance was used. Table A-2 in the Appendix presents these data with significant results highlighted. As with the previous water quality analysis, which tested the effect of the treatment systems, the data included in these analyses consisted of those collected during the summer stratification period only (Table 3-3).

Table 3-3
Data used in the comparison of water quality parameters from years prior to running HOS and years after operations ceased.

Location	Pre-HOS Years	Post HOS Years
Stevens Creek Reservoir	2010-2013	2021-2025
Guadalupe Reservoir	2008-2012	2021-2025
Almaden Reservoir	2008-2012	2023, 2025
Calero Reservoir	2008-2012	2025

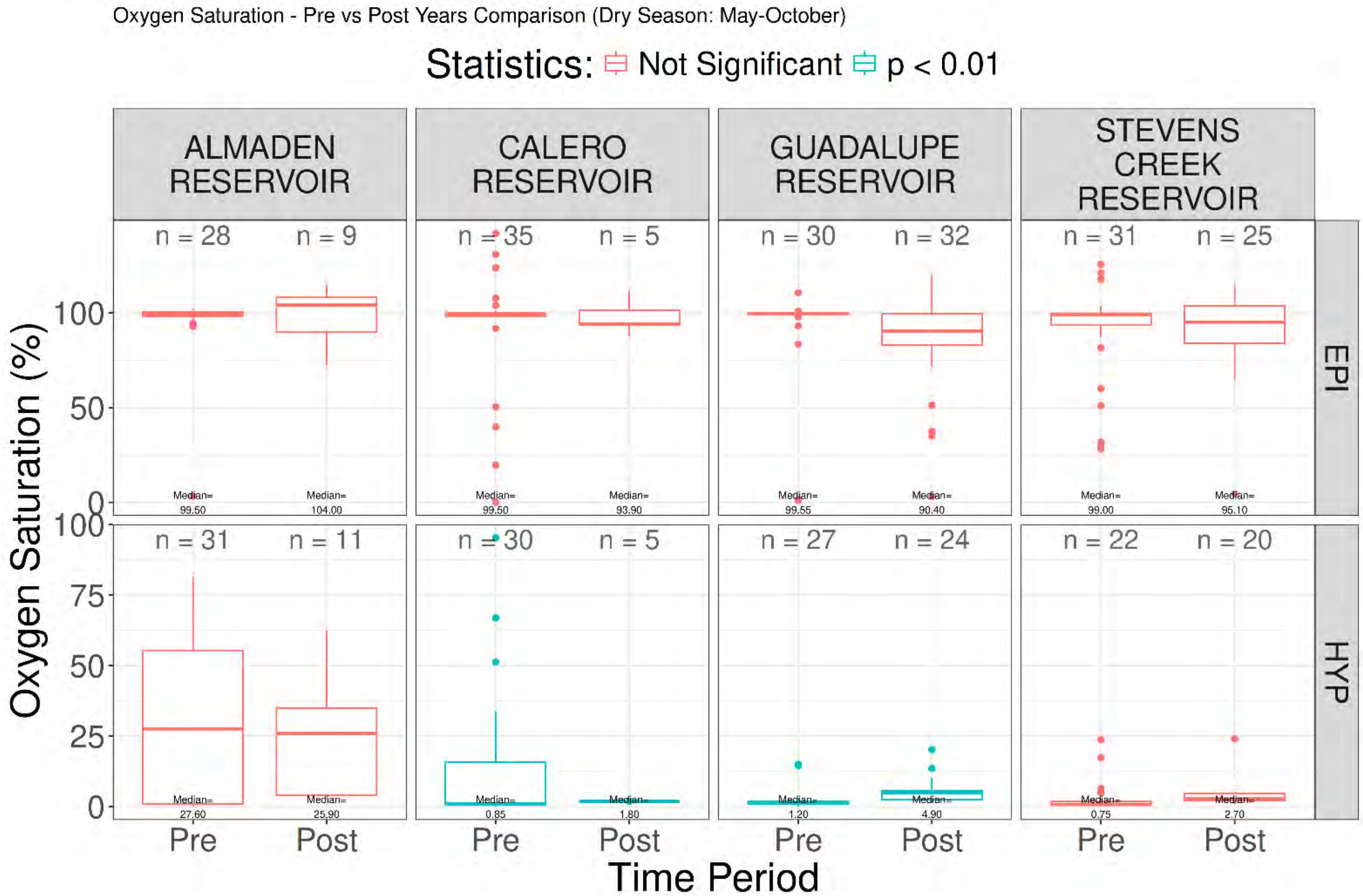

Figure 3-14 Epilimnetic and hypolimnetic Oxygen Saturation concentrations before HOSs were in operation (Pre) and after operations ended (Post).

Oxygen concentrations before HOS implementation, compared to concentrations after they were deactivated, show no significant differences, except in the hypolimnion of Guadalupe and Calero, where a slightly higher average concentration was noted after the HOSs were turned off, compared to previously documented concentrations; however, the concentrations remained hypoxic.

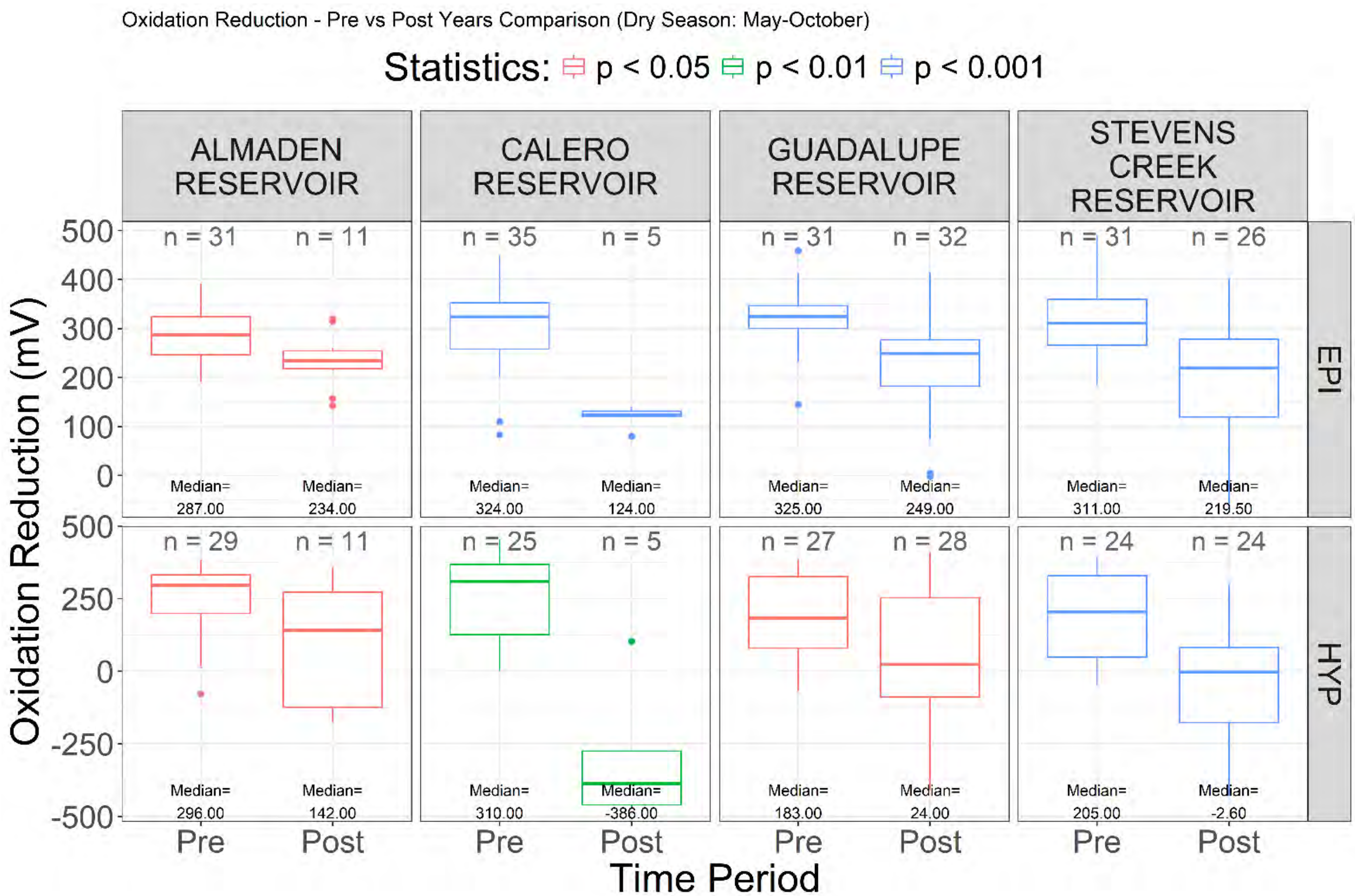

Figure 3-15 Epilimnetic and hypolimnetic ORP before HOSs were in operation (Pre) and after operations ended (Post).

Post-oxygenation ORP was significantly lower in the epilimnion and hypolimnion of all reservoirs, except in Almaden Reservoir and the hypolimnion of Guadalupe Reservoir, where differences were not statistically significant. Lakes worldwide, particularly in the temperate zone, have shown a consistent long-term trend of decreasing ORP in both the epilimnion and hypolimnion, primarily driven by rapid deoxygenation (Jane et al. 2021).

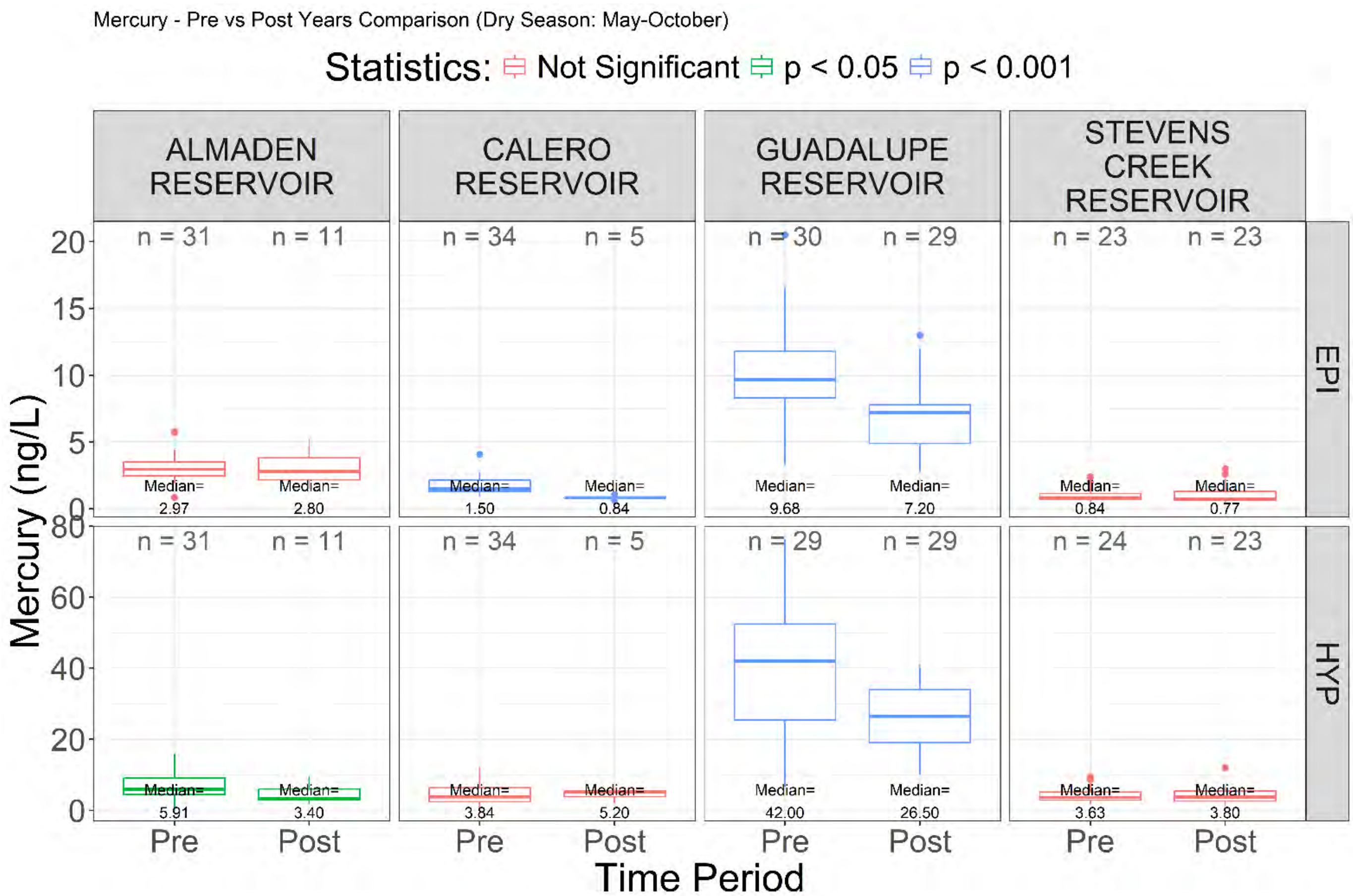

Figure 3-16 Epilimnetic and hypolimnetic Mercury before HOSs were in operation (Pre) and after operations ended (Post).

Mercury concentrations pre-oxygenation were universally higher than post-oxygenation, but the relationships in the epilimnion and hypolimnion of Amaden Reservoir and the hypolimnion of Guadalupe Reservoir were not statistically significant. Lower Hg concentrations in Almaden and Calero Reservoirs could be the result of source-control measures, notably the cleanups in the areas of Mine Hill and Lower Jacques Gulch, both of which flow directly into Almaden Reservoir and, in turn, affect Calero Reservoir by water transfers through the Almaden-Calero Canal. Fewer source control efforts have occurred in the watershed of Guadalupe Reservoir, and cannot explain the reduction in Hg there. This reduction in Hg is also illustrated in Figure 3-8. The reductions begin during HOS operations in the epilimnion and after operation ceases in both the hypolimnion and epilimnion. Changes in food-web dynamics, such as higher phytoplankton biomass, could reduce Hg concentrations through bloom dilution and somatic growth dilution in zooplankton and fish (Seelos et al., 2021); however, it would not reduce the total Hg within a reservoir (Razavi et al., 2015). Guadalupe Reservoir is heavily contaminated with Hg mine wastes in the form of cinnabar along its shoreline and has many mine sites in its watershed (Austin 2020). The main inflows come from the upper watershed. The reservoir, which stores about 3,415 acre-feet of water, is highly affected by large runoff events that bring Hg-contaminated sediments from historic mining areas. Between the collection of pre- and post-data, California experienced one of the most severe droughts in recent history (2011-2016). Less runoff of -contaminated sediments from the cinnabar shelf along the shoreline and in the upper watershed could explain the significant decrease in Guadalupe Reservoir Hg in recent years.

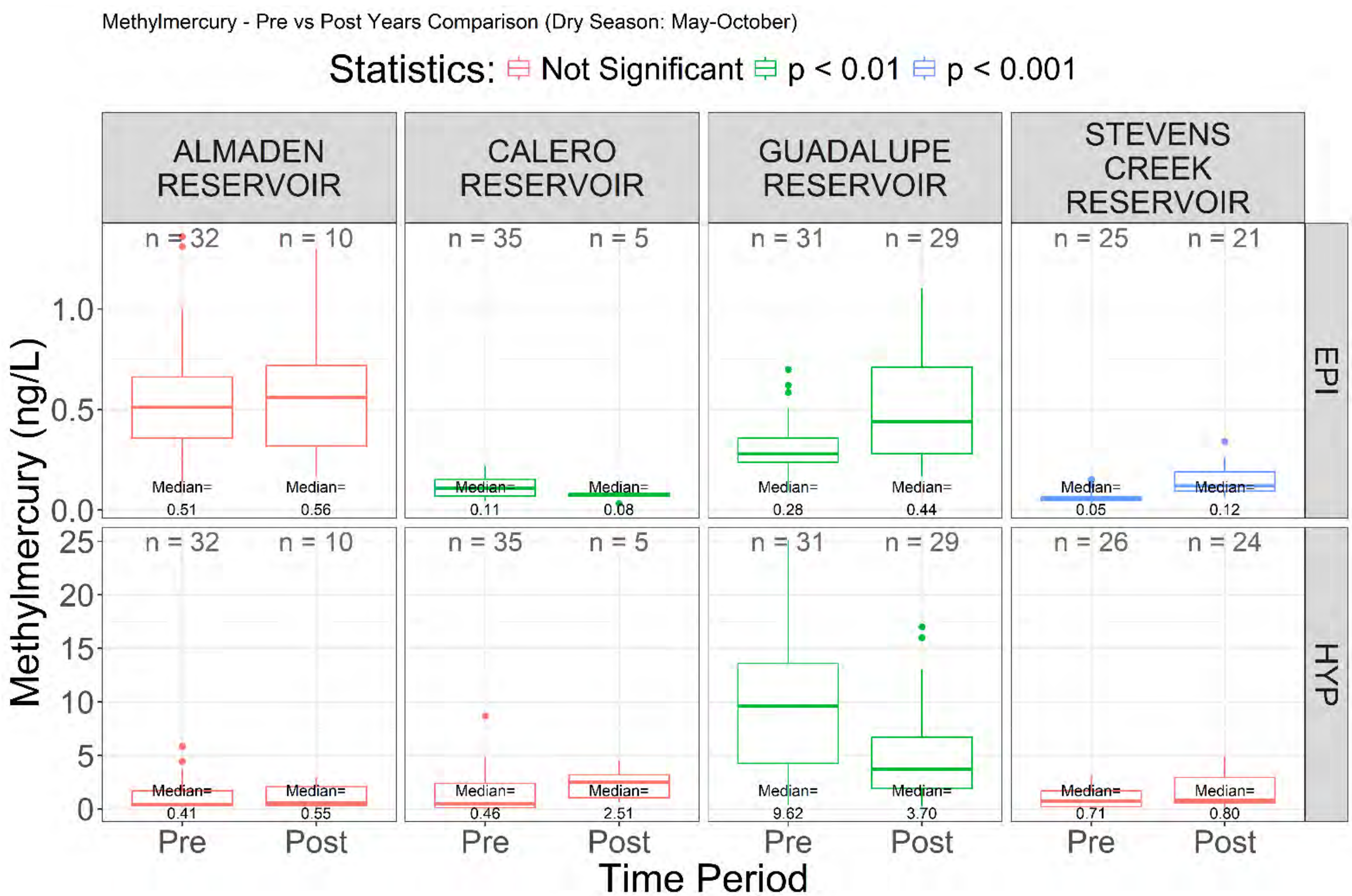

Figure 3-17 Epilimnetic and hypolimnetic MeHg concentrations before HOSs were in operation (Pre) and after operation ended (Post).

Pre- and post-oxygenation MeHg concentrations remained stable in the hypolimnion of all reservoirs, except for Guadalupe, which showed post-oxygenation MeHg concentrations less than half its pre-oxygenation concentrations (Figure 3-17). This trend aligns with the decrease in Total Hg concentrations. Conversely, slightly increased MeHg concentrations are detected in the epilimnion of Guadalupe and Stevens' Creek Reservoir in the post-oxygenation HOS data, which are low but could suggest ongoing methylation in the water column. This pattern has been observed near the top of the thermocline, where high phytoplankton respiration results in reduced oxygen concentrations. Similarly, the slight decrease at Calero Reservoir could also be related to water column methylation.

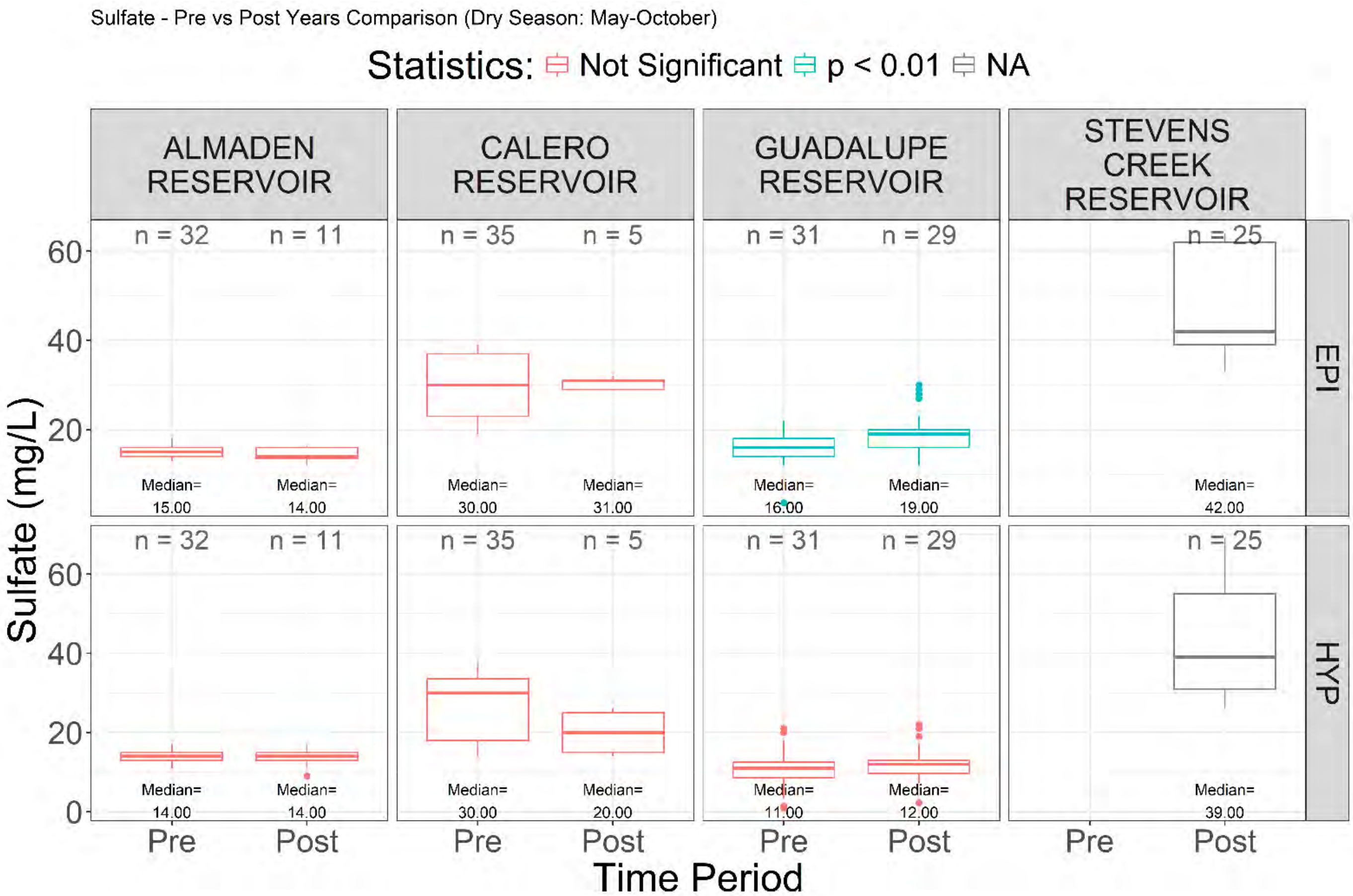

Figure 3-18 Epilimnetic and hypolimnetic Sulfate concentrations before HOSs was in operation (Pre) and after operations ended (Post).

Pre- and post-HOS sulfate concentrations remain unchanged in all reservoirs, except for a significant increase in the epilimnion of Guadalupe Reservoir (Figure 3-18). This result is consistent with the significantly higher MeHg concentration observed in the epilimnion in the post-oxygenation data for Guadalupe Reservoir (Figure 3-17). Sulfate reduction drives elevated MeHg formation in the water column of eutrophic lakes (Peterson et al. 2025). Methylmercury production during periods of stratification below the oxycline in a lens of water where chlorophyll-a concentrations increase relative to other mid-water column concentrations is common in many lakes. This phenomenon has been extensively documented in San Pablo Reservoir, where MeHg concentrations in the lens were found to be six times greater than those in the surface water (Stillwater 2025). There was no pre-HOS data for Stevens Creek Reservoir, so we were unable to determine any changes. Sulfate concentrations appear to return to baseline when HOS systems are turned off for the other reservoirs. Sulfate was prevalent throughout the hypolimnion during late stratification.

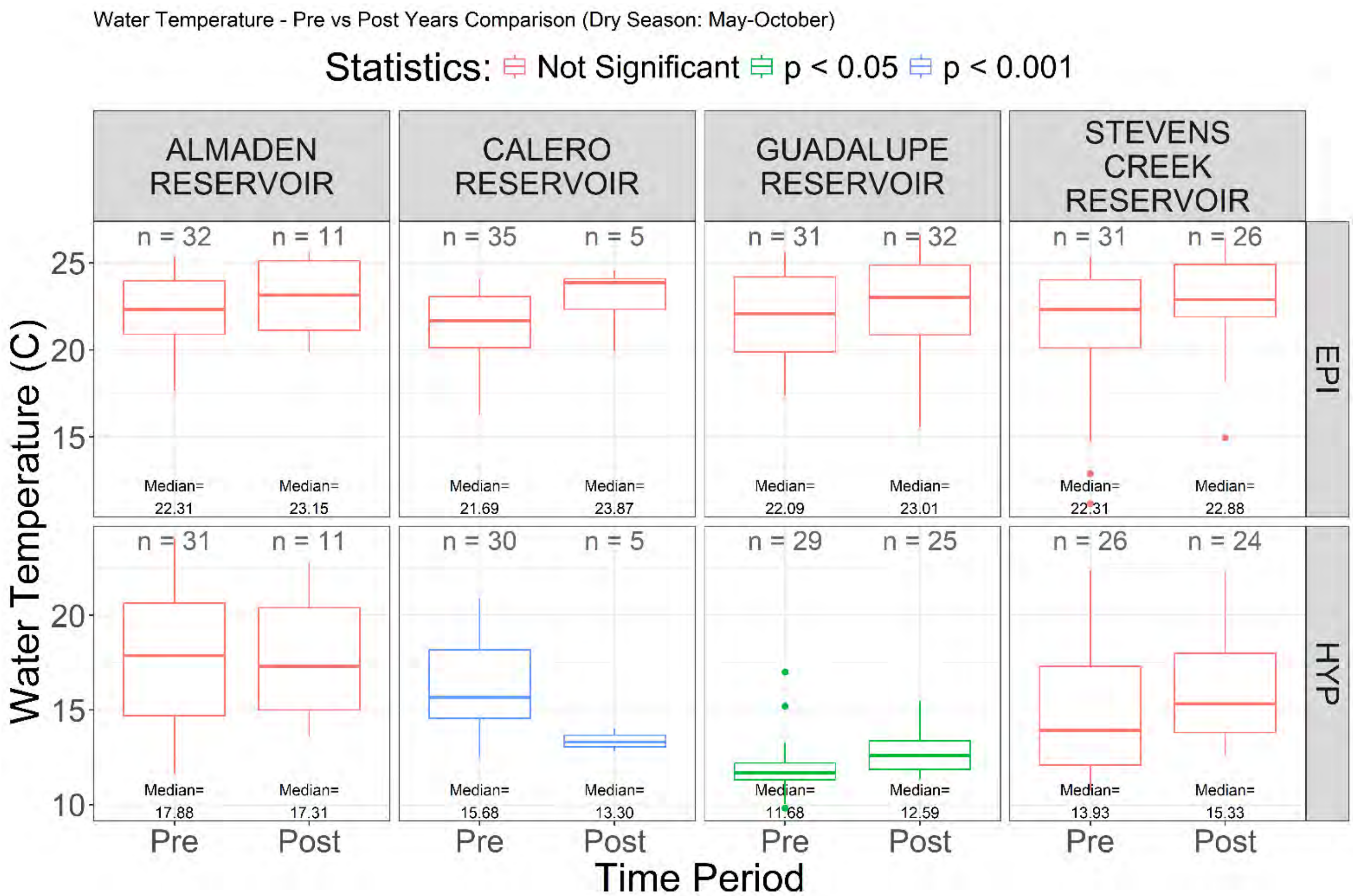

Figure 3-19 Epilimnetic and hypolimnetic Water Temperature before HOSs were in operation (Pre) and after operations ended (Post).

Post-HOS water temperatures appeared to return to the pre-HOS baseline, except in the hypolimnion of Guadalupe Reservoir, where post-HOS average temperatures are less than one degree higher than pre-HOS average temperatures (Figure 3-19). In contrast, in Calero, this trend is opposite and more pronounced with a three-degree difference post-HOS operation.

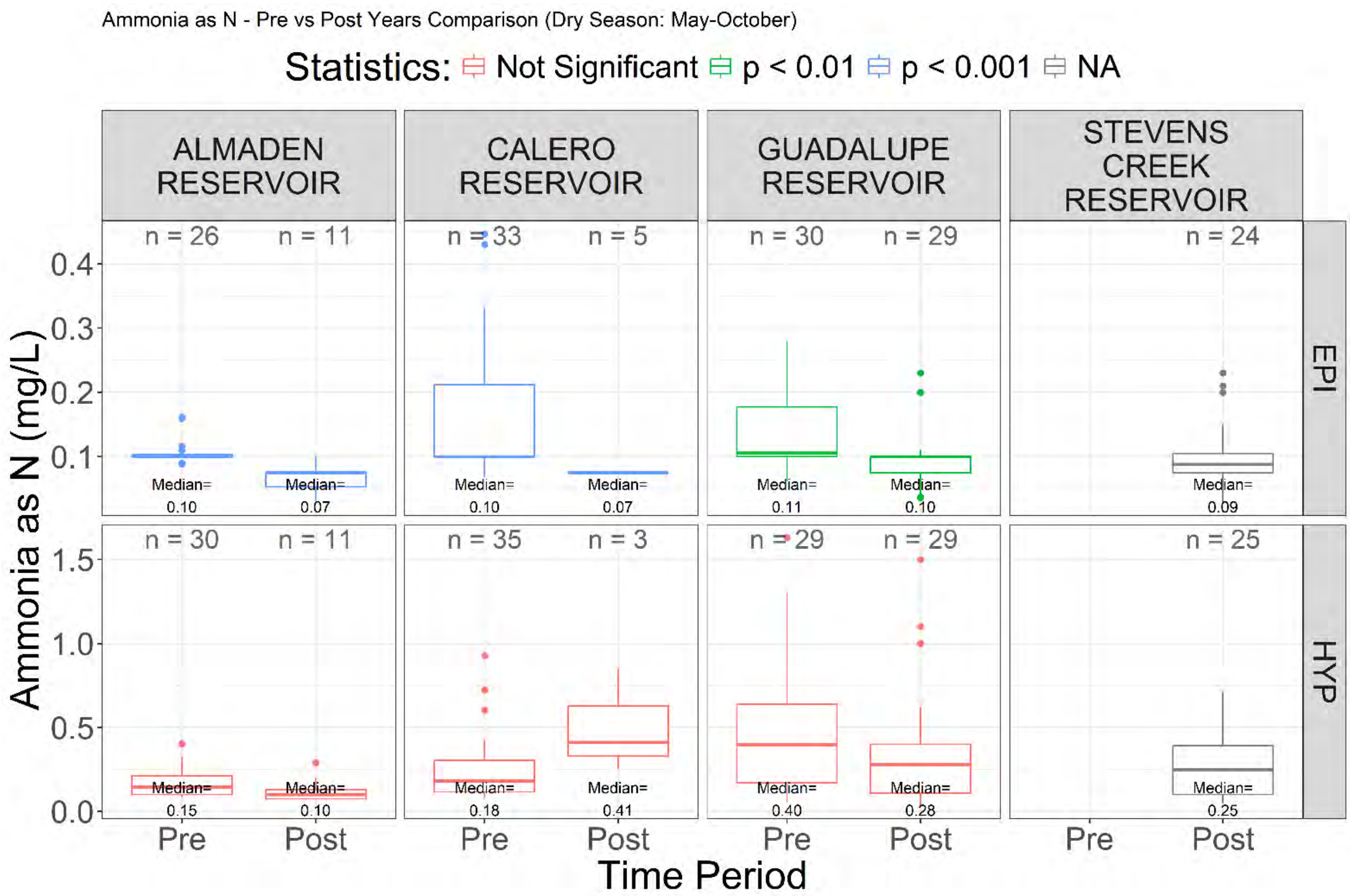

Figure 3-20 Epilimnetic and hypolimnetic Ammonia as N before HOSs were in operation (Pre) and after operations ended (Post).

Significant decreases in Ammonia as N are observed in the eplimnion of all reservoirs (Figure 3-20). There is no pre-data for Stevens Creek Reservoir. These results are consistent with other post-HOS data, indicating higher productivity levels and a shift toward eutrophication in these environments, characterized by lower ORP, higher chlorophyll and phycocyanin concentrations, as well as the observation of higher MeHg and sulfate concentrations in the epilimnion of some reservoirs. During large algal blooms, ammonia (NH_3) decreases because the algae consume it as a primary nutrient for rapid growth. Ammonia is a preferred and easily assimilated form of nitrogen for many species of algae.

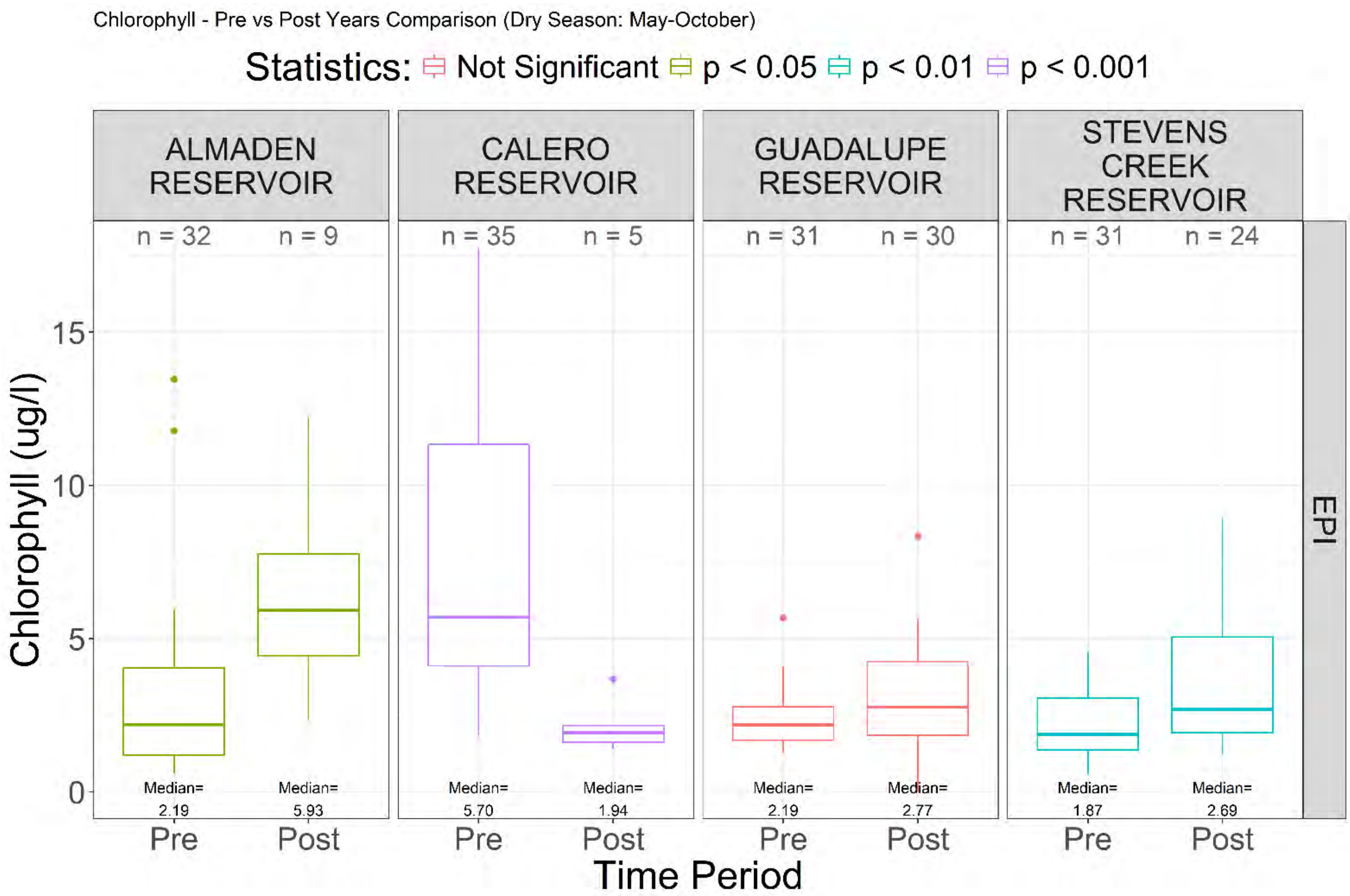

Figure 3-21 Epilimnetic Chlorophyll a concentrations before HOSs were in operation (Pre) and after operations ended (Post).

Chlorophyll *a* is the main photosynthetic pigment contained in all phytoplankton groups, including cyanobacteria. Cyanobacteria also contain the pigment phycocyanin. Phycocyanin sensors specifically target cyanobacteria, while Chlorophyll sensors measure general algal biomass. Generally, these two measurements correlate with each other. A decrease in chlorophyll a and an increase in phycocyanin over time can indicate a shift in an aquatic ecosystem to conditions that favor the dominance of cyanobacteria. Chlorophyll a increased in all reservoirs except for Calero. This increase is statistically significant in Stevens Creek and Almaden Reservoirs (Figure 3-21). Calero shows a significant decrease in Chlorophyll a in the post-HOS measurement. This signal may change with more sample points.

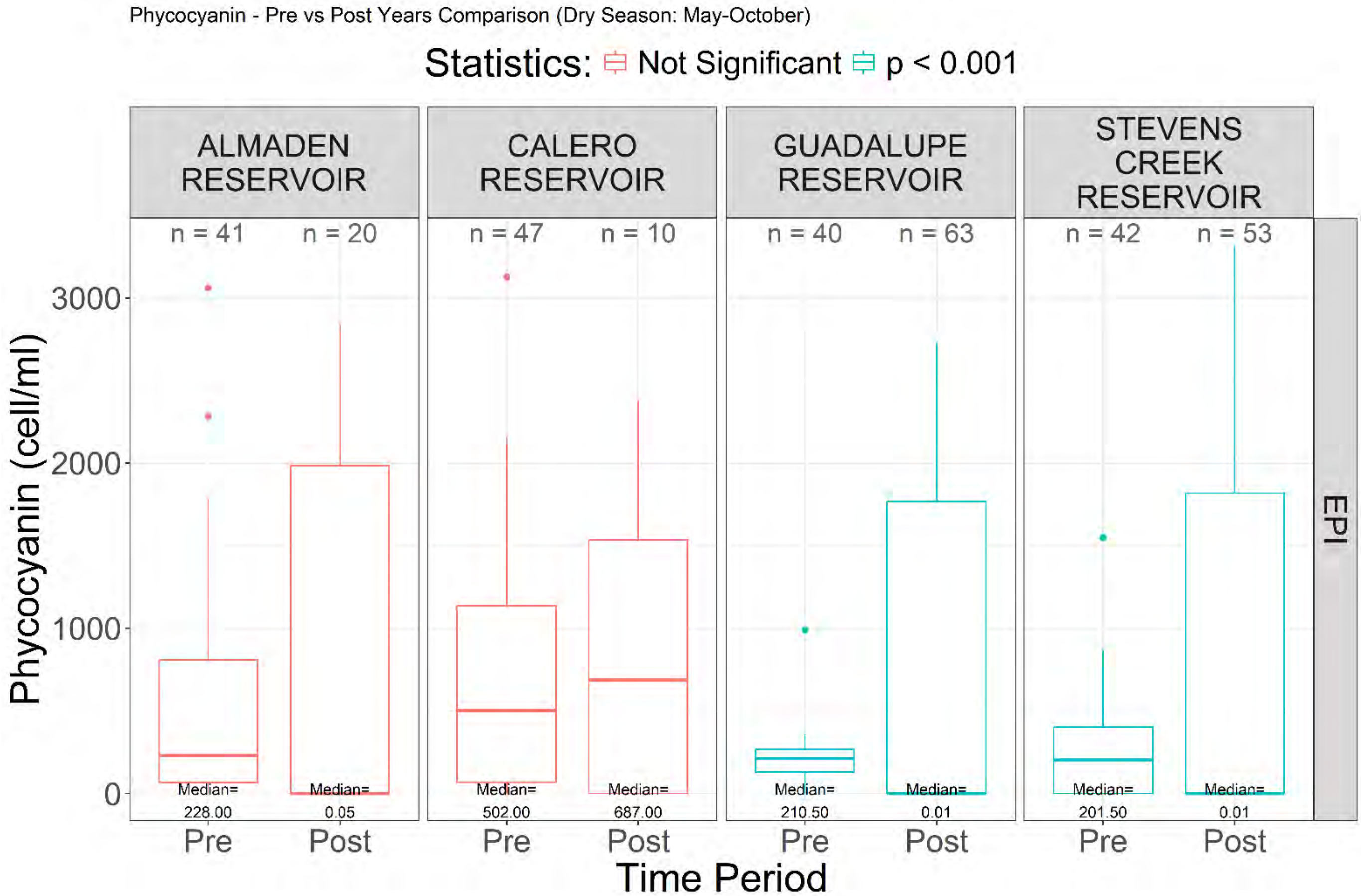

Figure 3-22 Epilimnetic Phycocyanin concentrations before HOSs were in operation (Pre) and after operations ended (Post).

Phycocyanin concentrations were higher in all reservoirs in the post-HOS measurements, including in Calero Reservoir, where the opposite was true of Chlorophyll a concentrations (Figure 3-22). This suggests that cyanobacteria populations have increased in recent years, and the increases were statistically significant in Guadalupe and Stevens Creek Reservoirs.

3.2.3 Fish Sampling Results

Since 2012, Valley Water has monitored fish assemblages in Almaden, Calero, Guadalupe, and Stevens' Creek reservoirs to determine whether they differ among reservoirs and to document changes in fish assemblages since HOS treatments began. After a decade of monitoring, few differences were found among the reservoirs. In July 2024, Valley Water recommended discontinuing assemblage monitoring, and the Regional Board approved the recommendation in a July 19th email, with the condition that "if there are future changes that dramatically affect water quality, then the fish assemblage monitoring may need to be resumed."
Fish assemblage sampling was conducted in quadrants to ensure representation of the reservoir. In 2025, the focus shifted to catching fish, so sampling in different quadrants was no longer necessary, and we sampled areas we thought had more fish, which led to CPM being much higher in 2025 than in previous years.

Although ascertaining the lake's fish assemblage was not the objective of this effort, and the results are unlikely to reflect true population dynamics, to be consistent with other reports, we continue to document this sampling effort, focusing on the fish targeted for body burden analysis. These species include largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and black crappie (*Pomoxis nigromaculatus*). The fish caught by species and year at individual water bodies since the inception of the monitoring program in 2012 is summarized in this section. Comparisons of data from prior years are also included. Data are presented by capture method (boat electrofishing or hook and line), recognizing that the method may bias the species captured. Data are reported for ten species, with black crappie, bluegill, and largemouth bass being the most common. Fish lengths are reported for these three species. Differences in fish community composition by year and reservoir are summarized below.

Almaden Reservoir:

Almaden Reservoir was sampled once in 2024, on April 10. However, summer sampling could not be conducted due to low water levels in the reservoir. Catch per minute (CPM) rates were highest for bluegill, largemouth bass, and black crappie, with similar rates across years (Figure 3-23). Fish lengths were similar across years. In 2025, the reservoir was sampled on April 22 and again on July 28. CPM rates were higher for bluegill, largemouth bass, and threadfin shad than for other species, with catch rates for bluegill and largemouth bass higher than in other years (Figure 3-23). Fish lengths were similar across years, but with fewer larger fish observed for largemouth bass (Figure 3-24).

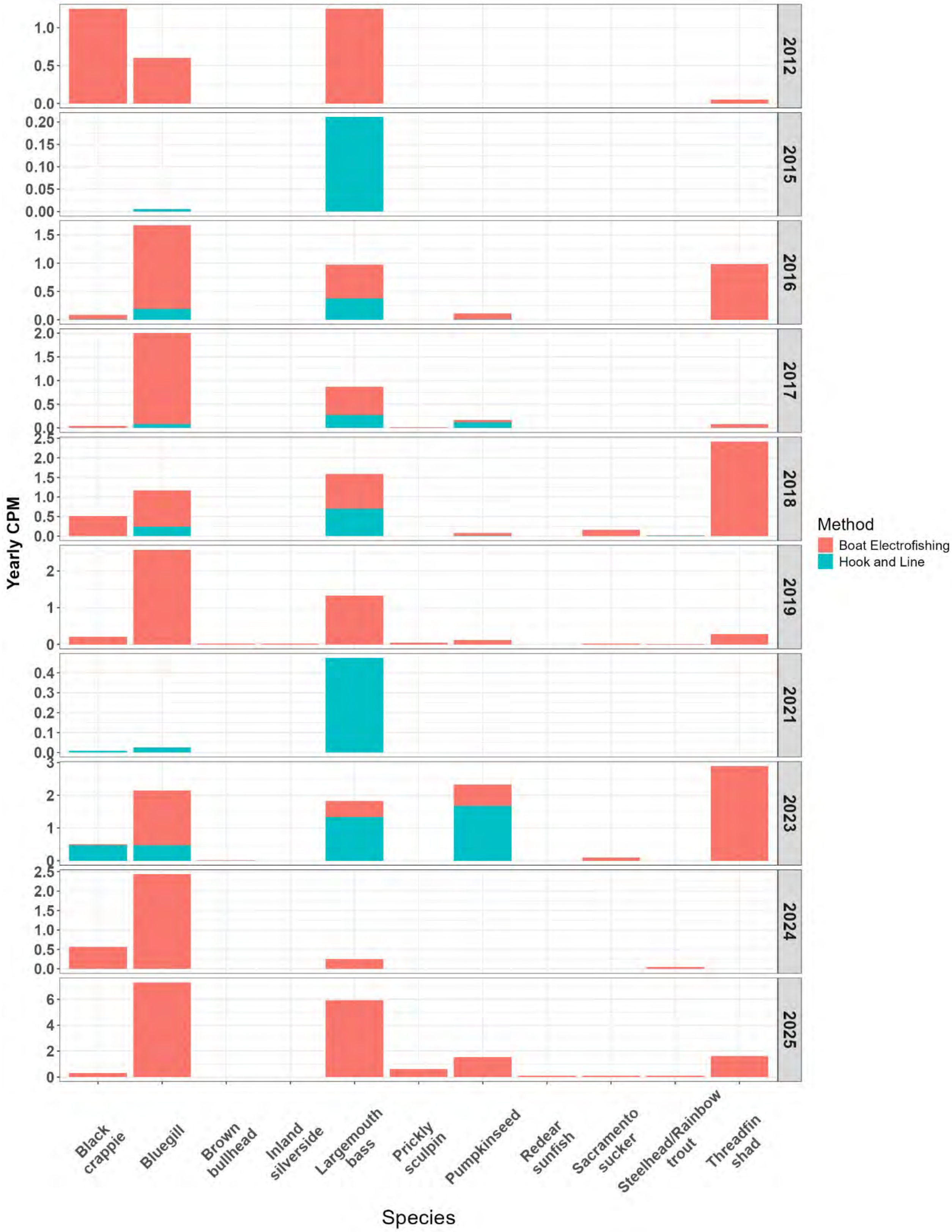

Figure 3-23 Fish species catch rates in Almaden Reservoir from 2012 until 2025.

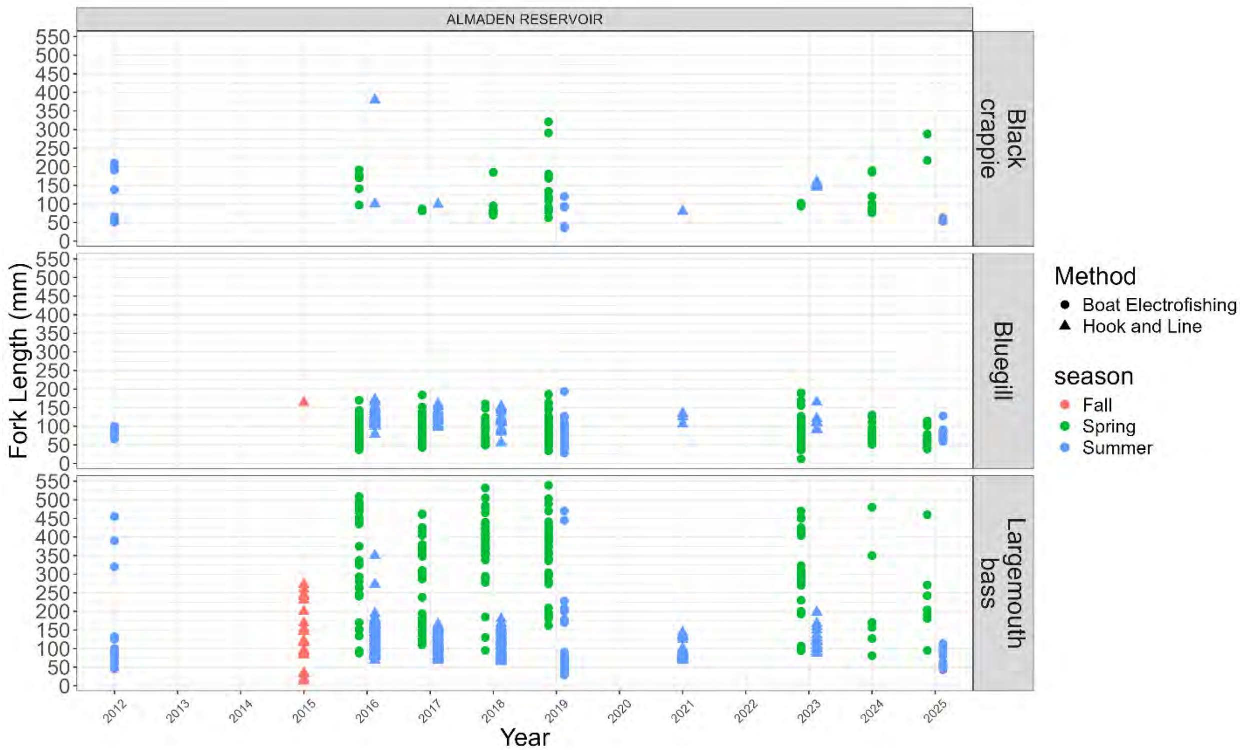

Figure 3-24 Size distribution of fish species in Almaden Reservoir from 2012 until 2025.

Calero Reservoir:

In 2024, Calero Reservoir was sampled on April 17 and August 20. CPM rates were highest for bluegill, largemouth bass, and black crappie, but were lower than those in previous years (Figure 3-25). Fish lengths were similar across years. In 2025, the reservoir was sampled on April 9 and again on September 17. Although ascertaining the lake's fish assemblage was not the objective of this effort, and results are not likely to represent true population dynamics, the following data were observed,
CPM rates were higher for bluegill, inland silverside, largemouth bass, and redear sunfish than for other species. Fish diversity was similar to other years, but catch levels for bluegill and redear sunfish were higher than in any other year sampled (Figure 3-25). This was likely due to targeted electrofishing, as the redear, bluegill, and black crappie are similar in appearance, and attempts to meet quotas for these fish skewed the results. Bluegill also tend to be the most abundant fish in Calero Reservoir. Fish lengths were similar across years, but with fewer larger fish observed for the largemouth bass (Figure 3-26).

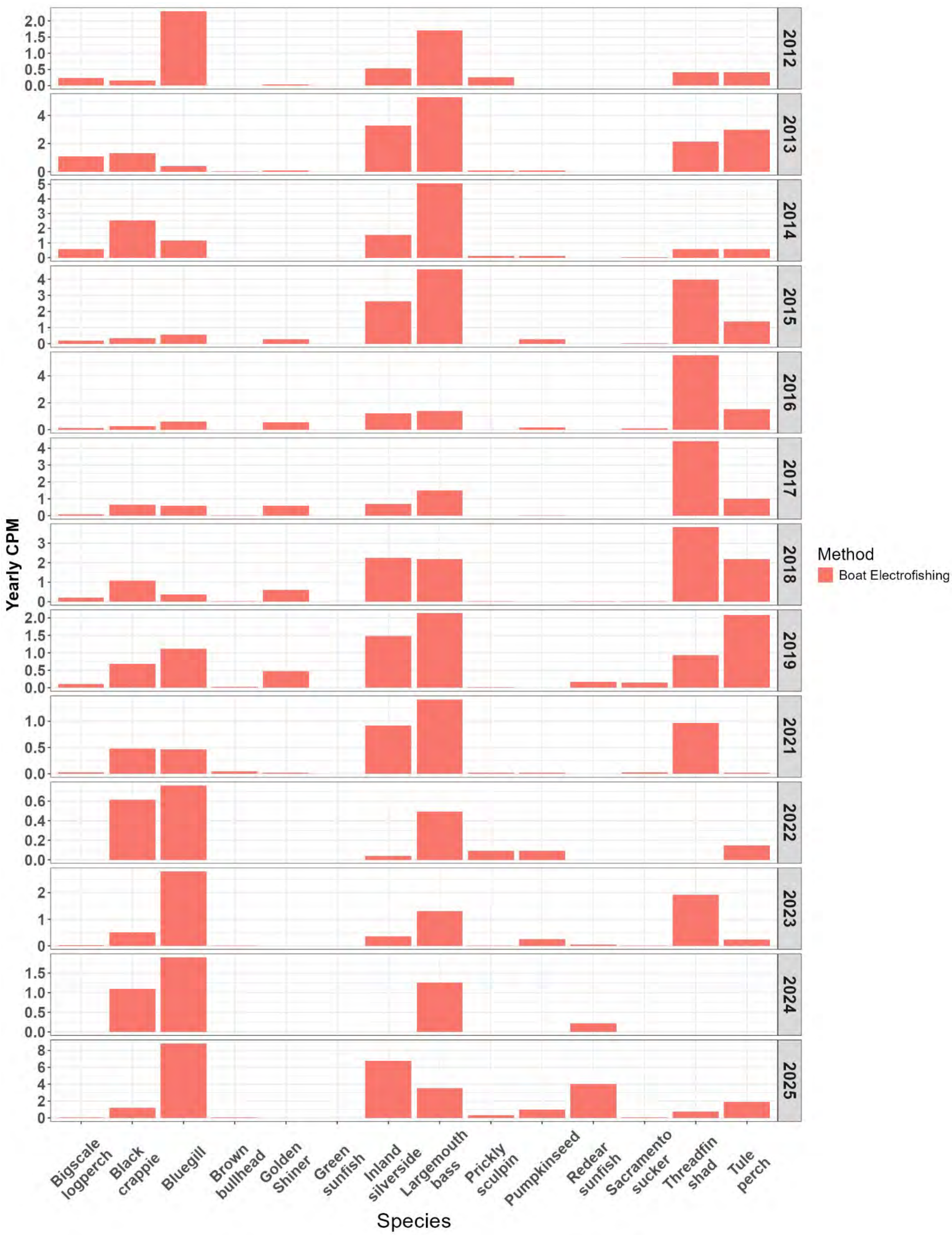

Figure 3-25 Fish species catch rates in Calero Reservoir from 2012 until 2025.

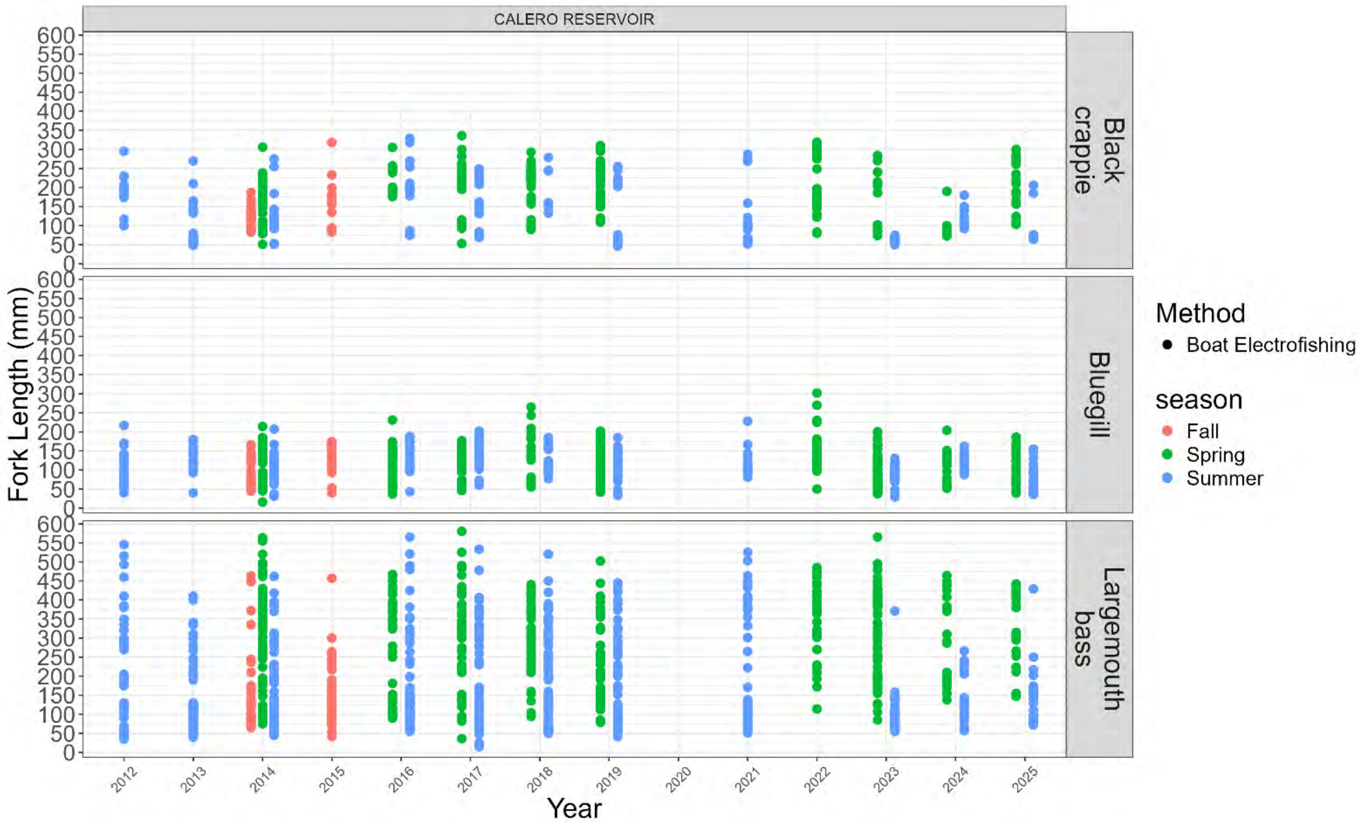

Figure 3-26 Size distribution of fish species in Calero Reservoir from 2012 until 2025.

Guadalupe Reservoir:

In 2024, Guadalupe Reservoir was sampled on April 25 and August 19. CPM rates were highest for bluegill and were similar to those of previous years (Figure 3-27). Fish lengths were similar across years. In 2025, the reservoir was sampled on April 16 and again on August 20. CPM rates were higher for bluegill and largemouth bass, with catch levels for bluegill higher than in all other years. This is again due to more habitat-targeted fishing in 2025 than to representative sampling in previous years. (Figure 3-27). Fish lengths were similar across years (Figure 3-28).

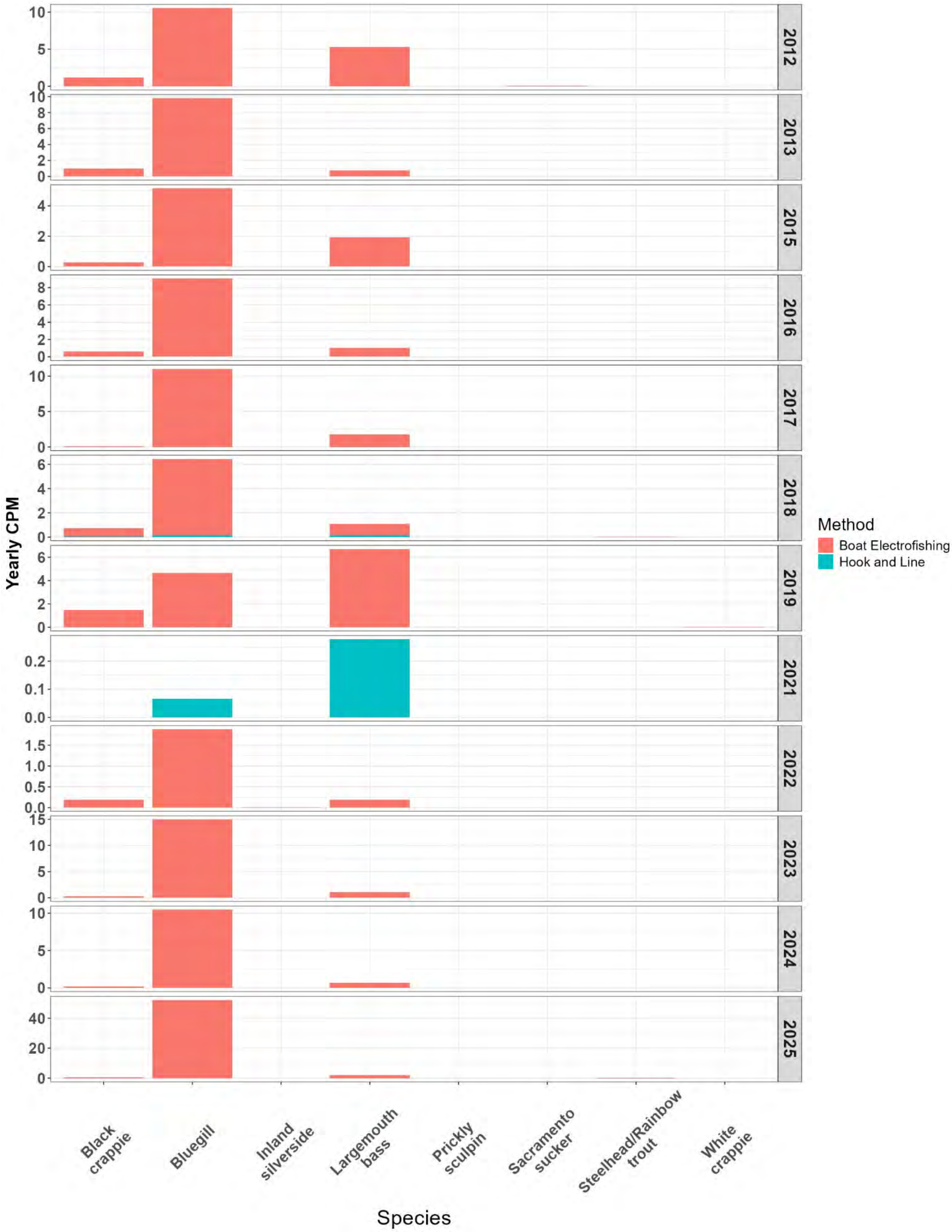

Figure 3-27 Fish species catch rates in Guadalupe from 2012 until 2025.

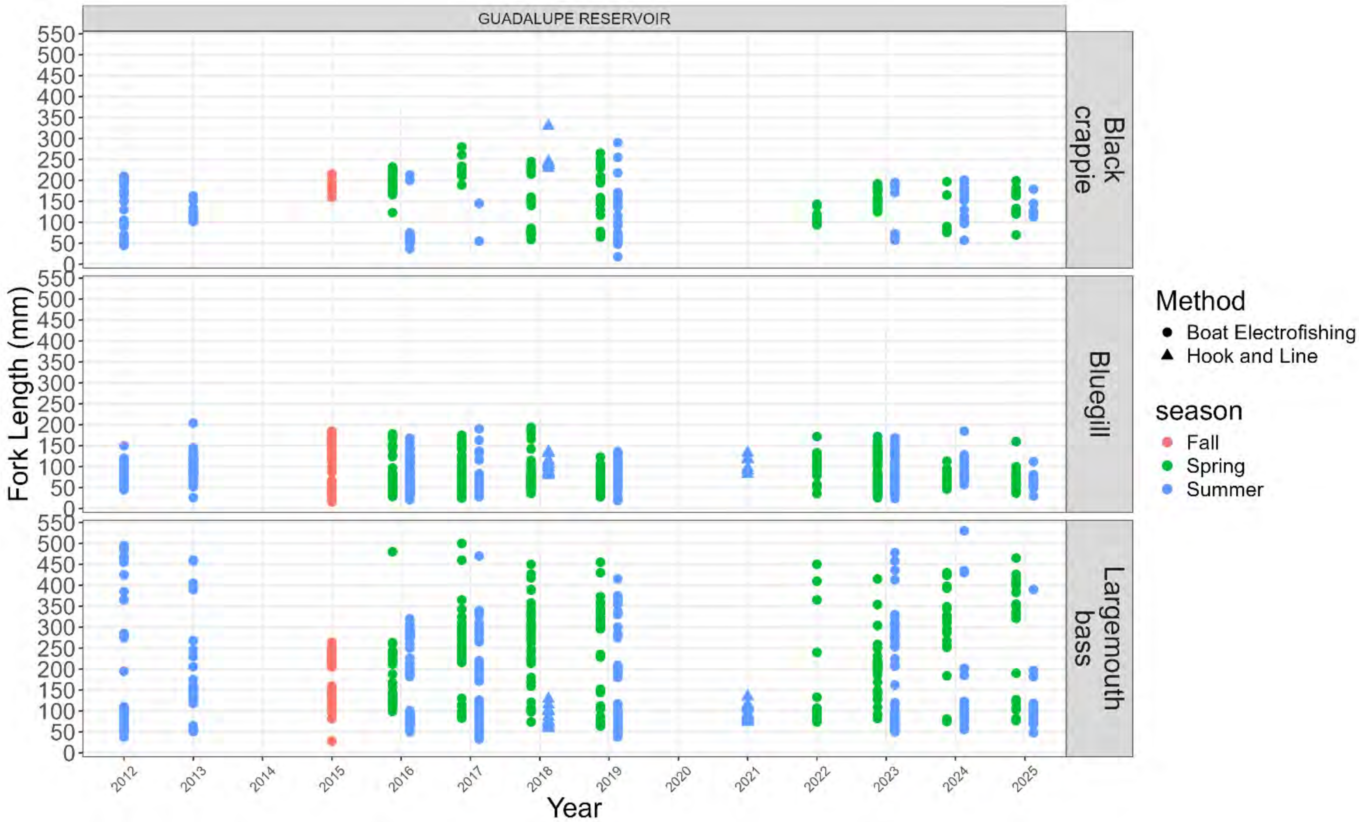

Figure 3-28 Size distribution of fish species in Guadalupe Reservoir from 2012 until 2025.

Stevens Creek Reservoir:

In 2024, Stevens Creek Reservoir was sampled on April 24 and August 26. In 2025, the reservoir was sampled on April 2 and again on August 26. CPM rates were highest for bluegill, largemouth bass, and black crappie, and were similar to those in previous years (Figure 3-29). Fish lengths were similar across years (Figure 3-30).

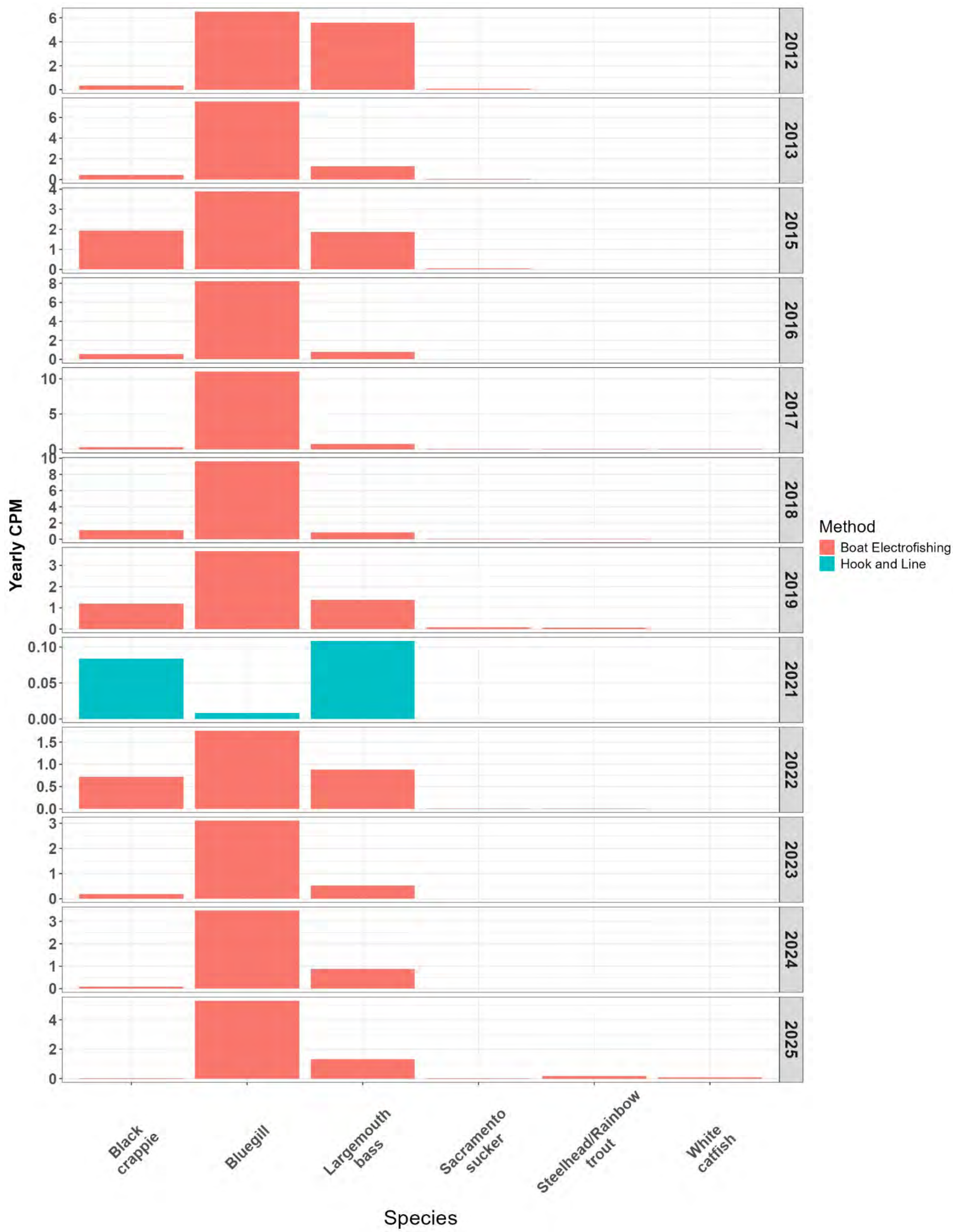

Figure 3-29 Fish species catch rates in Stevens Creek Reservoir from 2012 until 2025.

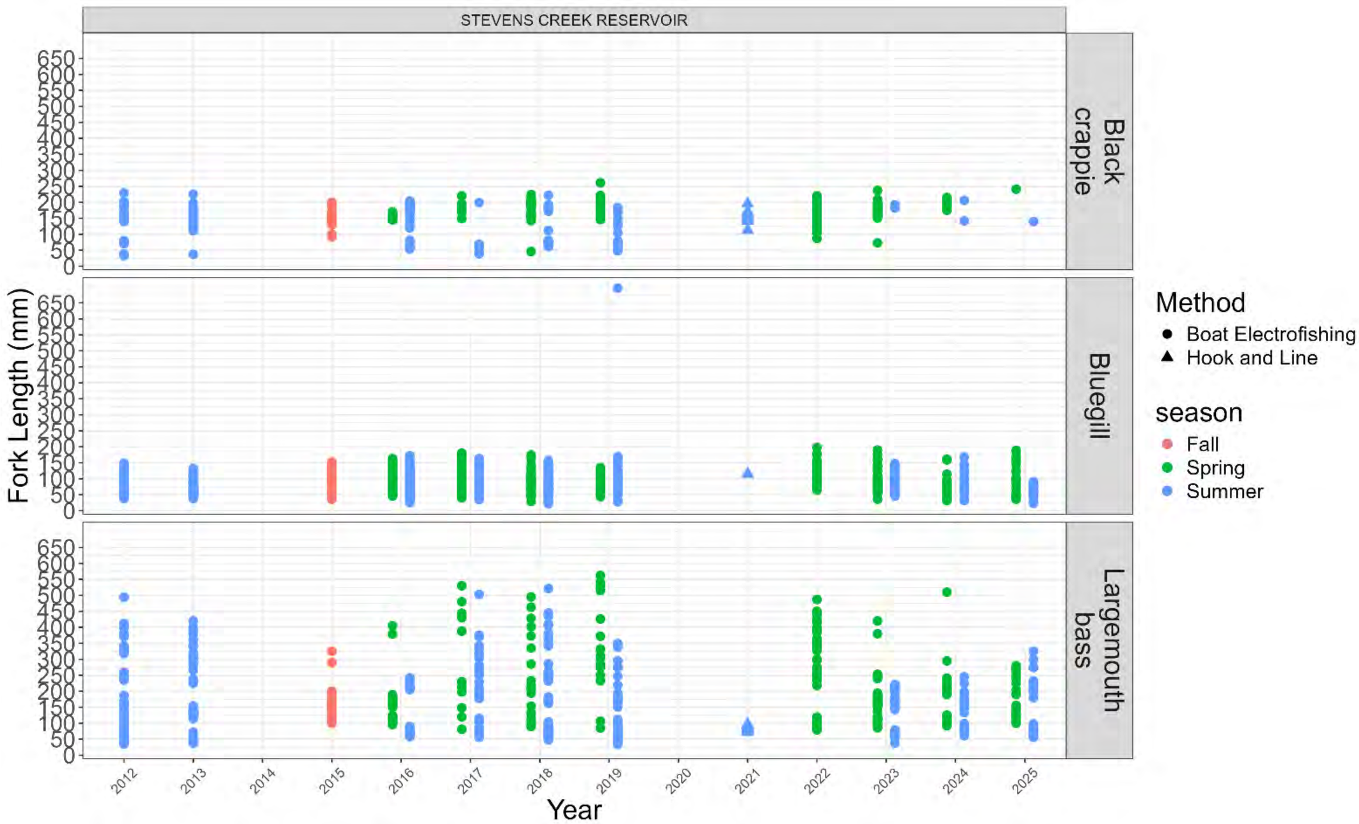

Figure 3-30 Size distribution of fish species in Stevens Creek Reservoir from 2012 until 2025.

3.2.4 FISH MERCURY

As part of the TMDL, Valley Water addresses the following questions regarding trends in fish tissue Hg concentrations:

- What is the seasonal and inter-annual variation in fish Hg in the first 5 years of implementation for remediation effectiveness indicators (REIs) and target fish?

- What is the trend in fish tissue Hg concentrations in target fish over the subsequent 15 years of implementation?

The inter-annual variability portion of Study Question 1 was resolved following the Coordinated Monitoring Program's 2017 Guadalupe River Coordinated Monitoring Program 5-Year Report. The Regional Board's 13267 letter requiring the second phase of coordinated monitoring states that previously reported fish data are useful to quantify the inter-annual variability of Hg in fish from reservoirs and creeks. Valley Water continues to investigate seasonal variability in its studies.

Fish monitoring is conducted twice annually in the spring and summer and is designed to evaluate the effectiveness of the treatment systems. Spring sampling also assesses reproductive risks to piscivorous birds. Fish tissue Hg data have been collected by Valley Water since 2011. Fish-tissue Hg data are collected to track progress toward Hg objectives: 0.05 mg Hg/kg (wet weight) for fish 50-150 mm in length at trophic level 3 (TL3A) and 0.1 mg Hg/kg (wet weight) for fish 150-350 mm in length (TL3B). Trophic level 3 fish, generally black crappie and bluegill, are sampled in spring and summer before and during the avian breeding season. Age-1 largemouth bass (REIs) measuring 55 to 102 mm have been used as short-term indicators of Hg bioaccumulation to evaluate management actions during summer sampling events. Sampling during this time period has ensured sufficient tissue for analysis and increased the likelihood of capturing a single cohort of young fish. Adult largemouth bass (TL 4), ranging from 102 to 350 mm in total length, are occasionally collected and analyzed when it isn't feasible to collect REI-sized fish. They represent the cohort of REI fish measured during the previous summer and have been used to determine bioaccumulation rates during wet seasons.

Sample sizes were originally determined through a power analysis of fish data collected from the program's inception through 2018. We repeated this analysis in 2025 using the t test method, with α (probability of incorrectly rejecting the null hypothesis) of 0.05, and a power (probability of correctly rejecting the null hypothesis) of 0.8. These are commonly assigned values in scientific studies. Ideally, the effect size (the statistically discernible difference between two groups) would be set at one times the TMDL target for small fish (0.05 mg/kg) or less. However, because fish tissue Hg concentrations are high and variable, detecting this small a difference would require a sample size of > 25 fish per collection category, which would be unfeasible and prohibitively expensive. We therefore calculated an ideal sample size to yield 95% confidence intervals with a margin of error of +/- 25% of the 2011 - 2025 mean Hg concentrations for each category in each reservoir, which allows us to detect practically significant changes in mercury concentration between groups. The results of this test were similar to last test performed in 2018 (Valley Water 2018). Based on these analyses and the practical limitations of achieving target sample sizes, we have attempted to catch 14 TL3A, 13 TL3B, and 15 REI fish for the spring and summer sampling events.

In response to the Regional Water Board Staff's recommendation in June 2025, Valley Water has shifted the fish collection effort to focus on changes in REI fish, collecting baseline data before implementing new management strategies. With four years of non-operational data from Guadalupe and Stevens Creek Reservoirs, this Biennial Report will include initial analysis of REI fish, including preoxygenation data and initial comparisons. This data will be presented in section 3.2.5 (Pre and Post HOS operation in REI fish).

Figure 3-31 shows Hg concentrations in all fish collected for body-burden Hg analysis across all sampling events from 2011 until present.

Most TL3A and TL3B fish have exceeded TMDL targets both historically and currently (0.05 mg/kg Hg ww and 0.1 mg/kg Hg ww, respectively), with Almaden and Guadalupe having the most contaminated fish. A small percentage of mostly smaller fish have occasionally fallen below the targets in the less contaminated reservoirs, Calero and Stevens Creek. This is also true of REI fish, which exceed the California prey fish objective of 0.05 mg/kg Hg ww. TL4 fish similarly exceed the California sport fish objective of 0.2 mg/kg ww. The plots show the relationship between fork length (mm) and Hg concentration for each species, with fork length linearly correlated with Hg across sampling events (Figure 3-21).

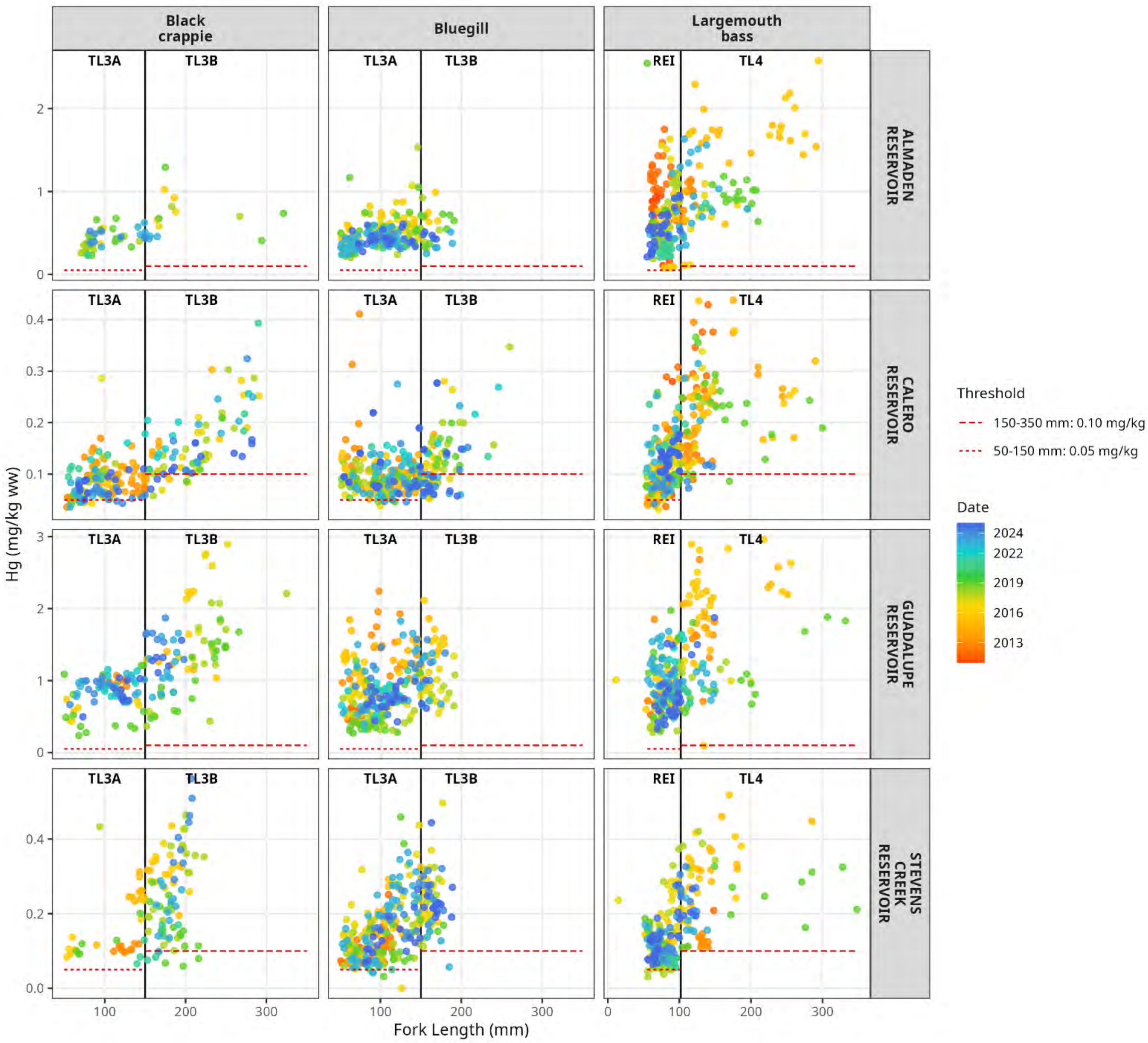

Figure 3-31 Hg concentrations and fork lengths (mm) in REI, TL3A, TL3B, and TL4 fish collected for body-burden Hg analysis during all sampling events from 2011 to 2025 in all reservoirs.

During this study period, Almaden Reservoir was sampled on April 10, 2024, April 22, 2025, and July 28, 2025. The reservoir was not sampled in summer 2024 due to low water levels. The number of REI fish caught each year has been highly variable, ranging from 5 to 29. In July 2025, 29 REI fish were collected, with an average Hg concentration of 0.54 mg/kg (coefficient of Variation (CV) = 0.38, length = 74.14 mm) (Table 3-4). The average Hg concentration was on the lower end of the range for fish collected over the last 14 years, with 2016 and 2021 being the lowest at 0.27 and 0.33 mg/kg, respectively (Table 3-5). The average length was at the lower end of the range for fish collected over the last 14 years (Table 3-5 and Figure 3-32), with only 2011, 2012, and 2019 being lower (70.37, 69.8, and 67.67 mm, respectively). The highest average length was recorded in 2015 at 94.2 mm. The highest average Hg concentration in REI fish was recorded in 2012 at 1.21 mg/kg. A CV of 0.31 indicates that the dataset's standard deviation is 31% of its mean. Above 30% is a moderate level of variation. The lower the CV, the higher the precision and consistency in measurements.

Table 3-4
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year) 2024–2025 sampling events in Almaden Reservoir. BC=black crappie; BG= bluegill; LG=largemouth bass.

		Total Mercury Concentrations (mg/kg ww)				Total Length (mm)			
Year	**Sample Size**	**Avg.**	**Min**	**Max**	**Coeff of Variation**	**Avg**	**Min**	**Max**	**Coeff of Variation**
4/10/24 BC	7	0.46	0.38	0.52	0.12	100.71	82	150	0.25
4/10/24 BG	10	0.41	0.31	0.49	0.13	114	87	136	0.14
4/22/25 BG	15	0.44	0.34	0.57	0.14	132.53	94	169	0.19
7/28/25 BG	9	0.44	0.28	0.61	0.26	84.78	65	128	0.21
7/28/25 LG	29	0.54	0.21	0.95	0.38	74.14	55	101	0.19

Table 3-5
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year) 2011–2025 for REI fish caught in Almaden Reservoir.

		Total Mercury Concentrations (mg/kg ww)				Total Length (mm)			
Year	**Sample Size**	**Avg.**	**Min**	**Max**	**Coeff of Variation**	**Avg**	**Min**	**Max**	**Coeff of Variation**
2011	19	0.70	0.11	1.00	0.34	70.37	62	87	0.11
2012	20	1.21	0.80	1.75	0.19	69.80	60	88	0.13
2013	11	0.68	0.51	0.86	0.17	89.20	72	99	0.12
2015	5	0.91	0.68	1.15	0.20	94.20	92	95	0.01
2016	22	0.27	0.08	0.95	1.15	87.77	79	100	0.05
2017	21	0.83	0.31	1.63	0.52	79.67	67	95	0.11
2018	23	0.65	0.19	1.21	0.48	83.04	63	100	0.13
2019	6	0.95	0.45	2.54	0.83	67.67	55	82	0.16
2021	18	0.33	0.21	0.92	0.49	82.06	71	97	0.08
2023	8	0.70	0.33	1.30	0.49	90.63	59	101	0.15
2025	29	0.54	0.21	0.95	0.38	74.14	55	101	0.19

Calero Reservoir was sampled on April 17, 2024, August 20, 2024, April 9, 2025, and September 17, 2025. Only 5 REI fish were caught on 04/17/24, 10 on 8/20/24, and none on 4/9/25. On 9/17/25, 20 REI fish were collected, with an average Hg concentration of 0.13 mg/kg (CV= 0.17, length = 86.45 mm) (Table 3-6). The average Hg concentrations have remained fairly stable in Calero Reservoir ranging from 0.09-0.18 mg/kg. The average length was near the middle of the range in 2024, while the average length in 2025 was the second highest of those measured over the last 11 years (Table 3-7 and Figure 3-32). The average number of REI fish caught during the last 14 years in Calero Reservoir has ranged from 7-28 fish.

Table 3-6
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year)
2024–2025 sampling events in Calero Reservoir. BC=black crappie; BG= bluegill; LG=largemouth bass

Year	Sample Size	Total Mercury Concentrations (mg/kg ww) Avg.	Min	Max	Coeff of Variation	Total Length (mm) Avg	Min	Max	Coeff of Variation
4/17/24 BC	9	0.11	0.06	0.32	0.76	135.44	88	276	0.50
4/17/24 BG	12	0.09	0.06	0.16	0.28	140.17	100	198	0.19
4/17/24 LG	5	0.1	0.07	0.12	0.21	129.6	111	146	0.13
8/20/24 BC	7	0.05	0.04	0.07	0.01	126.43	105	150	0.14
8/20/24 BG	12	0.07	0.05	0.15	0.40	144.67	105	208	0.19
8/20/24 LG	10	0.09	0.04	0.13	0.32	76.7	65	89	0.12
4/9/25 BC	17	0.11	0.06	0.17	0.28	178.06	104	282	0.36
4/9/25 BG	16	0.08	0.06	0.15	0.27	146.06	92	200	0.23
9/17/25 BC	9	0.09	0.05	0.16	0.37	100.67	68	212	0.55
9/17/25 BG	10	0.15	0.08	0.28	0.39	118.5	55	182	0.39
9/17/25 LG	20	0.13	0.09	0.18	0.17	86.45	73	100	0.10

Table 3-7
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year) 2011–2025 for REI fish caught in Calero Reservoir.

Year	Sample Size	Total Mercury Concentrations (mg/kg ww) Avg.	Min	Max	Coeff of Variation	Total Length (mm) Avg	Min	Max	Coeff of Variation
2011	16	0.11	0.07	0.28	0.49	74,75	61	90	0.13
2012	28	0.11	0.04	0.31	0.60	80.25	62	98	0.12
2013	8	0.11	0.05	0.19	0.37	77.38	57	89	0.12
2014	19	0.11	0.04	0.20	0.46	79.16	55	101	0.18
2015	8	0.18	0.14	0.29	0.26	90.63	71	100	0.11
2016	21	0.12	0.07	0.21	0.31	77.67	58	96	0.16
2017	22	0.13	0.03	0.98	1.56	75.23	61	96	0.15
2018	18	0.12	0.07	0.25	0.39	73.83	55	102	0.21
2019	7	0.11	0.06	0.26	0.60	82.57	61	101	0.19
2021	14	0.15	0.08	0.24	0.31	80.21	58	99	0.17
2023	20	0.13	0.05	0.25	0.39	74.38	55	97	0.18
2024	10	0.09	0.04	0.13	0.32	76.70	65	89	0.12
2025	19	0.13	0.09	0.18	0.18	86.89	73	100	0.10

Guadalupe Reservoir was sampled on April 25, 2024, August 19, 2024, April 16, 2025, and August 20, 2025. No REI fish were collected on 4/25/24, 13 on 8/19/24, and 8 on 4/16/25. On 08/20/25, 18 REIs were collected, with an average Hg concentration of 0.61 mg/kg (CV=0.23, length= 86.56 mm) (Table 3-8). The highest and lowest Hg concentrations were recorded in 2011 and 2015 at 0.55 and 1.54 mg/kg, respectively, but these values are based on a single measurement, and standard deviation could not be calculated. The Average Hg concentration was on the lower end of the range over the last 14 years, and 2024 was in the lower mid-range. The average lengths for the REI fish in 2024 and 2025 were the higher end (Table 3-9 and Figure 3-32).

Table 3-8
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year) 2024–2025 sampling events in Guadalupe Reservoir. BC=black crappie; BG= bluegill; LG=largemouth bass

		Total Mercury Concentrations (mg/kg ww)				Total Length (mm)			
Year	Sample Size	Avg.	Min	Max	Coeff of Variation	Avg	Min	Max	Coeff of Variation
4/25/24 BC	5	0.88	0.70	1.00	0.14	84.2	77	90	0.06
4/25/24 BG	10	1.00	0.61	1.57	0.31	111.2	149	83	0.24
8/19/24 BC	14	1.26	0.67	1.87	0.31	130.93	57	198	0.32
8/19/24 BG	11	1.02	0.53	1.57	0.36	124.91	69	180	0.31
8/19/24 LG	13	0.93	0.77	1.15	0.12	86.77	67	100	0.12
4/16/25 BC	13	1.01	0.50	1.56	0.31	141.92	73	195	0.23
4/16/25 BG	10	0.8	0.63	0.99	0.17	110.7	84	143	0.16
4/16/25 LG	8	1.24	0.38	1.87	0.39	100.13	76	149	0.27
8/20/25 BC	4	0.92	0.75	1.03	0.13	126	111	144	0.11
8/20/25 BG	13	0.72	0.43	1.00	0.23	117.38	88	157	0.21
8/20/25 LG	18	0.61	0.33	0.88	0.23	86.56	66	102	0.14

Table 3-9
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year) 2011–2025 for REI fish caught in Guadalupe Reservoir.

		Total Mercury Concentrations (mg/kg ww)				Total Length (mm)			
Year	Sample Size	Avg.	Min	Max	Coeff of Variation	Avg	Min	Max	Coeff of Variation
2011	1	0.55				74.00			
2012	10	0.77	0.52	0.95	0.17	78.00	60	89	0.13
2013	3	1.10	0.72	1.85	0.60	59.00	56	65	0.09
2015	1	1.54				95.00			
2016	20	0.93	0.65	1.63	0.28	80.60	64	102	0.13
2017	24	0.75	0.55	1.07	0.15	81.00	65	95	0.12
2018	23	0.60	0.28	1.61	0.63	79.43	59	100	0.19
2019	14	1.12	0.29	1.97	0.44	75.79	57	99	0.18
2021	18	0.75	0.52	0.92	0.14	81.78	73	95	0.09
2022	7	1.04	1.57	0.24	0.16	87.29	73	94	0.09
2023	22	1.15	0.40	1.68	0.30	69.95	56	92	0.12
2024	13	0.93	0.77	1.15	0.12	86.77	65	89	0.12
2025	27	0.70	0.33	1.51	0.42	85.57	66	102	0.13

Stevens Creek Reservoir was sampled on 04/24/24, 08/26/2024, 04/02/2025, and 08/26/2025. On 4/24/25, 10 REI fish were collected, on 8/26/24, 15 REI fish were collected, and on 4/2/25, 6 REI fish were collected. On 08/26/25, 20 REIs were collected, with an average Hg concentration of 0.12 mg/kg (CV=0.32, length =69.55 mm) (Table 3-10). The average Hg concentrations in Stevens Creek do not vary much, and both 2024 and 2025 fall in the middle of the range for fish collected over the last 13 years. The average length of fish in 2025 was in the middle of the range, and in 2024 at the higher range (Table 3-11 and Figure 3-32). The range of REI fish caught over the past 13 years has been 3-30 fish.

Table 3-10
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year) 2024–2025 sampling events in Stevens Creek Reservoir. BC=black crappie; BG= bluegill; LG=largemouth bass

		Total Mercury Concentrations (mg/kg ww)				Total Length (mm)			
Year	**Sample Size**	**Avg.**	**Min**	**Max**	**Coeff of Variation**	**Avg**	**Min**	**Max**	**Coeff of Variation**
4/24/24 BC	9	0.41	0.29	0.56	0.21	197.44	185	208	0.05
4/24/24 BG	13	0.24	0.16	0.32	0.22	147.15	93	178	0.20
4/24/24 LG	10	0.26	0.20	0.33	0.15	109.30	95	124	0.10
8/26/24 BG	11	0.20	0.13	0.30	0.27	141.27	105	170	0.15
8/26/24 LG	15	0.11	0.08	0.16	0.20	80.40	69	100	0.12
4/2/25 BG	17	0.21	0.11	0.44	0.38	145.53	85	189	0.24
4/2/25 LG	6	0.22	0.19	0.28	0.17	109.83	98	123	0.10
8/26/25 BG	13	0.15	0.27	0.42	0.06	124.69	81	170	0.26
8/26/25 LG	20	0.12	0.06	0.19	0.32	69.55	56	100	0.18

Table 3-11
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year) 2011–2025 for REI fish caught in Stevens Creek Reservoir.

		Total Mercury Concentrations (mg/kg ww)				Total Length (mm)			
Year	**Sample Size**	**Avg.**	**Min**	**Max**	**Coeff of Variation**	**Avg**	**Min**	**Max**	**Coeff of Variation**
2012	4	0.13	0.12	0.14	0.05	79.00	73	85	0.08
2013	3	0.07	0.07	0.08	0.10	67.67	59	72	0.11
2016	21	0.14	0.08	0.29	0.34	73.75	60	100	0.17
2017	30	0.17	0.08	0.29	0.36	77.50	56	102	0.18
2018	22	0.11	0.03	0.37	0.93	77.36	56	99	0.15
2019	7	0.13	0.08	0.18	0.28	67.86	55	88	0.18
2021	13	0.07	0.06	0.08	0.11	86.54	72	96	0.10
2023	16	0.13	0.07	0.19	0.23	69.13	55	96	0.17
2024	20	0.15	0.08	0.31	0.51	85.40	69	102	0.14
2025	22	0.13	0.06	0.28	0.41	72.14	56	100	0.20

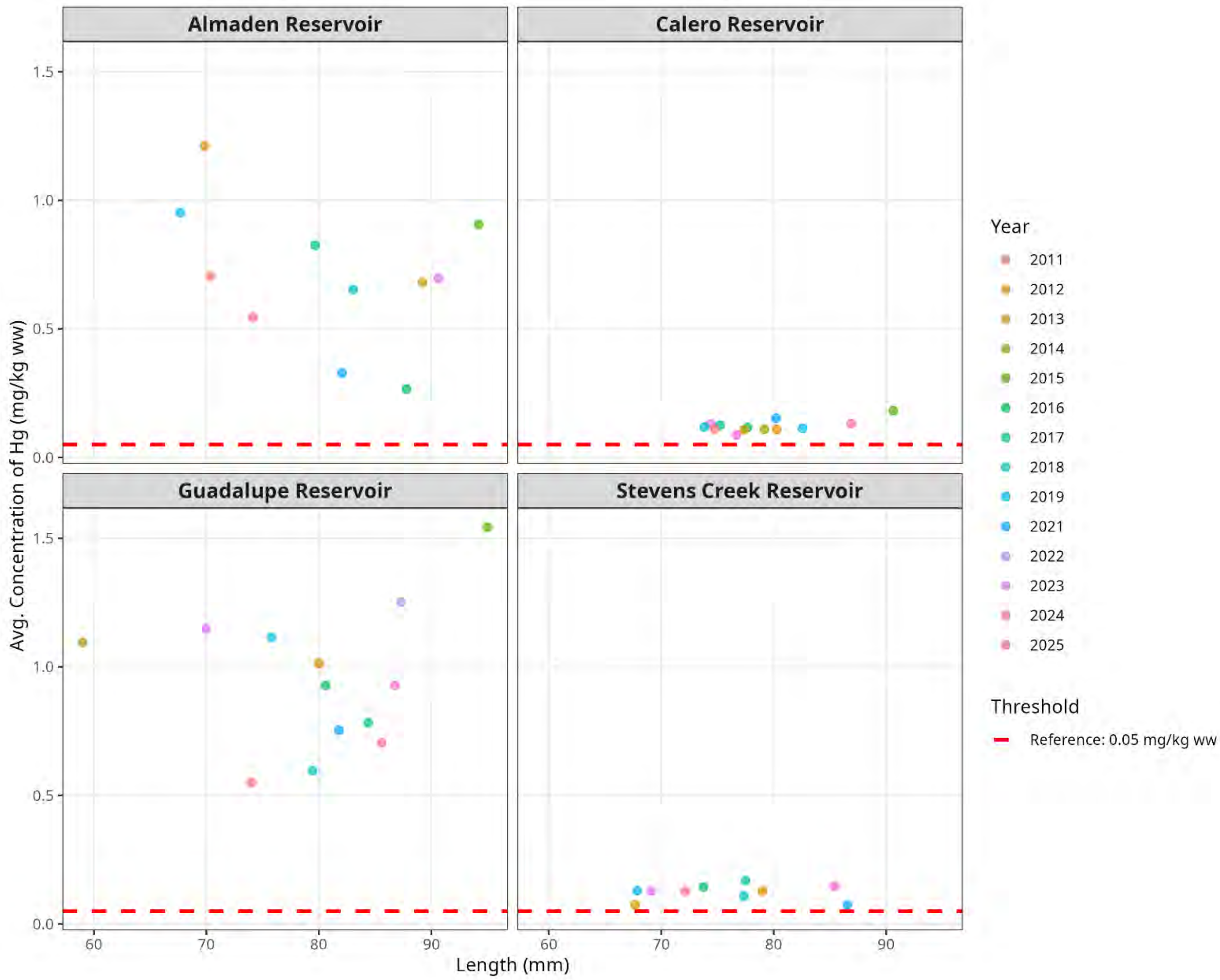

Figure 3-32 Average concentration of fish tissue THg (mg/kg) and fork length (mm) (by year) 2011–2025 for REI fish caught in Almaden Reservoir, Calero Reservoir, Guadalupe Reservoir, and Stevens Creek Reservoir.

In the 2022-2024 biennial report, average concentrations of Hg and average length REI data from the entire dataset were compared with data collected prior to the development of the TMDL for three of the four reservoirs (Almaden, Calero, and Guadalupe) and Lake Almaden (Table 3.12). Here, we add the last two years of data to the dataset, and, as in the last progress report, Guadalupe Reservoir and Almaden Lake show slightly higher Hg concentrations in recent years. It was concluded that, over this longer time period, fish Hg concentrations remain elevated and have not declined meaningfully from values observed in 2004. Stevens Creek Reservoir data are shown for completeness; this reservoir was not sampled for fish Hg in 2004. The table provides REI Hg concentrations for all TMDL reservoirs in the years preceding the operation of HOSs in 2004, but also combines data from all subsequent years, including those when the HOSs were operational and when they weren't. The table does not include collection season, and this is shown to be an important factor in interpreting Hg body burden results in young-of-year fish. It also doesn't break the data down by year of HOS operation. In the next section, we further break the data into the summer collection season, which is likely to include only age-1 fish, and differentiate between pre- and post-HOS data.

Table 3-12
Summary of Age-1 Largemouth Bass Mercury Data from Tetra Tech (2005a, upper rows with gray shading, data collected in 2004) and Valley Water fishery data (lower rows without shading, data collected from 2011-2025).

		Total Mercury Concentrations (mg/kg wet)				Total Length (cm)			
Waterbody	Sample Size	Avg.	Min	Max	Coeff of Variation	Avg	Min	Max	Coeff of Variation
Guadalupe Reservoir, 2004	20	0.83	0.6	1.11	0.17	9.0	7.7	9.7	0.07
Almaden Reservoir, 2004	20	0.96	0.58	1.53	0.29	6.9	5.6	8.2	0.10
Lake Almaden, 2004	20	0.39	0.21	0.53	0.22	9.3	8.0	10.2	0.08
Calero Reservoir, 2004	20	0.21	0.10	0.58	0.53	7.4	5.5	10.2	0.22
Guadalupe Reservoir, 2011-2025	271	1.10	0.09	2.96	0.52	10.17	1.10	33.20	0.42
Almaden Reservoir, 2011-2025	258	0.85	0.08	2.58	0.56	10.54	5.50	29.40	0.46
Lake Almaden, 2011-2025	40	0.52	0.35	0.83	0.31	7.79	6.30	8.90	0.10
Calero Reservoir, 2011-2025	336	0.16	0.03	0.98	0.59	10.16	5.40	30.00	0.41
Stevens Creek Reservoir, 2011-2025	233	0.17	0.03	0.52	0.56	9.74	1.50	34.80	0.46

3.2.5 PRE AND POST HOS OPERATION MERCURY IN REI FISH

After ceasing HOS operations and before starting alternative management efforts, Valley Water will establish a solid baseline of REI fish Hg data in Calero, Guadalupe, Almaden, and Stevens Creek Reservoirs.

Measurements taken from age-1 largemouth bass, also known as biosentinel fish, help track recent changes in MeHg accumulation. The MeHg found in REI fish tissue mainly comes from their diet during the sampled year, rather than from Hg accumulated in previous years. An exception is Hg in sac fry tissue, which is maternally derived and may distort dietary Hg assessments. Due to their highly predatory nature, young largemouth bass are more likely to offer insights into the patterns of profundal MeHg production than similarly sized herbivorous prey fish species (Stillwater Sciences, 2025).

To represent a single cohort of young largemouth bass (i.e., excluding individuals aged 1 year or older, if possible), only length-standardized data from the summer sampling events are shown here.

Figure 3-33 and Table 3-13 show all REI fish collected during the summer sampling period from 2011 until the present for Almaden Reservoir. All REI fish are highly elevated in Hg concentrations and significantly exceed the California prey fish objective of 0.05 µg/g Hg (wet weight). In addition to showing pre and post-HOS data for the summer REI samples, data is also shown for years when the HOS was operational in Figure 3-33. Only the pre and post-HOS data are shown in the Tables.

There were three pre-HOS measurements: two had the same sample size and approximately the same average length but differed in average Hg concentrations. In 2011, the average Hg concentration was 0.7 mg/kg (CV = 0.37, length = 69.9 mm). The sample size was 20 fish, and the size distribution was bimodal. In 2012, the average Hg concentration was 1.21 mg/kg (CV=0.19, length= 69.8 mm). The sample size was 20 fish, and the size distribution was similarly bimodal.

The third pre-REI fish had a larger average length and lower average Hg concentration. In 2013, the average 0.68 mg/kg (CV=0.17, length=89.2). The two post-REI measurements were highly variable in size but similar in Hg concentrations. In 2023, the average Hg concentration was 0.80 mg/kg (CV=0.46, length=88.5). The sample size was 20 fish, and the size distribution was bimodal. In 2025, the average Hg concentration was 0.54 mg/kg (CV = 0.38, length = 74.14 mm).

Bimodal size distributions are seen in new or recovering bass fisheries. Young largemouth bass (age-0) will commonly form two distinct size groups, or a bimodal distribution, by late summer or fall. This pattern often results from early-hatched, faster-growing fish outcompeting or outgrowing later-hatched, smaller ones due to limited food or habitat availability. Such conditions lead to high variability in length and two different growth rates within the same year class. This bimodal pattern reflects differences in survival and recruitment, with the larger, quicker-growing bass typically better suited for overwintering and reaching harvestable size (Maceina & Isely 1986). The average Hg concentration was lower in the post-HOS REI fish for Almaden Reservoir.Austin (2022) documented statistically significant decreases in Hg concentrations in REIs (biosentinel) fish Almaden Reservoir attributed to mine cleanup.

Figure 3-34 and Table 3-14 show all REI fish collected in the Summer from 2011 until the present for Calero Reservoir. REI fish are much less contaminated in Calero Reservoir but still exceed the California prey fish objective of 0.05 µg/g Hg (wet weight). There are four pre-HOS measurements and one post-HOS measurement. Mean Hg concentrations before and after HOS are similar. Pre and post-HOS are all approximately 0.1 mg/kg. Pre-HOS fish lengths vary from 71.38 to 104.92 mm, and the post-HOS sample mean length was 86.45 mm. All pre-HOS samples exhibit a bimodal size distribution. The highest mean Hg concentrations in REI fish were recorded when the HOS was in operation.

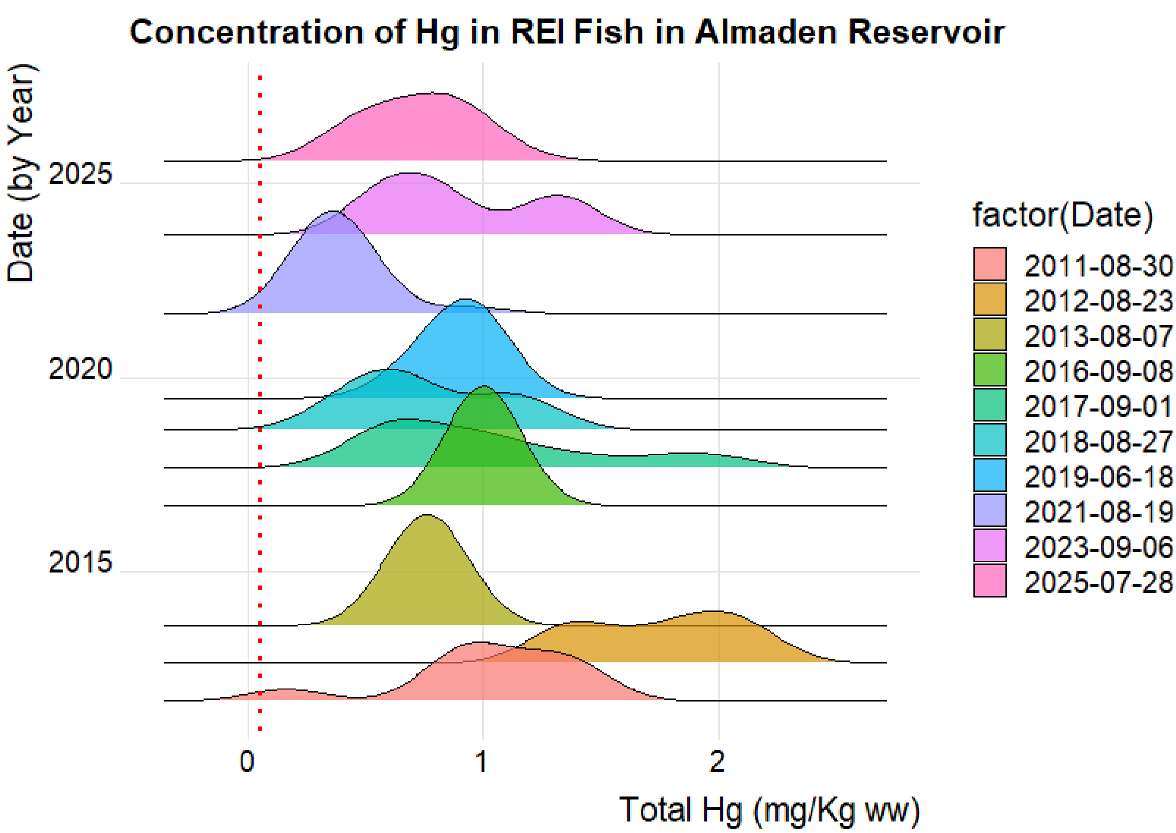

Figure 3-33 Almaden REI largemouth bass tissue mercury concentrations (mg/kg ww) in 100 mm length-standardized fish from Summer 2011 until Summer 2025.

Table 3-13
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year), prior to oxygenation in Almaden Reservoir, and data collected post oxygenation.

		Total Mercury Concentrations (mg/kg ww)				Total Length (mm)			
Year	Sample Size	Avg.	Min	Max	Coeff of Variation	Avg	Min	Max	Coeff of Variation
8/30/11 pre	20	0.70	0.11	1.00	0.34	69.9	61	87	0.11
8/23/12 pre	20	1.21	0.80	1.75	0.19	69.8	60	88	0.13
8/7/13 pre	10	0.68	0.51	0.86	0.17	89.2	72	99	0.12
9/6/23 post	6	0.80	0.48	1.30	0.46	88.5	59	101	0.18
7/28/25 post	29	0.54	0.21	0.95	0.38	74.14	55	101	0.19

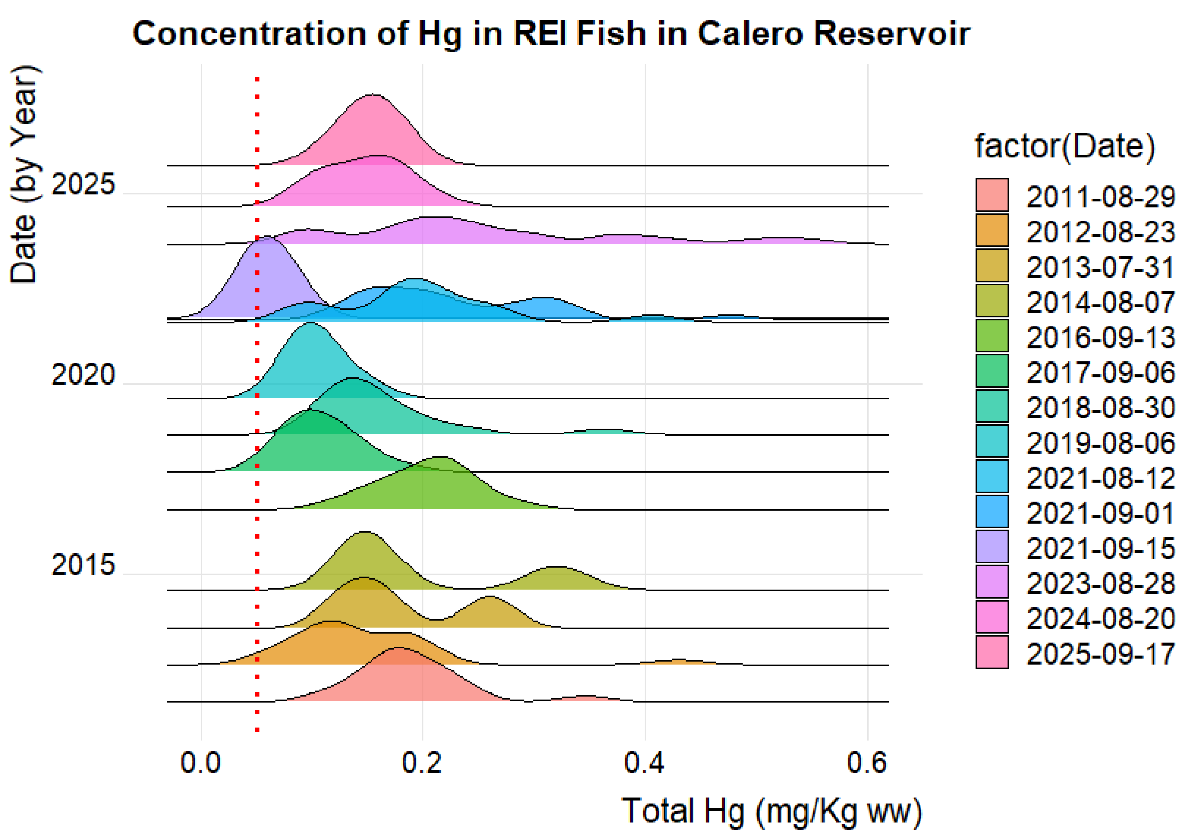

Figure 3-34 Calero REI largemouth bass tissue mercury concentrations (mg/kg ww) in 100 mm length-standardized fish from Summer 2011 until Summer 2025.

Figure 3-35 and Table 3-15 show all REI fish collected in the Summer from 2012 until the present for Guadalupe Reservoir. All REI fish are highly elevated in Hg concentrations and significantly exceed the California prey fish objective of 0.05 µg/g Hg (wet weight). The two pre-HOS measurements are highly variable, both in average length and Hg concentrations. The 2012 samples have an average Hg concentration of 0.77 mg/kg (CV=0.68, length= 0.77 mm). 2013 samples contain an average Hg concentration of 1.10 mg/kg (CV=0.60, length=59 mm). There are four post-HOS measurements, which range in Hg concentration from 0.61 to 1.76 mg/kg and in length from 72.79 to 86.77 mm. A bimodal size distribution is observed in 2023, but other samples are unimodal. The sample collected this year had the lowest recorded Hg concentration of 0.61 mg/kg (CV=0.23, length=86.56 mm)

Table 3-14
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year), prior to oxygenation in Calero Reservoir, and data collected post oxygenation.

		Total Mercury Concentrations (mg/kg ww)				Total Length (mm)			
Year	**Sample Size**	**Avg.**	**Min**	**Max**	**Coeff of Variation**	**Avg**	**Min**	**Max**	**Coeff of Variation**
8/29/11 pre	16	0.14	0.09	0.31	0.36	74.75	61	90	0.13
8/23/12 pre	20	0.12	0.05	0.35	0.54	80.6	62	91	0.12
7/31/13 pre	3	0.14	0.09	0.22	0.52	73.0	57	73	0.20
8/7/14 pre	7	0.13	0.07	0.25	0.07	64.71	55	80	0.15
9/17/25 post	20	0.13	0.09	0.18	0.17	86.45	73	100	0.10

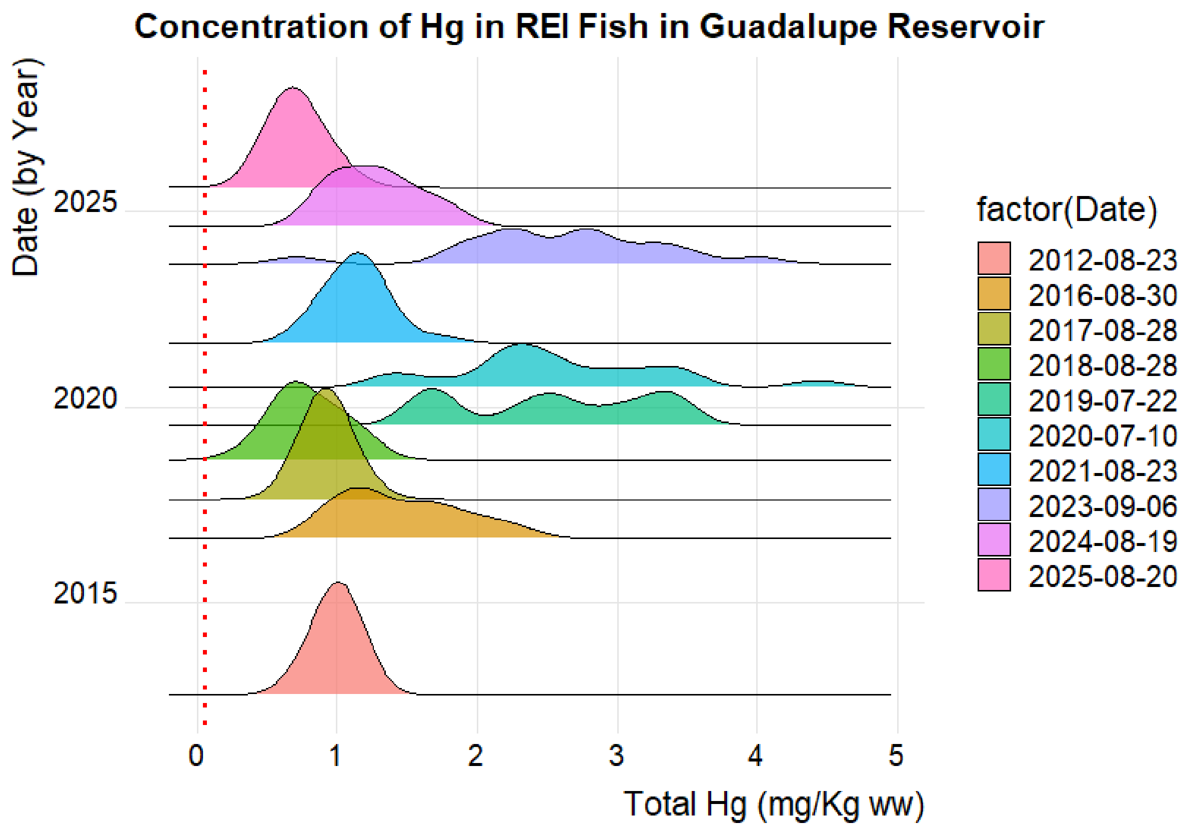

Figure 3-35 Guadalupe REI largemouth bass tissue mercury concentrations (mg/kg ww) in 100 mm length-standardized fish from Summer 2011 until Summer 2025.

Table 3-15
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year), prior to oxygenation in Guadalupe Reservoir, and data collected post oxygenation.

Year	Sample Size	Total Mercury Concentrations (mg/kg ww) Avg.	Min	Max	Coeff of Variation	Total Length (mm) Avg	Min	Max	Coeff of Variation
8/23/12 pre	10	0.77	0.52	0.95	0.68	77.8	60	89	0.13
7/17/13 pre	3	1.10	0.72	1.85	0.60	59	56	65	0.02
8/23/21 post	18	1.06	0.31	2.53	0.44	74.71	54	100	0.17
9/6/23 post	20	1.76	0.53	2.48	0.24	72.79	56	85	0.20
8/19/24 post	13	1.08	0.86	1.27	0.14	86.77	67	100	0.12
8/20/25 post	18	0.61	0.33	0.88	0.23	86.56	66	102	0.14

Figure 3-36 and Table 3-16 show all REI fish collected in the Summer from 2012 until the present for Stevens Creek Reservoir. REI fish are again much less contaminated than in Alamaden and Guadalupe Reservoirs but still exceed the California prey fish objective of 0.05 µg/g Hg (wet weight). There are two pre-HOS measurements and four post-HOS measurements for this reservoir. Mean Hg concentrations before and after HOS are similar. Pre and post-HOS are all near 0.1 mg/kg. Pre-HOS fish lengths vary from 92.8 to 118. mm, and the post-HOS sample mean length ranged from 63.71 to 86.54 mm. Most samples exhibit a unimodal size distribution. The highest mean Hg values for REI fish were documented when the HOS was in operation.

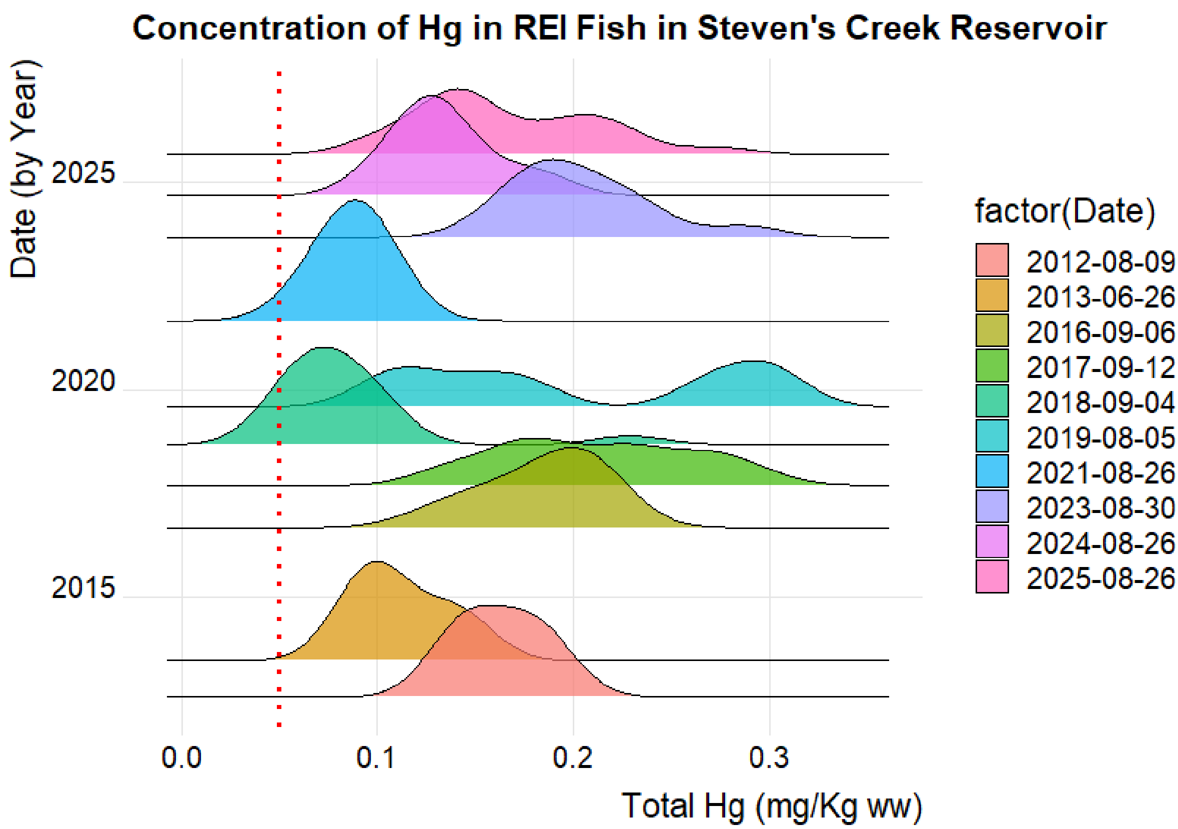

Figure 3-36 Stevens Creek REI largemouth bass tissue mercury concentrations (mg/kg ww) in 100 mm length-standardized fish from Summer 2011 until Summer 2025.

Table 3-16
Statistical Summary of fish tissue THg (mg/kg) and fork length (mm) (by year), prior to oxygenation in Stevens Creek Reservoir, and data collected post oxygenation.

Year	Sample Size	Total Mercury Concentrations (mg/kg ww)				Total Length (mm)			
		Avg.	Min	Max	Coeff of Variation	Avg	Min	Max	Coeff of Variation
8/9/12 pre	4	0.13	0.12	0.14	0.05	79.0	73	85	0.08
6/26/13 pre	3	0.07	0.07	0.08	0.11	67.67	59	72	0.10
8/26/21 post	13	0.07	0.06	0.08	0.11	86.54	72	96	0.10
8/30/23 post	13	0.13	0.10	0.16	0.15	64.62	55	80	0.11
8/26/24 post	15	0.11	0.08	0.16	0.20	80.4	69	100	0.12
8/26/25 post	20	0.12	0.06	0.19	0.32	69.55	56	100	0.18

3.2.6 Models and Trends

We continued to employ two approaches in this report to evaluate changes in fish tissue Hg concentrations, as we have in prior years. A multiple regression model aims to account for variations inherent in fish sampling, such as collection season, fish species, and fish length. A second, more direct approach evaluates the relationship between fish length and fish tissue Hg concentration across reservoirs and years (Seelos et al., 2021). A multiple regression model was used to isolate the trend in fish Hg from the covarying factors based on the following (Eq. 1):

$$\text{Hg}\ \frac{\text{mg}}{\text{kg}}\ \text{ww} = \alpha\alpha + \beta\beta_1 \cdot \text{Date} + \beta\beta_2 \cdot \text{Species} + \beta\beta_3 \cdot \text{Length(mm)} + \beta\beta_4 \cdot \text{CollectionSeason}$$

The regression approach fitted the following equation to fish Hg data from 2011 to 2025, with a distinct set of coefficients for each reservoir (Table 3-8). The key parameter of interest is the Sample Date coefficient, which represents the change in fish Hg concentrations over time. The model was applied to each reservoir using data collected after the onset of HOS operations and now includes the time since operations have ceased.

When the coefficient associated with date is significant at the 0.05 level, the regression indicates a statistically significant effect of time. When the coefficient is negative, a decrease over time is indicated. In Table 3-8, this decreasing trend is seen in Almaden and Guadalupe Reservoirs; however, the magnitude of the coefficient is small.

Seelos et al. (2021) initially reported a statistically significant decline in fish tissue Hg in all Reservoirs except Calero, which showed an increase; however, the magnitude of the coefficients was too small to be practically meaningful in Calero Reservoir. With an additional two years added to this dataset, Tetra Tech (2023) again reported a statistically significant increasing trend in fish Hg concentrations in Calero Reservoir; again, the magnitude of the coefficients was too small to be practically meaningful. Tetra Tech also reported statistically significant decreases in fish tissue Hg in Almaden and Guadalupe Reservoirs. Stevens Creek Reservoir was no longer significant. During this reporting period, there was a similarly significant decrease in fish tissue Hg concentrations in Almaden and Guadalupe Reservoirs. Calero and Stevens Creek Reservoirs were no longer significant.

Guadalupe has maintained a significant decline in fish tissue Hg concentrations over time. The fact that declining trends persisted in Guadalupe and Almaden reservoirs despite the nonoperation of the HOSs suggests that fish Hg trends are dependent on factors other than HOS, such as source control.

Some of the highest concentrations of fish tissue Hg documented in Figure 3-32 occurred across all species during the period of approximately 2015 to 2017, when the HOSs were operational. This was hypothesized to be a result of conditions related to drought (Seelos et al. 2021). The increase could also have also been due to the HOSs themselves mixing MeHg from profundal water into the photic zone, making it available for higher bioaccumulation rates in the food web (Tetra Tech, 2023). The data show that HOSs did not definitively cause a decrease in fish Hg concentrations in any of the reservoirs. Table A-3 in Appendix A shows the full regression diagnostics for the multiple linear regression of length vs. fish Hg relationship. For each of the four reservoirs, the table shows the estimated value of the regression coefficient, its estimated standard error, the resulting test statistic for statistical significance, and the corresponding p-value. Discrete variables, such as fish species and collection season, are expanded into binary indicators, with one level always being absorbed into the intercept term.

Table 3-17
Linear Regression Model Parameters. Bolded numbers indicate statistical significance of the regression parameter at the 0.05 level.

	$\alpha\alpha$	$\beta\beta_1$	$\beta\beta_2$ (Bluegill)	$\beta\beta_2$ (Largemouth Bass)	$\beta\beta_3$	$\beta\beta_4$
Almaden	**1.443**	**-6.912E-05**	0.154	0.090	**0.002**	0.045
Calero	0.002	5.01E-07	**0.042**	**0.041**	**0.006**	**0.027**
Guadalupe	**1.226**	**-5.13E-05**	0.111	0.116	**0.005**	**0.101**
Stevens Creek	**0.059**	-2.92E-06	-0.014	0.052	**0.001**	**0.047**

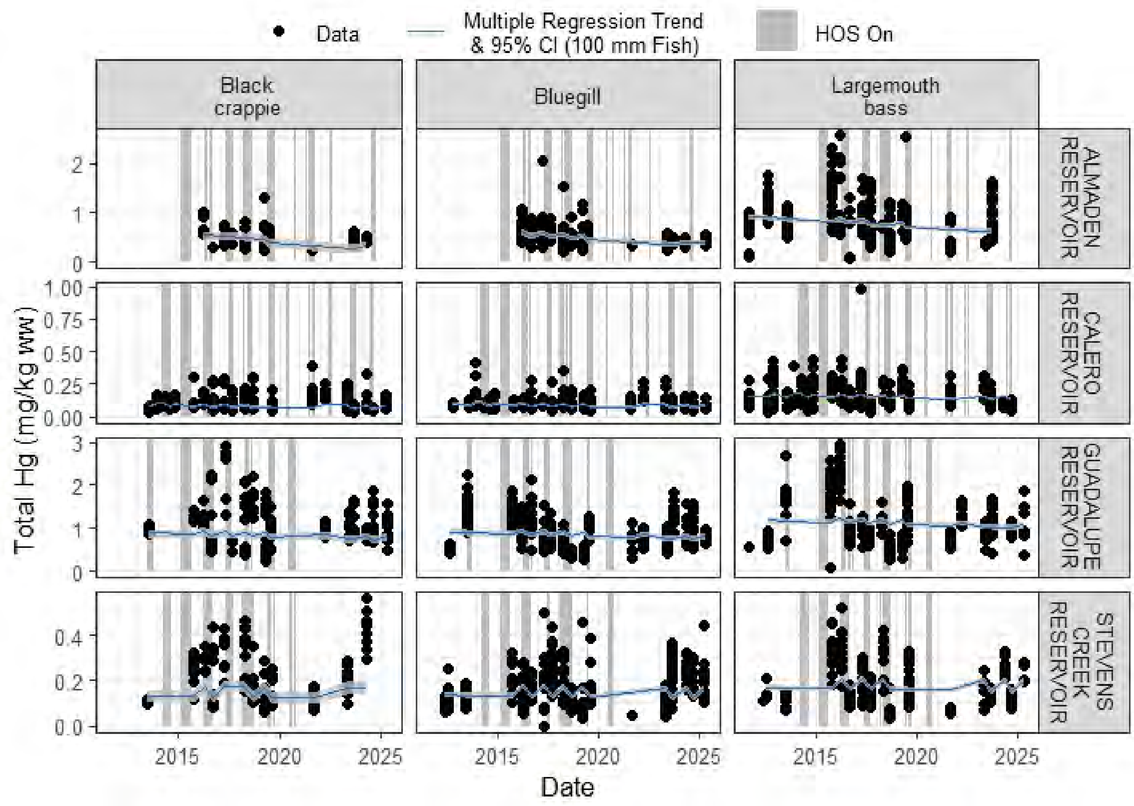

Figure 3-37 Linear regression models of Hg concentrations in Black crappie, Bluegill, and Largemouth bass tissue.

An alternative method for assessing fish tissue Hg concentrations is to analyze how the slope of the relationship between fish length and Hg changes over time. Generally, there is a positive correlation between fish length and Hg concentrations, with a stronger correlation indicating greater Hg bioaccumulation in the food web. If this slope varies annually—such as decreasing—it implies a reduction in bioaccumulation, which was expected when the HOSs were in operation. In the data for each of the four reservoirs and the three main species examined (Figures 3-38 to 3-45), the following patterns emerge:

With few exceptions, most reservoirs and species show a positive slope in the fish Hg versus length relationship, although some slopes are not statistically significant. This suggests Hg bioaccumulation across all reservoirs. The slopes are steeper in the reservoirs with higher Hg contamination, Almaden and Guadalupe, indicating increased bioaccumulation.

Largemouth bass exhibit the steepest slopes among fish species, with black crappie and bluegill following. These differences may be influenced by the sample sizes and dietary habits of each species.

Over time, the slopes do not exhibit a consistent pattern across different species and reservoirs, which suggests that the operation of the HOS is not reducing Hg bioaccumulation. The lack of such a pattern indicates no clear change in Hg bioaccumulation in fish, regardless of whether the HOS was operated.

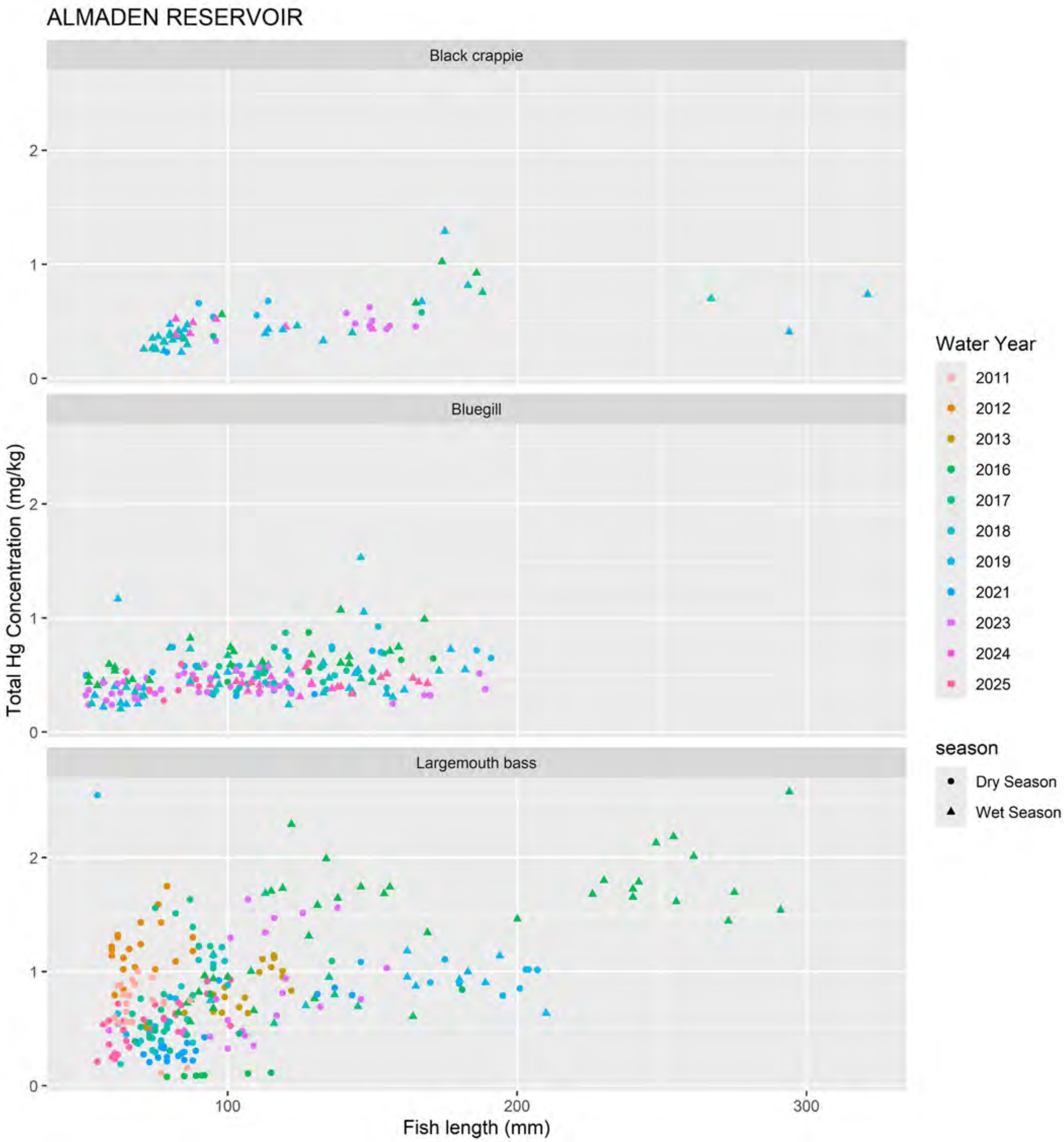

Figure 3-38 Fish length and Hg concentrations in Almaden Reservoir for each year of sampling, for three major species.

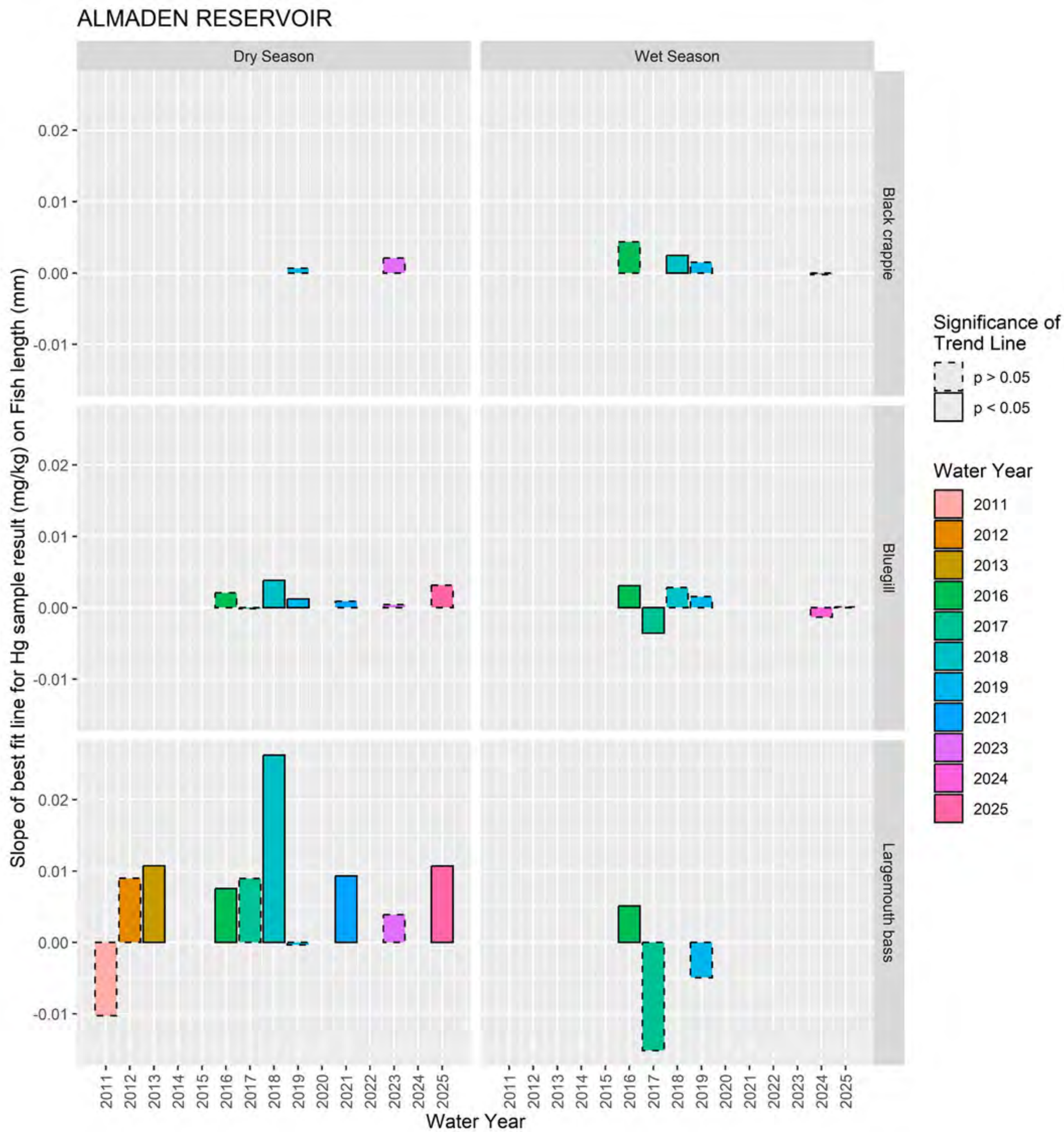

Figure 3-39 Fish Hg-length relationship for each year of data in Almaden Reservoir for three major species.

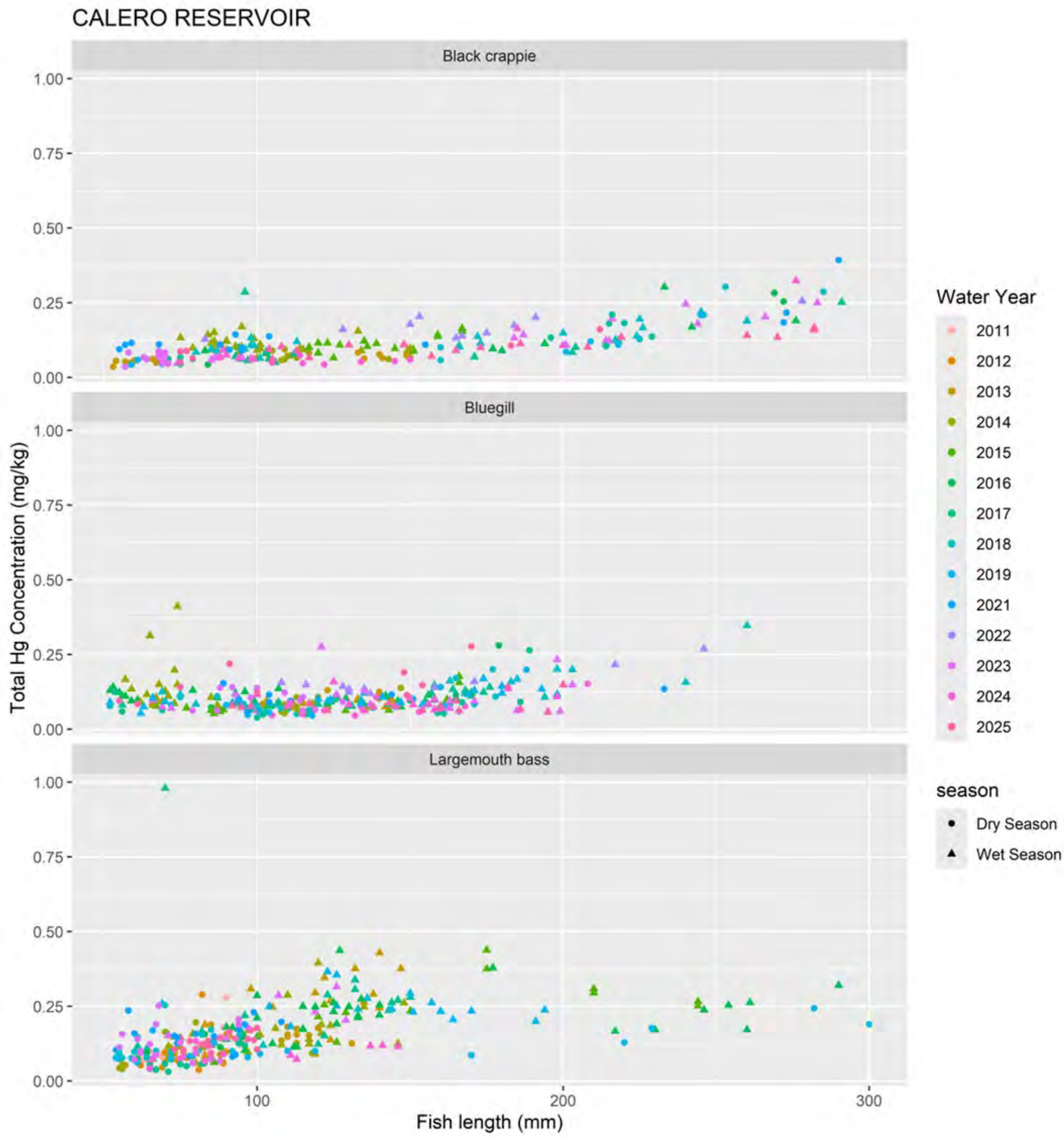

Figure 3-40 Fish length and Hg concentrations in Calero Reservoir for each year of sampling, for three major species.

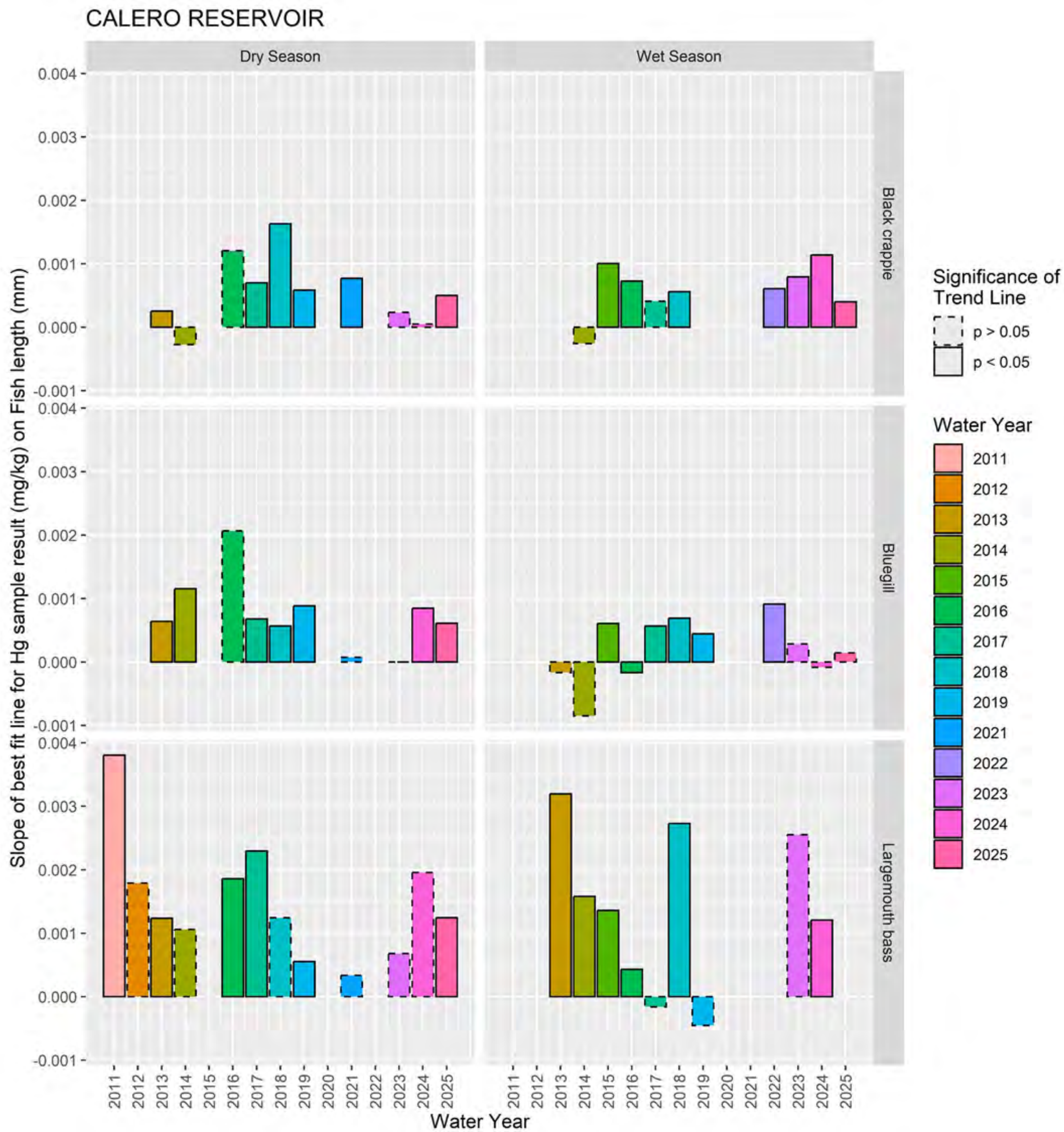

Figure 3-41 Fish Hg-length relationship for each year of data in Calero Reservoir for three major species.

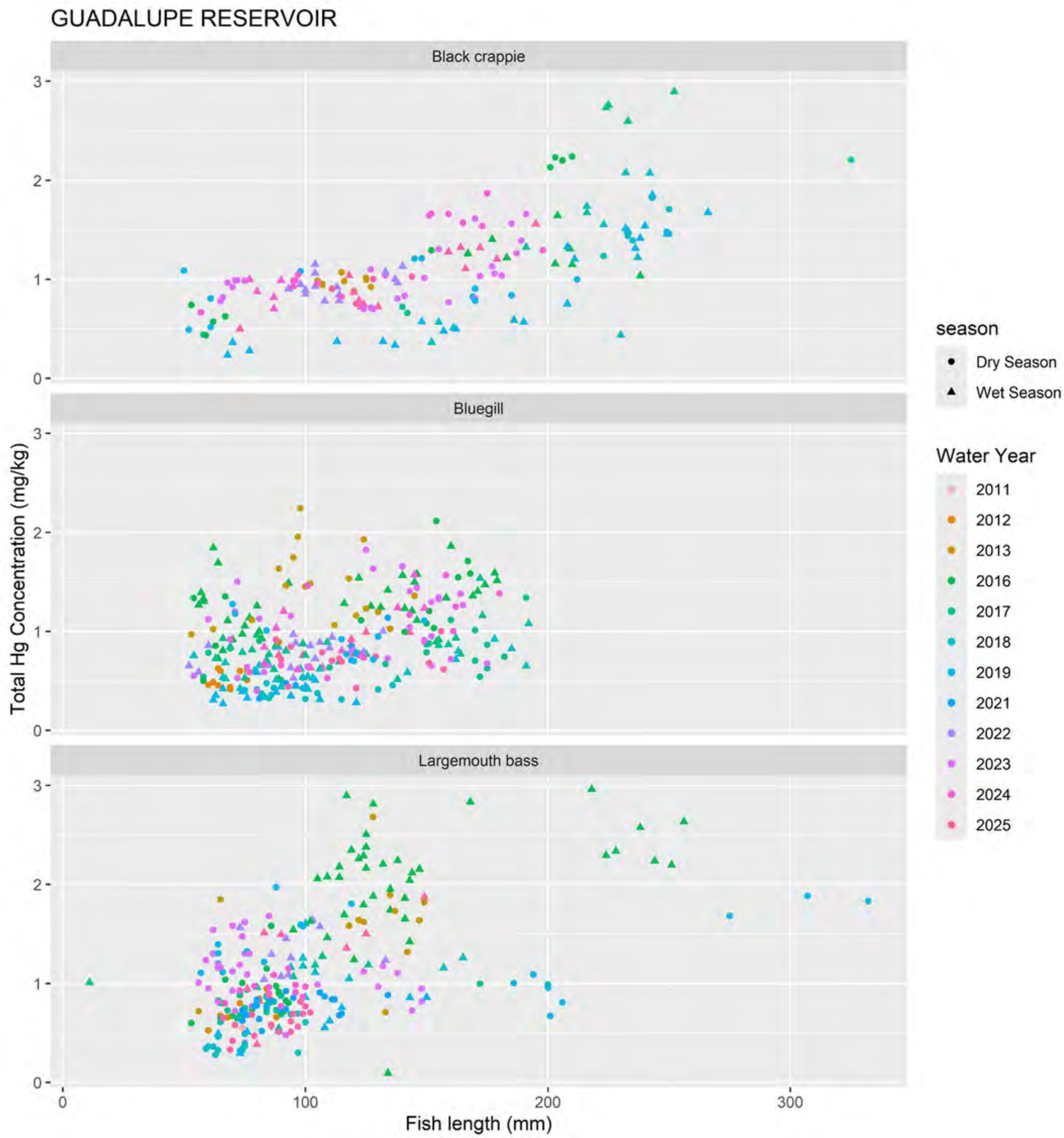

Figure 3-42 Fish length and Hg concentrations in Guadalupe Reservoir for each year of sampling for three major species.

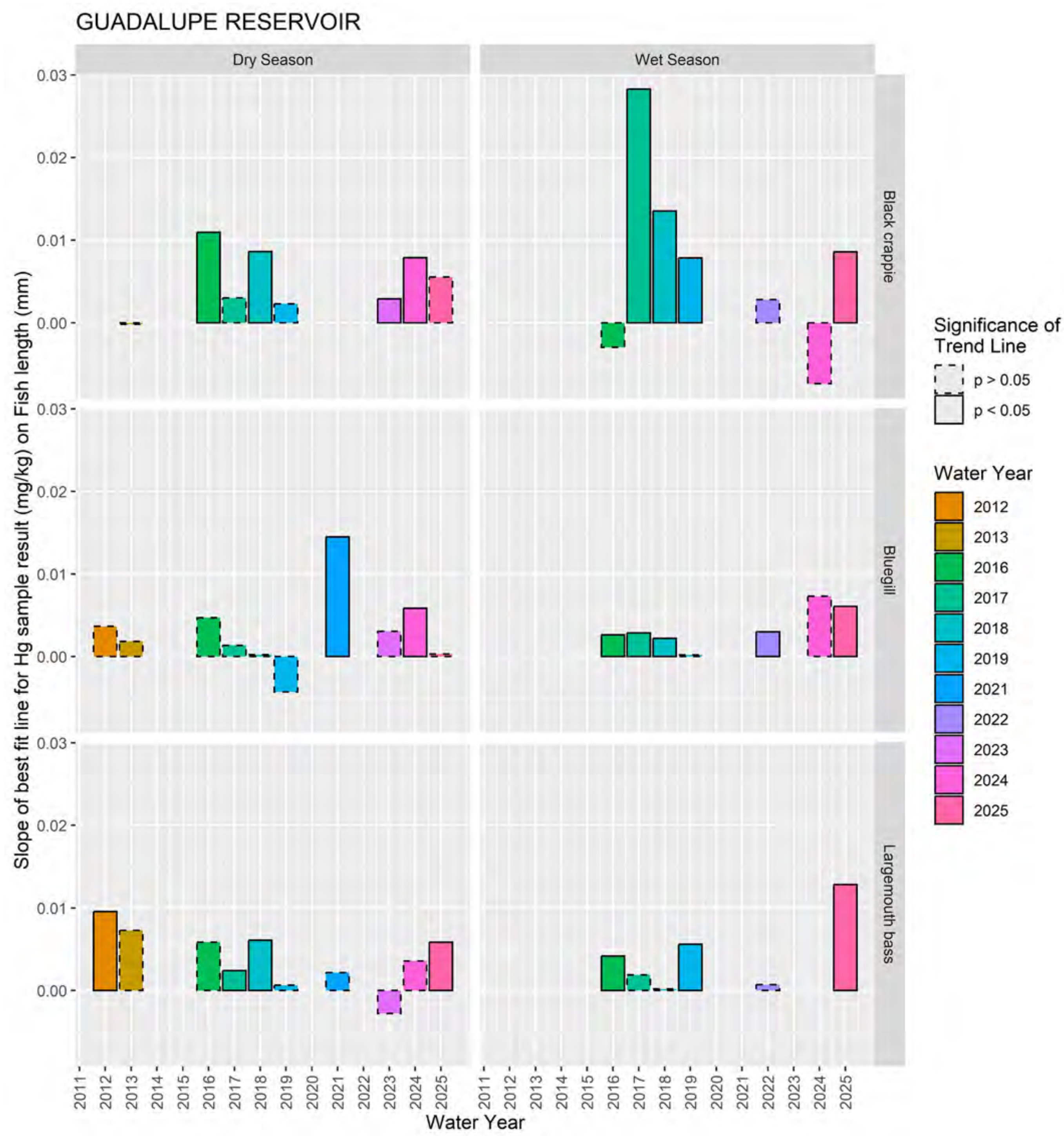

Figure 3-43 Fish Hg-length relationship for each year of data in Guadalupe Reservoir for three major species.

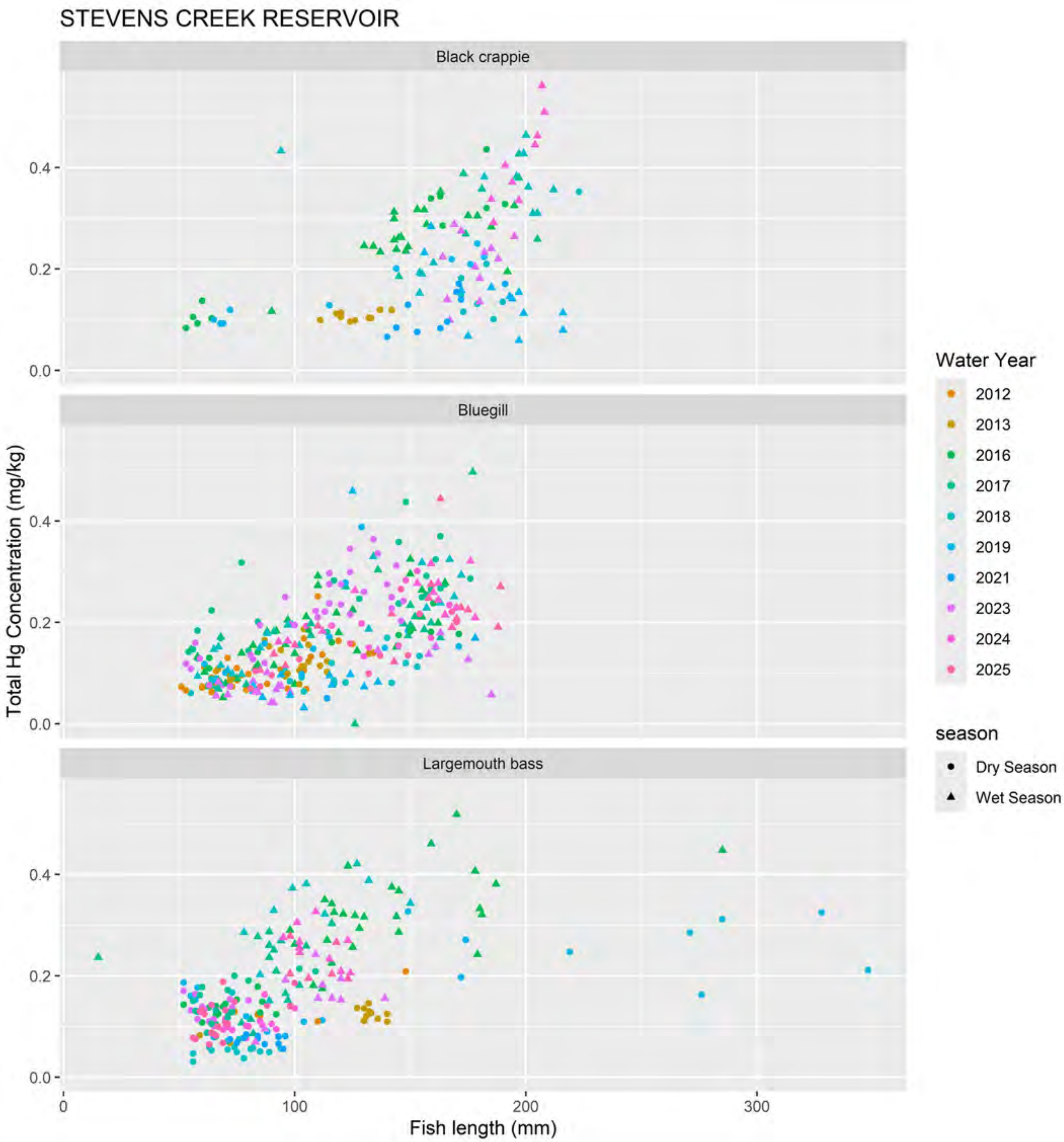

Figure 3-44 Fish length and Hg concentrations in Stevens Creek Reservoir for each year of sampling for three major species.

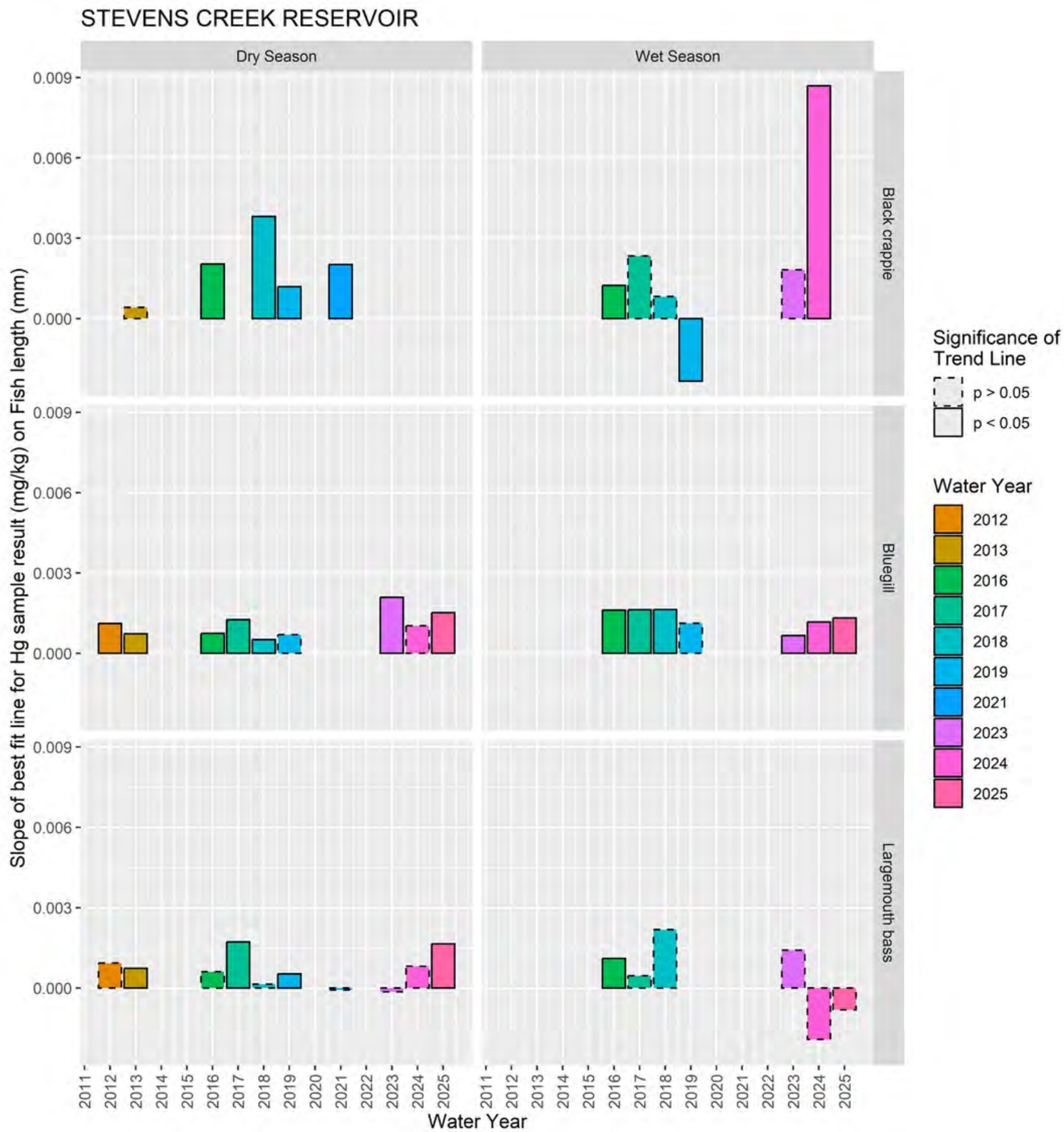

Figure 3-45 Fish Hg-length relationship for each year of data in Stevens Creek Reservoir for three major species.

Although water column Hg and fish tissue Hg are linked through food web exposure, time delays complicate their relationship. Examining previous water chemistry can help clarify how much water column changes, such as those managed by the HOSs, affect fish tissue Hg concentrations. Figures 3-46 and 3-47 show fish tissue Hg and average MeHg concentrations in water over the past 90 days in both the epilimnion and hypolimnion, categorized by reservoir and species. The correlation is weak, and similar outcomes are observed with antecedent MeHg over 30 and 180 days. In less polluted reservoirs like Calero and Stevens Creek, changes in MeHg are minimal. In more contaminated reservoirs, such as Guadalupe and Almaden, a weak, noisy positive trend suggests a limited effect of water column MeHg on fish tissue Hg. The noisy data reflect the constraints on how much fish tissue Hg can be affected by water column MeHg concentrations.

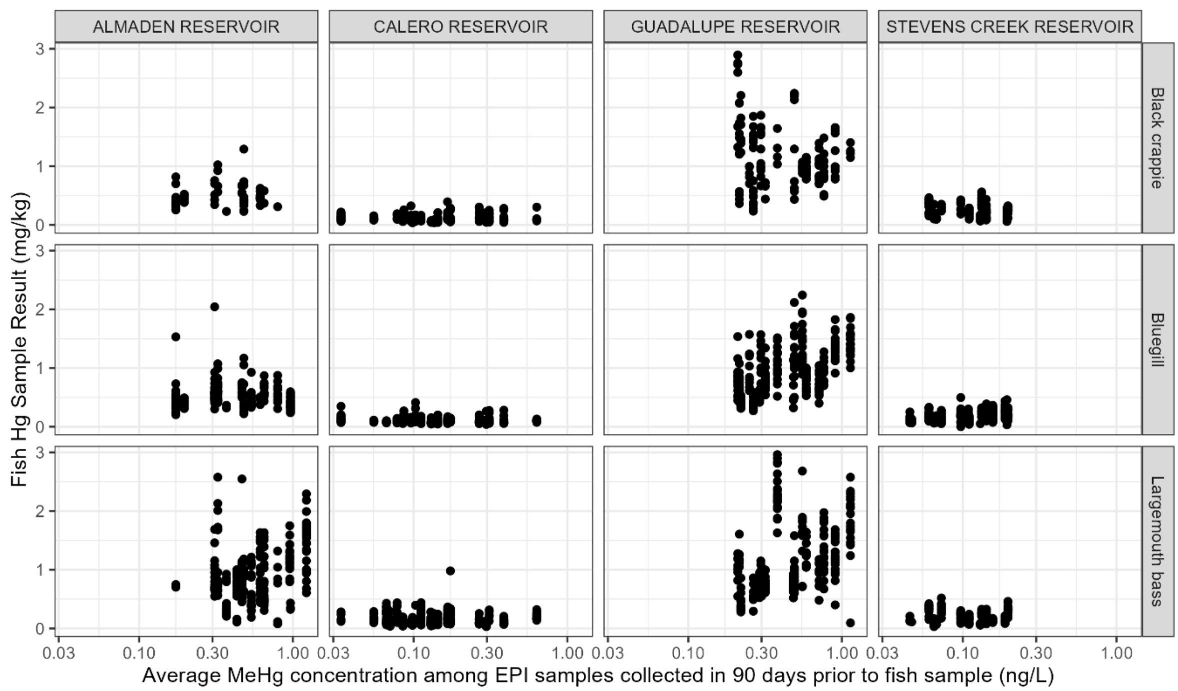

Figure 3-46 Fish Hg (not length normalized) and epilimnion MeHg over preceding 90 days.

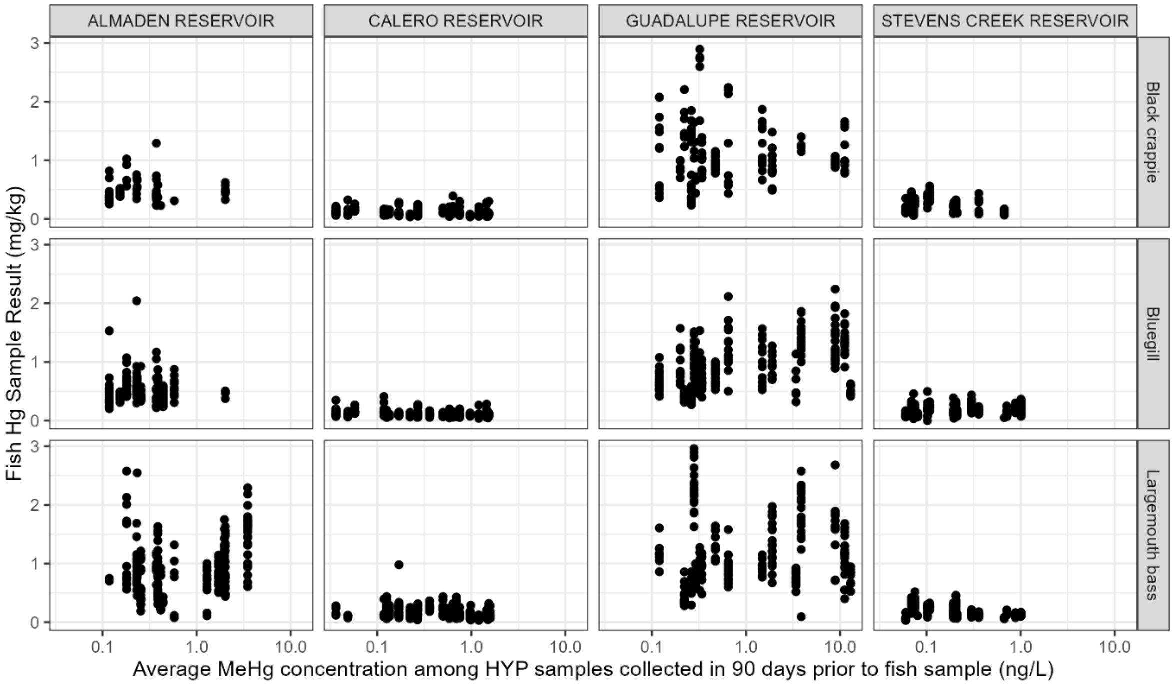

Figure 3-47 Fish Hg (not length normalized) and hypolimnion MeHg over preceding 90 days.

3.2.7 TOTAL MERCURY AND METHYLMERCURY LOADING

Methylmercury discharges from reservoirs may lead to higher bioaccumulation in downstream creeks. The total Hg and MeHg loadings to these creeks are calculated using daily outflows and flow-weighted mean (FWM) concentrations. Figures 3-48 and 3- 49 display graphs of discharge and concentrations of total Hg and MeHg at reservoir outlets. Figures 3-50 and 3-51 present the yearly total Hg and MeHg loads. These loads fluctuate based on periods of high flow, as shown in the discharge data. Over 16 years, both total Hg and MeHg loads have varied by more than 1,000 times, partly due to hydrology. Droughts from 2012 to 2016 greatly reduced Hg loading.

During normal flow years, most MeHg is released during the dry season, when production peaks. Guadalupe Reservoir discharges less MeHg than expected because of its more elevated outlet structure. Hypolimnetic oxygenation systems in Almaden, Guadalupe, and Stevens Creek reservoirs significantly decreased MeHg concentrations in bottom water, with mean reductions of 63-85% below pre-oxygenation concentrations, reducing loads during dry seasons (Seelos et al. 2021) (Figure 3-50, Figure 3-51, and Tables 3-18 to 3-21). However, this reduction was not due to methylation suppression but rather mixing and dilution with reservoir surface water (Seelos 2021 and Austin 2022).

The opposite trend is seen: despite average and above-average rainfall and average releases, dramatic increases in MeHg concentrations have occurred during 2021-2025 in Guadalupe and Stevens Creek Reservoirs. The same patterns have been observed in Almaden Reservoir in 2023 and 2025, and in Calero Reservoir in 2025, when the HOSs were turned off (Figure 3-51 and Tables 3-18 and 3-19). Data on Hg loads for each reservoir are provided in Tables 3-18 to 3-21.

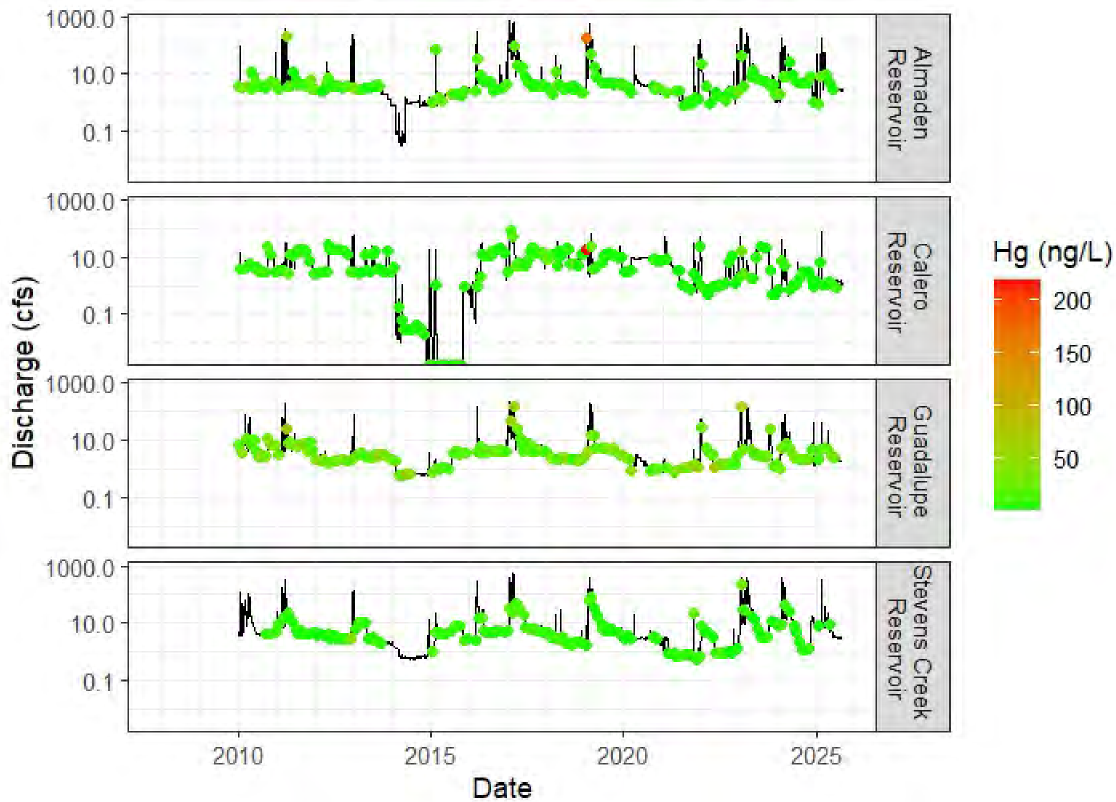

Figure 3-48 Hydrograph of outlet flow and measured total Hg concentrations at Almaden, Calero, Guadalupe, and Stevens Creek reservoirs. Low values indicate zero outflow at Calero Reservoir.

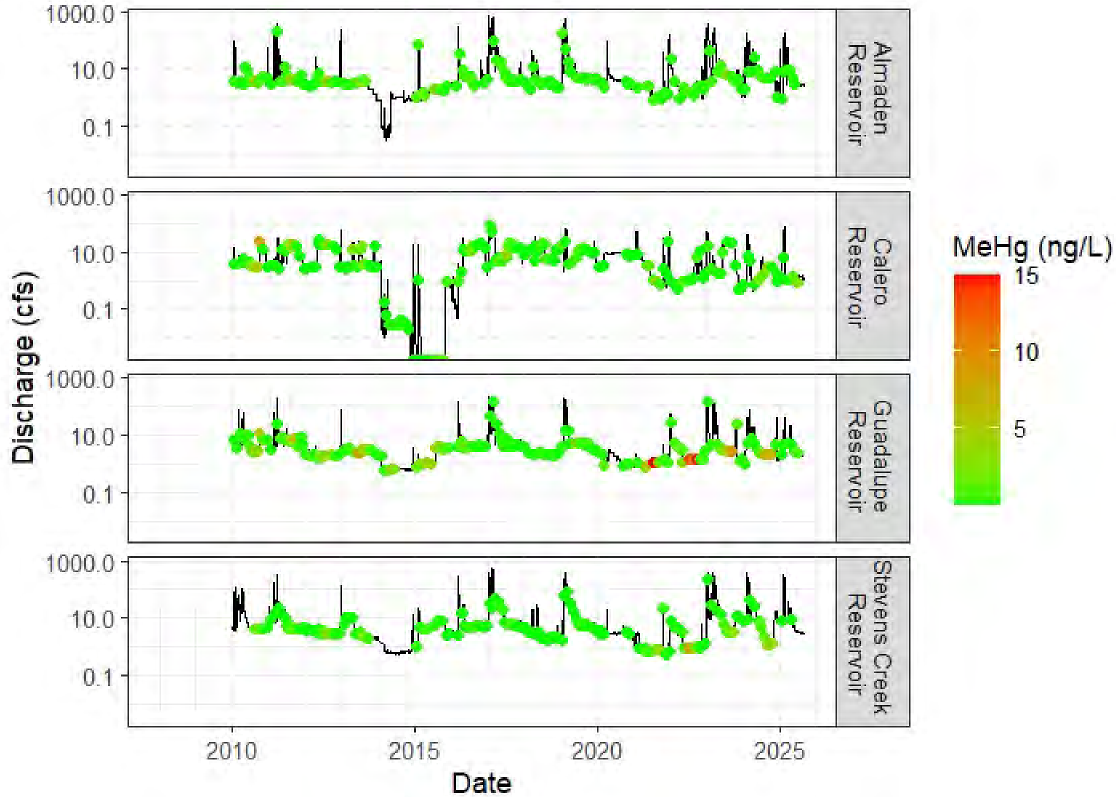

Figure 3-49 Hydrograph of outlet flow and measured MeHg concentrations at Almaden, Calero, Guadalupe, and Stevens Creek reservoirs. Low values indicate zero outflow at Calero Reservoir.

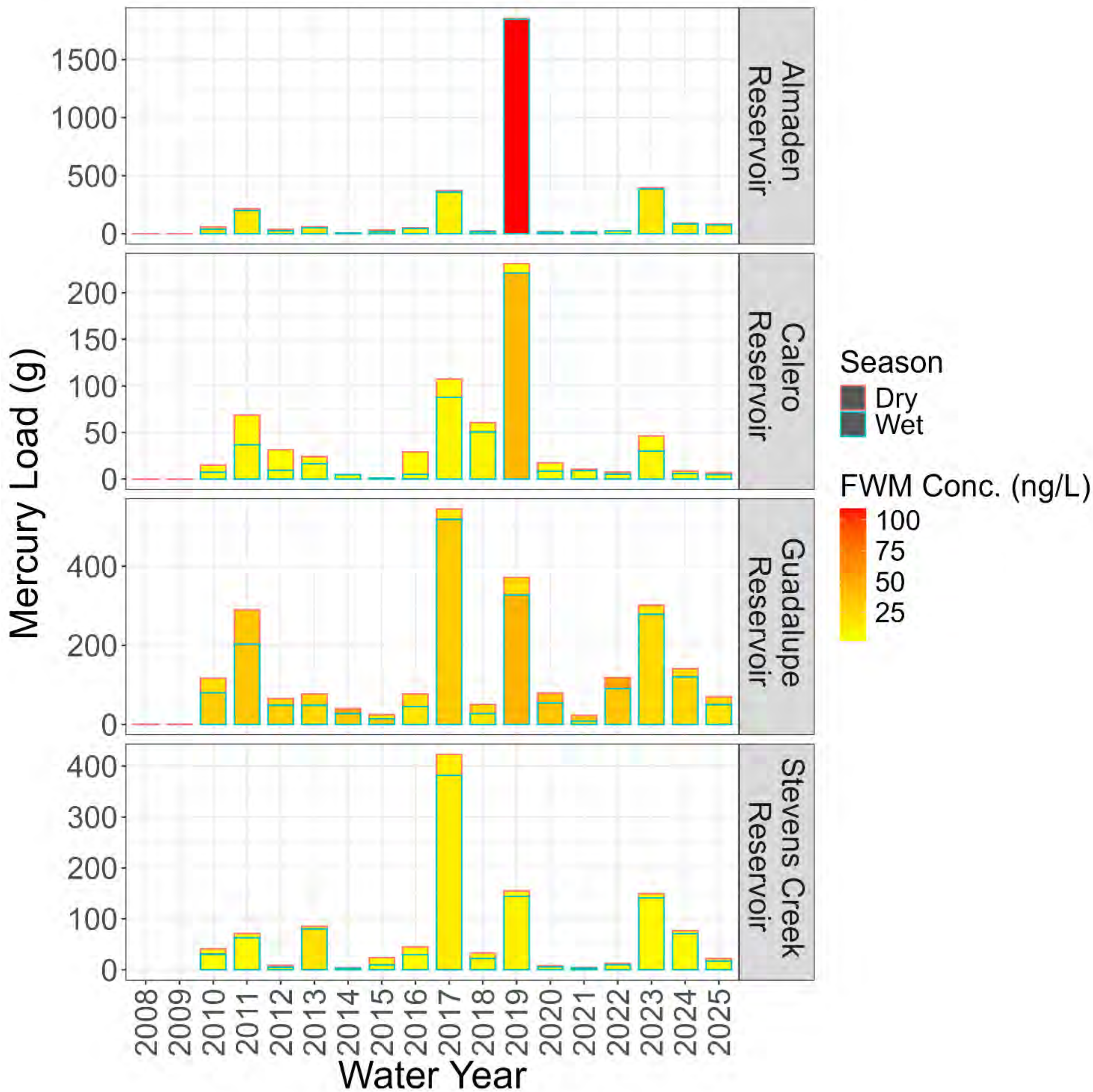

Figure 3-50 *Annual total Hg load and flow-weighted mean (FWM) Hg concentration by season.*

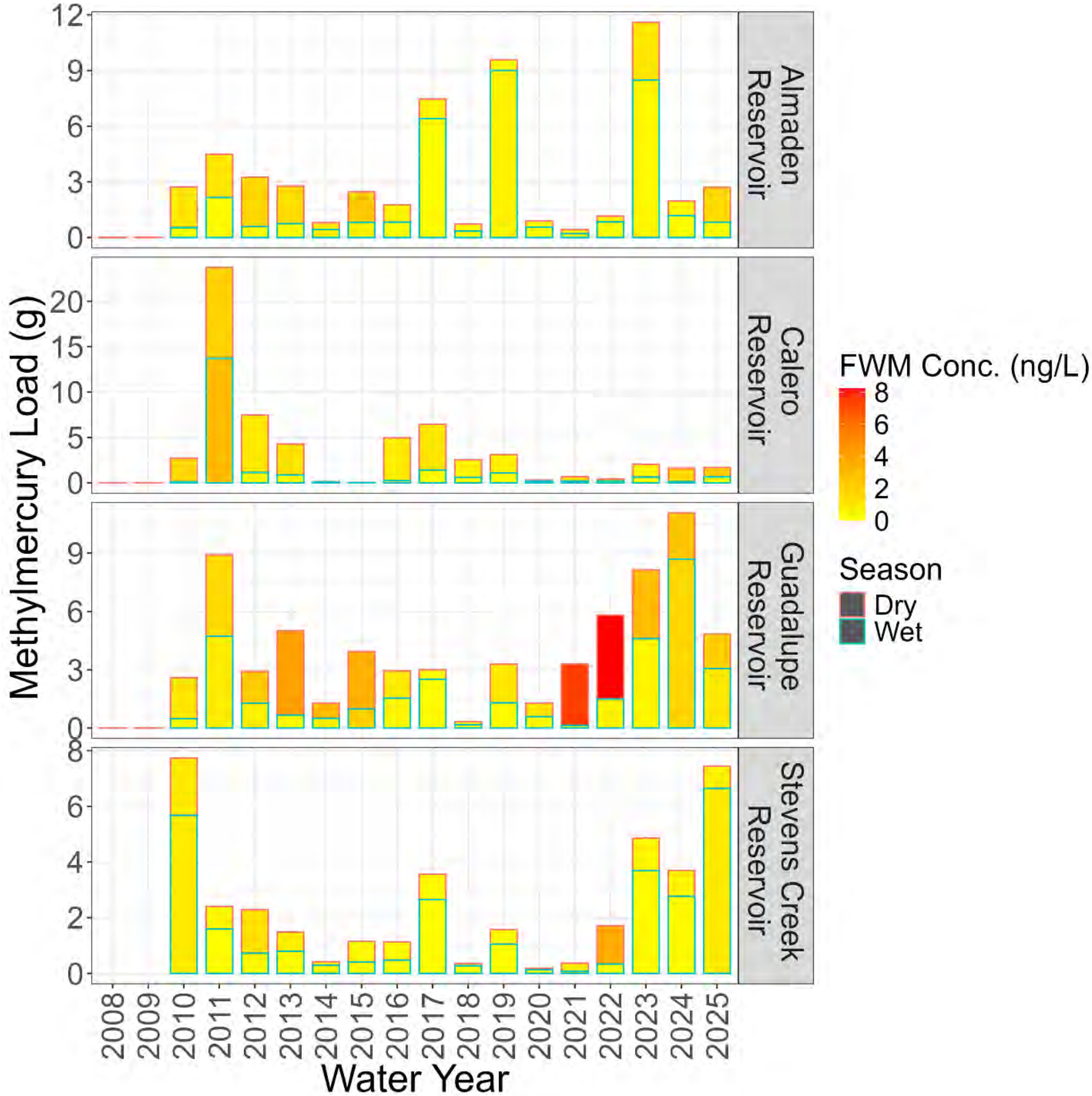

Figure 3-51 Annual MeHg load and flow-weighted mean (FWM) Hg concentration by season.

Table 3-18
Annual total Hg and MeHg loads (g) at Almaden Reservoir.

Water Year	Million Gallons Released	Hg Load (g)	Flow Weighted Mean Hg Conc. (ng/L)	MeHg Load (g)	Flow Weighted Mean MeHg Conc. (ng/L)
2017	10,179.5	371.48	9.64	7.46	0.19
2018	978.61	23.05	6.22	0.72	0.19
2019	5,081.98	1,854.85	96.42	9.58	0.50
2020	1,156.36	19.15	4.37	0.88	0.20
2021	526.15	18.47	9.27	0.43	0.22
2022	1,640.75	26.00	4.19	1.15	0.19
2023	7,082.51	396.42	14.79	11.61	0.43
2024	2561.7	90.58	9.34	1.97	0.20
2025	1690.66	82.82	12.94	2.7	0.42

Table 3-19
Annual total Hg and MeHg loads (g) at Calero Reservoir.

Water Year	Million Gallons Released	Hg Load (g)	Flow Weighted Mean Hg Conc. (ng/L)	MeHg Load (g)	Flow Weighted Mean MeHg Conc. (ng/L)
2017	4,289.18	107.57	6.63	6.45	0.40
2018	2,810.9	60.6	5.7	2.53	0.24
2019	2,431.73	231.31	25.13	3.11	0.34
2020	1,915.77	17.36	2.39	0.28	0.04
2021	1,256.45	10.50	2.21	0.66	0.14
2022	737.4	7.47	2.68	0.43	0.15
2023	2,560.53	46.26	4.77	2.03	0.21
2024	791.57	8.56	2.86	1.64	0.55
2025	681.2	6.91	2.68	1.69	0.66

Table 3-20
Annual total Hg and MeHg loads (g) at Guadalupe Reservoir.

Water Year	Million Gallons Released	Hg Load (g)	Flow Weighted Mean Hg Conc. (ng/L)	MeHg Load (g)	Flow Weighted Mean MeHg Conc. (ng/L)
2017	4,766.66	545.18	30.21	3.00	0.17
2018	672.85	50.68	19.90	0.33	0.13
2019	2,430.17	372.13	40.45	3.29	0.36
2020	567.2	79.34	36.95	1.29	0.60
2021	246.54	22.79	24.42	3.30	3.54
2022	815.79	118.21	38.28	5.81	1.88
2023	3,372.24	301.58	23.62	8.14	0.64
2024	1511.51	141.14	24.67	11.07	1.93
2025	988.51	70.2	18.76	4.83	1.29

Table 3-21
Annual total Hg and MeHg loads (g) at Stevens Creek Reservoir.

Water Year	Million Gallons Released	Hg Load (g)	Flow Weighted Mean Hg Conc. (ng/L)	MeHg Load (g)	Flow Weighted Mean MeHg Conc. (ng/L)
2017	8,724.84	422.88	12.80	3.56	0.11
2018	949.22	32.99	9.18	0.36	0.10
2019	4,802.16	154.86	8.52	1.57	0.09
2020	851.34	7.72	2.40	0.18	0.06
2021	336.70	4.48	3.51	0.37	0.29
2022	548.55	12.57	6.05	1.72	0.83
2023	6891.43	149.34	5.72	4.86	0.19
2024	3991.26	76.71	5.08	3.7	0.24
2025	2158.08	21.93	2.68	7.44	0.91

4. KEY FINDINGS AND RECOMMENDATIONS

Key findings from this study period:

Fish Trends:
During this period, we continue to see a statistically significant downward trend in fish tissue Hg concentrations in Almaden and Gaudalupe Reservoirs. These downward trends have persisted despite the HOSs remaining off in both reservoirs. Previous source-control projects may have contributed to this observed trend, as well as to reduced runoff of Hg-contaminated sediments during drought conditions.

Current fish tissue Hg data are insufficient to establish a true baseline with confidence. Additional focus on REI fish is necessary (see recommendations). We do not have enough pre- or post-REI data from Guadalupe yet, but the limited data we do have show that Hg concentrations were similar for REI fish pre- and post-HOS. It will be interesting to see if this trend continues as we collect more REI fish in the summer season.

Fish assemblage data have remained similar within reservoirs for many years. Although this information was expected to provide useful information on food web dynamics, sufficient data have been collected to answer most questions in that regard.

Mercury and Methylmercury:
Over the 16 years of loads displayed, both total Hg and MeHg loads can vary by more than three orders of magnitude from year to year, at least partly driven by hydrology (Tetra Tech 2023). Drought conditions appear to greatly affect the loading of Hg and MeHg to downstream creeks. Oxygenation systems significantly reduce MeHg loading but are likely to cause net warming, especially under low water conditions such as those encountered during droughts.

Total Hg and MeHg concentrations in the hypolimnion in Guadalupe Reservoir declined from pre-oxygenation levels. This may be due to reduced runoff of Hg-contaminated sediments during recent droughts. This will be important to keep in mind when planning for sorbent application treatments in the reservoir.

Recommendations:

- Modify fish sample sizes: We recommend targeting 30 REI fish (102mm) at Almaden Reservoir, 10 TL3A Category fish, 50-100mm, and 10 TL3B Category fish, 160-350mm, likely bluegill. For other reservoirs, we will target 7 bluegill 150-350mm, 7 Crappie 150-350mm, and 20 REI largemouth bass <102mm. Further details on this modification will be discussed in the Monitoring Plan under separate cover.

- Cease collecting fish assemblage data unless reservoir conditions significantly change, such as for seismic retrofit projects.
- Continue to research alternative oxygenation systems that might be more effective than the current line diffuser systems, such as the Speece cone installed at San Pablo Reservoir and Lake Hodges.
- Continue modeling work to gain insight into the biological oxygen demand at Calero reservoir to inform oxygenation system capacities and deployment details necessary to effectively oxygenate hypolimnetic waters under stratified conditions.
- Continue collaborating with research partners on methylation dynamics in Guadalupe Reservoir and work toward a practical small-scale field trial of sorbent treatment techniques.

5. ADDITIONAL ACTIVITIES UPDATES

After observing only small reductions in Hg concentrations in fish tissue following the operation of line diffuser hypolimnetic oxygenation systems, Valley Water partnered with several university research groups to better understand reservoir Hg biogeochemical processes and loading mechanisms, with the goal of identifying and testing more effective strategies for managing Hg contamination.

5.1 Special Study 1: Evaluation of Sorbents and Application Methods for Mercury Remediation in Mine-Contaminated Surface Water Reservoirs

Recent research suggests that sorbents, including activated carbon, modified clays, and surface-functionalized materials, can effectively remediate Hg in aquatic environments (Ghosh et al., 2011; Gilmour et al., 2013). Sorbent treatment methods, if effective and cost-efficient at the reservoir level, are preferred over oxygenation because they are generally static and avoid mixing or warming the water column. In June 2022, Valley Water partnered with Dr. Marc Beutel and Dr. Peggy O'Day from the University of California, Merced (UCM) Environmental Systems Graduate Group. This collaboration focuses on assessing sorbents and their application techniques for capping or binding Hg in mine-contaminated surface water reservoirs. The primary aim is to identify sorbents that effectively lower MeHg concentrations in the water column. Treatments must also not interfere with the reservoirs' capacity to achieve Basin Plan goals, such as controlling toxic substances like metals and preserving standard parameters. Experiments were completed in August 2025. A scientific paper has been submitted for peer review on the first phase of this project, and a second paper is being prepared for the subsequent phase.

The initial study comprised two tasks. The first task assessed different sorbents for their ability to remediate Hg contamination in reservoirs via Hg sorption experiments. Its aim was to identify one sorbent for additional testing. The second task involved using bench-scale chambers with sediment and water from Guadalupe Reservoir to assess the chosen sorbent under various application methods and conditions.

Task 1:

A review of the available literature on the effectiveness of sorbent media was conducted, which led to the selection of three carbon-based sorbents for laboratory testing. The chosen sorbents included conventional granular activated carbon (GAC), MerSorb (MER), a sulfur-functionalized GAC product specifically designed for Hg remediation, and Sedimite (SED), a clay-based GAC product used in various sediment remediation applications. Several experiments were conducted to evaluate the ability of these sorbents to remove aqueous Hg(II) both in the absence and presence of dissolved organic matter (DOM). Standard sorption tests involved adding approximately 100 ng/L Hg(II) and 10 mg/L dissolved organic carbon (DOC) to synthetic reservoir water. Results showed that all sorbents generally removed more than 85% of Hg(II) compared to the no-sorbent controls, with DOM causing modest reductions in Hg sorption. Similarly, in natural waters collected from Guadalupe Reservoir, both GAC and MER achieved greater than 95% Hg(II) removal under both Hg-enriched and ambient-Hg conditions, relative to the controls. MER had a minimal effect on pH while achieving similar Hg removal. Because of this, and because MER was specifically designed for Hg removal, it was selected for further study in the bench-scale chamber experiments in Task 2.

Task 2:

Using 2-L bench-scale chambers with sediment and water from Guadalupe Reservoir, MerSorb was evaluated under three application approaches. These included sediment application treatment (SAT), suspended bag treatment (SBT), and flow-through treatment (FTT).

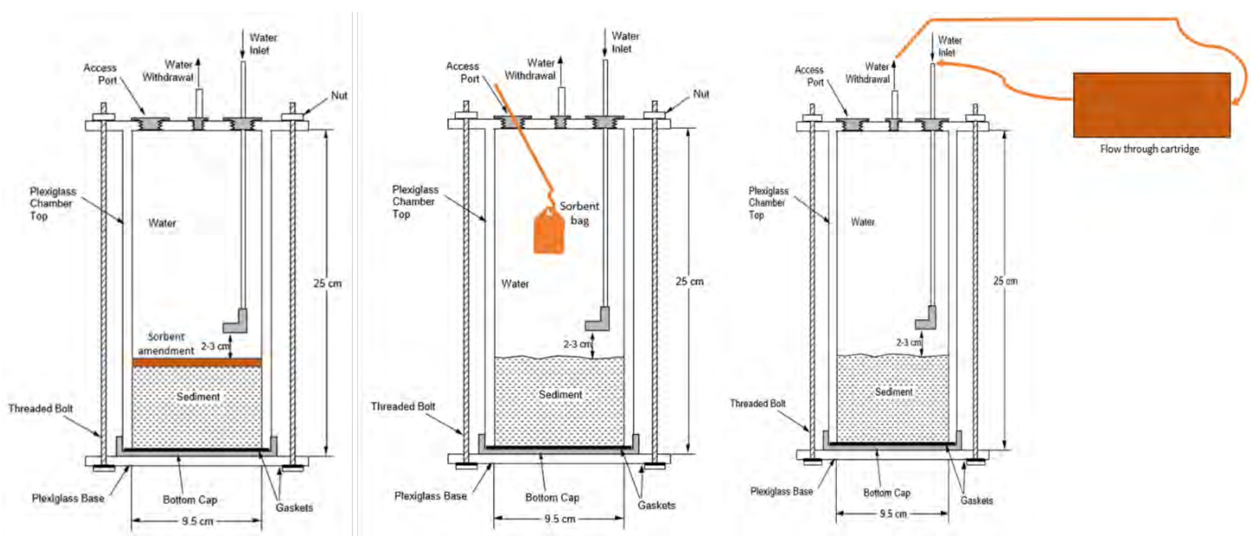

Figure 3-51 Schematic of MerSorb application methods, including sediment application treatment (SAT) (left), suspended bags treatment (SBT) (middle), and flow-through treatment (FTT) (right).

FTT exhibited growth of a robust biofilm on chamber walls and tubing after a few weeks of operation. Under anoxic conditions, this biofilm was composed of biodegradable organic matter that drove anaerobic respiration, ultimately leading to the reduction of sulfate. Reduced conditions led to sulfide build up, precipitation of a black iron-sulfide precipitate, and spikes in chamber water THg and DOC. These results raise questions about the effectiveness of the sorbent under highly reduced conditions, as well as the FTT approach in general.

Follow-Up Experiments:

A follow-up sediment-water chamber incubation study was conducted, building on the initial chamber study but with different objectives. The study evaluated three sorbents: GAC, MerSorb, and a newly acquired sorbent, MercLok, developed by Albemarle Corporation. MercLok is a brominated activated carbon product designed specifically for Hg remediation.
The study was conducted using chamber microcosms containing Hg contaminated profundal sediment and hypolimnetic water from Guadalupe Reservoir in the New Almaden Mining District, California. The chamber microcosms were divided into four treatments: a control (no adsorbent) and three adsorbent treatments, each with three replicates. Sorbents were applied, and chambers were incubated in the dark at 14 °C to simulate profundal conditions for 40 days, including four 10-day phases: oxic, hypoxic, anoxic, and hyperanoxic (strongly reducing). Under oxic conditions, all treatments effectively reduced the average THg in the water. When the conditions became more reducing, MercLok consistently maintained the lowest average THg concentrations across all redox phases, showing strong and stable effectiveness. GAC and Mersorb showed relatively high average THg .
This study aims to evaluate the efficacy of Merclok, an activated-carbon-based sorbent functionalized with bromine, as an in situ remediation to reduce Hg bioavailability and mitigate the risk of MeHg production. A key unknown is the optimal dosage of Merclok required to effectively immobilize Hg within the contaminated sediments. Sediment was collected from the Guadalupe Reservoir and added to a microcosm experiment in triplicate using 250 mL bottles containing 50 g of wet sediment. 0% (Control), 5%, 10%, and 20% by dry weight of Merclok was thoroughly mixed into the sediment and mixed daily. After 5, 8, and 14 days, the porewater was centrifuged at 8000 RPM for 5 minutes and filtered using a 0.45 µm filter. The extractant was analyzed with the Cold Vapor Mercury Analyzer. Results of Hg concentrations as a function of Merclok are pending. The result will help identify an optimal, cost-effective dosage for the remediation of Hg-contaminated sediment, thereby avoiding unnecessary expense due to over-application.

5.2 SPECIAL STUDY 2: INVESTIGATING MERCURY ATMOSPHERIC DEPOSITION USING LICHENS IN THE NEW ALMADEN PORTION OF THE GUADALUPE RIVER WATERSHED

Because limited information is available on Hg re-emissions and the atmospheric contribution of Hg to the New Almaden Mining District (NAMD), Valley Water signed two agreements with the Weiss-Penzias Laboratory at the University of California, Santa Cruz, to locate areas of high Hg deposition affecting reservoirs and streams in the Guadalupe Watershed. Identifying key hotspots that contribute to Hg in the watershed is essential for management and cleanup efforts. This project began in October 2022 and was completed on June 30, 2024.

Using biomonitoring (lichens and mosses) and passive air samplers (PASs) made from various synthetic materials offers a cost-effective and simple alternative to active air quality monitoring. Since they require no power and minimal effort, they are practical for widespread use. These methods have proven effective in pinpointing areas with high atmospheric Hg concentrations (Gačnik et al. 2024).

Total Hg concentrations in lichens were spatially mapped at sites near historic mining areas in the NAMD, with temporal changes in Hg uptake rates quantified through lichen transplants.
Two 9-month transplantation experiments with three lichen species were conducted at three NAMD sites and one background location. The uptake rate constants were significantly positive at all NAMD sites, increasing with the THg concentrations in the in-situ lichens (Hacienda > Mine Hill > Almaden Reservoir). No significant change in THg concentrations was observed during transplants at the background sites or in situ controls, indicating that lichens effectively detect Hg emissions and enable comparisons of contamination concentrations across sites
The results identified some weaknesses in using lichens as bioindicators for Hg pollution in a legacy mining district. To cover a larger area, multiple lichen species need to be sampled, including those with thalli of different ages that have absorbed varying amounts of Hg. This requires collecting enough lichens for homogenization to minimize these differences.
Despite these limitations, the study results demonstrated that THg concentrations in lichen surveys are useful across different contamination levels, indicating that Hg deposited on lichens is probably stored for many years before entering the soil as litterfall.

Weiss-Penzias P, Straw B, Rothman M, Zheng B, Seelos M, Rivas Meraz E, and O’Day PA (2025). Atmospheric mercury uptake to foliage using in situ and transplanted lichens at the New Almaden Mining District, California, United States. Front. Environ. Chem. 6:1568188. doi: 10.3389/fenvc.2025.1568188

5.3 SPECIAL STUDY 3: ASSESSMENT OF METHYLMERCURY SOURCES AND FORMATION PATHWAYS IN GUADALUPE RESERVOIR

In June 2023, Valley Water entered into an agreement with the Poulin Lab at the University of California at Davis to assess MeHg sources and formation pathways in Guadalupe Reservoir. The project was originally scheduled for completion by July 2025, but was extended to December 31, 2025. It was subsequently amended in December 2025 to include additional research and will now extend through 2027.

From August 2023 to July 2025, monthly monitoring was conducted at Guadalupe Reservoir to add to a dataset of Hg and related biogeochemical constituents, including filtered and particulate Hg, MeHg, dissolved organic matter, major anions, cations, sulfide, and total suspended solids.

To identify dominant zones of MeHg production, in situ methylation assays were performed in the sediments and water column across the stratification cycle of the reservoir, with treatments applied to isolate microbial pathways (e.g., sulfate reduction or methanogenesis). Complementary DNA sampling and metagenomic sequencing were conducted to target microbial communities involved and assess linkages to Hg methylation rates. Overall, the results aim to provide critical insights to support reservoir management and remediation actions. This information will then be integrated into the larger-scale project development of applied sorbent remediation efforts to the reservoir, coordinated with the Santa Clara Valley Water District and collaborating scientists at UC Merced.

Project Goals

Establish relationships between the biogeochemistry of reservoir waters and Hg(II) methylation through monthly sampling. This sub-objective will add critical measurements to ongoing monitoring efforts by Sponsor, including filtered versus particulate total Hg and MeHg, DOC concentration and composition, and distribution of terminal electron acceptors and byproducts of anaerobic microbial processes.

Quantify the diffusive flux of MeHg and other important biogeochemical constituents from sediments to the water column across the seasonal stratification cycle. This sub-objective focuses on the dynamics of diffusion between the sediment and the water column through careful profile collection, spanning from surface waters to the sediments. It involves collecting undisturbed sediment cores from various locations in the reservoir concurrently with water column profiles.

Conduct field incubations in the water column and sediments across the seasonal stratification cycle to quantify rates of Hg(II) methylation. This sub-objective focuses on the experimental quantification of Hg(II) methylation rates of water and sediments. These incubations will be performed by the University for 3-4 days across the pre-stratified, stratified, and post-stratified periods of Guadalupe Reservoir.

Update and timeline

During the recently concluded 2-year agreement, monthly ambient sampling and four intensives, which included experiments with the water column and sediments, were completed, paired with DNA filter collection.

1. Ambient Data: Ambient measurements (filtered, particulate HgT, MeHg, DOC, anions, sulfide, Fe/Mn) are mostly completed, aside from particulate MeHg on filters, which we are completing now. We expect to be able to provide the data and a report on the seasonal trends across the 24 collections, including filtered vs. particulate evaluation, and general biogeochemical processes involved. This is the deliverable to which we are committed under the existing agreement.

Timeline: February 28, 2026:

2. Water column incubations: The water column incubations total 375 discrete experimental samples for total Hg and MeHg analysis (by isotope dilution) and were conducted with and without microbial inhibitors for sulfate reduction and methanogenesis. The goals are to quantify the rates of MeHg formation in the reservoir water column over the stratification cycle and evaluate the role of sulfate-reducing bacteria and/or methanogens in the process (i.e., does the addition of an inhibitor shut down MeHg formation?). The conclusively of our interpretations will leverage the experimental results and results of DNA sequencing. These experiments were conducted in the middle of the reservoir and near the cinnabar shelf, with the goal of determining whether MeHg is formed in one location more than in another.
Timeline: Complete analyses by June 30, 2026.
ii. Interpretations in the context of microbial DNA results by June 30, 2027.

Additional research will now extend through 2027:

3. Sediment incubations: the sediment incubations total 100 discrete samples for total Hg and MeHg analysis (by isotope dilution). The goal is to quantify the rate of MeHg formation in the reservoir sediments.
a. Timeline:
i. Complete analyses by June 30, 2026.
ii. Interpretations by June 30, 2027.
4. Microbial DNA Sequencing and Analysis: the goal is to perform shotgun metagenomic sequencing on the filters from the 4 intensives. The data will be processed with two
separate goals, (1) identify when microbes have the hgcAB gene pair in the water column and what their metabolic capabilities are, and (2) abundance and trends in the genes for methanogenesis.
a. Timeline:
i. Complete sequencing by June 30, 2026
ii. Compete metagenome assembly for hgcAB by June 30, 2027
iii. Complete metagenome evaluation for methanogenesis genes Timeline: Jan 1, 2027.

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APPENDIX A WATER QUALITY DATA

Table A-1
Statistical summary of water quality data comparing dry season (May-Sept) data from pre-HOS years to when HOS was operational. Numerical value is estimated mean difference between the two conditions; orange shading indicates statistical significance at a 0.05 level.

Parameter	Depth Type	ALMADEN LAKE	ALMADEN RESERVOIR	CALERO RESERVOIR	GUADALUPE RESERVOIR	STEVENS CREEK RESERVOIR
Ammonia as N	EPI	-0.38	-0.01	-0.04	-0.01	0.00
Ammonia as N	HYP	-1.45	-0.05	-0.10	-0.26	-0.06
Chlorophyll	EPI	13.00	0.26	2.95	-0.34	0.21
Chlorophyll	EPIM	2.21	0.14	5.41	2.86	1.20
Chlorophyll	MID	5.64	0.41	2.97	-0.22	0.01
Chlorophyll	MIDH		0.08	1.18	-0.76	-0.40
Chlorophyll	HYP	1.44	0.56	0.92	-0.19	-0.13
Chlorophyll A	EPI	-0.01	0.00	0.03	0.00	0.00
Iron	EPI		0.00	-0.23	0.00	0.08
Iron	HYP		0.24	-0.49	-0.44	-2.73
Manganese	EPI		-0.01	0.00	0.00	-0.01
Manganese	HYP		-0.03	-0.32	-0.27	-0.23
Mercury	EPI	-16.42	-13.17	-23.85	-4.70	-7.46
Mercury	HYP	3.01	-1.65	-3.05	-4.12	-2.04
Methylmercury	EPI	-0.16	-0.05	-0.01	-0.05	0.00
Methylmercury	EPIM		0.04	0.10	0.79	0.00
Methylmercury	MID	-5.79	-0.23	-0.48	-0.25	-0.09
Methylmercury	MIDH		-0.40	-0.50	-0.81	-0.52
Methylmercury	HYP	-16.49	-1.11	-1.09	-7.97	-0.92
Methylmercury (Dissolved)	EPI	0.05	0.05	0.03	0.05	0.00
Methylmercury (Dissolved)	HYP	30.48	-0.58	0.12	-5.02	0.04
Nitrate as NO3	EPI	0.07	-0.68	-0.59	-0.51	-0.57
Nitrate as NO3	HYP	0.57	-0.53	1.01	0.41	0.92
Nitrite as NO2	EPI	1.30	0.00	-0.27	0.00	-0.41
Nitrite as NO2	HYP	1.37	0.00	-0.28	0.00	-0.61
Oxidation Reduction	EPI	-89.25	-63.32	-62.57	-41.77	-131.57
Oxidation Reduction	EPIM	-61.71	-75.61	-82.84	-81.24	-127.48
Oxidation Reduction	MID	-82.99	-69.95	-58.16	-59.76	-94.84
Oxidation Reduction	MIDH		-7.66	-1.83	-10.26	-5.60

Oxidation Reduction	HYP	-94.30	-26.99	-32.13	45.24	9.83
Oxygen Concentration	EPI	2.31	0.75	1.16	0.80	2.58
Oxygen Concentration	EPIM	1.10	2.34	2.59	2.35	2.39
Oxygen Concentration	MID	0.45	3.90	1.45	4.37	2.78
Oxygen Concentration	MIDH		5.96	1.35	7.03	5.76
Oxygen Concentration	HYP	-0.01	7.65	0.92	8.72	7.16
Oxygen Saturation	EPI	26.63	15.76	14.46	12.59	33.36
Oxygen Saturation	EPIM	12.18	32.45	33.12	33.56	30.60
Oxygen Saturation	MID	4.90	47.15	16.91	54.46	31.77
Oxygen Saturation	MIDH		68.71	15.18	78.76	61.88
Oxygen Saturation	HYP	-0.16	86.51	10.46	94.45	76.61
Phycocyanin (Cells)	EPI	1034.41	142.34	1129.05	51.68	10.20
Phycocyanin (Cells)	EPIM	-489.94	340.59	1864.16	267.67	254.87
Phycocyanin (Cells)	MID	1047.23	463.35	1113.96	46.03	49.05
Phycocyanin (Cells)	MIDH		270.82	675.06	30.60	-40.59
Phycocyanin (Cells)	HYP	377.46	259.24	690.08	113.39	-94.53
Phycocyanin (Volts)	EPI		0.00	0.01	0.00	0.00
Phycocyanin (Volts)	EPIM		0.00	0.01	0.00	0.00
Phycocyanin (Volts)	MID		0.00	0.00	0.00	0.00
Phycocyanin (Volts)	MIDH		0.00	0.00	0.00	0.00
Phycocyanin (Volts)	HYP		0.00	0.00	-0.01	0.00
Specific Conductivity	EPI	34.27	8.54	82.47	-12.45	28.28
Specific Conductivity	EPIM	65.52	1.50	75.03	5.29	22.27
Specific Conductivity	MID	22.84	6.24	73.43	18.95	33.76
Specific Conductivity	MIDH		4.38	56.20	19.41	9.49
Specific Conductivity	HYP	11.01	5.63	85.10	-13.39	55.00

Sulfate	EPI	1.82	0.48	5.29	0.16	0.68
Sulfate	HYP	9.12	1.15	6.56	3.23	3.37
Total Suspended Solids	HYP				-3.51	
Water Temperature	EPI	0.59	0.88	0.58	1.59	2.68
Water Temperature	EPIM	0.82	2.18	2.37	4.06	2.45
Water Temperature	MID	0.98	1.15	1.95	4.84	2.51
Water Temperature	MIDH		1.19	2.03	4.44	1.56
Water Temperature	HYP	1.72	1.34	2.26	4.97	2.45
pH	EPI	0.26	-0.48	-0.19	-0.27	-0.14
pH	EPIM	0.79	-0.26	0.39	0.03	-0.09
pH	MID	0.17	-0.35	0.04	0.01	-0.18
pH	MIDH		-0.43	-0.17	0.00	-0.33
pH	HYP	0.33	-0.41	-0.12	-0.07	-0.34

Table A-2

Statistical summary of water quality data comparing dry season (May-Sept) data from years before the HOS was turned on pre-HOS years to when HOS was operational. Numerical value is estimated mean difference between the two conditions; orange shading indicates statistical significance at a 0.05 level.

Site	Parameter	Depth	Time	Mean	Med	SD	n	pvalue	category
Almaden	Chlorophyll	EPI	Pre	3.09	2.20	2.90	32	0.01	$p < 0.05$
Almaden	Chlorophyll	EPI	Post	6.45	5.93	2.97	9	0.01	$p < 0.05$
Almaden	Water Temperature	EPI	Post	23.10	23.15	2.16	11	0.20	NS
Almaden	Water Temperature	EPI	Pre	22.08	22.31	2.29	32	0.20	NS
Almaden	Water Temperature	HYP	Pre	17.67	17.88	3.44	31	0.83	NS
Almaden	Water Temperature	HYP	Post	17.92	17.31	3.30	11	0.83	NS
Almaden	Oxygen Saturation	EPI	Post	98.48	104.0	14.47	9	0.63	NS
Almaden	Oxygen Saturation	EPI	Pre	95.59	99.50	18.24	28	0.63	NS
Almaden	Oxygen Saturation	HYP	Pre	28.85	27.60	26.54	31	0.51	NS
Almaden	Oxygen Saturation	HYP	Post	23.46	25.90	21.46	11	0.51	NS
Almaden	Oxidation Reduction	EPI	Post	234.9	234.0	54.55	11	0.02	$p < 0.05$
Almaden	Oxidation Reduction	EPI	Pre	284.6	287.0	47.88	31	0.02	$p < 0.05$
Almaden	Oxidation Reduction	HYP	Pre	243.9	296.0	122.4	29	0.04	$p < 0.05$
Almaden	Oxidation Reduction	HYP	Post	88.36	142.0	215.9	11	0.04	$p < 0.05$
Almaden	Sulfate	EPI	Post	14.45	14.00	1.69	11	0.43	NS
Almaden	Sulfate	EPI	Pre	14.91	15.00	1.23	32	0.43	NS
Almaden	Sulfate	HYP	Post	13.73	14.00	2.28	11	0.78	NS
Almaden	Sulfate	HYP	Pre	13.94	14.00	1.29	32	0.78	NS
Almaden	Methylmercury	EPI	Pre	0.55	0.51	0.30	32	0.80	NS
Almaden	Methylmercury	EPI	Post	0.58	0.56	0.35	10	0.80	NS
Almaden	Methylmercury	HYP	Post	1.13	0.55	1.17	10	0.76	NS
Almaden	Methylmercury	HYP	Pre	1.28	0.41	1.62	32	0.76	NS
Almaden	Mercury	EPI	Pre	3.12	2.97	1.00	31	0.91	NS
Almaden	Mercury	EPI	Post	3.07	2.80	1.21	11	0.91	NS
Almaden	Mercury	HYP	Post	4.49	3.40	2.38	11	0.02	$p < 0.05$
Almaden	Mercury	HYP	Pre	6.86	5.91	3.83	31	0.02	$p < 0.05$
Almaden	Ammonia as N	EPI	Pre	0.11	0.10	0.02	26	0.00	$p < 0.001$
Almaden	Ammonia as N	EPI	Post	0.07	0.08	0.02	11	0.00	$p < 0.001$
Almaden	Ammonia as N	HYP	Post	0.12	0.10	0.07	11	0.09	NS
Almaden	Ammonia as N	HYP	Pre	0.17	0.15	0.08	30	0.09	NS
Calero	Chlorophyll	EPI	Pre	7.58	5.70	4.55	35	0.00	$p < 0.001$

Calero	Chlorophyll	EPI	Post	2.16	1.94	0.90	5	0.00	p < 0.001
Calero	Water Temperature	EPI	Post	22.96	23.87	1.88	5	0.12	NS
Calero	Water Temperature	EPI	Pre	21.27	21.69	2.06	35	0.12	NS
Calero	Water Temperature	HYP	Pre	16.40	15.68	2.45	30	0.00	p < 0.001
Calero	Water Temperature	HYP	Post	13.36	13.30	0.47	5	0.00	p < 0.001
Calero	Oxygen Saturation	EPI	Post	91.80	93.70	3.47	3	0.01	p < 0.01
Calero	Oxygen Saturation	EPI	Pre	33.60	29.75	35.06	6	0.01	p < 0.01
Calero	Oxygen Saturation	HYP	Pre	6.91	0.80	10.62	27	0.02	p < 0.05
Calero	Oxygen Saturation	HYP	Post	1.82	1.80	0.04	5	0.02	p < 0.05
Calero	Oxidation Reduction	EPI	Post	119.0	124.0	23.09	5	0.00	p < 0.001
Calero	Oxidation Reduction	EPI	Pre	304.5	324.0	83.68	35	0.00	p < 0.001
Calero	Oxidation Reduction	HYP	Post	-298.0	-386.0	237.5	5	0.00	p < 0.01
Calero	Oxidation Reduction	HYP	Pre	257.9	310.0	150.9	25	0.00	p < 0.01
Calero	Sulfate	EPI	Pre	29.77	30.00	6.97	35	0.64	NS
Calero	Sulfate	EPI	Post	30.40	31.00	1.34	5	0.64	NS
Calero	Sulfate	HYP	Post	20.00	20.00	5.52	5	0.07	NS
Calero	Sulfate	HYP	Pre	26.06	30.00	8.41	35	0.07	NS
Calero	Methylmercury	EPI	Pre	0.11	0.11	0.05	35	0.01	p < 0.01
Calero	Methylmercury	EPI	Post	0.07	0.08	0.02	5	0.01	p < 0.01
Calero	Methylmercury	HYP	Post	2.38	2.51	1.58	5	0.32	NS
Calero	Methylmercury	HYP	Pre	1.53	0.46	1.95	35	0.32	NS
Calero	Mercury	EPI	Pre	1.72	1.50	0.64	34	0.00	p < 0.001
Calero	Mercury	EPI	Post	0.84	0.84	0.16	5	0.00	p < 0.001
Calero	Mercury	HYP	Post	4.49	5.20	1.54	5	0.92	NS
Calero	Mercury	HYP	Pre	4.58	3.85	2.76	34	0.92	NS
Calero	Ammonia as N	EPI	Pre	0.16	0.10	0.10	33	0.00	p < 0.001
Calero	Ammonia as N	EPI	Post	0.08	0.08	0.00	5	0.00	p < 0.001
Calero	Ammonia as N	HYP	Post	0.50	0.41	0.31	3	0.29	NS
Calero	Ammonia as N	HYP	Pre	0.25	0.18	0.19	35	0.29	NS
Guadalupe	Chlorophyll	EPI	Pre	2.46	2.19	1.04	31	0.16	NS
Guadalupe	Chlorophyll	EPI	Post	3.00	2.77	1.75	30	0.16	NS
Guadalupe	Water Temperature	EPI	Post	22.49	23.01	3.02	32	0.40	NS
Guadalupe	Water Temperature	EPI	Pre	21.89	22.09	2.51	31	0.40	NS
Guadalupe	Water Temperature	HYP	Pre	11.97	11.68	1.40	29	0.03	p < 0.05

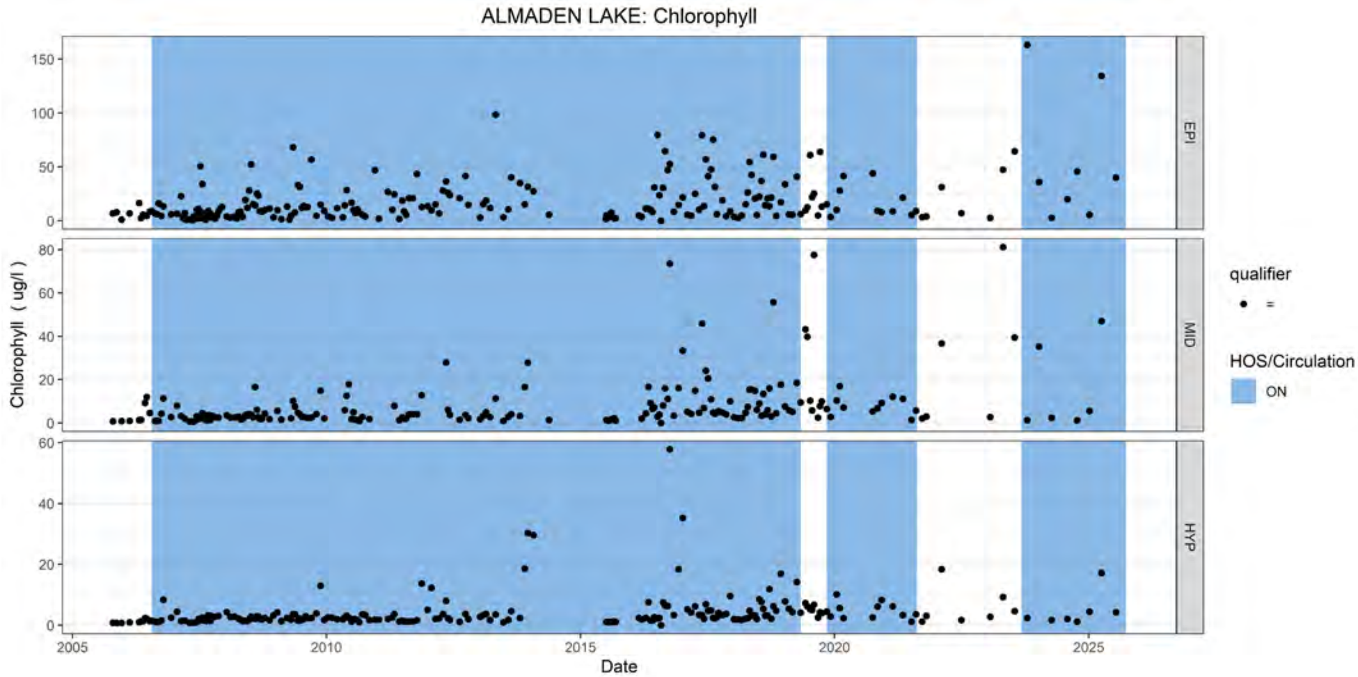
Guadalupe	Water Temperature	HYP	Post	12.71	12.59	1.01	25	0.03	$p < 0.05$
Guadalupe	Oxygen Saturation	EPI	Post	86.22	90.40	23.95	32	0.31	NS
Guadalupe	Oxygen Saturation	EPI	Pre	92.64	99.55	25.15	30	0.31	NS
Guadalupe	Oxygen Saturation	HYP	Post	5.57	4.90	4.27	24	0.01	$p < 0.01$
Guadalupe	Oxygen Saturation	HYP	Pre	2.27	1.20	3.67	27	0.01	$p < 0.01$
Guadalupe	Oxidation Reduction	EPI	Pre	327.7	325.0	59.16	31	0.00	$p < 0.001$
Guadalupe	Oxidation Reduction	EPI	Post	228.1	249.0	99.11	32	0.00	$p < 0.001$
Guadalupe	Oxidation Reduction	HYP	Post	68.36	24.00	208.9	28	0.01	$p < 0.05$
Guadalupe	Oxidation Reduction	HYP	Pre	190.0	183.0	136.8	27	0.01	$p < 0.05$
Guadalupe	Sulfate	EPI	Pre	15.89	16.00	3.56	31	0.00	$p < 0.01$
Guadalupe	Sulfate	EPI	Post	19.28	19.00	4.57	29	0.00	$p < 0.01$
Guadalupe	Sulfate	HYP	Post	12.43	12.00	4.18	29	0.10	NS
Guadalupe	Sulfate	HYP	Pre	10.54	11.00	4.62	31	0.10	NS
Guadalupe	Methylmercury	EPI	Pre	0.32	0.28	0.14	31	0.00	$p < 0.01$
Guadalupe	Methylmercury	EPI	Post	0.49	0.44	0.26	29	0.00	$p < 0.01$
Guadalupe	Methylmercury	HYP	Post	5.35	3.70	4.95	29	0.00	$p < 0.01$
Guadalupe	Methylmercury	HYP	Pre	9.79	9.62	6.68	31	0.00	$p < 0.01$
Guadalupe	Mercury	EPI	Pre	10.13	9.68	3.50	30	0.00	$p < 0.001$
Guadalupe	Mercury	EPI	Post	6.85	7.20	2.52	29	0.00	$p < 0.001$
Guadalupe	Mercury	HYP	Post	25.96	26.50	9.14	29	0.00	$p < 0.001$
Guadalupe	Mercury	HYP	Pre	39.80	42.00	17.48	29	0.00	$p < 0.001$
Guadalupe	Ammonia as N	EPI	Pre	0.13	0.11	0.06	30	0.01	$p < 0.01$
Guadalupe	Ammonia as N	EPI	Post	0.10	0.10	0.05	29	0.01	$p < 0.01$
Guadalupe	Ammonia as N	HYP	Post	0.34	0.28	0.34	29	0.17	NS
Guadalupe	Ammonia as N	HYP	Pre	0.47	0.40	0.38	29	0.17	NS
Stevens Creek	Chlorophyll	EPI	Pre	2.19	1.87	1.20	31	0.01	$p < 0.01$
Stevens Creek	Chlorophyll	EPI	Post	3.65	2.69	2.29	24	0.01	$p < 0.01$
Stevens Creek	Water Temperature	EPI	Post	22.76	22.89	2.62	26	0.09	NS
Stevens Creek	Water Temperature	EPI	Pre	21.31	22.31	3.60	31	0.09	NS
Stevens Creek	Water Temperature	HYP	Post	16.09	15.33	2.84	24	0.22	NS
Stevens Creek	Water Temperature	HYP	Pre	14.97	13.94	3.47	26	0.22	NS
Stevens Creek	Oxygen Saturation	EPI	Pre	90.62	99.00	24.55	31	0.98	NS
Stevens Creek	Oxygen Saturation	EPI	Post	90.44	95.10	22.83	25	0.98	NS
Stevens Creek	Oxygen Saturation	HYP	Post	4.25	2.70	4.84	20	0.46	NS

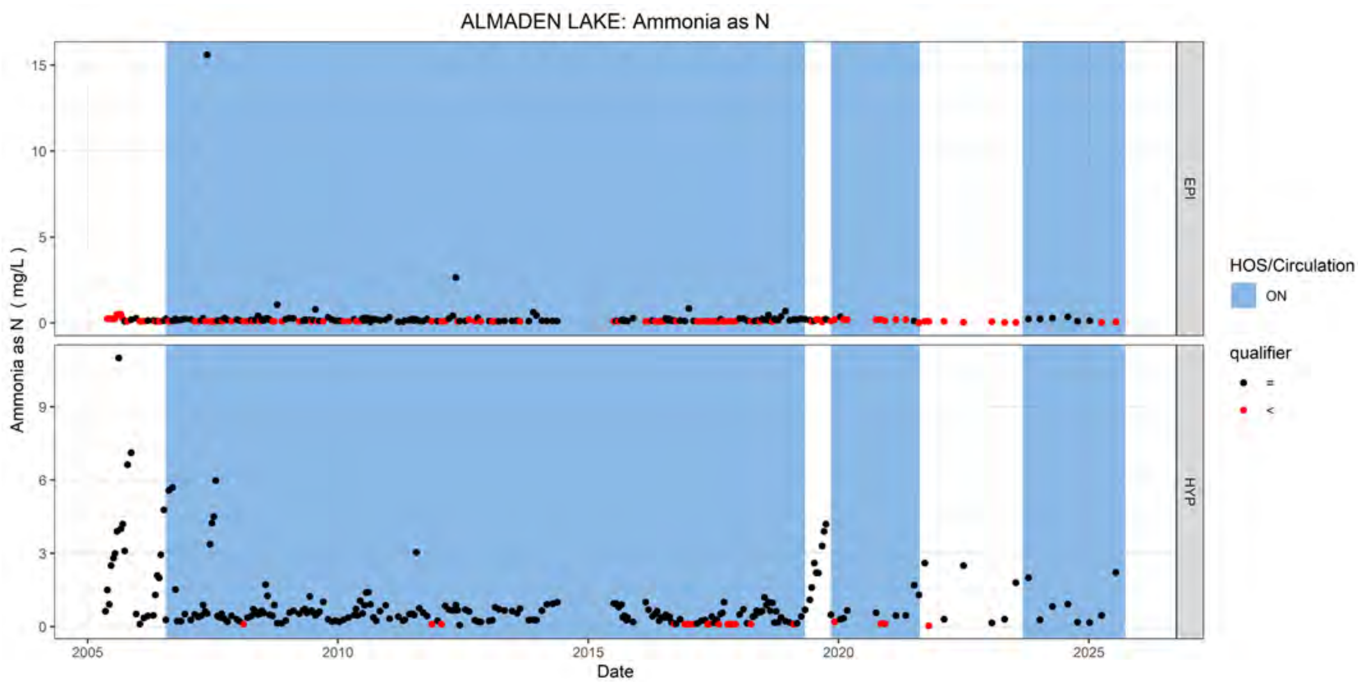
Stevens Creek	Oxygen Saturation	HYP	Pre	3.01	0.75	5.96	22	0.46	NS
Stevens Creek	Oxidation Reduction	EPI	Pre	312.3	311.0	77.81	31	0.00	p < 0.001
Stevens Creek	Oxidation Reduction	EPI	Post	195.6 7	219.5 0	115.9 4	26	0.00	p < 0.001
Stevens Creek	Oxidation Reduction	HYP	Post	-21.03	-2.60	195.4	24	0.00	p < 0.001
Stevens Creek	Oxidation Reduction	HYP	Pre	191.7	205.0	151.5	24	0.00	p < 0.001
Stevens Creek	Sulfate	EPI	Post	49.60	42.00	12.24	25	NA	NA
Stevens Creek	Sulfate	HYP	Post	43.64	39.00	13.89	25	NA	NA
Stevens Creek	Methylmercury	EPI	Pre	0.06	0.05	0.03	25	0.00	p < 0.001
Stevens Creek	Methylmercury	EPI	Post	0.14	0.12	0.07	21	0.00	p < 0.001
Stevens Creek	Methylmercury	HYP	Pre	0.96	0.71	0.89	26	0.07	NS
Stevens Creek	Methylmercury	HYP	Post	1.59	0.80	1.40	24	0.07	NS
Stevens Creek	Mercury	EPI	Pre	1.03	0.84	0.51	23	0.78	NS
Stevens Creek	Mercury	EPI	Post	1.08	0.77	0.70	23	0.78	NS
Stevens Creek	Mercury	HYP	Pre	4.44	3.63	2.26	24	0.72	NS
Stevens Creek	Mercury	HYP	Post	4.19	3.80	2.35	23	0.72	NS
Stevens Creek	Ammonia as N	EPI	Post	0.10	0.09	0.06	24	NA	NA
Stevens Creek	Ammonia as N	HYP	Post	0.27	0.25	0.19	25	NA	NA

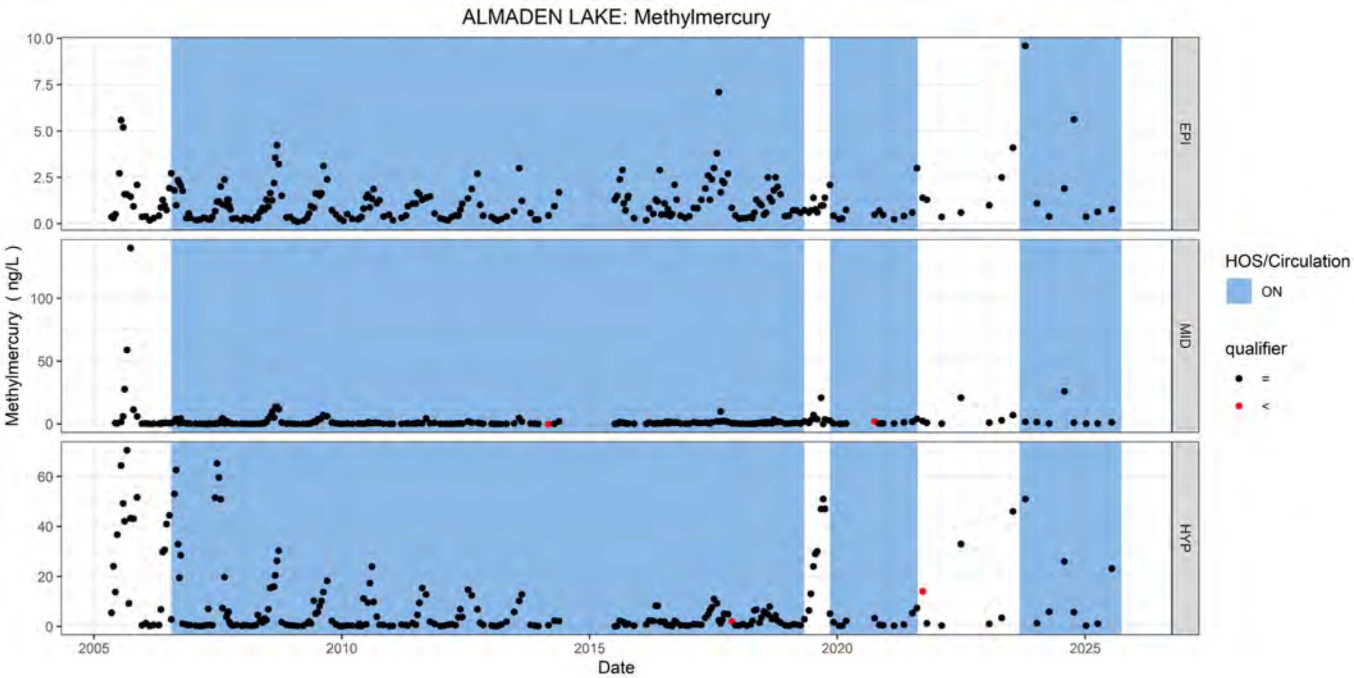
Table A-3
Summary Statistics of Fish Hg Models

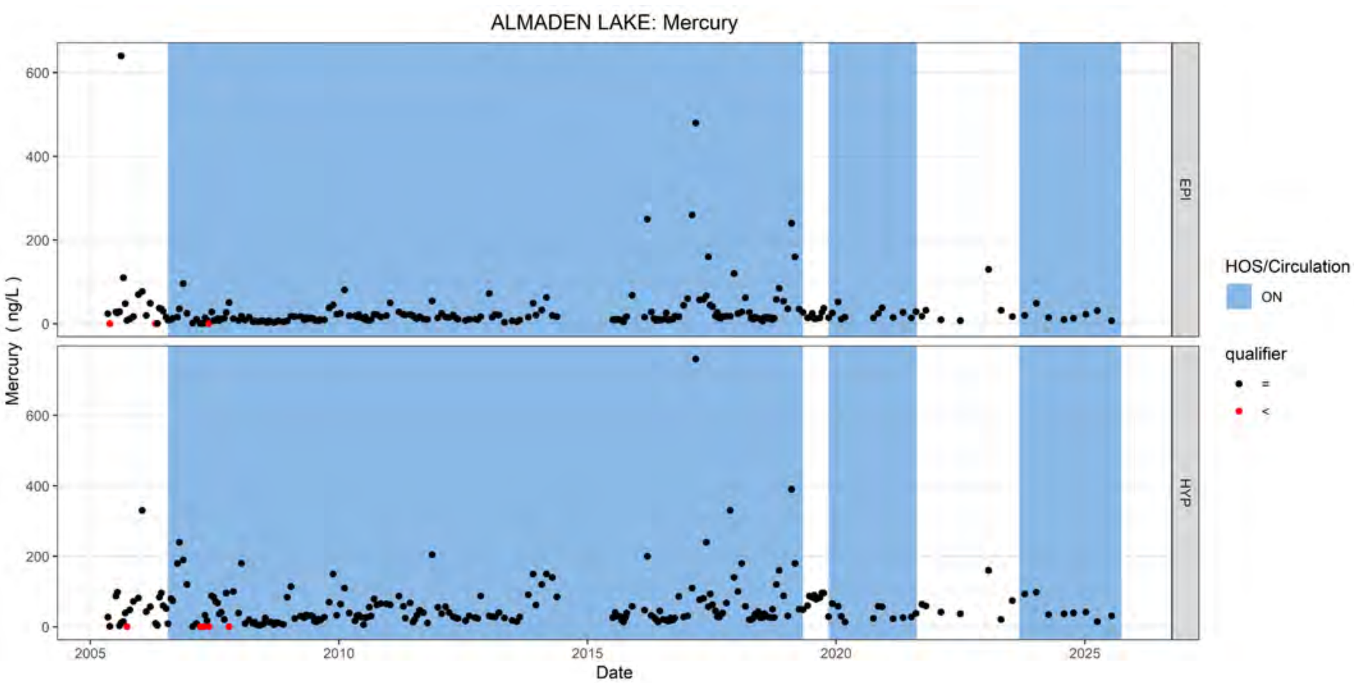
gisname	term	estimate	std.error	statistic	p.value	signif
	(Intercept)	1.442574	0.207813	6.941706	1.17E-11	***
	commonnameBluegill	0.153533	0.115576	1.328419	0.184629	NA
	commonnameLargemouth bass	0.093813	0.109058	0.860215	0.390071	NA
ALMADEN RESERVOIR	fishlength_mm	0.002167	0.000704	3.079539	0.002184	**
	sampledate	-6.91E-05	9.79E-06	-7.06208	5.35E-12	***
	seasonWet Season	0.04546	0.031726	1.432915	0.15249	NA
	commonnameBluegill:fishlength_mm	-0.00081	0.00092	-0.87738	0.380689	NA
	commonnameLargemouth bass:fishlength_mm	0.002729	0.000816	3.343273	0.000888	***
	(Intercept)	0.002068	0.025186	0.08209	0.934593	NA
	commonnameBluegill	0.041548	0.013825	3.005316	0.002727	**
	commonnameLargemouth bass	0.041428	0.012379	3.346688	0.000852	***
CALERO RESERVOIR	fishlength_mm	0.000615	5.93E-05	10.3731	6.87E-24	***
	sampledate	5.01E-07	1.31E-06	0.382851	0.70192	NA
	seasonWet Season	0.026526	0.004331	6.124398	1.36E-09	***
	commonnameBluegill:fishlength_mm	-0.00032	0.0001	-3.20802	0.001384	**
	commonnameLargemouth bass:fishlength_mm	0.000298	9.83E-05	3.028362	0.002529	**
	(Intercept)	1.226037	0.242455	5.056752	5.43E-07	***
	commonnameBluegill	0.110724	0.121251	0.913187	0.361453	NA
	commonnameLargemouth bass	0.11593	0.110499	1.049154	0.294463	NA
GUADALUPE RESERVOIR	fishlength_mm	0.005188	0.000559	9.288538	1.86E-19	***
	sampledate	-5.13E-05	1.16E-05	-4.42817	1.10E-05	***
	seasonWet Season	0.101471	0.032186	3.152625	0.001686	**
	commonnameBluegill:fishlength_mm	-0.00121	0.000883	-1.37086	0.17085	NA
	commonnameLargemouth bass:fishlength_mm	0.001216	0.0008	1.52037	0.128861	NA
	(Intercept)	0.058656	0.045587	1.286679	0.198657	NA
	commonnameBluegill	-0.01426	0.032376	-0.44051	0.659715	NA
	commonnameLargemouth bass	0.051814	0.031848	1.626921	0.104231	NA
STEVENS CREEK RESERVOIR	fishlength_mm	0.001184	0.000179	6.600117	8.44E-11	***
	sampledate	-2.92E-06	2.18E-06	-1.33991	0.180735	NA
	seasonWet Season	0.046694	0.006243	7.479266	2.39E-13	***
	commonnameBluegill:fishlength_mm	0.000178	0.000213	0.837565	0.402578	NA
	commonnameLargemouth bass:fishlength_mm	-0.00018	0.00021	-0.86818	0.385614	NA

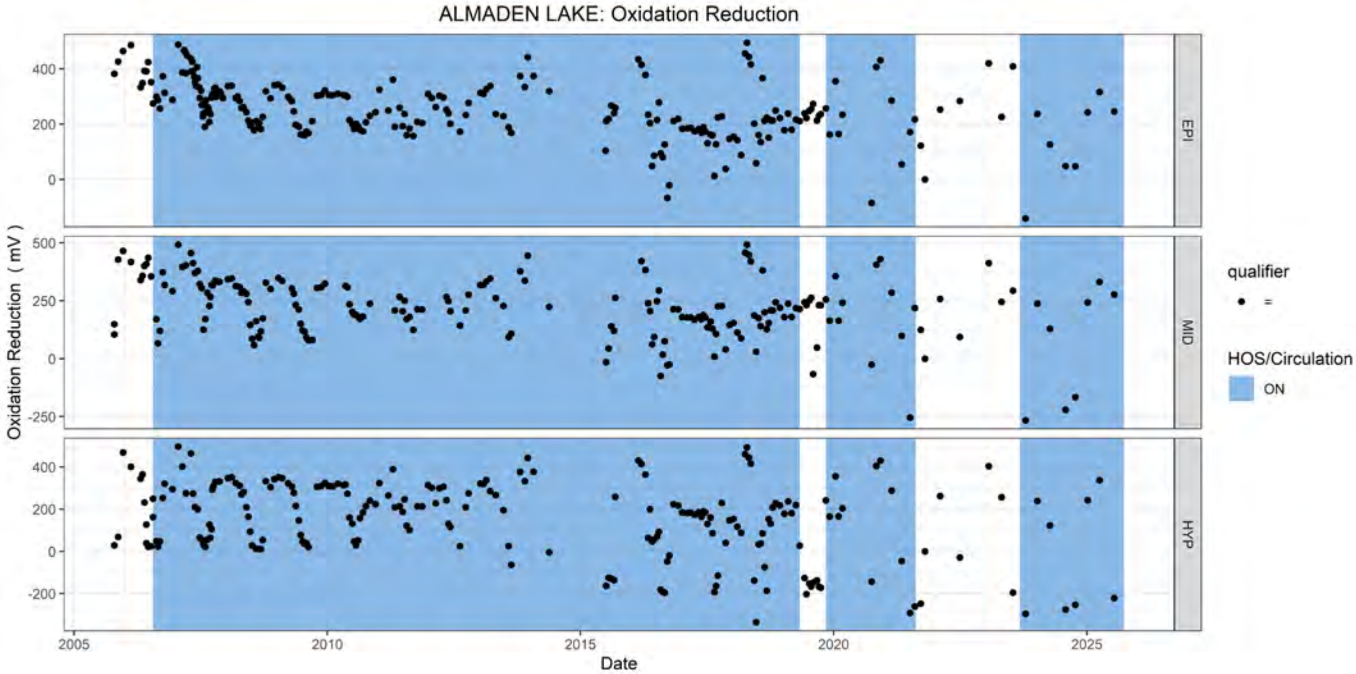
APPENDIX B TIME SERIES FIGURES

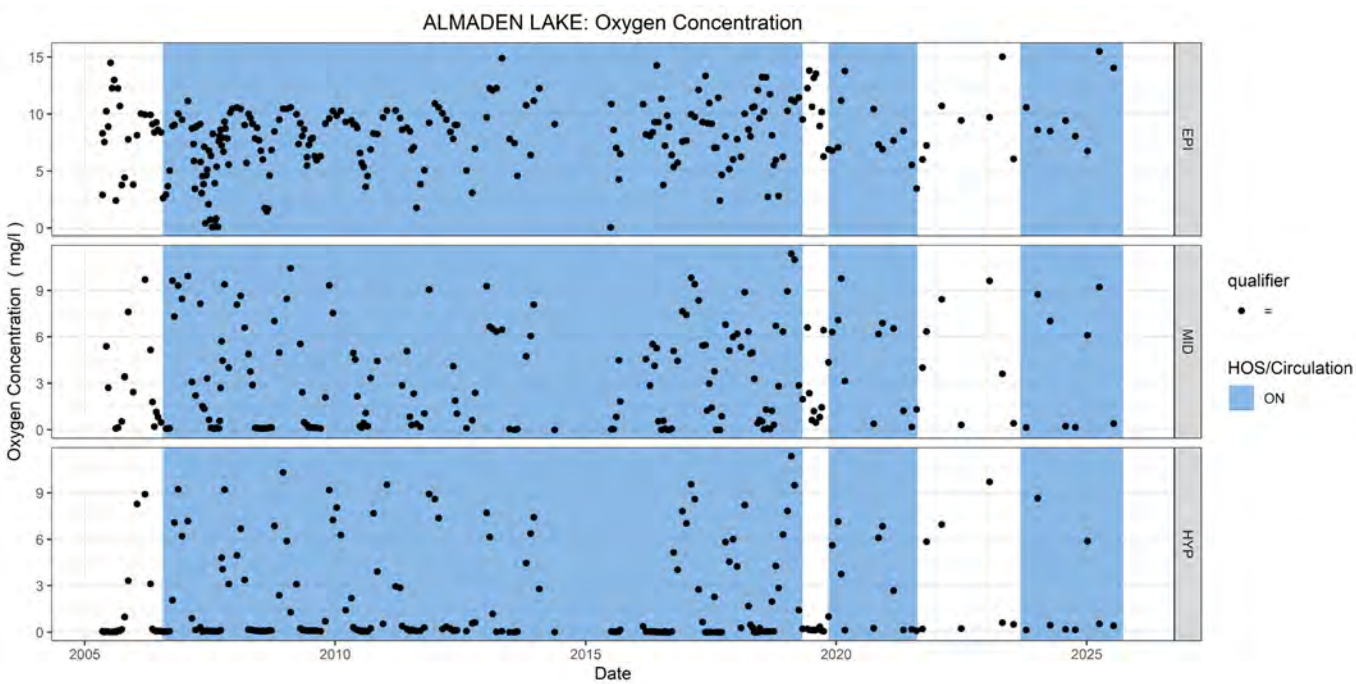


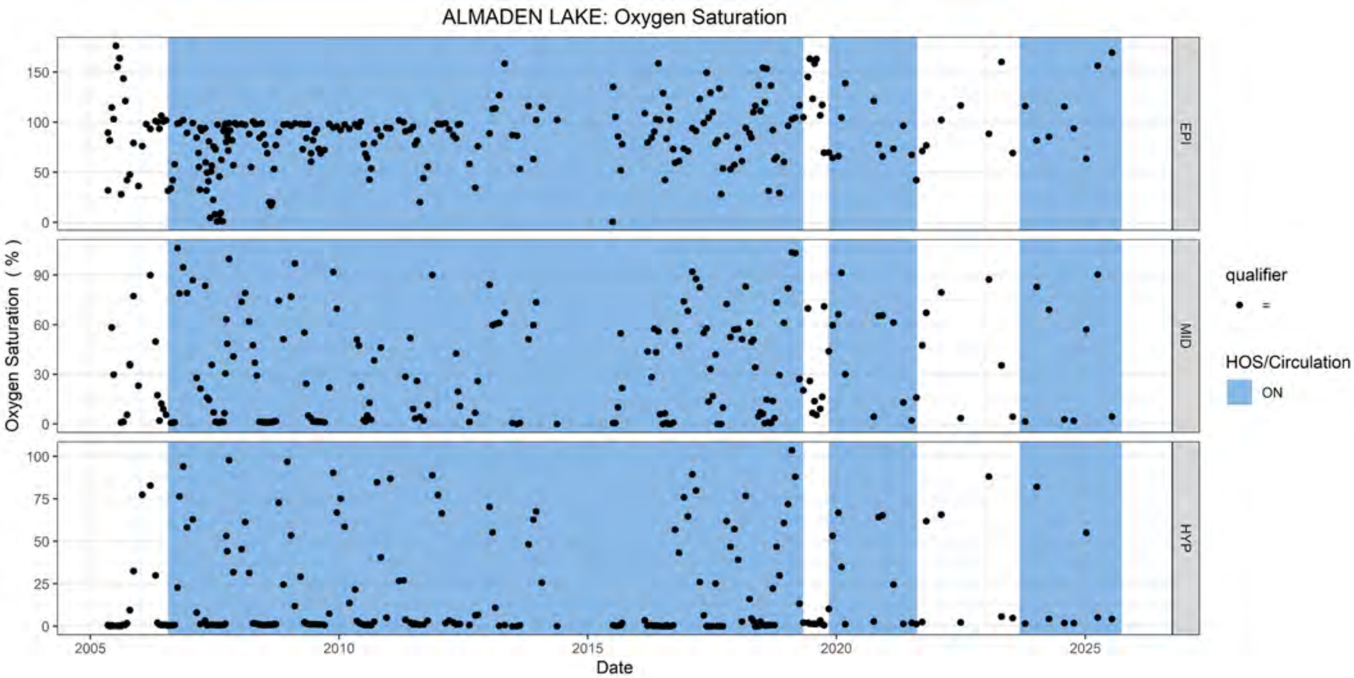


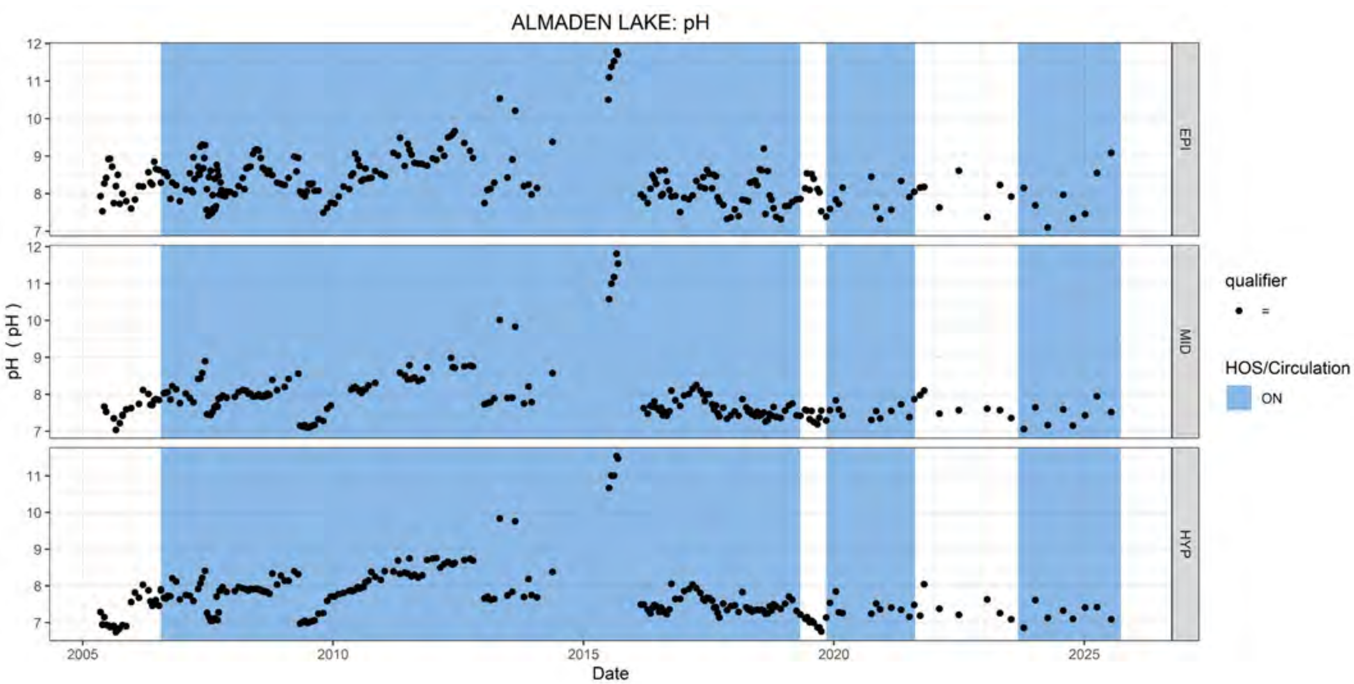

ALMADEN LAKE: Methylmercury
Methylmercury (ng/L)
Date
EPI
MID
HYP
HOS/Circulation
ON
qualifier
=
<

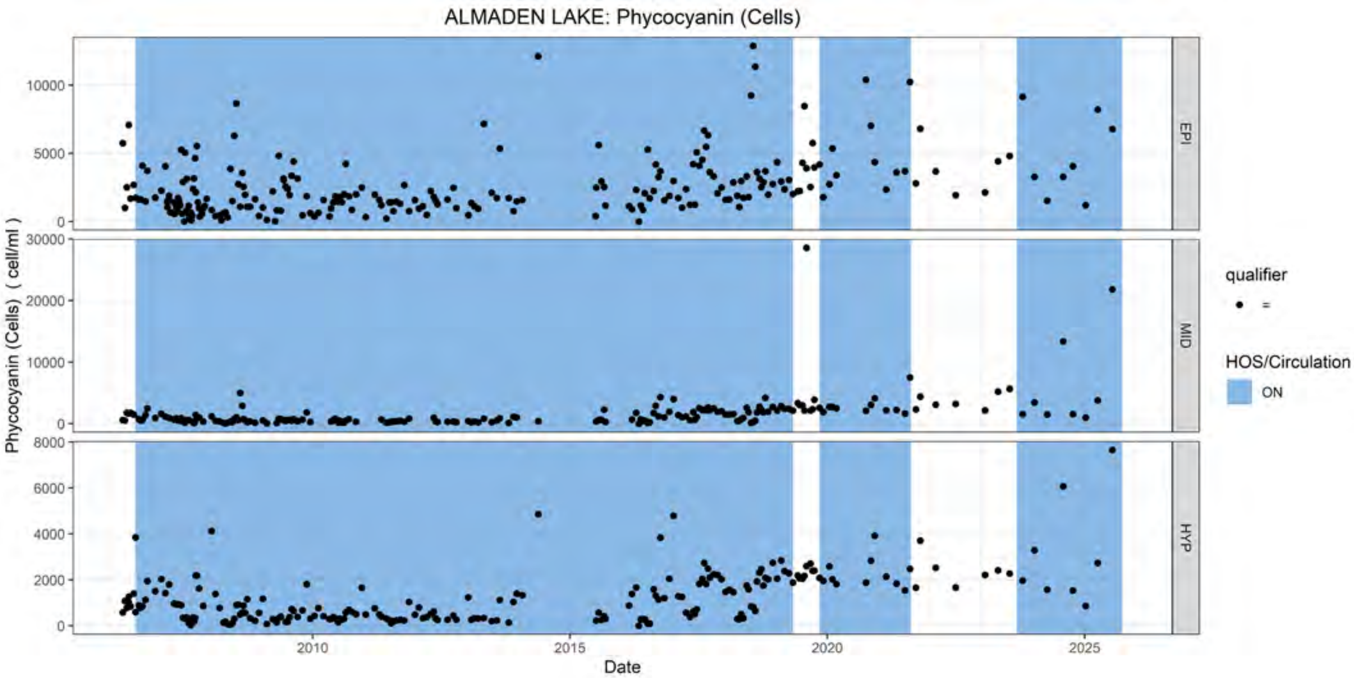

ALMADEN LAKE: Mercury
Mercury (ng/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<

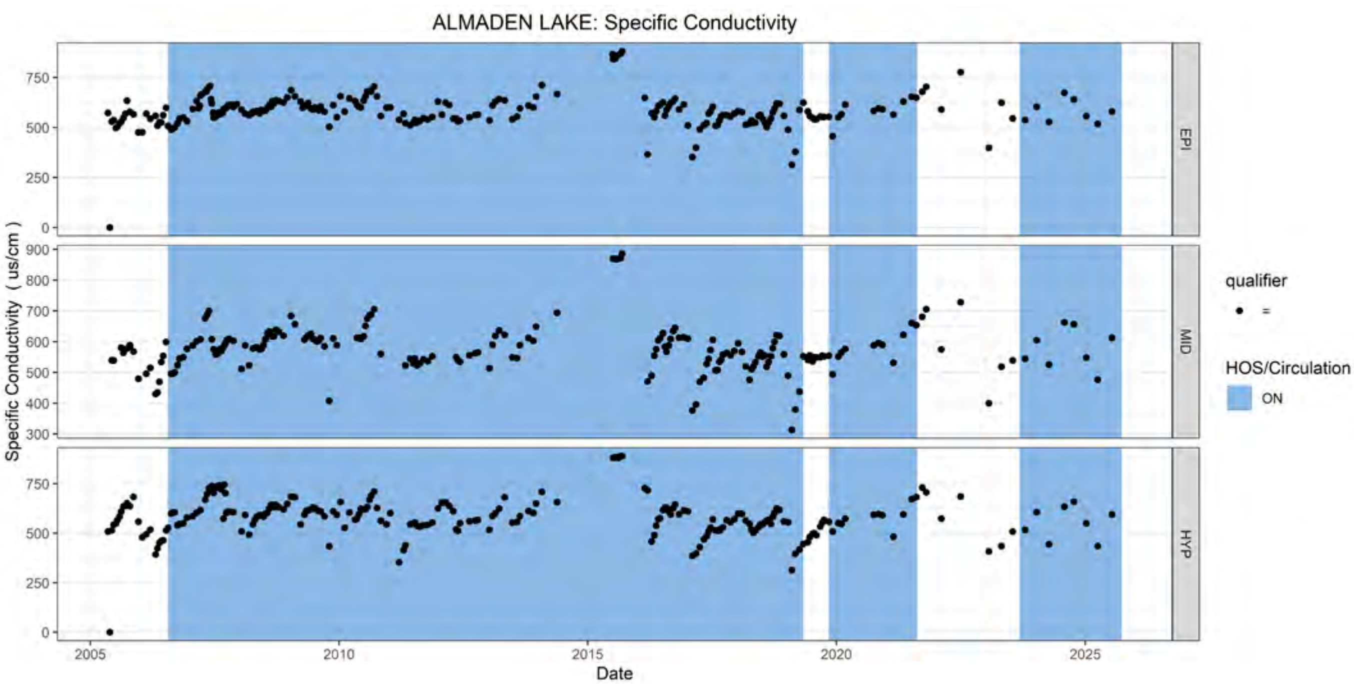

ALMADEN LAKE: Oxidation Reduction
Oxidation Reduction (mV)
Date
EPI
MID
HYP
qualifier
=
HOS/Circulation
ON

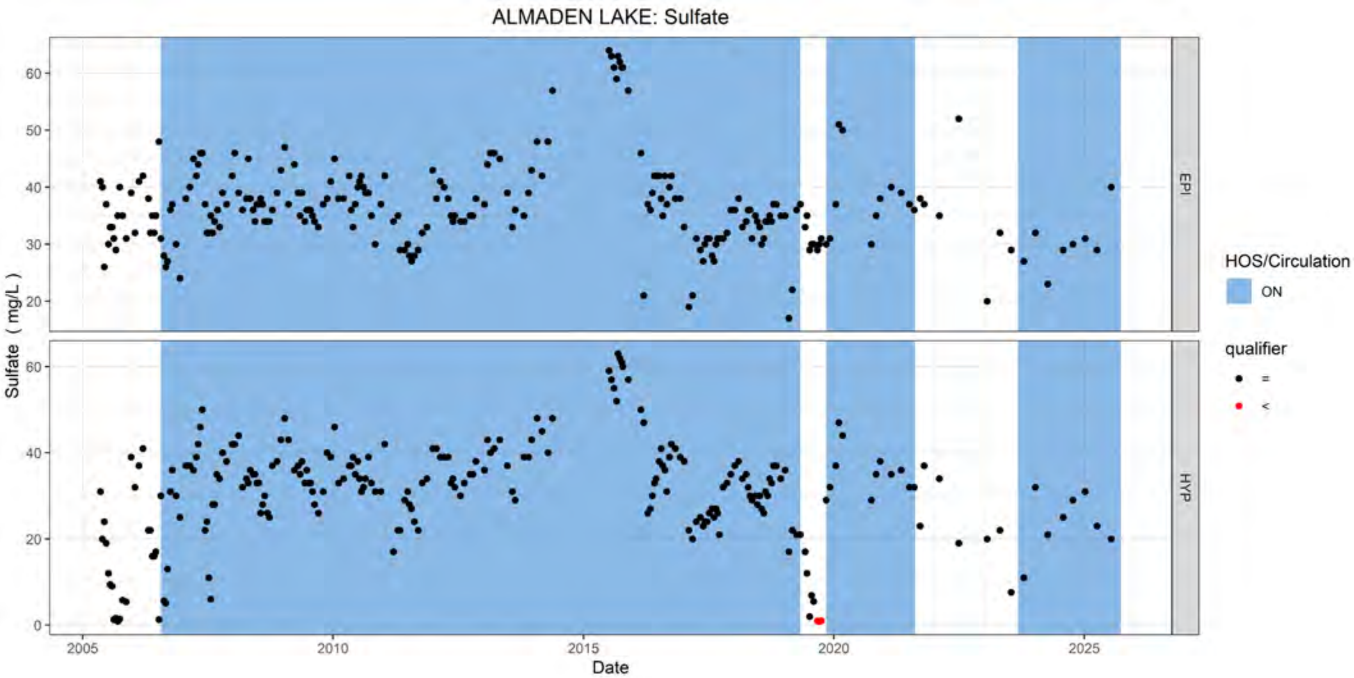

ALMADEN LAKE: Oxygen Concentration
Oxygen Concentration (mg/l)
Date
EPI
MID
HYP
qualifier
=
HOS/Circulation
ON

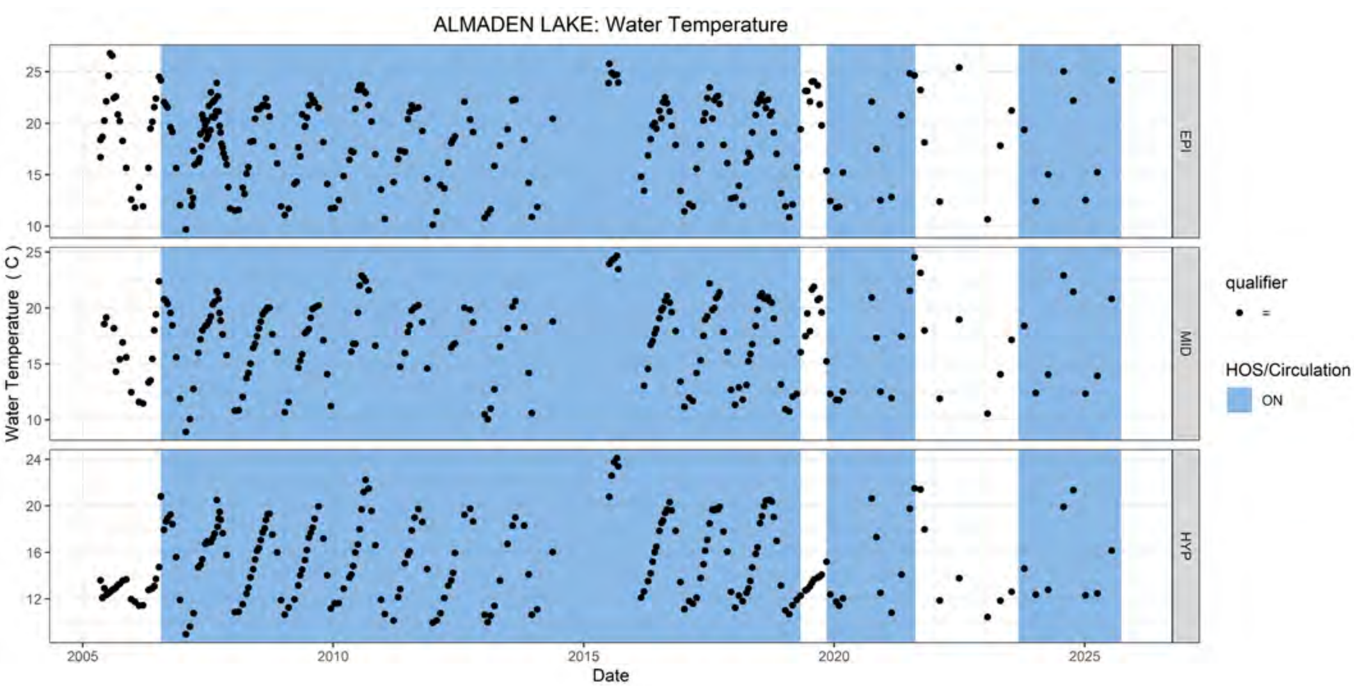

ALMADEN LAKE: Oxygen Saturation
Oxygen Saturation (%)
EPI
MID
HYP
Date
qualifier
=
HOS/Circulation
ON
150
100
50
0
90
60
30
75
25
2005
2010
2015
2020
2025

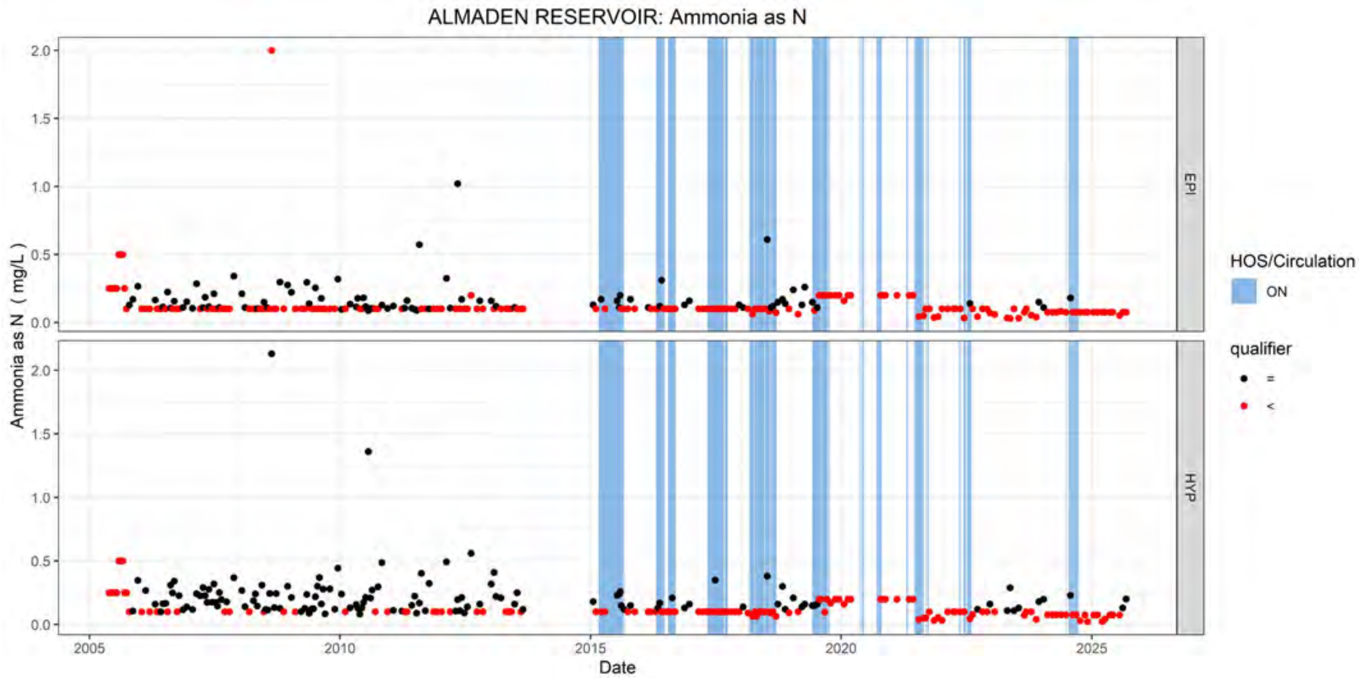

ALMADEN LAKE: pH
pH (pH)
EPI
MID
HYP
Date
qualifier
=
HOS/Circulation
ON
12
11
10
9
8
7
2005
2010
2015
2020
2025

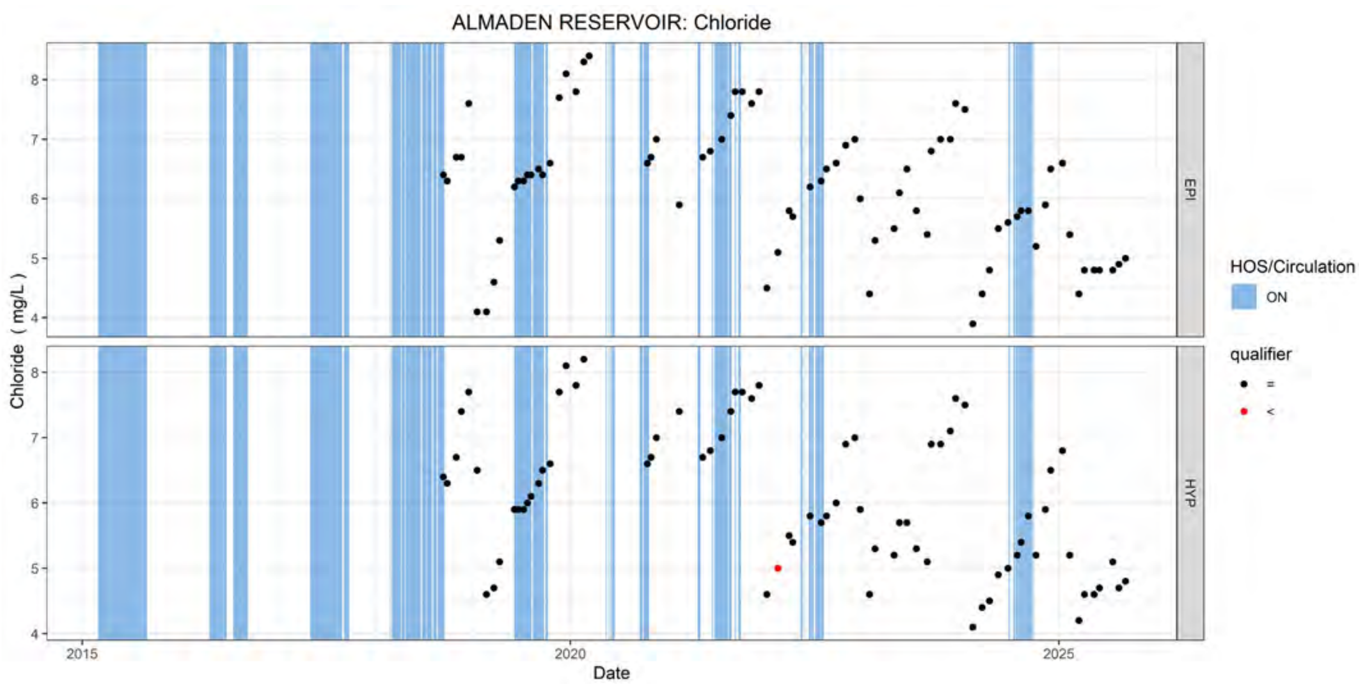

ALMADEN LAKE: Phycocyanin (Cells)
Phycocyanin (Cells) (cell/ml)
EPI
MID
HYP
Date
qualifier
=
HOS/Circulation
ON

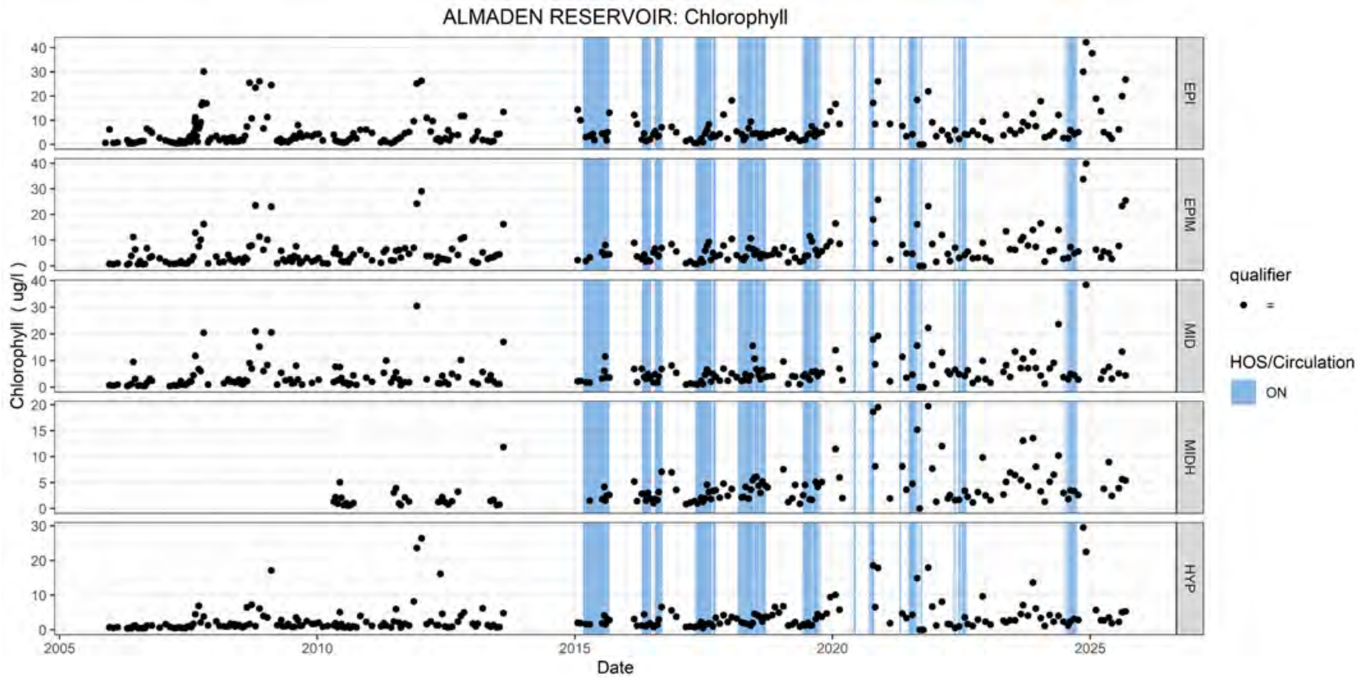

ALMADEN LAKE: Specific Conductivity
Specific Conductivity (us/cm)
EPI
MID
HYP
Date
qualifier
=
HOS/Circulation
ON

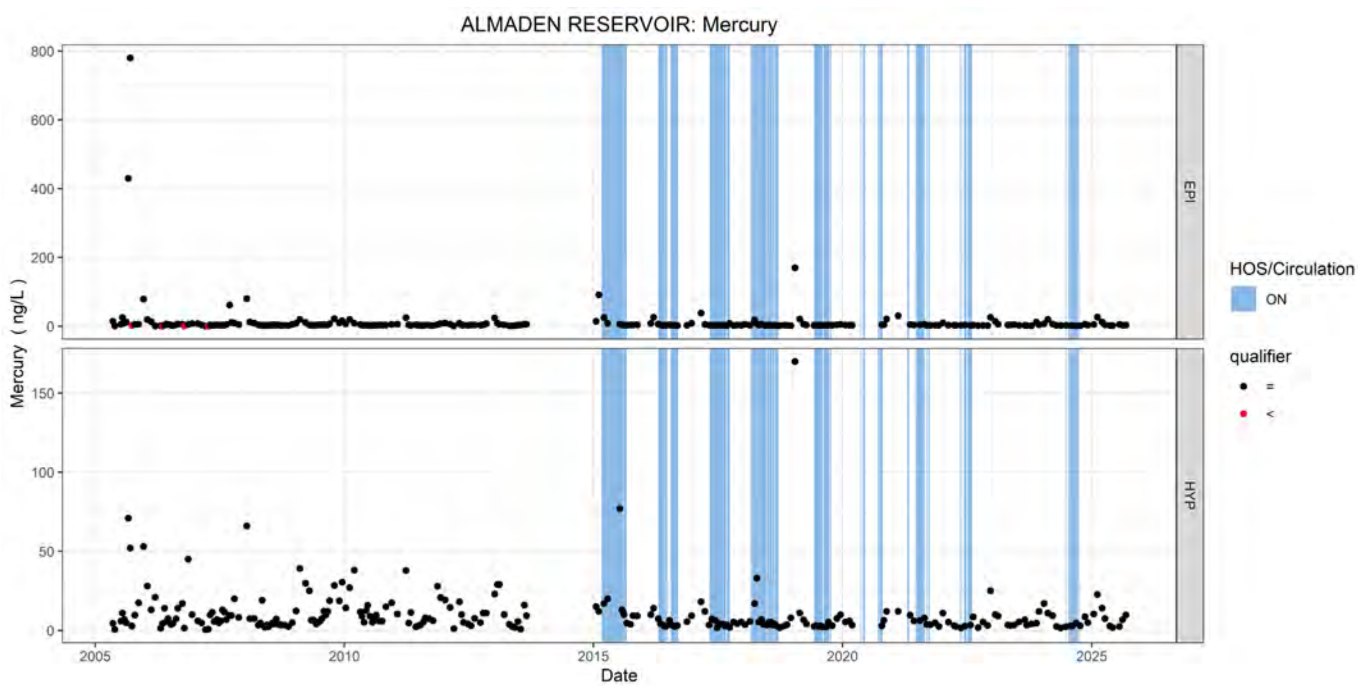

ALMADEN LAKE: Sulfate
Sulfate (mg/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020
2025

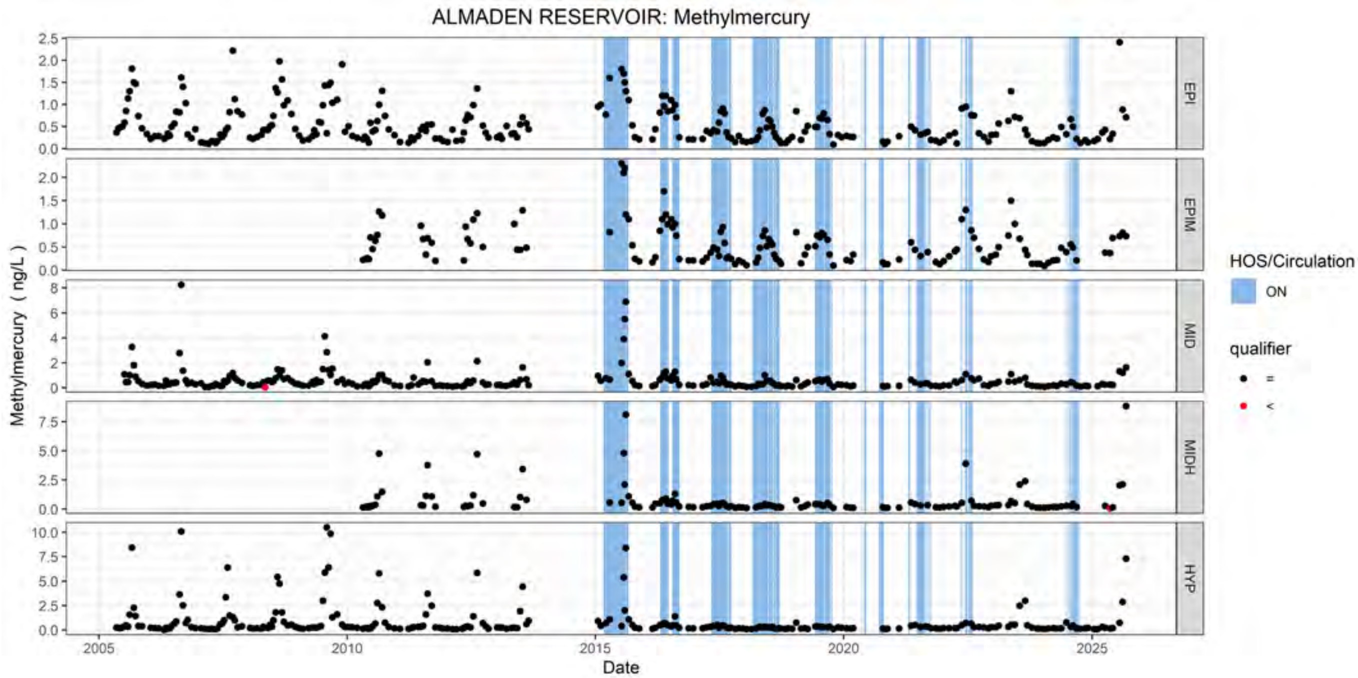

ALMADEN LAKE: Water Temperature
Water Temperature (C)
Date
EPI
MID
HYP
qualifier
=
HOS/Circulation
ON
2005
2010
2015
2020
2025


ALMADEN RESERVOIR: Ammonia as N
Ammonia as N (mg/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020
2025

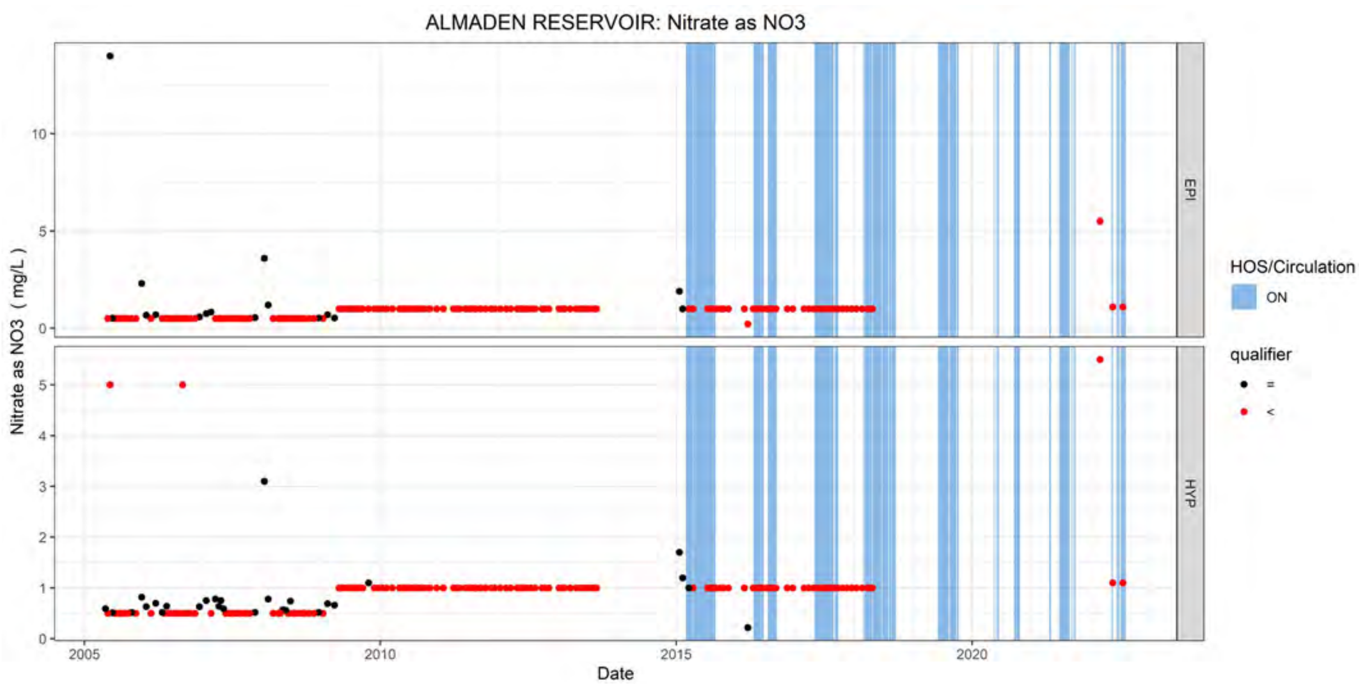

ALMADEN RESERVOIR: Chloride
Chloride (mg/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2015
2020
2025


ALMADEN RESERVOIR: Chlorophyll
Chlorophyll (ug/l)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON

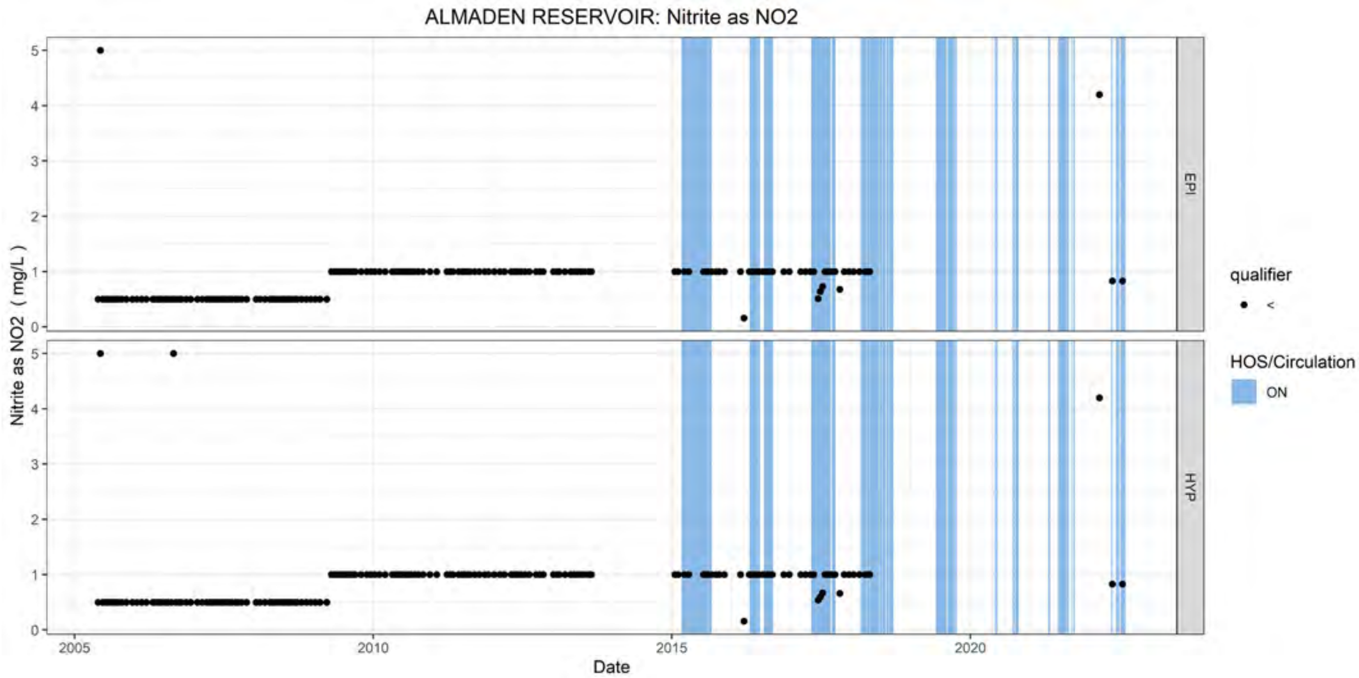

ALMADEN RESERVOIR: Mercury
Mercury (ng/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<



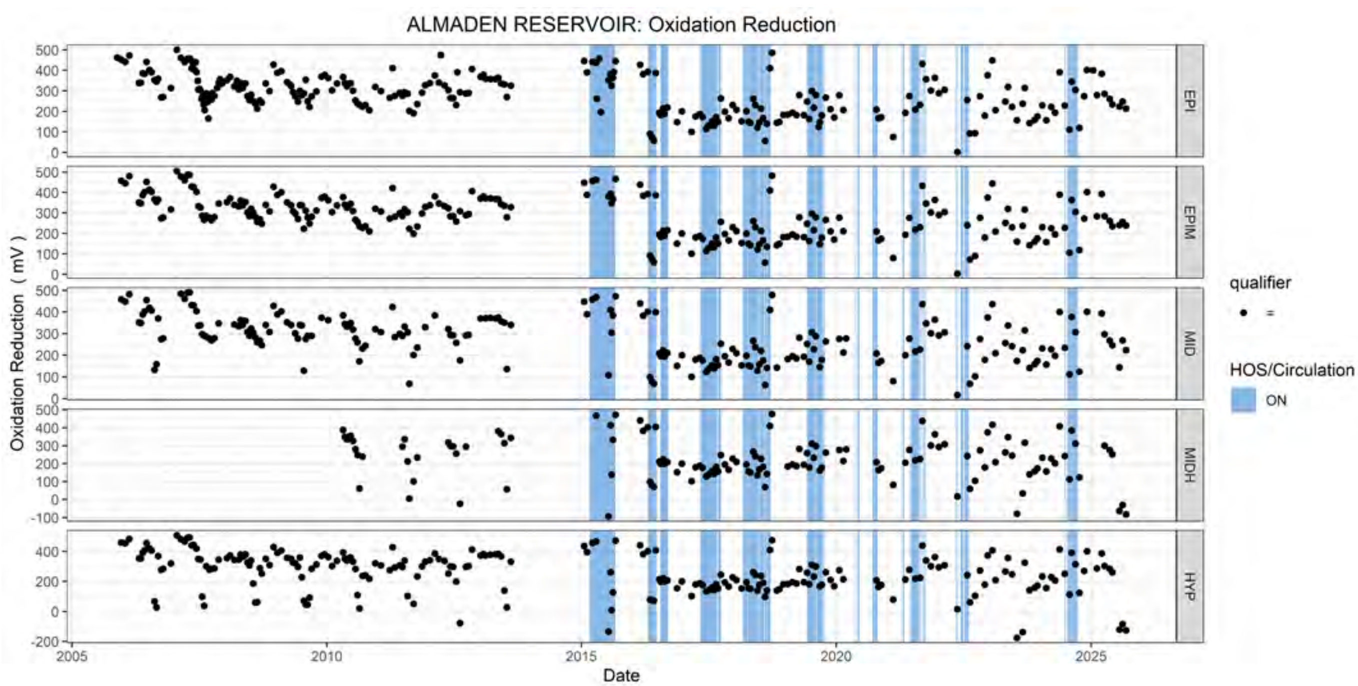
ALMADEN RESERVOIR: Methylmercury
Methylmercury (ng/L)
EPI
EPIM
MID
MIDH
HYP
Date
HOS/Circulation
ON
qualifier
=
<



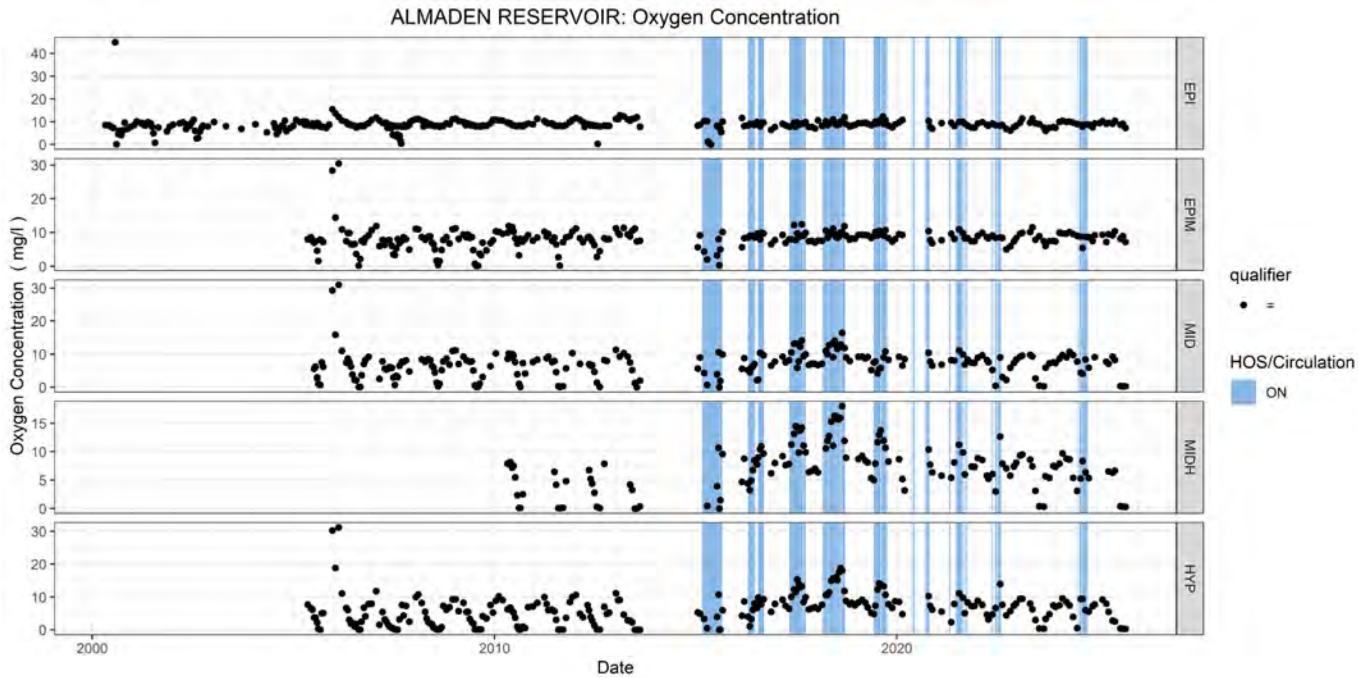
ALMADEN RESERVOIR: Nitrate as NO3
Nitrate as NO3 (mg/L)
EPI
HYP
Date
HOS/Circulation
ON
qualifier
=
<



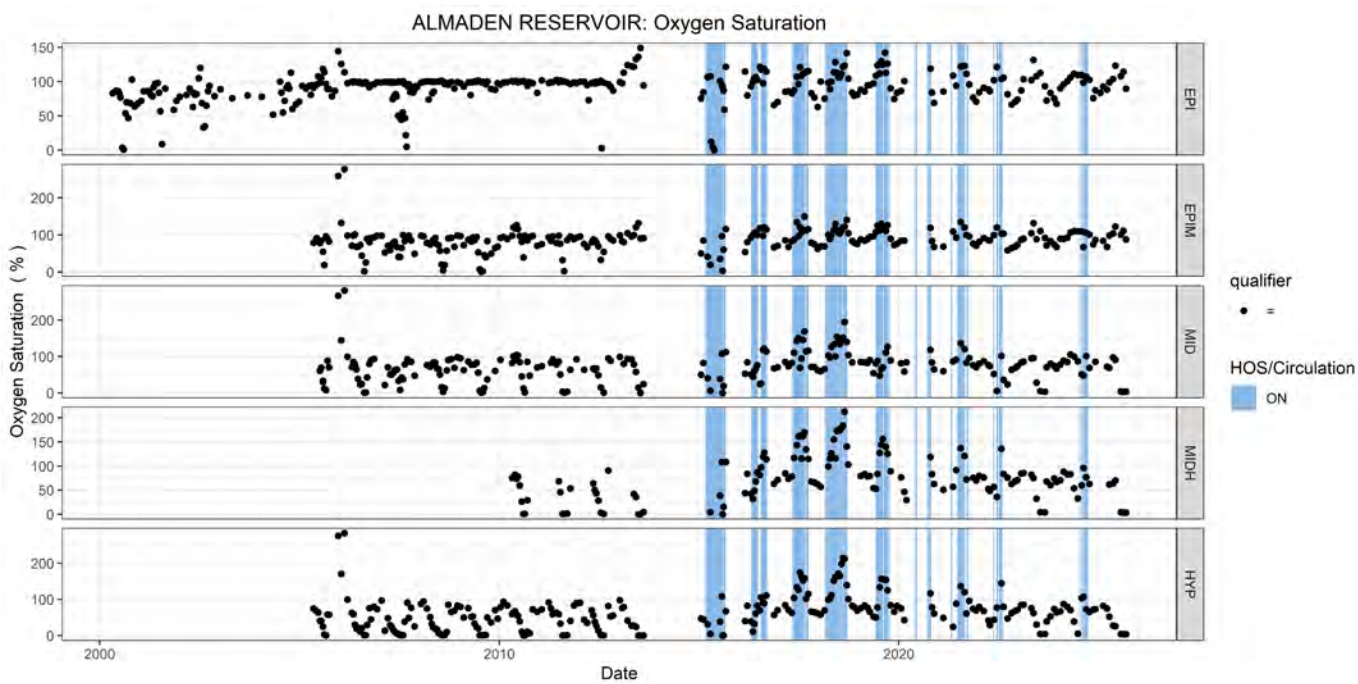
ALMADEN RESERVOIR: Nitrite as NO2
Nitrite as NO2 (mg/L)
EPI
HYP
Date
2005
2010
2015
2020
qualifier
<
HOS/Circulation
ON



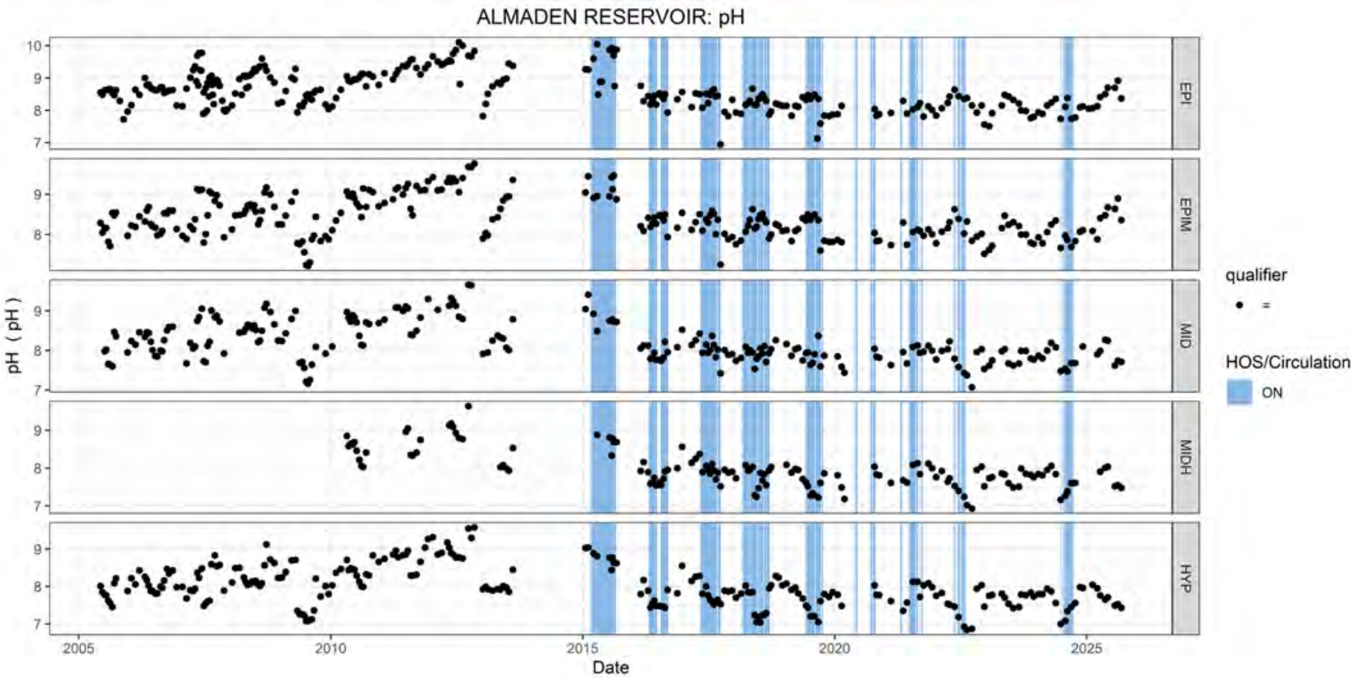
ALMADEN RESERVOIR: Oxidation Reduction
Oxidation Reduction (mV)
EPI
EPIM
MID
MIDH
HYP
Date
2005
2010
2015
2020
2025
qualifier
=
HOS/Circulation
ON

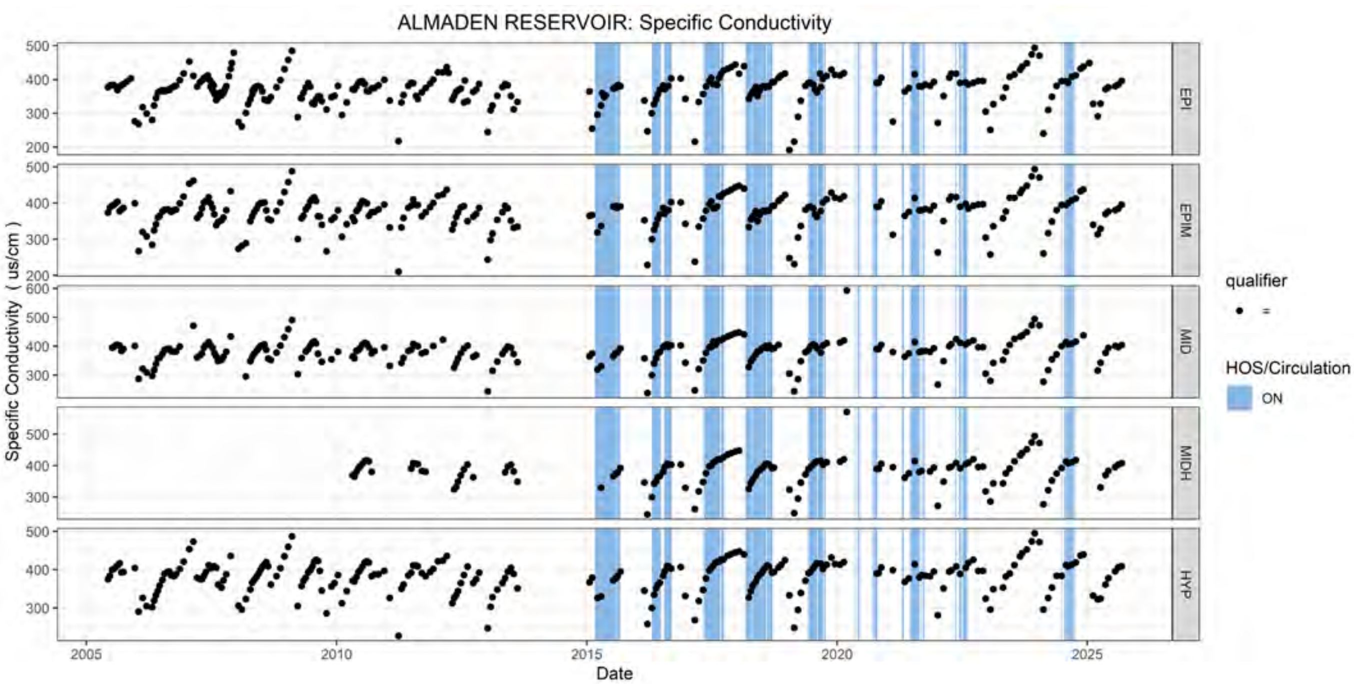


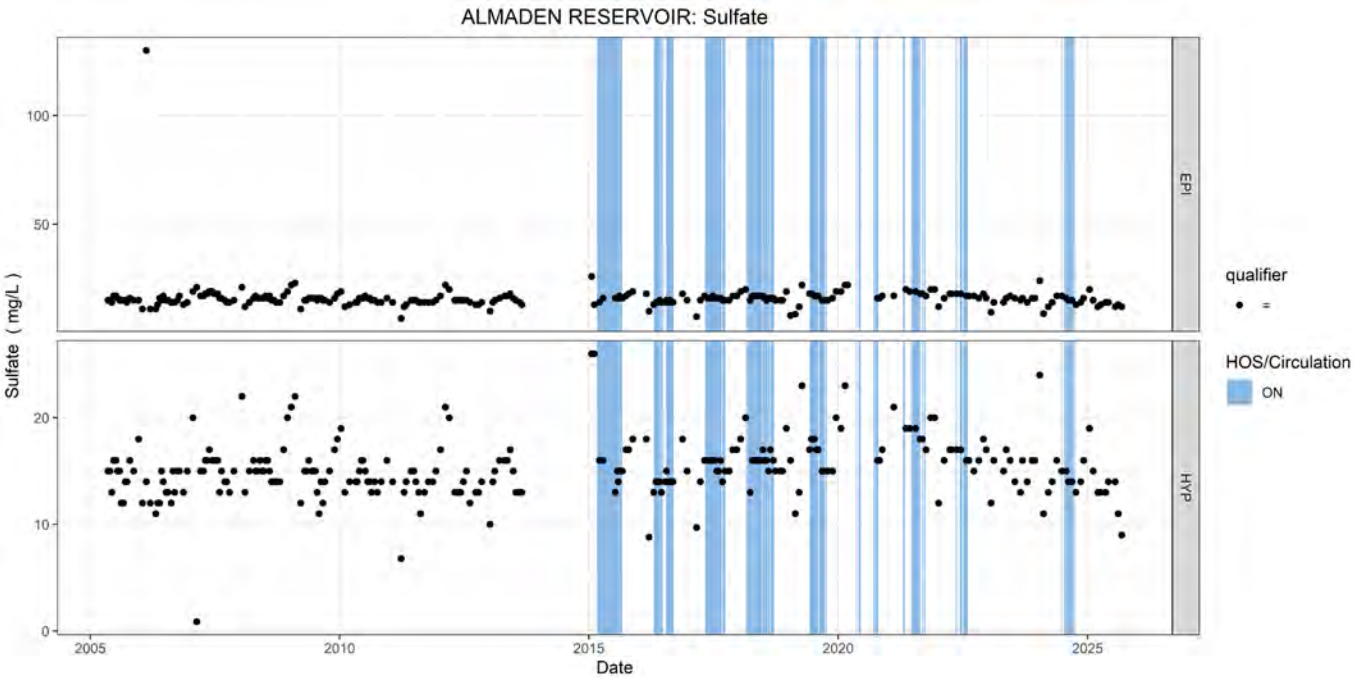
ALMADEN RESERVOIR: Oxygen Concentration
Oxygen Concentration (mg/l)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

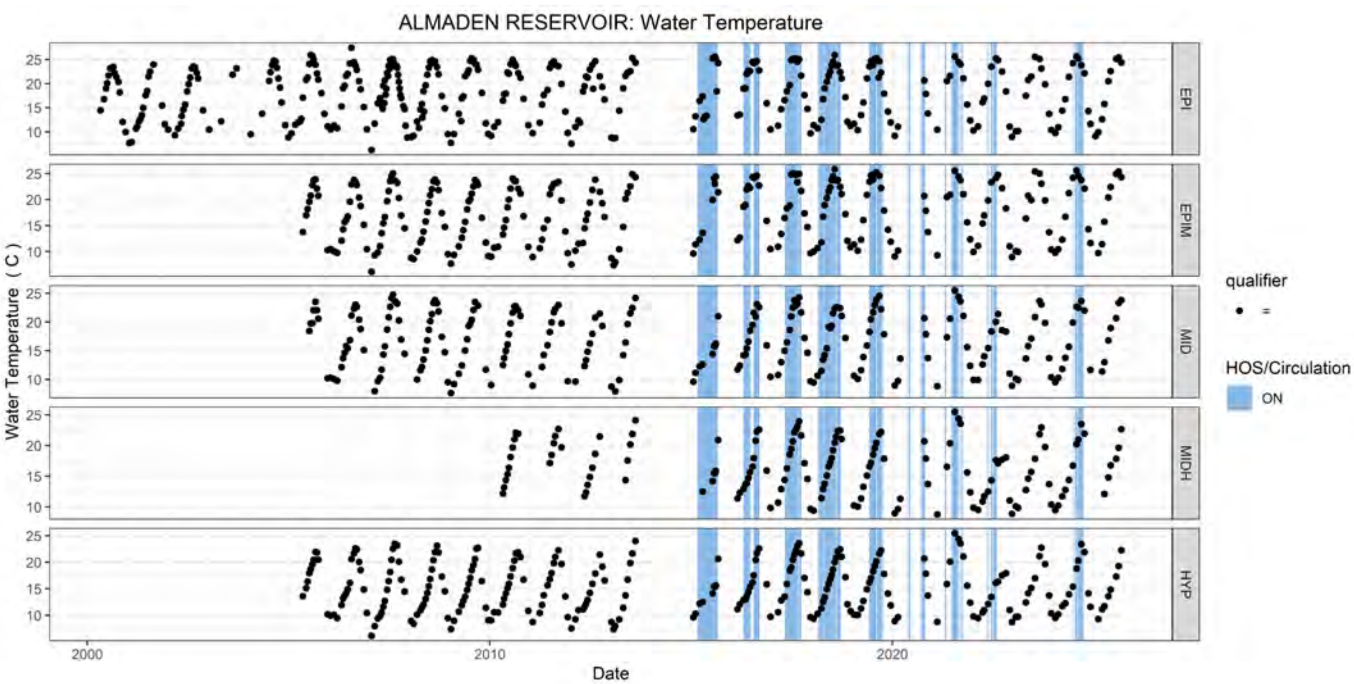


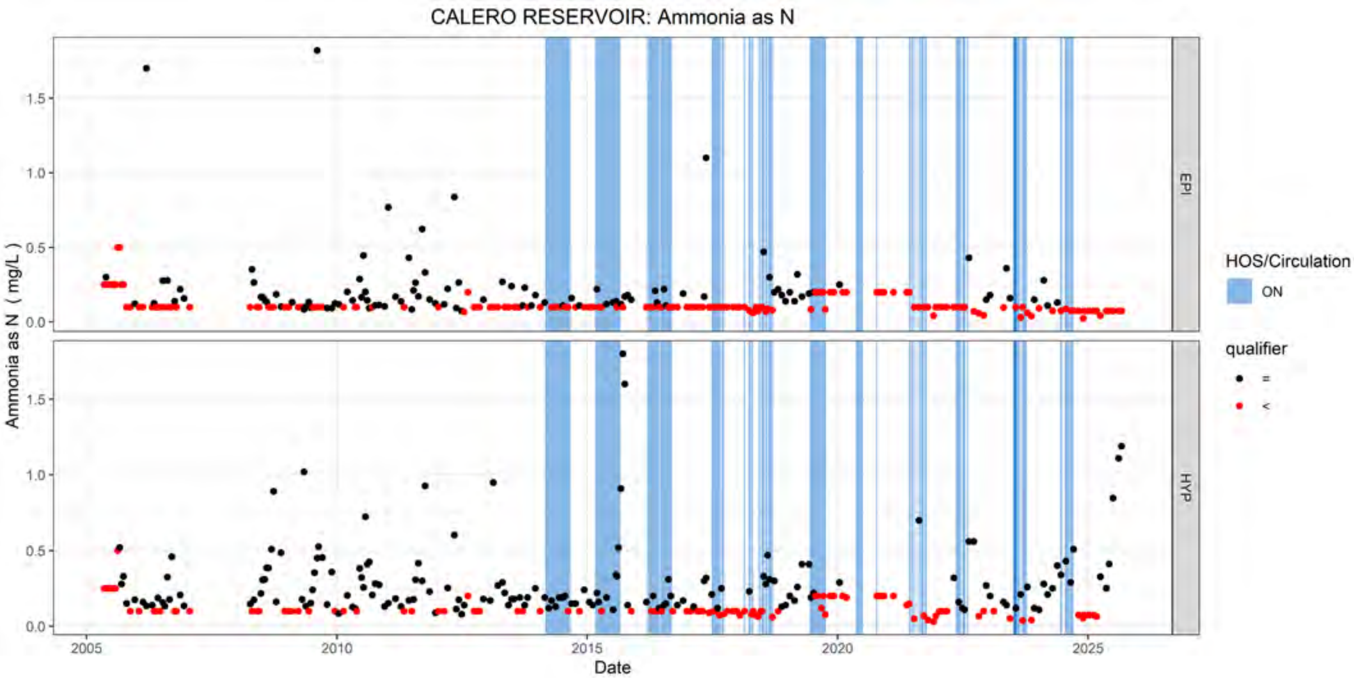
ALMADEN RESERVOIR: Oxygen Saturation
Oxygen Saturation (%)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

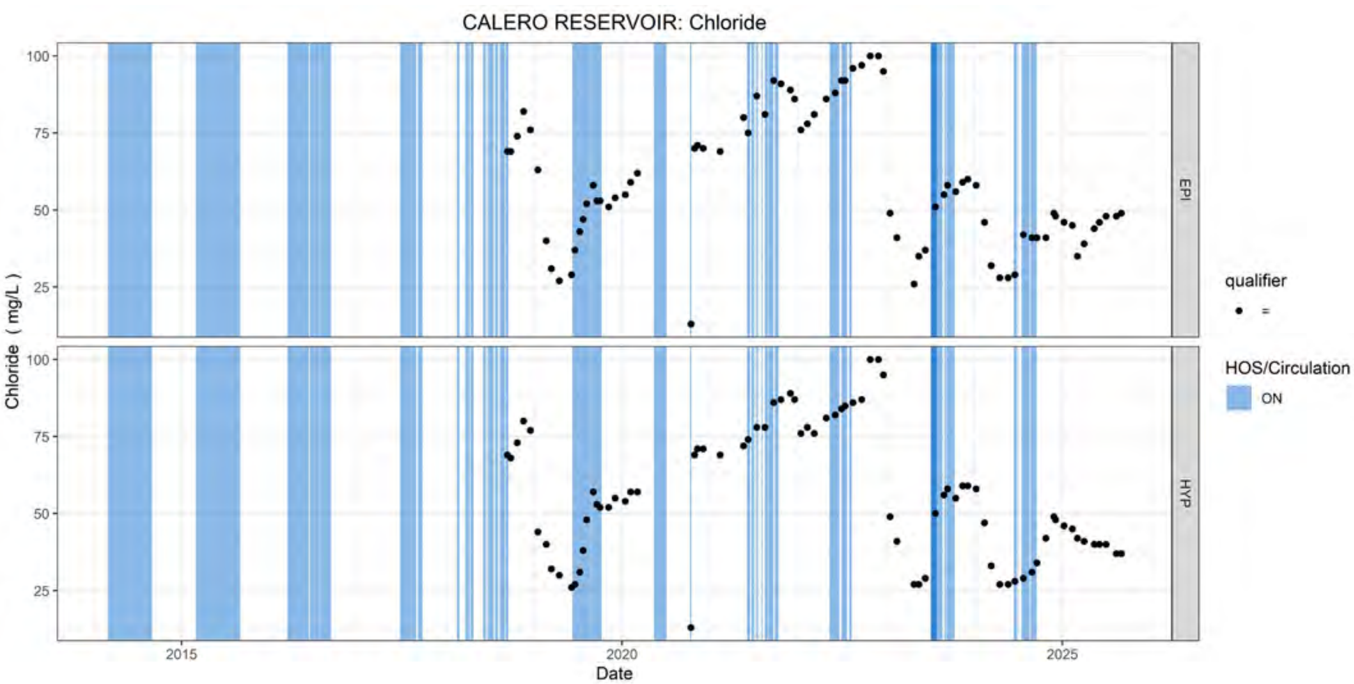

ALMADEN RESERVOIR: pH
pH (pH)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

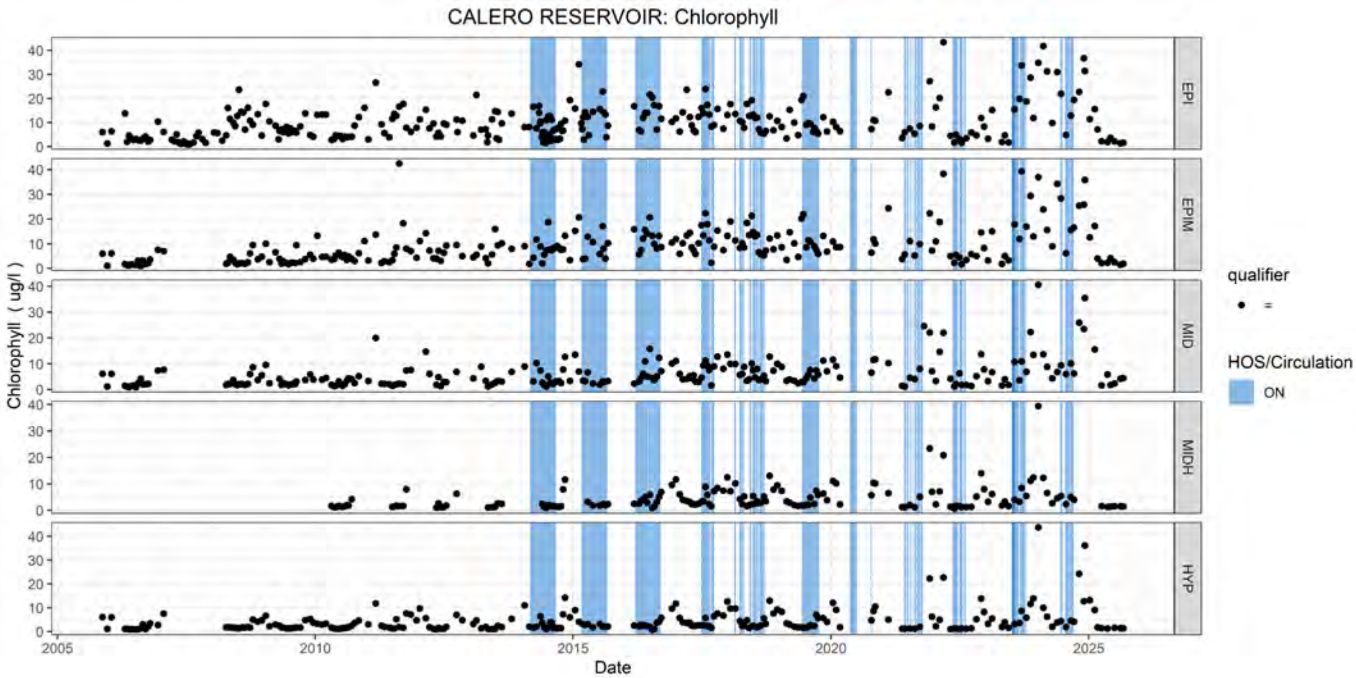

ALMADEN RESERVOIR: Specific Conductivity
Specific Conductivity (us/cm)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

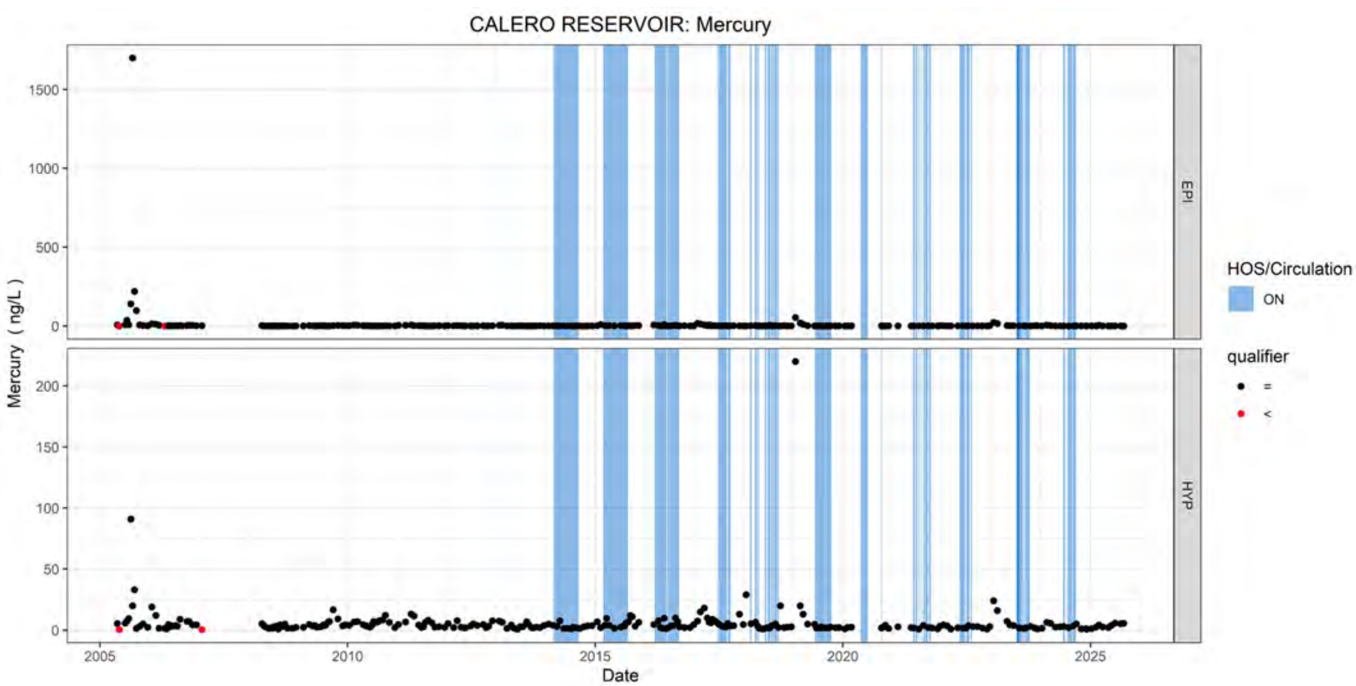

ALMADEN RESERVOIR: Sulfate
Sulfate (mg/L)
Date
EPI
HYP
qualifier
=
HOS/Circulation
ON
2005
2010
2015
2020
2025

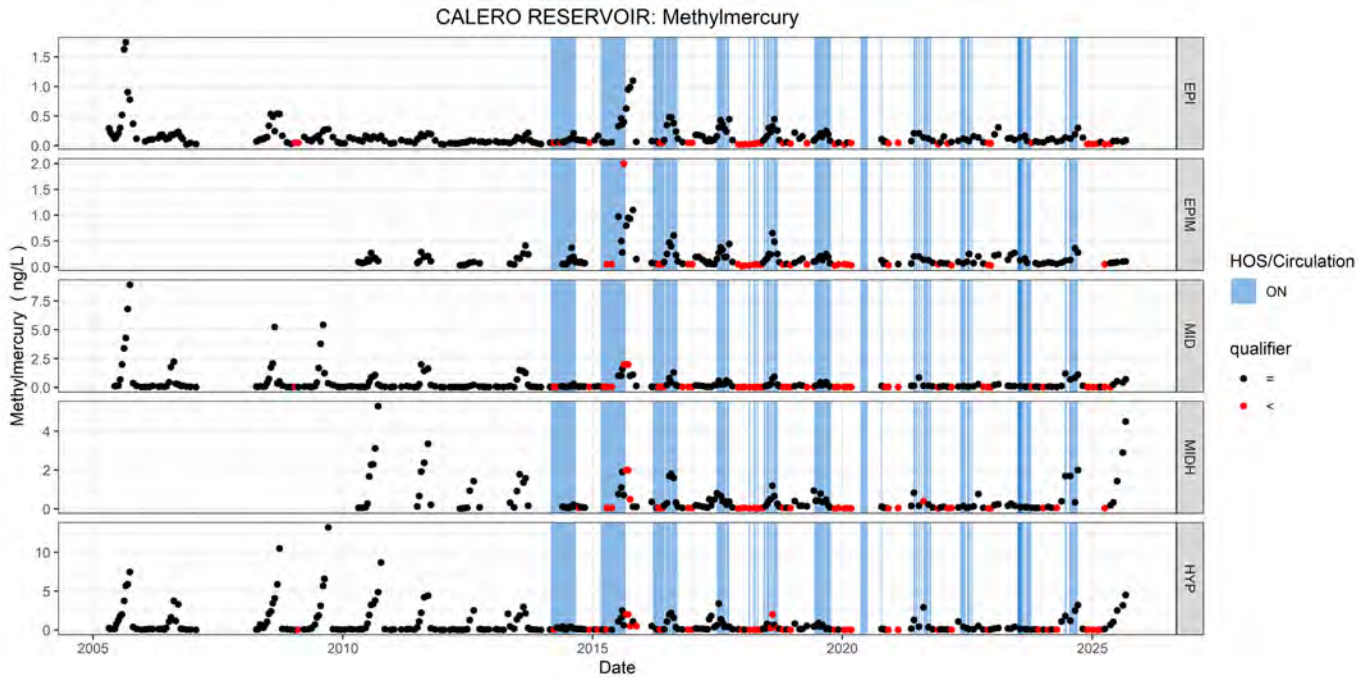

ALMADEN RESERVOIR: Water Temperature
Water Temperature (C)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON
2000
2010
2020

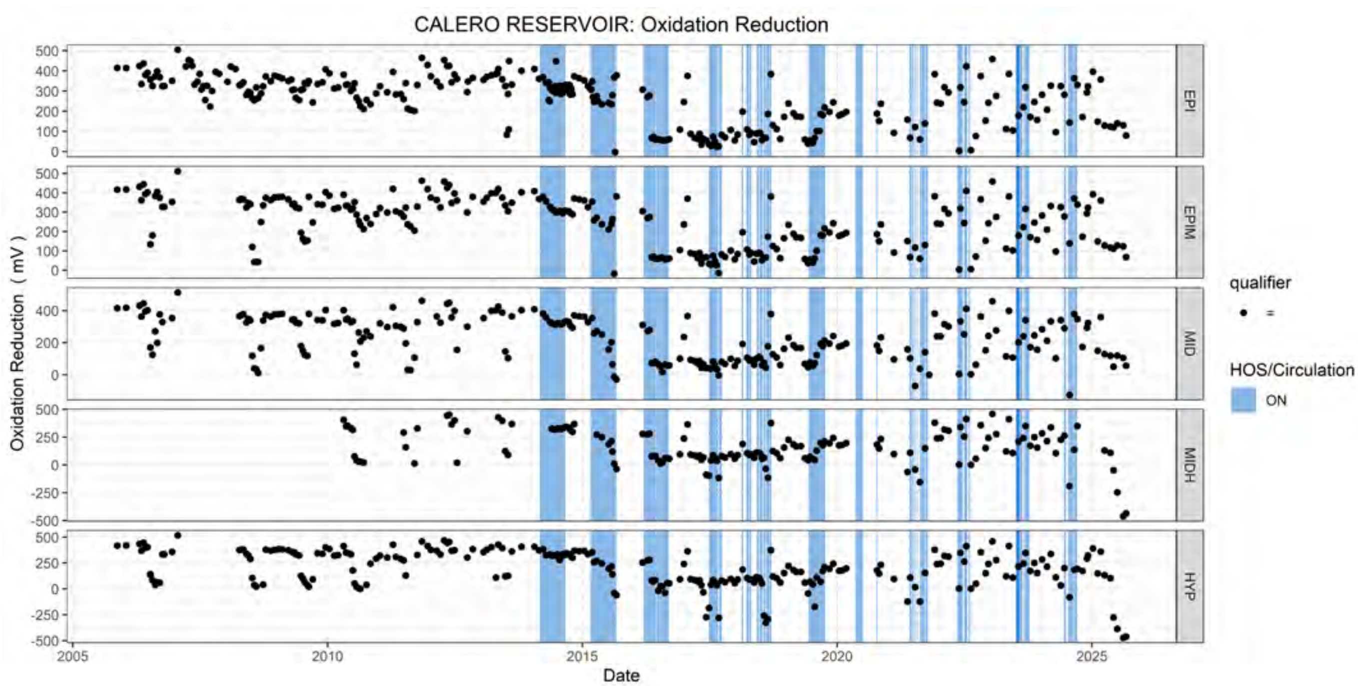

CALERO RESERVOIR: Ammonia as N
Ammonia as N (mg/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020
2025
0.0
0.5
1.0
1.5

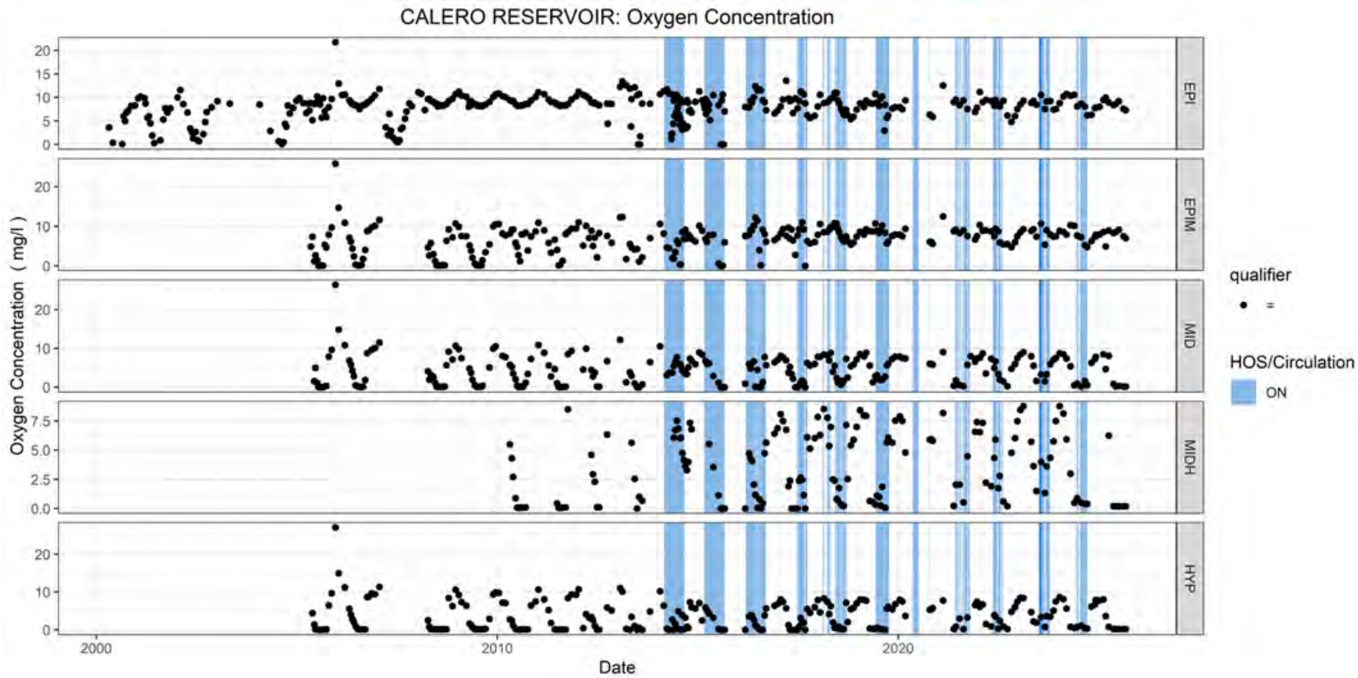

CALERO RESERVOIR: Chloride
Chloride (mg/L)
Date
EPI
HYP
qualifier
=
HOS/Circulation
ON
2015
2020
2025
25
50
75
100

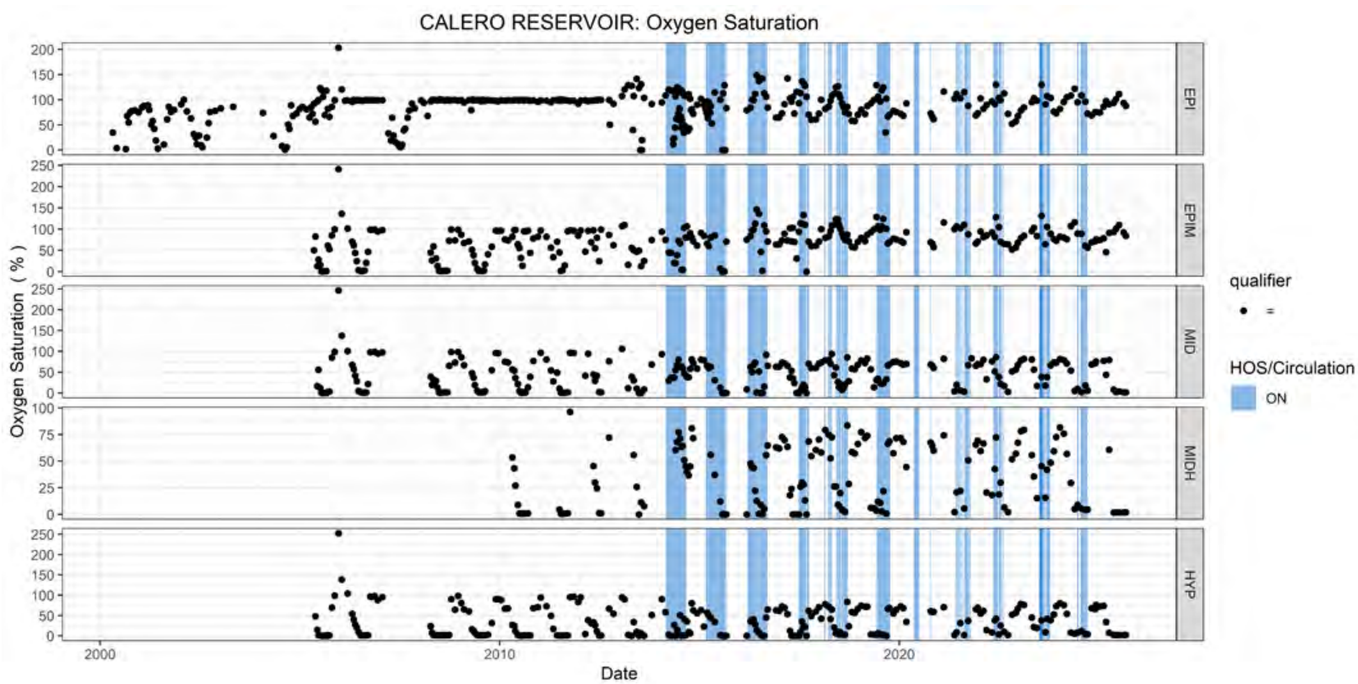

CALERO RESERVOIR: Chlorophyll
Chlorophyll (ug/l)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON
2005
2010
2015
2020
2025

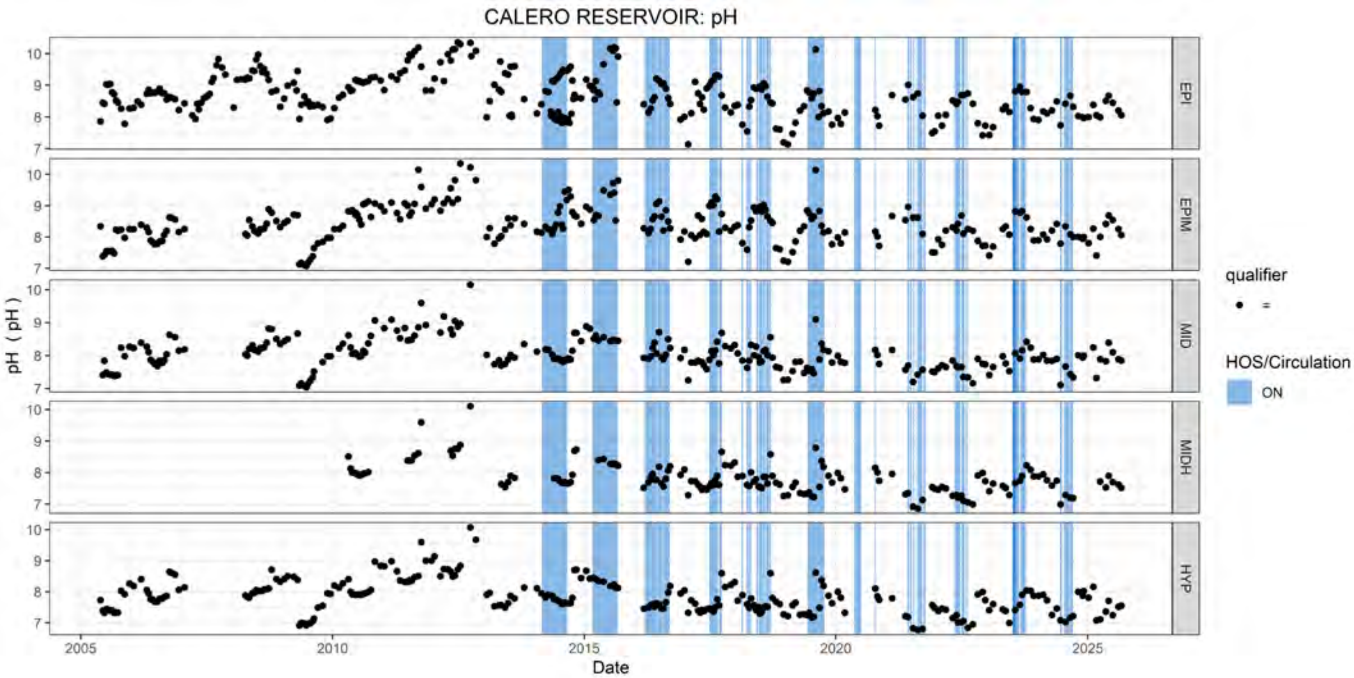

CALERO RESERVOIR: Mercury
Mercury (ng/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020
2025

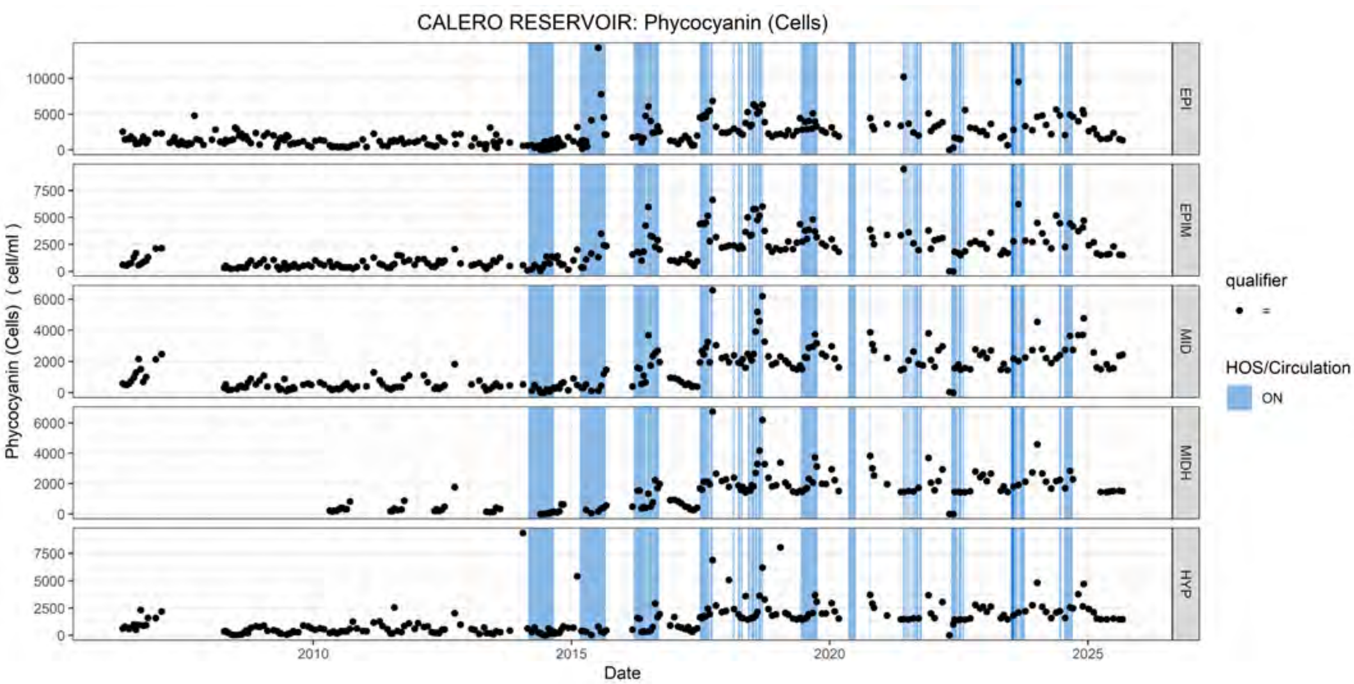

CALERO RESERVOIR: Methylmercury
Methylmercury (ng/L)
Date
EPI
EPIM
MID
MIDH
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020
2025

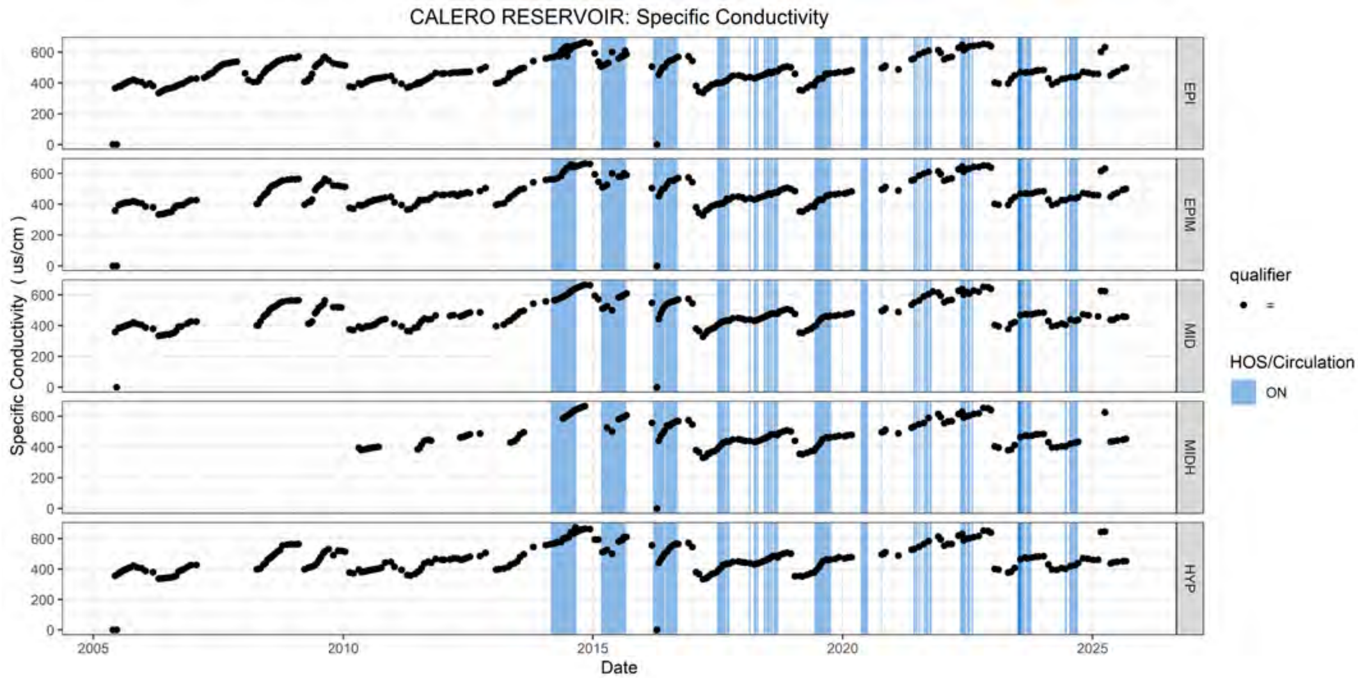

CALERO RESERVOIR: Oxidation Reduction
Oxidation Reduction (mV)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON
2005
2010
2015
2020
2025

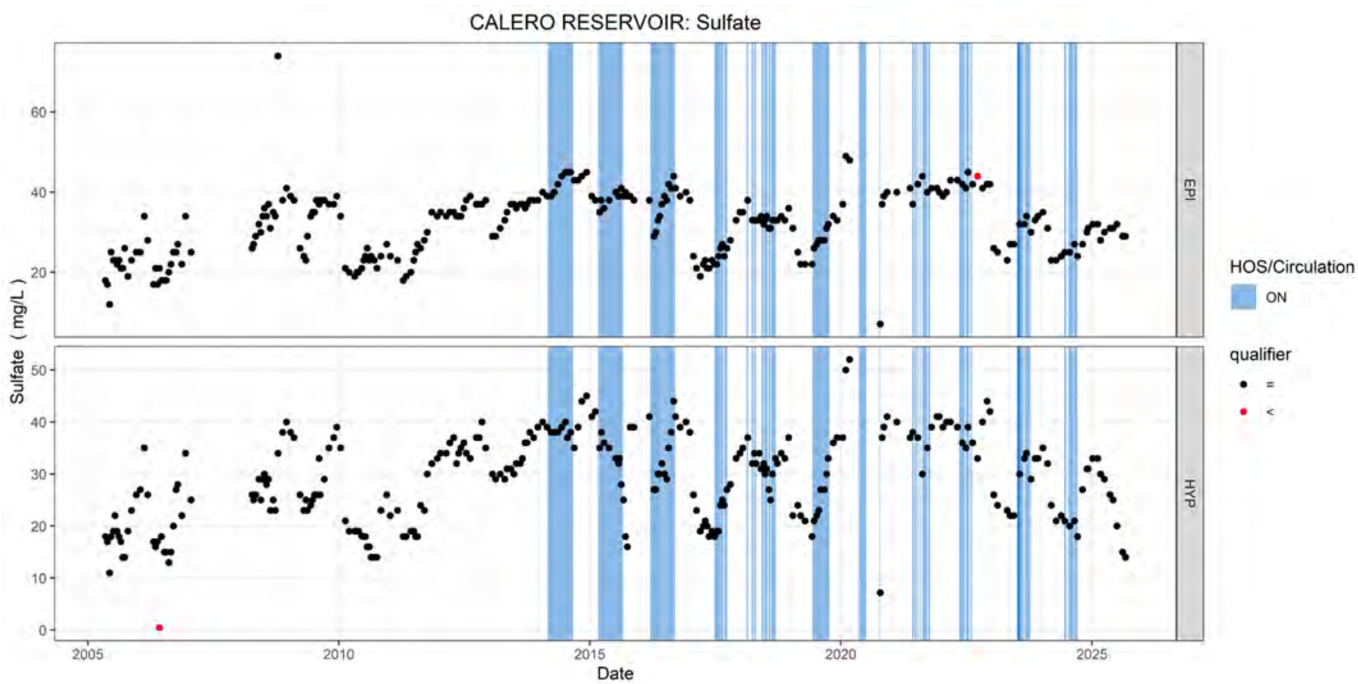

CALERO RESERVOIR: Oxygen Concentration
Oxygen Concentration (mg/l)
EPI
EPIM
MID
MIDH
HYP
Date
2000
2010
2020
qualifier
=
HOS/Circulation
ON

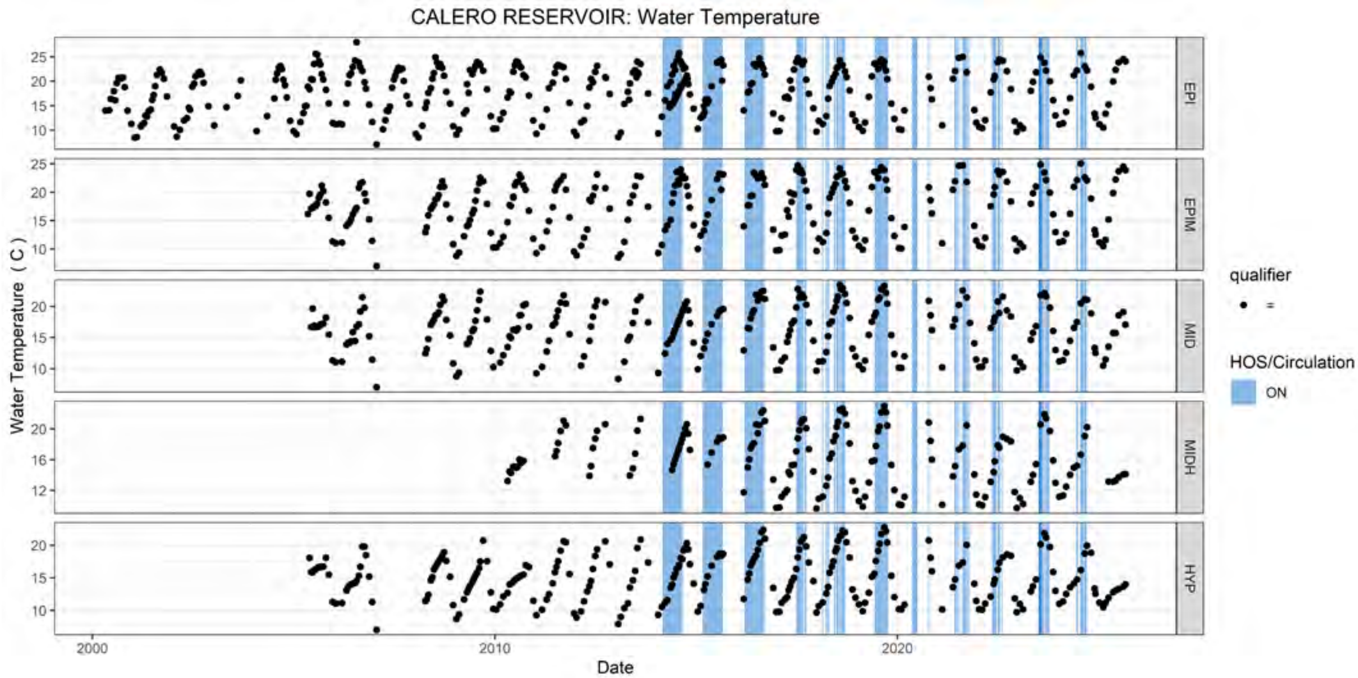

CALERO RESERVOIR: Oxygen Saturation
Oxygen Saturation (%)
EPI
EPIM
MID
MIDH
HYP
Date
2000
2010
2020
qualifier
=
HOS/Circulation
ON

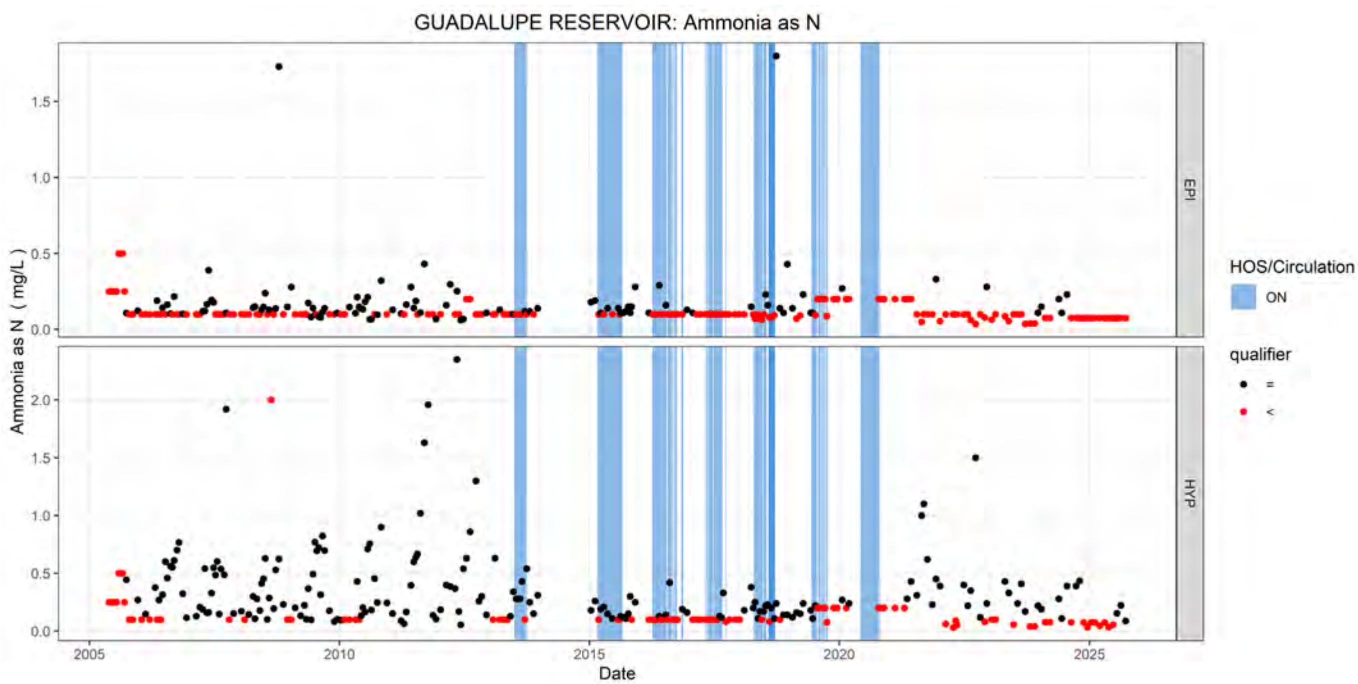

CALERO RESERVOIR: pH
EPI
EPIM
MID
MIDH
HYP
pH (pH)
Date
qualifier
=
HOS/Circulation
ON

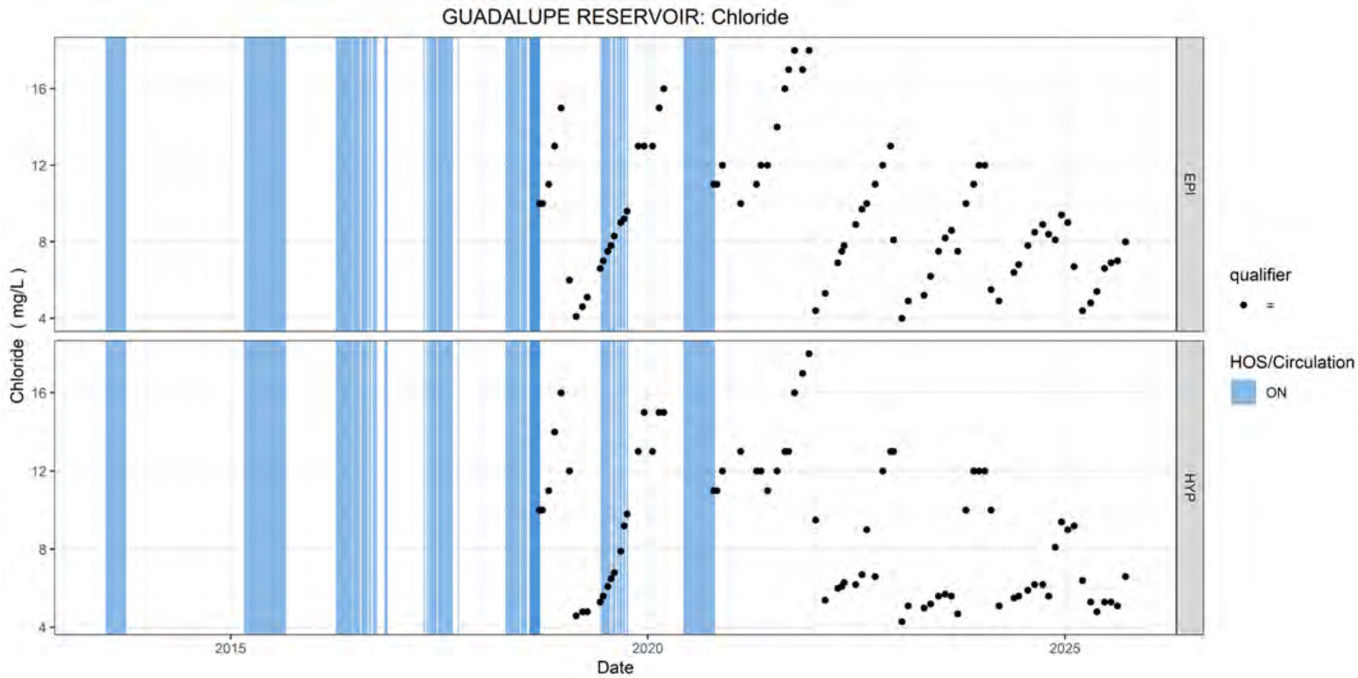

CALERO RESERVOIR: Phycocyanin (Cells)
EPI
EPIM
MID
MIDH
HYP
Phycocyanin (Cells) (cell/ml)
Date
qualifier
=
HOS/Circulation
ON


CALERO RESERVOIR: Specific Conductivity
Specific Conductivity (us/cm)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON
2005
2010
2015
2020
2025
0
200
400
600

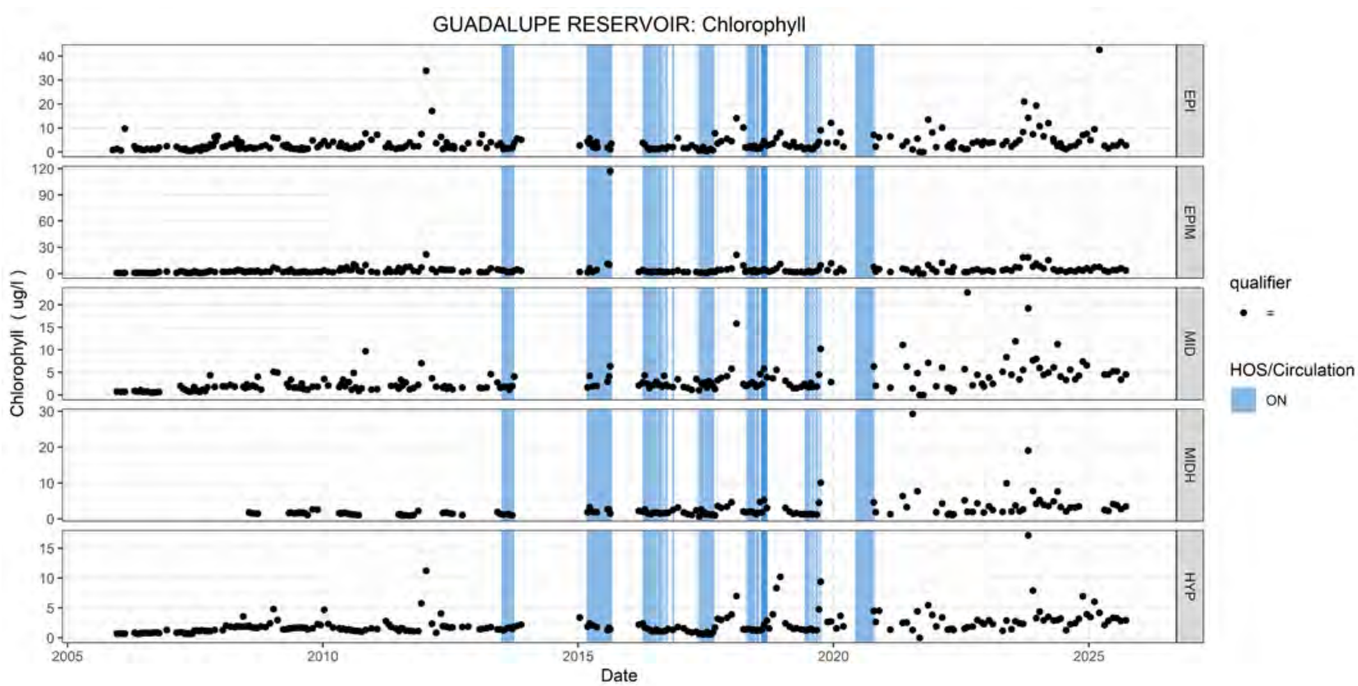

CALERO RESERVOIR: Sulfate
Sulfate (mg/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020
2025
0
10
20
30
40
50
60


CALERO RESERVOIR: Water Temperature
Water Temperature (C)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON
2000
2010
2020

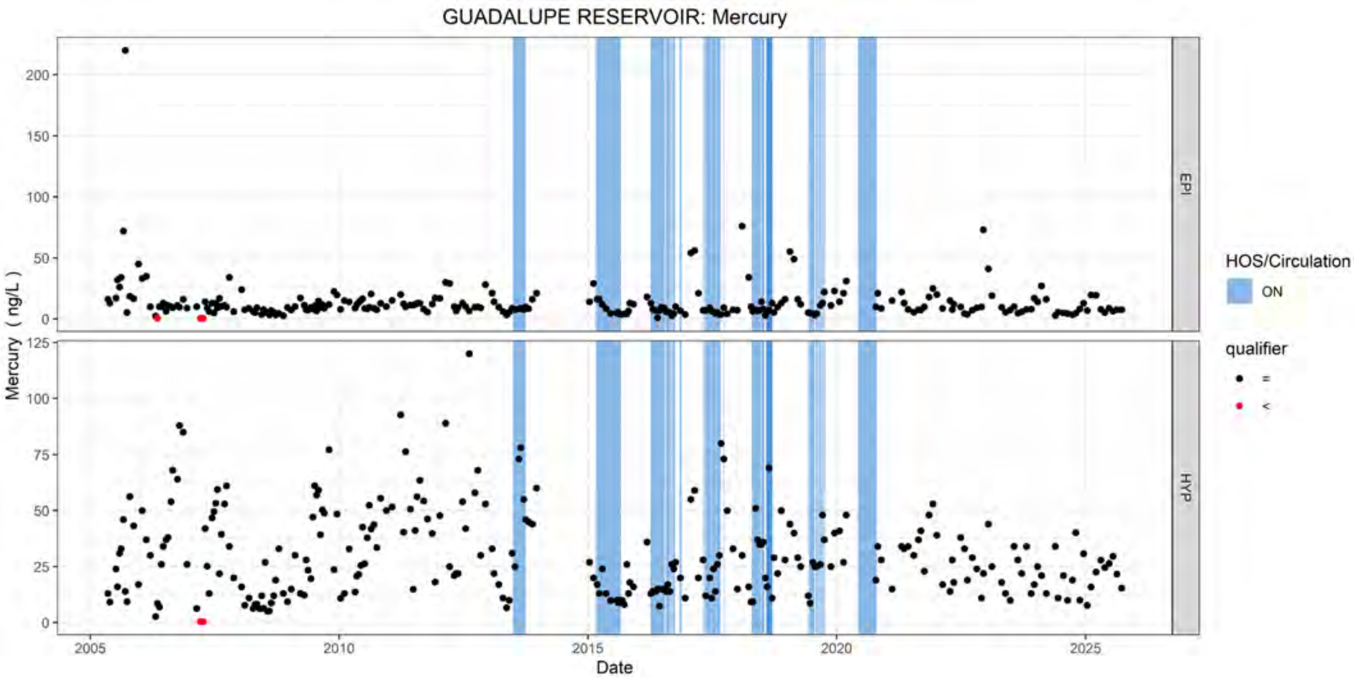

GUADALUPE RESERVOIR: Ammonia as N
Ammonia as N (mg/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020
2025



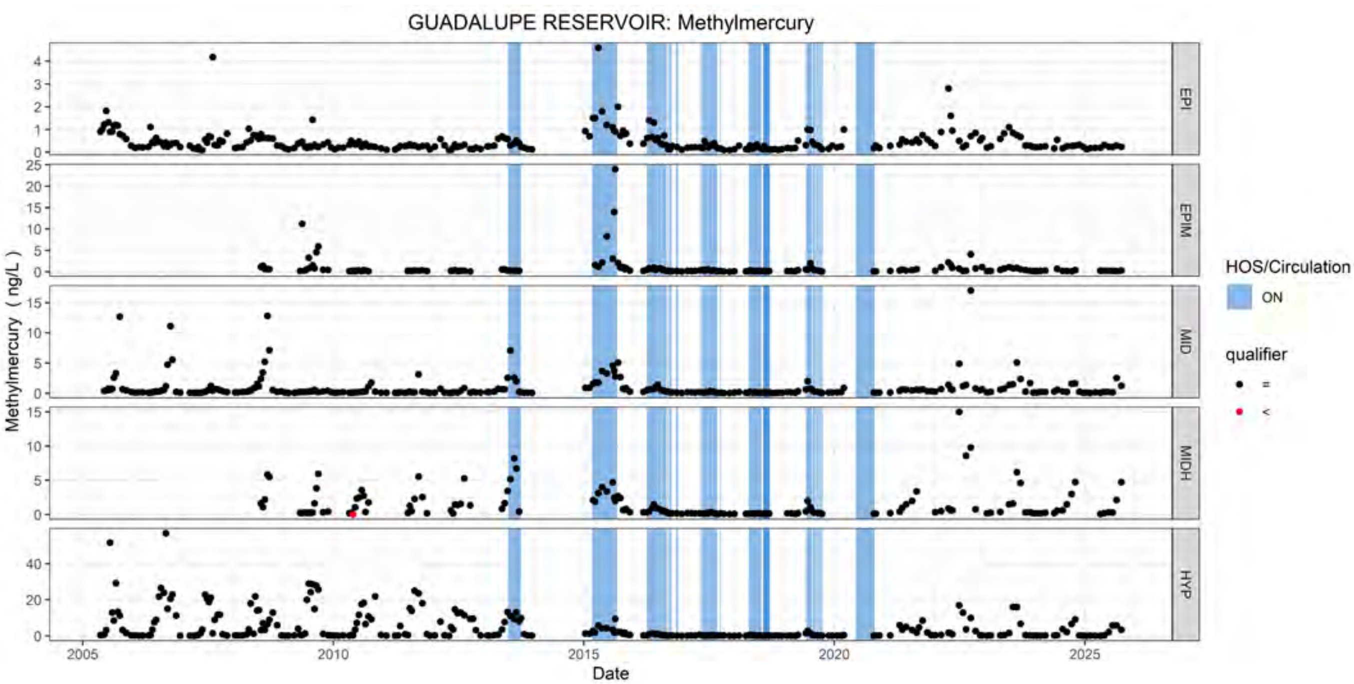
GUADALUPE RESERVOIR: Chloride
Chloride (mg/L)
Date
EPI
HYP
qualifier
=
HOS/Circulation
ON
2015
2020
2025



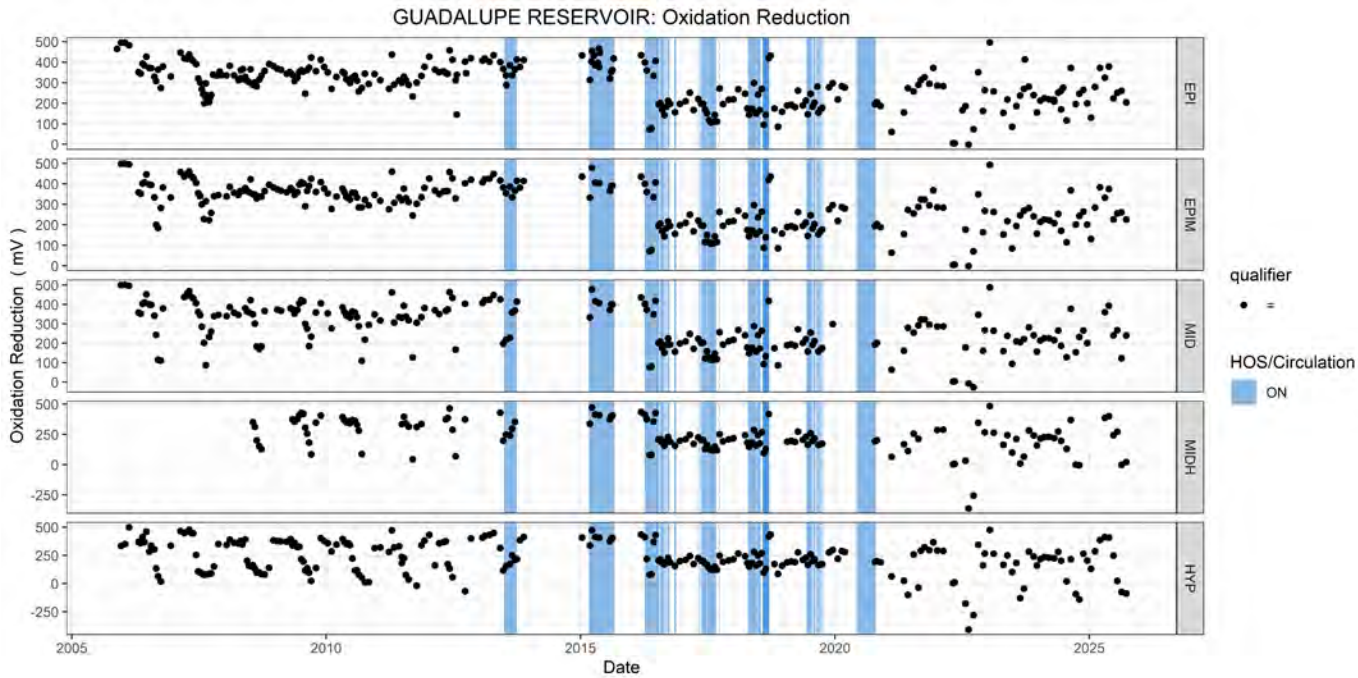
GUADALUPE RESERVOIR: Chlorophyll
Chlorophyll (ug/l)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON
2005
2010
2015
2020
2025

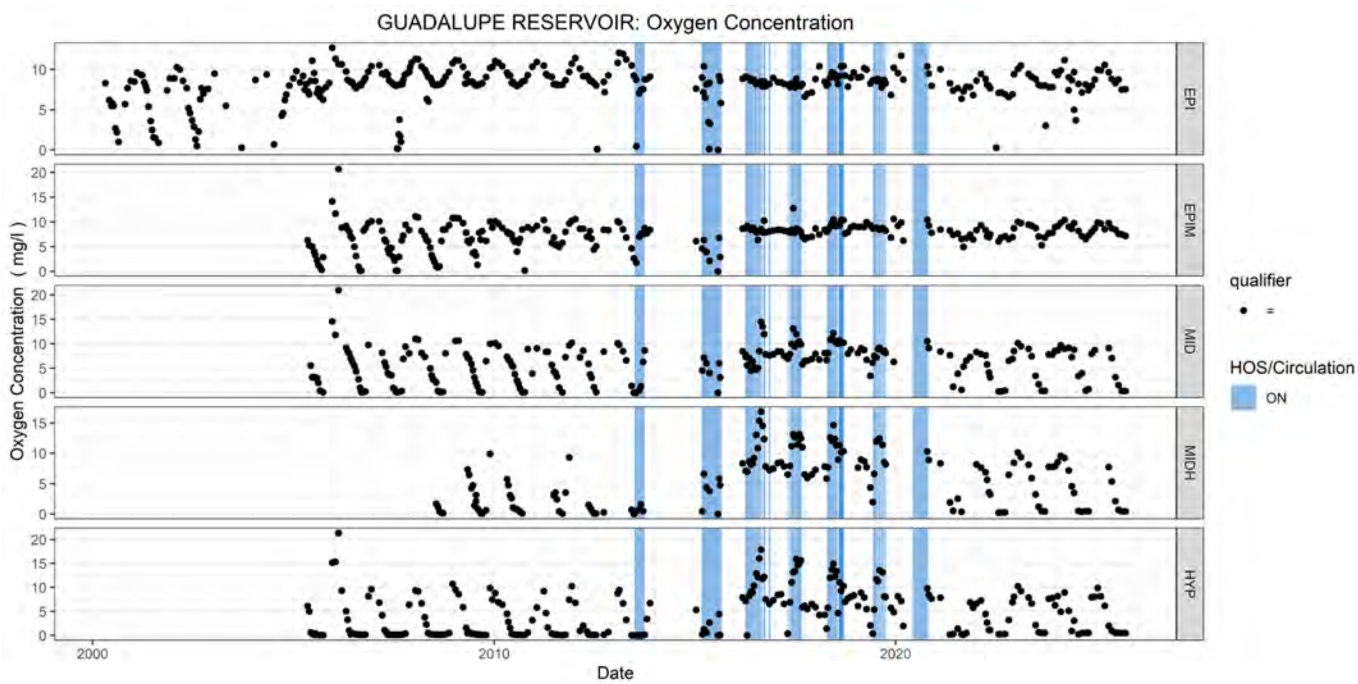


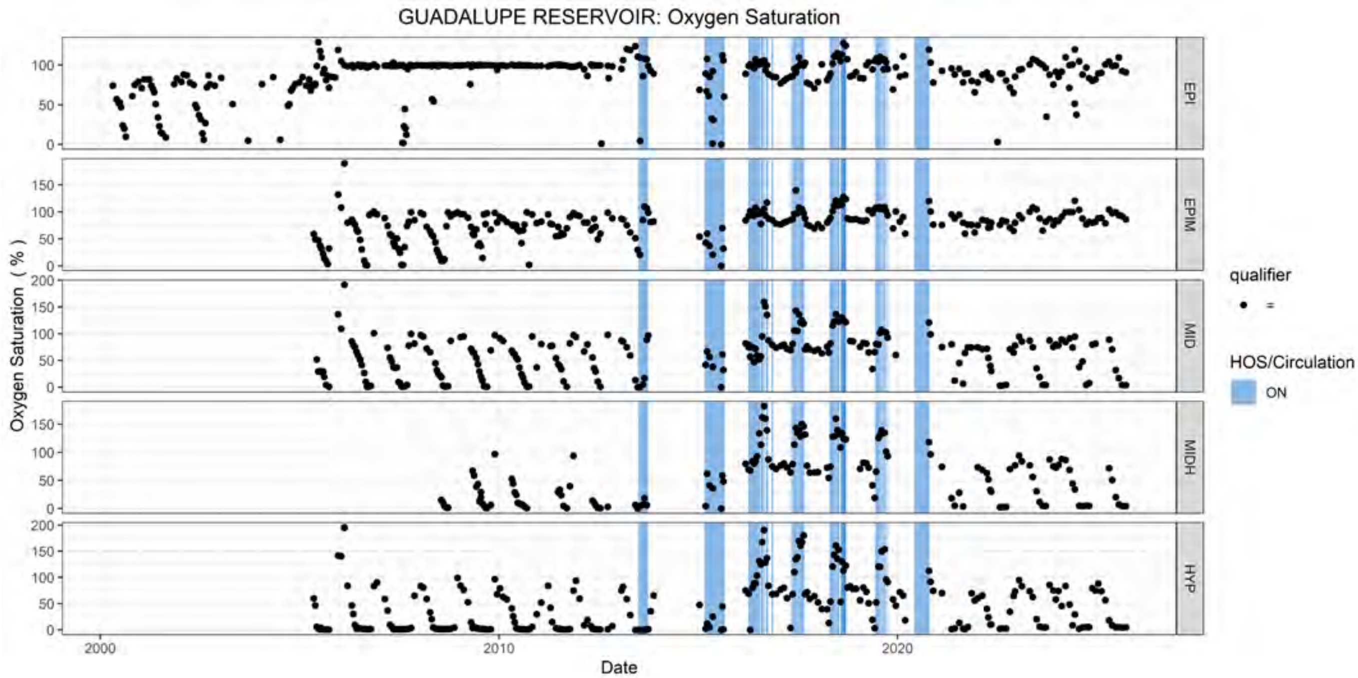
GUADALUPE RESERVOIR: Mercury
Mercury (ng/L)
EPI
HYP
Date
HOS/Circulation
ON
qualifier
=
<

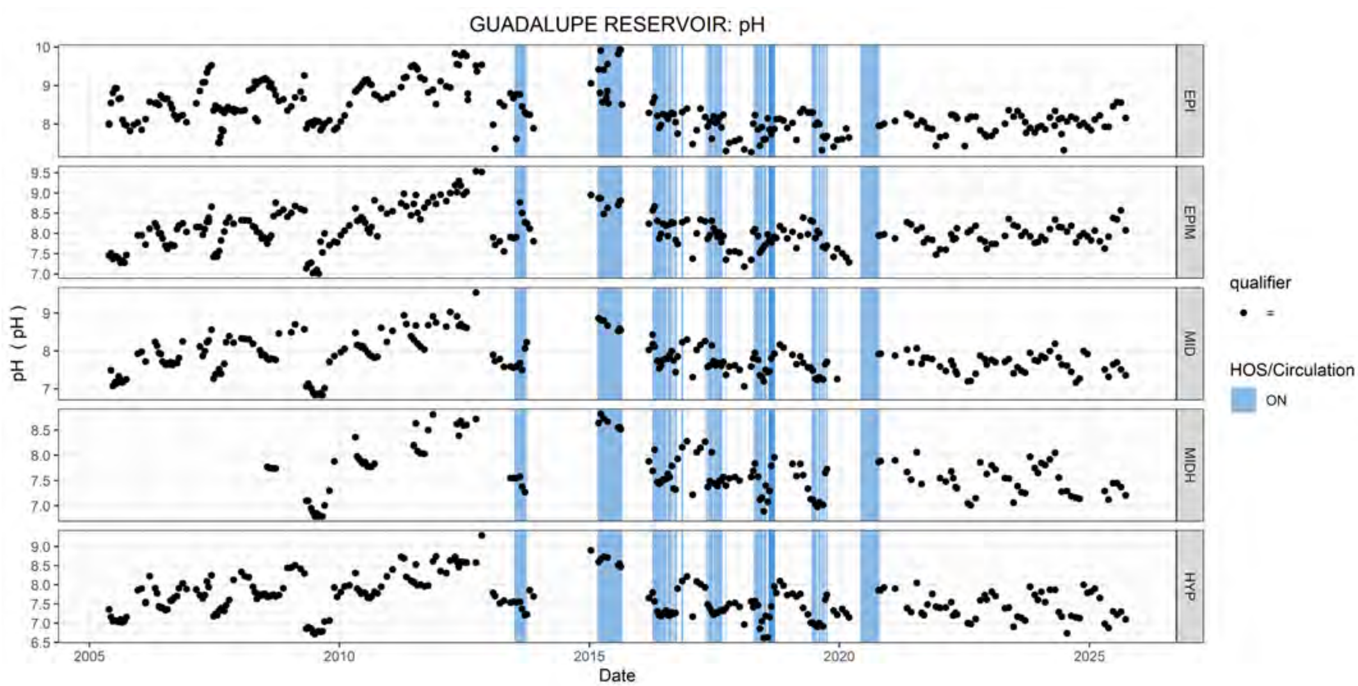


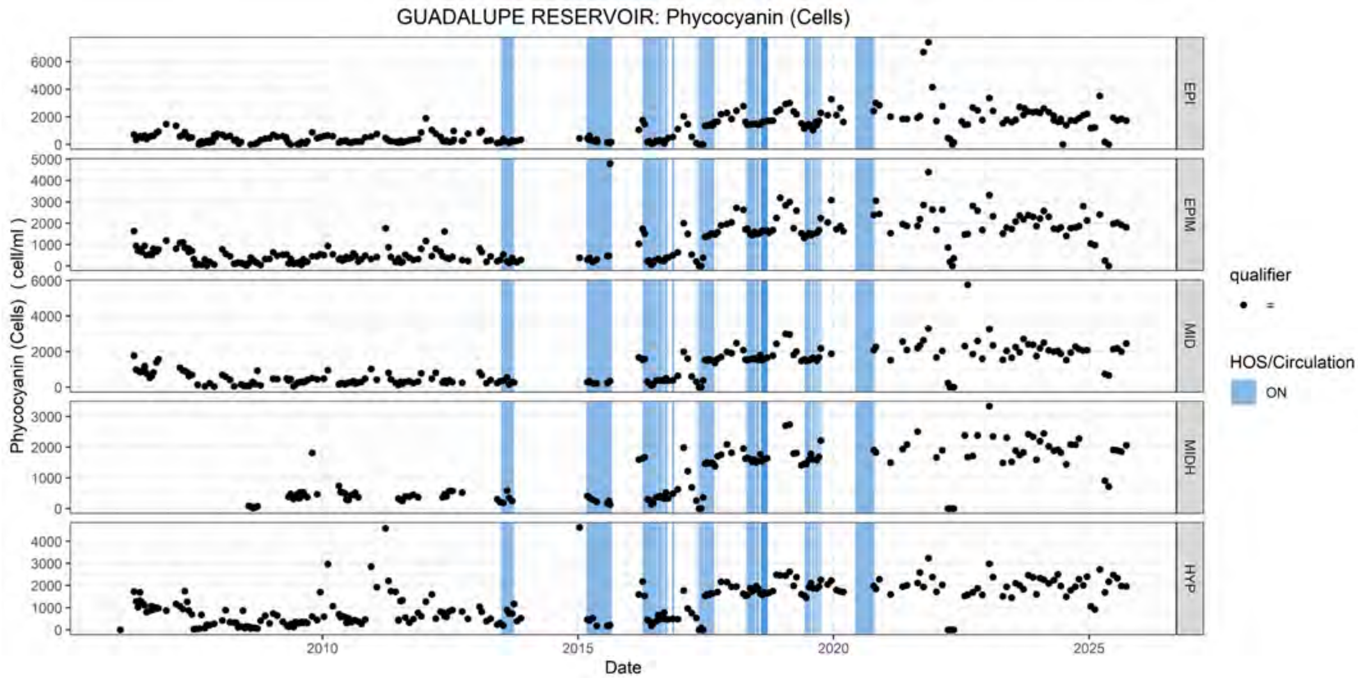
GUADALUPE RESERVOIR: Methylmercury
Methylmercury (ng/L)
EPI
EPIM
MID
MIDH
HYP
Date
HOS/Circulation
ON
qualifier
=
<

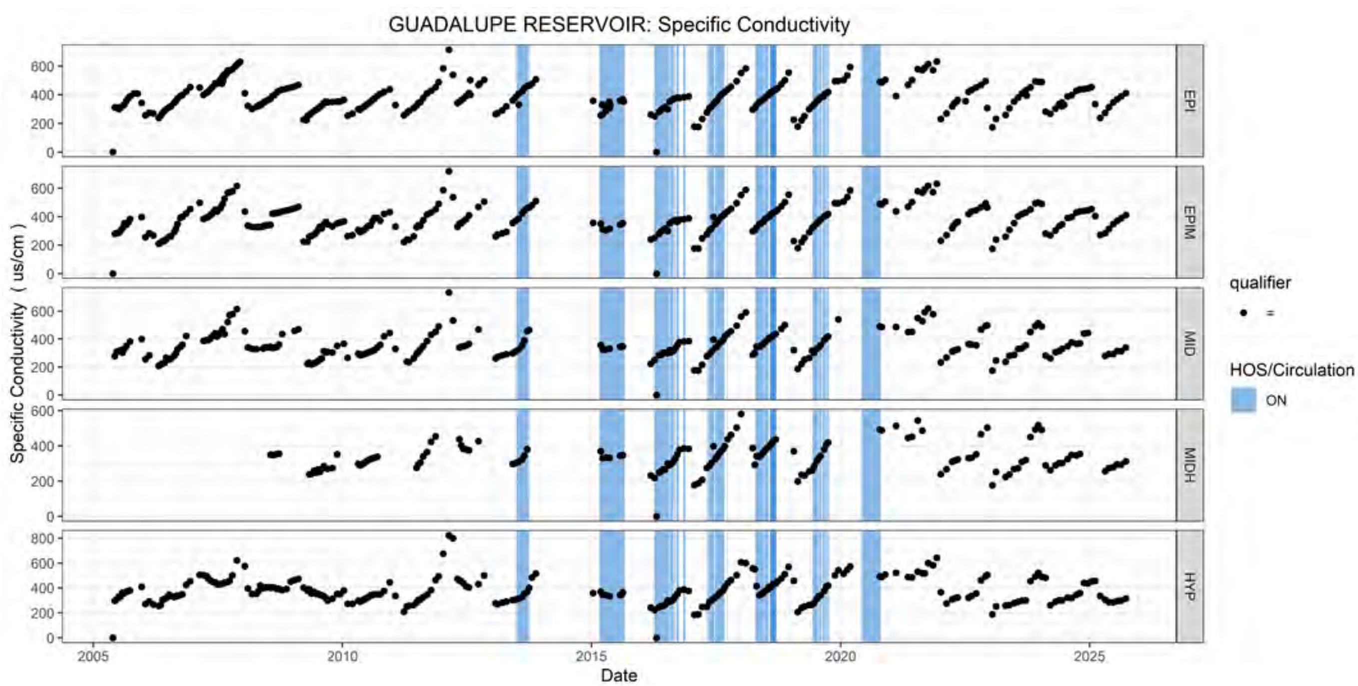

GUADALUPE RESERVOIR: Oxidation Reduction
Oxidation Reduction (mV)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

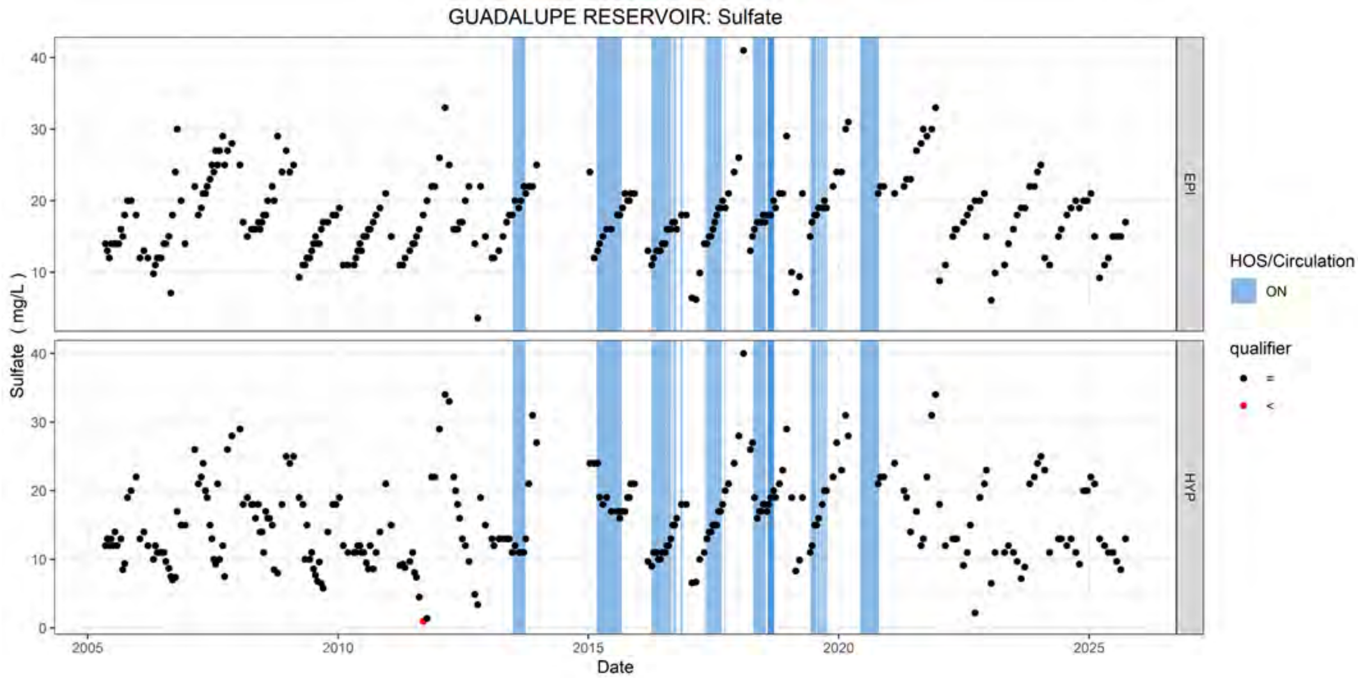

GUADALUPE RESERVOIR: Oxygen Concentration
Oxygen Concentration (mg/l)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

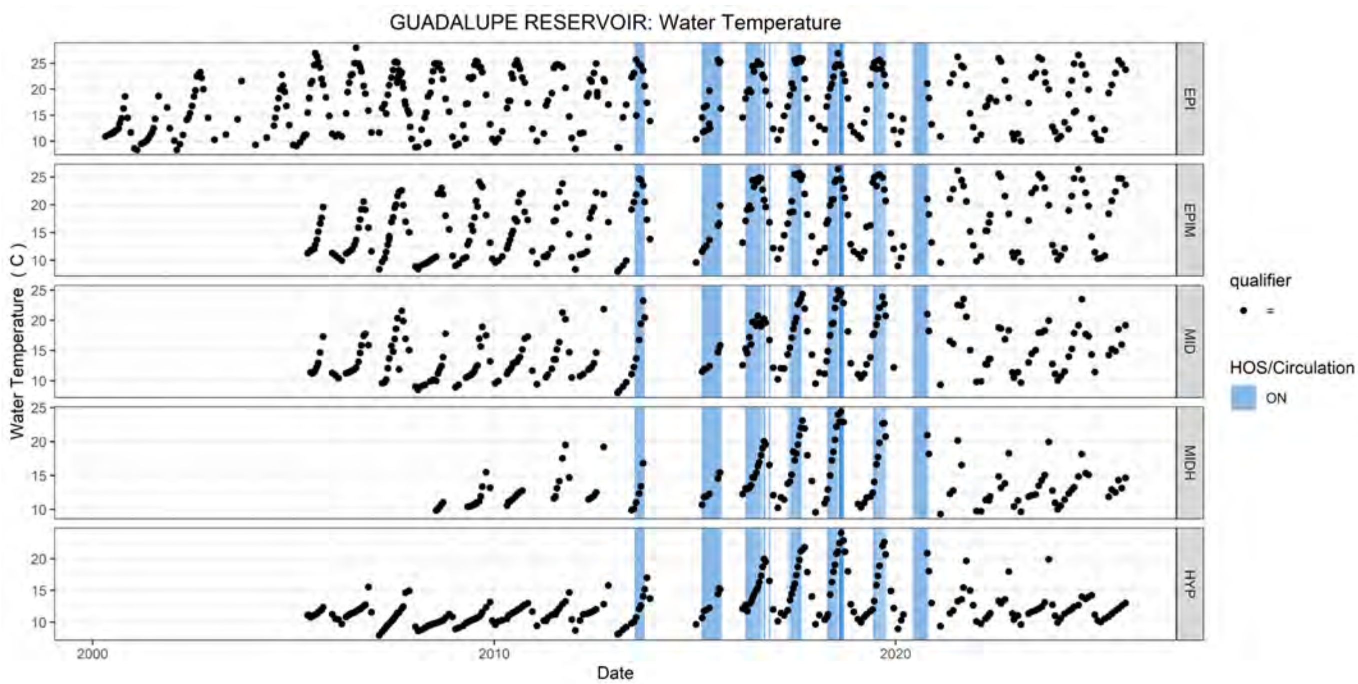

GUADALUPE RESERVOIR: Oxygen Saturation
Oxygen Saturation (%)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

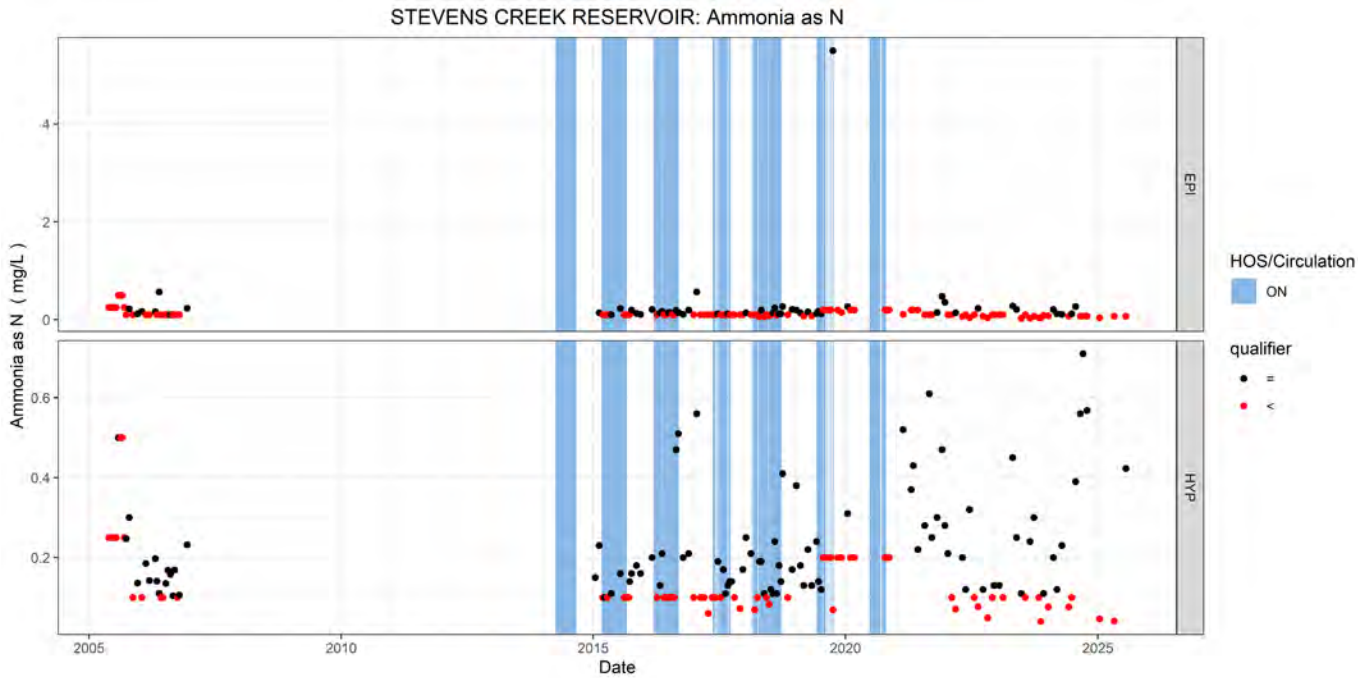

GUADALUPE RESERVOIR: pH
pH (pH)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

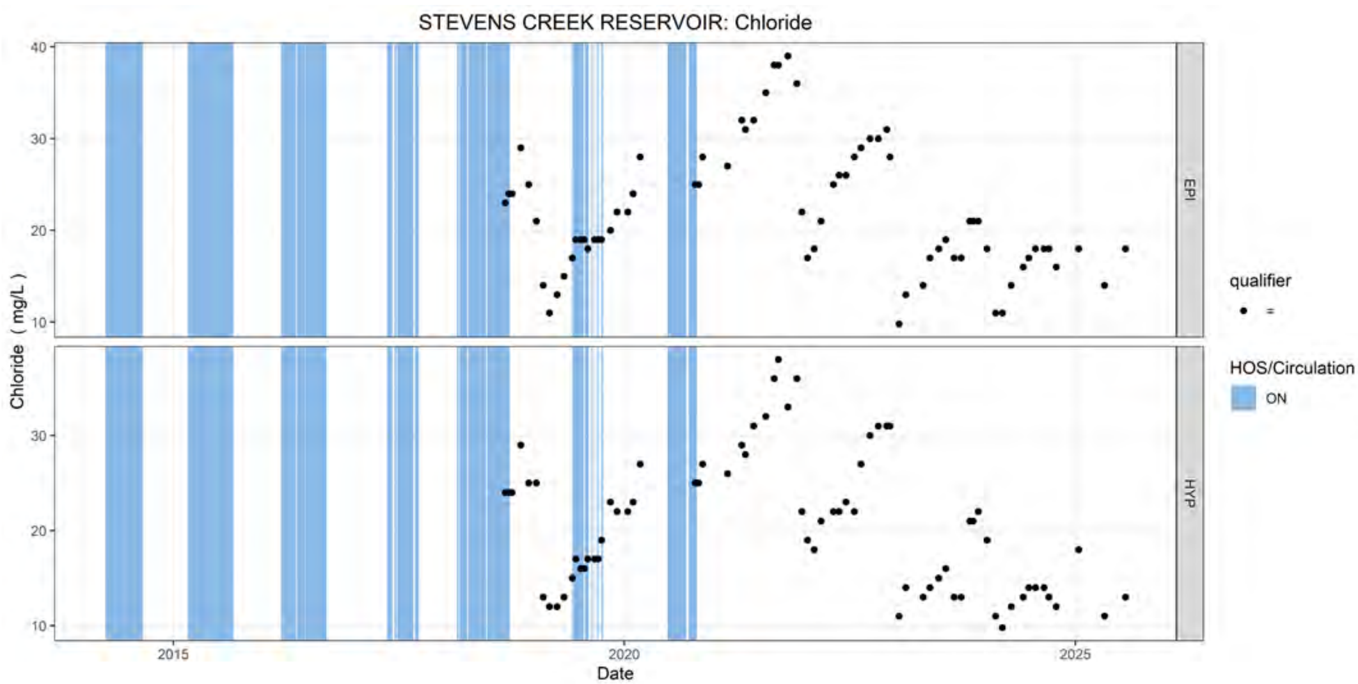

GUADALUPE RESERVOIR: Phycocyanin (Cells)
Phycocyanin (Cells) (cell/ml)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

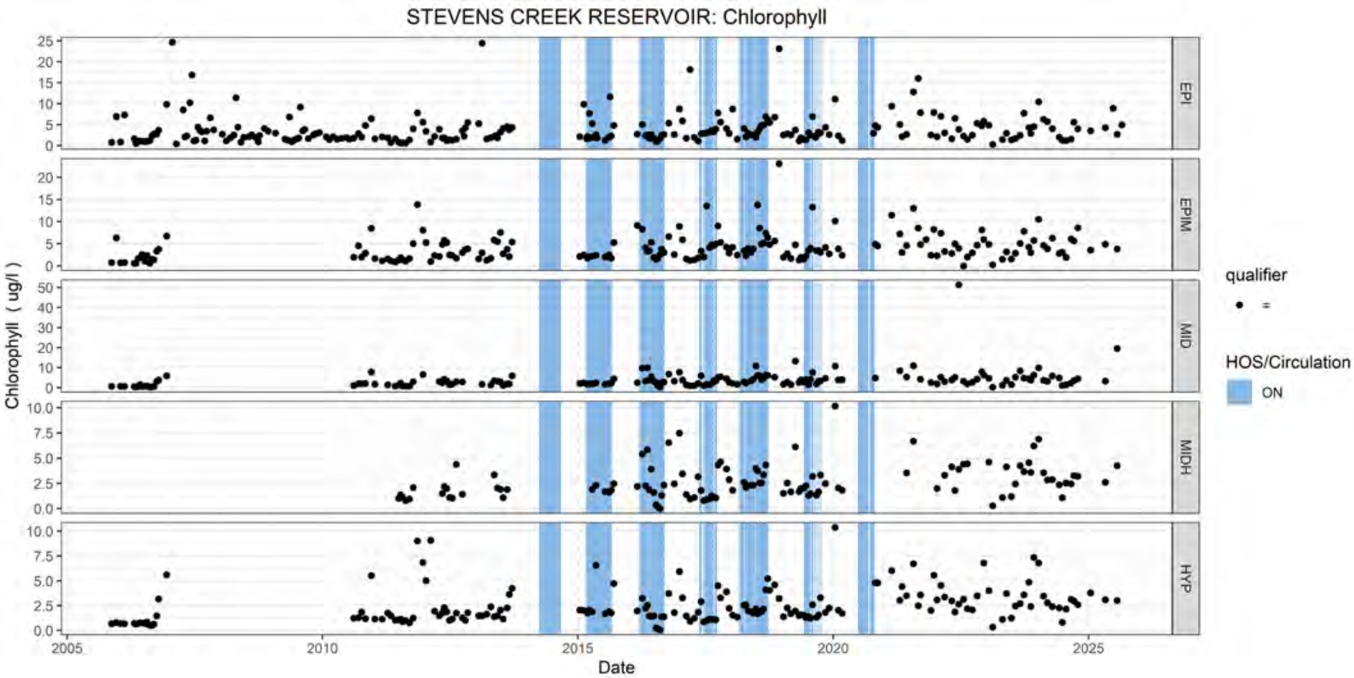

GUADALUPE RESERVOIR: Specific Conductivity
Specific Conductivity (us/cm)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
=
HOS/Circulation
ON

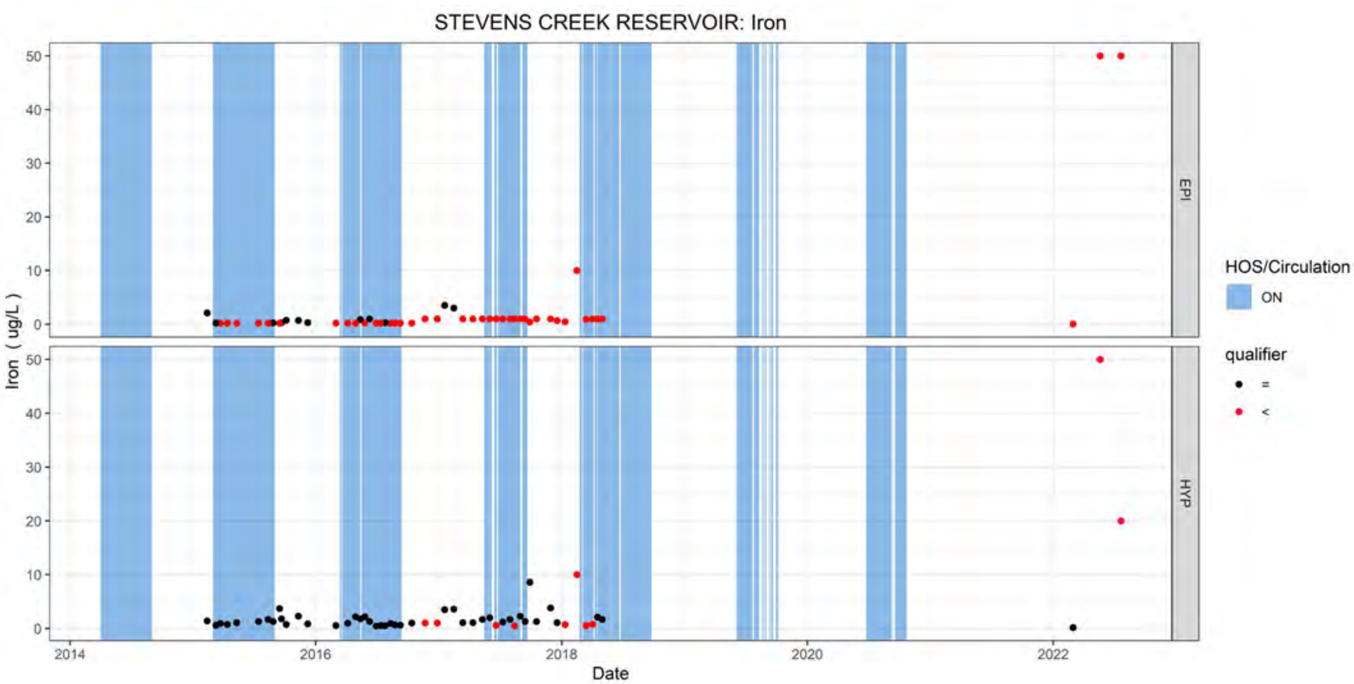

GUADALUPE RESERVOIR: Sulfate
Sulfate (mg/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020
2025

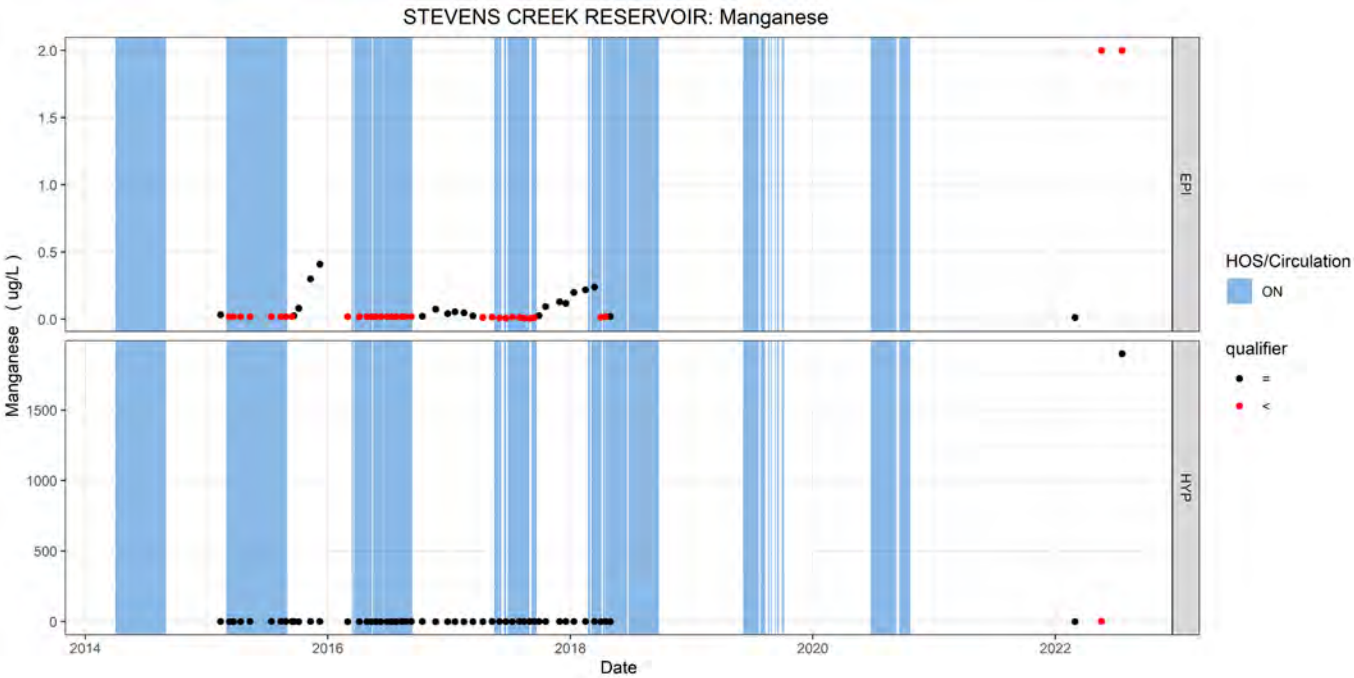

GUADALUPE RESERVOIR: Water Temperature
Water Temperature (C)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON
2000
2010
2020


STEVENS CREEK RESERVOIR: Ammonia as N
Ammonia as N (mg/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020
2025

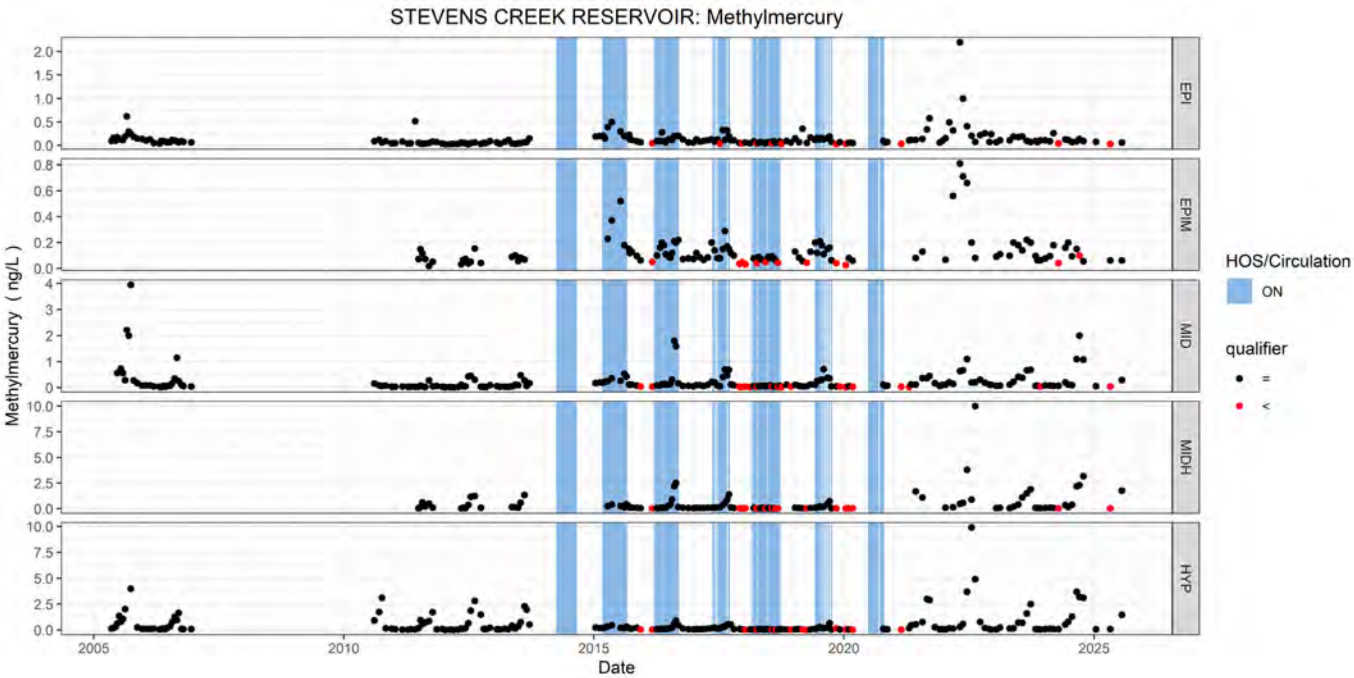

STEVENS CREEK RESERVOIR: Chloride
Chloride (mg/L)
Date
EPI
HYP
qualifier
=
HOS/Circulation
ON
2015
2020
2025


STEVENS CREEK RESERVOIR: Chlorophyll
Chlorophyll (ug/l)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON

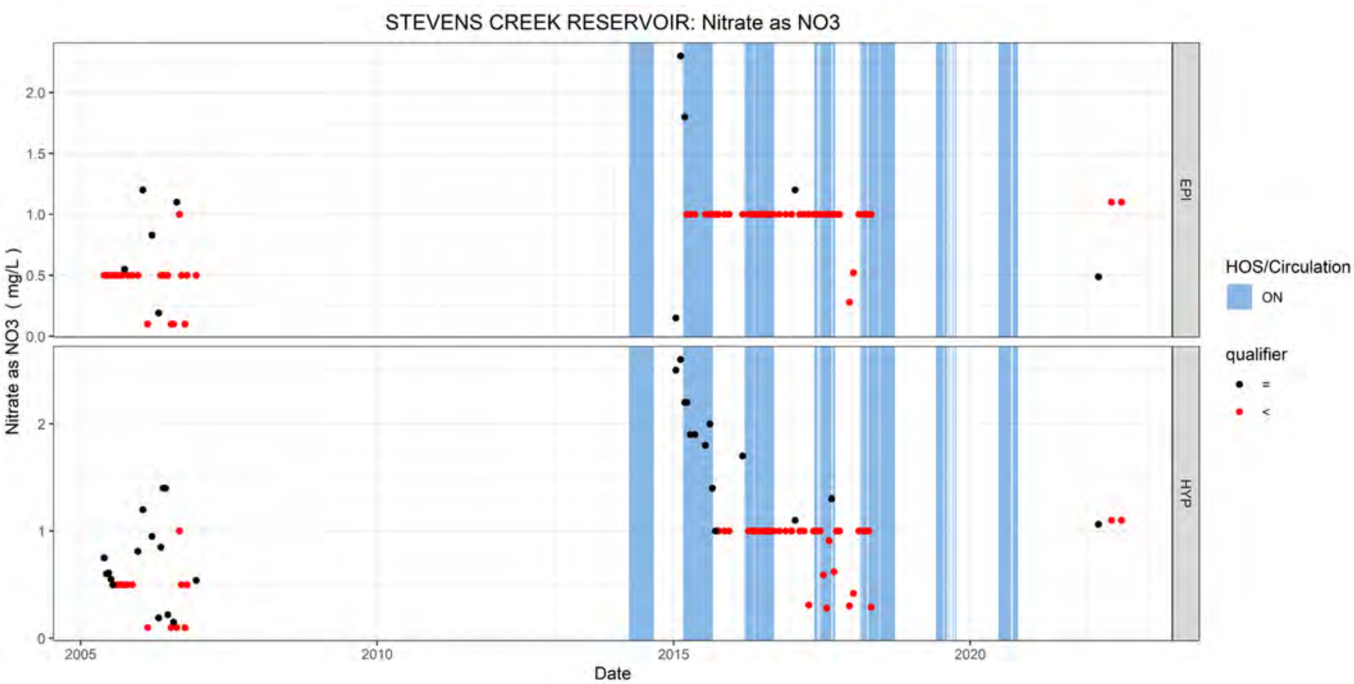

STEVENS CREEK RESERVOIR: Iron
Iron (ug/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<


STEVENS CREEK RESERVOIR: Manganese
Manganese (ug/L)
EPI
HYP
Date
HOS/Circulation
ON
qualifier
=
<

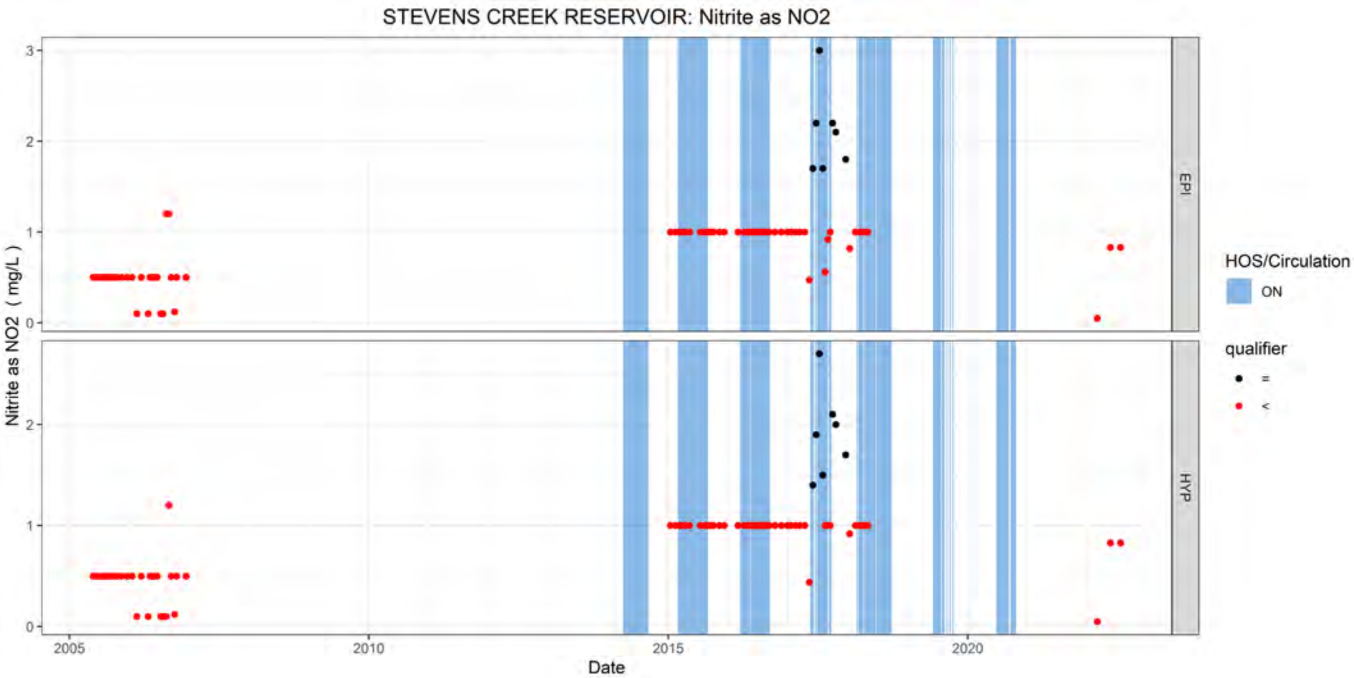

STEVENS CREEK RESERVOIR: Mercury
Mercury (ng/L)
EPI
HYP
Date
HOS/Circulation
ON
qualifier
=
<

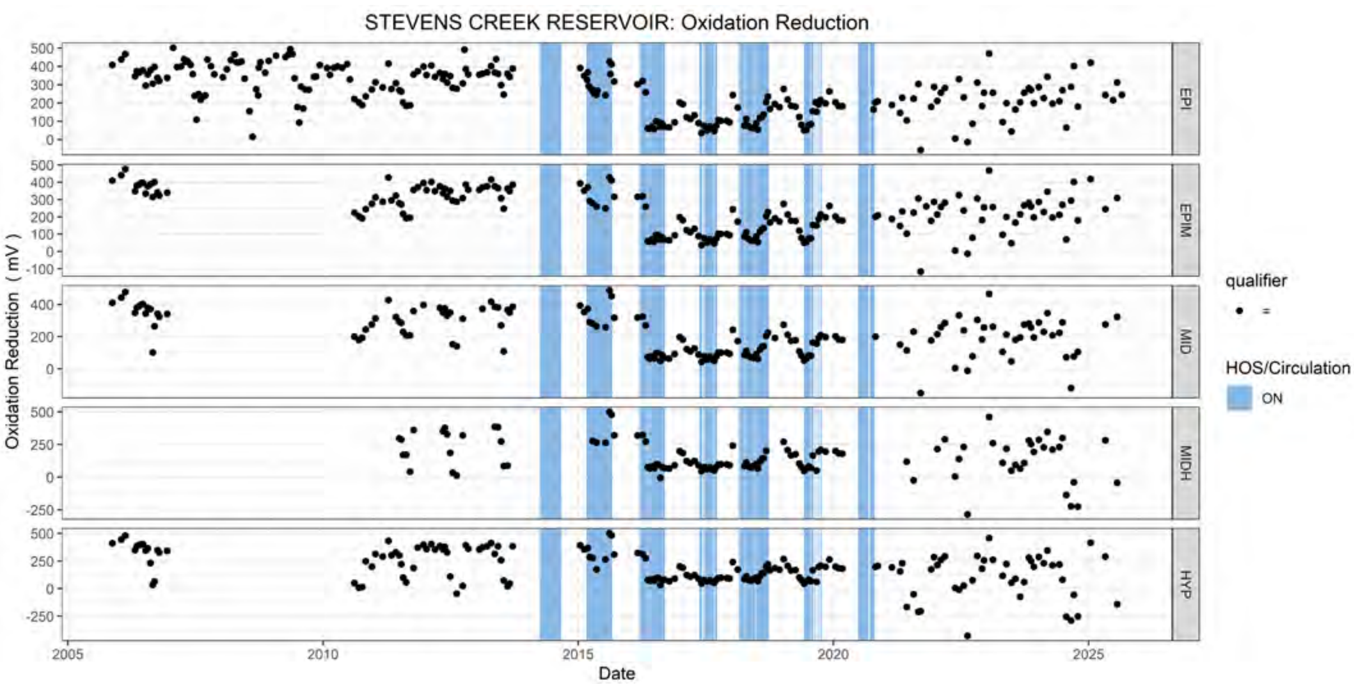


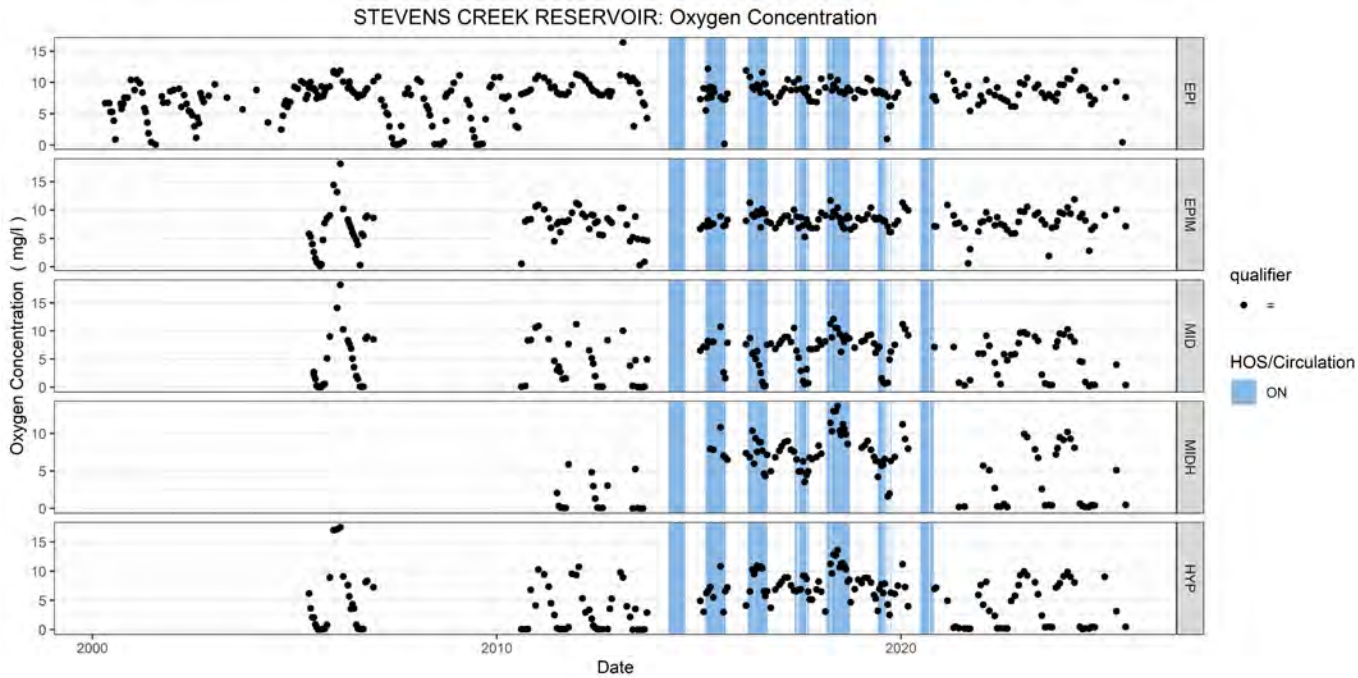
STEVENS CREEK RESERVOIR: Methylmercury
Methylmercury (ng/L)
EPI
EPIM
MID
MIDH
HYP
Date
HOS/Circulation
ON
qualifier
=
<



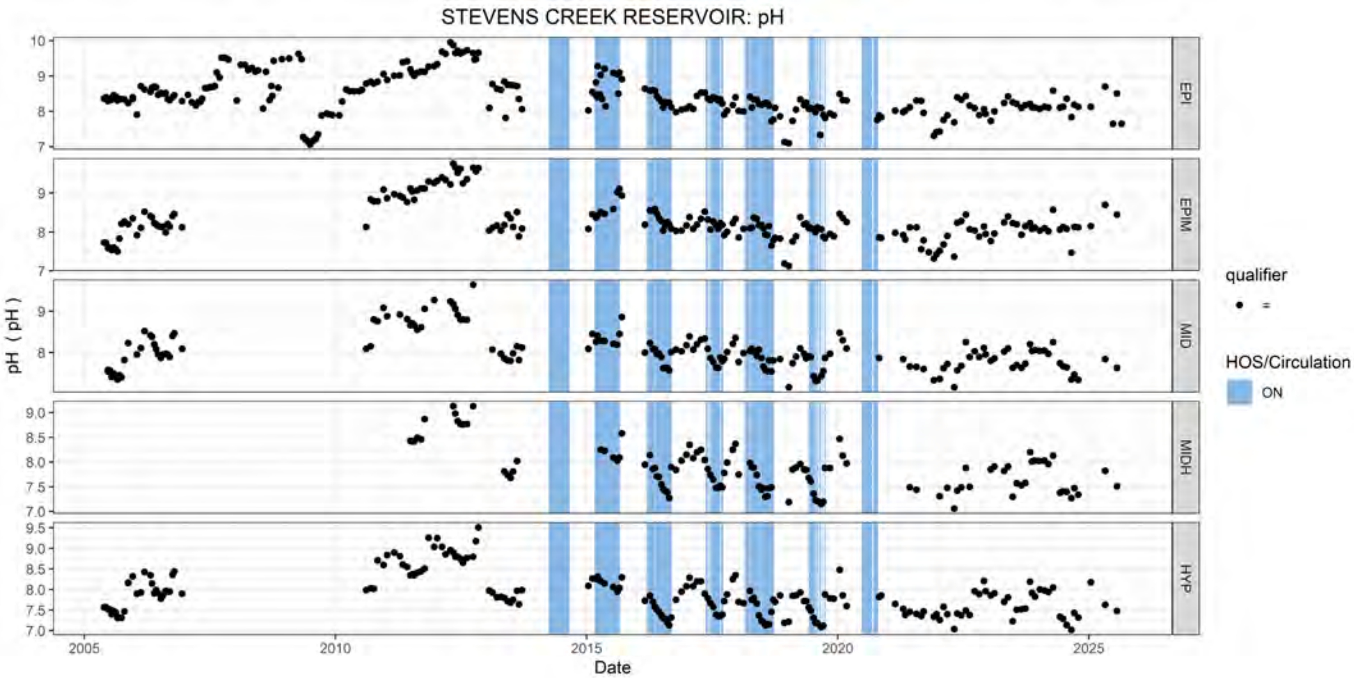
STEVENS CREEK RESERVOIR: Nitrate as NO3
Nitrate as NO3 (mg/L)
EPI
HYP
Date
HOS/Circulation
ON
qualifier
=
<

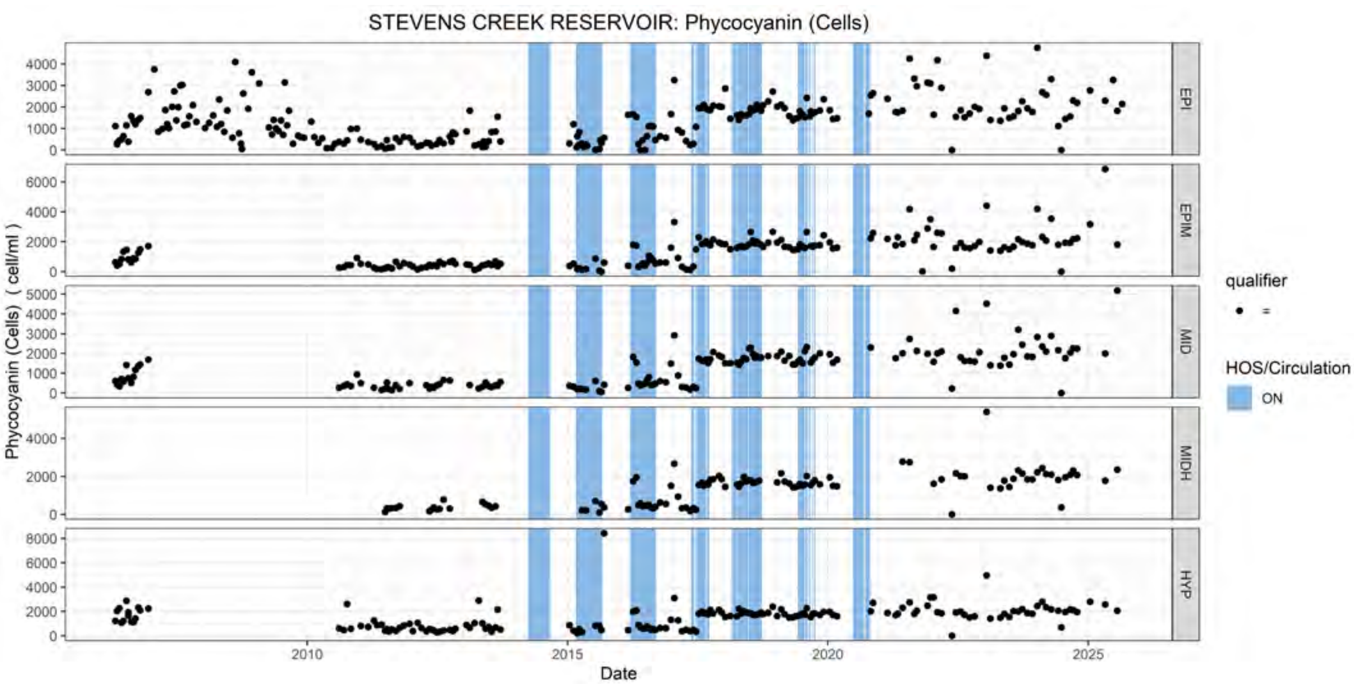

STEVENS CREEK RESERVOIR: Nitrite as NO2
Nitrite as NO2 (mg/L)
Date
EPI
HYP
HOS/Circulation
ON
qualifier
=
<
2005
2010
2015
2020

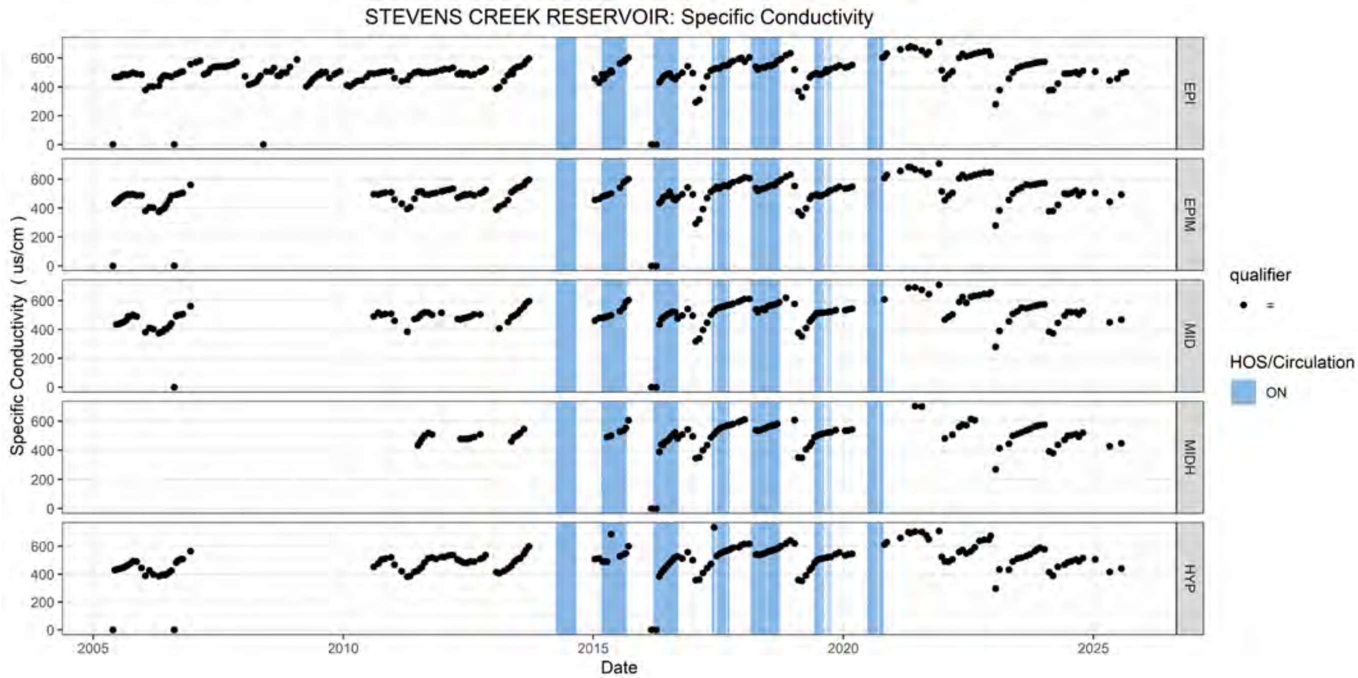

STEVENS CREEK RESERVOIR: Oxidation Reduction
Oxidation Reduction (mV)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON
2005
2010
2015
2020
2025

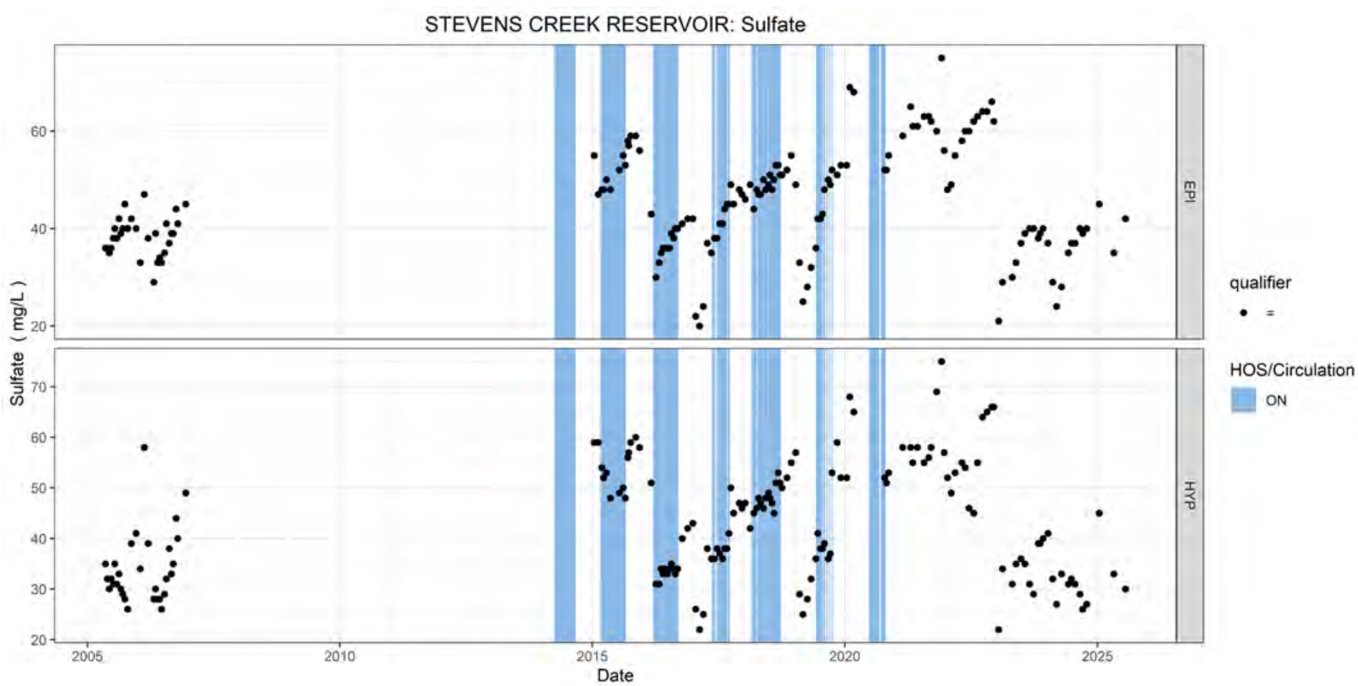

STEVENS CREEK RESERVOIR: Oxygen Concentration
Oxygen Concentration (mg/l)
Date
EPI
EPIM
MID
MIDH
HYP
2000
2010
2020
qualifier
=
HOS/Circulation
ON

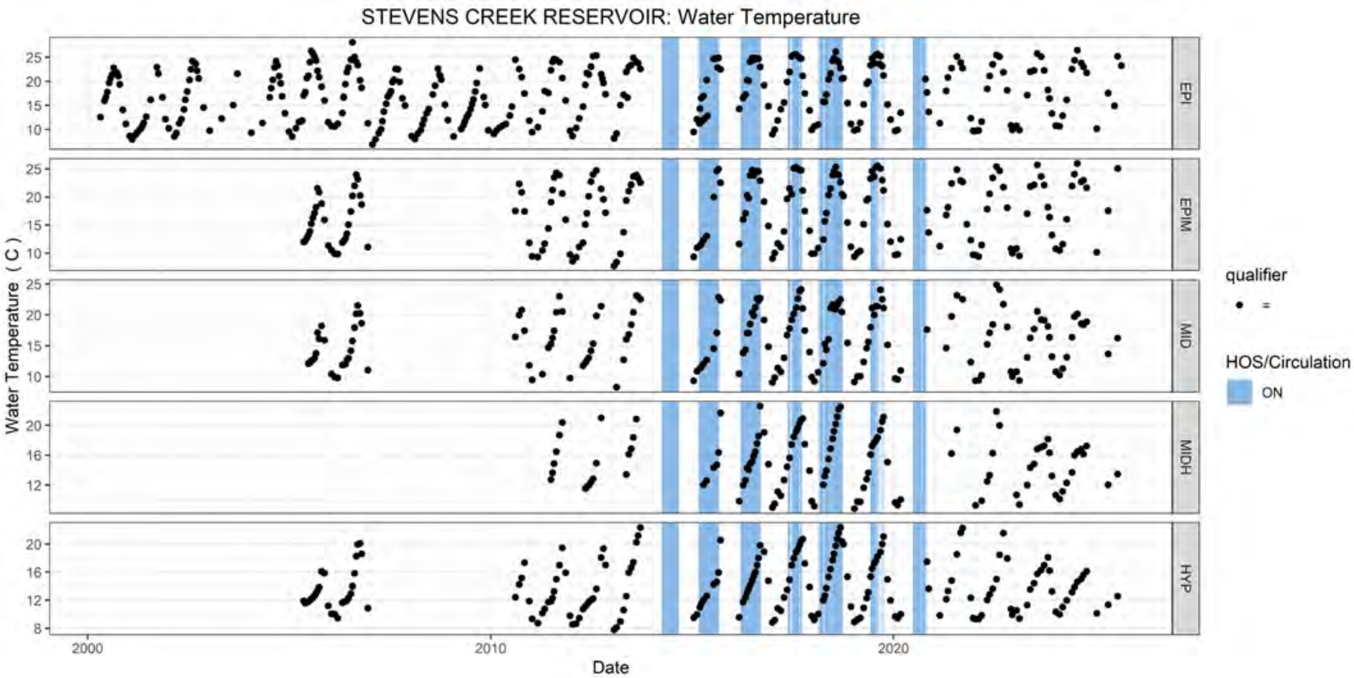

STEVENS CREEK RESERVOIR: Oxygen Saturation
Oxygen Saturation (%)
Date
EPI
EPIM
MID
MIDH
HYP
2000
2010
2020
qualifier
=
HOS/Circulation
ON


STEVENS CREEK RESERVOIR: pH
pH (pH)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON


STEVENS CREEK RESERVOIR: Phycocyanin (Cells)
Phycocyanin (Cells) (cell/ml)
Date
EPI
EPIM
MID
MIDH
HYP
qualifier
=
HOS/Circulation
ON


STEVENS CREEK RESERVOIR: Specific Conductivity
Specific Conductivity (us/cm)
EPI
EPIM
MID
MIDH
HYP
Date
qualifier
HOS/Circulation
ON


STEVENS CREEK RESERVOIR: Sulfate
Sulfate (mg/L)
EPI
HYP
Date
qualifier
HOS/Circulation
ON



STEVENS CREEK RESERVOIR: Water Temperature
Water Temperature (C)
Date
EPI
EPIM
MID
MIDH
HYP
2000
2010
2020
qualifier
=
HOS/Circulation
ON