East Bay Regional Park District

Harmful Algal Blooms (HABs) 2023 Annual Report

East Bay Regional Park District's Monitoring and Remediation Program Summary

Execute Summary

The East Bay Regional Park District (Park District) provides healthy and safe outdoor recreational opportunities across Alameda and Contra Costa Counties. Understanding risk factors helps the Park District ensure safe recreational conditions. Cyanobacteria and their toxins have created challenging conditions in recreational waterbodies. The Park District has created an internal cross-divisional team and a plan to address these risk factors. The program includes pre-emptive surveys and monitoring to identify poor water quality conditions as early as possible. In evaluating safety, the Park District follows State guidance for Harmful Algal Blooms (HABs) postings and reporting and provides extensive public notification of the conditions. The Park District also uses nutrient monitoring in Lake Anza and Lake Temescal to help inform possible options for remediating HABs.

This Annual Report summarizes Park Districts' actions, monitoring data, remediation actions and closure reporting for 2023. Of note is that after 8 years of fish toxin testing no toxins have been detected in fish fillets and thus confidence in our fisheries' health is maintained[1]. The nutrient treatments at Lake Temescal were not as successful as hoped and closure advisories ended the 2023 recreational swim season on August 30th. Lake Anza's hypolimnetic oxygenation system (HOS) has been successful in drastically reducing the annual phosphorus spikes from the sediment during the summer months, but there are still eutrophic levels of phosphorus bioavailable. The report discusses plans and strategies for 2024 as the Park District continues its adaptive management approach.

Background

The East Bay Regional Park District (Park District) preserves a rich heritage of natural and cultural resources across Alameda and Contra Costa Counties. Park District lands span 125,000 acres, encompassing 73 unique parks with 1,250 miles of trails and 55 miles of shoreline. Harmful Algal Blooms (HABs) have been the causative agent of frequent closures of Park District beaches since the first documented toxic bloom at Lake Temescal in 2014. The HABs program was created to ensure public health and safety are achieved. Utilizing data-based decision

[1] One exception was due to cross-contamination of filets during sampling

making, the Park District implements an adaptive management framework that supports our goals of reducing the number of annual HABs related closures and providing safe water body-contact recreational experiences at our freshwater recreation areas.

This 2023 annual report is prepared for and submitted to the San Francisco Regional Water Quality Control Board to describe the Park District's activities to monitor and remediate HABs in our recreational lakes and reservoirs. These annual summary reports have been prepared and submitted since 2017.

HABs Program Introduction

In 2014, the Park District began an active HABs monitoring program at our fresh water recreational swimming areas: Lake Anza, Lake Temescal, Shadow Cliffs, Horseshoe Lake at Quarry Lakes, and Del Valle. Prioritizing public health and safety, our HABs program is vital to maintaining our freshwater swim areas. As blooms occurred at non-body contact water bodies, including Lake Chabot, Big break and Contra Loma, the Park District added those sites to our visual monitoring and collects samples and report advisories as needed.

Monitoring and Postings

The Park District uses a modified version of guidance provided by the California Cyanobacteria and Harmful Algal Bloom (CCHAB) Network to identify the trigger levels for posting HABs "Caution" and "Danger/Closure" signage (**Table 1.**). Monitoring is conducted weekly April through October and twice monthly November through March.

The Park District website is regularly updated as waterbody advisory designations change, and weekly email updates are sent to a variety of internal and external stakeholders. HABs monitoring is done in addition to bacteria monitoring at recreational swim beaches.

Table 1. *Park District modified cyanotoxin trigger levels based on CCHAB Network guidance.*

	Caution Action Trigger	Danger/Closure Action Trigger
Primary Tiggers		
Total Microcystins	0.8 µg/L	6 µg/L
Anatoxin-A	Detection	20 µg/L
Cylindrospermopsin	1 µg/L	4 µg/L
Secondary Tiggers		
	Blooms, scums, mats, etc.	

Remediation Overview

Beginning in 2017, the Park District installed temperature and dissolved oxygen (DO) loggers into Lake Temescal at the deepest area of the lake near the dam and began monthly monitoring

for standard water quality parameters, nutrient data (**Appendix A**), and depth profiles at designated sites. DO and temperature loggers are currently maintained at both Lake Anza and Lake Temescal, which have provided valuable data used to evaluate the effectiveness of treatment methods. For example, at Lake Temescal, water quality data was used to discern the effects of nutrient binding agents[2] on orthophosphate and phosphate levels. The Park District also maintains a robust dataset of water quality parameters for Lake Anza and Lake Temescal dating from August 2017 to the present.

Fish Tissue Monitoring

The Park District has been collecting fish tissue samples[3] to better understand the effects of HABs on freshwater fish from our lakes and reservoirs since 2015. Due to COVID-19 restrictions in 2020, no fish tissue samples were collected that year, but annual collections resumed in 2021.

[2] Nutrient binding agents used at Lake Temescal since 2017 are Phoslock, Aluminum Sulfide, and EutroSorb

[3] Liver and muscle fillet samples are collected annually.

2023 HABs Program Activities

Communication

In 2023, the Park District continues to send regular (weekly or bi-weekly) lake conditions and monitoring updates to stakeholders from state and local regulatory agencies, internal groups, and various park and water municipality partners. Public outreach occurred via website postings and physical signage postings at swim areas, park entrances, and known dog accessible entry points (**Figure 1**).

Figure 1. *The East Bay Regional Park District's HABs advisory signage.*

Monitoring and Toxin Analysis

The Park District performed routine monitoring at eight different parks (**Figure 2**) and periodic monitoring at a handful of other locations in 2023. Periodic monitoring took place when trained staff were dispatched to non-routine locations for other workstreams and were able to batch HABs monitoring into the same field day. Cyanotoxin testing took place depending on need-based factors including recreational usage, visual observations, and current advisory postings.

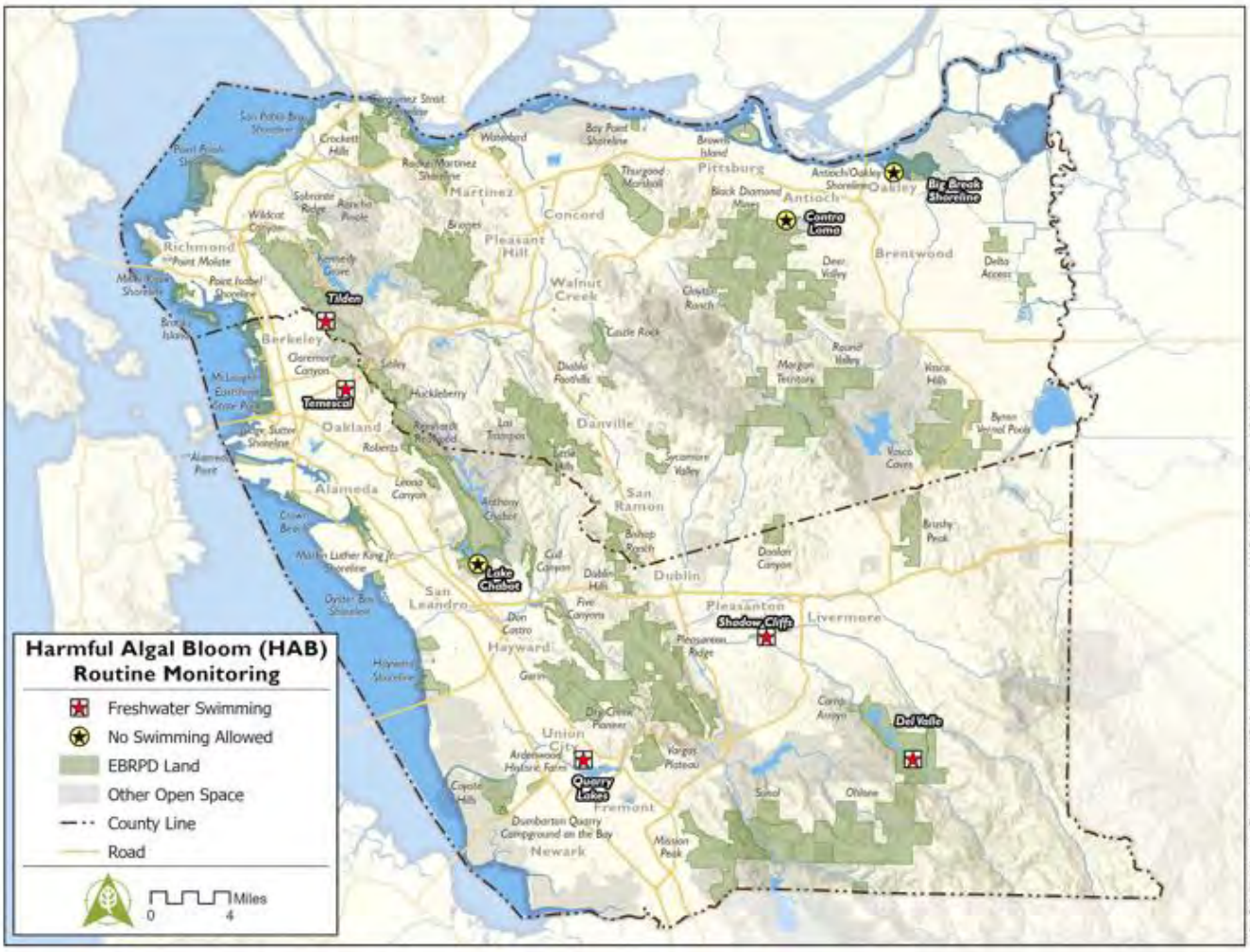

Figure 2. *Map of routine HABs monitoring locations, represented by red stars. Locations are as follows: Contra Loma, Big Break, Lake Anza, Lake Temescal, Lake Chabot, Shadow Cliffs, Quarry Lakes, and Del Valle.*

Testing was done primarily through either strip test kits or using our Cyanotoxin Automated Assay System (CAAS). In August, the Park District upgraded our CAAS to the newer CAAS Cube model. There are no differences in detection limits between the older and newer CAAS models. The maximum detection limit of both machines is 5 parts per billion (ppb) undiluted, which can be brought up to a maximum of 50 ppb via sample dilution at a 1 to 10 ratio. The minimum detection limit is 0.15 ppb for undiluted samples. The strip test kits are used to detect Microcystins, Cylindrospermopsin, Anatoxin-A, and Saxitoxin, with detection limits ranging from 2.5 to 10 ppb depending on the analyte. Occasionally, strip test kits were diluted at a 1 to 1 ratio to double the maximum detection limit to 20 ppb.

Postings and Closures

The Park District experienced many HABs related advisory postings and closures in 2023. In general, these advisories are prompted by cyanobacteria toxin tests, but the presence of benthic cyanobacteria will also prompt a Caution advisory. Figure 3 shows a breakdown of all advisories and closures at Park District reservoirs and lakes, including waterbodies that do not allow body contact. This year also saw the re-opening of two swimming areas that had formerly been closed for years. Lake Anza re-opened to swimming after being closed since 2019 due to maintenance issues and COVID restrictions. Shadow Cliffs Reservoir also re-opened to swimming this year after closing to swimming and boating in 2020 due to low water levels.

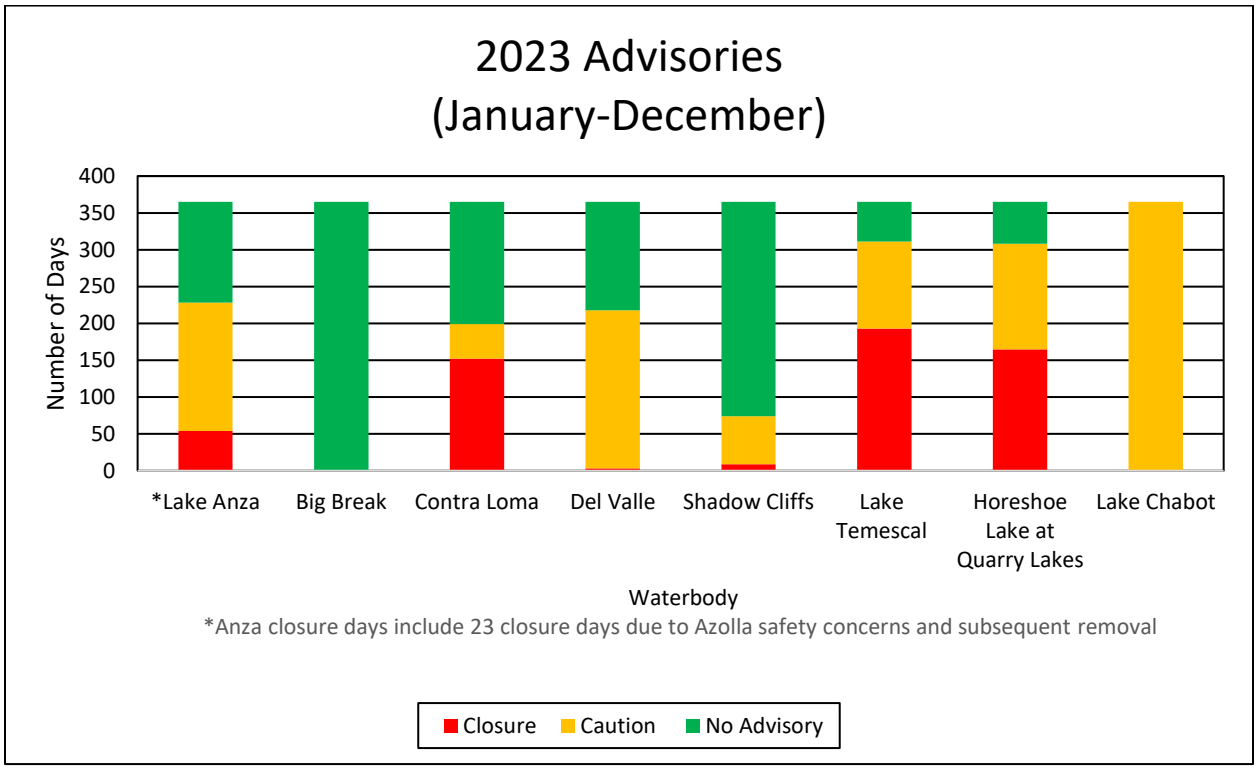

Figure 3. *2023 HABs advisories at all Park District fresh waterbodies.*

Lake Anza had periods of closure during swim season. Of the 54 closure days, 31 days were due to HABs Danger/Closure advisory postings. The remaining 23 days of closure were due to a population boom of *Azolla*, a small aquatic fern, that completely covered the swim area and most of the lake in the middle of August. Out of concern for the safety of our patrons, the Park District closed the swim area and removed the *Azolla* through a combination of boom netting, raking, and mechanical harvesting. The beach re-opened the second week of September. Unfortunately, ten days after re-opening, the lake experienced a HABs bloom that closed swimming again and the swim beach remained closed the remainder of swim season.

Big Break Regional Shoreline is the Park District's only Delta access point that is routinely monitored for HABs. Though swimming is not allowed at Big Break, it is a popular launch site for kayakers. In 2023, Big Break was the only routinely monitored site that had no HABs advisories. Though planktonic cyanobacteria were observed in very low quantities a handful of times, no toxins were detected.

Contra Loma Reservoir is another location that does not allow body contact, but it is open to boating and fishing. Contra Loma inherited a Caution Advisory from the end of 2022, which was de-posted mid-February. At the beginning of August, a bloom produced high toxins prompting the posting of Danger Advisory signage, which remained in place the rest of the year.

Del Valle inherited a Danger advisory from 2022 that lasted until Feb 5th, 2023, and in late December 2023, Del Valle reservoir had an increase in cyanobacteria biomass and closed to water contact with a cyanobacteria Danger advisory (December 28, 2023).

Shadow Cliffs Arroyo also inherited a Danger advisory from 2022 that lasted until Feb 3rd, 2023, and in late December 2023 Shadow Cliffs Reservoir had an increase in cyanobacteria biomass and closed to water contact with a cyanobacteria Danger advisory (December 22, 2023).

Lake Temescal began the year with a Caution advisory inherited from 2022. In April, all advisory signage was removed. The first week of June, the swim beach opened for the season, but was quickly closed again when a cyanobacteria bloom brought the lake to a Danger advisory. After myriad treatments, the beach was able to open at a Caution advisory for about two weeks before again being closed for another Danger advisory, where it stayed the rest of the year.

Horseshoe Lake at Quarry Lakes inherited a Danger advisory from 2022 that carried through the last week of February when advisory signage was swapped for Caution advisory. A month later at the end of March, the lake went back to Danger advisory signage. At the beginning of August, toxins dropped enough to allow the swim beach to re-open at a Caution advisory. In mid-September, all advisory signage was taken down for a month until it went back to a Caution in mid-October. The lake ended the year with no advisory signage after everything was de-posted on December 8th.

Shinn Pond and Lago Los Osos at Quarry Lakes Regional Recreation Area started the year off with Caution advisories from 2022, and Horseshoe Lake's Danger advisory was posted on Dec 30th, 2022. Horseshoe Lake was downgraded to a Caution advisory on Feb 24th and was back to a Danger advisory on March 30th. Horseshoe Lake oscillated back to a Caution advisory on April 20th and quickly back to a Danger advisory on May 4th. The swim beach was closed from May 4th until August 2nd. On April 2nd, Horseshoe Lake was downgraded to a Caution advisory and the swim beach re-opened. All cyanobacteria advisories were removed at Horseshoe on Sept 15th, and on October 19th Horseshoe was back to a Caution advisory. On December 8th, Horseshoe

Lake was downgraded, and all advisories were removed. 2023 ended without any cyanobacteria advisories.

Lake Chabot is a special status lake in that its posting status has not changed since 2015. Caution Advisory signage is always posted around the lake regardless of toxin concentration or bloom conditions.

2023 Swim Season Advisories

The Park District's official swim season spans from April through October, though operations staff can choose to alter the swim season of their parks based on factors including, but not limited to, staffing availability, water quality concerns, maintenance needs. All freshwater swim areas experienced HABs related advisory postings during swim season in 2023 (**Figure 4**).

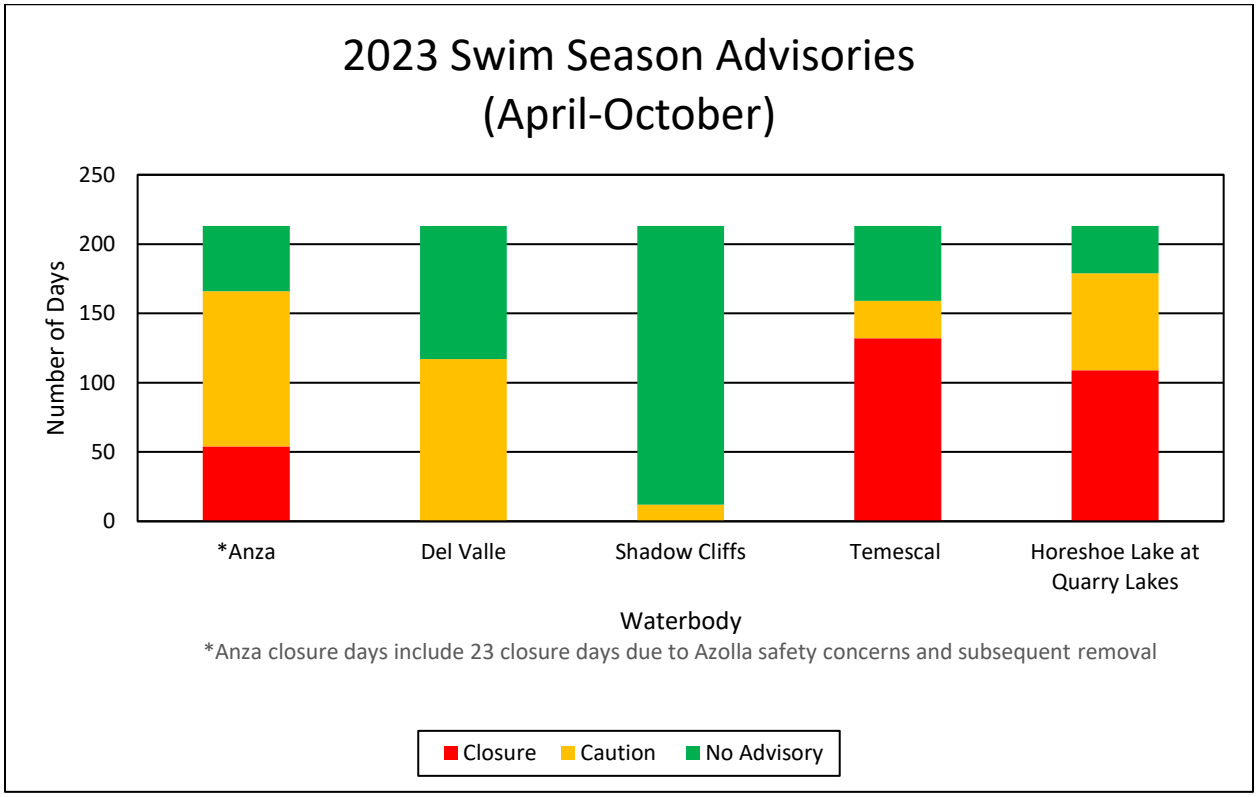

Figure 4. *2023 HABs advisories at Park District swim areas during swim season (April-October).*

HABs closures had the highest impact at the Lake Temescal swim beach. Out of the 213 days that make up swim season, 132 days had Danger/Closure Advisories posted. The blooms Lake Temescal experienced were so severe that staff had no choice but to close swim season on August 30th due to high concentrations of Microcystins that lasted through the remainder of the year. In total, the swim area was only open two weeks of the 2023 swim season due to HABs related closures and treatments.

Horseshoe Lake at Quarry Lakes was also impacted by HABs related closures, with 107 days of swim season spent at a Danger/Closure Advisory. Unfortunately, the closure was during the prime swimming months of May through July. When the closure was lifted on August 2nd, the swim beach remained open the rest of 2023.

As discussed above, Lake Anza was closed for 31 days due to HABs advisories.

Del Valle Reservoir and Shadow Cliffs Lake did not have any HABs related closures during the 2023 swim season. Both lakes did have Caution advisories posted during swim season, with Del Valle totaling 117 days at Caution and Shadow Cliffs totaling 12 days at Caution.

Special Projects: Lake Temescal

Introduction

Since the first toxin bloom was detected in 2014, the Park District has taken an active role in the management and remediation of HABs at Lake Temescal. Chemical binding agents as EutroSORB WC, EutroSORB G, Phoslock, and aluminum sulfide have been utilized throughout the years to aid in the sequestration of nutrients with the goal of reducing the frequency and duration of HABs. In 2023, The Park District continued to utilize monitoring and nutrient remediation to understand and manage blooms.

Monitoring

The primary monitoring methods employed at Lake Temescal include: weekly HAB monitoring, real-time dissolved oxygen and temperature data reported from permanently deployed data loggers, and monthly depth profiles in conjunction with watershed nutrient monitoring. Weekly HAB monitoring encompassed a spectrum of tasks including visual observations, sampling, microscopy, and toxin testing. Real-time loggers are stationed between the northwest fishing dock and the swim beach. There are two loggers: one in the epilimnion of the lake at 1 meter in depth and the other in the hypolimnion at 4 meters of depth. Monthly watershed monitoring was conducted at six strategic sampling locations, one of which was exclusively sampled during storm season (**Figure 5**).

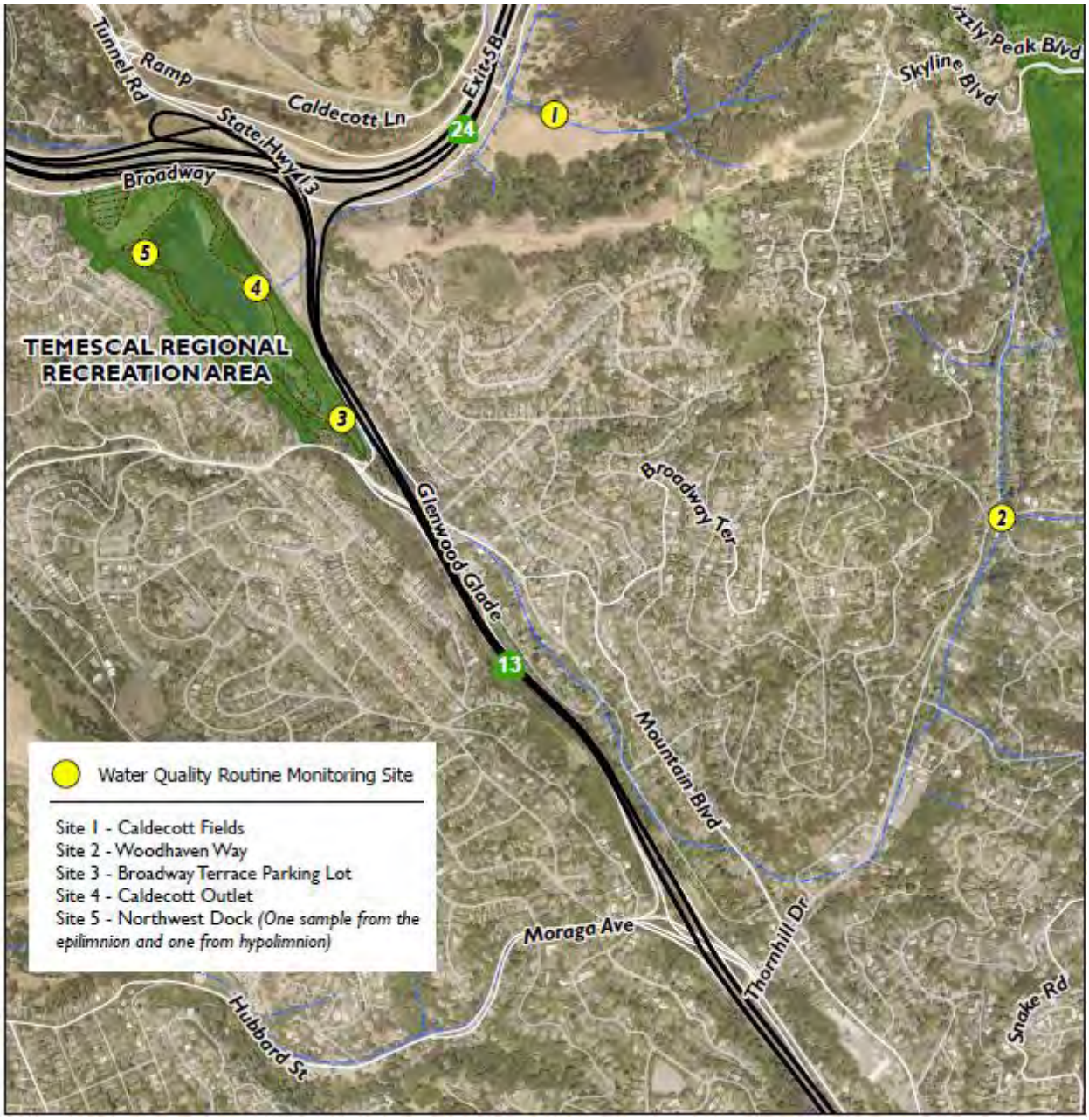

Figure 5. *Temescal watershed monitoring locations for monthly nutrient sampling. CCF: Caldecott Fields (only during the storm season), WH: Woodhaven, CU: Culvert, CO: Caldecott Outlet, NWD: Northwest Dock Surface and Hypolimnion.*

Each watershed monitoring location was chosen to represent the two watersheds that lead into Lake Temescal. Temescal Creek is represented through the Woodhaven and Culvert sampling locations. All runoff from the Caldecott Tunnel and surrounding areas is represented through the Caldecott Fields and Caldecott Outlet sampling locations. The Northwest Dock Surface and Hypolimnion represent the lake itself.

Lake Temescal spent most of 2023 at a Danger Advisory (**Figure 6**). In the first week of June, a bloom high in Microcystins occurred and took hold of the entire lake. At the end of June, the Park District treated the lake with a combination of Phycomycin and two EutroSORB products. These treatments were ineffective against the ongoing bloom. At the end of July, toxin concentration began to drop, and in the beginning of August, the lake was closed to treat it with GreenClean Pro and Clearcast. The Danger Advisories were replaced with Caution Advisories in mid-August after two weeks of consistent non-detects and a diminishment in bloom conditions. Unfortunately, these improved conditions were short-lived, and the lake returned to a Danger Advisory at the end of August. With no end in sight after four more weeks of high toxin concentrations, it was decided to officially end the swim season at Lake Temescal and the beach remained closed though the end of the Park District's swim season in October.

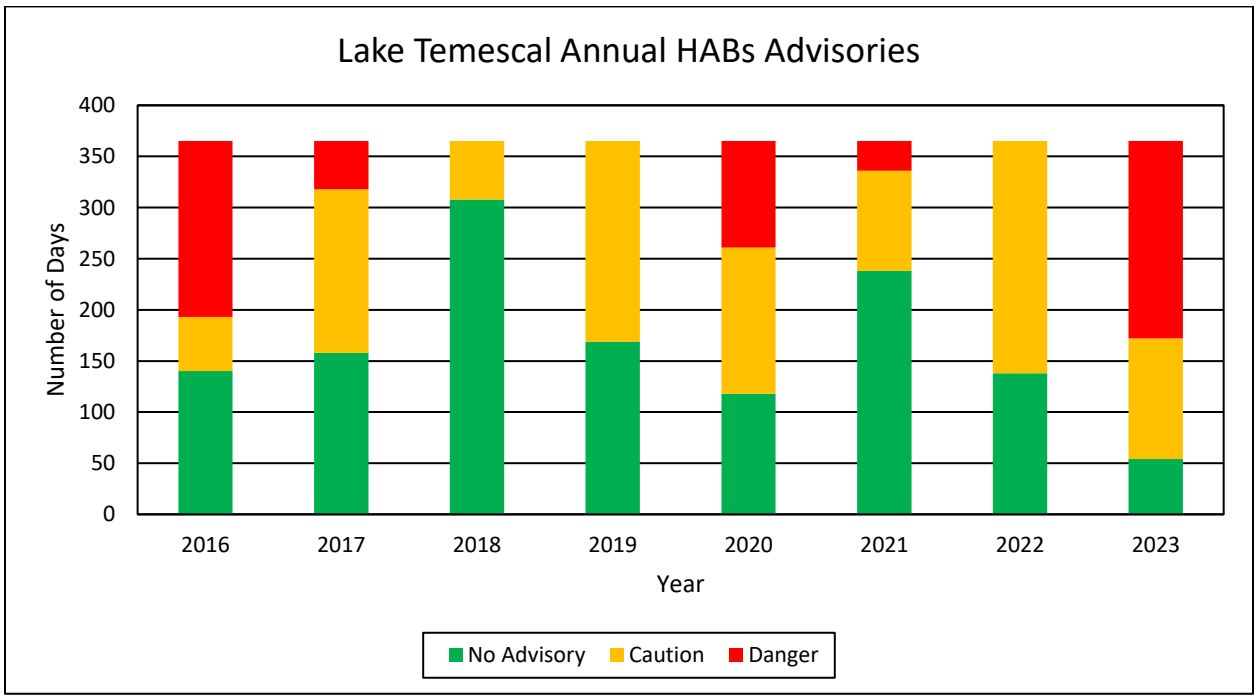

Figure 6. *Number of days spent at no advisory, caution advisory, or danger advisory due to HABs at Lake Temescal 2016-2023*[4]*.*

Two real-time temperature loggers continued to report temperature and dissolved oxygen (DO) data from the north end of the lake in 2023. Both sondes are located on the north end of the lake, between the northwest fishing dock and the swim beach. Temperature and DO are key parameters that influence nutrient availability as well as indicate physical lake conditions such as stratification and mixing events. Anoxia (lack of oxygen) in the hypolimnion allows nutrients to be released from the sediment and to cycle into the surface water via internal loading.

[4] Though Lake Temescal did not experience any HABs related closures in 2022, there were closures due to sanitary sewer overflows (SSOs) in 2022. The City of Oakland notified the Park District of 10 SSOs that reached Lake Temescal in 2022. This data is not represented in Figure 6.

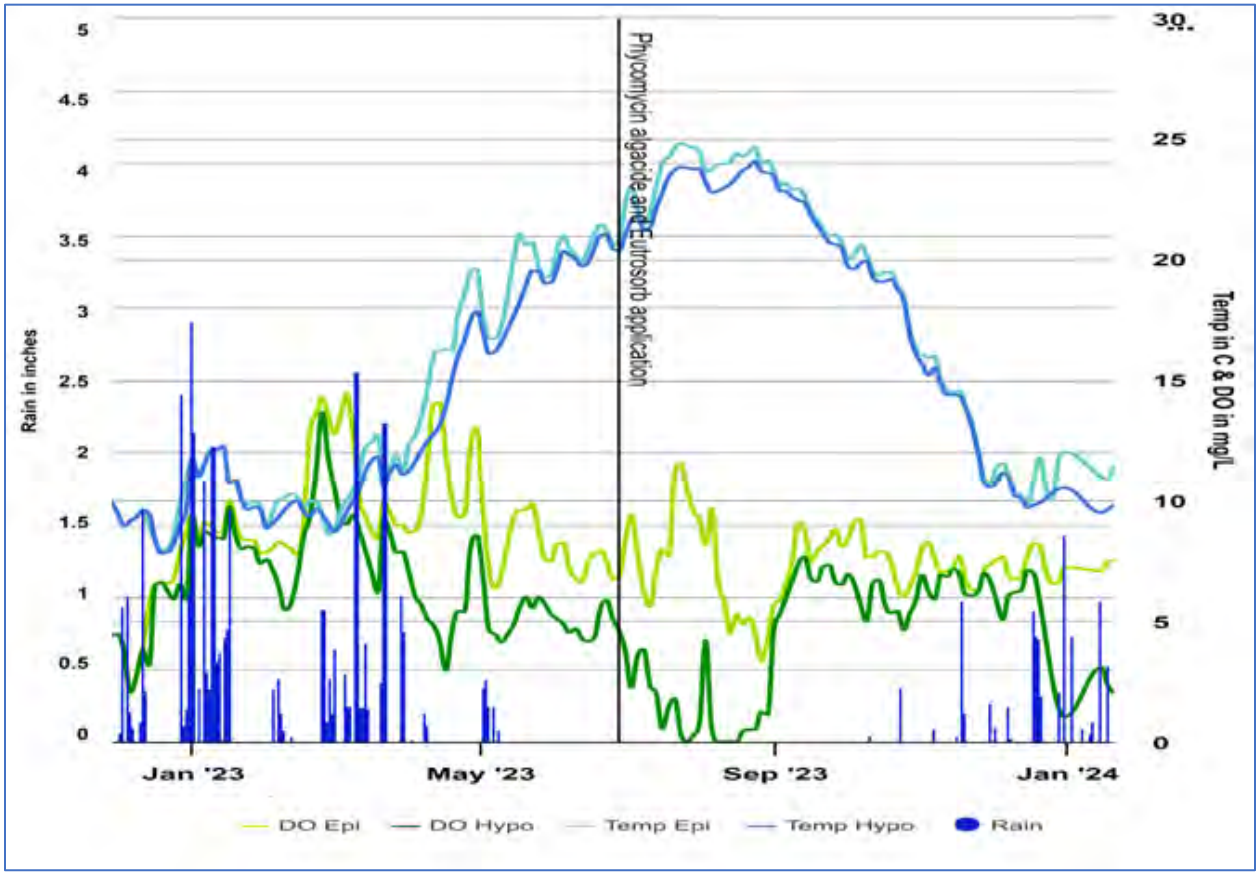

Figure 7. *Temperature and dissolved oxygen data reported by two real-time loggers at Lake Temescal. One logger is in the epilimnion (1 meter) and the other in the hypolimnion (4 meters).*

Figure 7 shows the temperature and DO data collected by the real-time loggers in 2023 Notably, the lake experienced periods of anoxia in the hypolimnion that coincided with some of the worst bloom conditions in July and August 2023. Figure 8 shows an increase in orthophosphate during the periods of anoxia.

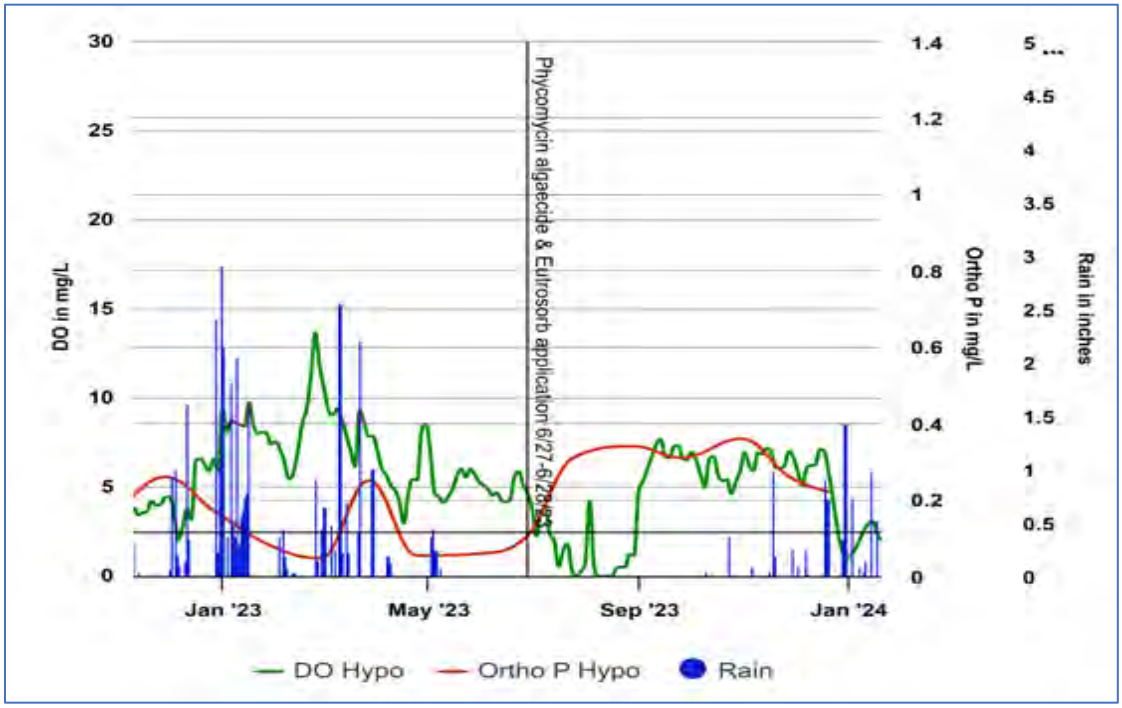

Figure 8. *Real-time dissolved oxygen data and monthly nutrient Orthophosphate as P data in the hypolimnion.*

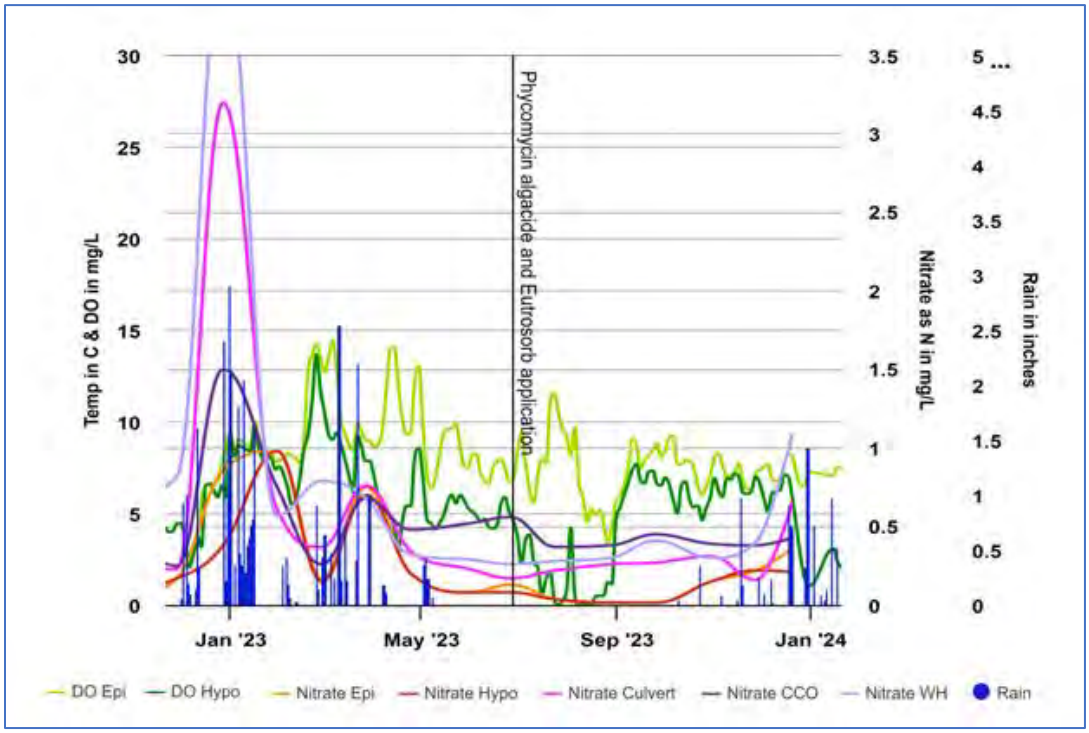

Figure 9. *Real-time dissolved oxygen data and monthly nitrate in the Temescal watershed.*

A highlight of watershed monitoring is the valuable insight into what nutrients flow into Lake Temescal, particularly via stormwater. In 2023, the lake received high amounts of nitrate through Woodhaven and the Culvert, both of which come from Temescal Creek, during the January storms. A smaller but still significant amount of nitrate also came through the Caldecott Outlet in the same timeframe. The figure shows that the watershed loading translates into increased nitrate concentrations first at the epilimnion, then at the hypolimnion. When rain began again towards the end of the year, we can see the same pattern develop. (**Figure 9**).

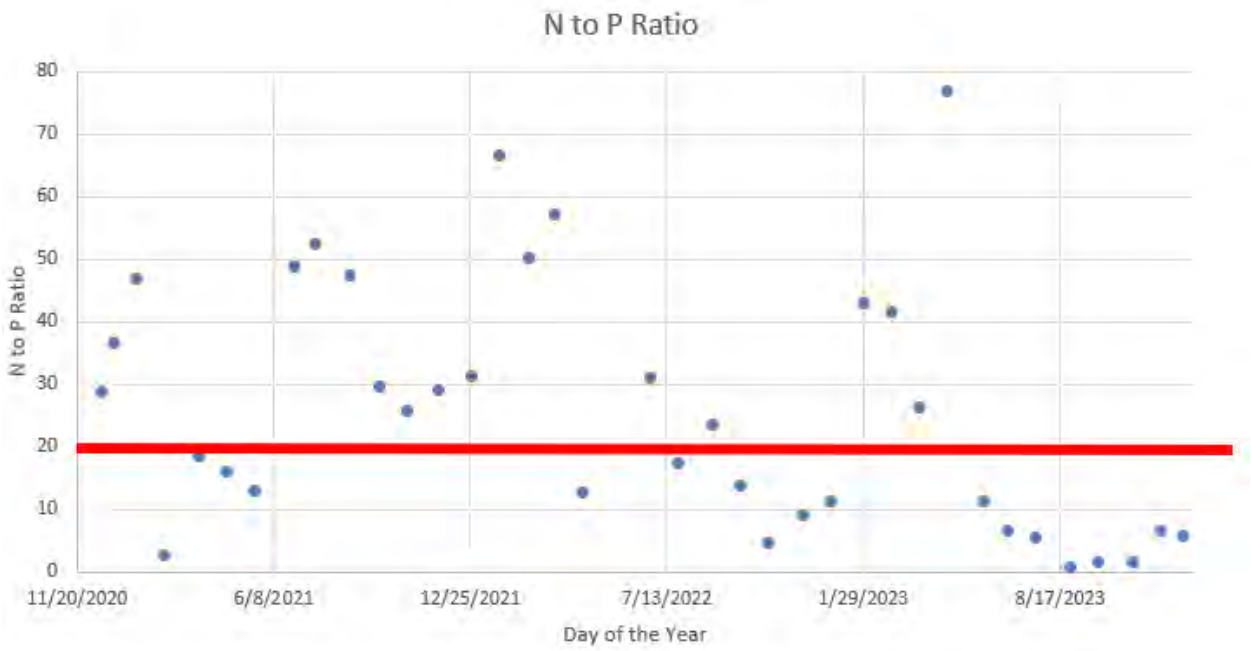

Figure 10. *Nitrogen to Phosphorus ratio at Lake Temescal (The red line indicates a 20 to 1 N to P ratio, which can be used as a conservative alert for cyanobacteria biomass/toxins to increase, if the ratio drops below).*

Most the nitrogen seems to come into Lake Temescal during the winter/spring rainy season and gets depleted during the summer (denitrification). If the loss of nitrogen is combined with an increase of anoxic phosphorus during the summer, the N to P ratio can drop significantly. Nitrogen and phosphorus are key nutrients due to their role in cyanobacterial growth. A very low N to P ratio supports nitrogen-fixing cyanobacteria. Once nitrogen-fixing cyanobacteria produced enough nitrogen, other non-nitrogen-fixing cyanobacteria can follow if sufficient phosphorus is in the system.

Figure 10 shows the nitrogen to phosphorus ratios at Lake Temescal since the end of 2020. External nitrogen loading during the winter has the N to P ratios consistently start out high in the spring and then decline until they become low in the fall. We saw low N to P ratios starting in May of 2023 and continuing for the remainder of the year; this corresponded with high cyanobacteria toxins from June through October. An N to P ratio of 20 to 1 can be used as a

conservative warning sign for a pending bloom or an increase of toxins, should the ratio further decrease towards 10 and below.

Remediation

The Park District's has two goals for remediation at Lake Temescal: 1) maintaining the overall ecosystem health for the benefit of wildlife and 2) ensuring safe water quality through swim season for park patrons. To achieve these goals, the Park District utilized chemical treatments and sediment basin dredging. The purpose of these remediation efforts is the abatement of nutrients that already exist in the lake and limit further nutrient deposition.

This year, the lake was chemically treated four times. The first two treatments were applied to the entire lake, while the second two treatments focused on the swim beach. The first treatment was with a popular algicide, Phycomycin (hydrogen peroxide treatment), on June 26th. Phycomycin was used to knock down the cyanobacteria biomass that continued to contribute to Microcystis production and in turn our elevated Microcystin cyanotoxin levels and Danger advisory. The following day, a combination of two EutroSORB products (lanthanum modified bentonite) designed to sequester phosphorus were used. EutroSORB WC (water column) was intended to strip the water column of available nutrients, and the second, EutroSORB G, was intended to eliminate phosphorus being released from the sediment to prevent internal loading. On August 2nd, aquatic vegetation was raked out of the swim beach area and treated with Green Clean Pro, and on September 6th, the swim beach area received a second raking and another treatment with Green Clean Pro.

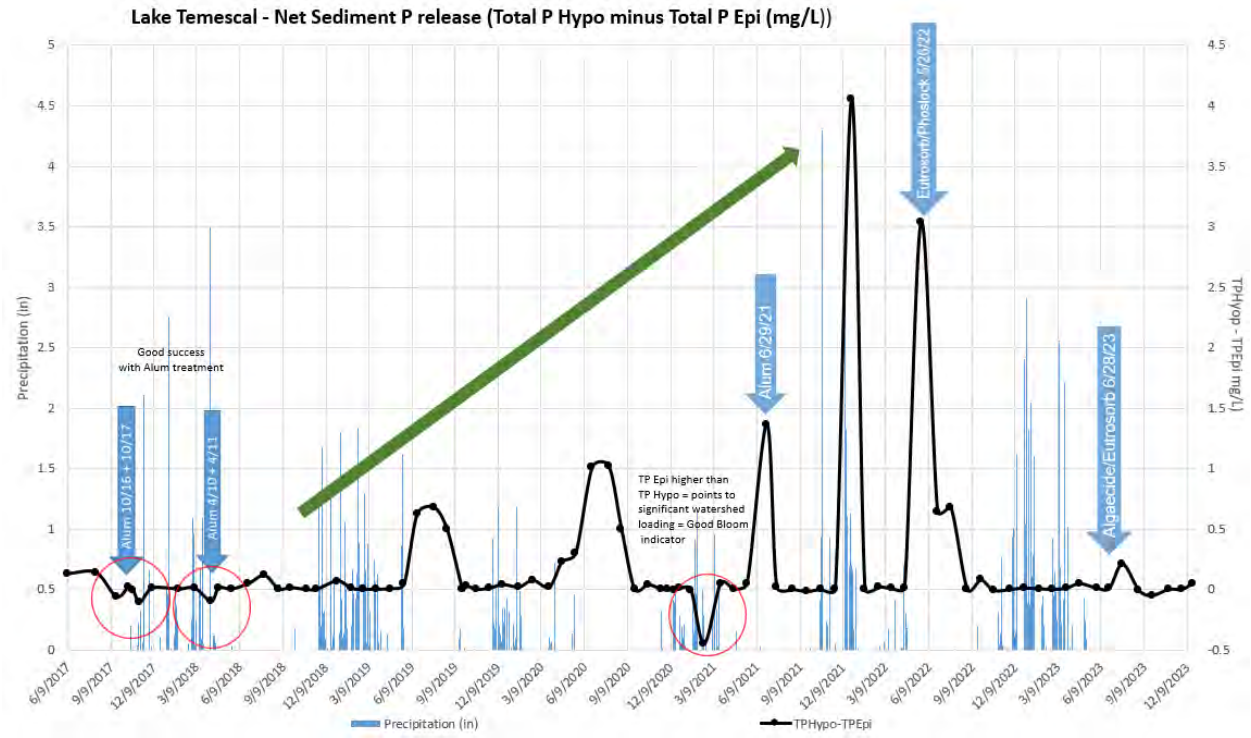

Figure 11. *Increased internal phosphorus loading and treatments.*

Figure 11 displays the net sediment P release (calculated by subtracting Total P at the epilimnion from Total P at the hypolimnion) and an increase of internal loading year by year starting in 2019, after 2 successful alum treatments. Spikes during 2021 and 2022 treatments lead to the assumption that the applications occurred too late in the season to prevent the release. The prolonged storm season in 2023 changed the typical early anoxia pattern through cooler lake temperatures and the lake treatment in June seemed to have been effective in preventing a significant release. The Park District also explored the possibility of installing an aeration system in Lake Temescal in 2023. The idea was ultimately dismissed due to a lack of staffing to oversee installation, management, and maintenance of the system.

Future Management Actions

Moving forward into 2024, the Park District plans on continuing similar management strategies. We have received guidance from outside limnologists and other water quality professionals that we should begin chemical treatments earlier in the year than we have historically treated the lake. These advisors recommended beginning treatments as early as March so that our treatments can be preventative as opposed to reactionary. Watershed nutrient sampling, depth profiles, and routine HABs monitoring will continue as usual in 2024.

Long Term Management Actions

The Park District is pursuing the expansion of its capability to extract more sediments from the existing sediment basins, while exploring the opportunities to expand these basins. We continue to explore the creation of a comprehensive watershed management plan that will pull together stakeholders, educate and encourage best management practices and advocate for infrastructure improvements. Finally, continue to explore the potential for lake-wide dredging and basin restoration of the Temescal reservoir.

Special Projects: Lake Anza

Introduction

The summer of 2020, a hypolimnetic oxygenation system (HOS) was installed in Lake Anza to help combat HABs. Adding oxygen to the hypolimnion keeps chemical bonds strong aiding in the sequestration of nutrients essential to the growth of cyanobacteria. 2023 marked the third full year of HOS operation. This year marked the grand re-opening of the swimming beach at Lake Anza for the first time since summer 2018. However, it also saw the first toxic cyanobacteria bloom the lake has seen since its period of closure from 2019-2022, and another boom of both *Azolla* and duckweed, which continues to contribute to the complex water quality concerns Lake Anza experiences.

Monitoring

There were three primary monitoring methods employed at Lake Anza: weekly HAB monitoring, real-time dissolved oxygen and temperature data reported from permanently deployed data loggers, and monthly depth profiles in conjunction with watershed nutrient monitoring. Weekly HAB monitoring encompassed a spectrum of tasks including visual observations, sampling, microscopy, and toxin testing. Real-time loggers are stationed at the deepest part of the lake and include a logger array at 1m, 3m, 4m, 5m, 10m, 11 and 12m. Monthly watershed nutrient monitoring was conducted at three locations, one, the incoming watershed and two locations at the deepest part of the lake, with samples being collected at 1m depth from the surface and 0.5m depth from the bottom of the lake.

Figure 12. *Anza watershed monitoring locations for monthly nutrient sampling. CU: Culvert, CO: Caldecott Outlet, NWD: Northwest Dock Epilimnion and Hypolimnion*

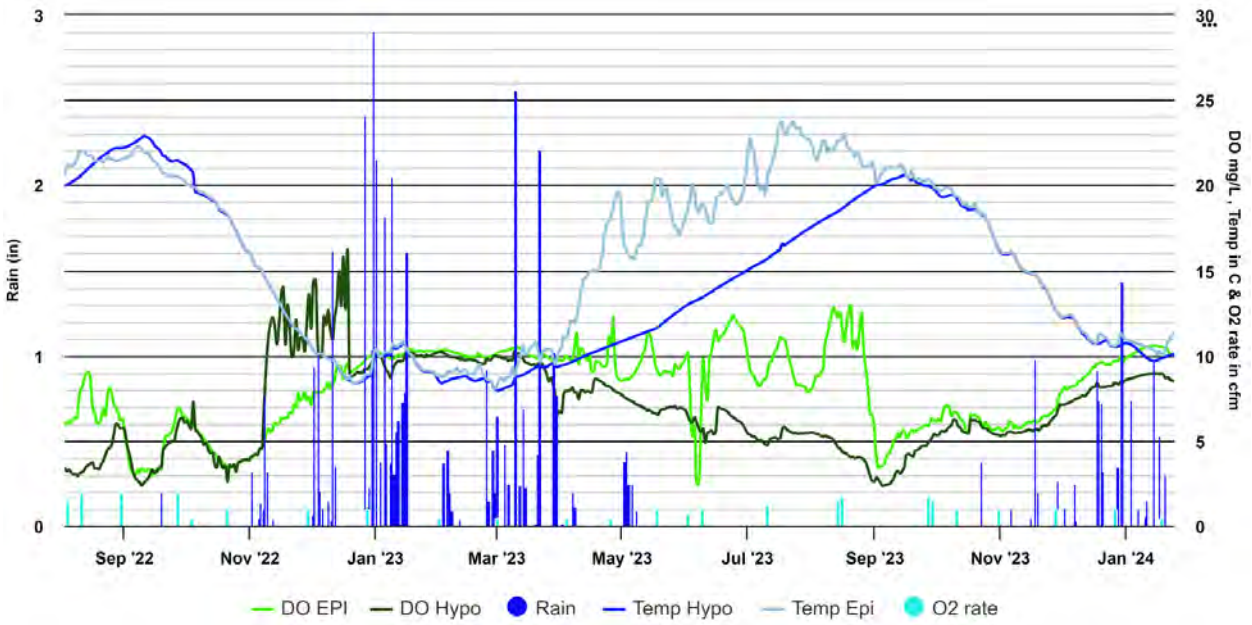

Figure 13. *Real-time dissolved oxygen and temperature data at the epilimnion and hypolimnion, rain and the oxygen flow rate.*

Real-time dissolved oxygen and temperature data at Lake Anza indicates that the hypolimnetic oxygenation system prevents a proper thermal stratification of the lake. Figure 13 shows that stratification starts around April with a low oxygen flow rate and good dissolved oxygen at the hypolimnion. As the dissolved oxygen decreases and anoxic conditions begin, an increased oxygen flow rate breaks the stratification. Breaking the stratification allows phosphorus, released from the sediment, to mix with the entire lake.

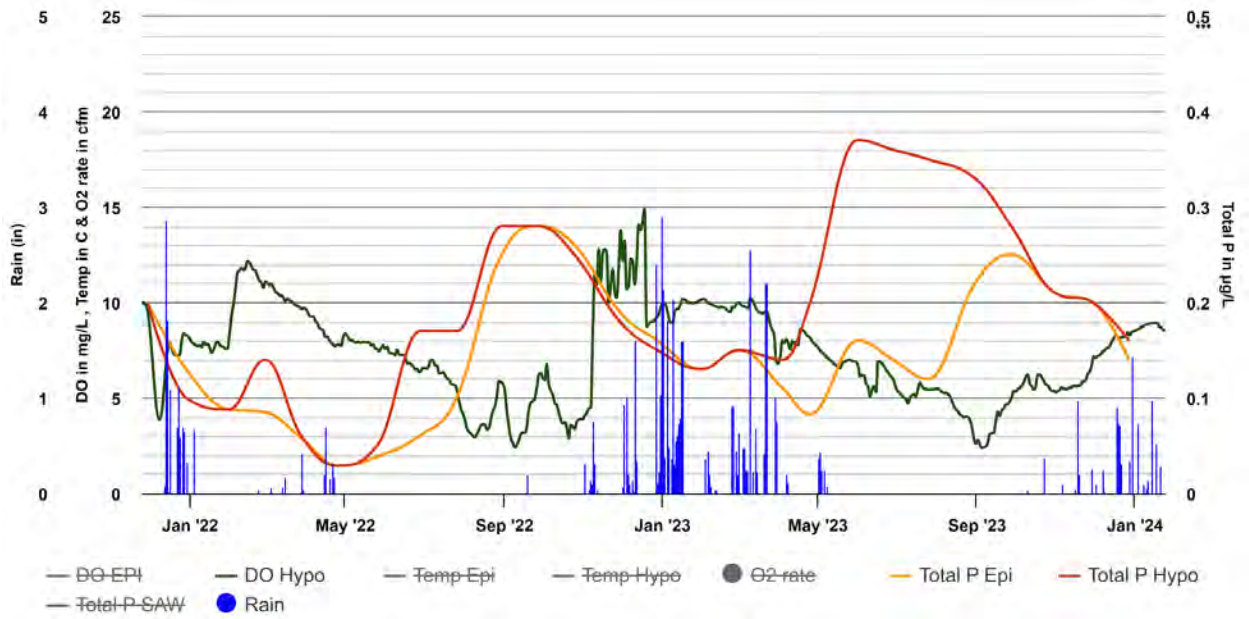

Figure 14. *Real-time dissolved oxygen at the hypolimnion and monthly total phosphorus sampling data at the epilimnion and hypolimnion*

Reviewing Figure 14, phosphorus is released from the sediment even with plenty of oxygen in the hypolimnion. We are assuming that the oxygenation system diffusers are 6-8 inches off the bottom of the lake leaving a small layer of anoxia above to the sediment which could be releasing phosphorus from the sediments.

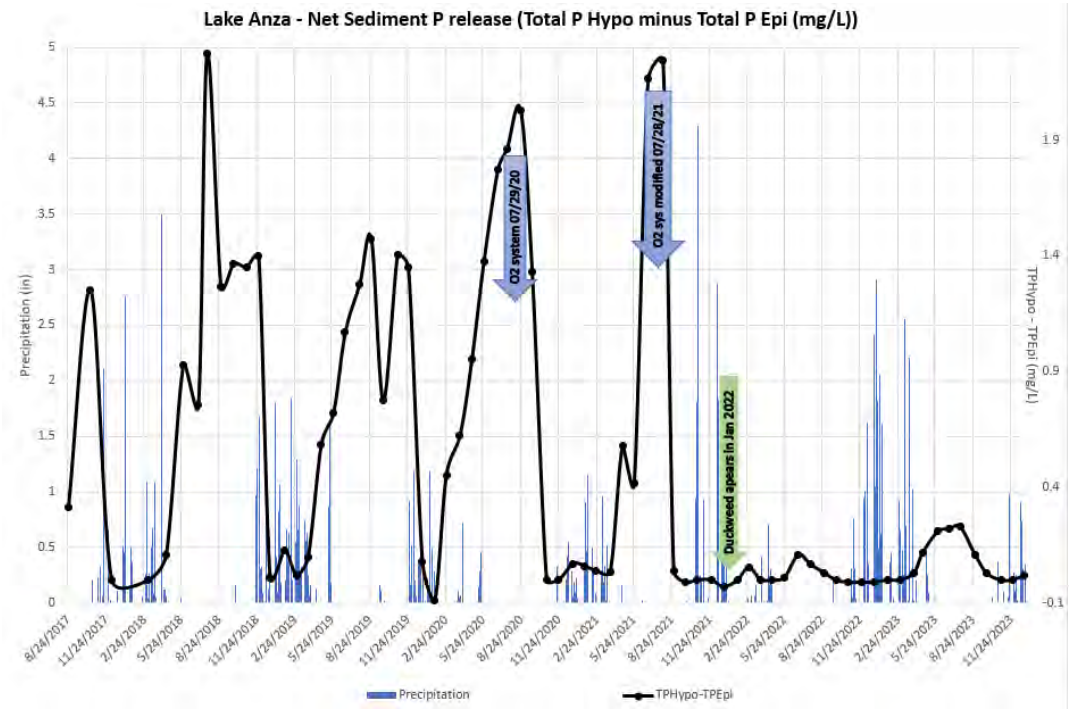

Figure 15. *Phosphorus sediment release vs precipitation.*

Figure 15 displays the net sediment P release (calculated by subtracting Total P at the epilimnion from Total P at the hypolimnion) since 2017. Even one year after the HOS was installed in 2020, a large net sediment P release was noticeable. This was caused by a 1-meter gap between the diffuser pipe and the anchor. This setup was modified in July of 2021, when the diffuser pipe was attached directly to the anchor. While this new setup decreased the sediment release during the following years drastically, we can still see slight net sediment P releases over the summer months, slightly higher in 2023.

Maintenance Activities

By August 2023, *Azolla*, a small aquatic fern, covered approximately 95% of the lake's surface, compelling the Park District to close the beach due to safety concerns. Through a combination of boom netting, raking, and utilizing a mechanical aquatic harvester, Tilden staff cleared the majority of *Azolla* which led to an eventual re-opening of the swim beach to swimming.

Future Management Actions

Watershed nutrient sampling, depth profiles, and routine HABs monitoring will continue as usual in 2024. The Park District intends to continue our HOS treatment, create a current bathometric map, and is exploring phosphorus binding (nutrient limiting) treatments of EurtoSORB products.

Fish Tissue Toxin Monitoring Project

In 2017, the Park District established a program to collect and test liver and muscle tissue from fish in Park District waterbodies to better understand the effects of HABs on resident fish populations. Resident fish (largemouth bass and carp), or fish that have spawned and reared in Park District reservoirs, are tested as opposed to stocked fish (trout and catfish), or fish that are nursery raised and planted in our waterbodies. Annual testing has been carried out since 2017 apart from 2020 when surveys were suspended due to COVID-19 work restriction policies. In 2023, twenty-four fish were tested across five parks: Contra Loma, Lake Chabot, Del Valle, Lake Temescal, and Horseshoe Lake at Quarry Lakes. In 2021, the Park District got our first toxin detection in muscle tissue since beginning this project in 2017. The field crew believes that detection was due to sampler error in processing samples, so in response, in 2022, the Park District added in disinfection protocol during processing. All twenty-four samples collected in 2023 resulted in toxin non-detects in muscle tissue. Liver tissue Microcystins concentrations ranged from non-detect to 22.69 ng/g (**Appendix B**). All results remain in line with guidance and current Park District policy which allows fishing throughout HABs (**Table 2**).

***Table 2**. Office of Environmental Health Hazard Assessment (OEHHA) toxicological summary of suggested action levels to reduce potential adverse health effects of six cyanotoxins when consuming sport fish and shellfish.*

Table 4: Cyanotoxin Action Levels for Sport Fish and Shellfish

Chemical	RfD[1]	Action Level[2]
Units	mg/kg-d	ng/g tissue ww[4]
Microcystins[3]	6.4×10^{-6}	10
Cylindrospermopsin	3.3×10^{-5}	70
Anatoxin-a	2.5×10^{-3}	5000

[1] RfDs calculations described in section III above
[2] Based on typical consumption rate of self-caught fish in California (one meal per week) and body weight of 70 kg. See Appendix II for calculations. Children are assumed to eat smaller meals (2 - 4 ounces uncooked).
[3] Apply action levels to the sum of all detected microcystins until subchronic toxicities of the other variants are clarified.
[4] Wet weight. Action level units assume fresh (or wet) weight of the fish tissue.

All samples were collected by Park District fisheries biologists and analyzed by Bend Genetics Lab. Much like 2022, a stepwise comparison of this year's results shows that liver samples from Lake Chabot fish were significantly higher in Microcystin toxins than that of fish collected in all other waterbodies (**Figure 16**). Liver samples collected since 2016, however, showed no significant differences in microcystin when grouped by year (**Figure 17**).

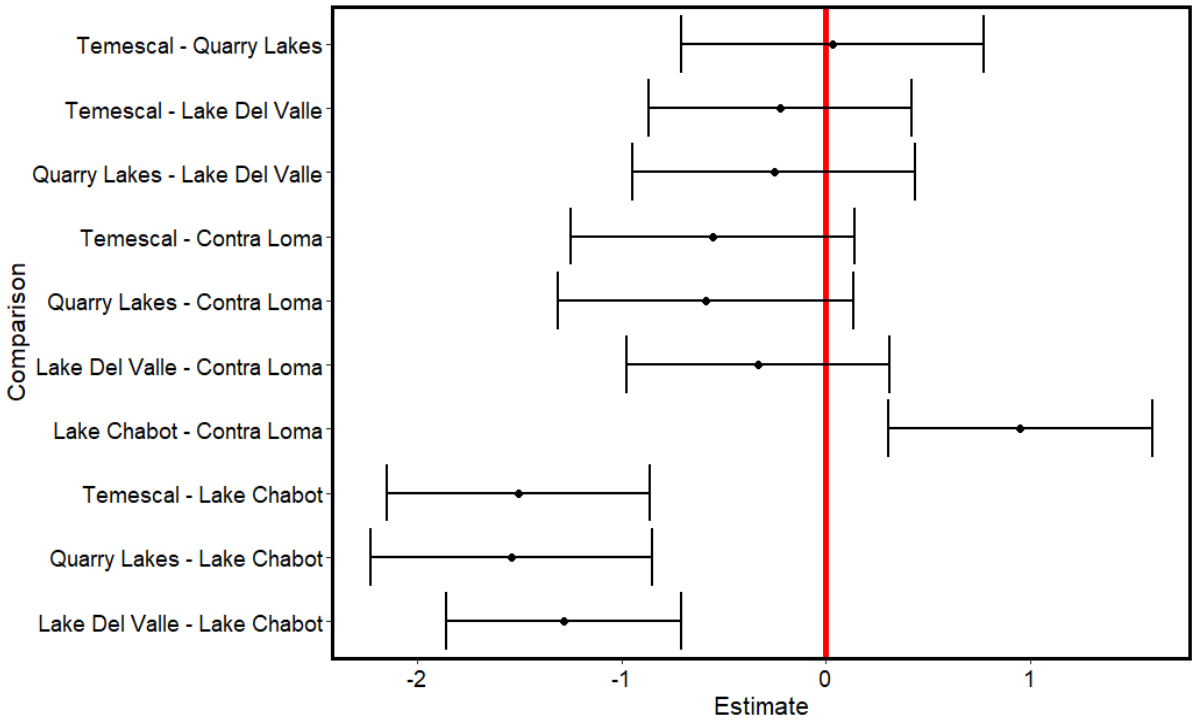

Figure 16. *Stepwise comparison of Microcystin toxins detected in liver tissue of largemouth bass collected across five lakes. No overlap with the red line indicates statistical significance.*

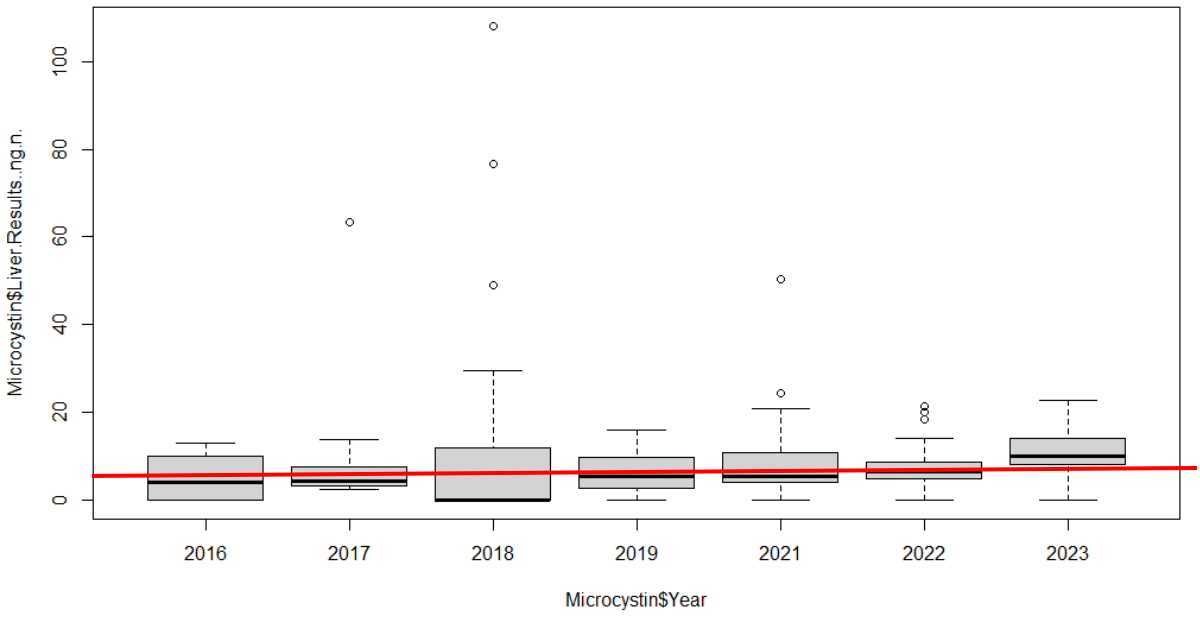

Figure 17. *Microcystin toxins detected in liver tissue of largemouth bass annually across five lakes. No overlap with the red line indicates statistical significance.*

Summary

2023 was another year of trials, errors, and successes for the Park District. We performed hundreds of toxin tests across our eight routinely monitored waterbodies. Advisory signage was posted and de-posted depending on toxin concentrations and visible conditions. We continued to manage Lake Anza with the hypolimnetic oxygenation (HOS) system, monthly watershed, and nutrient monitoring, and routine HABs monitoring. We continued to manage Lake Temescal with chemical treatments, monthly watershed, and nutrient monitoring, and routine HABs monitoring. Our fish tissue toxin monitoring program continued to ensure fish in our waterbodies are safe to consume when they are cleaned, gutted, and cooked. And our databases continue to be updated with our most recent monitoring data. We also have a new staff position, Ecological Services Coordinator, whose priority is managing the complex and ever-changing conditions of our recreational waterbodies with an emphasis on HABs remediation.

Future Steps

In 2024, we hope to prioritize treatment at both Lake Temescal and Lake Anza. The goal will be to treat Lake Temescal much earlier in the season than previously (in February or March). HOS operations will continue to benefit Lake Anza by preventing anoxia in the hypolimnion. The Park District has acquired an aquatic harvester to manage submerged and free-floating pest species and will be preparing guidance and protocols for use of the harvester around sensitive species and habitats. Our Ecological Services Coordinator for lakes plans to utilize new data-based approaches to better manage Park District waterbodies.

Though HABs incidents will persist into the new year, the Park District is committed to evaluating adaptive management strategies to limit the size, duration, and negative effects on resources and recreation these blooms create throughout the lands and waterbodies we steward.

Appendix A: Water Quality & Nutrient Parameters

HydroLab 4 (HL4) Multiparameter Meter

Temperature	Dissolved Oxygen
Specific Conductivity	pH
Turbidity	Depth

Lake Temescal Nutrient Monitoring Parameters

Nitrate as N	Nitrite as N
Nitrate as NO_3^-	Nitrite as NO_2^-
Dissolved Orthophosphate as P	Dissolved Phosphorus
Total Phosphorus as P	Ortho-Phosphorus as Phosphate
Manganese	Hardness
Dissolved Manganese	Alkalinity
TKN	Iron
Ammonia	Dissolved Iron
Chlorophyll A	Chlorophyll B

Lake Anza Nutrient Monitoring Parameters

Nitrate as N	Nitrite as N
Nitrite as NO_2^-	Nitrate as NO_3^-
Orthophosphate as P	Orthophosphate as PO_4
TKN	Total Phosphorus as P
Dissolved Phosphorus	Ortho-Phosphorus as Phosphate
Dissolved Orthophosphate as P	Dissolved Iron
Iron	Manganese
Chlorophyll A	Chlorophyll B

Appendix B: Fish Tissue Toxin Results

Bend Genetics, LLC
107 Scripps Drive, Ste. 210
Sacramento, CA 95825
Tel: (916) 550-1048

Date: 11/30/2023

Subject: Analysis of microcystins in fish tissues

From: Tim Otten, Laboratory Director

To: Hal MacLean, Water Management Supervisor
East Bay Regional Park District

Testing results are attached for microcystin ELISA analyses conducted on 24 sets of fish tissue samples (fillets and livers) received on 11/7/2023. Tissue samples were dissected, weighed, then homogenized using an Omni TH-115 tissue homogenizer. Total microcystins were extracted in 80% methanol. Samples were diluted accordingly and analyzed by direct monoclonal ELISA. All data have been reviewed and are considered final.

Analyses included in this report:

- Quantification of total microcystins by direct monoclonal enzyme linked immunosorbent assay (ELISA). Values are reported in units of nanograms of toxin per gram (wet weight) of tissue.

Bend Genetics, LLC
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Sacramento, CA 95825
Tel: (916) 550-1048

Project: East Bay Regional Parks
Fish tissue microcystin testing
Reported: 11/30/2023 16:00

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Location	BG_ID	Date Collected	Date Received	Matrix
2023-CL-001-F	Contra Loma LMB	EB179F	7/11/2023 21:02	11/7/2023 10:22	Tissue - Fillet
2023-CL-001-L	Contra Loma LMB	EB179L	7/11/2023 21:02	11/7/2023 10:22	Tissue - Liver
2023-CL-002-F	Contra Loma LMB	EB180F	7/11/2023 21:02	11/7/2023 10:22	Tissue - Fillet
2023-CL-002-L	Contra Loma LMB	EB180L	7/11/2023 21:02	11/7/2023 10:22	Tissue - Liver
2023-CL-003-F	Contra Loma LMB	EB181F	7/11/2023 21:02	11/7/2023 10:22	Tissue - Fillet
2023-CL-003-L	Contra Loma LMB	EB181L	7/11/2023 21:02	11/7/2023 10:22	Tissue - Liver
2023-CL-004-F	Contra Loma LMB	EB182F	7/11/2023 21:02	11/7/2023 10:22	Tissue - Fillet
2023-CL-004-L	Contra Loma LMB	EB182L	7/11/2023 21:02	11/7/2023 10:22	Tissue - Liver
2023-CL-005-F	Contra Loma LMB	EB183F	7/11/2023 21:02	11/7/2023 10:22	Tissue - Fillet
2023-CL-005-L	Contra Loma LMB	EB183L	7/11/2023 21:02	11/7/2023 10:22	Tissue - Liver
2023-LC-001-F	Lake Chabot LMB	EB184F	6/27/2023 21:30	11/7/2023 10:22	Tissue - Fillet
2023-LC-001-L	Lake Chabot LMB	EB184L	6/27/2023 21:30	11/7/2023 10:22	Tissue - Liver
2023-LC-002-F	Lake Chabot LMB	EB185F	6/27/2023 21:30	11/7/2023 10:22	Tissue - Fillet
2023-LC-002-L	Lake Chabot LMB	EB185L	6/27/2023 21:30	11/7/2023 10:22	Tissue - Liver
2023-LC-003-F	Lake Chabot LMB	EB186F	6/27/2023 21:30	11/7/2023 10:22	Tissue - Fillet
2023-LC-003-L	Lake Chabot LMB	EB186L	6/27/2023 21:30	11/7/2023 10:22	Tissue - Liver
2023-LC-004-F	Lake Chabot LMB	EB187F	6/27/2023 21:30	11/7/2023 10:22	Tissue - Fillet
2023-LC-004-L	Lake Chabot LMB	EB187L	6/27/2023 21:30	11/7/2023 10:22	Tissue - Liver
2023-LC-005-F	Lake Chabot LMB	EB188F	6/27/2023 21:30	11/7/2023 10:22	Tissue - Fillet
2023-LC-005-L	Lake Chabot LMB	EB188L	6/27/2023 21:30	11/7/2023 10:22	Tissue - Liver
2023-DV-001-F	Del Valle LMB	EB189F	7/13/2023 21:31	11/7/2023 10:22	Tissue - Fillet
2023-DV-001-L	Del Valle LMB	EB189L	7/13/2023 21:31	11/7/2023 10:22	Tissue - Liver
2023-DV-002-F	Del Valle LMB	EB190F	7/13/2023 21:31	11/7/2023 10:22	Tissue - Fillet
2023-DV-002-L	Del Valle LMB	EB190L	7/13/2023 21:31	11/7/2023 10:22	Tissue - Liver
2023-DV-003-F	Del Valle LMB	EB191F	7/13/2023 21:31	11/7/2023 10:22	Tissue - Fillet
2023-DV-003-L	Del Valle LMB	EB191L	7/13/2023 21:31	11/7/2023 10:22	Tissue - Liver
2023-DV-004-F	Del Valle LMB	EB192F	7/13/2023 21:31	11/7/2023 10:22	Tissue - Fillet
2023-DV-004-L	Del Valle LMB	EB192L	7/13/2023 21:31	11/7/2023 10:22	Tissue - Liver
2023-DV-005-F	Del Valle LMB	EB193F	7/13/2023 21:31	11/7/2023 10:22	Tissue - Fillet
2023-DV-005-L	Del Valle LMB	EB193L	7/13/2023 21:31	11/7/2023 10:22	Tissue - Liver

Bend Genetics, LLC
107 Scripps Drive, Ste. 210
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Tel: (916) 550-1048

Project: East Bay Regional Parks
Fish tissue microcystin testing
Reported: 11/30/2023 16:00

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Location	BG_ID	Date Collected	Date Received	Matrix
2023-TEM-001-F	Temescal LMB	EB194F	6/20/2023 21:06	11/7/2023 10:22	Tissue - Fillet
2023-TEM-001-L	Temescal LMB	EB194L	6/20/2023 21:06	11/7/2023 10:22	Tissue - Liver
2023-TEM-002-F	Temescal LMB	EB195F	6/20/2023 21:06	11/7/2023 10:22	Tissue - Fillet
2023-TEM-002-L	Temescal LMB	EB195L	6/20/2023 21:06	11/7/2023 10:22	Tissue - Liver
2023-TEM-003-F	Temescal LMB	EB196F	6/20/2023 21:06	11/7/2023 10:22	Tissue - Fillet
2023-TEM-003-L	Temescal LMB	EB196L	6/20/2023 21:06	11/7/2023 10:22	Tissue - Liver
2023-TEM-004-F	Temescal LMB	EB197F	6/20/2023 21:06	11/7/2023 10:22	Tissue - Fillet
2023-TEM-004-L	Temescal LMB	EB197L	6/20/2023 21:06	11/7/2023 10:22	Tissue - Liver
2023-TEM-005-F	Temescal LMB	EB198F	6/20/2023 21:06	11/7/2023 10:22	Tissue - Fillet
2023-TEM-005-L	Temescal LMB	EB198L	6/20/2023 21:06	11/7/2023 10:22	Tissue - Liver
2023-QL-001-F	Quarry Lake LMB	EB199F	7/18/2023 20:30	11/7/2023 10:22	Tissue - Fillet
2023-QL-001-L	Quarry Lake LMB	EB199L	7/18/2023 20:30	11/7/2023 10:22	Tissue - Liver
2023-QL-002-F	Quarry Lake LMB	EB200F	7/18/2023 20:30	11/7/2023 10:22	Tissue - Fillet
2023-QL-002-L	Quarry Lake LMB	EB200L	7/18/2023 20:30	11/7/2023 10:22	Tissue - Liver
2023-QL-003-F	Quarry Lake LMB	EB201F	7/18/2023 20:30	11/7/2023 10:22	Tissue - Fillet
2023-QL-003-L	Quarry Lake LMB	EB201L	7/18/2023 20:30	11/7/2023 10:22	Tissue - Liver
2023-QL-004-F	Quarry Lake LMB	EB202F	7/18/2023 20:30	11/7/2023 10:22	Tissue - Fillet
2023-QL-004-L	Quarry Lake LMB	EB202L	7/18/2023 20:30	11/7/2023 10:22	Tissue - Liver

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SAMPLE RESULTS

Sample ID	Method	Target	Result	Units	Quantitation Limit	Dilution Factor	Notes
2023-CL-001-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-CL-001-L	ELISA	Microcystin/Nod.	10.51	ng/g ww	3.75	25	
2023-CL-002-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-CL-002-L	ELISA	Microcystin/Nod.	7.65	ng/g ww	3.75	25	
2023-CL-003-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-CL-003-L	ELISA	Microcystin/Nod.	7.74	ng/g ww	3.75	25	
2023-CL-004-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-CL-004-L	ELISA	Microcystin/Nod.	14.98	ng/g ww	3.75	25	
2023-CL-005-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-CL-005-L	ELISA	Microcystin/Nod.	22.69	ng/g ww	3.75	25	
2023-LC-001-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-LC-001-L	ELISA	Microcystin/Nod.	19.04	ng/g ww	3.75	25	
2023-LC-002-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-LC-002-L	ELISA	Microcystin/Nod.	15.37	ng/g ww	3.75	25	
2023-LC-003-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-LC-003-L	ELISA	Microcystin/Nod.	22.02	ng/g ww	3.75	25	
2023-LC-004-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-LC-004-L	ELISA	Microcystin/Nod.	12.19	ng/g ww	3.75	25	
2023-LC-005-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-LC-005-L	ELISA	Microcystin/Nod.	9.75	ng/g ww	3.75	25	
2023-DV-001-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-DV-001-L	ELISA	Microcystin/Nod.	9.20	ng/g ww	3.75	25	
2023-DV-002-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-DV-002-L	ELISA	Microcystin/Nod.	15.23	ng/g ww	3.75	25	
2023-DV-003-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-DV-003-L	ELISA	Microcystin/Nod.	6.93	ng/g ww	3.75	25	
2023-DV-004-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-DV-004-L	ELISA	Microcystin/Nod.	5.13	ng/g ww	3.75	25	
2023-DV-005-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-DV-005-L	ELISA	Microcystin/Nod.	9.78	ng/g ww	3.75	25	

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SAMPLE RESULTS

Sample ID	Method	Target	Result	Units	Quantitation Limit	Dilution	Notes
2023-TEM-001-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-TEM-001-L	ELISA	Microcystin/Nod.	8.26	ng/g ww	3.75	25	
2023-TEM-002-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-TEM-002-L	ELISA	Microcystin/Nod.	12.29	ng/g ww	3.75	25	
2023-TEM-003-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-TEM-003-L	ELISA	Microcystin/Nod.	ND	ng/g ww	3.75	25	U
2023-TEM-004-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-TEM-004-L	ELISA	Microcystin/Nod.	8.09	ng/g ww	3.75	25	
2023-TEM-005-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-TEM-005-L	ELISA	Microcystin/Nod.	ND	ng/g ww	3.75	25	U
2023-QL-001-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-QL-001-L	ELISA	Microcystin/Nod.	8.69	ng/g ww	3.75	25	
2023-QL-002-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-QL-002-L	ELISA	Microcystin/Nod.	12.88	ng/g ww	3.75	25	
2023-QL-003-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-QL-003-L	ELISA	Microcystin/Nod.	10.99	ng/g ww	3.75	25	
2023-QL-004-F	ELISA	Microcystin/Nod.	ND	ng/g ww	1.88	12.5	U
2023-QL-004-L	ELISA	Microcystin/Nod.	10.28	ng/g ww	3.75	25	

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QUALITY CONTROL

Method	Analyte	Result	Qualifiers / Comments	Units	Spike Level	%REC	%REC Limits
ELISA	MC - Negative	ND	U, Batch 1	µg/L	0		
ELISA	MC - Positive	0.77	Batch 1	µg/L	0.75	102.2	70-130
ELISA	MC - Matrix sp.	0.81	Batch 1	µg/L	1.00	81.3	70-130
ELISA	MC - Negative	ND	U, Batch 2	µg/L	0		
ELISA	MC - Positive	0.75	Batch 2	µg/L	0.75	99.4	70-130
ELISA	MC - Matrix sp.	1.15	Batch 2	µg/L	1.21	95.1	70-130

QUALIFIERS/COMMENTS/NOTES

C1	The reported concentration for this analyte is below the quantification limit.
C2	The reported concentration for this analyte is above the calibration range of the instrument.
J	The reported result for this analyte should be considered an estimated value.
U	Undetected