

Guadalupe River Watershed Mercury TMDL: Reservoir Monitoring Plan (2018 - 2020)



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1 Background and Purpose

In 2008, the San Francisco Bay Regional Water Quality Control Board (Regional Board) amended the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) to establish water and fish tissue objectives addressing mercury pollution in the Guadalupe River Watershed. The Santa Clara Valley Water District (District) has voluntarily undertaken technical studies in affected reservoirs to improve knowledge of mercury cycling, bioaccumulation, and remediation methods. The District operates four line-diffuser hypolimnetic oxygenation systems and four solar-powered hypolimnetic circulators aiming to prevent anoxic conditions that facilitate the methylation of mercury. As part of its technical studies, the District evaluates the effectiveness of these systems in reducing methylmercury concentrations in the water column and in fish. Though these studies are voluntary, the Regional Board “will compel the District to undertake monitoring and special studies through California Water Code 13267 requirements” if necessary [4]. The District must report to the Regional Board on the results of these studies in December of odd years.

The District has conducted monitoring to answer three study questions (Special Studies) required in the TMDL:

1. *“How do the reservoirs and lakes in this watershed differ from one another? Factors to consider include, but are not limited to, area of connected wetlands, food web, water chemistry (phosphorus, pH, acid neutralizing capacity, and dissolved organic carbon), water level fluctuations, and infrastructure (outlet structure). Do outlet samples adequately represent hypolimnetic methylmercury concentrations for each reservoir? How significant are these differences?”*
2. *“Is it possible to increase the assimilative capacity for methylmercury in reservoirs and lakes?”*
3. *What are the mercury and methylmercury loads from points of discharge?*

Following submission of the District’s *2016 - 2017 Progress Report on Methylmercury Production and Control Measures* [10], the Regional Board concluded that the report “satisf[ies] the Guadalupe TMDL requirement for Special Study 1, which is to evaluate how the reservoirs and lakes in the Guadalupe River watershed differ from one another” [7]. Therefore, this monitoring plan is focused on answering the remaining two study questions.

In the TMDL Staff Report, *assimilative capacity* is defined as “less bioaccumulation despite the same methylmercury production.” [4]. By this definition, increasing a reservoir’s assimilative capacity would involve attempting to reduce bioaccumulation by manipulating the food web or trophic status. However, because the District operates treatment systems intending to reduce methylmercury production in all affected reservoirs, it is not possible to investigate these additional variables independently. Thus, the District addresses Special Study 2 by evaluating the effectiveness of the treatment systems in reducing methylmercury production and bioaccumulation. The Regional Board concurred with this interpretation in its June 2018 letter to the District, stating “[t]he District’s oxygenation work is adequately addressing Special Study 2, which is to assess whether it is possible to increase the assimilative capacity for methylmercury in lakes” [7]. In

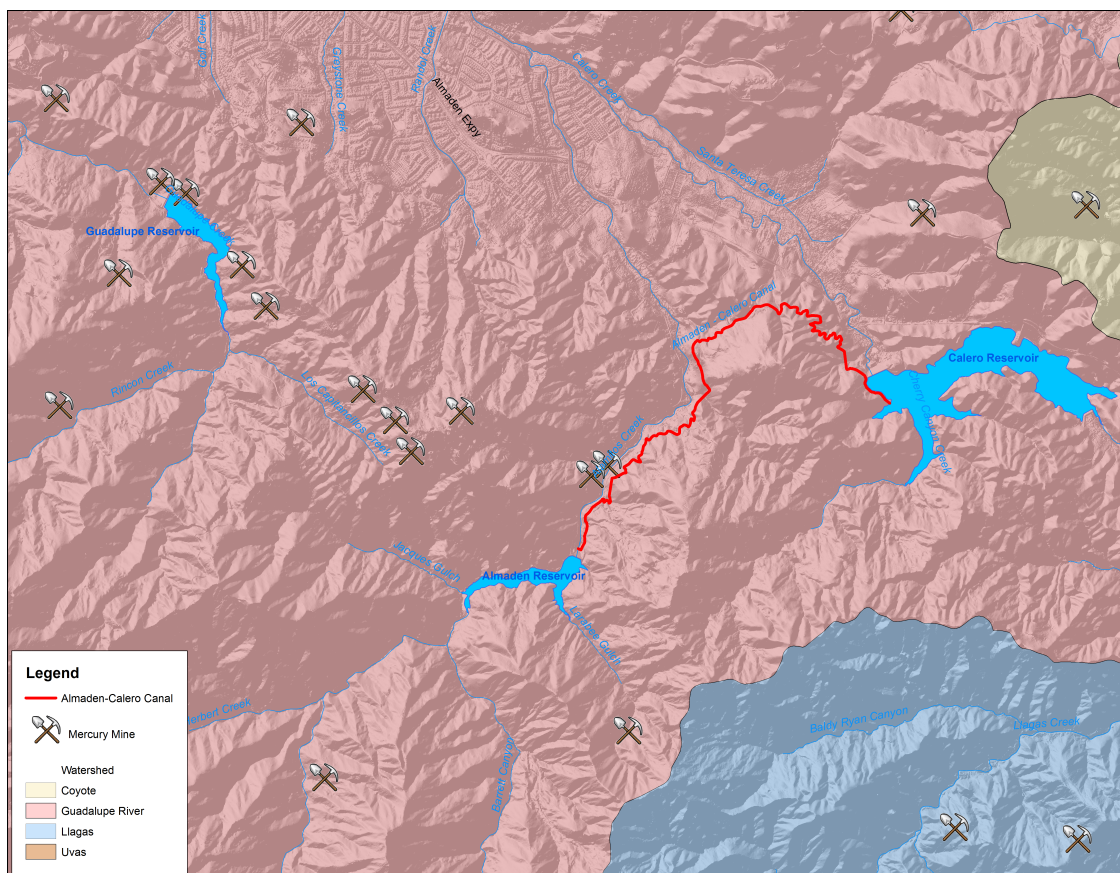
this monitoring plan, influencing a reservoir’s *assimilative capacity* for methylmercury is defined as reducing methylmercury production and bioaccumulation.

2 Monitoring Stations

The Guadalupe River Watershed is located in the South San Francisco Bay, draining north (Figure A.1). To maintain compliance with the TMDL, the District conducts monitoring at four mercury-impaired water bodies in the watershed (Almaden Lake, Almaden Reservoir, Calero Reservoir, Guadalupe Reservoir) and one mercury-impaired reference site outside of the watershed (Stevens Creek Reservoir).

Almaden and Guadalupe reservoirs are located adjacent to, and have received mercury mining waste from, the former New Almaden Mining District: North America’s largest and most productive historic mercury mine (Figure 1). Calero Reservoir is outside the mining district’s catchment area, and is believed to be primarily contaminated by historic and ongoing water transfers from Almaden Reservoir through the Almaden-Calero Canal (Figure A.2).

Figure 1: New Almaden Mining District and Upper Guadalupe Watershed Reservoirs



Stevens Creek Reservoir is located outside of the Guadalupe River Watershed, and has not been impacted by mercury mining. However, the reservoir is listed as impaired for mercury on the Environmental Protection Agency’s Clean Water Act Section 303(d) list due to mercury concentrations

in fish that exceed regulatory thresholds [2]. Though Stevens Creek Reservoir’s mercury source is unknown, a study published in 2010 found elevated wet deposition of mercury in the vicinity of the nearby LeHigh Cement and Permanente Quarry, likely supplying mercury to the reservoir [9].

Reservoirs were previously monitored at two locations: the deepest area (above the reservoir portal), and at the outlet (where water is discharged downstream) (Figures A.3 to A.6). However, because the District demonstrated in its *2016 - 2017 Progress Report on Methylmercury Production and Control Measures* that water quality data measured at the reservoir outlets were statistically indistinguishable from data measured one meter from the reservoir bottom in all reservoirs except Guadalupe [10], the Regional Board approved the elimination of the following monitoring stations: Almaden Reservoir Outlet (station 91850-4), Calero Reservoir Outlet (station 91870-4), and Stevens Creek Reservoir Outlet (station 91910-2). This approval is documented in the Regional Board’s March 2018 letter to the District, which states “[Regional] Board staff concur with the proposal to discontinue outlet sampling at Almaden, Calero, and Stevens Creek reservoirs because hypolimnia data will continue to be collected and [are] demonstrated by analysis in this report to be statistically indistinguishable from outlet data” [6].

Almaden Lake was previously monitored at seven locations: Sites 1 - 5, the lake inlet, and the lake outlet. Because little pre-treatment data exist at sites 3 - 5, and Site 2 is very similar to Site 1, the District recommended eliminating Sites 2 - 5 in its *2016 - 2017 Progress Report on Methylmercury Production and Control Measures*. The Regional Board approved this recommendation in its March 2018 letter to the District, stating “Water [Regional] Board staff agree with proposal to eliminate Sampling Sites 2 - 5 at Lake Almaden.”

Considering the monitoring site deletions approved by the Regional Board, the following stations will be monitored as part of this plan:

- Almaden Lake Inlet (92401-6)
- Almaden Lake Outlet (92401-7)
- Almaden Lake Station 1 (92401-8)
- Almaden Reservoir (91850-1)
- Calero Reservoir (91870-2)
- Guadalupe Reservoir (91890-1)
- Guadalupe Reservoir Outlet (91890-4)
- Stevens Creek Reservoir (91910-1)

3 Treatment Systems

Almaden Reservoir Three circulators were deployed in Almaden Reservoir in April of 2007. Two epilimnetic circulators intended to improve planktonic assemblages and reduce load of organic matter to the bottom of the reservoir, while one hypolimnetic circulator aimed to improve oxygen levels and suppress hypoxic conditions that facilitate the methylation of mercury. These systems were found to be ineffective in reducing methylmercury production [8]. In April of 2014, the

District installed a line-diffuser hypolimnetic oxygenation system in Almaden Reservoir. It has been operated nearly continuously during periods of thermal stratification since 2016.

Calero Reservoir A line-diffuser hypolimnetic oxygenation system was installed in Calero Reservoir in November of 2011, but was not operated until April of 2013. The system is operated nearly continuously during periods of thermal stratification.

Guadalupe Reservoir Three epilimnetic circulators were deployed in Guadalupe Reservoir in 2007 to improve planktonic assemblages and reduce organic loading to the bottom of the reservoir. These proved ineffective and were subsequently removed [8]. A line-diffuser hypolimnetic oxygenation system was installed in June of 2013, and operated intermittently from July to September. The system was not operated in 2014, operated intermittently in 2015, and is now operated nearly continuously during periods of thermal stratification.

Almaden Lake Almaden Lake is equipped with four solar-powered hypolimnetic circulators. The first was installed at Site 1 in 2006. A second device was installed in March of 2007 (Site 2), and the remaining two were installed in January of 2009. These devices are situated in the deepest portions of the lake, which were the main pits of the historic gravel quarry. Monitoring Site 1 is used to evaluate effectiveness because it is located in the primary quarry pit, and contains the most historical data. The solar circulator at Site 1 was lowered in 2007, after it was initially found to be ineffective due to its position high above the lake bottom. The effects of the lowering appeared to take effect in 2009. Due to inconsistent operation, data collected before 2009 were considered to be pre-treatment.

Stevens Creek Reservoir (Reference Site) A line-diffuser hypolimnetic oxygenation system was installed in Stevens Creek Reservoir in 2013. It operated intermittently in 2015, and is now operated nearly continuously during periods of thermal stratification.

4 Water Quality Monitoring

This section describes the water quality monitoring that will be completed to address study questions 2 and 3.

4.1 Monitoring Analytes

4.1.1 Sonde Profiles

At each sampling event, the District will take water quality profiles at reservoir stations at depth increments ranging from 0.25 meters to 1 meter. These will be collected using Hydrolab DS5 sondes, recording the following parameters:

- Depth (m)
- Temperature (C)
- Dissolved Oxygen (mg/L)
- Dissolved Oxygen (% Sat.)
- ORP (mV)

- Chlorophyll *a* (µg/L)
- Phycocyanin (cells/mL and volts)
- Specific Conductivity (µS/cm)
- pH

Sondes will be calibrated monthly to bi-monthly in accordance with standard procedures from the manufacturer.

4.1.2 Grab Sampling

Past Sampling Previously, the District monitored for total methylmercury at five depths throughout the water column, and the following analytes in the epilimnion (2 meters from the surface) and hypolimnion (1 meter from the bottom):

- Ammonia
- Nitrate
- Nitrite
- Sulfate
- Total Iron
- Total Manganese
- Total Mercury
- Total Phosphorus

Approved Reductions Following the completion of Special Study 1, which in part investigates the chemical differences of the water bodies, the Regional Board approved removing the following parameters:

- Ammonia
- Nitrate
- Nitrite
- Total Iron
- Total Manganese
- Total Phosphorus

This approval is documented in the Regional Board’s March 2018 letter to the District, stating “[Regional] Board staff agree with proposal to discontinue monitoring of the following analytes: Ammonia, Total Phosphorus, Nitrate, and Nitrite” and “[Regional] Board staff agree with the proposal to discontinue manganese and iron sampling in reservoirs” [6]. The Regional Board considers Special Study 1 to be adequately addressed.

Future Sampling From October 1, 2018 onward, the District will monitor total methylmercury at five depths throughout the water column, and the following analytes in the epilimnion (2 meters from the surface) and hypolimnion (1 meter from the bottom):

- Sulfate
- Chloride
- Total Mercury
- Dissolved Methylmercury (0.45 micron filter)
- Ammonia

Chloride is conservative throughout the water column, and unaffected by stratification, making the sulfate:chloride ratio an indicator of microbial sulfate reduction. Dissolved methylmercury will be monitored to represent the amount available for bioaccumulation, in contrast with total methylmercury, which includes methylmercury in algae and adsorbed to particles.

Procedures Water samples will be collected using a Wildco beta-type Van Dorn sampling device (2.2 liter) at discrete depths. Epilimnion samples will be collected at a depth of two meters. Hypolimnion samples will be collected approximately one meter above the lake or reservoir bottom. Three middle depth total methylmercury samples will be collected at even intervals between the epilimnion and hypolimnion during mixed conditions. During thermal stratification, these samples will be collected at the top, middle, and bottom of the thermocline. Samples will be dispensed using “Clean Hands-Dirty Hands” procedures of EPA Method 1669 [3] into the containers described in Table 1.

Table 1: Sample Collection Bottles and Preservatives

Analyte	Container Material	Volume	Preservative
Ammonia (as N)	HDPE	500mL	Sulfuric Acid
Low-Level Mercury	Flourinated Polyethelene	250mL, double bagged	Unpreserved
Chloride, Sulfate	HDPE	500mL	Unpreserved
Total Methylmercury	Flourinated Polyethelene	250mL, double bagged	Hydrochloric Acid

Analytical Methods Samples will be analyzed by a certified contracted laboratory (Test America Inc.), and/or by the District’s internal Water Quality Laboratory. Table 2 describes the laboratory methods used for chemical analysis, as well as current reporting limits, below which measured values are considered “non-detects”. Note that these reporting limits have changed over time, requiring the use of statistical methods for censored data when analyzing parameters with a significant percentage of non-detect values. The contracted lab will use quality control procedures such as method blanks, blank spikes, matrix spikes, and duplicates to ensure the defensibility and accuracy of results.

Inlet and Outlet Sites At the inlet and outlet of Almaden Lake, and the outlet of Guadalupe Reservoir, the District will collect total mercury and total methylmercury samples. Additionally, staff will record the following parameters using YSI ProODO and Pro1030:

Table 2: Laboratory Analysis Methods

Analyte	Method	Current Reporting Limit
Ammonia (as N)	EPA 350.1	0.1 mg/L
Low-Level Mercury	EPA 1631 E	0.5 ng/L
Chloride, Sulfate	EPA 300	1 mg/L
Total Methylmercury	EPA 1630	0.05 ng/L

- Temperature (C)
- Dissolved Oxygen (mg/L)
- ORP (mV)
- Specific Conductivity ($\mu\text{S}/\text{cm}$)

4.2 Monitoring Frequency

Water quality monitoring will occur twice-monthly at each station during periods of thermal stratification, and monthly during mixed conditions. At each reservoir station, District staff will collect a sonde profile, and the grab samples described in section 4.1.2. At each inlet and outlet station, staff will collect data using water quality meters, as well as total mercury and total methylmercury samples.

4.3 Load Calculations

Total annual mercury and methylmercury loads discharged from reservoirs will be calculated using continuous (15 minute) stream flow data recorded by outlet gauges. Loads will be calculated as the total volume of water transferred between sampling events multiplied by mercury and methylmercury concentrations measured. This is the same method used in previous biennial reports.

Total mercury and methylmercury samples collected at the following stations will be used to calculate loads:

- Almaden Reservoir Hypolimnion (91850-1)
- Calero Reservoir Hypolimnion (91870-2)
- Guadalupe Reservoir Outlet (91890-4)
- Stevens Creek Reservoir Hypolimnion (91910-1)

Loads from Almaden Lake will not be calculated because the outflow is not gauged, loads were not calculated previously, and the lake is not a point of discharge (being unimpounded along Los Alamitos Creek).

5 Fish Monitoring

Section 9-35 of the TMDL Staff Report requires the District address the following questions regarding trends in fish tissue mercury concentrations:

1. *What is the seasonal and inter-annual variation in fish mercury in the first 5 years of implementation for remediation effectiveness indicators (REIs) and target fish?*
2. *What is the trend in fish tissue mercury concentrations in target fish over the subsequent 15 years of implementation?*

Fish monitoring is conducted twice annually, and is designed to evaluate the effectiveness of the treatment systems and assess reproductive risks to piscivorous birds. The inter-annual variability portion 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 “[previously reported fish data] are useful to quantify the interannual variability of mercury in fish from reservoirs and creeks” [5]. The District continues to investigate seasonal variability in its studies.

5.1 Sampling Methods

The District will collect fish for body burden mercury and assemblage analysis from Almaden, Calero, Guadalupe, and Stevens Creek reservoirs. The Coordinated Monitoring Program (CMP) collects fish from Almaden Lake and required stream sampling sites. Depending on reservoir water level, the District will fish using either boat electrofishing, trolling, or hook-and-line methods. Electrofishing is typically conducted at night to improve sampling efficiency. Other methods are used during daylight hours.

When boat electrofishing is used, fish will be captured using a Smith-Root Model H electrofishing boat. Boat electrofishing samples the water column between the surface and approximately 15 feet of depth, depending on the conductivity and settings. Boat electrofishing possesses a sampling bias including the area that can be sampled, species catch ability, and netting efficiency. Only fish near shore or within the top of the water column can be collected, and reservoir conditions such as turbidity, aquatic vegetation, and water level limit sampling and netting ability. The pelagic tendency of forage fish makes them more susceptible to capture using boat electrofishing, so results may overestimate prey populations relative to predatory fish. Three to five sampling fetches will be collected throughout the reservoirs. Fetches are defined as fifteen-minute passes of specific areas of shoreline, and the distance sampled depends on fish abundance and netting efficiency. The reservoirs are divided into “quadrants,” and each quadrant will be sampled during a monitoring event. Sampling will be conducted at night to increase capture efficiency.

When low water levels prohibit the use of the electrofishing boat, samples will be collected using hook-and-line methods. Sampling will be conducted from a 14-foot aluminum Jon Boat. Methods may include open-water trolling along transects and stationary angling along shore margins. Hook-and-line sampling may present a bias toward larger fish, as gape size can limit catchability of smaller fish. Additionally, the sampling location and ability of the angler may confound the collection results. The primary intention of non-electrofishing methods is to collect fish for the body burden analysis, so more emphasis will be placed on collecting target fish than providing an estimate of fish assemblage or size distribution.

5.2 Body Burden Mercury Monitoring

The body burden analysis targets trophic level 3 and 4 fish, including (but not limited to) largemouth bass (*Micropterus salmoides*, TL4), bluegill (*Lepomis macrochirus*, TL3), and black crappie

(*Pomoxis nigromaculatus*, TL3). Common trophic level 3 fish are shown in Table 3. All fish sampled will fall within two size classes: 50 mm to 150 mm, and 150 mm to 350 mm. Fish selected to be sacrificed will be placed in individual zip-lock bag, labeled, and placed on ice for transport back to District facilities. The samples will then be removed from the ice, processed (numbered, remeasured, weighed, and double-labeled), and placed in the freezer in preparation for transport to the contracted laboratory (Brooks Applied Labs, LLC).

Table 3: Common Trophic Level 3 Fish

Common Name	Scientific Name
small bullheads	Ameiurus nebulosus
carp	Cyprinus carpo
small catfishes	Ictalurids
black crappie	Pomoxis nigromaculatus
white crappie	Pomoxis annularis
goldfish	Carassius auratus
killifish	Cyprinodontiformes
bigscale logperch	Percina macrolepida
mosquitofish	Gambusia affinis
California roach	Hesperoleucus symmetricus
golden shiner	Notemigonus crysoleucas
inland silverside	Menidia beryllina

5.2.1 Scientific Collecting Permit

The District Fisheries Biologist will obtain a Scientific Collecting Permit (SCP) from California Department of Fish and Wildlife for take and collection of fish. Species collected must include largemouth bass, black crappie, and bluegill in the 50 - 150 mm and 150 - 350 mm size ranges. The District's current (2018) SCP allows for the collection of 42 fish per reservoir three times per year.

5.2.2 Fish Collection Categories

The TMDL Staff Report requires the collection of three categories of fish. The fish tissue objectives apply to trophic level 3 fish, which are intended to minimize reproductive and developmental risks to piscivorous birds. Additionally, "remediation effectiveness indicators" are required to be monitored as short-term indicators of the effectiveness of management actions.

Remediation Effectiveness Indicators (REIs) are samples designed to be sensitive measures of mercury exposure variability in space and time. In the Guadalupe River Watershed, based on recommendations from the Regional Board, we have chosen "age-1" largemouth bass ranging from 55 to 102 mm in length as the primary REIs [4]. The 55 - 102 mm length for age-1 fish is based on Table 8-4 of Tetra Tech's 2005 *Data Collection Report* [1], which describes minimum and maximum lengths for age-1 fish observed in the affected reservoirs. Because largemouth bass spawn during the springtime, REI samples are collected during the summer sampling event to ensure adequate tissue mass for laboratory analysis. Largemouth bass within the REI size range collected during the springtime are likely to represent the previous year's cohort.

Target Fish (TL3A and TL3B) are defined as 50 to 350 mm trophic level 3 fish. These fish are collected to measure progress in attaining fish tissue objectives of 0.05 mg Hg/kg (wet weight)

for 50-150 mm fish (TL3A), and 0.1 mg Hg/kg (wet weight) for 150-350 mm fish (TL3B). These allocations are intended to be protective of piscivorous birds. Thus, trophic level 3 target fish are collected just before or during the avian breeding season (spring sampling event), and during the summer sampling event.

Adult largemouth bass (TL4) range from 102 to 350 mm. Though these fish do not serve as targets or REIs, abundant historical data exists. Adult largemouth bass samples (102 - 200 mm) will be collected during the spring sampling event only, representing the cohort of REI fish measured during the previous summer. This data will serve to determine bioaccumulation rates that occur during the wet season, as well as to minimize extrapolation in length-standardization.

5.2.3 Sample Sizes

Power Analysis District staff conducted a power analysis to determine sample sizes for fish tissue collection events using data collected from 2011 to 2018. We used 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 mercury concentrations are high and variable, detecting this small a difference would require a sample size of > 30 fish per collection category, which would be unfeasible and prohibitively expensive. Therefore, we have selected an effect size of 25% of the 2011 - 2018 mean mercury concentration of each collection category in each reservoir (ME in table 5). This will allow us to detect practically significant changes in mercury concentrations between groups.

The results of the power analysis are shown in Figure 2. Different potential sample sizes are shown by different colored lines. As sample size increases, the detectable effect size decreases, and power increases. The more samples are collected, the smaller the difference in detectable effect size becomes. This illustrates the concept of “diminishing returns:” the more samples are collected beyond a certain threshold, the less the statistical benefit of the increased sample size.

Figure 2: Power Analysis of Fish Categories by Reservoir

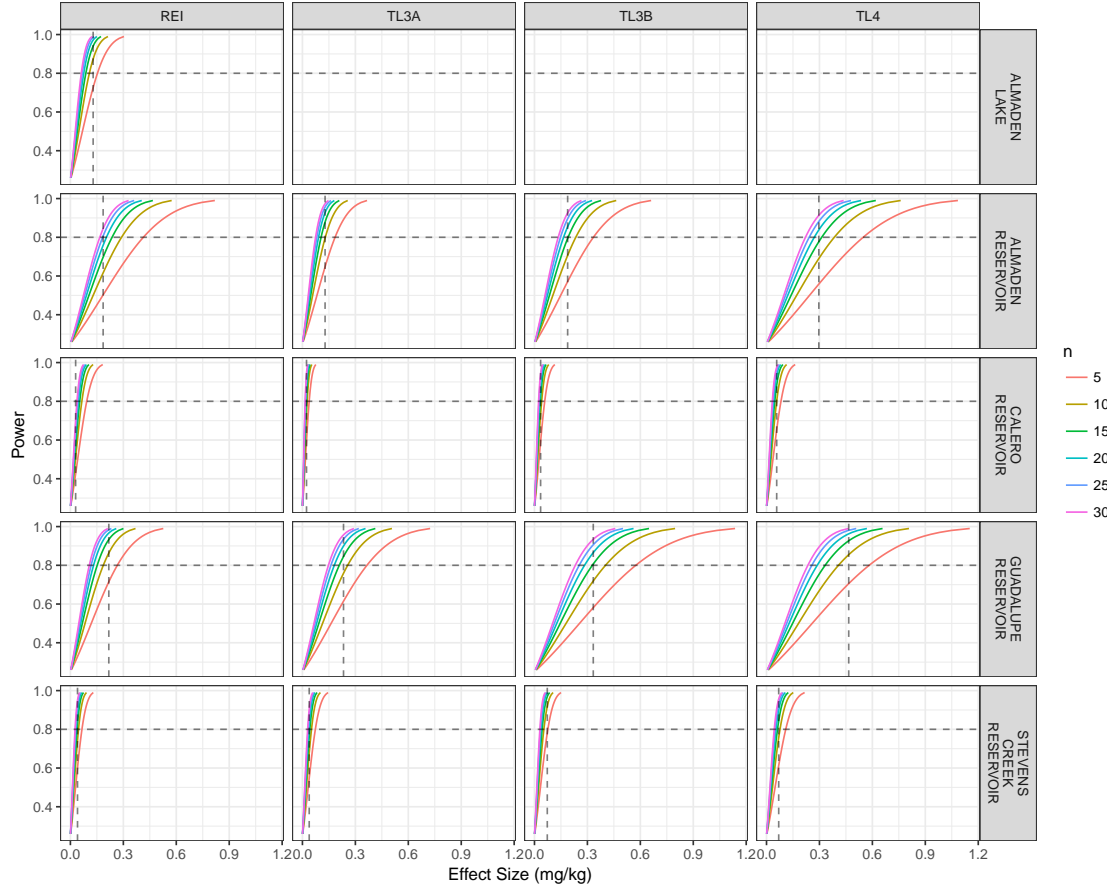


Table 4 shows the ideal sample sizes of the power analysis. These are based on a targeted effect size of 25% of the 2011 - 2018 mean mercury concentrations for each category in each reservoir, α of 0.05, and a power of 0.8. In Almaden and Calero reservoirs, the sum of REI or TL4, TL3A, and TL3B fish required for the above criteria exceeds the 42 fish take limit of the Scientific Collecting Permit.

Sample Size Based on Confidence Interval In addition to the power analysis, District Staff calculated ideal sample sizes to yield 95% confidence intervals with a margins of error of $\pm 25\%$ of the 2011 - 2018 mean mercury concentrations for each category in each reservoir. Results are shown in table 5. As coefficient of variation (mean divided by standard deviation) increases, the required sample size increases (Figure 3).

5.3 Assemblage Monitoring

Sampling Quadrants Reservoirs are divided into “quadrants” to investigate spatial differences in fish assemblages. District biologists will sample each quadrant during a monitoring event. These quadrants are displayed in figures A.8 to A.11. Sampling quadrants are consistent with quadrants used in previous years.

Table 4: Sample Sizes from Power Analysis

Reservoir	Category	n
ALMADEN LAKE	REI	8
ALMADEN RESERVOIR	REI	8
ALMADEN RESERVOIR	TL3A	10
ALMADEN RESERVOIR	TL3B	15
ALMADEN RESERVOIR	TL4	17
CALERO RESERVOIR	REI	35
CALERO RESERVOIR	TL3A	15
CALERO RESERVOIR	TL3B	10
CALERO RESERVOIR	TL4	10
GUADALUPE RESERVOIR	REI	8
GUADALUPE RESERVOIR	TL3A	12
GUADALUPE RESERVOIR	TL3B	15
GUADALUPE RESERVOIR	TL4	8
STEVENS CREEK RESERVOIR	REI	10
STEVENS CREEK RESERVOIR	TL3A	15
STEVENS CREEK RESERVOIR	TL3B	8
STEVENS CREEK RESERVOIR	TL4	12

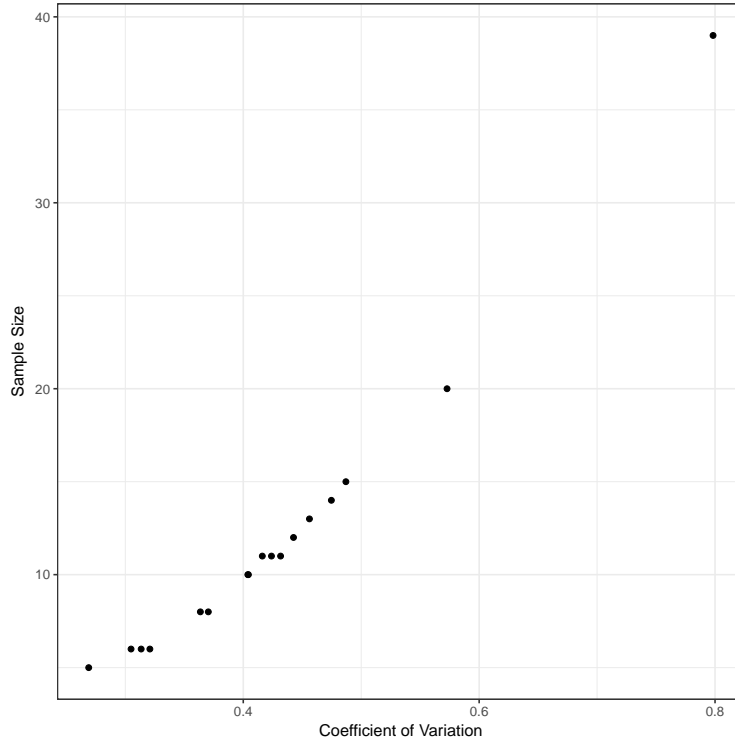
Table 5: Calculated Sample Sizes to Yield 95% Confidence Intervals with 25% Margin of Error

Reservoir	Category	Mean (mg/kg)	SD	ME	CV	n
ALMADEN LAKE	REI	0.515	0.157	0.129	0.304854369	6
ALMADEN RESERVOIR	REI	0.742	0.425	0.186	0.57277628	20
ALMADEN RESERVOIR	TL3A	0.513	0.19	0.128	0.37037037	8
ALMADEN RESERVOIR	TL3B	0.752	0.343	0.188	0.456117021	13
ALMADEN RESERVOIR	TL4	1.186	0.563	0.296	0.47470489	14
CALERO RESERVOIR	REI	0.119	0.095	0.03	0.798319328	39
CALERO RESERVOIR	TL3A	0.092	0.039	0.023	0.423913043	11
CALERO RESERVOIR	TL3B	0.139	0.06	0.035	0.431654676	11
CALERO RESERVOIR	TL4	0.231	0.084	0.058	0.363636364	8
GUADALUPE RESERVOIR	REI	0.871	0.273	0.218	0.313432836	6
GUADALUPE RESERVOIR	TL3A	0.931	0.376	0.233	0.40386681	10
GUADALUPE RESERVOIR	TL3B	1.333	0.59	0.333	0.442610653	12
GUADALUPE RESERVOIR	TL4	1.864	0.598	0.466	0.320815451	6
STEVENS CREEK RESERVOIR	REI	0.161	0.067	0.04	0.416149068	11
STEVENS CREEK RESERVOIR	TL3A	0.154	0.075	0.038	0.487012987	15
STEVENS CREEK RESERVOIR	TL3B	0.29	0.078	0.072	0.268965517	5
STEVENS CREEK RESERVOIR	TL4	0.277	0.112	0.069	0.40433213	10

Abundance and Age Classes After each 15-minute sampling fetch, the electrofishing boat will be anchored away from the shoreline. Fish will be identified to species, measured, and counted. Fork lengths will be measured and recorded for the first 25 individuals of each species observed. These data will be used to infer age classes and relative abundance of each species.

When hook and line or trolling methods are used, all fish will be identified, measured, and counted. These methods are biased toward larger, more predatory fish, so results will likely be less representative of the true assemblage than when boat electrofishing methods are used.

Figure 3: Relationship Between Coefficient of Variation and Required Sample Size



5.4 Monitoring Events

The District will complete two sampling events annually: one in spring, and one in summer.

5.4.1 Spring Sampling Event

A spring sampling event is conducted between the months of March and April. Because the spring event occurs just before or during bird breeding season, target fish collected in this period should represent the reproductive risks to piscivorous birds. Though not required, additional largemouth bass from 102-200 mm may be collected to assess the degree of bioaccumulation that occurs between the summer and spring sampling events. Bass in this size range are assumed to represent the remediation effectiveness indicator cohort sampled in the previous fall. Sampling the same cohort in the spring allows us to investigate the role of reservoir turnover and other seasonal factors that may influence bioaccumulation.

Based on the power and confidence interval sample size analyses described in section 5.2.3, take limitations of the Scientific Collecting Permit described in section 5.2.1, and practical limitations of successfully obtaining the target sample size, the District will attempt to collect the samples described in Table 6

5.4.2 Summer Sampling Event

A summer sampling event is conducted between the months of August and September. Since sunfish spawn during spring, 55 - 102mm largemouth bass collected at this time should represent age-0+ remediation effectiveness indicators. These fish are assumed to have been exposed

Table 6: Fish Sample Target for Spring Sampling Event

Category	n
TL3A	14
TL3B	13
TL4 (102 - 200 mm)	15

exclusively to conditions in which the treatment systems were operated, during the season of peak methylmercury production, and therefore adequately assess remediation effectiveness. Additional target fish are collected during the summer sampling event to investigate seasonal variability in mercury concentrations.

During the summer sampling event, the District will attempt to collect the samples described in Table 7.

Table 7: Fish Sample Target for Spring Sampling Event

Category	n
TL3A	14
TL3B	13
REI (55 - 102 mm)	15

6 Data Management

All data will be stored managed in the District’s Environmental Monitoring Information Management System (EM-IMS) database. The database contains modules for storing water quality, fish tissue, and fish assemblage data. Data management will be the responsibility of the Environmental Planning Unit.

7 Additional Studies

The District may engage in additional studies and collaborations in attempt to answer key management questions that complicate effective methylmercury controls.

8 Reporting

As required by the TMDL Staff Report, the District will submit technical reports to the Regional Board detailing the studies described herein in December of odd years (2019, 2021, etc.).

9 Sampling Summary Tables

Sample collection summaries are shown in tables 8 and 9.

References

- [1] Guadalupe river watershed tmdl project technical memorandum 5.3.2: Data collection report. Technical report, Tetra Tech, 2005.
- [2] 2010 integrated report (clean water act section 303(d) list / 305(b) report). Technical report, State Water Resources Control Board, 2010.
- [3] U.S. Environmental Protection Agency. *Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels*, July 1996.
- [4] Carrie Austin, Sandia Potter, James Ponton, Dyan Whyte, and Thomas Mumley. Guadalupe river watershed mercury total maximum daily load (tmdl) project staff report for proposed basin plan amendment. Staff, California Water Quality Control Board San Francisco Bay Region, 2008.
- [5] San Francisco Bay Regional Water Quality Control Board. Water code section 13267 technical report requirement for a monitoring plan for mercury in waters downstream of new almaden mercury mining district, guadalupe mercury mine, and/or bernal mercury mine, June 2017.
- [6] San Francisco Bay Regional Water Quality Control Board. Comments on 20162017 progress report on methylmercury production and control measures, June 2018.
- [7] San Francisco Bay Regional Water Quality Control Board. District currently meeting requirements in the guadalupe river watershed mercury total maximum daily load, June 2018.
- [8] Santa Clara Valley Water District. Methylmercury production and control in lakes and reservoirs contaminated by historic mining activities in the guadalupe river watershed. Technical, Santa Clara Valley Water District, 2013.
- [9] Sarah Rothenberg, Lester McKee, Alicia Gilbreath, Donald Yee, Mike Connor, and Xuewu Fu. Wet deposition of mercury within the vicinity of a cement plant before and during cement plant maintenance. *Atmospheric Environment*, 44(10):1255–1262, 2010.
- [10] Mark Seelos. Guadalupe river watershed mercury tmdl: 2017-2018 progress report on methylmercury production and control measures. Staff, Santa Clara Valley Water District, 2017.

Table 8: Sampling Summary Table

Water Body	Station	Analyte	Matrix	Depths	Frequency	Analysis
Almaden Lake	92401-6	Oxidation Reduction Potential	Water	1	monthly or semi-monthly	Sonde
		Oxygen Concentration	Water	1	monthly or semi-monthly	Sonde
		Specific Conductivity	Water	1	monthly or semi-monthly	Sonde
		Temperature	Water	1	monthly or semi-monthly	Sonde
		Total Mercury	Water	1	monthly or semi-monthly	Laboratory
		Total Methylmercury	Water	1	monthly or semi-monthly	Laboratory
	92401-7	Oxidation Reduction Potential	Water	1	monthly or semi-monthly	Sonde
		Oxygen Concentration	Water	1	monthly or semi-monthly	Sonde
		Specific Conductivity	Water	1	monthly or semi-monthly	Sonde
		Temperature	Water	1	monthly or semi-monthly	Sonde
		Total Mercury	Water	1	monthly or semi-monthly	Laboratory
		Total Methylmercury	Water	1	monthly or semi-monthly	Laboratory
	92401-8	Ammonia (N)	Water	2	monthly or semi-monthly	Laboratory
		Chloride	Water	2	monthly or semi-monthly	Laboratory
		Chlorophyll a	Water	Profile	monthly or semi-monthly	Sonde
		Dissolved Methylmercury	Water	2	monthly or semi-monthly	Laboratory
		Oxidation Reduction Potential	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Concentration	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Saturation	Water	Profile	monthly or semi-monthly	Sonde
		pH	Water	Profile	monthly or semi-monthly	Sonde
		Phycocyanin	Water	Profile	monthly or semi-monthly	Sonde
		Specific Conductivity	Water	Profile	monthly or semi-monthly	Sonde
		Sulfate	Water	2	monthly or semi-monthly	Laboratory
		Temperature	Water	Profile	monthly or semi-monthly	Sonde
		Total Mercury	Water	2	monthly or semi-monthly	Laboratory
		Total Methylmercury	Water	3	monthly or semi-monthly	Laboratory
	Almaden Reservoir	Ammonia (N)	Water	2	monthly or semi-monthly	Laboratory
		Chloride	Water	2	monthly or semi-monthly	Laboratory
		Chlorophyll a	Water	Profile	monthly or semi-monthly	Sonde
		Dissolved Methylmercury	Water	2	monthly or semi-monthly	Laboratory
		Oxidation Reduction Potential	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Concentration	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Saturation	Water	Profile	monthly or semi-monthly	Sonde
		pH	Water	Profile	monthly or semi-monthly	Sonde
		Phycocyanin	Water	Profile	monthly or semi-monthly	Sonde
		Specific Conductivity	Water	Profile	monthly or semi-monthly	Sonde
		Sulfate	Water	2	monthly or semi-monthly	Laboratory
		Temperature	Water	Profile	monthly or semi-monthly	Sonde
		Total Mercury	Water	2	monthly or semi-monthly	Laboratory
		Total Methylmercury	Water	5	monthly or semi-monthly	Laboratory
	Reservoir	Assemblage	Fish	NA	semi-annually	Laboratory
		Percent Solids	Fish	NA	semi-annually	Laboratory
		Total Mercury	Fish	NA	semi-annually	Laboratory
Calero Reservoir	91870-2	Ammonia (N)	Water	2	monthly or semi-monthly	Laboratory
		Chloride	Water	2	monthly or semi-monthly	Laboratory
		Chlorophyll a	Water	Profile	monthly or semi-monthly	Sonde
		Dissolved Methylmercury	Water	2	monthly or semi-monthly	Laboratory
		Oxidation Reduction Potential	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Concentration	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Saturation	Water	Profile	monthly or semi-monthly	Sonde
		pH	Water	Profile	monthly or semi-monthly	Sonde
		Phycocyanin	Water	Profile	monthly or semi-monthly	Sonde
		Specific Conductivity	Water	Profile	monthly or semi-monthly	Sonde
		Sulfate	Water	2	monthly or semi-monthly	Laboratory
		Temperature	Water	Profile	monthly or semi-monthly	Sonde
		Total Mercury	Water	2	monthly or semi-monthly	Laboratory
		Total Methylmercury	Water	5	monthly or semi-monthly	Laboratory
	Reservoir	Assemblage	Fish	NA	semi-annually	Laboratory
		Percent Solids	Fish	NA	semi-annually	Laboratory
		Total Mercury	Fish	NA	semi-annually	Laboratory

Table 9: Sampling Summary Table, cont.

Water Body	Station	Analyte	Matrix	Depths	Frequency	Analysis
Guadalupe Reservoir	91890-1	Ammonia (N)	Water	2	monthly or semi-monthly	Laboratory
		Chloride	Water	2	monthly or semi-monthly	Laboratory
		Chlorophyll a	Water	Profile	monthly or semi-monthly	Sonde
		Dissolved Methylmercury	Water	2	monthly or semi-monthly	Laboratory
		Oxidation Reduction Potential	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Concentration	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Saturation	Water	Profile	monthly or semi-monthly	Sonde
		pH	Water	Profile	monthly or semi-monthly	Sonde
		Phycocyanin	Water	Profile	monthly or semi-monthly	Sonde
		Specific Conductivity	Water	Profile	monthly or semi-monthly	Sonde
		Sulfate	Water	2	monthly or semi-monthly	Laboratory
		Temperature	Water	Profile	monthly or semi-monthly	Sonde
		Total Mercury	Water	2	monthly or semi-monthly	Laboratory
		Total Methylmercury	Water	5	monthly or semi-monthly	Laboratory
	91890-4	Oxidation Reduction Potential	Water	1	monthly or semi-monthly	Sonde
		Oxygen Concentration	Water	1	monthly or semi-monthly	Sonde
		Specific Conductivity	Water	1	monthly or semi-monthly	Sonde
		Temperature	Water	1	monthly or semi-monthly	Sonde
		Total Mercury	Water	1	monthly or semi-monthly	Laboratory
		Total Methylmercury	Water	1	monthly or semi-monthly	Laboratory
	Reservoir	Assemblage	Fish	NA	semi-annually	Laboratory
		Percent Solids	Fish	NA	semi-annually	Laboratory
		Total Mercury	Fish	NA	semi-annually	Laboratory
Stevens Creek Reservoir	91910-1	Ammonia (N)	Water	2	monthly or semi-monthly	Laboratory
		Chloride	Water	2	monthly or semi-monthly	Laboratory
		Chlorophyll a	Water	Profile	monthly or semi-monthly	Sonde
		Dissolved Methylmercury	Water	2	monthly or semi-monthly	Laboratory
		Oxidation Reduction Potential	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Concentration	Water	Profile	monthly or semi-monthly	Sonde
		Oxygen Saturation	Water	Profile	monthly or semi-monthly	Sonde
		pH	Water	Profile	monthly or semi-monthly	Sonde
		Phycocyanin	Water	Profile	monthly or semi-monthly	Sonde
		Specific Conductivity	Water	Profile	monthly or semi-monthly	Sonde
		Sulfate	Water	2	monthly or semi-monthly	Laboratory
		Temperature	Water	Profile	monthly or semi-monthly	Sonde
		Total Mercury	Water	2	monthly or semi-monthly	Laboratory
		Total Methylmercury	Water	5	monthly or semi-monthly	Laboratory
	Reservoir	Assemblage	Fish	NA	semi-annually	Laboratory
		Percent Solids	Fish	NA	semi-annually	Laboratory
		Total Mercury	Fish	NA	semi-annually	Laboratory

A Maps

Figure A.1: Guadalupe River Watershed Location

Guadalupe River Watershed Location

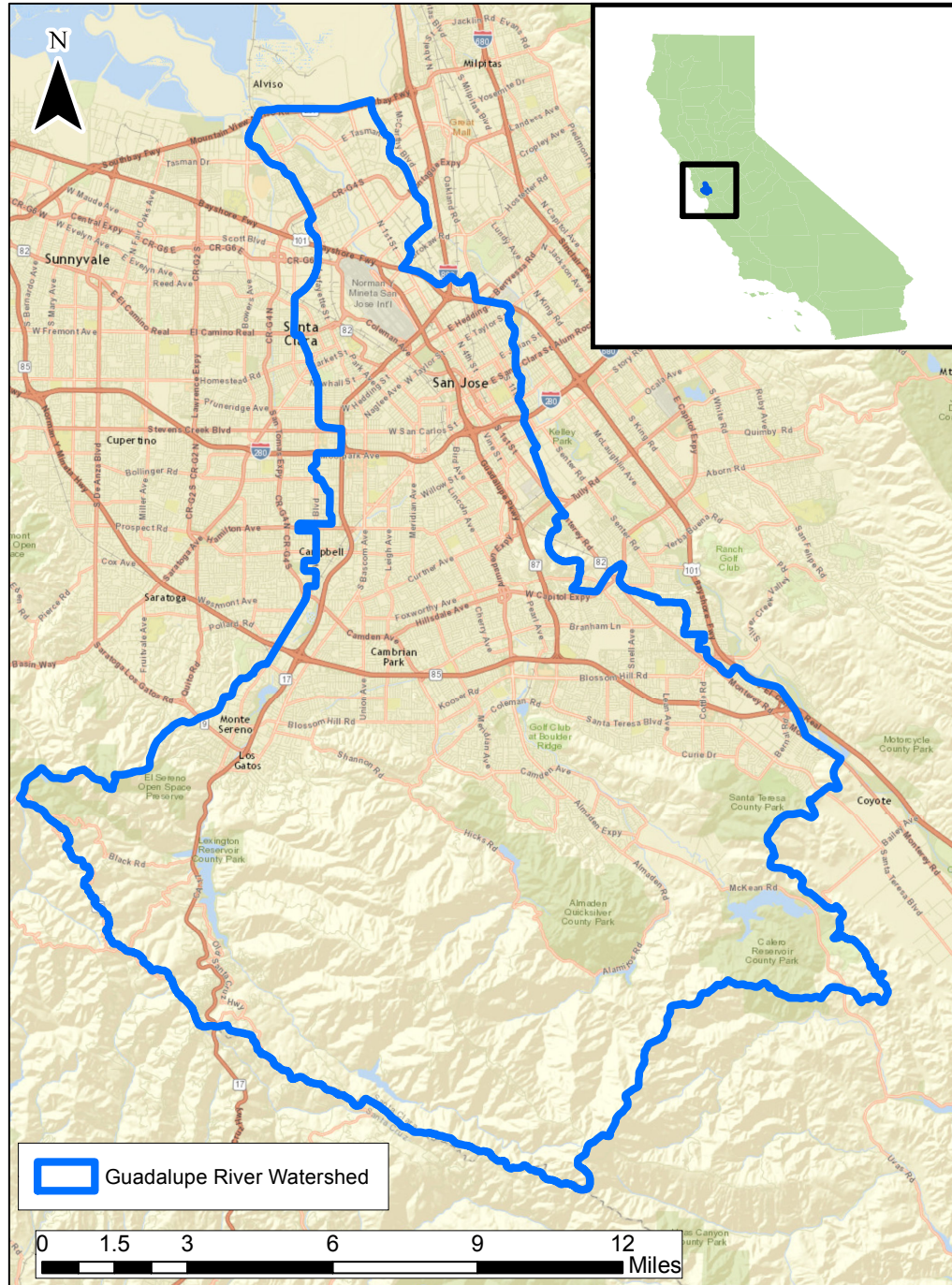


Figure A.2: Hydrologic Connectivity of Upper Guadalupe River Watershed

Hydrologic Connectivity of the Upper Guadalupe Watershed

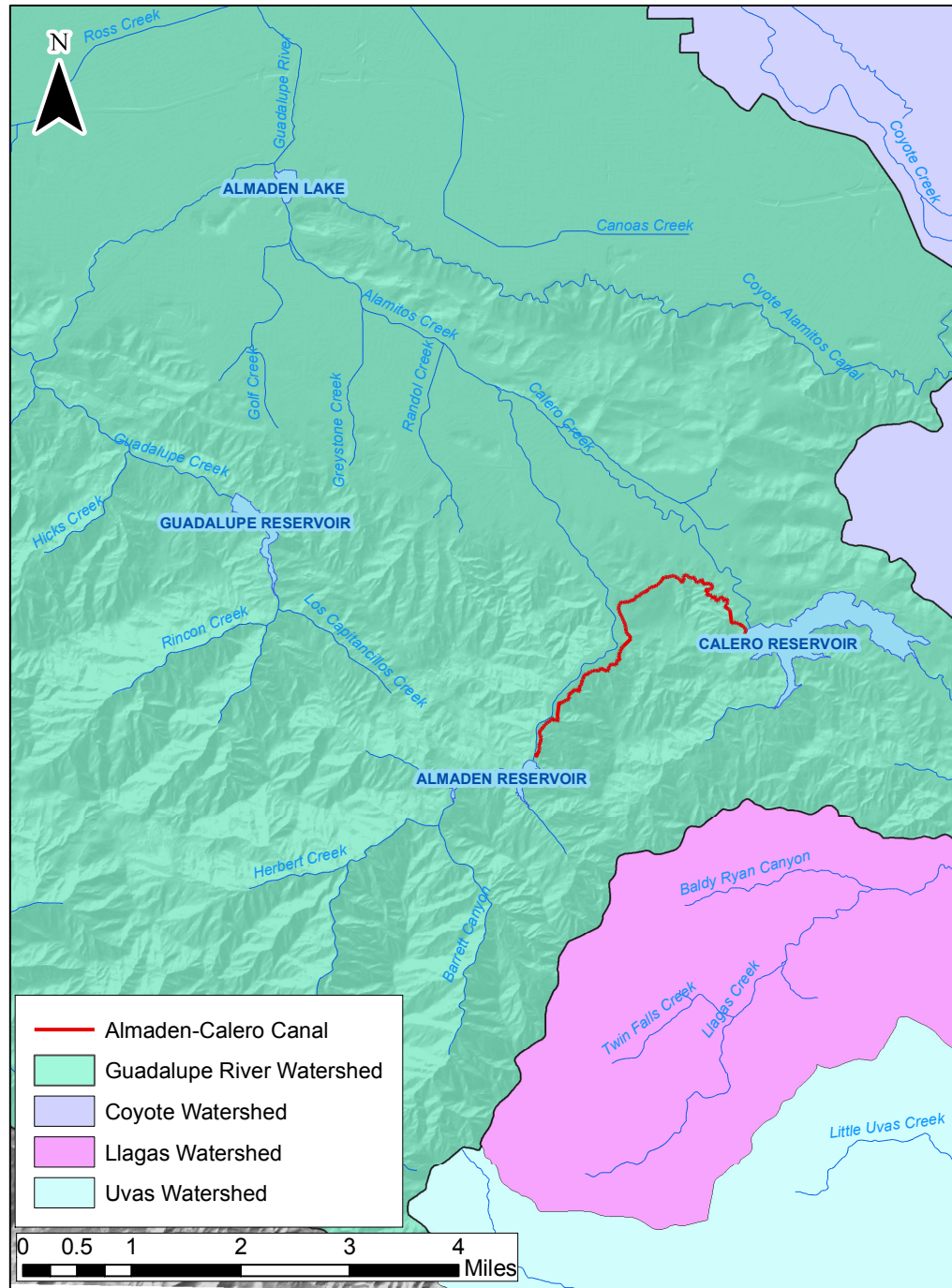


Figure A.3: Almaden Reservoir Sampling Sites

Almaden Reservoir Sampling Sites

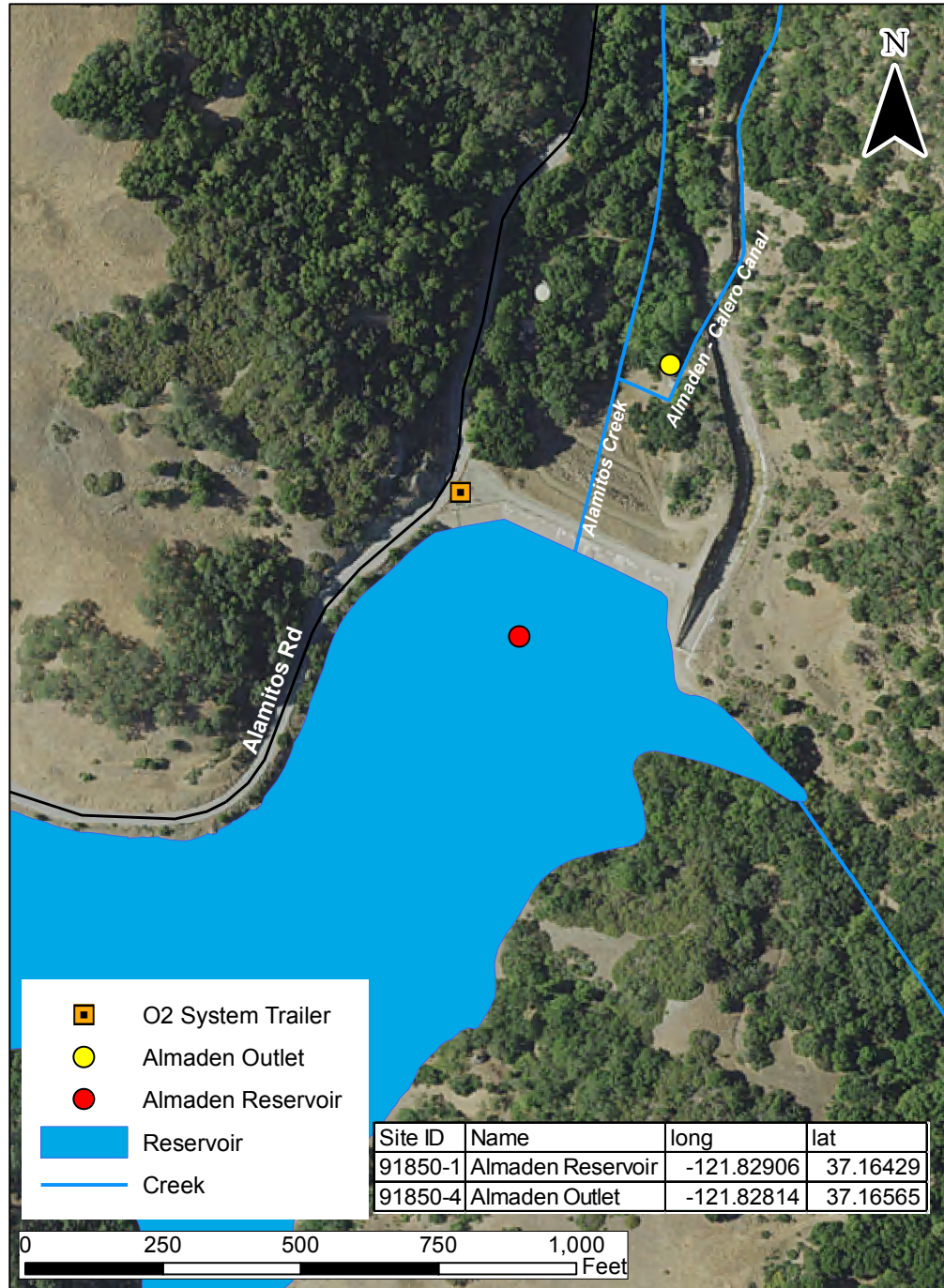


Figure A.4: Calero Reservoir Sampling Sites

Calero Reservoir Sampling Sites



Figure A.5: Guadalupe Reservoir Sampling Sites

Guadalupe Reservoir Sampling Sites

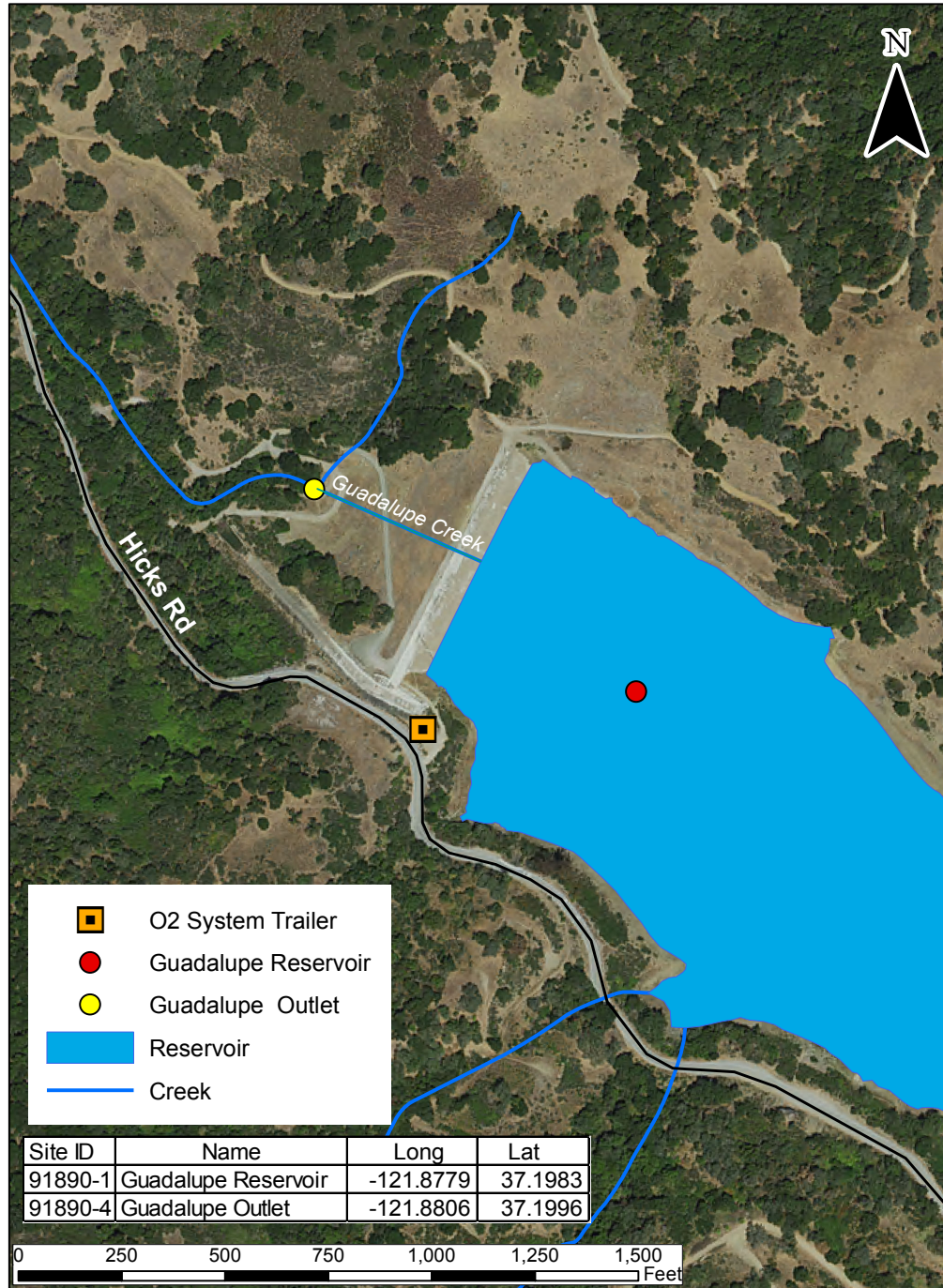


Figure A.6: Stevens Creek Reservoir Sampling Sites

Stevens Creek Reservoir Sampling Sites

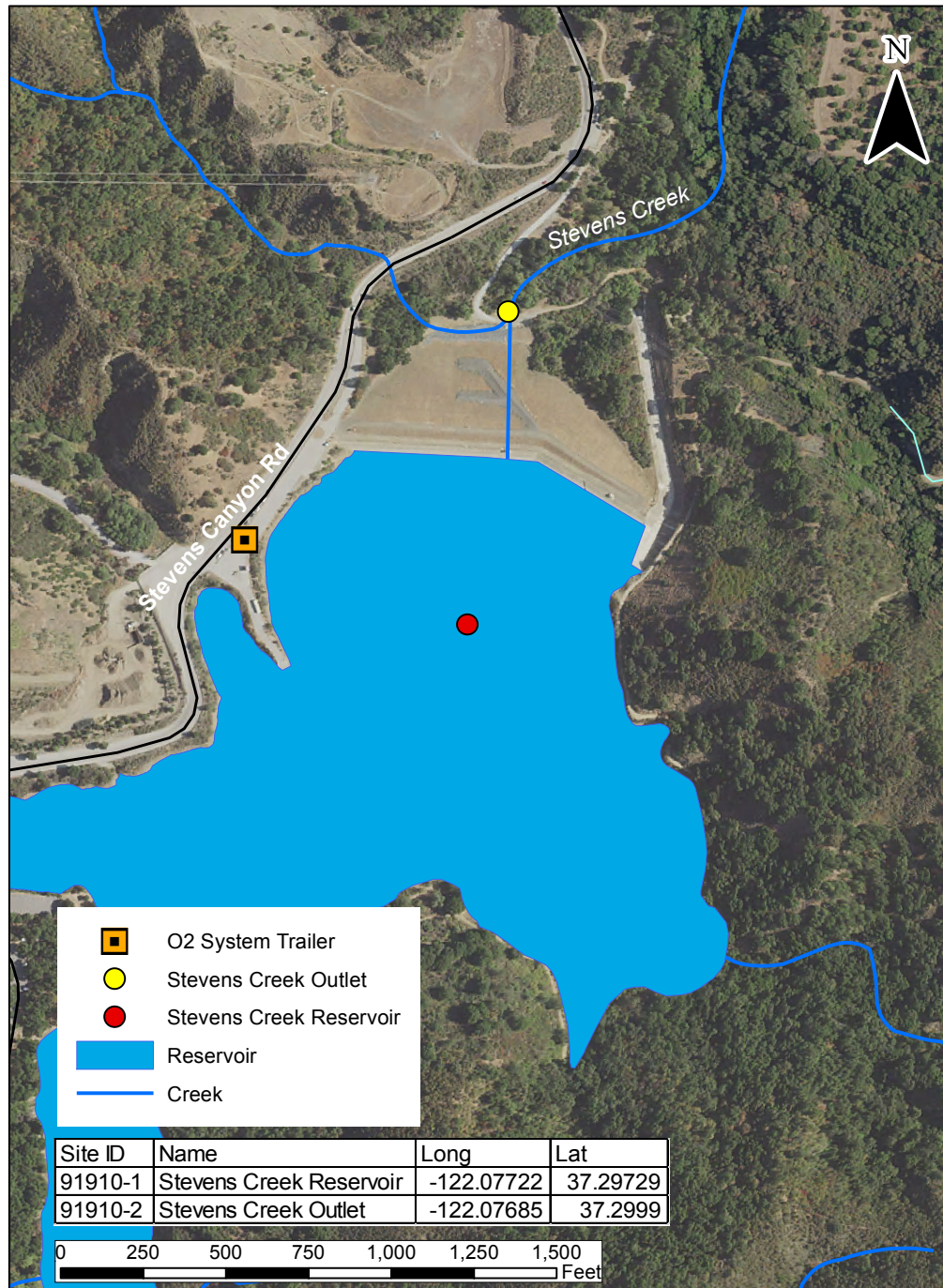


Figure A.7: Almaden Lake Sampling Sites

Lake Almaden Sampling Sites

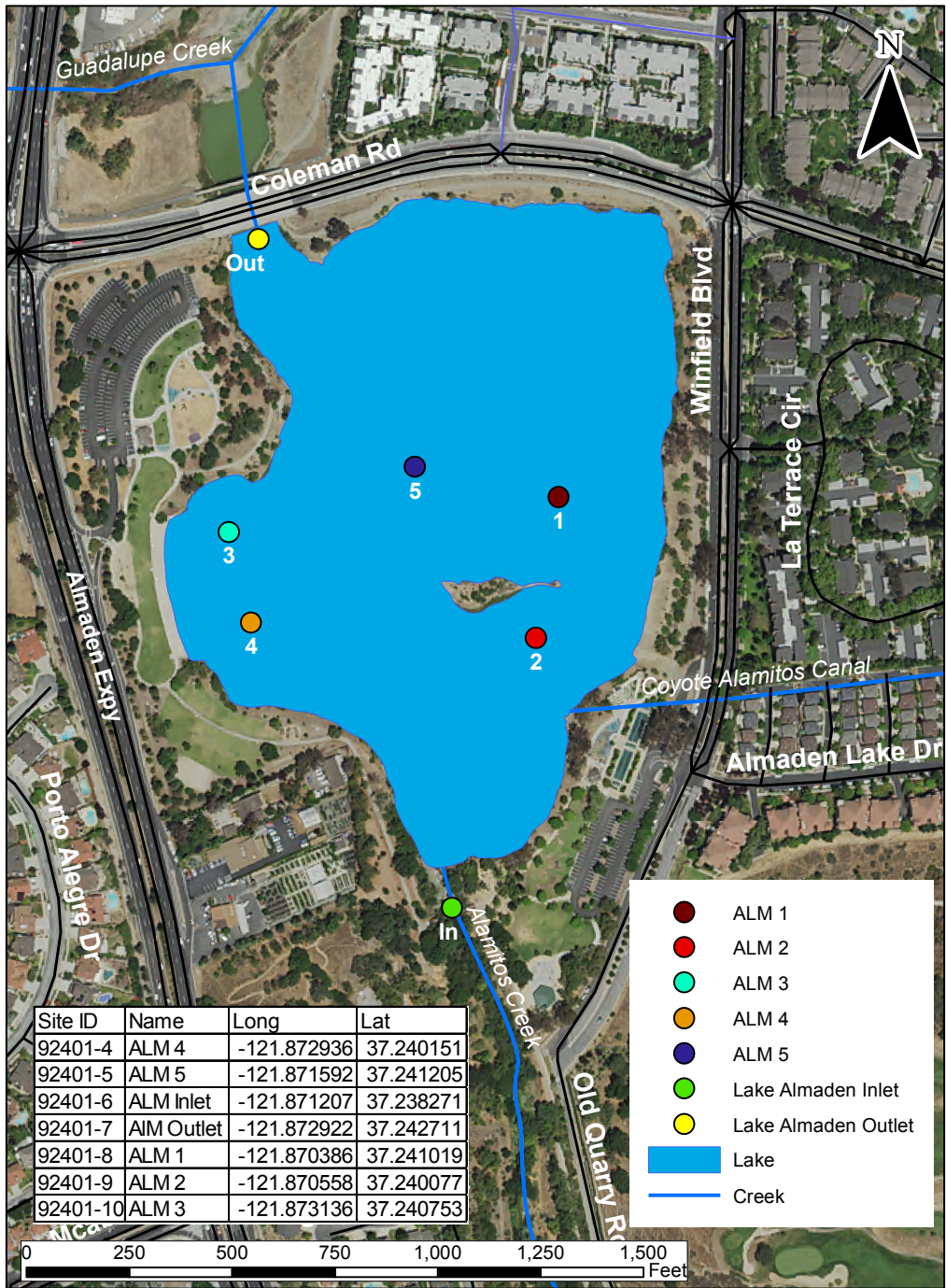


Figure A.8: Almaden Reservoir Fish Monitoring Quadrants

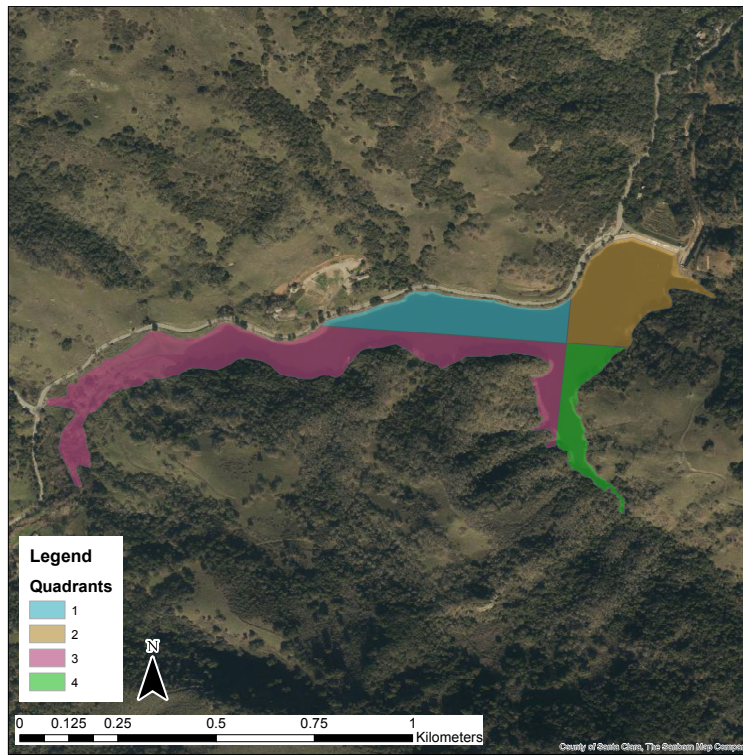


Figure A.9: Calero Reservoir Fish Monitoring Quadrants

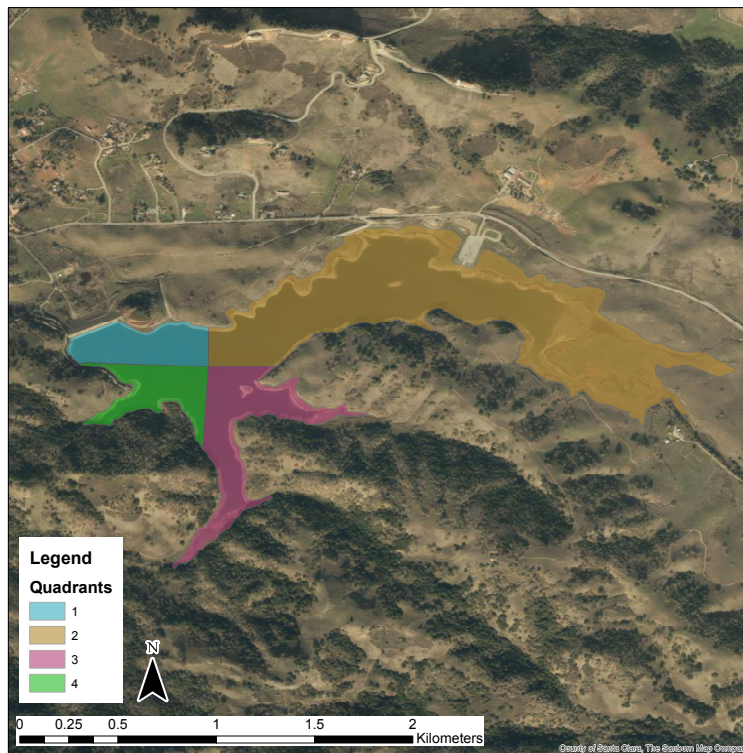


Figure A.10: Guadalupe Reservoir Fish Monitoring Quadrants

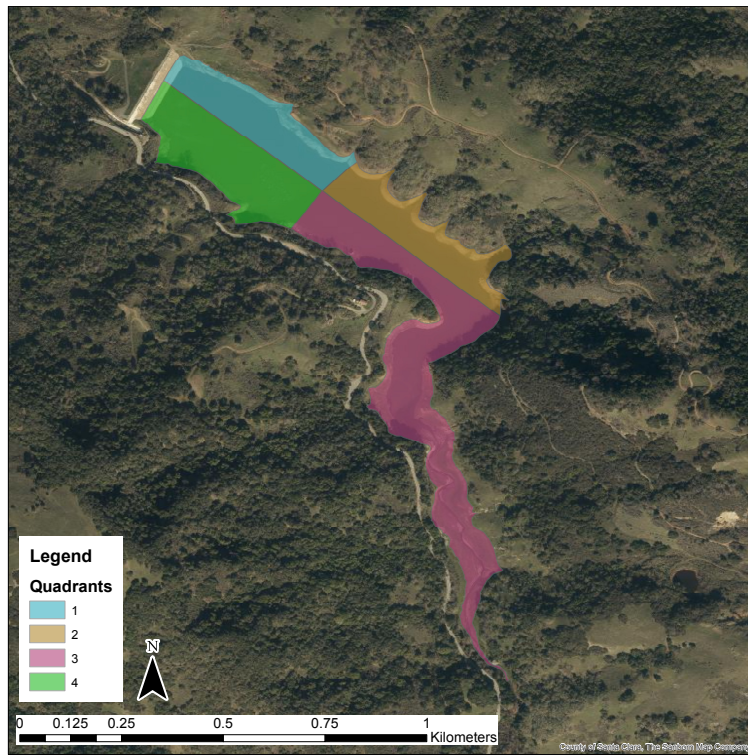


Figure A.11: Stevens Creek Reservoir Fish Monitoring Quadrants

