CACHE CREEK OFF-CHANNEL AGGREGATE MINING PONDS – 2017 MERCURY MONITORING

Final Report
December 2018

Monitoring and Report by

Darell G. Slotton, Ph.D.*
and
Shaun M. Ayers

* *(530) 574-3491*
dgslotton@ucdavis.edu

TABLE OF CONTENTS

SUMMARY OF THE 2017 MONITORING AND ITS FINDINGS

- This Fall 2017 monitoring was the third year of fish mercury testing (Year 3) for four off-channel wet pit aggregate mining ponds adjacent to lower Cache Creek between Capay and Woodland: Cemex – Phase 1 (West), Cemex – Phase 3-4 (East), Teichert – Reiff, and Syar – B1 ponds. Three other ponds were added to the monitoring program in 2017: Teichert – Mast, Teichert – Storz, and Syar – 'West' ponds. For these ponds, this was Year 1 of mercury monitoring. The Storz Pond was partially sampled in 2016; 2017 was the first year of complete testing there. The monitoring is required by Section 10-5.517 of the Yolo County Code. That Ordinance requires 5 years of annual pre-reclamation mercury monitoring for mining ponds and then bi-annual monitoring for 10 years following reclamation to permanent water bodies.

- A variety of collecting techniques were used to obtain samples of the fish present in each of these ponds, including seines, gill nets, baited setlines, dip nets, and angling. Large, angling-sized fish were tested individually for fillet muscle mercury, relevant to human consumption. Small, young, 'biosentinel' fish were analyzed whole-body, relevant to wildlife consumption and inter-annual comparisons, in replicate multiple-individual composite samples.

- Samples of both large and small fish of multiple species, as available, were collected from the seven identified ponds. A total of 137 larger, angling-sized fish were sampled individually for fillet muscle mercury analysis in this 2017 monitoring. Additionally, a total of 466 small, young biosentinel fish were split into 70 multi-individual, whole fish composite samples by site, species, and size. These were also analyzed for mercury.

- The new 2017 data were compared with results from 2015 and 2016, and with the most closely corresponding 'baseline' and historic fish collections conducted previously in Cache Creek (from the stretch of creek within the planning and aggregate-mining area). As in 2015 and 2016, the ponds sampled in Fall 2017 were found to show distinct, individual mercury signatures that were broadly consistent across the different fish types tested.

- The **Cemex – Phase 1 (West) Pond** was sampled in 2017 for Largemouth Bass, Channel Catfish, White Catfish, Green Sunfish, and small, young Largemouth Bass, Green Sunfish and Mosquitofish. The Phase 1 Pond fish data indicate an increase in methylmercury availability and uptake there in 2016 and 2017, though to levels still similar to the low-mid range of historic creek comparisons. The general stepwise increase in fish mercury seen in the Phase 1 Pond from 2015 to 2016 to 2017 corresponded to changes in pond operations that, among other things, resulted in less disturbance of the water column, less mixing, and less sediment suspension. Water column profiling was initiated in 2018 to provide additional information. This pond was not found to be "elevated for two or more consecutive years", which would trigger consideration of mercury remediation and seasonal water column profiling as a first step. However, the overall low mercury status of this pond, and the observed changes over the years monitored, made it a key comparison for remediation insights for the elevated ponds. This pond continued to be categorized as "low/not elevated" relative to the Ordinance.

- The **Cemex – Phase 3-4 (East) Pond** was sampled in 2017 for adult Largemouth Bass and small, young Largemouth Bass, Green Sunfish, and Mosquitofish. This was Year 3 of fish mercury monitoring. The 2017 data exhibited an odd mix of trends, as compared to 2015 and 2016. Adult Largemouth Bass and Mosquitofish mercury concentrations were clearly up, while juvenile Bass and juvenile Green Sunfish levels were significantly decreased. As the juvenile fish reflect recent mercury exposure (as they are only months old), it is possible that the large fish had higher exposure earlier in the year and then levels came down. In any case, overall fish mercury at this pond was elevated over comparable creek baseline samples for the majority of sample types. The adult bass, in particular, were at levels well above consumption guidelines. As the pond was found to be "elevated for two or more consecutive years", that triggered consideration of mercury remediation. The first stage of remediation is to obtain additional water quality information, through seasonal water column profiling of a range of relevant constituents, and characterize bottom sediment mercury. This work was initiated in 2018.

- The **Teichert – Reiff Pond** was sampled in 2017, as in prior years, for White Catfish, Carp, and small, young Red Shiners. In addition in 2017, Largemouth Bass, both juveniles and young adults, were found and sampled. This was Year 3 of fish mercury monitoring. Teichert – Reiff Pond showed a continuing increase in fish mercury in all sample types that had comparative data from 2015, 2016, and 2017 (White Catfish, Carp, and Red Shiner). First-time collections of juvenile and young adult Largemouth Bass had very high mercury levels in 2017. Relative to available creek comparison data, the 2017 Reiff Pond fish mercury levels were significantly higher than all historic baseline data for all species sampled: White Catfish, Carp, Red Shiner, and both juvenile and adult Largemouth Bass. Like the events noted for the Cemex – Phase 1 Pond, there was a similar change in operations at the Reiff Pond across the years monitored, with plant slurry inflows lessening and then stopping in 2017. We believe it is likely that the increases in fish mercury seen at Reiff Pond were linked, at least in part, to these changes. The pond was found to be "elevated for two or more consecutive years", triggering consideration of mercury remediation. The first stage of remediation is to obtain additional water quality information, through seasonal water column profiling of a range of relevant constituents, and characterize bottom sediment mercury. This work was initiated in 2018.

- The **Syar – B1 Pond**, half of a 2 pond site, was sampled in 2017 for adult Largemouth Bass and small, young Largemouth Bass, Green Sunfish, and Mosquitofish. This was Year 3 of fish mercury monitoring. A substantial decline in concentrations was seen in 2017. In particular, available samples of adult Largemouth Bass were down from previous (very high) levels by 45%. Juvenile bass and Green Sunfish were down as well. In comparison to corresponding baseline/historic samples from Cache Creek, the B1 Pond juvenile bass were still significantly higher in 2017. Mosquitofish were significantly higher than 2 of 3 baseline comparisons. Juvenile Green Sunfish were still significantly higher than 4 of 5 comparisons. The adult bass, though, which had previously been significantly higher than all available baseline creek comparisons, were down to a level statistically similar to 5 of 7 comparison sets. This pond may be trending toward a more ambiguous assessment level, though it was previously the highest fish mercury site of those monitored, and clearly "elevated". Water column profiling and bottom sediment work there began in 2018.

- The **Teichert – Storz Pond** was sampled for the first time in 2016, with a partial small fish collection made without the use of a boat. In 2017, it was possible to get the boat into this site for Year 1 of full fish mercury monitoring. The fish community appeared to consist of Mosquitofish and young adult Largemouth Bass. We collected good samples of each, plus a sparser sample of smaller, younger Largemouth Bass. Findings in 2017 were mixed. The primary, large fish sample of bass had mercury within the historic range of baseline creek fish. It was second lowest of the 6 monitored ponds that contained bass. The Mosquitofish composite samples were significantly higher than creek comparison samples, with similar sized fish. Next year, with two full years of data, we will be in a better position to characterize mercury levels here and advise on future steps.

- The **Teichert – Mast Pond** was sampled for the first time in 2017. This was Year 1 of fish mercury monitoring. Located at the Teichert–Esparto Plant near the Reiff Pond, we were unable to access this site in 2015 and 2016 due to active mining and steep-walled edges. Active mining here slowed in 2017 and then went on hold, with Teichert's efforts shifting to the downstream Woodland Plant region (Storz Pond etc). This led to the halting of slurry discharge to the Reiff Pond, noted above. A full set of Mosquitofish (4 composites of 10 fish each) was collected. Other fish species were not found at that time, despite extensive collection efforts. Relative to baseline Cache Creek mosquitofish samples, they were significantly higher than the two River Mile 15 comparisons and statistically similar to historic samples from River Mile 17. Relative to other off-channel aggregate mining ponds monitored in this program, Mosquitofish mercury levels at this site were higher than those seen in adjacent Reiff Pond in 2015-2016, and were similar to levels in the other two elevated-mercury ponds, Cemex – Phase 3-4 and Syar – B1. Next year, with two full years of data, we will be in a better position to characterize mercury levels here and advise on future steps.

- The **Syar – 'West' Pond**, part of a 2 pond site, was sampled for the first time in 2017. This was Year 1 of fish mercury monitoring, as per the ordinance. The pond was of additional interest because of high mercury levels at the nearby B1 Pond and the observation of extensive fishing by nearby Esparto residents at both ponds. Collections in 2017 included Largemouth Bass, Green Sunfish, and small, young Largemouth Bass, Green Sunfish, and Mosquitofish. Fish mercury in the West Pond was found to be similar to levels analyzed in the nearby B1 Pond. In comparison to corresponding baseline/historic samples from Cache Creek, the West Pond fish in 2017 were significantly higher in mercury for most of the small fish comparisons. For adult Largemouth Bass, they were higher than 3 of 7 comparison data sets and statistically similar to 4 of the 7. Next year, with two full years of data, we will be in a better position to characterize mercury levels here and advise on future steps.

- For ponds found to have higher fish mercury than corresponding samples from Cache Creek over 2 or more consecutive years, the Ordinance calls for suspension of wet pit mining and preparation of a plan to either (1) back-fill the pit in reclamation to "five feet above the average seasonal high groundwater level with a suitable backfill material" or (2) "present a mitigation plan to the Yolo County Community Development Agency".

- The three identified elevated mercury ponds (Syar–B1, Cemex – Phase 3-4, and Teichert–Reiff), as well as the identified lower mercury Cemex – Phase 1 Pond, are not currently being mined, so mining suspension there is not a current issue.

- As a first phase of mitigation, it was recommended last year that additional information first be collected, to guide potential future strategies. This includes testing bottom sediments and initiating a water column profiling program. The County Ordinance, as written, calls for water column profiling during all fish monitoring years. Profiling was not conducted in the initial monitoring years, based on the recommendation of this monitoring/research team. We felt that it was premature, until and unless elevated levels were found. However, after initial fish monitoring identified three ponds as elevated in fish mercury relative to the creek, it was recommended that this work be started. Timing and test parameters are detailed in the Discussion/Conclusions section of the report. It was recommended that water column profiling be conducted at the three identified higher mercury ponds, as well as at the identified lower mercury Cemex – Phase 1 pond. Specialized sampling equipment was obtained and water column profiling was conducted throughout May-Oct 2018. The range of fish mercury levels between these ponds presents an opportunity to investigate what may be driving the high levels at some locations and lower levels at others. If these factors can be better understood, it will allow for the team to develop realistic mercury reduction strategies for the elevated mercury sites.

INTRODUCTION

This monitoring was conducted for Yolo County in the fall of 2017, to provide ongoing fish mercury information from a set of aggregate mining ponds located adjacent to lower Cache Creek. The monitoring was triggered by Section 10.5.517 of the Yolo County Reclamation Ordinance (Yolo County Code), which was enacted in 1996. In this introduction, as last year, we will first present and discuss the various sections of the Ordinance, to explain the County history with this issue and to place the current monitoring into context. The Ordinance is reproduced without breaks in Appendix A. Below, Ordinance text is shown in ***bold italics***, with discussion and commentary in regular text.

Yolo County, CA Code of Ordinances
Sec. 10-5.517. Mercury bioaccumulation in wildlife.

Prior to the approval of reclamation of aggregate mining areas to permanent lakes, the County shall commission a sampling and analysis program, to be implemented in one existing wet pit mining area within the OCMP planning area, to evaluate the potential for increased methylmercury production associated with wet pit mining and reclamation of mining areas to permanent lakes. The program shall include the sampling of water and sediments from the bottom of the existing pit and analysis of the samples for organic content; pH; dissolved oxygen content; dissolved carbon content; and total mercury. In addition, samples of predatory fish (preferably largemouth bass) shall be collected and analyzed for mercury and methylmercury content.

If the initial sampling indicates either of the following conditions, the County shall perform verification sampling:

(a) Average concentrations of total mercury in excess of 0.000012 milligrams per liter (mg/l) in the water; and
(b) Average mercury levels in fish samples in excess of 0.5 milligrams per kilogram (mg/kg).

If verification sampling indicates exceedance of these mercury criteria, the County shall approve the reclamation of mining areas to permanent lakes only if the average level of mercury in fish collected from the existing mining pits is shown to be equal to or less than ambient (background) mercury levels determined from a representative sample of similar species of fish (of similar size) collected in the Cache Creek channel within the planning area.

A mercury assessment program, as listed above, was conducted at the time the Ordinance was developed at two then-active off-channel mining ponds (OCMP 1996). These ponds were located just east of Highway 505, on the current Cemex property, formerly owned by Solano Gravel. The ponds were moderately deep (app. 40 feet) and representative of proposed future off-channel gravel mining ponds. Water, sediment, fish, and aquatic invertebrates were analyzed for mercury and methylmercury. Related analyses included water column profiling of the specified parameters and analysis of associated water and sediment components. The 1996 assessment of the representative off-channel mining ponds found water mercury concentrations of <0.000002-0.000004 mg/l from all depths, which was lower and less variable than corresponding water mercury in Cache Creek. The fish collections included 24 angling-sized fish of several species found to be present in the ponds. Average mercury concentration for these fish was 0.39 mg/kg, lower than the 0.50 mg/kg threshold level listed for average fish mercury levels in the ordinance. A set of comparison fish from lower Cache Creek averaged a similar, and statistically indistinguishable, 0.36 mg/kg. It is notable that the initial Cache Creek comparison fish were primarily taken in the Settling Basin, located downstream of the planning area. Subsequent baseline comparison creek fish collected within the planning area included fish with significantly higher mercury concentrations.

Based in part on the results of the initial 1996 study, the planning process and aggregate mining operations went forward.

> ***The determination of the ambient mercury level shall be performed by the County prior to the excavation of any new wet pit mine and at years ten (10), twenty (20) and thirty (30) in the permit time period, and shall be paid for by the mining permit operators on a fair-share basis. The County shall evaluate available data to determine any significant change in ambient concentrations of mercury in fish within the Cache Creek channel.***

The initial ambient (baseline) testing in Cache Creek was conducted for fish and water mercury in 1995 and more extensively for fish in 1997, though, as noted above, the fish were primarily taken from the downstream Settling Basin. The 10-year reassessment was inadvertently missed in 2007 and was conducted in 2011 when the oversight was discovered by County staff. Results of that updated baseline fish monitoring are reported in Slotton and Ayers (2013). The 2011 baseline collections were made at 3 creek sites within the planning and aggregate mining zone, between River Miles 15 (downstream of County Road 94B) and 28 (below Capay diversion dam). Those collections found a range of fish mercury concentrations, including significantly higher levels at some of the creek sites, as compared to the earlier findings from the downstream Settling Basin. The highest concentrations were found in adult bass, pikeminnows, and green sunfish.

In the event of approval of reclamation of mined areas to permanent lakes, each mining area to be reclaimed to a permanent lake as part of each approved long-range mining plan shall be evaluated annually by the operator for five (5) years after creation of the lake for conditions that could result in significant methylmercury production.

An additional ten (10) years of biennial monitoring shall be performed after reclamation of each lake has been completed.

In May of 2015, the County identified six aggregate mining ponds for monitoring. The primary criteria for these ponds was that they were "wet" (had filled with groundwater), had active mining permits, and were approved for reclamation to permanent lakes/ponds. There are currently four aggregate mining operations (Cemex, Teichert Esparto, Teichert Woodland, and Syar) that require the initial five years of monitoring. The six identified ponds include two from Cemex (Phase 1 and Phase 3-4), two from Teichert Esparto (Reiff and Mast), one from Teichert Woodland (Storz), and one from Syar (B1). Locations of these ponds, as well as the baseline Cache Creek sampling sites from 2011-2012, are shown in Figure A. The monitoring history of the subject ponds is summarized in Table A.

The evaluations shall be conducted by a qualified aquatic biologist or limnologist acceptable to the County and shall include the following analyses:

(c) Lake condition profiling during the period of June through September, including measurements of pH; eH (or redox potential); temperature; dissolved oxygen; and total dissolved carbon.

This type of analysis can be very useful in sorting out the possible sources of high methylmercury exposure, if a problem exists. Rather than initiating water column profiling immediately, it was decided that lake profiling of relevant water column parameters should be conducted *if* significantly elevated fish mercury is found in subject ponds in repeated years. This is discussed in more detail in the Discussion/Conclusions section.

(d) Collection of a representative sample of fish specimens (including a minimum of five (5) predator fish if available) and analysis of the specimens for mercury content. Sampling and analysis shall be conducted using methodologies which are consistent with the California State Water Resources Control Board Toxic Substances Monitoring Program procedures, or more stringent procedures.

Fish sampling is the core of most modern mercury monitoring. Fish represent the direct potential exposure to human and wildlife fish-consumers. They also provide an ideal measure of relative mercury exposure, for comparison between ponds and between ponds and Cache Creek. A fish mercury monitoring program for the Yolo County aggregate mining ponds was initiated in 2015, using methodologies consistent with the programs of government agencies and other institutions that have developed in the region since the original drafting of the Ordinance.

(e) The results of the evaluation shall be summarized in a report and submitted to the County. The report shall include a comparison of the site-specific data to available data on the background concentrations of mercury in fish within the Cache Creek watershed. The County shall be responsible for submitting the data on mercury levels in fish to the California Department of Fish and Game and the Office of Environmental Health Hazard Assessment for a determination of whether a fish advisory should be issued.

The first year of mercury monitoring for this program was 2015, conducted in the fall. Results and discussion of the first year work can be found in Slotton and Ayers (2017). Second year monitoring was conducted at the 4 original ponds in 2016 and reported in Slotton and Ayers (2018). The report that follows, here, summarizes the third year monitoring at those ponds, and Year 1 fish monitoring for the Teichert – Mast, Teichert – Storz, and Syar – West Ponds, conducted in Fall 2017.

(f) If a fish advisory is issued, the owner/operator shall be required to post warnings on fences surrounding the mining pit lakes which prohibit fishing in the lakes and describe the fish advisory.

The County was advised to initiate this action, based on the 2 years of fish monitoring data available after 2016, and posting was done.

If the average fish specimen mercury content exceeds the statistically verified ambient mercury concentrations for comparable fish species (of similar size) collected within the CCRMP planning area for two (2) consecutive years, wet pit mining on property controlled by the mining operator/owner shall be suspended and the owner/operator shall either:

(g) Present a revised reclamation plan to the Yolo County Community Development Agency which provides for filling the reclaimed lake to a level five (5') feet above the average seasonal high groundwater level with a suitable backfill material; or

(h) Present a mitigation plan to the Yolo County Community Development Agency which provides a feasible and reliable method or reducing methylmercury production or exposure to elevated mercury levels. Potential mitigation could include permanent aeration of the bottom levels of the lake, alteration of the water chemistry (increasing pH or dissolved organic carbon levels), control of anaerobic bacteria populations, or removal and replacement of affected fish populations. The mitigation plan would require review by the Regional Water Quality Control Board, California Department of Fish and Game, and the Yolo County Department of Environmental Health. (The removal and replacement of fish is not intended to be a long-term solution.)

The reclamation plan shall be modified such that the mitigation approved for methylmercury reduction shall be applied to all mining areas proposed for reclamation to permanent lakes within the reclamation plan. (§ 1, Ord. 1191, eff. September 5, 1996)

These next steps, and how they relate to the currently monitored ponds, are addressed in the Discussion/Conclusions section.

All seven of the currently identified ponds (Table A) were monitored for fish mercury in 2017. Four of the ponds have been monitored since 2015 and, for them, this was Year 3 of sampling: Cemex – Phase 1 (West), Cemex – Phase 3-4 (East), Teichert – Reiff, and Syar – B1. Three additional ponds were added to the monitoring in 2017; for these, it was Year 1: Teichert – Mast, Teichert – Storz, and Syar – West. In both 2015 and 2016, Mast Pond was inaccessible because of active mining operations and steep cliff edges. Storz Pond was not accessible in 2015 but we were able to partially sample small fish in 2016 by wade-seining the shore. In 2017, all seven ponds were successfully sampled for fish. At the Mast Pond, large species were not found, but we were able to collect good samples of Mosquitofish. Both large and small fish samples of multiple species, as available, were collected and analyzed from the other 6 ponds. Fish constitute the most straightforward, clear measure of methylmercury exposure and bioaccumulation in an aquatic system, so this monitoring focuses on fish. Other sample types all have difficulties and complications associated with their collection, analysis, or interpretation. The creek baseline work also sampled aquatic invertebrates for potential comparison in the event that no fish were present at some pond sites, but all the target ponds studied so far have had useful fish populations for monitoring.

The purpose of this report is to present the new 2017 fish mercury data from the tested aggregate mining ponds and, for each pond, to compare levels to similar baseline samples taken from the planning area of Cache Creek in 2011-2012 and in earlier studies. A key objective is to help the mining operators and Yolo County determine if specific pond sites are falling within or outside the general range of fish mercury concentrations seen in adjacent Cache Creek. This will help guide future reclamation and, if necessary, remediation.

The factors that influence production of methylmercury and its uptake by fish are complex and can change from one year to the next, often leading to a range of fish mercury levels over time rather than some absolute value. Because of this, the Ordinance states that multiple years of data are needed to make assessments. So, another objective is to compare this year's data (2017) with monitoring results found at the same sites in the previous monitoring years (2015 and 2016).

Following, below, are the methods we used and a presentation of the 2017 mercury data, by individual pond site. Each data table is accompanied by a matching figure with the same number that graphically shows the information. For each site, we first present the analytical results from each individual large fish sample and each small fish composite sample. Then we show the new data in reduced form (means, error bars, etc.) for each sample type and compare to 2015-2016 same-site findings and the most closely comparable historic creek data. For creek comparisons, we are focusing on historic data specifically from the planning / aggregate-mining section of the creek, roughly between River Mile 28 (below the Capay diversion dam) and River Mile 15 (app. 1 km below County Road 94B). In particular, these include the 2011 Baseline collections from RM15 (River Mile 15), RM20, and RM28, which were conducted specifically to provide comparable samples for the pond monitoring, as possible. In the data tables and figures, the 2011 Baseline comparison data are highlighted with bold text and symbols. Additional historic sampling that was coincidentally done within the planning region of Cache Creek includes a project around the Cache Creek Nature Preserve in 2000-2006 (RM15 and RM17 small fish) and a CalFed 1998-2000 UC Davis study of the entire Cache Creek watershed that included some fish collections in the study zone.

After individual sections for each pond, a final data section consolidates summary results for each fish type, from all the sites and baseline comparisons. In the Discussion/Conclusions, the available pond data to-date are placed into the context of the Yolo County Ordinance, with next steps and recommendations. The Ordinance text is attached, without commentary, as Appendix A. Appendix B includes representative photos of the Fall 2017 monitoring work.

Table A. Wet Pits Subject to Annual Mercury Monitoring
(modified from Yolo County Exhibit C)

Operator	Site	Pit	Year Mining Crossed Water Table (app)	End Reclamation Plan	Year Monitoring Began	Monitoring Year in Fall 2017
Cemex	Madison	**Phase 1**	< 1996	Lake and habitat	2015	Year 3
Cemex	Madison	**Phase 3/4**	≤ 2002	Lake and habitat	2015	Year 3
Teichert	Esparto	**Reiff**	≤ 2002	Lake and habitat	2015	Year 3
Teichert	Esparto	**Mast**	2007-2008	Lake and habitat	2017	Year 1
Teichert	Woodland	**Storz**	2010-2011	Lake and habitat	2016 (partial)	Year 1 (full)
Syar	Madison	**B1**	≤ 2002	Lake and habitat	2015	Year 3
Syar	Madison	**West**	≤ 2002	Lake and habitat	2017	Year 1

Off-Channel Aggregate Mining Ponds Sampled in 2017 and Baseline 2011-2012 Sampling Locations in Cache Creek

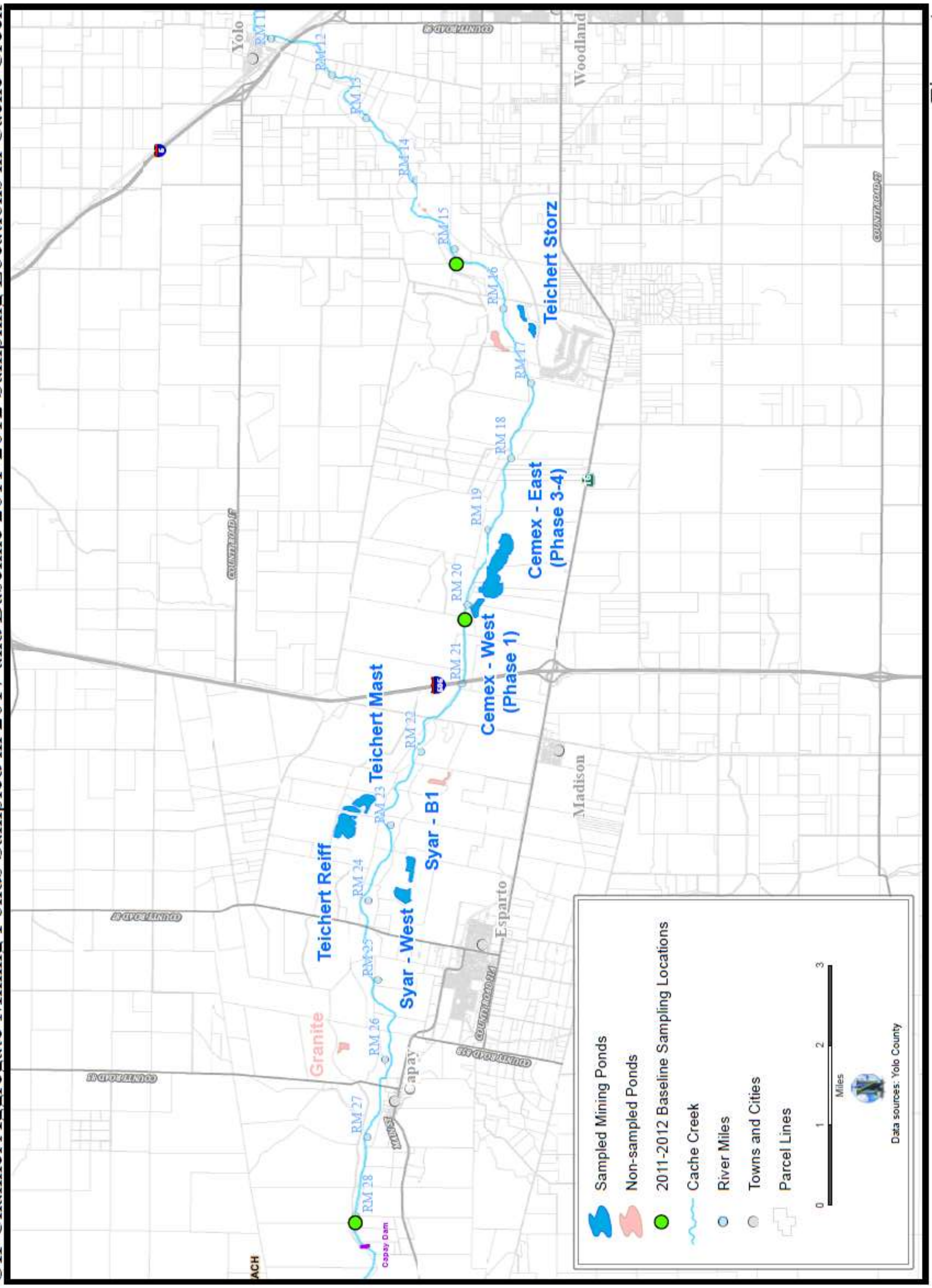

Figure A

METHODS

Field sampling was coordinated with staff of the three mining companies, Teichert, Cemex, and Syar. Access ramps for boat launching were constructed at some of the ponds, which was a big help. We used our sampling boat to move around each of the ponds and collect the fish.

The fish samples were taken with a variety of techniques. Adult fish were collected with gill nets in a variety of mesh sizes, also with baited set lines laid at the bottom of ponds (catfish), and by angling (bass). Gill nets and set lines, deployed in both daylight and nighttime conditions, were carefully monitored to remove captured fish, to minimize unnecessary mortality. Small, young fish samples were collected with a variety of seines and hand nets.

Large fish were field identified, weighed and measured, and sampled for mercury analysis using a non-destructive biopsy technique we developed that allows us to return the fish back to the water in good condition (Slotton et al. 2002). In this technique, laboratory digestion tubes, to be used in the analysis, are pre-weighed, empty, to 0.0001 g accuracy. In the field, several scales are removed from each fish on the left side above the lateral line and a small biopsy sample of app. 0.200 g (about the size of a raisin) is taken from the left fillet. The sample is carefully placed into a pre-weighed digestion tube. Tubes are sealed with Parafilm™ and stored on ice in sealed, freezer-weight bags. Later, at the laboratory, the tubes with sample pieces are again weighed and the exact weight of each sample is determined by subtracting the empty tube weight.

Small fish were field identified, cleaned and sorted by species, bagged in labeled freezer-weight, zip-close bags with air removed, and transported on ice to the laboratory. Samples were then weighed, measured, and assembled into composite groupings of similar-sized fish. Each composite sample was frozen in doubled freezer-weight bags with water surrounding and air removed, a technique our group has found to maintain natural moisture levels through the freezing process, something that can be a major problem for small fish samples (Slotton et al. 2015). Pre-analytical processing included weighing and measuring the fish in each composite group and drying the sample to constant weight in a laboratory oven at 55 °C. Solids percentage was calculated during this process, through sequential weighings of empty weigh pans, pans with wet sample, and pans with dry sample. Dried samples were later homogenized to fine powders using a laboratory grinder.

Large fish fillet muscle samples were analyzed for mercury directly, on a wet (fresh) weight basis. Small fish composite samples were analyzed whole body, homogenized into dry powders for consistency, as described above. Dry weight results were converted to original wet/fresh weight concentrations using the calculated percentage solids values. For all mercury analyses, samples were weighed into 20 ml digestion tubes and digested at 90 °C in a mixture of concentrated nitric and sulfuric acids with potassium permanganate, in a two stage process. Digested samples were then analyzed for total mercury by cold vapor atomic absorption (CVAA) spectrophotometry, using a dedicated Perkin Elmer Flow Injection Mercury System (FIMS) with an AS-90 autosampler. The method is a variant of EPA Method 245.6, with modifications developed by our laboratory (Slotton et al. 2015).

Extensive Quality Assurance / Quality Control (QA/QC) samples were included in all analytical runs and tracked with control charts. These included an 8 point aqueous standard curve for each batch and, for each 20 field samples: 3 method blanks, 3 standard reference materials with certified levels of mercury, 3 continuing calibration samples, a laboratory duplicate, a spiked field sample, a spike duplicate, and an aqueous calibration sample. QA/QC Results for this project were all well within control limits.

PRESENTATION OF THE FALL 2017 RESULTS

1. CEMEX – PHASE 1 (West) POND

1. CEMEX – PHASE I (West) POND *(Tables 1-8, Figures 1-8)*

This pond is the older of the 2 current Cemex ponds, dating from the 1990s. It is located just south of Cache Creek and east of Highway 505. The Phase 1 Pond is an oval shaped bowl that is app. 400 m long and 150 m wide. Depths ranged to approximately 7 m (23 feet). This pond went through some changes over the recent years of monitoring. Active mining was still underway in 2015, the first monitoring year. In 2016 there was little or no mining in the pond itself, but it continued to receive the silt and clay slurry effluent of the general plant operations, so the water was very turbid. In 2017, our understanding was that active mining was on hold at both Cemex ponds, so there was less slurry effluent to the Phase 1 Pond. This (2017) was Year 3 of monitoring here.

We sampled the pond during day, twilight, and night conditions with a full range of techniques, and were able to obtain samples of the fish species available. For the first time, we found Green Sunfish (*Lepomis cyanellus*) in this pond, in addition to the bass and catfish taken in previous years. Large, angling-sized fish taken included: 17 Largemouth Bass (*Micropterus salmoides*), 2 Channel Catfish (*Ictalurus punctatus*), 6 White Catfish (*Ameiurus catus*), and 5 Green Sunfish. The small fish present were juvenile Largemouth Bass (4-5"), Mosquitofish (1-2", *Gambusia affinis*), and juvenile Green Sunfish (1-3"). Four multi-individual composite samples were analyzed for each of these small fish species.

In total, this added up to 30 large fish muscle samples and 12 composite small fish samples, 42 separate fish mercury samples, analyzed from the Cemex – Phase 1 (West) Pond in the Fall 2017 monitoring. The analytical results from each individual large fish muscle sample and each small, young fish composite sample can be seen in Tables 1 and 2 and, graphically, in Figures 1 and 2. Then, for each large and small fish species taken, the new data are shown in reduced form (means, error bars, etc) and compared to 2015-2016 results and the most closely comparable historic creek data (Tables 3-8, Figures 3-8).

Large, Angling-sized Fish

Largemouth Bass

The Phase 1 Pond adult Bass samples had fillet muscle mercury ranging from 0.198-0.606 ppm, averaging 0.393 ppm. This was up from 2016 (0.350 ppm), which was up from 2015 (0.278 ppm). These year-to-year changes were not statistically significant at the 95% level of confidence, but they indicate an incremental rise in bass mercury in the Phase 1 Pond in recent years. Concentrations generally increased with fish size, as is typical. Similar to the 2015 and 2016 sets of bass, the 2017 bass samples ranged in size between 227 and 367 mm (about 9-15"). Adult Bass represent the top predator fish in this region and will typically have the highest mercury levels at any given site. The Phase 1 Pond bass remained lower in mercury than 6 of 7 similar baseline/historic samples from Cache Creek (statistically lower than the River Mile 28 site). As noted in the previous reports, the Phase 1 (West) Pond bass were among the lower mercury top predator fish samples we have collected in California across many studies. Although the overall concentrations remained relatively low, the gradual increases seen between 2015 and 2017 may provide evidence of some of the factors influencing fish mercury exposure in the aggregate mining ponds. The gradual increases in bass mercury uptake corresponded to changes in mining practices at this site: from active mining plus slurry effluent, to slurry effluent only, to no mining or slurry.

Channel Catfish

The two Channel Catfish taken had fillet muscle mercury of 0.233-0.239 ppm in 528-530 mm fish (14"), averaging 0.236 ppm. This was somewhat higher than the 2015 average of 0.198 ppm and more than double the anomalously low 2016 level of 0.100 ppm, though with only 2 samples in each year, the differences could not be assessed statistically. The 2016 fish were considerably smaller than the pair taken in 2015 (1,150 g / 2.5 lbs vs 2,130 g / 4.7 lbs). This may largely explain the apparent decline in 2016. Across the three years of monitoring to date, Channel Catfish mercury was at a level similar to or lower than the baseline comparison catfish taken at River Mile 28 and River Mile 20. Again, we cannot assess statistical significance with the small number of fish available. Note that the Phase 1 Pond Channel Catfish, averaging 1,573 g (3.5 pounds) across the 3 monitored years, were much larger and older than the catfish samples available from the creek, which averaged only 148 g (0.33 lbs). As mercury concentrations in predatory fish tend to increase with age and size, comparably-sized creek catfish, if present, could be expected to have higher mercury levels. Collections to-date have not found larger individuals within the planning stretch of the creek.

White Catfish

Six large fish were taken, ranging from 570-655 mm (22-26") in length and 1,980-2,680 g (4.1-5.9 pounds) in weight. Fillet muscle mercury ranged from 0.353-0.693 ppm, averaging 0.448 ppm. Within the pond, the 2017 levels were up somewhat from 2016, though not significantly. This was, however, significantly higher than the creek comparisons. As noted above for Channel Catfish, the Phase 1 Pond White Catfish were much larger and older than the catfish samples available from the creek, which averaged 148 g (0.33 lbs) across all samples. Comparably-sized creek catfish could be expected to have higher mercury levels.

Green Sunfish

Five fish were taken, ranging from 76-193 mm (3-8") in length and 8-135 g (<0.1-0.3 pounds) in weight. Fillet muscle mercury ranged from 0.170-0.352 ppm, averaging 0.273 ppm. This was similar to the creek comparison samples: statistically higher than the 2011 River Mile 20 creek comparison fish, statistically lower than the 2011 fish from River Mile 28, and statistically similar to the River Mile 15 sample.

Small, Young Fish

Juvenile Largemouth Bass

The juvenile bass multiple-fish composites had whole-body mercury ranging from 0.121-0.176 ppm, averaging 0.146 ppm. As seen above for the adult bass, this represented a continuing increase in fish mercury bioaccumulation from 2015 to 2016 to 2017. Each of these increases was statistically significant. As discussed above, these changes may be linked to changes in pond management across this period. Relative to baseline juvenile bass comparison numbers from Cache Creek, the 2017 Phase 1 fish were statistically higher than the River Mile 15 comparison (0.050 ppm) and statistically similar to River Mile 28 (0.142 ppm).

Mosquitofish

The Mosquitofish multiple-fish composites had whole-body mercury ranging from 0.100-0.182 ppm, averaging 0.135 ppm. As seen in the adult and juvenile bass, this was a continuing increase from 2016 (0.093 ppm) and 2015 (0.075 ppm). The year-to-year differences were not statistically significant, but the overall increase between 2015 and 2017 was. The 2017 Mosquitofish average remained similar to or lower than comparable Cache Creek samples from River Miles 15 and 17 (0.094-0.172 ppm). The differences were not significant statistically.

Juvenile Green Sunfish

This was a first year of collections for this species. The juvenile Green Sunfish multiple-fish composites had whole-body mercury ranging from 0.090-0.139 ppm, averaging 0.118 ppm. This was in a range similar to baseline juvenile Green Sunfish comparison numbers from Cache Creek (0.084-0.169 ppm).

Summary

The small, young-of-year fish samples are sensitive indicators of mercury exposure conditions in the year sampled, because that is the only time they have accumulated their mercury. Each year's new cohort can show exposure changes more distinctly than the large fish, which develop their mercury levels over multiple years of growth. The Phase 1 Pond small fish data indicate a relative increase in methylmercury availability and uptake there in 2016 and 2017, though to levels still similar to the low-mid range of historic creek comparisons. The adult Largemouth Bass sample was consistent with this increase. The Channel Catfish samples were up somewhat in 2017, though still within the baseline range of comparable creek samples. The White Catfish samples were also up somewhat. They averaged significantly higher mercury than the available creek catfish comparisons, though the much smaller-sized creek samples make comparisons difficult for all the catfish samples. The general stepwise increase in fish mercury seen in the Phase 1 Pond from 2015 to 2017 corresponded to changes in pond operations that, among other things, resulted in less disturbance of the water column, less mixing, and less sediment suspension. Water column profiling was initiated in 2018 to provide additional information. This pond was not found to be "elevated for two or more consecutive years", which would trigger consideration of mercury remediation and seasonal water column profiling as a first step. However, the overall low mercury status of this pond, and the interesting changes over the years monitored, made it a key comparison for remediation insights for the elevated ponds.

Table A1, below, summarizes the statistical comparisons between Phase 1 Pond fish and comparable Cache Creek samples, for the data sets with sufficient numbers of fish to compare statistically. This pond site was unique in showing consistently lower to similar fish mercury levels, relative to creek comparisons in most sample types.

Table A1. Cemex – Phase 1 Pond Fish Mercury: Statistical comparisons
(for sample sets with enough fish to compare statistically; 95% confidence level)

< *Pond fish were significantly lower in mercury than at the baseline site*
> *Pond fish were significantly higher in mercury than at the baseline site*
= *Pond fish were not significantly different than at the baseline site*

Fish Species		***vs*** ***Same Site 2016 , 2015***	*– vs Baseline and Historic Comparable Cache Creek Data Sets –* **RM28 2011**	RM20 2000	**RM20 2011**	RM17 00-02	RM15 00-02	**RM15 2011**
Large fish fillet muscle mercury								
Largemouth Bass	**2015**		<	<				=
	2016	=	<	=				=
	2017	= , =	<	=				=
White Catfish	**2015**	na						
	2016	na						
	2017	na	>					
Green Sunfish	**2017**	na	<		>			=
Small, young fish whole body, composite mercury								
Largemouth Bass	**2015**		<					=
	2016	>	<					=
	2017	> , >	=					=
Mosquitofish	**2015**					<	=	=
	2016	=				<	=	=
	2017	= , >				=	=	=
Green Sunfish	**2017**	na	=		>	=	=	=

Table 1. Cemex – Phase 1 (West) Pond: Large fish sampled, Fall 2017

Fish Species	Fish Total Length (mm)	(inches)	Fish Weight (g)	(lbs)	Muscle Mercury (µg/g = ppm, wet wt)
Largemouth Bass	227	8.9	195	0.4	**0.215**
Largemouth Bass	243	9.6	170	0.4	**0.198**
Largemouth Bass	249	9.8	190	0.4	**0.234**
Largemouth Bass	252	9.9	205	0.5	**0.202**
Largemouth Bass	259	10.2	215	0.5	**0.266**
Largemouth Bass	264	10.4	225	0.5	**0.283**
Largemouth Bass	266	10.5	235	0.5	**0.352**
Largemouth Bass	272	10.7	250	0.6	**0.224**
Largemouth Bass	318	12.5	410	0.9	**0.556**
Largemouth Bass	319	12.6	360	0.8	**0.565**
Largemouth Bass	332	13.1	475	1.0	**0.538**
Largemouth Bass	333	13.1	455	1.0	**0.502**
Largemouth Bass	338	13.3	410	0.9	**0.512**
Largemouth Bass	340	13.4	495	1.1	**0.379**
Largemouth Bass	346	13.6	510	1.1	**0.463**
Largemouth Bass	355	14.0	640	1.4	**0.606**
Largemouth Bass	367	14.4	622	1.4	**0.582**
Channel Catfish	528	20.8	1405	3.1	**0.239**
Channel Catfish	533	21.0	1475	3.3	**0.233**
White Catfish	570	22.4	1980	4.4	**0.353**
White Catfish	590	23.2	1980	4.4	**0.389**
White Catfish	615	24.2	1850	4.1	**0.368**
White Catfish	628	24.7	2220	4.9	**0.410**
White Catfish	630	24.8	2010	4.4	**0.477**
White Catfish	655	25.8	2680	5.9	**0.693**
Green Sunfish	76	3.0	8	0.0	**0.170**
Green Sunfish	84	3.3	10	0.0	**0.304**
Green Sunfish	85	3.3	10	0.0	**0.321**
Green Sunfish	87	3.4	12	0.0	**0.219**
Green Sunfish	193	7.6	135	0.3	**0.352**

Table 2. Cemex – Phase 1 (West) Pond: Small Fish Sampled, Fall 2017
(multi-individual, whole body composite samples)
'**n**' = *number: number of individual fish per composite*

Fish Species	**n** (indivs. in comp)	Av. Fish Length (mm)	(inches)	Av. Fish Weight (g)	(oz)	Whole-Body Mercury (µg/g = ppm, wet wt)
Largemouth Bass (juv)	**2**	101	4.0	13.6	0.48	**0.121**
Largemouth Bass (juv)	**2**	115	4.5	20.8	0.74	**0.148**
Largemouth Bass (juv)	**2**	121	4.8	23.5	0.83	**0.137**
Largemouth Bass (juv)	**2**	132	5.2	29.7	1.05	**0.176**
Green Sunfish (juv)	**10**	35	1.4	0.7	0.02	**0.090**
Green Sunfish (juv)	**10**	41	1.6	1.1	0.04	**0.109**
Green Sunfish (juv)	**10**	50	2.0	1.9	0.07	**0.139**
Green Sunfish (juv)	**8**	63	2.5	4.1	0.15	**0.133**
Mosquitofish	**10**	28	1.1	0.2	0.01	**0.100**
Mosquitofish	**10**	32	1.2	0.3	0.01	**0.108**
Mosquitofish	**10**	34	1.3	0.4	0.01	**0.149**
Mosquitofish	**10**	39	1.5	0.6	0.02	**0.182**

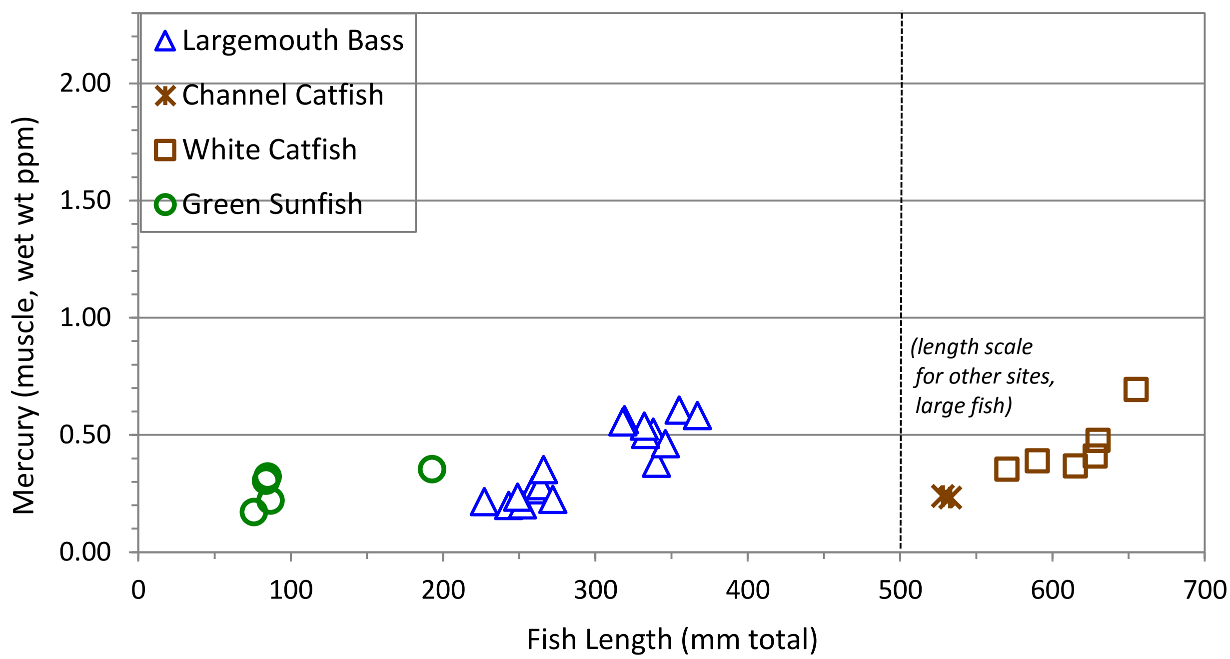

Figure 1. **Cemex – Phase 1 (West) Pond: large fish sampled, Fall 2017**
(fillet muscle mercury in individual fish)

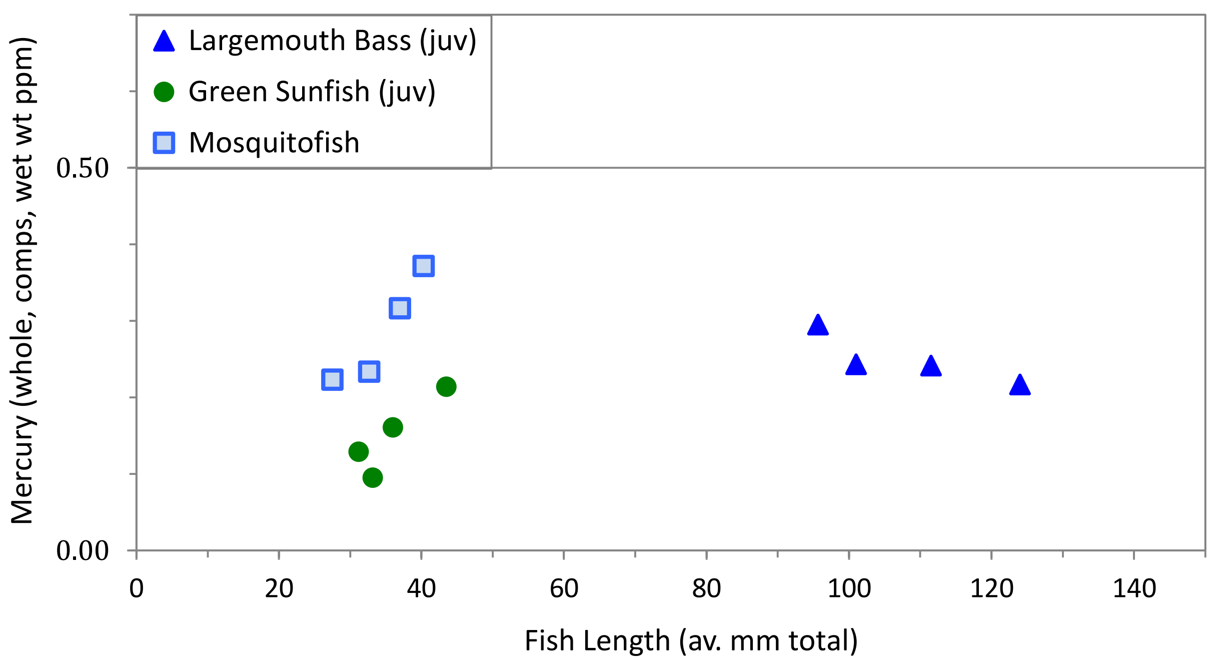

Figure 2. **Cemex – Phase 1 (West) Pond: small, young fish sampled, Fall 2017**
(mercury in whole-body, multi-individual composite samples)

Table 3. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Cemex – Phase 1 (West)	2015	**18**	305	393	**0.278**	± 0.055
Cemex – Phase 1 (West)	2016	**20**	313	383	**0.350**	± 0.066
Cemex – Phase 1 (West)	2017	**17**	299	357	**0.393**	± 0.079
Historic/Baseline Data (comparable predatory species)						
Largemouth Bass						
River Mile 28	**2011**	**9**	**199**	**137**	**0.663**	**± 0.116**
Smallmouth Bass						
River Mile 28	**2011**	**7**	**265**	**326**	**0.782**	**± 0.188**
River Mile 20	2000	7	234	183	0.444	± 0.061
River Mile 15	1997	2	383	780	0.939	
Sacramento Pikeminnow						
River Mile 28	**2011**	**10**	**311**	**262**	**0.726**	**± 0.102**
River Mile 20	2000	8	269	147	0.509	± 0.204
River Mile 15	**2011**	**9**	**264**	**145**	**0.327**	**± 0.066**

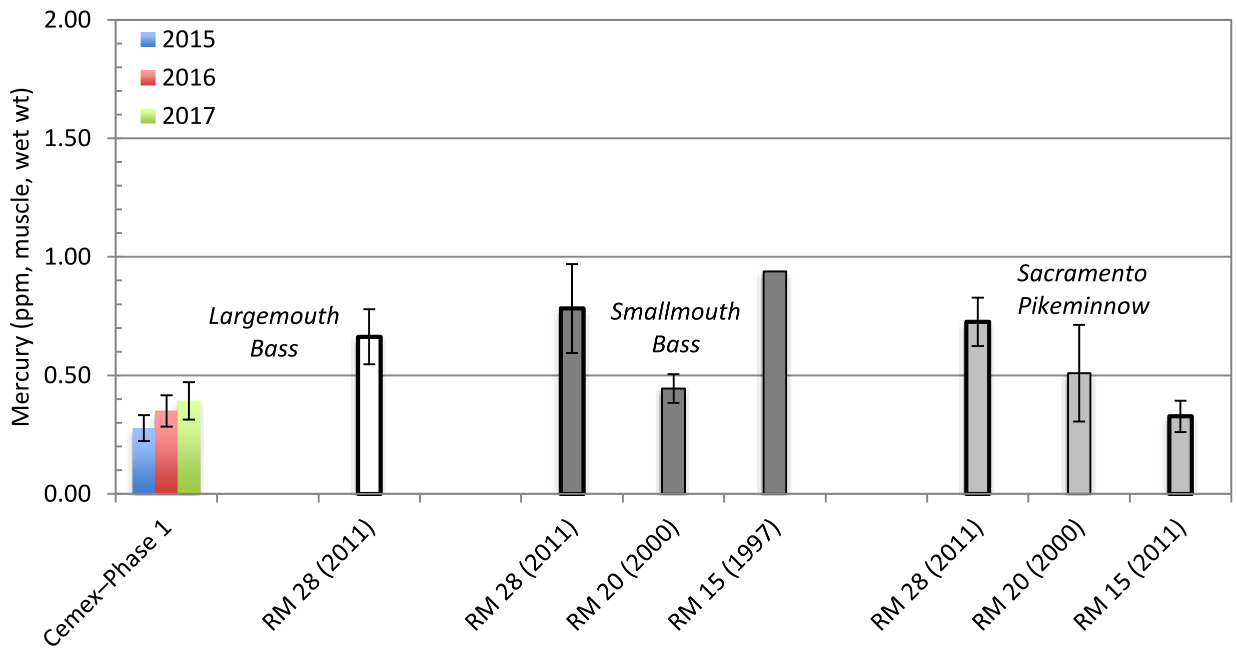

Figure 3. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Table 4. Channel and White Catfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Channel Catfish						
Cemex – Phase 1 (West)	2015	**2**	595	2,130	**0.198**	
Cemex – Phase 1 (West)	2016	**2**	412	1,150	**0.100**	
Cemex – Phase 1 (West)	2017	**2**	531	1,440	**0.236**	
White Catfish						
Cemex – Phase 1 (West)	2016	**3**	661	2,900	**0.372**	
Cemex – Phase 1 (West)	2017	**6**	615	2,120	**0.448**	± 0.134
Historic/Baseline Data						
Channel Catfish						
Rumsey	2000	1	411	565	0.225	
River Mile 28	**2011**	**5**	**239**	**102**	**0.229**	**± 0.102**
River Mile 20	2000	1	368	380	0.225	

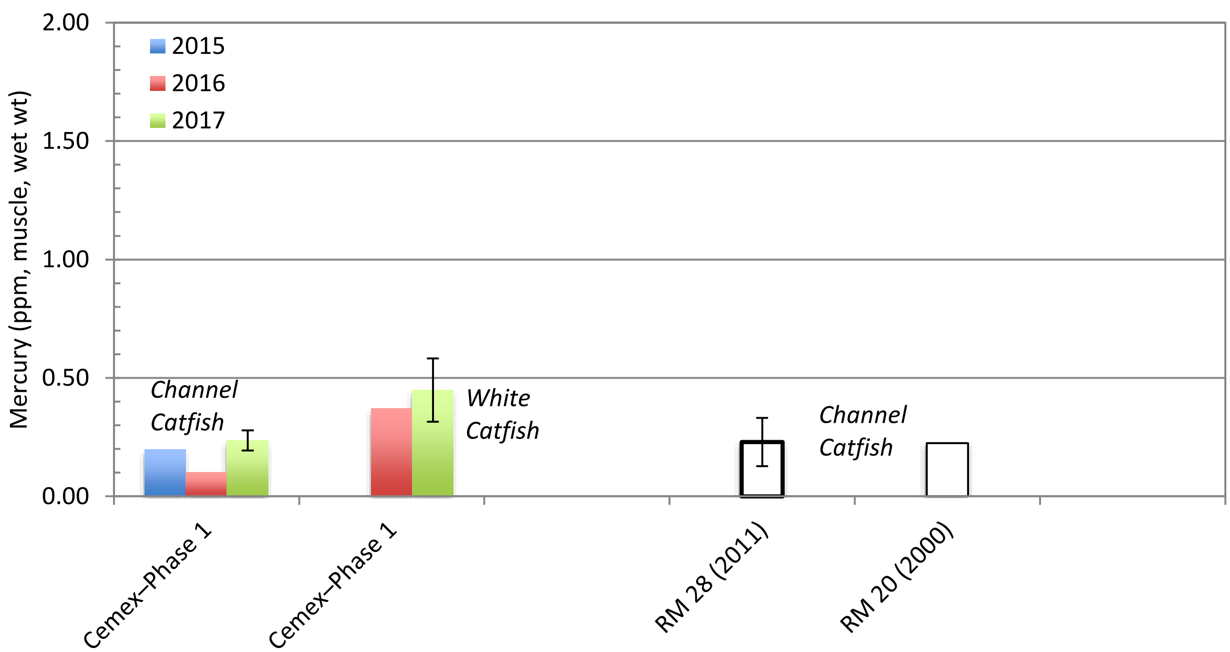

Figure 4. Channel and White Catfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Table 5. Green Sunfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Green Sunfish						
Cemex – Phase 1 (West)	2016	**–**	–	–	**–**	**–**
Cemex – Phase 1 (West)	2017	**5**	105	35	**0.273**	± 0.094
Historic/Baseline Data						
River Mile 28	**2011**	**3**	**139**	**47**	**0.540**	**± 0.124**
River Mile 20	2000	4	132	41	0.271	
River Mile 20	**2011**	**10**	**122**	**31**	**0.138**	**± 0.029**
River Mile 15	**2011**	**10**	**133**	**41**	**0.195**	**± 0.031**

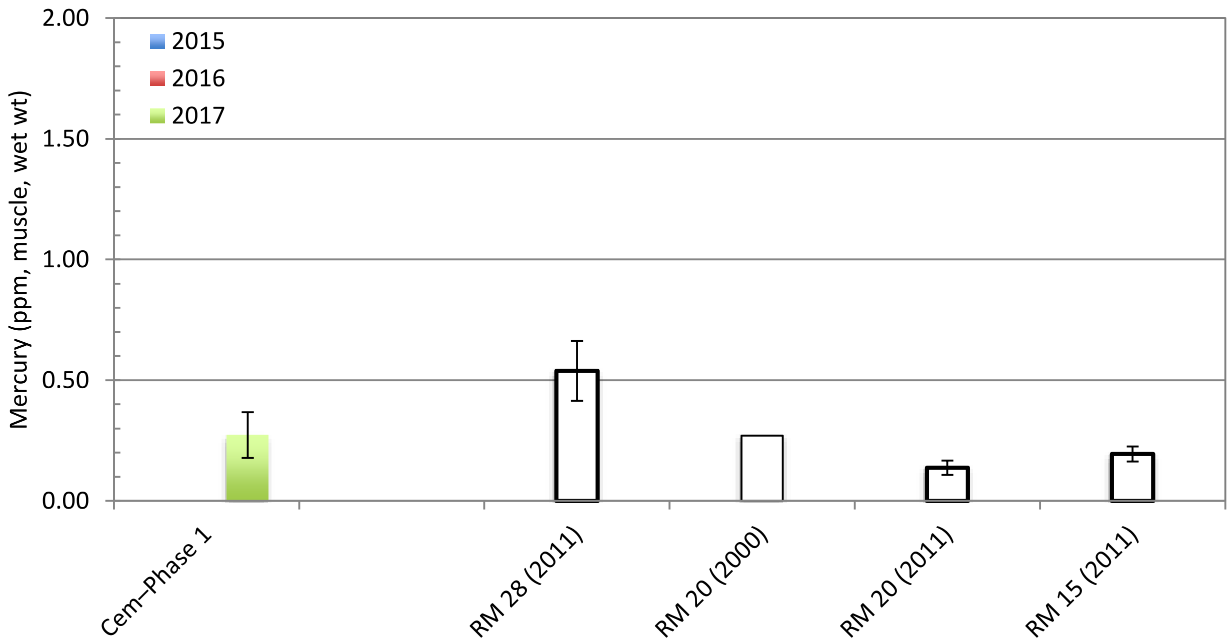

Figure 5. Green Sunfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Small, Young Fish Samples *(note lower concentration scales)*

Table 6. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	**n** (comps)	**n** (inds/ (comp)	**Av Lgth** (mm total)	**Av Wt** (grams)	**Hg** (µg/g = ppm, wet wt)	**Std. Dev.**
Largemouth Bass (juveniles)							
Cemex – Phase 1 (West)	2015	**4**	8	109	17	**0.044**	± 0.007
Cemex – Phase 1 (West)	2016	**4**	3	102	17	**0.094**	± 0.012
Cemex – Phase 1 (West)	2017	**4**	2	117	22	**0.146**	± 0.023
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**3-5**	**75**	**6**	**0.142**	**± 0.026**
River Mile 15	**2011**	**3**	**1**	**93**	**10**	**0.050**	**± 0.024**

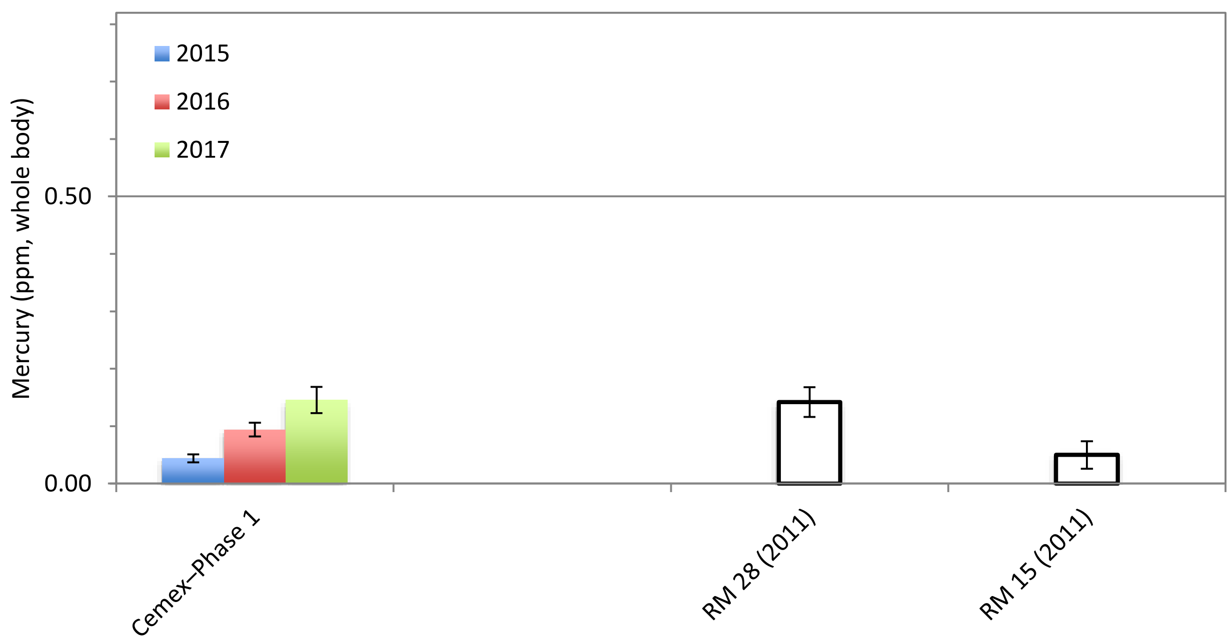

Figure 6. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 7. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	**Year**	**n** (comps)	**n** (inds/ (comp)	**Av Lgth** (mm total)	**Av Wt** (grams)	**Hg** (µg/g = ppm, wet wt)	**Std. Dev.**
Mosquitofish							
Cemex – Phase 1 (West)	2015	**4**	10	39	0.6	**0.075**	± 0.015
Cemex – Phase 1 (West)	2016	**4**	10	34	0.4	**0.093**	± 0.039
Cemex – Phase 1 (West)	2017	**4**	10	33	0.4	**0.135**	± 0.038
Historic/Baseline Data							
River Mile 17	2000-2002	13	5-30	26-47	0.2-1.1	0.172	± 0.048
River Mile 15	2000-2002	10	5-30	26-47	0.2-1.0	0.094	± 0.029
River Mile 15	**2011**	**4**	**1-10**	**37**	**0.7**	**0.103**	**± 0.048**

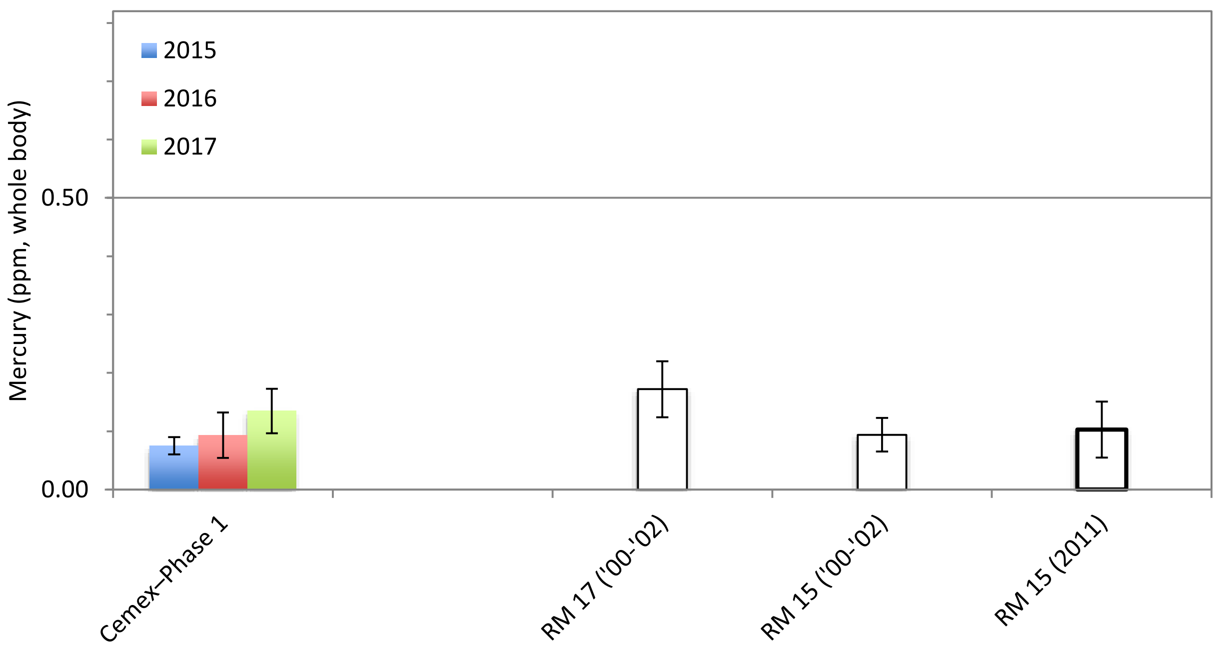

Figure 7. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 8. Juvenile Green Sunfish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Green Sunfish (juveniles)							
Cemex – Phase 1 (West)	2016	–	–	–	–	–	
Cemex – Phase 1 (West)	2017	**4**	8-10	47	1.9	**0.118**	± 0.023
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**4**	**53**	**2.8**	**0.139**	**± 0.014**
River Mile 20	**2011**	**4**	**4**	**58**	**3.4**	**0.084**	**± 0.004**
River Mile 17	2000-2002	8	5-10	41-90	1-6	0.169	± 0.045
River Mile 15	2000-2002	8	4-8	40-87	1-6	0.117	± 0.028
River Mile 15	**2011**	**4**	**4-5**	**56**	**3.1**	**0.086**	**± 0.018**

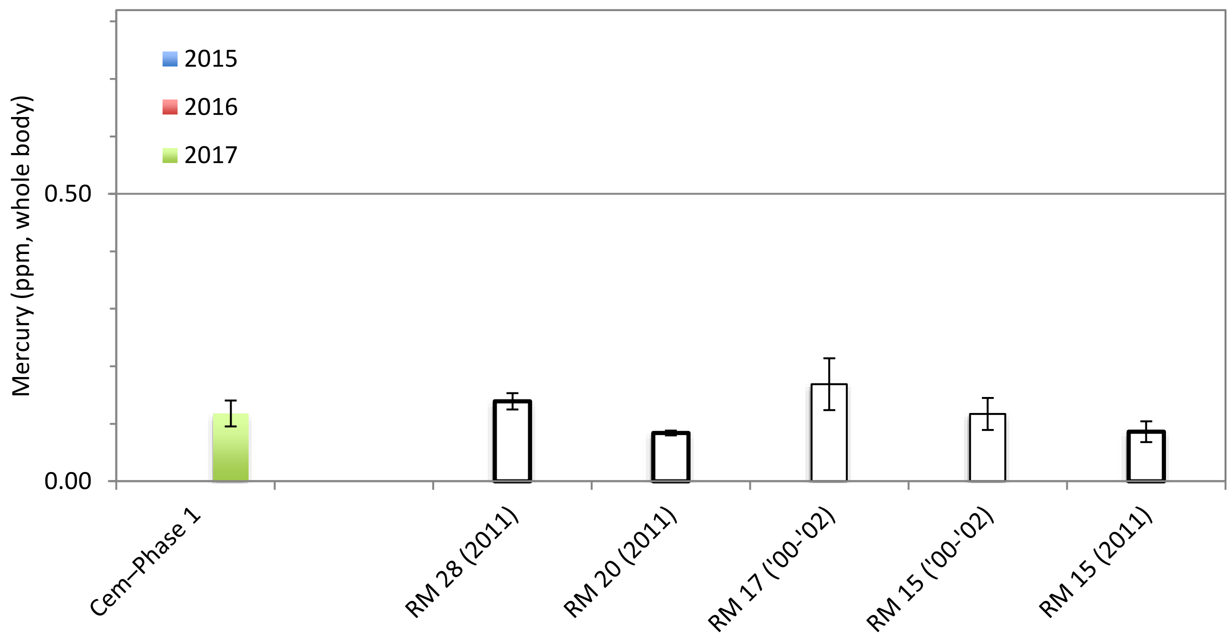

Figure 8. Juv. Green Sunfish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

2. CEMEX – PHASE 3-4 (East) POND

2. CEMEX – PHASE 3-4 (East) POND *(Tables 9-15, Figures 9-15)*

This pond is the more recent (approx. 2002), and more recently active, of the two Cemex ponds. It is also located just south of Cache Creek and east of Highway 505. It is east of the Cemex – Phase 1 (West) Pond. The Phase 3-4 Pond is a large, elongated water body that is app. 1,200 m long (1.2 km) and 300 m wide. Depths ranged from extensive areas of 0-2 m shallows to deeper areas of approximately 12 m (40 feet). Cemex staff told us that active mining was halted there in 2017, to be resumed at some future date. This (2017) was Year 3 of monitoring.

We sampled the pond during day and twilight conditions with a range of techniques, and were able to obtain useful samples of most of the fish species present. These included individual fillet muscle samples of 20 Largemouth Bass (*Micropterus salmoides*) across the range of sizes present. The small fish were again juvenile Largemouth Bass (4-5"), juvenile Green Sunfish (1-2"), and Mosquitofish (1-2", *Gambusia affinis*). We collected 9 young-of-year bass, which were divided into 4 composite samples of 2-3 fish each. Twenty juvenile Green Sunfish were placed into 4 size group composite samples of 2-6 fish each. Mosquitofish were sampled with 4 composite samples of 6-10 fish each.

In total, 20 large fish muscle samples and 12 small fish composite samples, 32 separate mercury samples, were analyzed from the Cemex-Phase 3-4 Pond in the Fall 2017 monitoring. The analytical results from each individual large fish muscle sample and each small, young fish composite sample can be seen in Tables 9 and 10 and, graphically, in Figures 9 and 10. Then, for each sample type, the new data are shown in reduced form (means, error bars, etc.) and compared to 2015-2016 results and the most closely comparable historic creek data (Tables 11-15, Figures 11-15).

Large, Angling-sized Fish

Largemouth Bass

The Phase 3-4 Pond adult Largemouth Bass samples had fillet muscle mercury ranging from 0.552-1.785 ppm, averaging 1.093 ppm. This was up from 2016 (0.858 ppm) and 2015 (0.840 ppm). The change was statistically significant relative to 2015. Concentrations generally increased with fish size, as is typical. Similar to the 2015-2016 sets of bass, the 2017 samples ranged between 267 and 382 mm (about 10-15"). Adult bass represent the top predator fish in this region and will typically have the highest mercury levels at any given site. The Phase 3-4 Pond bass in 2017 were higher in mercury than all of the baseline creek comparisons. The difference was statistically significantly for 5 of the 7 historic comparisons.

Green Sunfish

We have not been able to collect this species in useful numbers since 2015, despite considerable effort. For completion, the earlier data are included in Table 12 and Figure 12.

Small, Young Fish

Juvenile Largemouth Bass

The juvenile bass multiple-fish composites had whole-body mercury ranging from 0.217-0.295 ppm, averaging 0.249 ppm. This was down, relative to similar-sized samples analyzed in 2016 (0.372 ppm) and 2015 (0.334 ppm). The decline was statistically significant, and notable in its difference from the adult bass trend, which increased. Relative to baseline juvenile bass comparison data from Cache Creek, though, they remained significantly higher than the two sample sets available: River Mile 28 (0.142 ppm) and River Mile 15 (0.050 ppm).

Juvenile Green Sunfish

The juvenile Green Sunfish multiple-fish composites had whole-body mercury ranging from 0.095-0.214 ppm, averaging 0.150 ppm. Like the juvenile bass, this was a statistically significant decline, relative to samples analyzed in 2016 (0.233 ppm) and 2015 (0.275 ppm). However, it is important to note that the fish available for collection in 2017 were considerably smaller and younger (36 mm, 0.7 g) than those analyzed in 2015-2016 (47-49 mm, 1.8-2.0 g), and this may have been a factor in the apparent decline in mercury. Compared to baseline juvenile Green Sunfish from Cache Creek, Phase 3-4 Pond fish in 2015 and 2016 were higher than all creek comparisons, and significantly higher in 4 of 5 comparisons. The decline in concentrations in 2017 moved pond juvenile sunfish mercury to a range similar to 3 of 5 creek comparison sets. The 2017 level remained significantly higher than 2 of the 5 creek comparisons.

Mosquitofish

The Mosquitofish multiple-fish composites had whole-body mercury ranging from 0.223-0.371 ppm, averaging 0.286 ppm. Unlike the trend seen with the small bass and sunfish, this was an increase, relative to similar-sized samples analyzed in 2016 (0.157 ppm) and 2015 (0.228 ppm). The year-to-year change versus 2016 was statistically significant. The 2017 average was statistically higher than all 3 of the comparable Cache Creek sample sets from River Miles 15 and 17 (0.094-0.172 ppm).

Summary

In summary, fish mercury in the Cemex – Phase 3-4 Pond exhibited an odd mix of trends, as compared to 2015 and 2016. Adult Largemouth Bass and Mosquitofish mercury concentrations were clearly up, while juvenile Bass and juvenile Green Sunfish levels were significantly decreased. As the juvenile fish reflect recent mercury exposure (as they are only months old), it is possible that the large fish had higher exposure earlier in the year and then levels came down. We would expect to see lower levels in the small Mosquitofish as well, though. In any case, overall fish mercury at this pond was elevated over comparable creek baseline samples for the majority of sample types. The adult bass, in particular, were at levels well above consumption guidelines. As this pond was found to be relatively "elevated for two or more consecutive years", that triggered consideration of mercury remediation. The first stage of remediation is to obtain additional water quality information, through seasonal water column profiling of a range of relevant constituents. Seasonal water column profiling was initiated in 2018.

Table A2, below, summarizes the statistical comparisons between Phase 3-4 Pond fish and comparable Cache Creek samples, for the data sets with sufficient numbers of fish to compare statistically.

Table A2. Cemex – Phase 3-4 Pond Fish Mercury: Statistical comparisons
(for sample sets with enough fish to compare statistically; 95% confidence level)

< *Pond fish were significantly lower in mercury than at the baseline site*
> *Pond fish were significantly higher in mercury than at the baseline site*
= *Pond fish were not significantly different than at the baseline site*

Fish Species		***vs*** ***Same Site*** **2016 , 2015**	*– vs Baseline and Historic Comparable Cache Creek Data Sets –* **RM28 2011**	RM20 2000	**RM20 2011**	RM17 00-02	RM15 00-02	**RM15 2011**
Large fish fillet muscle mercury								
Largemouth Bass	**2015**		=	>				>
	2016	=	=	>				>
	2017	= , >	>	>				>
Green Sunfish	**2015**		=		>			>
	2016	*na*						
	2017	*na*						
Small, young fish whole body, composite mercury								
Largemouth Bass	**2015**		>					>
	2016	=	>					>
	2017	< , <	>					>
Green Sunfish	**2015**		>		>	>	>	>
	2016	=	>		>	=	>	>
	2017	< , <	=		>	=	=	>
Mosquitofish	**2015**					=	>	=
	2016	=				=	>	=
	2017	> , =				>	>	>

Table 9. Cemex – Phase 3-4 Pond (East): Large fish sampled, Fall 2017

Fish Species	Fish Total Length (mm)	(inches)	Fish Weight (g)	(lbs)	Muscle Mercury (µg/g = ppm, wet wt)
Largemouth Bass	267	10.5	245	0.5	**0.694**
Largemouth Bass	280	11.0	255	0.6	**0.636**
Largemouth Bass	289	11.4	285	0.6	**0.817**
Largemouth Bass	302	11.9	370	0.8	**0.711**
Largemouth Bass	312	12.3	400	0.9	**0.972**
Largemouth Bass	318	12.5	425	0.9	**0.646**
Largemouth Bass	320	12.6	430	0.9	**0.807**
Largemouth Bass	322	12.7	410	0.9	**0.943**
Largemouth Bass	328	12.9	430	0.9	**0.552**
Largemouth Bass	328	12.9	445	1.0	**0.960**
Largemouth Bass	331	13.0	425	0.9	**1.149**
Largemouth Bass	344	13.5	470	1.0	**1.359**
Largemouth Bass	355	14.0	640	1.4	**1.174**
Largemouth Bass	356	14.0	550	1.2	**1.468**
Largemouth Bass	360	14.2	495	1.1	**1.785**
Largemouth Bass	367	14.4	650	1.4	**1.488**
Largemouth Bass	370	14.6	645	1.4	**1.388**
Largemouth Bass	373	14.7	660	1.5	**1.301**
Largemouth Bass	378	14.9	710	1.6	**1.415**
Largemouth Bass	382	15.0	640	1.4	**1.603**

Table 10. Cemex – Phase 3-4 Pond (East): Small Fish Sampled, Fall 2017
(multi-individual, whole body composite samples)
'**n**' = *number: number of individual fish per composite*

Fish Species	**n** (indivs. in comp)	Av. Fish Length (mm)	(inches)	Av. Fish Weight (g)	(oz)	Whole-Body Mercury (µg/g = ppm, wet wt)
Largemouth Bass (juv)	**3**	96	3.8	10.3	0.36	**0.295**
Largemouth Bass (juv)	**2**	101	4.0	12.3	0.43	**0.243**
Largemouth Bass (juv)	**2**	112	4.4	16.5	0.58	**0.241**
Largemouth Bass (juv)	**2**	124	4.9	23.9	0.84	**0.217**
Green Sunfish (juv)	**6**	31	1.2	0.4	0.02	**0.129**
Green Sunfish (juv)	**6**	33	1.3	0.5	0.02	**0.095**
Green Sunfish (juv)	**6**	36	1.4	0.7	0.02	**0.161**
Green Sunfish (juv)	**2**	44	1.7	1.3	0.05	**0.214**
Mosquitofish	**10**	28	1.1	0.2	0.01	**0.223**
Mosquitofish	**10**	33	1.3	0.3	0.01	**0.233**
Mosquitofish	**10**	37	1.5	0.6	0.02	**0.316**
Mosquitofish	**6**	40	1.6	0.8	0.03	**0.371**

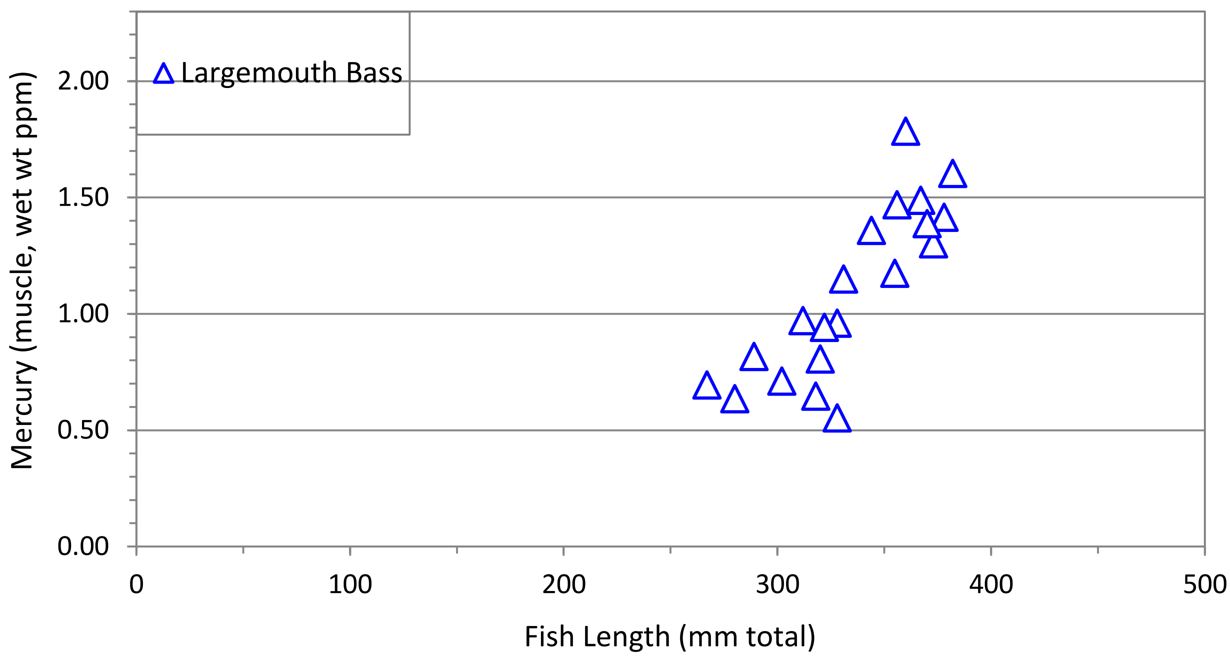

Figure 9. Cemex – Phase 3-4 Pond (East): Large fish sampled, Fall 2017
(fillet muscle mercury in individual fish)

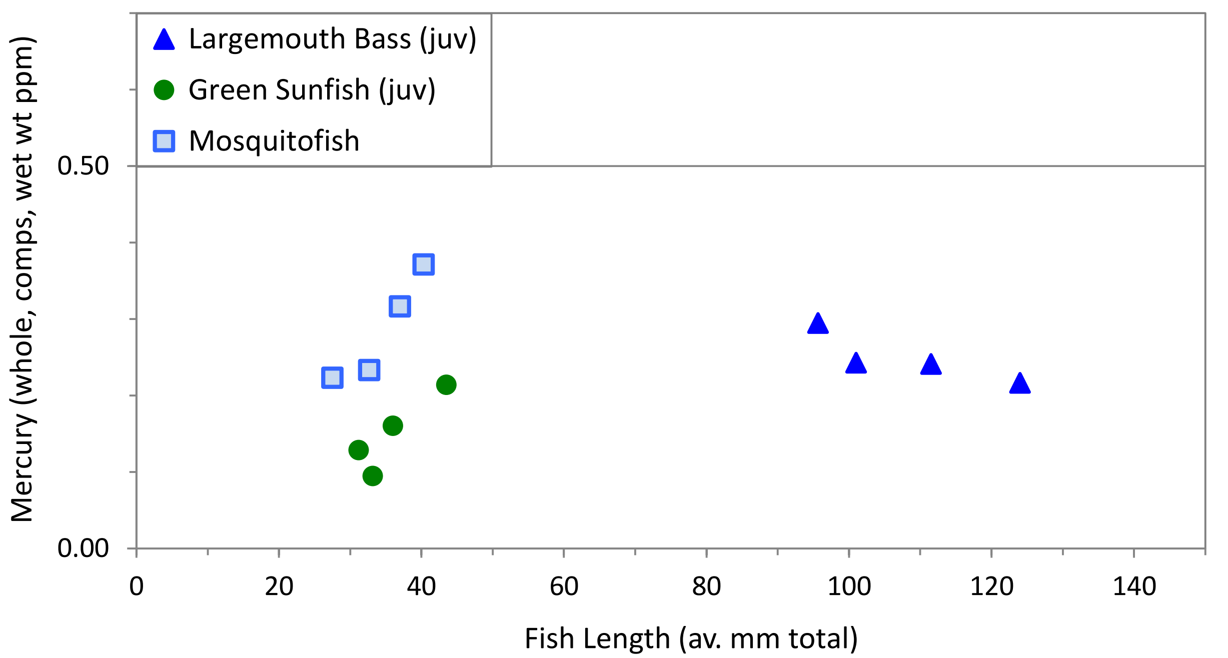

Figure 10. Cemex – Phase 3-4 Pond (East): Small, young fish sampled, Fall 2017
(mercury in whole-body, multi-individual composite samples)

Table 11. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Cemex – Phase 3-4 (East)	2015	**20**	344	526	**0.840**	± 0.113
Cemex – Phase 3-4 (East)	2016	**20**	344	557	**0.858**	± 0.139
Cemex – Phase 3-4 (East)	2017	**20**	334	479	**1.093**	± 0.172
Historic/Baseline Data (comparable predatory species)						
Largemouth Bass						
River Mile 28	**2011**	**9**	**199**	**137**	**0.663**	**± 0.116**
Smallmouth Bass						
River Mile 28	**2011**	**7**	**265**	**326**	**0.782**	**± 0.188**
River Mile 20	2000	7	234	183	0.444	± 0.061
River Mile 15	1997	2	383	780	0.939	
Sacramento Pikeminnow						
River Mile 28	**2011**	**10**	**311**	**262**	**0.726**	**± 0.102**
River Mile 20	2000	8	269	147	0.509	± 0.204
River Mile 15	**2011**	**9**	**264**	**145**	**0.327**	**± 0.066**

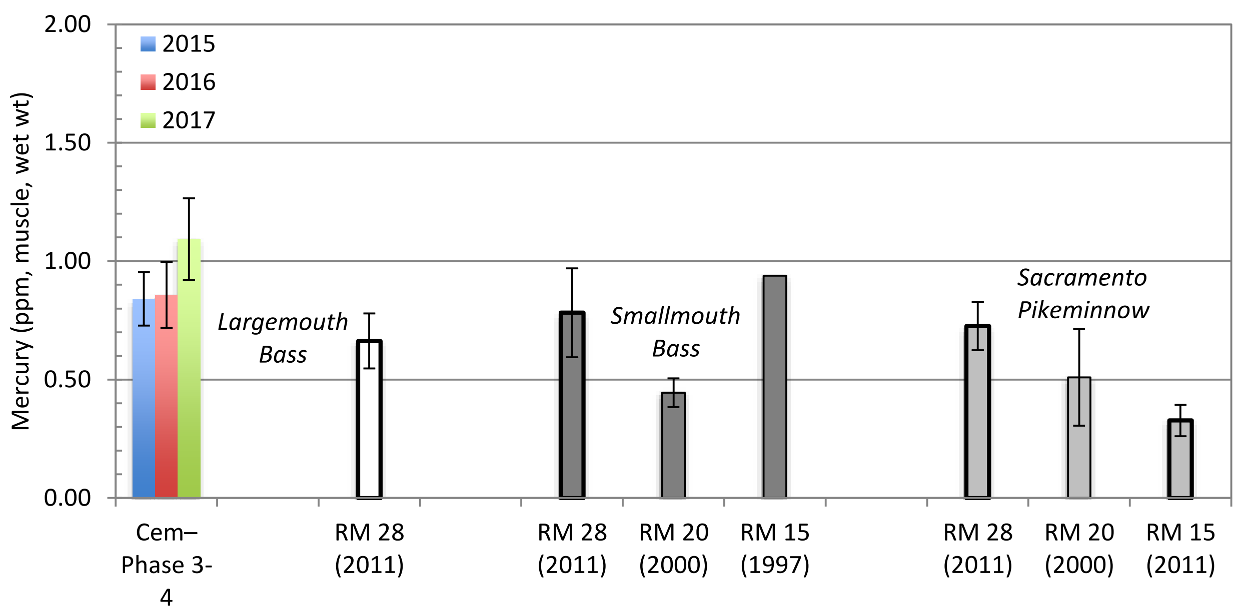

Figure 11. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Table 12. Green Sunfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Green Sunfish						
Cemex – Phase 3-4 (East)	2015	**10**	133	67	**0.534**	± 0.076
Cemex – Phase 3-4 (East)	2016	**1**	101	16	**0.382**	
Cemex – Phase 3-4 (East)	2017	**–**	–	–	**–**	
Historic/Baseline Data						
River Mile 28	**2011**	**3**	**139**	**47**	**0.540**	**± 0.124**
River Mile 20	2000	4	132	41	0.271	
River Mile 20	**2011**	**10**	**122**	**31**	**0.138**	**± 0.029**
River Mile 15	**2011**	**10**	**133**	**41**	**0.195**	**± 0.031**

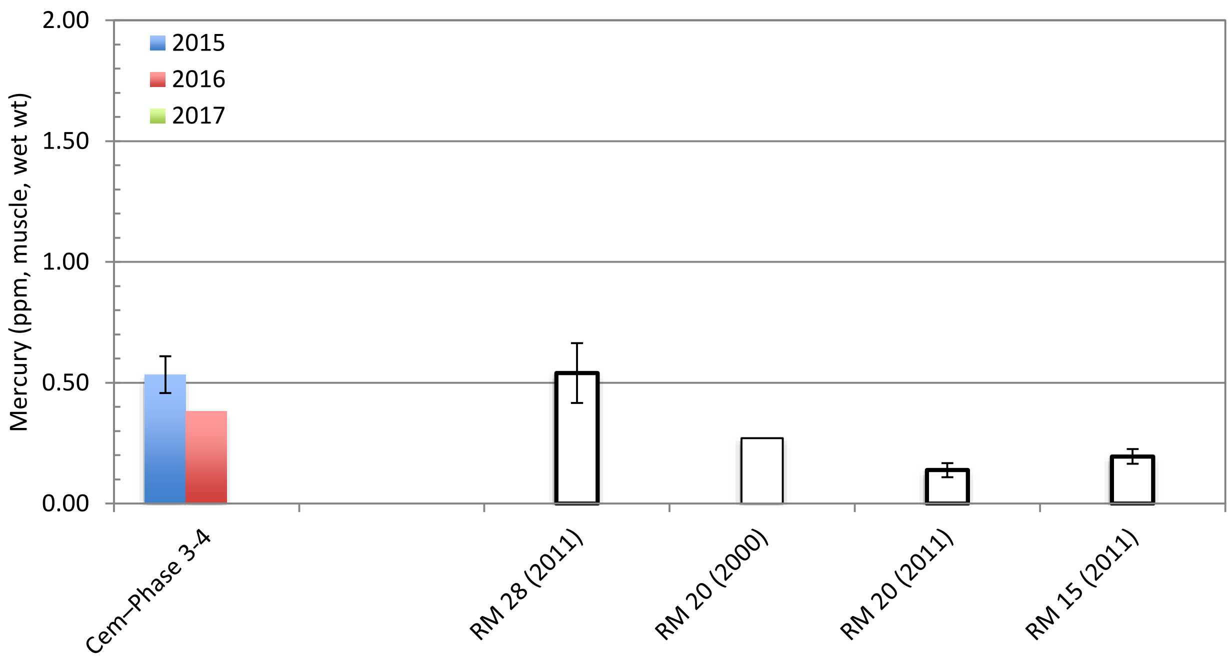

Figure 12. Green Sunfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Small, Young Fish Samples (note lower concentration scales)

Table 13. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Largemouth Bass (juveniles)							
Cemex – Phase 3-4 (East)	2015	**4**	7	108	16	**0.334**	± 0.052
Cemex – Phase 3-4 (East)	2016	**4**	2	114	18	**0.372**	± 0.053
Cemex – Phase 3-4 (East)	2017	**4**	2-3	108	16	**0.249**	± 0.033
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**3-5**	**75**	**6**	**0.142**	**± 0.026**
River Mile 15	**2011**	**3**	**1**	**93**	**10**	**0.050**	**± 0.024**

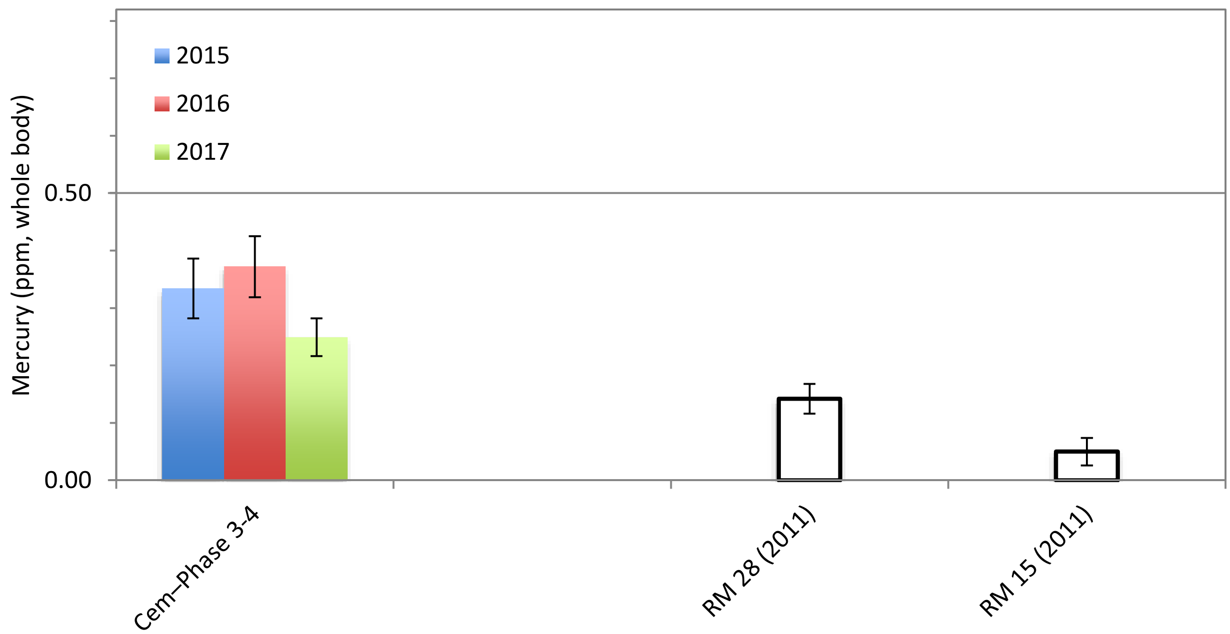

Figure 13. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 14. Juvenile Green Sunfish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Green Sunfish (juveniles)							
Cemex – Phase 3-4 (East)	2015	**4**	10	47	1.8	**0.275**	± 0.022
Cemex – Phase 3-4 (East)	2016	**4**	4-5	49	2.0	**0.233**	± 0.026
Cemex – Phase 3-4 (East)	2017	**4**	2-6	36	0.7	**0.150**	± 0.051
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**4**	**53**	**2.8**	**0.139**	**± 0.014**
River Mile 20	**2011**	**4**	**4**	**58**	**3.4**	**0.084**	**± 0.004**
River Mile 17	2000-2002	8	5-10	41-90	1-6	0.169	± 0.045
River Mile 15	2000-2002	8	4-8	40-87	1-6	0.117	± 0.028
River Mile 15	**2011**	**4**	**4-5**	**56**	**3.1**	**0.086**	**± 0.018**

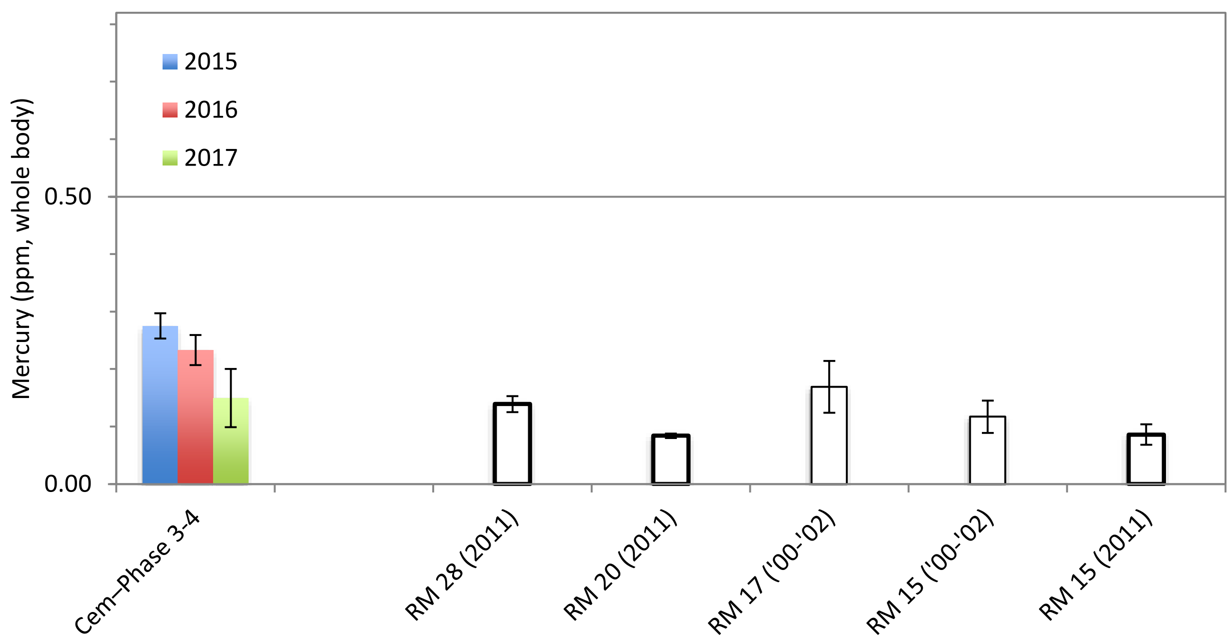

Figure 14. Juv. Green Sunfish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 15. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Mosquitofish							
Cemex – Phase 3-4 (East)	2015	**4**	10	37	0.6	**0.228**	± 0.059
Cemex – Phase 3-4 (East)	2016	**4**	10	37	0.6	**0.157**	± 0.037
Cemex – Phase 3-4 (East)	2017	**4**	6-10	34	0.5	**0.286**	± 0.071
Historic/Baseline Data							
River Mile 17	2000-2002	13	5-30	26-47	0.2-1.1	0.172	± 0.048
River Mile 15	2000-2002	10	5-30	26-47	0.2-1.0	0.094	± 0.029
River Mile 15	**2011**	**4**	**1-10**	**37**	**0.7**	**0.103**	**± 0.048**

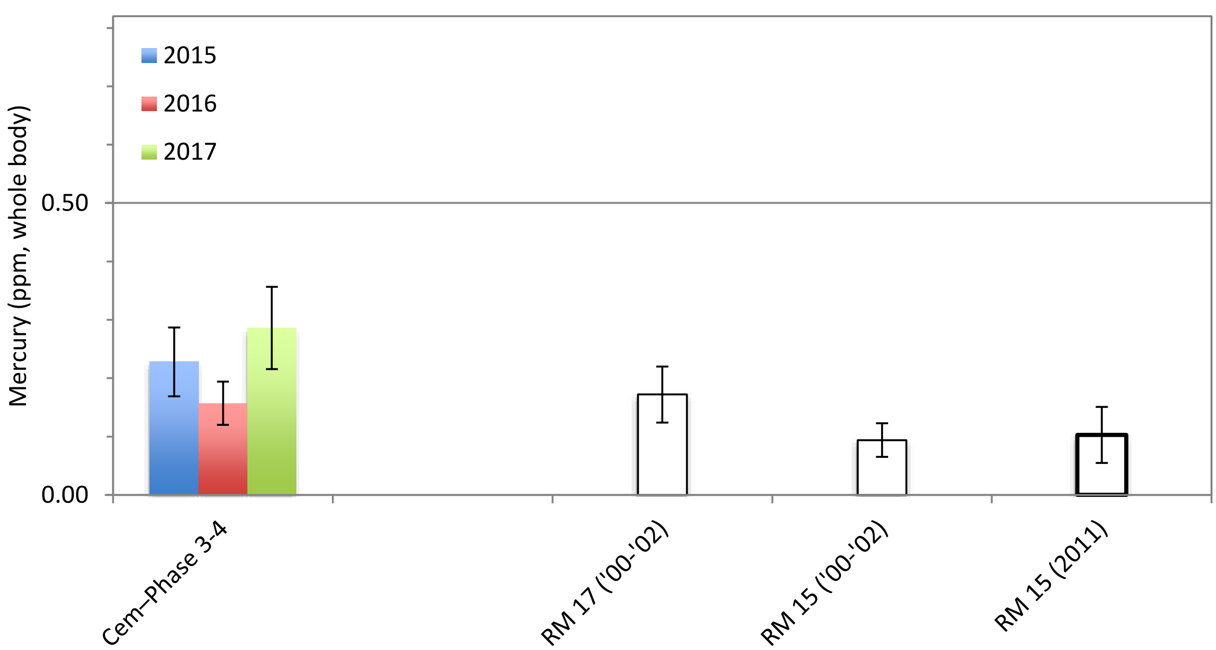

Figure 15. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

3. TEICHERT – REIFF POND

3. TEICHERT – REIFF POND *(Tables 16-23, Figures 16-23)*

This pond is the largest of the Teichert wet pits. It is located at Teichert's Esparto Facility, just north of Cache Creek and west of Highway 505, between 505 and County Road 87. Reiff is a square-shaped pond that is approximately half a kilometer on a side. Depths ranged from 0-2 m shallows along the margins to a deeper central area approximately 7 m (23 feet) deep. First created in or before 2002, our understanding is that this pond did not have active mining in 2015 or 2016, but did receive plant silt/clay slurry. In 2017, active mining appeared to have been halted at the Esparto Plant in general, stopping the slurry inflows. This (2017) was Year 3 of monitoring.

We sampled the pond during day, twilight, and night conditions with a range of techniques as in prior years. The fish collected are listed in Tables 16 and 17. These included, for large, angling-sized fish, samples of White Catfish (*Ameiurus catus*, 16 taken), Carp (*Cyprinus carpio*, 9 taken) and, for the first time at this pond, Largemouth Bass (*Micropterus salmoides*, 5 taken). White Catfish, as in 2015-2016, were the dominant large fish here. The small fish present were Red Shiners (*Cyprinella lutrensis*, ~2") and juvenile Largemouth Bass. We collected 4 sets of 10 each Red Shiners and 4 sets of 1-2 each young bass, which were sparse at this time.

In total, this added up to 30 large fish muscle samples and 8 young, small fish composites, or 38 separate mercury samples analyzed from the Reiff Pond in the Fall 2017 monitoring. The analytical results from each individual large fish muscle sample and each small fish composite sample can be seen in Tables 16 and 17 and, graphically, in Figures 16 and 17. Then, for each large and small fish species taken, the new data are shown in reduced form (means, error bars, etc.) and compared to 2015-2016 results and the most closely comparable historic creek data (Tables 18-23, Figures 18-23).

Large, Angling-sized Fish

White Catfish

The White Catfish samples had fillet muscle mercury ranging from 0.769-1.978 ppm, averaging 1.287 ppm. This was up from 2016 (0.996 ppm) and 2015 (0.737 ppm). The increase was statistically significant over 2015. As discussed earlier for the Cemex – Phase 1 Pond, the apparent increases seen in Reiff Pond fish mercury between 2015 and 2017 may be linked to similar changes in mining operations across that period. Relative to comparative creek samples, the Reiff Pond White Catfish remained significantly higher (5-7 times higher) in mercury than the available baseline/historic samples. As noted earlier for the Cemex – Phase 1 catfish, the relatively small physical size of the available comparison catfish from Cache Creek makes comparison problematic. However, these Reiff Pond catfish mercury levels are very high under any interpretation.

Carp

It was possible to sample a more extensive set of Carp in 2017, with 9 fish analyzed. Carp fillet muscle mercury ranged from 0.623-2.072 ppm, averaging 1.122 ppm. This was up from 2016 (0.854 ppm) and about triple the 2015 average (0.351 ppm). With the high variability in 2016-2017 and small number of samples in 2015, the differences between years cannot be assessed for statistical significance, though an increasing trend is apparent. Comparative samples of this species have not been taken from Cache Creek in the Planning Area, though 5 sets of the trophically similar (similar diet, habit, and mercury accumulation) Sacramento Sucker have, between 1997 and 2011. The 2017 Reiff Pond Carp were significantly higher in mercury than all 5 historic creek data sets. We should note, however, that the Reiff Pond Carp were considerably larger and older, averaging about 425 mm (17") and 950 g (2.1 pounds) in 2015-2016, than the Sacramento Sucker samples from the Creek, which averaged 304 mm (12") and 208 g (0.5 pound). The 2017 samples were larger still, averaging 481 mm (19") and 1,499 g (3.3 pounds)

Largemouth Bass

For the first time, bass were found in the Reiff Pond, present in the (young) 70-200 mm range (3-8"). Five fish were sampled toward the upper end of this range. They had extremely high mercury levels for such young, small fish, at 1.474-1.883 ppm, averaging 1.679 ppm. This was significantly higher than all the baseline/historic comparative creek levels.

Small, Young Fish

Mosquitofish

Mosquitofish could not be located or collected from Reiff Pond in 2017. This may have been directly linked to the new presence of Largemouth Bass, which likely prey heavily on them. Data from 2015 and 2016 are presented for the record.

Red Shiner

The Red Shiner multiple-fish composites had whole-body mercury ranging from 0.523-0.867 ppm, averaging 0.695 ppm. This was significantly higher, relative to similar-sized fish collected in 2016 (0.412 ppm), which were significantly higher than similar 2015 fish (0.152 ppm). Like the Mosquitofish historic trend (Fig. 21), the Reiff Pond Red Shiner samples initially (2015) averaged similar or lower mercury than the 6 historic/baseline sample sets from the creek (0.123-0.242 ppm), statistically lower than the River Mile 28 data set. In contrast, the 2016 average was significantly higher than 5 of 6 comparable Cache Creek sample sets, and the recent 2017 fish were significantly higher than all historic creek comparisons.

Juvenile Largemouth Bass

The juvenile bass samples had whole-body mercury ranging from 0.536-0.977 ppm, averaging 0.798 ppm. Like the larger bass analyzed for fillet muscle mercury, these are very high concentrations. Relative to baseline juvenile bass comparison data from Cache Creek, they are significantly higher than the two sample sets available: River Mile 28 (0.142 ppm) and River Mile 15 (0.050 ppm). The pond samples were considerably larger, averaging 137 mm (5.4") and 32 g, than the creek samples, which averaged 84 mm (3.3") and 8 g. But this is not enough to compensate for the 5-16 fold higher mercury levels seen in the pond.

Summary

In summary, the Teichert – Reiff Pond showed a continuing increase in fish mercury in all sample types that had comparative data from 2015, 2016, and 2017 (White Catfish, Carp, and Red Shiner). First-time collections of juvenile and young adult Largemouth Bass had very high mercury levels in 2017. Relative to available creek comparison data, the 2017 Reiff Pond fish mercury levels were significantly higher than all historic baseline data for all species sampled: White Catfish, Carp, Red Shiner, and both juvenile and adult Largemouth Bass. Like the events noted for the Cemex – Phase 1 Pond, there was a similar change in operations at the Reiff Pond across the years monitored, with plant slurry inflows lessening and then stopping in 2017. We believe it is very likely that the steady increase in fish mercury seen at Reiff Pond was linked, at least in part, to these changes. Mining may eventually resume at the Esparto facility where Reiff and Mast Ponds are located; current Teichert operations have been focused on the downstream Woodland plant area. As this pond was found to be "elevated for two or more consecutive years", that triggered consideration of mercury remediation. The first stage of remediation is to obtain additional water quality information, through seasonal water column profiling of a range of relevant constituents, and characterize bottom sediment mercury. This work was initiated in 2018.

Table A3, below, summarizes the statistical comparisons between Reiff Pond fish and corresponding Cache Creek samples, for the data sets with sufficient numbers of fish to compare statistically.

Table A3. Teichert – Reiff Pond Fish Mercury: Statistical comparisons
(for sample sets with enough fish to compare statistically; 95% confidence level)

< *Pond fish were significantly lower in mercury than at the baseline site*
> *Pond fish were significantly higher in mercury than at the baseline site*
= *Pond fish were not significantly different than at the baseline site*

Fish Species		*vs* *Same Site 2016 , 2015*	**RM28 2011**	RM20 2000	RM17 00-02	RM15 1997	RM15 00-02	**RM15 2011**
			– vs Baseline and Historic Comparable Cache Creek Data Sets –					
Large fish fillet muscle mercury								
White Catfish	**2015**		>					
	2016	=	>					
	2017	= , >						
Largemouth Bass	**2017**		>	>				>
Small, young fish whole body, composite mercury								
Mosquitofish	**2015**				<		=	=
	2016	>			=		>	>
	2017	*na*						
Red Shiner	**2015**		<	=	=	=	=	
	2016	>	>	>	=	>	>	
	2017	> , >	>	>	>	>	>	
Largemouth Bass	**2017**		>					>

Table 16. Teichert – Reiff Pond: Large fish sampled, Fall 2017

Fish Species	Fish Total Length (mm)	(inches)	Fish Weight (g)	(lbs)	Muscle Mercury (µg/g = ppm, wet wt)
White Catfish	272	10.7	220	0.5	**1.648**
White Catfish	290	11.4	295	0.7	**1.941**
White Catfish	300	11.8	355	0.8	**1.069**
White Catfish	307	12.1	380	0.8	**1.405**
White Catfish	320	12.6	385	0.8	**1.978**
White Catfish	327	12.9	460	1.0	**0.791**
White Catfish	347	13.7	610	1.3	**1.236**
White Catfish	353	13.9	635	1.4	**1.334**
White Catfish	359	14.1	695	1.5	**1.402**
White Catfish	359	14.1	820	1.8	**1.042**
White Catfish	377	14.8	805	1.8	**0.887**
White Catfish	390	15.4	860	1.9	**1.424**
White Catfish	401	15.8	995	2.2	**0.769**
White Catfish	417	16.4	990	2.2	**1.039**
White Catfish	432	17.0	1,110	2.4	**1.556**
White Catfish	434	17.1	1,220	2.7	**1.072**
Carp	401	15.8	870	1.9	**0.623**
Carp	425	16.7	1,020	2.2	**0.837**
Carp	455	17.9	1,150	2.5	**0.885**
Carp	457	18.0	1,240	2.7	**1.195**
Carp	466	18.3	1,320	2.9	**1.260**
Carp	512	20.2	1,480	3.3	**1.141**
Carp	524	20.6	1,930	4.3	**0.861**
Carp	537	21.1	2,220	4.9	**1.228**
Carp	548	21.6	2,260	5.0	**2.072**
Largemouth Bass	184	7.2	72	0.2	**1.696**
Largemouth Bass	187	7.4	70	0.2	**1.684**
Largemouth Bass	187	7.4	78	0.2	**1.474**
Largemouth Bass	193	7.6	85	0.2	**1.660**
Largemouth Bass	193	7.6	85	0.2	**1.883**

Table 17. Teichert – Reiff Pond: Small Fish Sampled, Fall 2017
(multi-individual, whole body composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Fish Species	n (indivs. in comp)	Av. Fish Length (mm)	(inches)	Av. Fish Weight (g)	(oz)	Whole-Body Mercury (µg/g = ppm, wet wt)
Largemouth Bass (juv)	**1**	126	5.0	23.9	0.84	**0.536**
Largemouth Bass (juv)	**1**	131	5.2	26.2	0.92	**0.977**
Largemouth Bass (juv)	**1**	135	5.3	29.5	1.04	**0.873**
Largemouth Bass (juv)	**2**	157	6.2	48.2	1.70	**0.806**
Red Shiner	**10**	43	1.7	0.7	0.02	**0.523**
Red Shiner	**10**	48	1.9	1.1	0.04	**0.682**
Red Shiner	**10**	52	2.0	1.2	0.04	**0.710**
Red Shiner	**10**	56	2.2	1.5	0.05	**0.867**

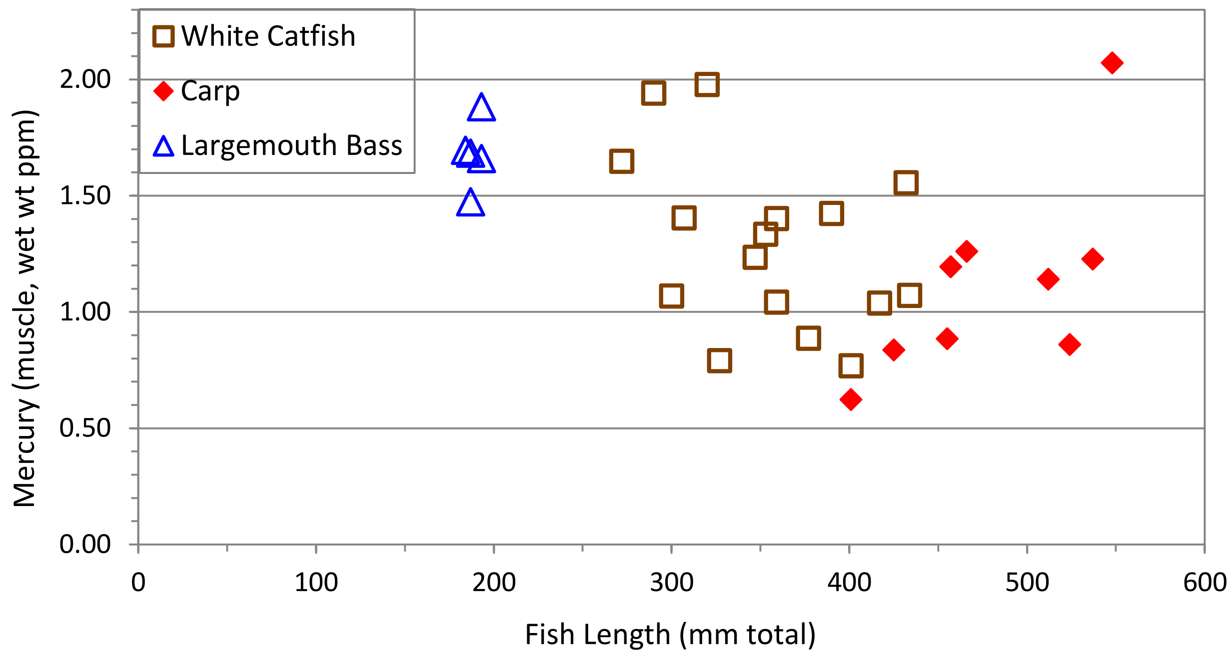

Figure 16. Teichert – Reiff Pond: large fish sampled, Fall 2017
(fillet muscle mercury in individual fish)

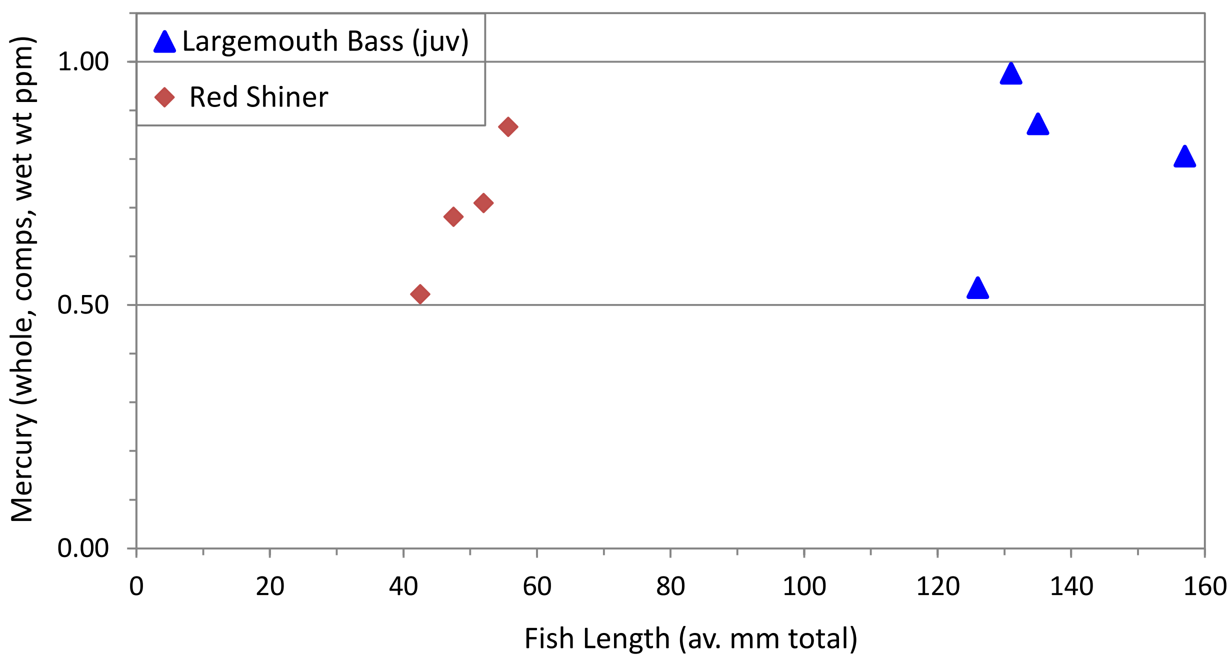

Figure 17. Teichert – Reiff Pond: small, young fish sampled, Fall 2017
(mercury in whole-body, multi-individual composite samples)

Table 18. White Catfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
White Catfish						
Teichert – Reiff	2015	**20**	347	658	**0.737**	± 0.156
Teichert – Reiff	2016	**20**	297	341	**0.996**	± 0.153
Teichert – Reiff	2017	**16**	355	677	**1.287**	± 0.197
Historic/Baseline Data						
Channel Catfish						
Rumsey	2000	1	411	565	0.225	
River Mile 28	**2011**	**5**	**239**	**102**	**0.229**	**± 0.102**
River Mile 20	2000	1	368	380	0.225	
River Mile 03	1997	10	336	304	0.174	± 0.019

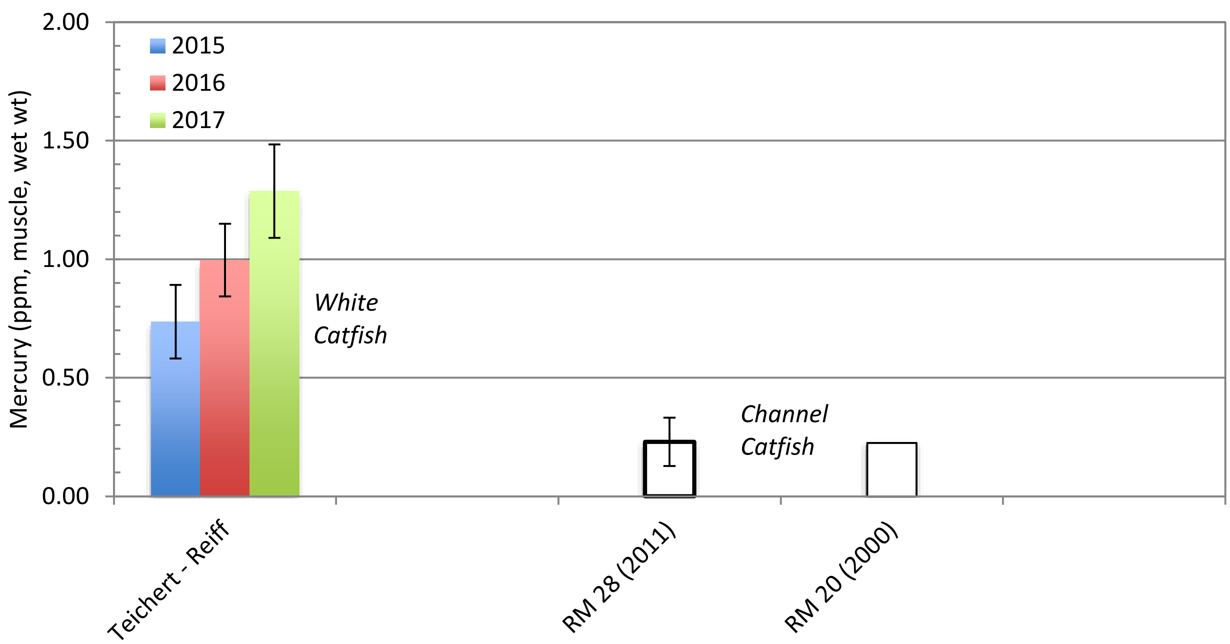

Figure 18. White Catfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Table 19. Carp summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Carp						
Teichert – Reiff	2015	**2**	421	918	**0.351**	
Teichert – Reiff	2016	**5**	430	975	**0.854**	± 0.387
Teichert – Reiff	2017	**9**	481	1,499	**1.122**	± 0.321
Historic/Baseline Data (most comparable species available)						
Sacramento Sucker						
Rumsey	2000	6	328	396	0.198	± 0.113
River Mile 20	2000	5	253	174	0.154	± 0.034
River Mile 15	**2011**	**8**	**276**	**231**	**0.143**	**± 0.011**
River Mile 08	2000	4	319	336	0.339	
River Mile 03	1997	5	343	402	0.263	± 0.068

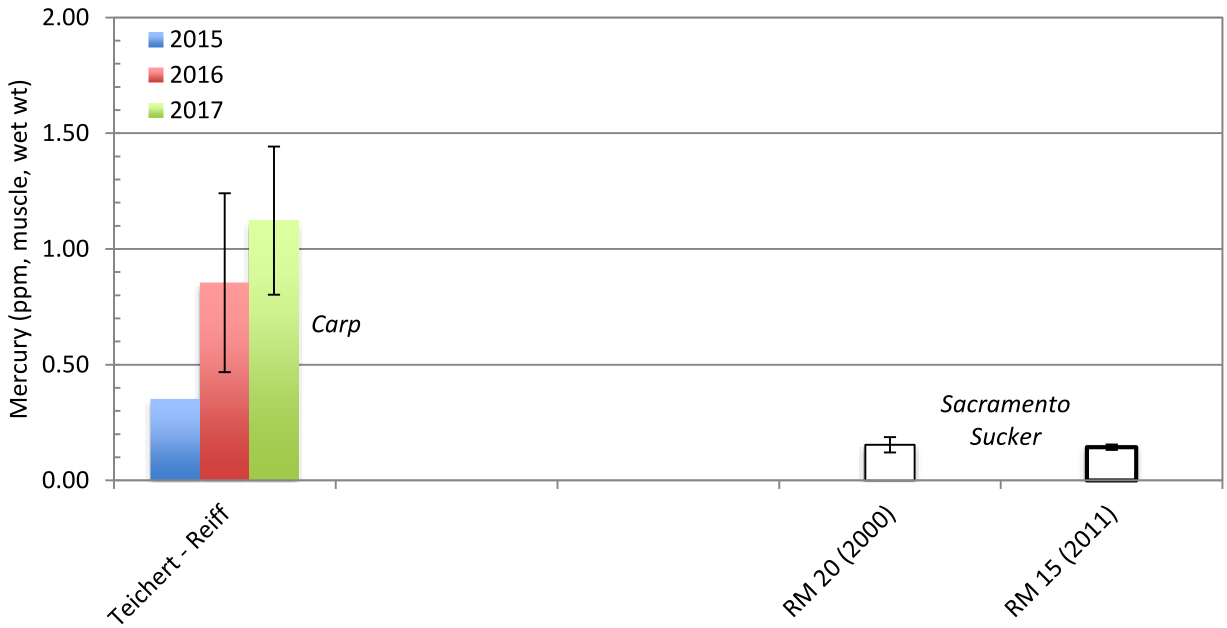

Figure 19. Carp summary data, and historic creek comparisons

Table 20. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Teichert – Reiff	2016	–	–	–	–	
Teichert – Reiff	2017	5	189	78	1.679	± 0.180
Historic/Baseline Data (comparable predatory species)						
Largemouth Bass						
River Mile 28	**2011**	**9**	**199**	**137**	**0.663**	**± 0.116**
Smallmouth Bass						
River Mile 28	**2011**	**7**	**265**	**326**	**0.782**	**± 0.188**
River Mile 20	2000	7	234	183	0.444	± 0.061
River Mile 15	1997	2	383	780	0.939	
Sacramento Pikeminnow						
River Mile 28	**2011**	**10**	**311**	**262**	**0.726**	**± 0.102**
River Mile 20	2000	8	269	147	0.509	± 0.204
River Mile 15	**2011**	**9**	**264**	**145**	**0.327**	**± 0.066**

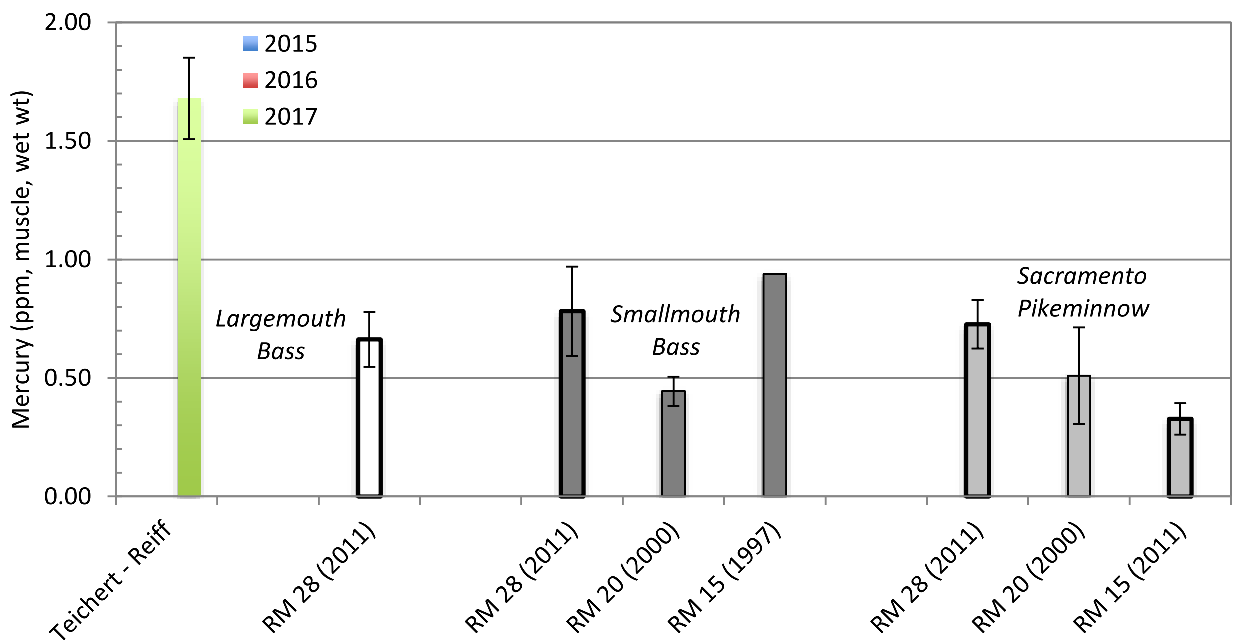

Figure 20. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Small, Young Fish Samples *(note lower concentration scales)*

Table 21. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	**n** (comps)	**n** (inds/ (comp)	**Av Lgth** (mm total)	**Av Wt** (grams)	**Hg** (µg/g = ppm, wet wt)	**Std. Dev.**
Mosquitofish							
Teichert – Reiff	2015	**4**	12	38	0.6	**0.094**	± 0.010
Teichert – Reiff	2016	**4**	10	36	0.5	**0.212**	± 0.041
Teichert – Reiff	2017	–	–	–	–	–	
Historic/Baseline Data							
River Mile 17	2000-2002	13	5-30	26-47	0.2-1.1	0.172	± 0.048
River Mile 15	2000-2002	10	5-30	26-47	0.2-1.0	0.094	± 0.029
River Mile 15	**2011**	**4**	**1-10**	**37**	**0.7**	**0.103**	**± 0.048**

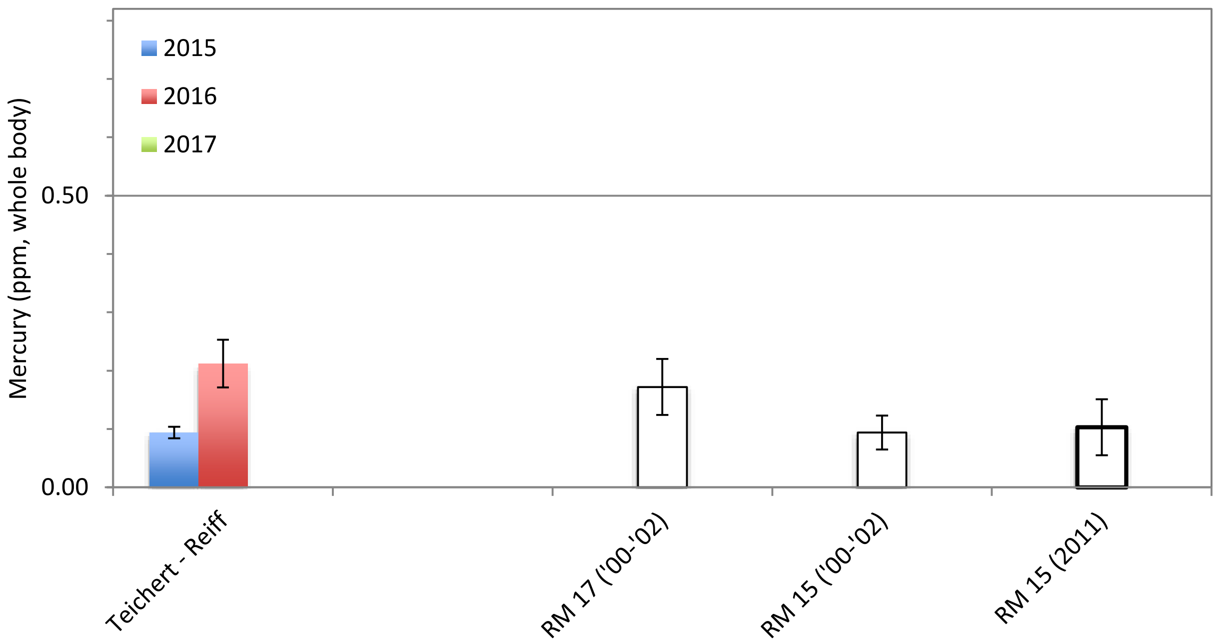

Figure 21. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 22. Red Shiner summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	**Year**	**n** (comps)	**n** (inds/ (comp)	**Av Lgth** (mm total)	**Av Wt** (grams)	**Hg** (µg/g = ppm, wet wt)	**Std. Dev.**
Red Shiners							
Teichert – Reiff	2015	**4**	10	50	1.3	**0.152**	± 0.018
Teichert – Reiff	2016	**4**	10	47	1.1	**0.412**	± 0.084
Teichert – Reiff	2017	**4**	10	49	1.1	**0.695**	± 0.141
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**10**	**48**	**1.0**	**0.242**	**± 0.036**
River Mile 20	2000	3	9	42	0.6	0.166	± 0.003
River Mile 17	2000-2002	11	6-15	27-58	0.2-1.8	0.225	± 0.086
River Mile 15	1997	3	19	37	0.5	0.159	± 0.024
River Mile 15	2000-2002	13	6-12	30-60	0.2-2.0	0.131	± 0.033
River Mile 08	2000	4	10	42	0.7	0.123	± 0.016

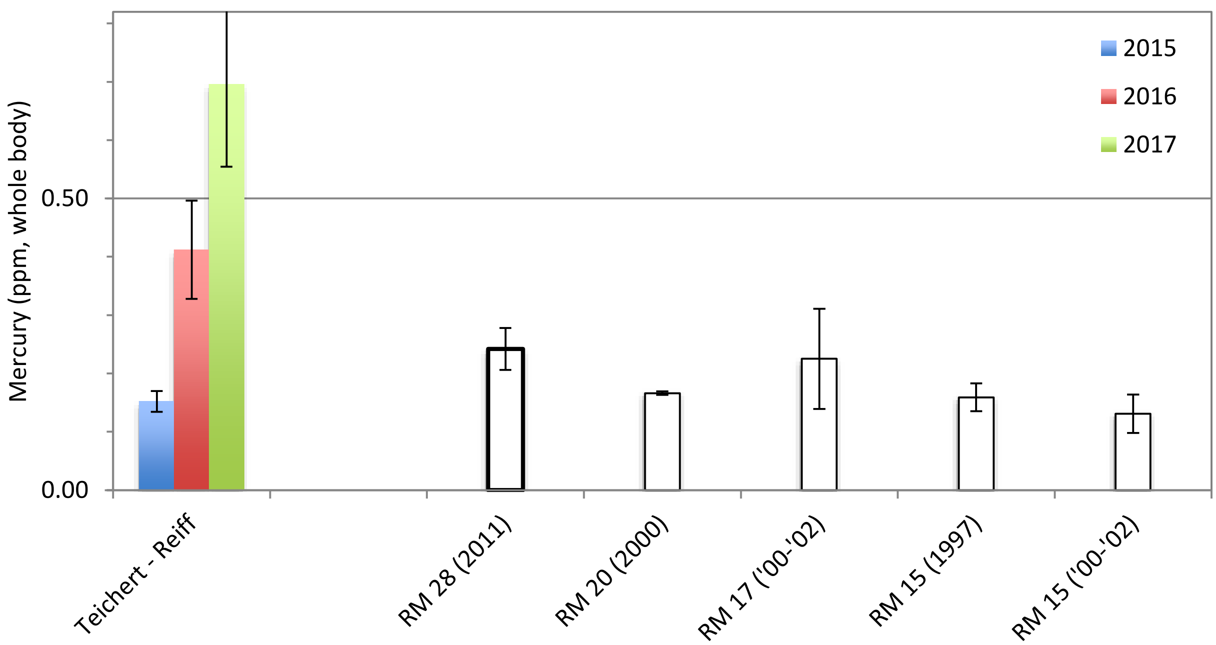

Figure 22. Red Shiner summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 23. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Largemouth Bass (juveniles)							
Teichert – Reiff	2015	–	–	–	–	–	–
Teichert – Reiff	2016	–	–	–	–	–	–
Teichert – Reiff	2016	**4**	10	36	–	**0.212**	± 0.041
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**3-5**	**75**	**6**	**0.142**	**± 0.026**
River Mile 15	**2011**	**3**	**1**	**93**	**10**	**0.050**	**± 0.024**

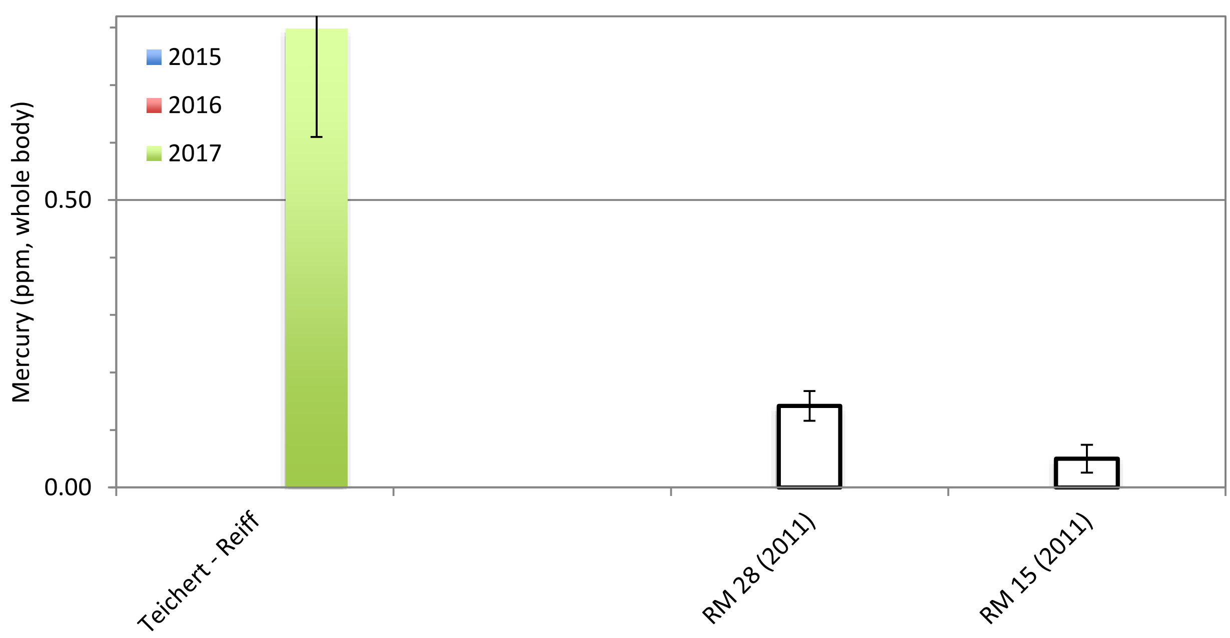

Figure 23. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

4. TEICHERT – MAST POND

4. TEICHERT – MAST POND *(Tables 24-25, Figures 24-25)*

The Mast Pond is located at Teichert's Esparto Facility, just north of Cache Creek and west of Highway 505 between 505 and County Road 87. It is near the Reiff pond, which is northwest of Mast. Mast Pond, at the time of sampling in Fall 2017, was separated into two basins. The northwest basin was an elongated oval approximately 425 m long and 150 m wide. The southeast basin was an irregular shape approximately 400 m by 400 m. Depths were not measured but appeared to be similar to the Reiff Pond, to about 9 m (30 feet). This pond was first created in or before 2002 along with Reiff. It was the site of extensive active mining in 2015 and 2016, which was apparently halted in 2017. In 2017, active mining was halted at the Esparto Plant in general, with Teichert's focus shifting to the downstream Woodland Plant area. This (2017) was Year 1 of monitoring for the Teichert – Mast Pond.

We sampled both basins of the pond with a range of techniques, but were unable to locate or collect large fish in 2017. They may not be present. Extensive seining yielded just one species of small fish, Mosquitofish, present in high densities. As these were the only samples available, we collected full sets (4 composites of 10 fish each) from each of the two basins. The Mosquitofish collected are listed in Table 24.

In total this added up to 8 young, small fish composite mercury samples analyzed from the Mast Pond in the Fall 2017 monitoring. The analytical results from each small fish composite sample can be seen in Table 24 and, graphically, in Figure 24. Then the data are shown in reduced form (means, error bars, etc.) and compared the most closely comparable historic creek data (Table 25, Figure 25).

Small, Young Fish

Mosquitofish

The Mosquitofish multiple-fish composites, overall across both Mast basins, had whole-body mercury ranging from 0.181-0.579 ppm, averaging 0.312 ppm. Fish from the northwest basin ranged from 0.244-0.579 ppm, averaging 0.351 ppm. Fish from the southeast basin were slightly lower, ranging from 0.181-0.412 ppm, and averaging 0.273 ppm. The difference was not significant statistically. The 2017 Mast Pond samples averaged higher mercury than the 3 historic sample sets from the creek (0.094-0.172 ppm), statistically higher than the two River Mile 15 data sets.

Summary

With only one species collected and one year of sampling, conclusions are limited for this pond. Relative to baseline Cache Creek mosquitofish samples, they were significantly higher than the two River Mile 15 comparisons and statistically similar to historic samples from River Mile 17. Relative to other off-channel aggregate mining ponds monitored in this program, Mast Mosquitofish mercury levels were higher than those seen in adjacent Reiff Pond in 2015-2016, and were similar to levels in the other two elevated-mercury ponds, Cemex – Phase 3-4 and Syar – B1.

Table A4, below, summarizes the statistical comparisons between Mast Pond Mosquitofish and corresponding Cache Creek baseline samples.

Table A4. Teichert – Mast Pond Fish Mercury: Statistical comparisons
(for sample sets with enough fish to compare statistically; 95% confidence level)

< *Pond fish were significantly lower in mercury than at the baseline site*
> *Pond fish were significantly higher in mercury than at the baseline site*
= *Pond fish were not significantly different than at the baseline site*

Fish Species		***vs Same Site 2016***	*– vs Baseline and Historic Comparable Cache Creek Data Sets –* RM17 00-02	RM15 00-02	**RM15 2011**
Small, young fish whole body, composite mercury					
Mosquitofish	**2016**	(no data)			
	2017		=	>	>

Table 24. Teichert – Mast Pond: Small Fish Sampled, Fall 2017
(multi-individual, whole body composite samples)
'**n**' = *number: number of individual fish per composite*

Fish Species	**n** (indivs. in comp)	**Av. Fish Length** (mm)	(inches)	**Av. Fish Weight** (g)	(oz)	**Whole-Body Mercury** (µg/g = ppm, wet wt)
Northwest Basin						
Mosquitofish	**10**	27	1.1	0.2	0.01	**0.244**
Mosquitofish	**10**	33	1.3	0.4	0.01	**0.273**
Mosquitofish	**10**	38	1.5	0.6	0.02	**0.307**
Mosquitofish	**10**	43	1.7	0.9	0.03	**0.579**
Southeast Basin						
Mosquitofish	**10**	28	1.1	0.2	0.01	**0.181**
Mosquitofish	**10**	33	1.3	0.3	0.01	**0.185**
Mosquitofish	**10**	37	1.5	0.6	0.02	**0.313**
Mosquitofish	**10**	43	1.7	0.8	0.03	**0.412**

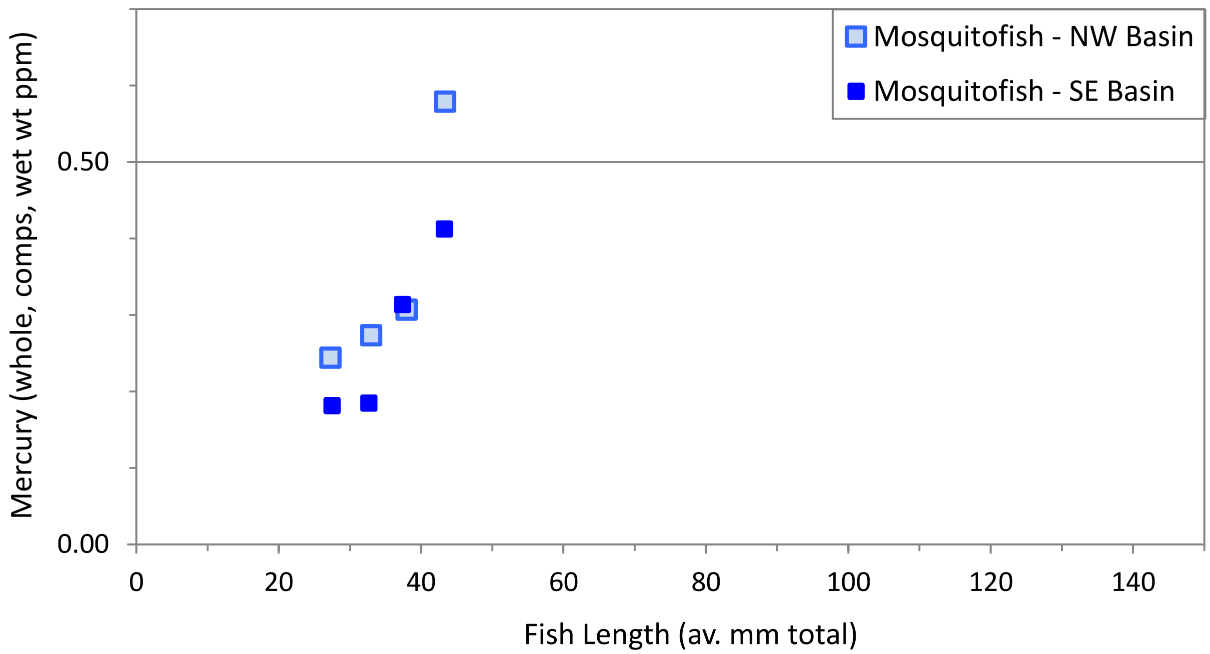

Figure 24. Teichert – Mast Pond: Small Fish Sampled, Fall 2017
(mercury in whole-body, multi-individual composite samples)

Table 25. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	**Year**	**n** (comps)	**n** (inds/ (comp)	**Av Lgth** (mm total)	**Av Wt** (grams)	**Hg** (µg/g = ppm, wet wt)	**Std. Dev.**
Mosquitofish							
Teichert – Mast (NW)	2017	4	10	35	0.5	0.351	± 0.154
Teichert – Mast (SE)	2017	4	10	35	0.5	0.273	± 0.111
Teichert – Mast (ALL)	2017	8	10	35	0.5	0.312	± 0.231
Historic/Baseline Data							
River Mile 17	2000-2002	13	5-30	26-47	0.2-1.1	0.172	± 0.048
River Mile 15	2000-2002	10	5-30	26-47	0.2-1.0	0.094	± 0.029
River Mile 15	**2011**	**4**	**1-10**	**37**	**0.7**	**0.103**	**± 0.048**

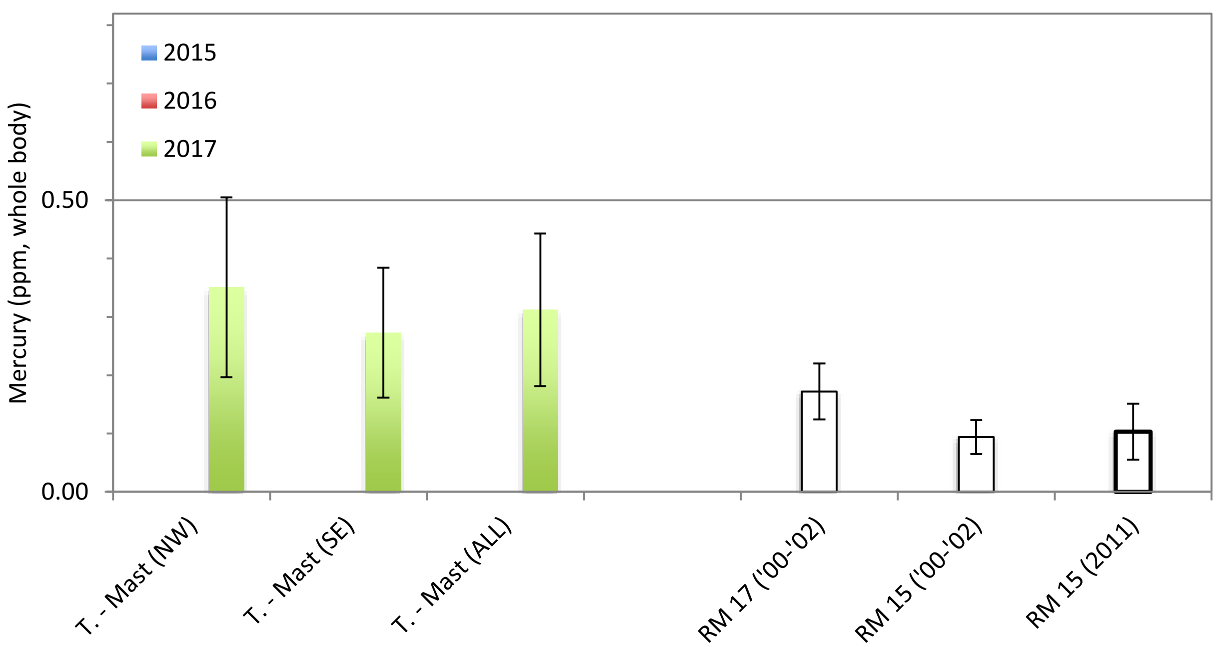

Figure 25. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

5. TEICHERT – STORZ POND

5. TEICHERT – STORZ POND *(Tables 26-30, Figures 26-30)*

This pond is part of the Teichert–Woodland operations, located approximately 7 river miles downstream from the Reiff and Mast Ponds and Teichert–Esparto Plant. The Storz Pond is south of Cache Creek and just west of County Road 94b, near the Cache Creek Nature Preserve (which is located on the other, north, side of the creek). Our understanding is that it first become a wet pit in 2010-2011. Depths in 2017 were shallow, ranging to approximately 6 m (20'). Storz consists of 2 sub-basins that alternate between being connected and split, depending on runoff inputs. In Fall 2017, they were recently separated, after having been connected during higher water levels earlier in the season. Together, they are approximately 150 m x 800 m in size.

We began sampling this pond in 2016, but were unable to get our boat in at that time. By shore seining, we collected a good sample of Mosquitofish, (*Gambusia affinis*, 1-2") in 2016, but no additional species. In 2017, we were able to get our boat into the pond and sample more completely, making 2017 Year 1 of full sampling here. This time, in addition to Mosquitofish, we collected Largemouth Bass (*Micropterus salmoides*). Bass were present in the 130-275 mm (5-11") size range. Twenty of the larger fish were sampled for fillet muscle mercury and the 4 smallest were analyzed whole-body, comparable to other small fish samples. Mosquitofish were again sampled with 4 size-class composites of 8-10 fish each.

In total, 20 large fish muscle samples and 8 young, small fish composite samples, or 28 separate mercury samples, were analyzed from the Teichert – Storz Pond in the Fall 2017 monitoring. The fish metrics and analytical results from each of the bass muscle and small fish composite samples are shown in Tables 26-27 and, graphically, in Figures 26-27. The data are shown in reduced form (means, error bars) and compared to the most closely comparable historic creek data in Tables 28-30 and Figures 28-30.

Large, Angling-sized Fish

Largemouth Bass

Accessing the pond by boat for the first time, we were able to collect bass in 2017. Twenty fish were sampled across the fairly small size range present at that time (211-273 mm or 8-11"). Fillet muscle mercury ranged between 0.541 and 0.864 ppm, averaging 0.657 ppm. Relative to historic baseline creek comparison samples, this was lower than or similar to 5 of 7 sets and significantly higher than 2. Compared to other aggregate mining ponds being monitored at this time, it was the second lowest in bass mercury of the 6 ponds that contained bass.

Small, Young Fish

Mosquitofish

The Mosquitofish multiple-fish composites had whole-body mercury ranging from 0.268-0.314 ppm, averaging 0.282 ppm. This was higher than the 2016 samples, which averaged 0.229 ppm, but the difference was not significant. The 2017 samples were less variable with size. As compared to baseline creek samples, the 2017 Storz Pond Mosquitofish were significantly higher in mercury than the 3 creek sample sets, which averaged 0.094-0.172 ppm.

Juvenile Largemouth Bass

The juvenile bass samples had whole-body mercury ranging from 0.254-0.390 ppm, averaging 0.337 ppm. Relative to baseline juvenile bass comparison data from Cache Creek, this was significantly higher than the two sample sets available: River Mile 28 (0.142 ppm) and River Mile 15 (0.050 ppm). As noted for Reiff Pond, the Storz juvenile bass samples were considerably larger (averaging 143 mm and 35 g) than the available creek samples (averaging 84 mm and 8 g). Smaller, younger samples, if available in the pond, could be expected to contain lower mercury levels more consistent with the creek comparison data.

Summary

The first year of full monitoring at Storz Pond gave mixed results. The primary, large fish sample of bass had mercury within the historic range of baseline creek fish. It was second lowest of the 6 monitored ponds that contained bass. The smaller bass that were analyzed as juveniles had significantly higher levels than creek comparisons, but the larger size of the Storz samples may partly or entirely explain that difference. The Mosquitofish composite samples were significantly higher than creek comparison samples, with similar sized fish. Next year, with two full years of data, we will be in a better position to characterize mercury levels here and advise on future steps.

Table A5, below, summarizes the statistical comparisons between the Storz Pond fish and comparable Cache Creek samples, for the data sets with sufficient numbers of fish to compare statistically. The '=' signs indicate 'not statistically differentiable', rather than necessarily identical concentrations.

Table A5. Teichert – Storz Pond Fish Mercury: Statistical comparisons
(for sample sets with enough fish to compare statistically; 95% confidence level)

< *Pond fish were significantly lower in mercury than at the baseline site*
\> *Pond fish were significantly higher in mercury than at the baseline site*
= *Pond fish were not significantly different than at the baseline site*

Fish Species		*vs* *Same Site 2016*	*– vs Baseline and Historic Comparable Cache Creek Data Sets –* **RM28 2011**	RM20 2000	RM17 00-02	RM15 00-02	**RM15 2011**
Large fish fillet muscle mercury							
Largemouth Bass	**2016**	*(not sampled)*					
	2017		=, =, =	>, =			>
Small, young fish whole body, composite mercury							
Mosquitofish	**2016**				=	>	>
	2017	=			>	>	>
Largemouth Bass	**2016**	*(not sampled)*					
	2017		>				>

Table 26. Teichert – Storz Pond: Large fish sampled, Fall 2017

Fish Species	Fish Total Length (mm)	(inches)	Fish Weight (g)	(lbs)	Muscle Mercury (µg/g = ppm, wet wt)
Largemouth Bass	211	8.3	122	0.3	**0.864**
Largemouth Bass	212	8.3	127	0.3	**0.635**
Largemouth Bass	216	8.5	128	0.3	**0.690**
Largemouth Bass	218	8.6	133	0.3	**0.751**
Largemouth Bass	225	8.9	145	0.3	**0.788**
Largemouth Bass	230	9.1	138	0.3	**0.557**
Largemouth Bass	232	9.1	152	0.3	**0.611**
Largemouth Bass	241	9.5	188	0.4	**0.680**
Largemouth Bass	243	9.6	180	0.4	**0.630**
Largemouth Bass	247	9.7	215	0.5	**0.700**
Largemouth Bass	250	9.8	200	0.4	**0.541**
Largemouth Bass	252	9.9	210	0.5	**0.705**
Largemouth Bass	258	10.2	232	0.5	**0.659**
Largemouth Bass	262	10.3	255	0.6	**0.586**
Largemouth Bass	265	10.4	265	0.6	**0.605**
Largemouth Bass	266	10.5	240	0.5	**0.642**
Largemouth Bass	268	10.6	285	0.6	**0.552**
Largemouth Bass	269	10.6	265	0.6	**0.623**
Largemouth Bass	269	10.6	283	0.6	**0.620**
Largemouth Bass	273	10.7	295	0.7	**0.699**

Table 27. Teichert – Storz Pond: Small Fish Sampled, Fall 2017
(multi-individual, whole body composite samples)
'**n**' = *number: number of individual fish per composite*

Fish Species	**n** (indivs. in comp)	Av. Fish Length (mm)	(inches)	Av. Fish Weight (g)	(oz)	Whole-Body Mercury (µg/g = ppm, wet wt)
Mosquitofish	**10**	27	1.0	0.2	0.01	**0.277**
Mosquitofish	**10**	28	1.1	0.2	0.01	**0.268**
Mosquitofish	**10**	30	1.2	0.2	0.01	**0.314**
Mosquitofish	**8**	33	1.3	0.3	0.01	**0.269**
Largemouth Bass (juv)	**1**	137	5.4	29.5	1.04	**0.336**
Largemouth Bass (juv)	**1**	138	5.4	30.4	1.07	**0.366**
Largemouth Bass (juv)	**1**	147	5.8	40.1	1.42	**0.254**
Largemouth Bass (juv)	**1**	150	5.9	38.8	1.37	**0.390**

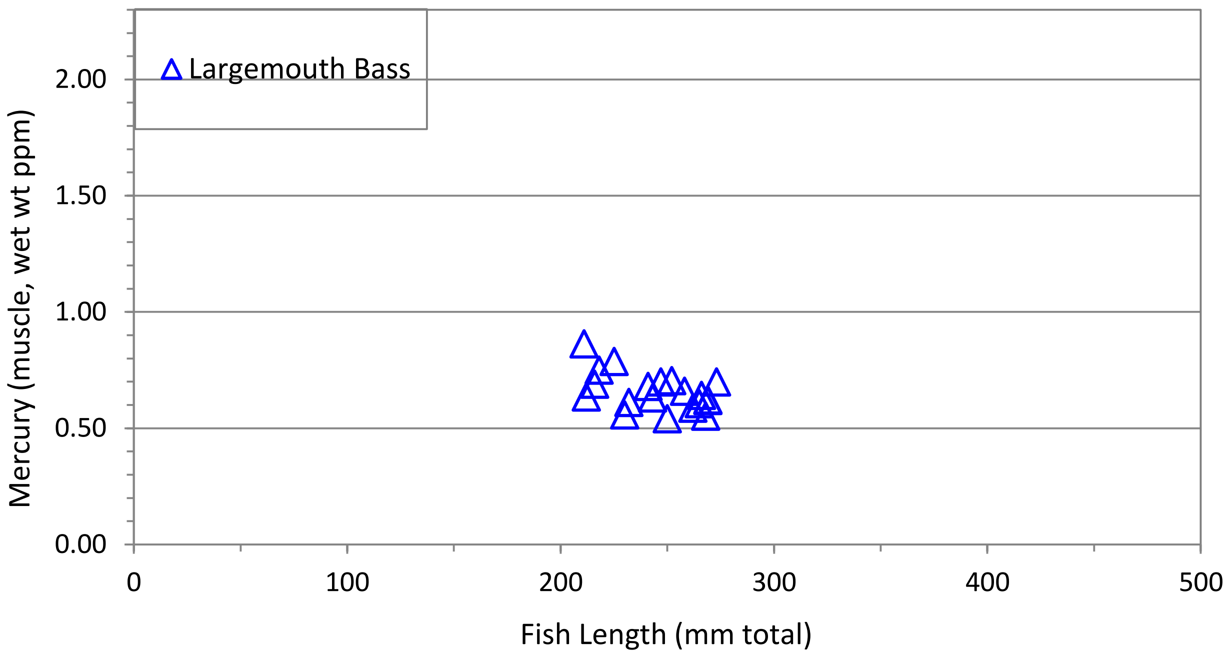

Figure 26. Teichert – Storz Pond: Large Fish Sampled, Fall 2017
(mean fillet muscle mercury, with 95% confidence intervals)

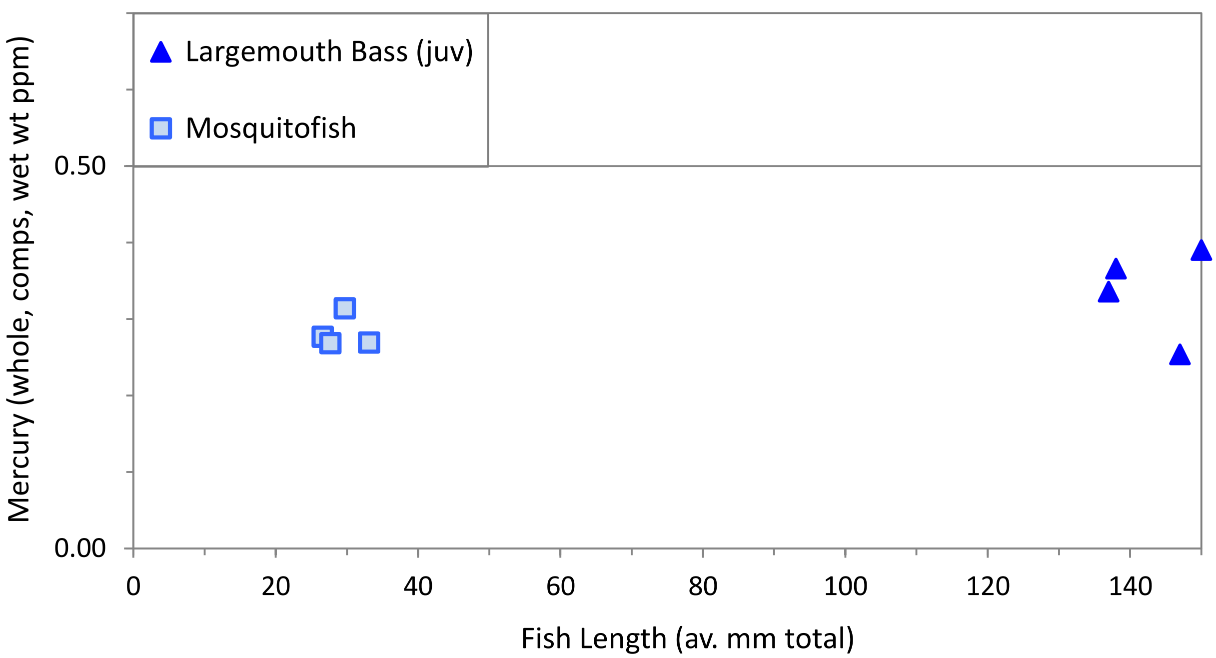

Figure 27. Teichert – Storz Pond: Small Fish Sampled, Fall 2017
(mercury in whole-body, multi-individual composite samples)

Table 28. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Teichert – Storz	2016	–	–	–	–	
Teichert – Storz	2017	**20**	245	203	**0.657**	± 0.038
Historic/Baseline Data (comparable predatory species)						
Largemouth Bass						
River Mile 28	**2011**	**9**	**199**	**137**	**0.663**	**± 0.116**
Smallmouth Bass						
River Mile 28	**2011**	**7**	**265**	**326**	**0.782**	**± 0.188**
River Mile 20	2000	7	234	183	0.444	± 0.061
River Mile 15	1997	2	383	780	0.939	
Sacramento Pikeminnow						
River Mile 28	**2011**	**10**	**311**	**262**	**0.726**	**± 0.102**
River Mile 20	2000	8	269	147	0.509	± 0.204
River Mile 15	**2011**	**9**	**264**	**145**	**0.327**	**± 0.066**

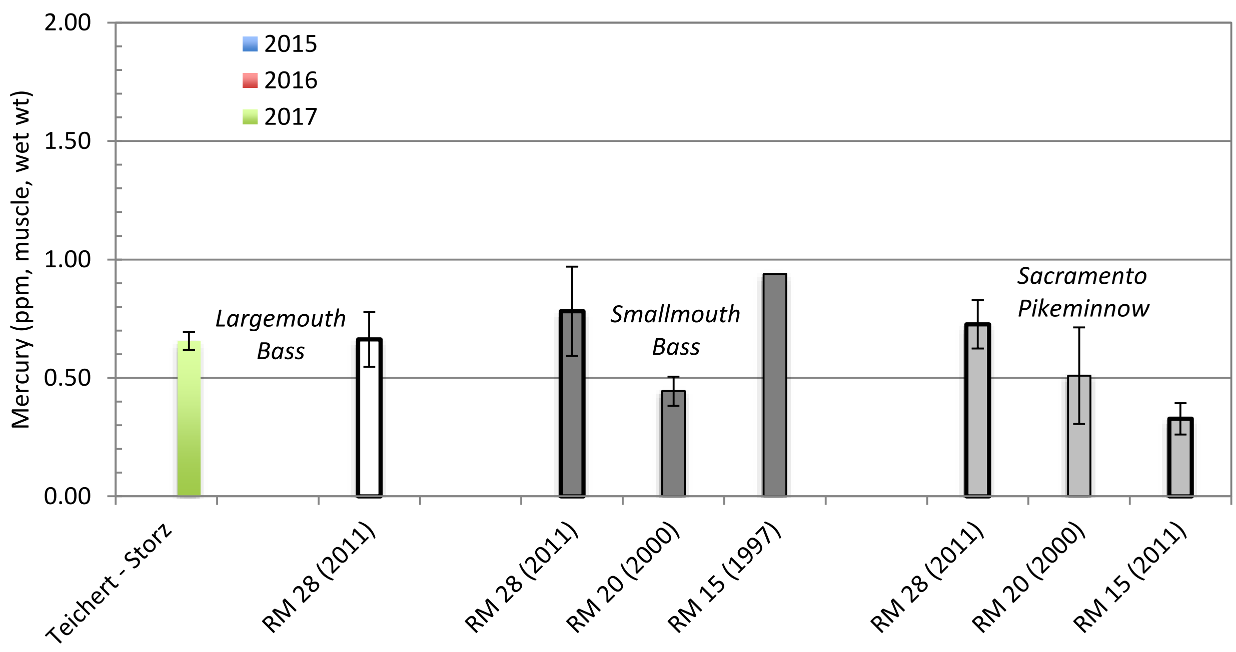

Figure 28. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Small, Young Fish Samples *(note lower concentration scales)*

Table 29. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	**Year**	**n** (comps)	**n** (inds/ (comp)	**Av Lgth** (mm total)	**Av Wt** (grams)	**Hg** (µg/g = ppm, wet wt)	**Std. Dev.**
Mosquitofish							
Teichert – Storz	2016	**4**	10	35	0.5	**0.229**	± 0.109
Teichert – Storz	2017	**4**	8-10	29	0.2	**0.282**	± 0.022
Historic/Baseline Data							
River Mile 17	2000-2002	13	5-30	26-47	0.2-1.1	0.172	± 0.048
River Mile 15	2000-2002	10	5-30	26-47	0.2-1.0	0.094	± 0.029
River Mile 15	**2011**	**4**	**1-10**	**37**	**0.7**	**0.103**	**± 0.048**

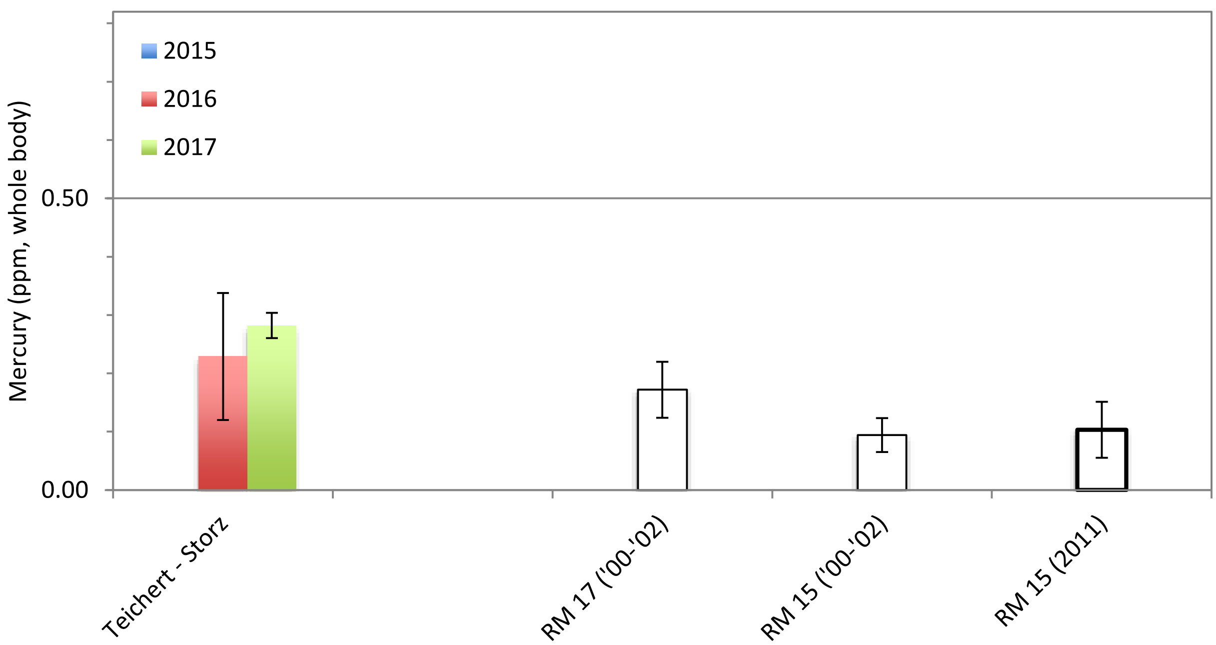

Figure 29. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 30. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Largemouth Bass (juveniles)							
Teichert – Storz	2016	–	–	–	–	–	–
Teichert – Storz	2017	**4**	1	143	35	**0.337**	± 0.059
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**3-5**	**75**	**6**	**0.142**	**± 0.026**
River Mile 15	**2011**	**3**	**1**	**93**	**10**	**0.050**	**± 0.024**

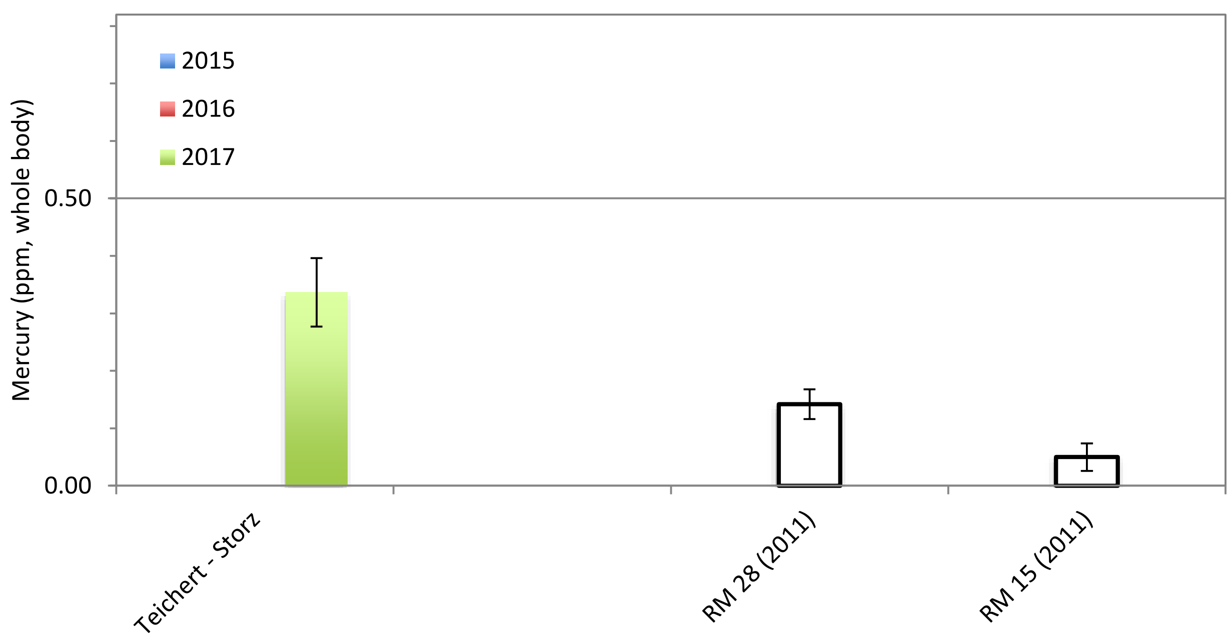

Figure 30. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

6. SYAR – B1 POND

6. SYAR – B1 POND *(Tables 31-37, Figures 31-37)*

The Syar Cache Creek mining operation, begun before 2002, has been idle since 2011 and remained inactive throughout the 3 years it has been monitored (2015-2017). The site is located south of Cache Creek and west of Highway 505, between 505 and County Road 87. There are actually two mid-sized ponds at the site. One has an irregular shape about 500 m long x 75-200 m wide. The other, located to the west, is approximately 300 m x 400 m in size. There is a narrow, shallow, 400 m long channel that can link the two basins under high rainfall, high water level conditions. This was not the case in 2015-2016 and throughout the previous drought years, when the ponds were independent of each other. We were provided access to the eastern pond of the two since 2015, and refer to that as the Syar – B1 Pond. Beginning in 2017, we also sampled the western pond (Syar – West Pond), discussed in the next section. This (2017) was Year 3 of monitoring for the Syar – B1 Pond.

The B1 Pond is located in a steep-sided surrounding depression. Following years of drought conditions, the heavier rainfall inputs of Winter 2017 raised the water level by at least 10 feet, with depths still ranging to about 9 m (30 feet) during the fall sampling.

As at the other sites, we sampled the B1 Pond during day, twilight, and night conditions on multiple days and with a range of techniques. We were able to obtain good samples of most of the fish species present, though some were notably sparser in numbers than in previous years. Fishing pressure has been heavy and obvious at this pond. Following this year's collections, Syar placed a large concrete block in front of the main gate that could only be moved with heavy equipment. This has lowered fishing pressure. The 2017 collections included fillet muscle samples of 16 Largemouth Bass (*Micropterus salmoides*). The small, young fish present were juvenile Largemouth Bass (3-5"), juvenile Green Sunfish (~2") and Mosquitofish (*Gambusia affinis*, 1-2"). We collected only 6 small bass, which were divided into 4 composite samples of 1-2 fish each. The 26 juvenile Green Sunfish taken were put into 4 composite samples of 6-7 fish each. Mosquitofish were sampled with 4 composite samples of 9-10 fish each.

In total, 16 large fish muscle samples and 12 young, small fish composite samples, or 28 separate mercury samples, were analyzed from the Syar – B1 Pond in the Fall 2017 monitoring. The fish metrics and analytical results from each individual large fish muscle sample and each small, young fish composite sample can be seen in Tables 31 and 32 and, graphically, in Figures 31 and 32. Then, for each sample type, the new data are shown in reduced form (means, error bars, etc.) and compared to 2015-2016 results and the most closely comparable historic creek data (Tables 33-37, Figures 33-37).

Large, Angling-sized Fish

Largemouth Bass

The B1 Pond adult Largemouth Bass samples had fillet muscle mercury ranging from 0.434-1.889 ppm, averaging 0.904 ppm. This was down by nearly half from the levels found in 2015-2016, when they averaged 1.628 and 1.640 ppm, which were extremely high fish mercury levels. The observed drop was statistically significant. After previously being significantly higher than all 7 comparable baseline/historic samples from Cache Creek, the 2017 decline in bass mercury concentrations brought the B1 Pond fish into a range statistically similar to 5 of 7 baseline comparisons. The declinining mercury trend was unfortunately confounded by a corresponding decline in fish sizes available in 2017. This was presumably due to fishing pressure removing the largest fish, and may be part of the explanation for the lower levels. In any case, the bass that were present in the pond in Fall 2017 were down substantially in mercury concentrations.

Green Sunfish

Adult Green Sunfish could not be found for collection in 2017. We are including data from previous years in Table 34 and Fig. 34 for completion.

Small, Young Fish

Juvenile Largemouth Bass

The juvenile bass multiple-fish composites had whole-body mercury ranging from 0.233-0.616 ppm, averaging 0.461 ppm. This was down somewhat, relative to samples analyzed in 2016 (0.524 ppm), which was down from 2015 (0.589 ppm). Due to high variability of mercury levels in the 2016 and 2017 samples, the declines were not statistically significant. However, the 2017 fish available for analysis were larger, averaging 18 g, as compared to the 2016 set which averaged only 5 g. If mercury exposure levels were unchanged between the years, these larger fish would be expected to contain higher mercury levels. The lower concentrations seen in the larger 2017 fish indicate a declining trend in mercury exposure to the fish in 2017. Relative to baseline juvenile bass comparison data from Cache Creek, though, they remained significantly higher than the two sample sets available: River Mile 28 (0.142 ppm) and River Mile 15 (0.050 ppm).

Juvenile Green Sunfish

The juvenile Green Sunfish multiple-fish composites had whole-body mercury ranging from 0.161-0.316 ppm, averaging 0.225 ppm. This was down, relative to fish analyzed in 2016 (0.414 ppm) and 2015 (0.325 ppm). The drop from 2016 was statistically significant. In yet another case of changing fish sizes confounding comparisons, the available 2017 juvenile Green Sunfish were smaller than the 2015 and 2016 sample sets, as well as most of the baseline comparison samples. This may have been a factor in the apparent decline in concentrations in 2017. Relative to baseline juvenile Green Sunfish comparison numbers from Cache Creek, they remained higher. The difference was statistically significant for 4 of the 5 comparisons.

Mosquitofish

The Mosquitofish multiple-fish composites had whole-body mercury ranging from 0.200-0.436 ppm, averaging 0.309 ppm. This was similar statistically, relative to somewhat smaller samples analyzed in 2015 (0.268 ppm). Mosquitofish could not be collected in 2016. The 2017 average remained higher than the 3 comparable Cache Creek sample sets from River Miles 15 and 17 (0.094-0.172 ppm). The difference was statistically significant for 2 of the 3 comparisons.

Summary

In summary, fish mercury in the Syar – B1 Pond showed a substantial decline in 2017. In particular, available samples of adult Largemouth Bass were down from previous (very high) levels by 45%. Juvenile bass and Green Sunfish were down as well. Interpretation of these declines, though, was confounded by changes in the sizes of fish available in 2017. The smaller sizes available of both the adult bass and juvenile sunfish may partly explain the apparent decline in 2017 mercury levels. However, the fact that a decline was also observed in the available samples of juvenile bass, which were much larger, not smaller, than those of the previous year, indicate an overall decline in mercury exposure. In comparison to corresponding baseline/historic samples from Cache Creek, the B1 Pond juvenile bass were still significantly higher in 2017. Mosquitofish were significantly higher than 2 of 3 baseline comparisons. Juvenile Green Sunfish were still significantly higher than 4 of 5 comparisons. The adult bass, though, which had previously been significantly higher than all available baseline creek comparisons, were down to a level statistically similar to 5 of 7 comparison sets. They remained significantly higher than 2 of the 7.

Table A6, below, summarizes the statistical comparisons between B1 Pond fish and comparable Cache Creek samples, for the data sets with sufficient numbers of fish to compare statistically.

Table A6. Syar – B1 Pond Fish Mercury: Statistical comparisons
(for sample sets with enough fish to compare statistically; 95% confidence level)

< *Pond fish were significantly lower in mercury than at the baseline site*
> *Pond fish were significantly higher in mercury than at the baseline site*
= *Pond fish were not significantly different than at the baseline site*

Fish Species	*vs* Same Site 2015, 2016	*– vs Baseline and Historic Comparable Cache Creek Data Sets –* RM28 2011	RM20 2000	RM20 2011	RM17 00-02	RM15 1997	RM15 00-02	RM15 2011
Large fish fillet muscle mercury								
Largemouth Bass 2015		>	>					>
2016	=	>	>					>
2017	< , <	= , = , =	> , =					>
Green Sunfish 2015		>		>				>
2016	*(n=1)* *							
2017	*(not available)*							
Small, young fish whole body, composite mercury								
Largemouth Bass 2015		>						>
2016	=	>						>
2017	= , =	>						>
Green Sunfish 2015		>		>	=		>	>
2016	=	>		>	>		>	>
2017	< , =	>		>	=		>	>
Mosquitofish 2015					=		>	>
2016	*(not available)*							
2017	*na* , =				=		>	>

* *(n=1)* means there was only one fish taken of this species, precluding statistical comparisons

Table 31. Syar – B1 Pond: Large fish sampled, Fall 2017

Fish Species	Fish Total Length (mm)	(inches)	Fish Weight (g)	(lbs)	Muscle Mercury (µg/g = ppm, wet wt)
Largemouth Bass	181	7.1	65	0.1	**0.728**
Largemouth Bass	205	8.1	115	0.3	**0.480**
Largemouth Bass	206	8.1	105	0.2	**0.492**
Largemouth Bass	211	8.3	115	0.3	**0.684**
Largemouth Bass	214	8.4	120	0.3	**0.434**
Largemouth Bass	214	8.4	120	0.3	**0.479**
Largemouth Bass	225	8.9	125	0.3	**0.654**
Largemouth Bass	240	9.4	165	0.4	**1.373**
Largemouth Bass	247	9.7	190	0.4	**0.494**
Largemouth Bass	297	11.7	350	0.8	**0.945**
Largemouth Bass	303	11.9	365	0.8	**0.961**
Largemouth Bass	304	12.0	330	0.7	**0.959**
Largemouth Bass	304	12.0	335	0.7	**0.876**
Largemouth Bass	318	12.5	455	1.0	**1.590**
Largemouth Bass	335	13.2	645	1.4	**1.889**
Largemouth Bass	358	14.1	635	1.4	**1.428**

Table 32. Syar–B1 Pond: Small Fish Sampled, Fall 2017
(multi-individual, whole body composite samples)
'**n**' = *number: number of individual fish per composite*

Fish Species	**n** (indivs. in comp)	Av. Fish Length (mm)	(inches)	Av. Fish Weight (g)	(oz)	Whole-Body Mercury (µg/g = ppm, wet wt)
Largemouth Bass (juv)	**1**	80	3.1	5.2	0.18	**0.233**
Largemouth Bass (juv)	**2**	96	3.8	10.5	0.37	**0.416**
Largemouth Bass (juv)	**2**	111	4.4	15.1	0.53	**0.616**
Largemouth Bass (juv)	**1**	124	4.9	40.5	1.43	**0.579**
Green Sunfish (juv)	**6**	33	1.3	0.5	0.02	**0.161**
Green Sunfish (juv)	**7**	37	1.4	0.7	0.03	**0.183**
Green Sunfish (juv)	**7**	40	1.6	0.9	0.03	**0.242**
Green Sunfish (juv)	**6**	51	2.0	1.9	0.07	**0.316**
Mosquitofish	**10**	28	1.1	0.2	0.01	**0.200**
Mosquitofish	**10**	33	1.3	0.3	0.01	**0.235**
Mosquitofish	**10**	37	1.5	0.5	0.02	**0.363**
Mosquitofish	**9**	41	1.6	0.7	0.03	**0.436**

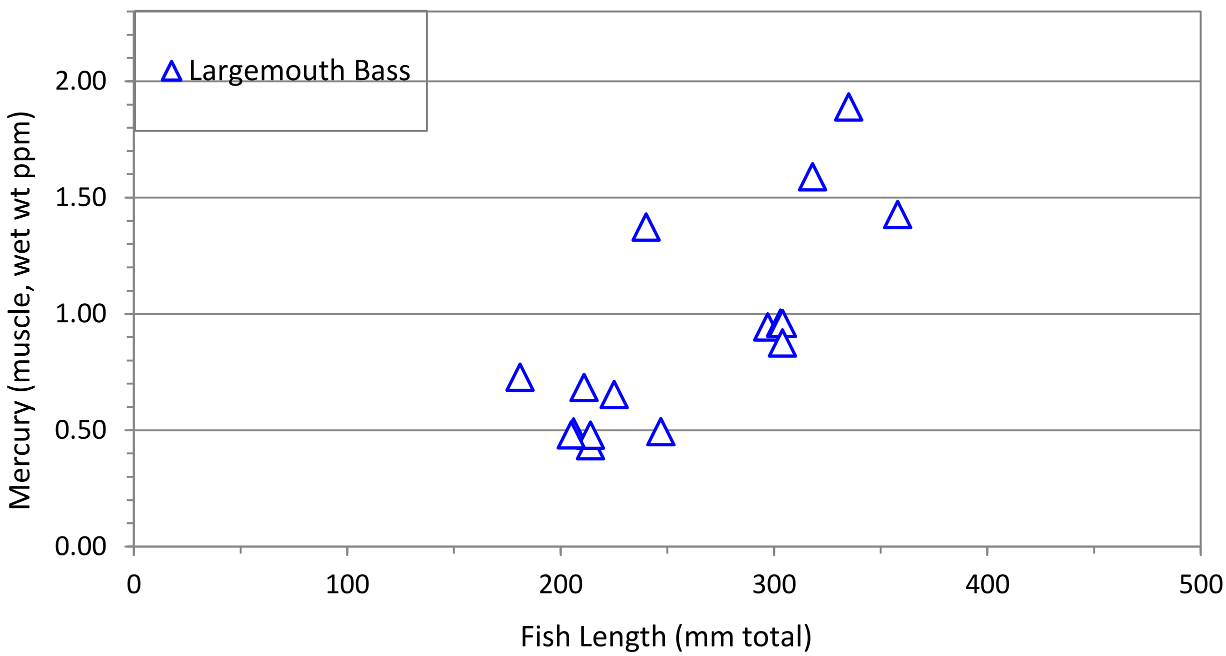

Figure 31. **Syar – B1 Pond: large fish sampled, Fall 2017**
(fillet muscle mercury in individual fish)

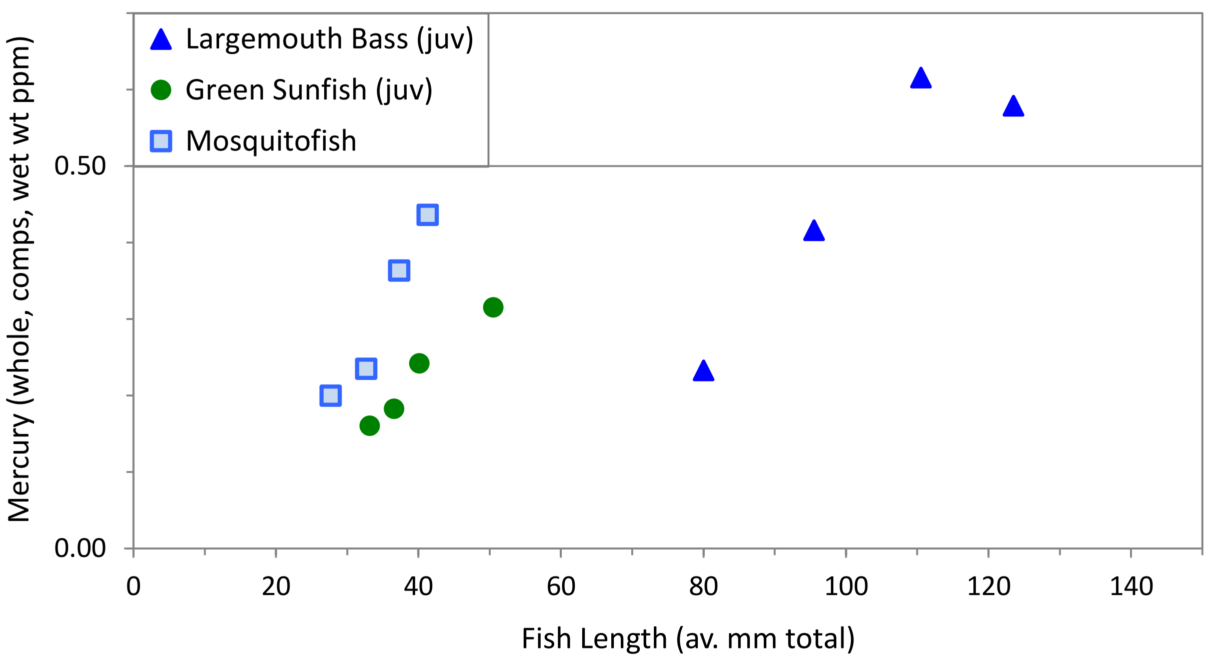

Figure 32. **Syar – B1 Pond: small, young fish sampled, Fall 2017**
(mercury in whole-body, multi-individual composite samples)

Table 33. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	Std. Dev.
Syar – B1	2015	**18**	281	355	**1.628**	± 0.332
Syar – B1	2016	**20**	318	489	**1.640**	± 0.152
Syar – B1	2017	**16**	260	265	**0.904**	± 0.239
Historic/Baseline Data (comparable predatory species)						
Largemouth Bass						
River Mile 28	**2011**	**9**	**199**	**137**	**0.663**	**± 0.116**
Smallmouth Bass						
River Mile 28	**2011**	**7**	**265**	**326**	**0.782**	**± 0.188**
River Mile 20	2000	7	234	183	0.444	± 0.061
River Mile 15	1997	2	383	780	0.939	
Sacramento Pikeminnow						
River Mile 28	**2011**	**10**	**311**	**262**	**0.726**	**± 0.102**
River Mile 20	2000	8	269	147	0.509	± 0.204
River Mile 15	**2011**	**9**	**264**	**145**	**0.327**	**± 0.066**

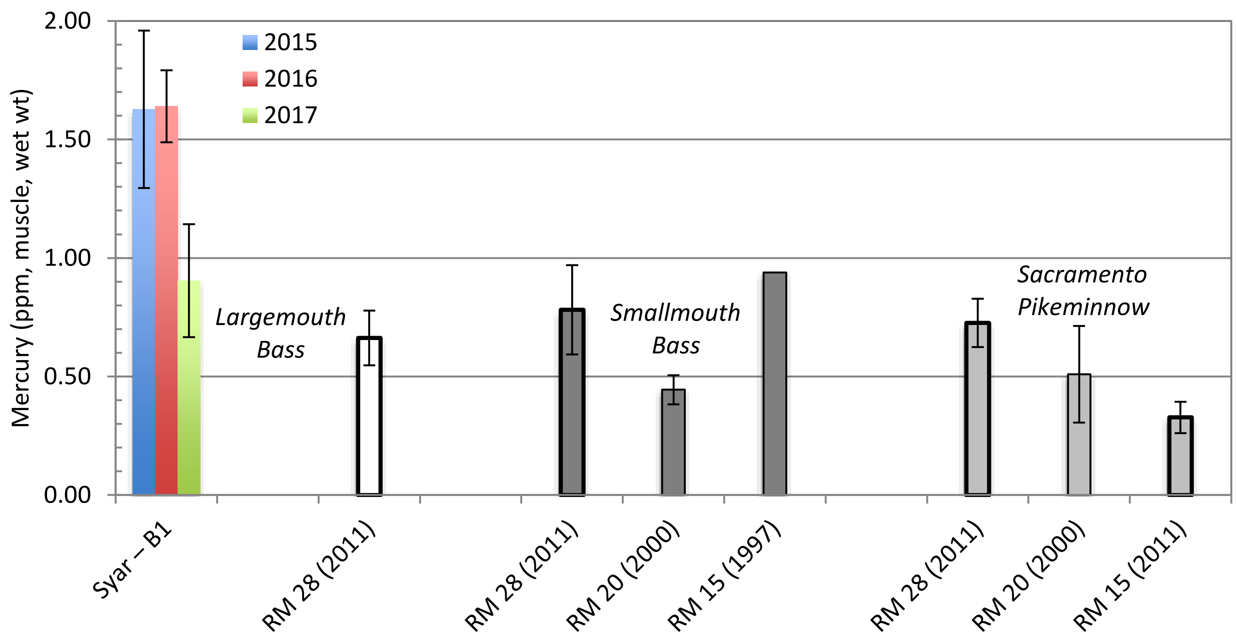

Figure 33. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Table 34. Green Sunfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	Std. Dev.
Green Sunfish						
Syar – B1	2015	**10**	118	25	**0.777**	± 0.086
Syar – B1	2016	**1**	83	12	**1.446**	
Syar – B1	2017	**–**	–	–	**–**	
Historic/Baseline Data						
River Mile 28	**2011**	**3**	**139**	**47**	**0.540**	**± 0.124**
River Mile 20	2000	4	132	41	0.271	
River Mile 20	**2011**	**10**	**122**	**31**	**0.138**	**± 0.029**
River Mile 15	**2011**	**10**	**133**	**41**	**0.195**	**± 0.031**

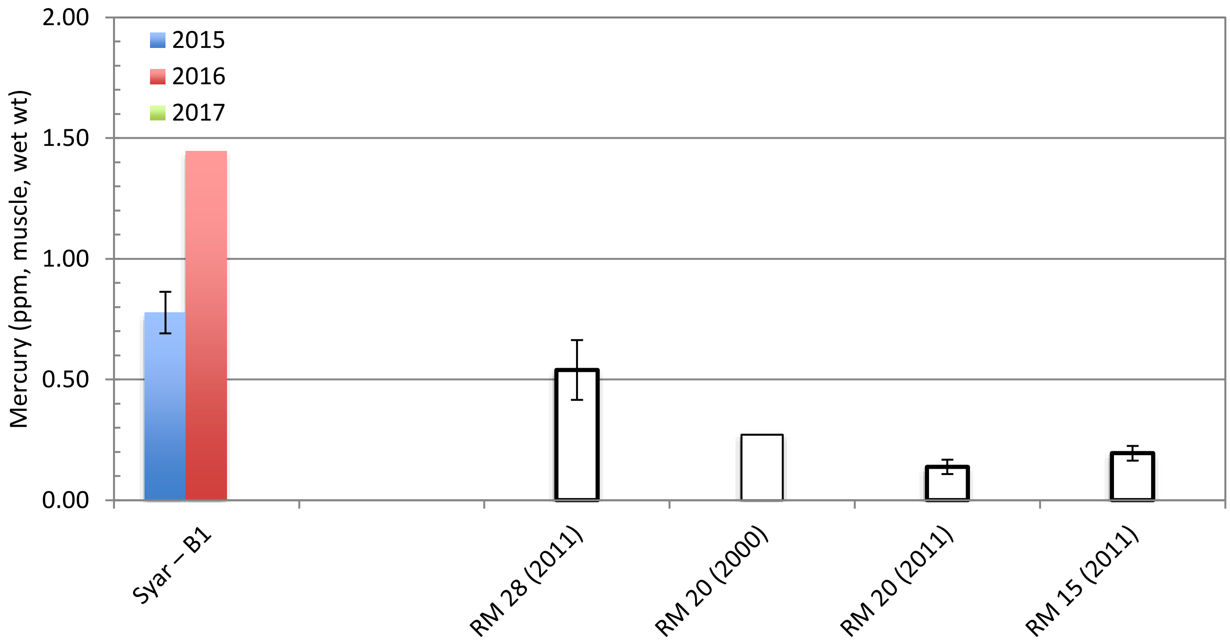

Figure 34. Green Sunfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Small, Young Fish Samples *(note lower concentration scales)*

Table 35. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Largemouth Bass (juveniles)							
Syar – B1	2015	**4**	7	159	44	**0.589**	± 0.030
Syar – B1	2016	**4**	10	74	5	**0.524**	± 0.119
Syar – B1	2017	**4**	1-2	102	18	**0.461**	± 0.175
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**3-5**	**75**	**6**	**0.142**	**± 0.026**
River Mile 15	**2011**	**3**	**1**	**93**	**10**	**0.050**	**± 0.024**

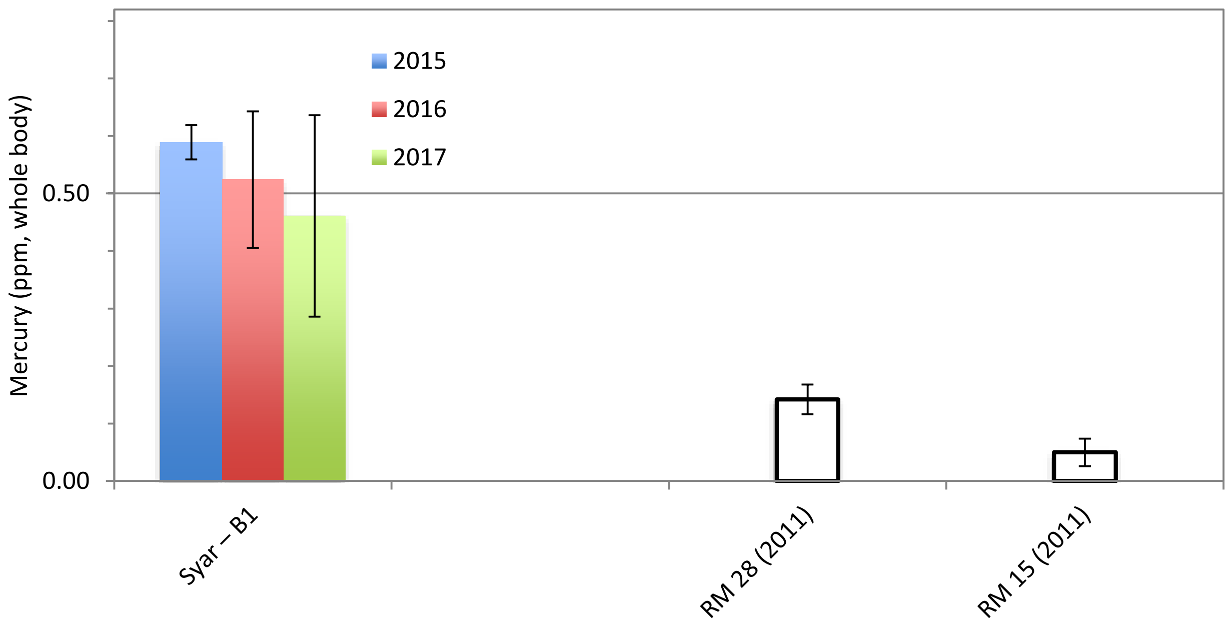

Figure 35. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 36. Juvenile Green Sunfish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Green Sunfish (juveniles)							
Syar – B1	2015	**4**	8-9	47	1.7	**0.325**	± 0.097
Syar – B1	2016	**4**	4	50	1.9	**0.414**	± 0.076
Syar – B1	2017	**4**	6-7	40	1.0	**0.225**	± 0.069
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**4**	**53**	**2.8**	**0.139**	**± 0.014**
River Mile 20	**2011**	**4**	**4**	**58**	**3.4**	**0.084**	**± 0.004**
River Mile 17	2000-2002	8	5-10	41-90	1-6	0.169	± 0.045
River Mile 15	2000-2002	8	4-8	40-87	1-6	0.117	± 0.028
River Mile 15	**2011**	**4**	**4-5**	**56**	**3.1**	**0.086**	**± 0.018**

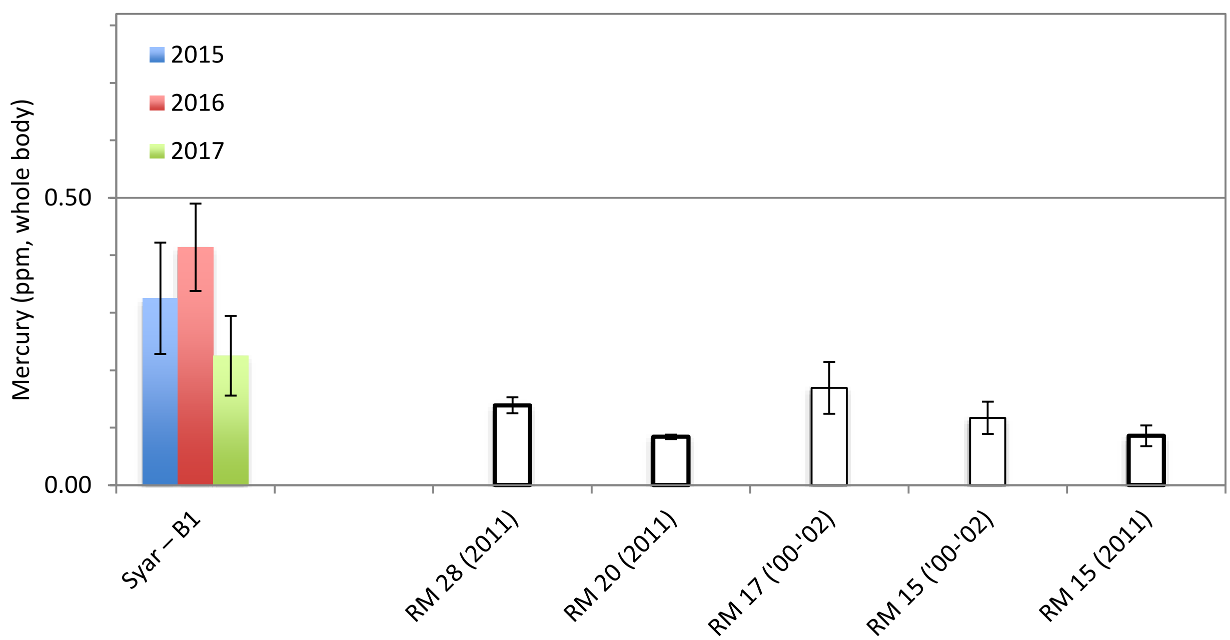

Figure 36. Juv. Green Sunfish summary data (all sites) and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 37. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	**n** (comps)	**n** (inds/ (comp)	**Av Lgth** (mm total)	**Av Wt** (grams)	**Hg** (µg/g = ppm, wet wt)	**Std. Dev.**
Mosquitofish							
Syar – B1	2015	**4**	5-10	31	0.3	**0.268**	± 0.043
Syar – B1	2016	**–**	–	–	–	**–**	
Syar – B1	2017	**4**	9-10	35	0.4	**0.309**	± 0.110
Historic/Baseline Data							
River Mile 17	2000-2002	13	5-30	26-47	0.2-1.1	0.172	± 0.048
River Mile 15	2000-2002	10	5-30	26-47	0.2-1.0	0.094	± 0.029
River Mile 15	**2011**	**4**	**1-10**	**37**	**0.7**	**0.103**	**± 0.048**

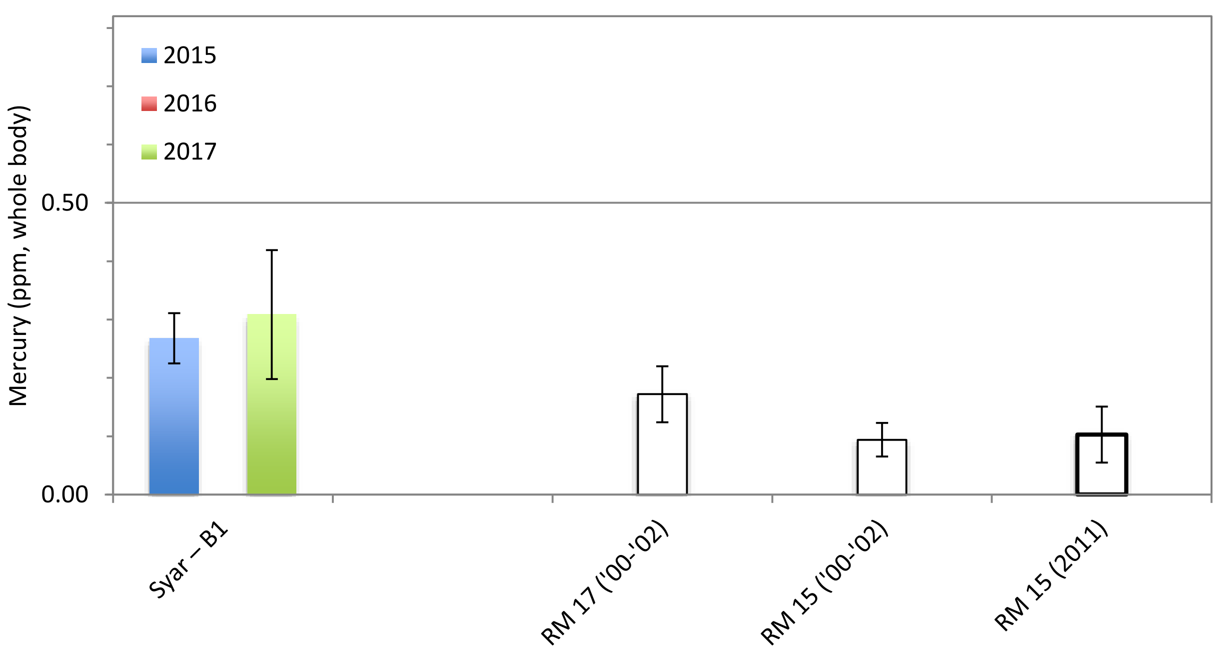

Figure 37. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

7. SYAR – WEST POND

7. SYAR – WEST POND *(Tables 38-44, Figures 38-44)*

As described in the previous section, this pond is located about half a kilometer west of the B1 Pond. It is approximately 300 m x 400 m in size. Depth was not determined exactly, but appeared to be considerably deeper overall than the B1 Pond, with extensive areas more than 6 m (20 feet) deep. This pond was added to the monitoring in line with the Ordinance. It was also of interest because of high fish mercury levels in the adjacent B1 Pond and the observation of extensive fishing activity at both ponds. This (2017) was Year 1 of monitoring for the Syar – West Pond.

As at the other sites, we sampled the West Pond during day, twilight, and night conditions on multiple days with a range of techniques. We were able to obtain useful samples of most of the fish species present. These included fillet muscle samples of 17 Largemouth Bass (*Micropterus salmoides*) and 4 Green Sunfish (*Lepomis cyanellus*). The small, young fish present were juvenile Largemouth Bass (3-6"), juvenile Green Sunfish (~2") and Mosquitofish (*Gambusia affinis*, 1-2"). We collected only 2 small bass, which were analyzed individually. The 25 juvenile Green Sunfish taken were put into 4 composite samples of 5-10 fish each. Mosquitofish were sampled with 4 composite samples of 10 fish each.

In total, 21 large fish muscle samples and 10 young, small fish composite samples, or 31 separate mercury samples, were analyzed from the Syar – West Pond in the Fall 2017 monitoring. The analytical results from each individual large fish muscle sample and each small, young fish composite sample can be seen in Tables 38 and 39 and, graphically, in Figures 38 and 39. Then, for each sample type, the new data are shown in reduced form (means, error bars, etc.) and compared to the most closely comparable historic creek data (Tables 40-44, Figures 40-44).

Large, Angling-sized Fish

Largemouth Bass

The West Pond adult Largemouth Bass samples had fillet muscle mercury ranging from 0.395-1.738 ppm, averaging 0.925 ppm. This was nearly identical to the levels found in bass from the B1 Pond, which averaged 0.904 ppm. Relative to historic/baseline creek comparisons, it was significantly higher than 3 of 7 comparison data sets and statistically similar to 4 of the 7.

Green Sunfish

The Green Sunfish samples had fillet muscle mercury of 0.509-0.640 ppm, averaging 0.579 ppm. As compared to baseline/historic Cache Creek samples, for the 3 sets with statistically comparable data, the 2017 Syar – West Pond Green Sunfish were similar to one set (2011 River Mile 28, averaging 0.540 ppm) and significantly higher than the other 2 (River Mile 20, averaging 0.138 ppm; and River Mile 15, averaging 0.195 ppm). Relative to the nearby B1 Pond, this was significantly lower than levels found there in 2015. Comparable data are not available from other years.

Small, Young Fish

Juvenile Largemouth Bass

The juvenile bass had whole-body mercury of 0.384-0.453 ppm, averaging 0.418 ppm. Relative to baseline juvenile bass comparison data from Cache Creek, they were significantly higher than the two sample sets available: River Mile 28 (0.142 ppm) and River Mile 15 (0.050 ppm). As compared to 2017 samples from the adjacent B1 Pond (0.461 ppm), levels were similar.

Juvenile Green Sunfish

The juvenile Green Sunfish multiple-fish composites had whole-body mercury ranging from 0.150-0.317 ppm, averaging 0.237 ppm. Relative to baseline/historic juvenile Green Sunfish comparison numbers from Cache Creek, they were higher. The difference was statistically significant for 4 of the 5 comparisons. Relative to corresponding fish from the adjacent B1 Pond (0.225 ppm), the West Pond juvenile Green Sunfish were statistically similar (0.237 ppm).

Mosquitofish

The Mosquitofish multiple-fish composites had whole-body mercury ranging from 0.176-0.332 ppm, averaging 0.236 ppm. This was significantly higher than 2 of the 3 comparable Cache Creek sample sets (River Mile 15, 0.094-0.103 ppm) and statistically similar to 1 of the 3 sets (River Mile 17, 0.172 ppm). Relative to corresponding fish from the adjacent B1 Pond (0.309 ppm), the West Pond juvenile Green Sunfish were lower (0.236 ppm), though the difference was not statistically significant.

Summary

In summary, fish mercury in the Syar – West Pond was found to be similar to levels seen in the nearby B1 Pond. In comparison to corresponding baseline/historic samples from Cache Creek, the West Pond fish in 2017 were significantly higher in mercury for most of the small fish comparisons. For adult Largemouth Bass, they were higher than 3 of 7 comparison data sets and statistically similar to 4 of the 7.

Table A7, below, summarizes the statistical comparisons between West Pond fish and comparable Cache Creek samples, for the data sets with sufficient numbers of fish to compare statistically.

Table A7. Syar – West Pond Fish Mercury: Statistical comparisons

(for sample sets with enough fish to compare statistically; 95% confidence level)

< *Pond fish were significantly lower in mercury than at the baseline site*
> *Pond fish were significantly higher in mercury than at the baseline site*
= *Pond fish were not significantly different than at the baseline site*

	– vs Baseline and Historic Comparable Cache Creek Data Sets –						
Fish Species	**RM28 2011**	RM20 2000	**RM20 2011**	RM17 00-02	RM15 1997	RM15 00-02	**RM15 2011**
Large fish fillet muscle mercury							
Largemouth Bass 2017	= , = , =	> , >			=		>
Green Sunfish 2017	=		>				>
Small, young fish whole body, composite mercury							
Largemouth Bass 2017	>						>
Green Sunfish 2017	>		>		=	>	>
Mosquitofish 2017							

Table 38. Syar – West Pond: Large fish sampled, Fall 2017

Fish Species	Fish Total Length (mm)	(inches)	Fish Weight (g)	(lbs)	Muscle Mercury (µg/g = ppm, wet wt)
Largemouth Bass	187	7.4	70	0.2	**0.512**
Largemouth Bass	211	8.3	115	0.3	**0.626**
Largemouth Bass	220	8.7	130	0.3	**0.464**
Largemouth Bass	242	9.5	165	0.4	**0.395**
Largemouth Bass	242	9.5	155	0.3	**0.485**
Largemouth Bass	248	9.8	175	0.4	**0.816**
Largemouth Bass	253	10.0	200	0.4	**0.780**
Largemouth Bass	266	10.5	225	0.5	**0.530**
Largemouth Bass	276	10.9	250	0.6	**0.881**
Largemouth Bass	283	11.1	280	0.6	**1.187**
Largemouth Bass	312	12.3	390	0.9	**1.051**
Largemouth Bass	318	12.5	435	1.0	**0.966**
Largemouth Bass	322	12.7	410	0.9	**1.310**
Largemouth Bass	351	13.8	555	1.2	**1.243**
Largemouth Bass	354	13.9	560	1.2	**1.447**
Largemouth Bass	359	14.1	622	1.4	**1.287**
Largemouth Bass	367	14.4	695	1.5	**1.738**
Green Sunfish	83	3.3	9	<0.1	**0.565**
Green Sunfish	85	3.3	9	<0.1	**0.640**
Green Sunfish	90	3.5	12	<0.1	**0.603**
Green Sunfish	113	4.4	18	<0.1	**0.509**

Table 39. Syar – West Pond: Small Fish Sampled, Fall 2017
(multi-individual, whole body composite samples)
'**n**' = *number: number of individual fish per composite*

Fish Species	**n** (indivs. in comp)	Av. Fish Length (mm)	(inches)	Av. Fish Weight (g)	(oz)	Whole-Body Mercury (µg/g = ppm, wet wt)
Largemouth Bass (juv)	**1**	86	3.4	7.7	0.27	**0.384**
Largemouth Bass (juv)	**1**	160	6.3	47.0	1.66	**0.453**
Green Sunfish (juv)	**10**	33	1.3	0.5	0.02	**0.150**
Green Sunfish (juv)	**10**	40	1.6	1.1	0.04	**0.199**
Green Sunfish (juv)	**10**	46	1.8	1.6	0.06	**0.283**
Green Sunfish (juv)	**5**	60	2.4	3.7	0.13	**0.317**
Mosquitofish	**10**	27	1.1	0.2	0.01	**0.176**
Mosquitofish	**10**	30	1.2	0.3	0.01	**0.204**
Mosquitofish	**10**	35	1.4	0.5	0.02	**0.232**
Mosquitofish	**10**	42	1.6	0.8	0.03	**0.332**

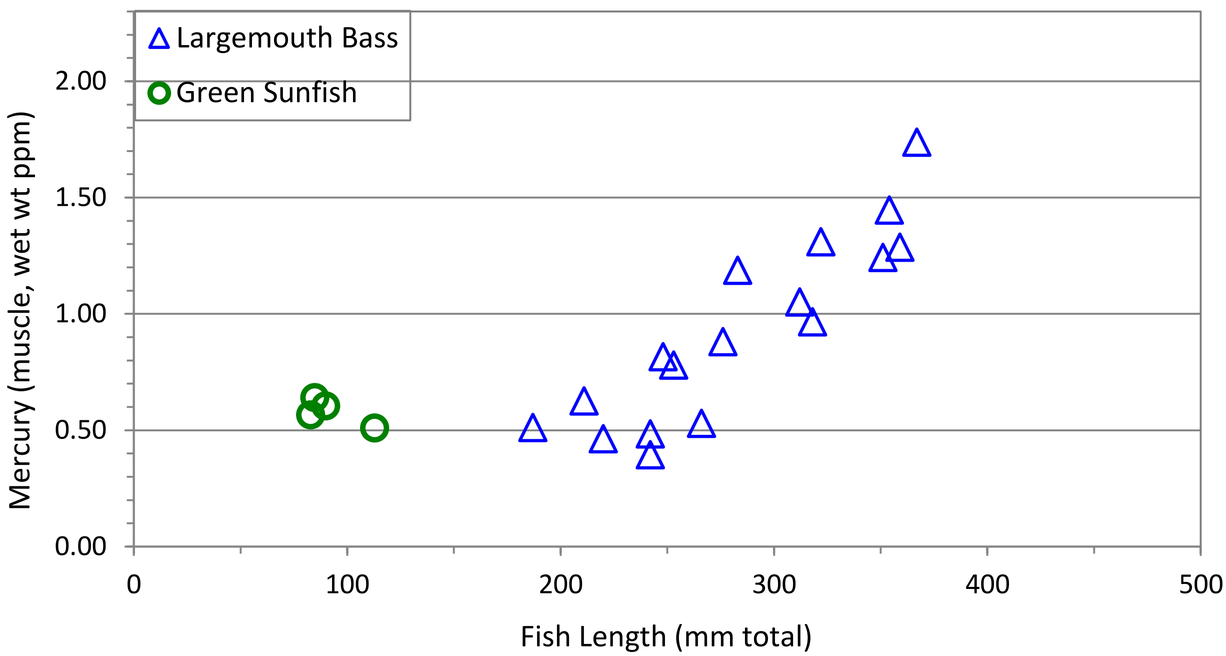

Figure 38. **Syar – West Pond: large fish sampled, Fall 2017**
(fillet muscle mercury in individual fish)

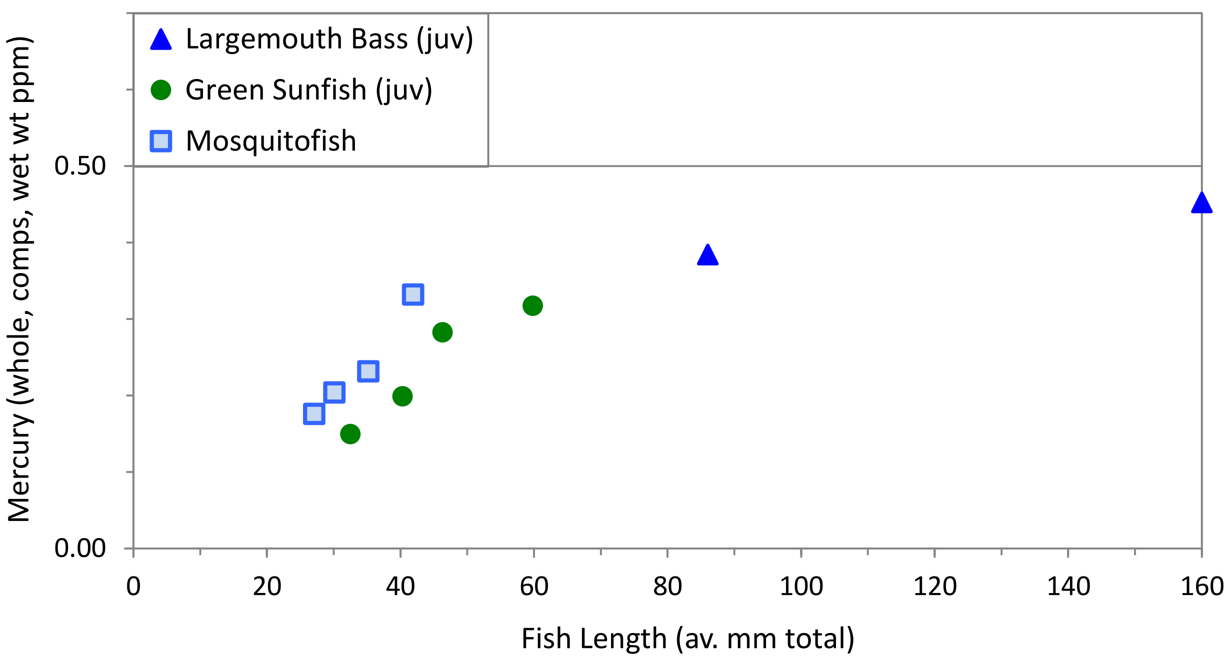

Figure 39. **Syar – West Pond: small, young fish sampled, Fall 2017**
(mercury in whole-body, multi-individual composite samples)

Table 40. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	Std. Dev.
Syar – West Pond	2016	–	–	–	–	
Syar – West Pond	2017	**17**	283	320	**0.925**	± 0.205
Historic/Baseline Data (comparable predatory species)						
Largemouth Bass						
River Mile 28	**2011**	**9**	**199**	**137**	**0.663**	**± 0.116**
Smallmouth Bass						
River Mile 28	**2011**	**7**	**265**	**326**	**0.782**	**± 0.188**
River Mile 20	2000	7	234	183	0.444	± 0.061
River Mile 15	1997	2	383	780	0.939	
Sacramento Pikeminnow						
River Mile 28	**2011**	**10**	**311**	**262**	**0.726**	**± 0.102**
River Mile 20	2000	8	269	147	0.509	± 0.204
River Mile 15	**2011**	**9**	**264**	**145**	**0.327**	**± 0.066**

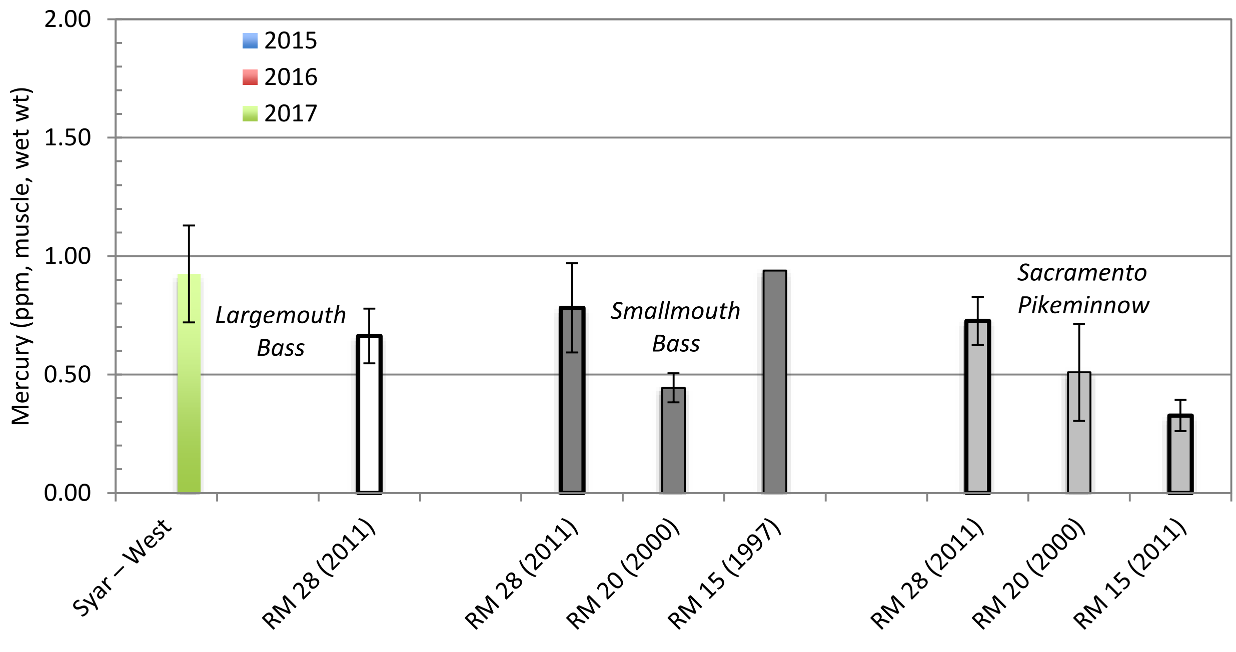

Figure 40. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Table 41. Green Sunfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	Std. Dev.
Green Sunfish						
Syar – West Pond	2016	**–**	–	–	**–**	
Syar – West Pond	2017	**4**	93	12	**0.579**	± 0.089
Historic/Baseline Data						
River Mile 28	**2011**	**3**	**139**	**47**	**0.540**	**± 0.124**
River Mile 20	2000	4	132	41	0.271	
River Mile 20	**2011**	**10**	**122**	**31**	**0.138**	**± 0.029**
River Mile 15	**2011**	**10**	**133**	**41**	**0.195**	**± 0.031**

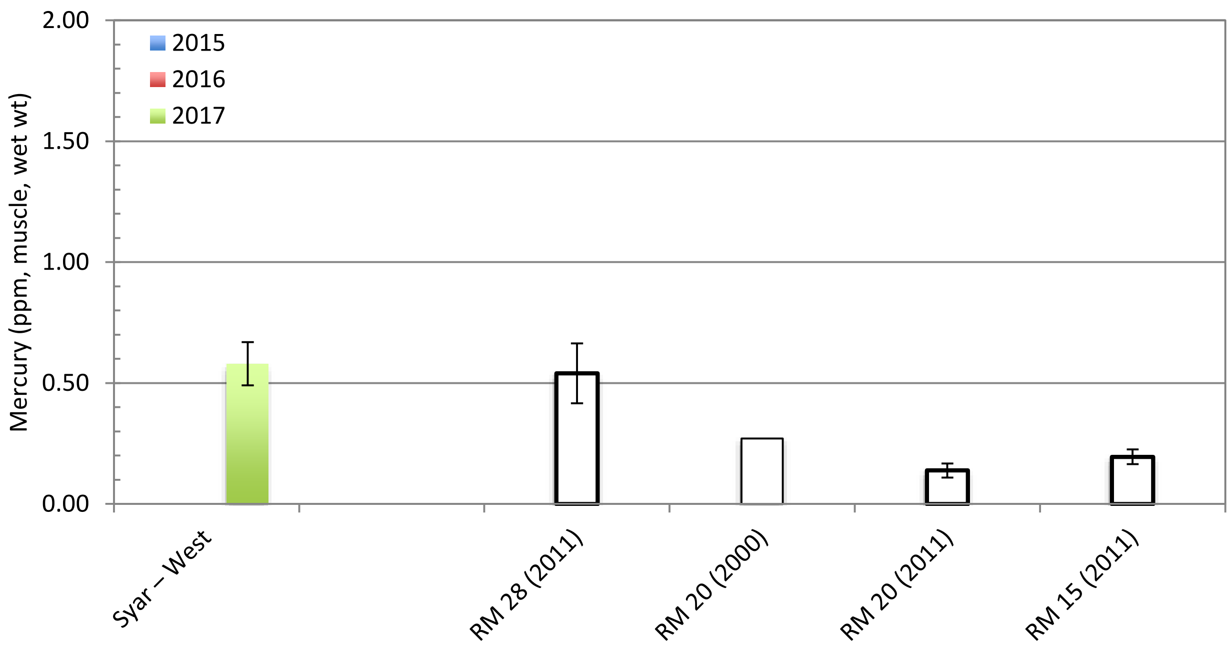

Figure 41. Green Sunfish summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Small, Young Fish Samples *(note lower concentration scales)*

Table 42. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Largemouth Bass (juveniles)							
Syar – West Pond	2016	–	–	–	–	–	
Syar – West Pond	2017	**2**	1	123	27	**0.418**	± 0.042
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**3-5**	**75**	**6**	**0.142**	**± 0.026**
River Mile 15	**2011**	**3**	**1**	**93**	**10**	**0.050**	**± 0.024**

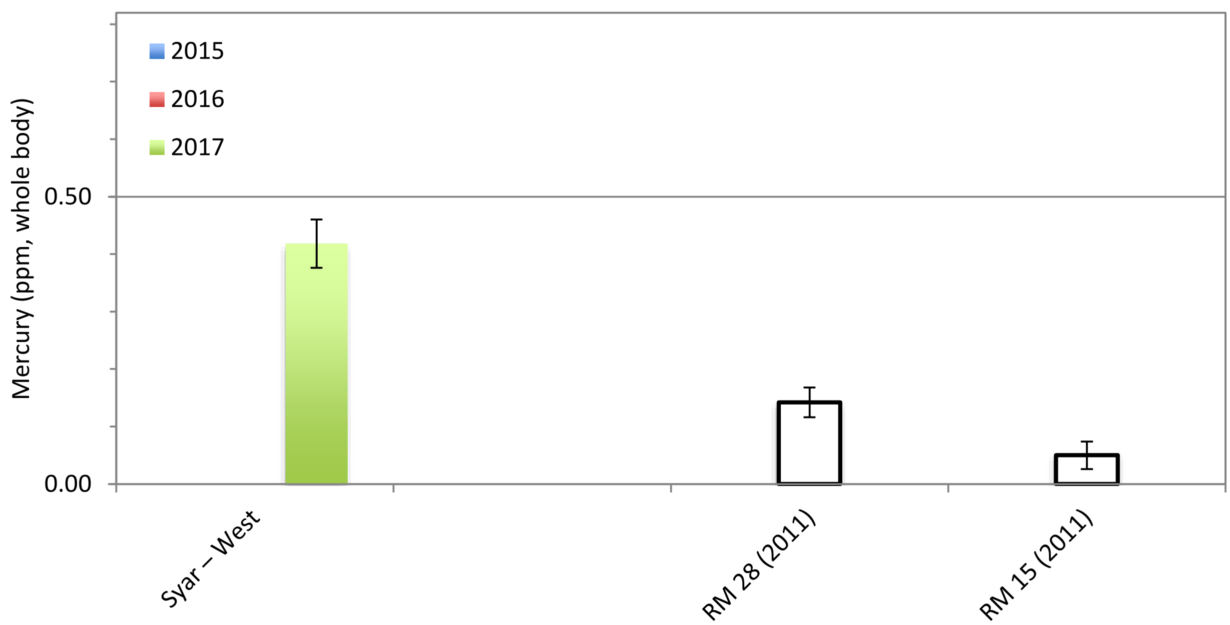

Figure 42. Juvenile Largemouth Bass summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 43. Juvenile Green Sunfish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Green Sunfish (juveniles)							
Syar – West Pond	2016	–	–	–	–	–	
Syar – West Pond	2017	**4**	5-10	45	1.7	**0.237**	± 0.077
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**4**	**53**	**2.8**	**0.139**	**± 0.014**
River Mile 20	**2011**	**4**	**4**	**58**	**3.4**	**0.084**	**± 0.004**
River Mile 17	2000-2002	8	5-10	41-90	1-6	0.169	± 0.045
River Mile 15	2000-2002	8	4-8	40-87	1-6	0.117	± 0.028
River Mile 15	**2011**	**4**	**4-5**	**56**	**3.1**	**0.086**	**± 0.018**

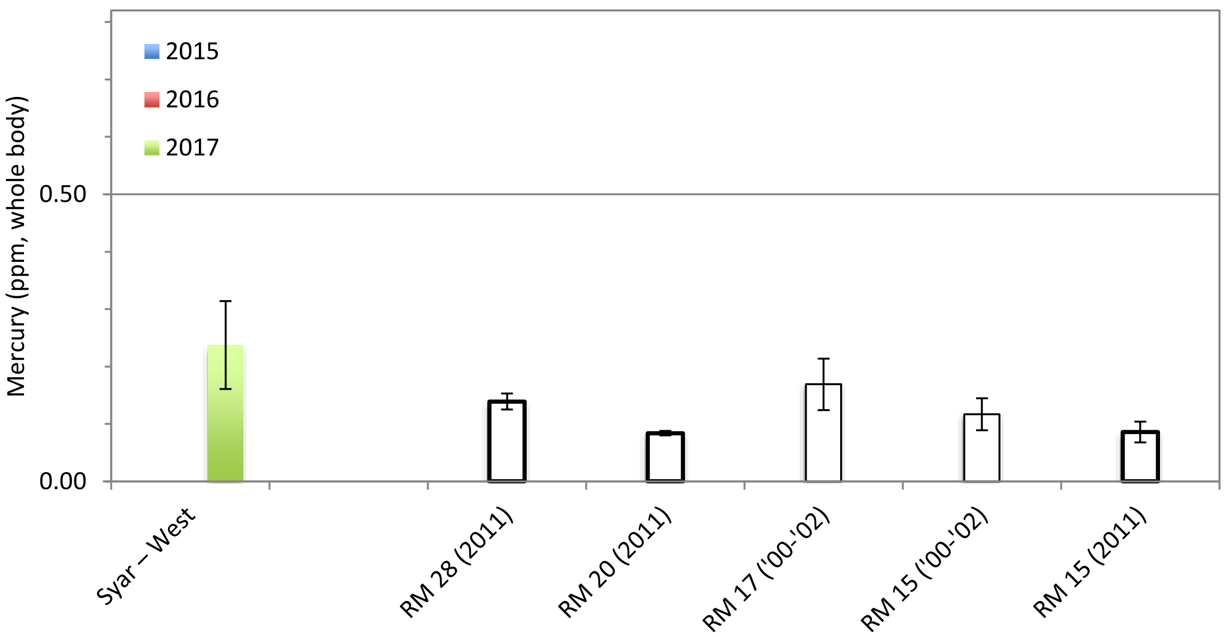

Figure 43. Juv. Green Sunfish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

Table 44. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	**n** (comps)	**n** (inds/ (comp)	**Av Lgth** (mm total)	**Av Wt** (grams)	**Hg** (µg/g = ppm, wet wt)	**Std. Dev.**
Mosquitofish							
Syar – West Pond	2016	**–**	–	–	–	**–**	
Syar – West Pond	2017	**4**	10	34	0.4	**0.236**	± 0.068
Historic/Baseline Data							
River Mile 17	2000-2002	13	5-30	26-47	0.2-1.1	0.172	± 0.048
River Mile 15	2000-2002	10	5-30	26-47	0.2-1.0	0.094	± 0.029
River Mile 15	**2011**	**4**	**1-10**	**37**	**0.7**	**0.103**	**± 0.048**

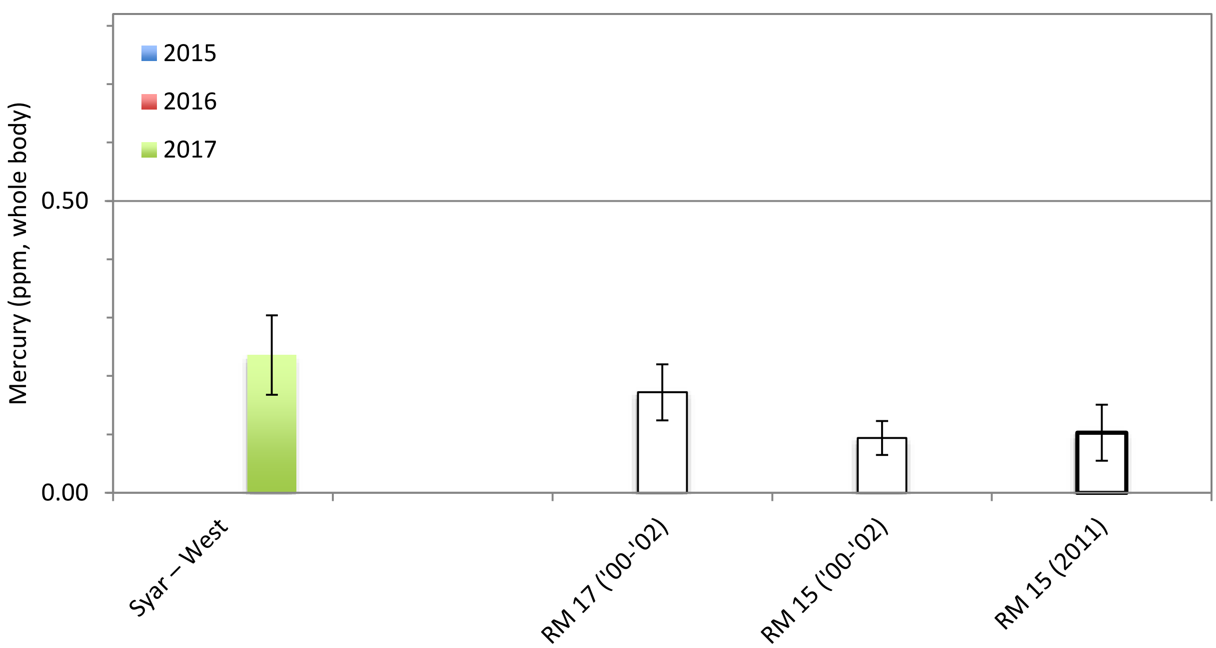

Figure 44. Mosquitofish summary data, and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

8. COMPARISON OF ALL THE MONITORED SITES AND HISTORICAL DATA, BY FISH SPECIES

5. COMPARISON OF ALL THE MONITORED SITES AND HISTORICAL DATA, BY FISH SPECIES

This section is presented to consolidate the monitoring data and place the various findings into relative context. For each fish sample type, data are presented numerically and then graphically.

Table 45. Largemouth Bass summary data (all sites) and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Largemouth Bass						
Cemex – Phase 1 (West)	2015	**18**	305	393	**0.278**	± 0.055
Cemex – Phase 1 (West)	2016	**20**	313	383	**0.350**	± 0.066
Cemex – Phase 1 (West)	2017	**17**	299	357	**0.393**	± 0.079
Cemex – Phase 3-4 (East)	2015	**20**	344	526	**0.840**	± 0.113
Cemex – Phase 3-4 (East)	2016	**20**	344	557	**0.858**	± 0.139
Cemex – Phase 3-4 (East)	2017	**20**	334	479	**1.093**	± 0.172
Syar – B1	2015	**18**	281	355	**1.628**	± 0.332
Syar – B1	2016	**20**	318	489	**1.640**	± 0.152
Syar – B1	2017	**16**	260	265	**0.904**	± 0.239
Syar – West	2017	**17**	283	320	**0.925**	± 0.205
Teichert – Reiff	2017	**5**	189	78	**1.679**	± 0.180
Teichert – Storz	2017	**20**	245	203	**0.657**	± 0.038
Historic/Baseline Data (comparable predatory species)						
Largemouth Bass						
River Mile 28	**2011**	**9**	**199**	**137**	**0.663**	**± 0.116**
Smallmouth Bass						
River Mile 28	**2011**	**7**	**265**	**326**	**0.782**	**± 0.188**
River Mile 20	2000	7	234	183	0.444	± 0.061
River Mile 15	1997	2	383	780	0.939	
Sacramento Pikeminnow						
River Mile 28	**2011**	**10**	**311**	**262**	**0.726**	**± 0.102**
River Mile 20	2000	8	269	147	0.509	± 0.204
River Mile 15	**2011**	**9**	**264**	**145**	**0.327**	**± 0.066**

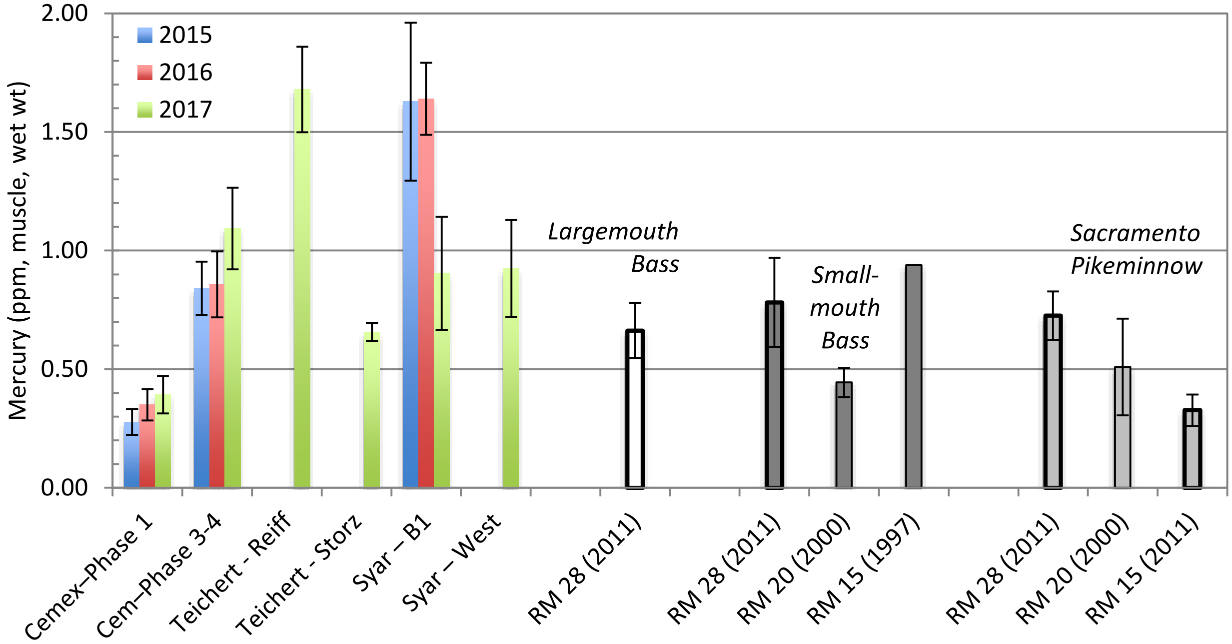

Figure 45. Largemouth Bass summary data, and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Table 46. Catfish summary data (all sites) and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Channel Catfish						
Cemex – Phase 1 (West)	2015	**2**	595	2,130	**0.198**	
Cemex – Phase 1 (West)	2016	**2**	412	1,150	**0.100**	
Cemex – Phase 1 (West)	2017	**2**	531	1,440	**0.236**	
White Catfish						
Cemex – Phase 1 (West)	2016	**3**	661	2,900	**0.372**	
Cemex – Phase 1 (West)	2017	**6**	615	2,120	**0.448**	± 0.134
Teichert – Reiff	2015	**20**	347	658	**0.737**	± 0.156
Teichert – Reiff	2016	**20**	297	341	**0.996**	± 0.153
Teichert – Reiff	2017	**16**	355	677	**1.287**	± 0.197
Historic/Baseline Data						
Channel Catfish						
Rumsey	2000	1	411	565	0.225	
River Mile 28	**2011**	**5**	**239**	**102**	**0.229**	**± 0.102**
River Mile 20	2000	1	368	380	0.225	
River Mile 03	1997	10	336	304	0.174	± 0.019

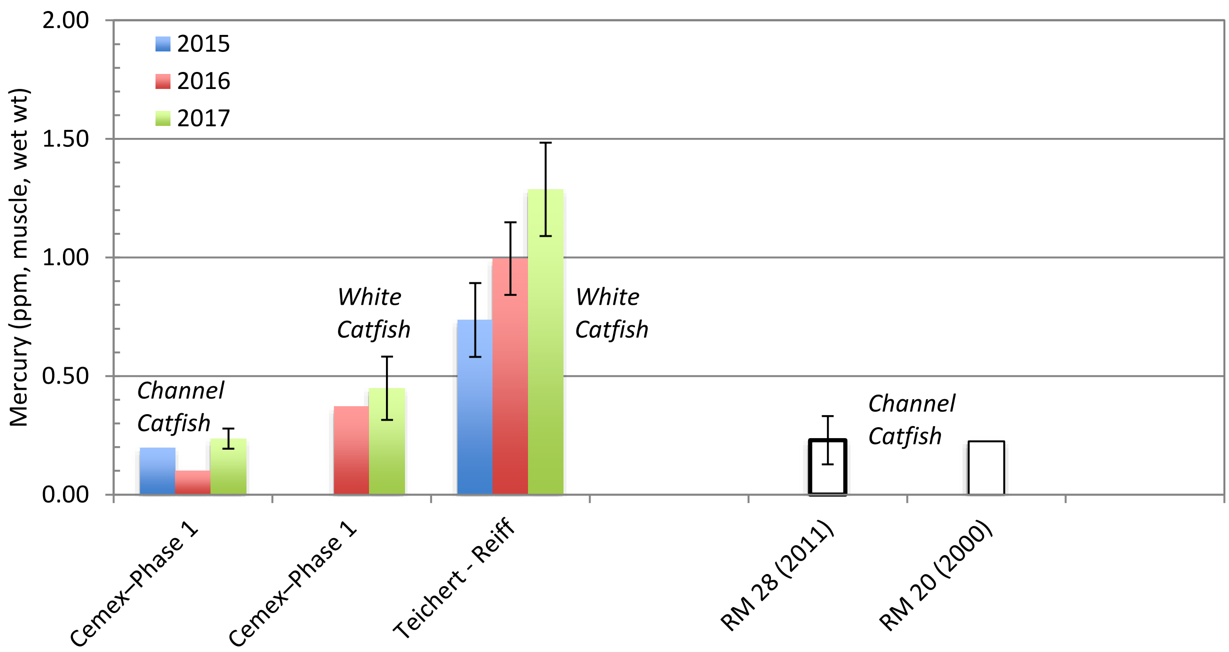

Figure 46. Catfish summary data (all sites) and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Table 47. Green Sunfish summary data (all sites) and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Site	Year	Number of Fish	Av Length (mm total)	Av Weight (grams)	Av Hg (µg/g = ppm, wet wt)	95% C.I.
Green Sunfish						
Cemex – Phase 1 (West)	2017	**5**	105	35	**0.273**	± 0.094
Cemex – Phase 3-4 (East)	2015	**10**	133	67	**0.534**	± 0.076
Cemex – Phase 3-4 (East)	2016	**1**	101	16	**0.382**	
Cemex – Phase 3-4 (East)	2017	–	–	–	–	
Teichert – Reiff	2015	**1**	140	40	**0.328**	
Teichert – Reiff	2016	–	–	–	–	
Teichert – Reiff	2017	–	–	–	–	
Syar – B1	2015	**10**	118	25	**0.777**	± 0.086
Syar – B1	2016	**1**	83	12	**1.446**	
Syar – B1	2017	–	–	–	–	
Syar – West Pond	2017	**4**	93	12	**0.579**	± 0.089
Historic/Baseline Data						
River Mile 28	**2011**	**3**	**139**	**47**	**0.540**	**± 0.124**
River Mile 20	2000	4	132	41	0.271	
River Mile 20	**2011**	**10**	**122**	**31**	**0.138**	**± 0.029**
River Mile 15	**2011**	**10**	**133**	**41**	**0.195**	**± 0.031**

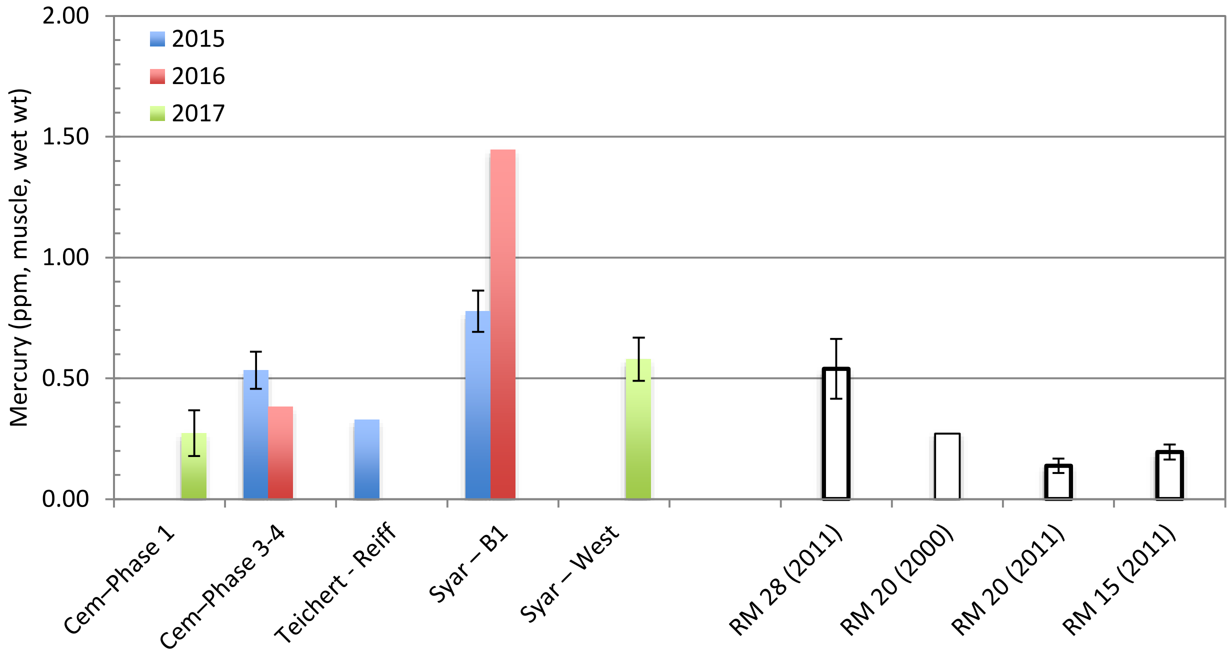

Figure 47. Green Sunfish summary data (all sites) and historic creek comparisons
(mean fillet muscle mercury, with 95% confidence intervals)

Small, Young Fish Samples *(note lower concentration scales)*

Table 48. Juvenile Bass summary data (all sites) and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	**Year**	**n** (comps)	**n** (inds/ (comp)	**Av Lgth** (mm total)	**Av Wt** (grams)	**Hg** (µg/g = ppm, wet wt)	**Std. Dev.**
Largemouth Bass (juveniles)							
Cemex – Phase 1 (West)	2015	**4**	8	109	17	**0.044**	± 0.007
Cemex – Phase 1 (West)	2016	**4**	3	102	17	**0.094**	±0.012
Cemex – Phase 1 (West)	2017	**4**	2	117	22	**0.146**	± 0.023
Cemex – Phase 3-4 (East)	2015	**4**	7	108	16	**0.334**	± 0.052
Cemex – Phase 3-4 (East)	2016	**4**	2	114	18	**0.372**	±0.053
Cemex – Phase 3-4 (East)	2017	**4**	2-3	108	16	**0.249**	± 0.033
Syar – B1	2015	**4**	7	159	44	**0.589**	± 0.030
Syar – B1	2016	**4**	10	74	5	**0.524**	±0.119
Syar – B1	2017	**4**	1-2	102	18	**0.461**	± 0.175
Syar – West Pond	2017	**2**	1	123	27	**0.418**	± 0.042
Teichert – Reiff	2017	**4**	1-2	137	32	**0.798**	± 0.188
Teichert – Storz	2017	**4**	1	143	35	**0.337**	± 0.059
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**3-5**	**75**	**6**	**0.142**	**± 0.026**
River Mile 15	**2011**	**3**	**1**	**93**	**10**	**0.050**	**± 0.024**

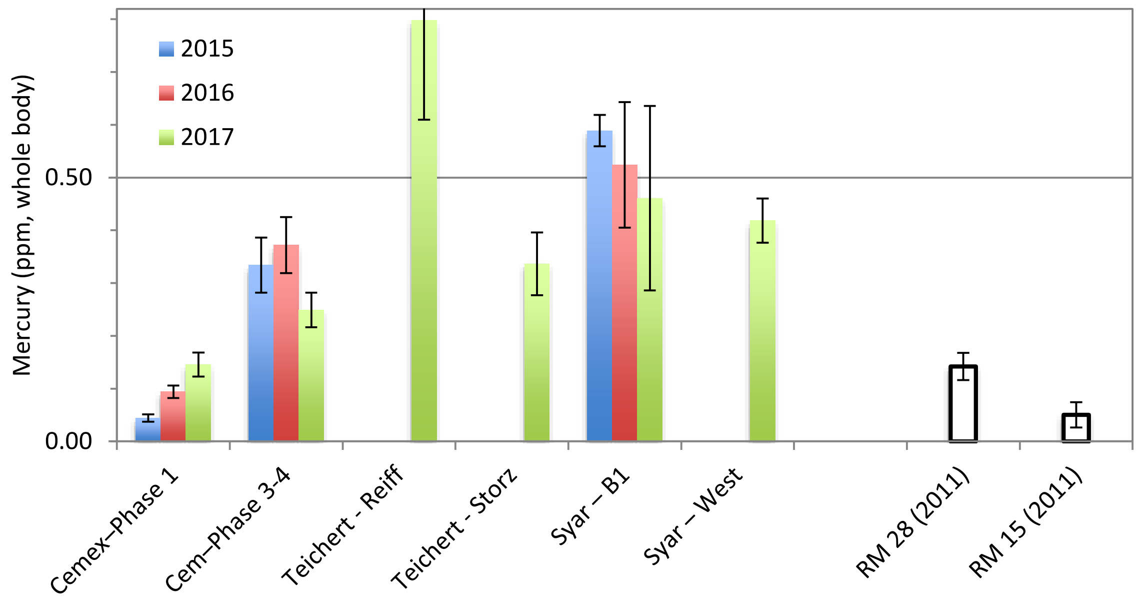

Figure 48. Juvenile Bass summary data (all sites) and historic creek comparisons *(means of multiple whole-body, multi-individual composite samples)*

Table 49. Juvenile Green Sunfish summary data (all sites) and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Green Sunfish (juveniles)							
Cemex – Phase 1 (West)	2017	**4**	8-10	47	1.9	**0.118**	± 0.023
Cemex – Phase 3-4 (East)	2015	**4**	10	47	1.8	**0.275**	± 0.022
Cemex – Phase 3-4 (East)	2016	**4**	4-5	49	2.0	**0.233**	± 0.026
Cemex – Phase 3-4 (East)	2017	**4**	2-6	36	0.7	**0.150**	± 0.051
Teichert – Reiff	2015	**–**	1	68	2.7	**0.241**	
Teichert – Reiff	2016	**–**	–	–	–	**–**	
Teichert – Reiff	2017	**–**	–	–	–	**–**	
Syar – B1	2015	**4**	8-9	47	1.7	**0.325**	± 0.097
Syar – B1	2016	**4**	4	50	1.9	**0.414**	± 0.076
Syar – B1	2017	**4**	6-7	40	1.0	**0.225**	± 0.069
Syar – West Pond	2017	**4**	5-10	45	1.7	**0.237**	± 0.077
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**4**	**53**	**2.8**	**0.139**	**± 0.014**
River Mile 20	**2011**	**4**	**4**	**58**	**3.4**	**0.084**	**± 0.004**
River Mile 17	2000-2002	8	5-10	41-90	1-6	0.169	± 0.045
River Mile 15	2000-2002	8	4-8	40-87	1-6	0.117	± 0.028
River Mile 15	**2011**	**4**	**4-5**	**56**	**3.1**	**0.086**	**± 0.018**

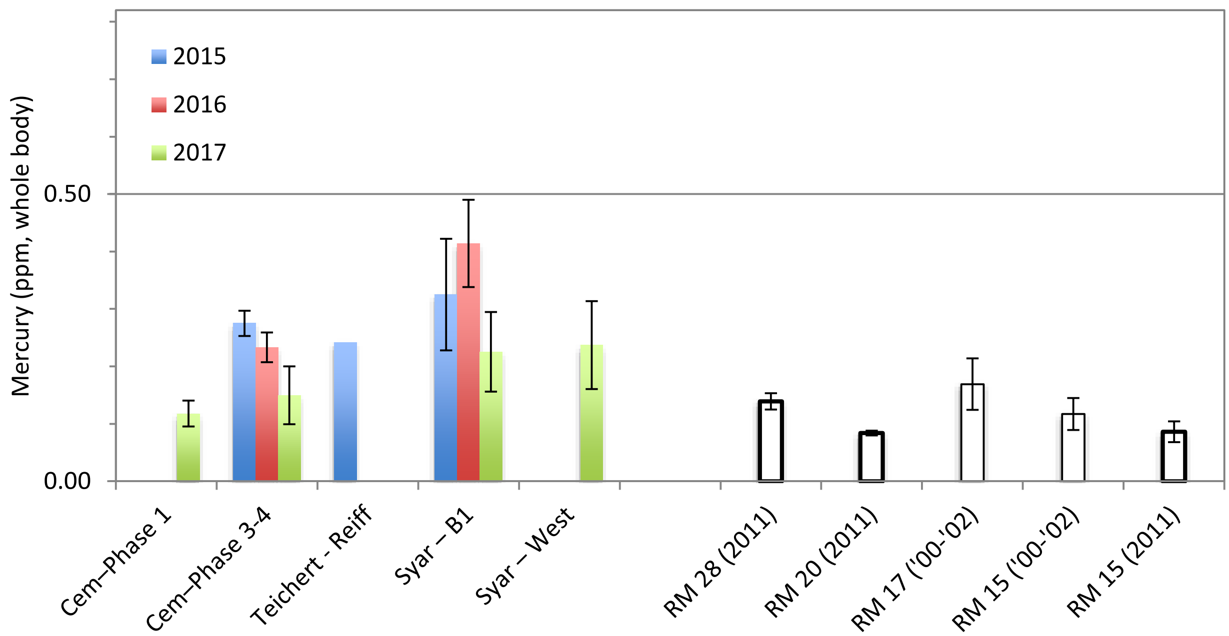

Figure 49. **Juv. Green Sunfish summary data (all sites) and historic creek comparisons** *(means of multiple whole-body, multi-individual composite samples)*

Table 50. Mosquitofish summary data (all sites) and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Cemex – Phase 1 (West)	2016	**4**	10	34	0.4	**0.093**	± 0.039
Cemex – Phase 1 (West)	2017	**4**	10	33	0.4	**0.135**	± 0.038
Cemex – Phase 3-4 (East)	2015	**4**	10	37	0.6	**0.228**	± 0.059
Cemex – Phase 3-4 (East)	2016	**4**	10	37	0.6	**0.157**	± 0.037
Cemex – Phase 3-4 (East)	2017	**4**	6-10	34	0.5	**0.286**	± 0.071
Teichert – Reiff	2015	**4**	12	38	0.6	**0.094**	± 0.010
Teichert – Reiff	2016	**4**	10	36	0.5	**0.212**	± 0.041
Teichert – Reiff	2017	**–**	–	–	–	**–**	
Teichert – Mast (NW)	2017	**4**	10	35	0.5	**0.351**	± 0.154
Teichert – Mast (SE)	2017	**4**	10	35	0.5	**0.273**	± 0.111
Teichert – Storz	2016	**4**	10	35	0.5	**0.229**	± 0.109
Teichert – Storz	2017	**4**	8-10	29	0.2	**0.282**	± 0.022
Syar – B1	2015	**4**	5-10	31	0.3	**0.268**	± 0.043
Syar – B1	2016	**–**	–	–	–	**–**	
Syar – B1	2017	**4**	9-10	35	0.4	**0.309**	± 0.110
Syar – West Pond	2017	**4**	10	34	0.4	**0.236**	± 0.068
Historic/Baseline Data							
River Mile 17	2000-2002	13	5-30	26-47	0.2-1.1	0.172	± 0.048
River Mile 15	2000-2002	10	5-30	26-47	0.2-1.0	0.094	± 0.029
River Mile 15	**2011**	**4**	**1-10**	**37**	**0.7**	**0.103**	**± 0.048**

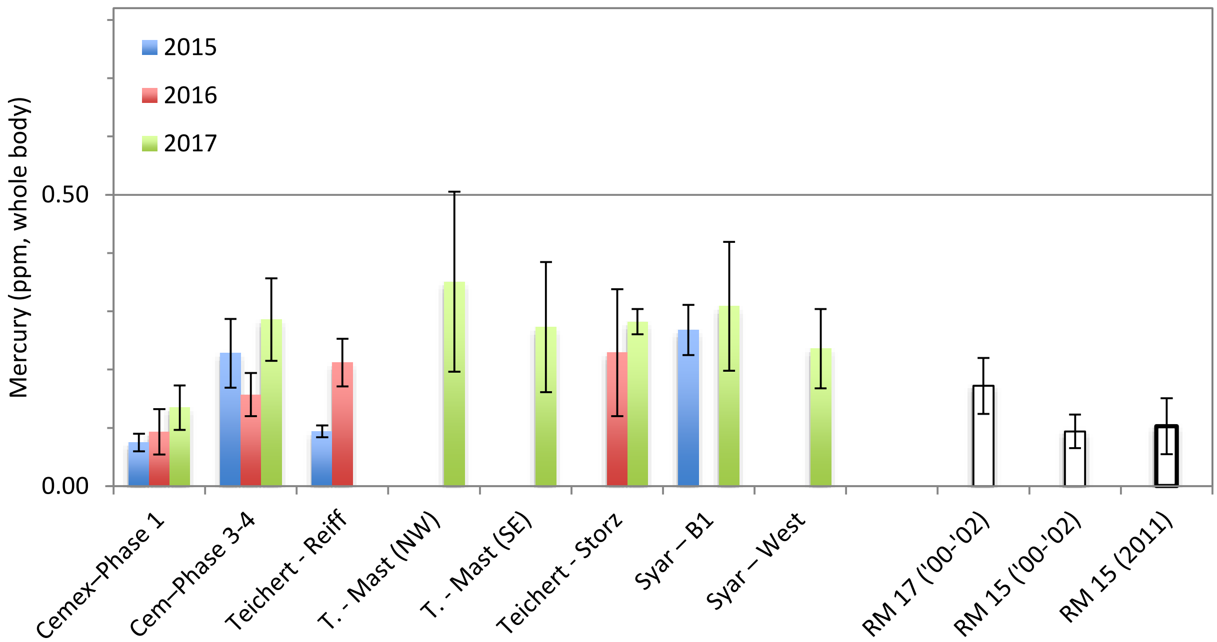

Figure 50. Mosquitofish summary data (all sites), and historic creek comparisons *(means of multiple whole-body, multi-individual composite samples)*

Table 51. Red Shiner summary data (all sites), and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)
'**n**' = *number: number of composite samples; number of individual fish per composite*

Site	Year	n (comps)	n (inds/ (comp)	Av Lgth (mm total)	Av Wt (grams)	Hg (µg/g = ppm, wet wt)	Std. Dev.
Red Shiners							
Teichert – Reiff	2015	**4**	10	50	1.3	**0.152**	± 0.018
Teichert – Reiff	2016	**4**	10	47	1.1	**0.412**	± 0.084
Teichert – Reiff	2017	**4**	10	49	1.1	**0.695**	± 0.141
Historic/Baseline Data							
River Mile 28	**2011**	**4**	**10**	**48**	**1.0**	**0.242**	**± 0.036**
River Mile 20	2000	3	9	42	0.6	0.166	± 0.003
River Mile 17	2000-2002	11	6-15	27-58	0.2-1.8	0.225	± 0.086
River Mile 15	1997	3	19	37	0.5	0.159	± 0.024
River Mile 15	2000-2002	13	6-12	30-60	0.2-2.0	0.131	± 0.033
River Mile 08	2000	4	10	42	0.7	0.123	± 0.016

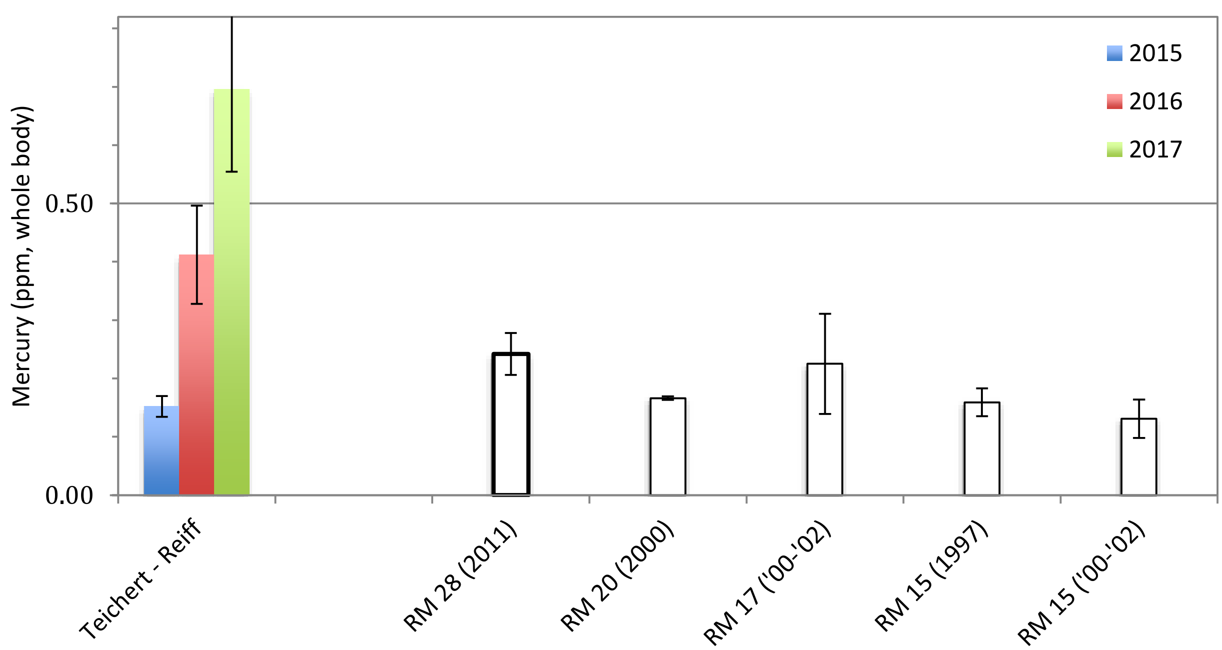

Figure 51. Red Shiner summary data (all sites), and historic creek comparisons
(means of multiple whole-body, multi-individual composite samples)

DISCUSSION AND CONCLUSIONS

There are now three years of fish mercury monitoring data from 4 of the 7 aggregate mining ponds identified by the County for annual monitoring: Cemex – Phase 1, Cemex – Phase 3-4, Teichert – Reiff, and Syar – B1. The Ordinance calls for action based on two years of data, as follows:

If the average fish specimen mercury content exceeds the statistically verified ambient mercury concentrations for comparable fish species (of similar size) collected within the CCRMP planning area for two (2) consecutive years, wet pit mining on property controlled by the mining operator/owner shall be suspended and the owner/operator shall either:

(g) Present a revised reclamation plan to the Yolo County Community Development Agency which provides for filling the reclaimed lake to a level five (5') feet above the average seasonal high groundwater level with a suitable backfill material;

or

(h) Present a mitigation plan to the Yolo County Community Development Agency which provides a feasible and reliable method or reducing methylmercury production or exposure to elevated mercury levels. Potential mitigation could include permanent aeration of the bottom levels of the lake, alteration of the water chemistry (increasing pH or dissolved organic carbon levels), control of anaerobic bacteria populations, or removal and replacement of affected fish populations. The mitigation plan would require review by the Regional Water Quality Control Board, California Department of Fish and Game, and the Yolo County Department of Environmental Health. (The removal and replacement of fish is not intended to be a long-term solution.)

The reclamation plan shall be modified such that the mitigation approved for methylmercury reduction shall be applied to all mining areas proposed for reclamation to permanent lakes within the reclamation plan. (§ 1, Ord. 1191, eff. September 5, 1996)

Last year, with two consecutive years of data from the initial four monitored ponds, those ponds were assessed for general mercury status relative to baseline creek controls. This was the conclusion at that time: "One of the 4 ponds – Cemex–Phase 1 – was clearly low in fish mercury, significantly lower than or similar to corresponding baseline samples from Cache Creek. One pond was clearly elevated, Syar-B1, significantly higher than corresponding baseline samples from the creek. The other two ponds, Cemex–Phase 3-4 and Teichert-Reiff, were more ambiguous, with a mixture of statistically similar and statistically higher fish mercury levels, relative to creek comparisons. Taken together for each pond, we interpret these mixed results as averaging to an elevation relative to the creek. We recognize that this is a consequential designation that might be argued differently. Part of the calculation is the fact that the primary large fish in these ponds, Largemouth Bass in Cemex – Phase 3-4 and White Catfish in Teichert – Reiff, had average mercury levels of 0.737-0.996 ppm across both sampling years, with individual fish ranging as high as 1.996 ppm. These are very high concentrations, in general and as compared to the 0.500 ppm level indicated as an initial threshold in the Ordinance."

The two ponds with "ambiguous" assessments following the 2015 and 2016 collections (Cemex – Phase 3-4 and Teichert – Reiff) both showed continued increases in fish mercury in 2017, placing them clearly in the "elevated" category, consistent with the previous assessments. Based on those assessments, the following recommendations were made in last year's report (in blue):

1. At this point, maintain mining activities as planned

At two of the identified higher mercury ponds, Syar – B1 and Teichert – Reiff, mining has been discontinued for a number of years, so suspension of activities is probably not an issue. At the third, Cemex – Phase 3-4, there has been and continues to be active mining. Initial disturbance of mercury-containing submerged sediments has been linked to temporary increases in methylmercury production and bioaccumulation (e.g. Eggleton and Thomas 2004, Mailman *et al.* 2006). However, in these Yolo County mining ponds, evidence suggests that suspension of mining may not lower the production and bioaccumulation of methylmercury, and could actually increase the problem. It is notable that the highest mercury site, Syar-B1, was idle since 2011 and had the clearest water of the ponds monitored. In contrast, the lowest mercury site, Cemex–Phase 1, received the plant silt and clay slurry from active mining and had the most turbid water. At least two factors linked to methylmercury production and bioavailability may be at play in these systems. First, active mining and slurry inflows likely disrupt warm season water column stratification, keeping active ponds relatively more mixed. This could slow or stop the seasonal development of anoxic bottom water zones and the production and movement of methylmercury into the water column (e.g. Perron *et al.* 2014, Hsu-Kim *et al.* 2018). Second, active mining and slurry inflows put a large amount of silt and clay into the water, resulting in the cloudy appearance.

These suspended particles contain surface charges that operate as binding sites for dissolved substances, including mercury. This can remove a fraction of inorganic and methyl mercury from the dissolved state, slowing both production and bioaccumulation (e.g. Rudd and Turner 1983). Water column profiling will help to better understand these processes, and others. In the meantime, observations to-date suggest that suspension of mining may not be helpful and could be counter-productive.

Since the time of that recommendation (2017), active mining remained on hold at the Teichert – Reiff, Syar – B1, and Cemex – Phase 1 ponds, and later went on hold at the Cemex – Phase 3-4 Pond as well. In addition, plant slurry discharges gradually slowed and ceased to the Cemex – Phase 1 and Teichert – Reiff ponds. These were/are the receiving waters for the Cemex and Teichert–Esparto processing plants. It appears that this transition has been accompanied by a rise in fish mercury at both locations.

2. Initiate water column profiling

The Ordinance called for water column profiling in each pond, beginning in Year 1 of monitoring. It was decided that this was premature until and unless a problem was identified. At this point, profiling is clearly warranted to help identify factors linked to elevated fish mercury in some ponds and lower mercury in others. We recommend that this work be started at:

– the 1 very elevated mercury pond (Syar – B1),

– the 2 other identified elevated mercury ponds (Teichert – Reiff and Cemex – Phase 3-4),

– the lower mercury Cemex – Phase 1 Pond (for comparison purposes).

This will provide a range of fish mercury conditions to compare water quality results to.

Water column profiling should include a determination of pond bottom depth and sequential water quality data collection at approximately every meter from surface to bottom. A time period of May through October is recommended, in order to follow lake condition across the typical warm season cycle for this region (this is longer than the June-September period listed in the Ordinance). This period could be well characterized with 5 water column profiling events per year, distributed approximately every 6 weeks between early May and late October.

Two key parameters to profile from surface to bottom are temperature and dissolved oxygen, because one of the most important potential mercury issues in ponds and lakes is the phenomenon of warm season thermal stratification (annual physical separation, like oil and water, of sun-warmed upper waters from cool deep waters). This can lead to the depletion of oxygen in the isolated bottom water through normal microbial metabolism, and the production and movement of methylmercury into that anoxic water, and then into the food web. Other important water quality parameters to profile include:

– Conductivity, a measure of dissolved ions
– pH, a measure of how acidic or basic the water is
– ORP, oxidation-reduction potential, which effects chemical reactions
– Suspended Solids and/or Turbidity, measuring particle density in the water
– DOM, Dissolved Organic Matter, closely linked to methylmercury
– Algal density: chlorophyll and/or phycocyanin (blue-green algae)

Nutrient ions like nitrate would also be useful. Results of the profiling may indicate additional water parameters that could be useful to test in the future to help determine appropriate mitigation approaches.

Water column profiling was initiated in 2018, as described above. The four ponds with multiple years of fish mercury data were tested seasonally, five times between May and October.

3. Characterize pond bottom sediment

At the ponds being tested for water column parameters, some basic information about the bottom sediments will be essential, to see if there are any large differences between the ponds that could help account for the mercury bioaccumulation patterns. It is recommended, for each pond, that 6 independent bottom samples be taken from locations distributed across the pond, specifically of fine-grained surficial sediments (top 2 cm). These should be analyzed for total mercury and organic matter content, on a dry weight basis. Additional sediment analyses may be warranted in the future to help determine appropriate mitigation approaches.

Sediment characterization and analysis was conducted in Fall 2018.

The Ordinance states that operators of identified elevated-mercury ponds:

(g) Present a revised reclamation plan to the Yolo County Community Development Agency which provides for filling the reclaimed lake to a level five (5') feet above the average seasonal high groundwater level with a suitable backfill material; or

(h) Present a mitigation plan to the Yolo County Community Development Agency which provides a feasible and reliable method or reducing methylmercury production or exposure to elevated mercury levels.

A realistic mitigation approach cannot be developed without site-specific information. It is this monitoring and research team's opinion that the above recommended steps should be considered the first phase of mitigation.

The last line of the Ordinance states:

The reclamation plan shall be modified such that the mitigation approved for methylmercury reduction shall be applied to all mining areas proposed for reclamation to permanent lakes within the reclamation plan. (§ 1, Ord. 1191, eff. September 5, 1996)

We now understand that each aquatic system has its own unique mercury dynamics. It is probably not appropriate to apply one mitigation, that may be feasible in one system, to another, very different water body. For example, a deep lake thermal destratification technique is not applicable to lakes that have no anoxic bottom waters. Similar water bodies may benefit from the same mitigation approach, but each should be assessed, and mitigated, individually.

REFERENCES CITED

Cooke, J., C. Foe, S. Stanish, and P. Morris. 2004. Cache Creek, Bear Creek, and Harley Gulch TMDL for Mercury, Staff Report. *California Environmental Protection Agency, Regional Water Quality Control Board, Central Valley Region*. 135 pp.

Eggleton, J. and K.V. Thomas. 2004. A review of factors affecting the release and bioavailability of contaminants during sediment disturbance events. *Environment International*, 30(7): 973-980.

Hsu-Kim, H., C.S. Eckley, D. Achá, X. Feng, C.C. Gilmour, S. Jonsson, C.P.J. Mitchell. 2018. Challenges and opportunities for managing aquatic mercury pollution in altered landscapes. *Ambio*, 47(2): 141-169.

Mailman, M., L. Stepnuk, N. Cicek, R.A. (Drew) Bodaly. 2006. Strategies to lower methyl mercury concentrations in hydroelectric reservoirs and lakes: A review. *Science of the Total Environment*, 368(1): 224-235.

OCMP. 1996. Off-Channel Gravel Pit Lakes – Mercury Considerations. Lower Cache Creek. *Yolo County California. Preliminary Study, April 1996, document date May 2, 1996, Appendix C in the OCMP FEIR.*

Perron, T., J. Chételat, J. Gunn, B.E. Beisner, and M. Amyot. 2014. Effects of Experimental Thermocline and Oxycline Deepening on Methylmercury Bioaccumulation in a Canadian Shield Lake. *Environmental Science and Technology*, 48(5): 2626–2634.

Rudd, J.W.M. and M.A. Turner. 1983. The English–Wabigoon River System: II. Suppression of Mercury and Selenium Bioaccumulation by Suspended and Bottom Sediments. *Canadian Journal of Fisheries and Aquatic Sciences*, 40(12): 2218-2227.

Slotton, D.G., S.M. Ayers, and J.E. Reuter. 1997. Mercury in lower Cache Creek biota: baseline assessment, Fall 1997. *Report prepared for Yolo County Planning Dept.*, December 1997, 28 pp.

Slotton, D.G., S.M. Ayers, J.E. Reuter, and C.R. Goldman. 2002. Environmental monitoring for mercury in water, sediment, and biota in Davis Creek and Davis Creek Reservoir. *Report for Yolo County*. 99 pp. (similar reports from 1987-2001).

Slotton, D.G., S.M. Ayers, T.H. Suchanek, R.D. Weyand, and A.M. Liston. 2004. Mercury bioaccumulation and trophic transfer in the Cache Creek watershed of California, in relation to diverse aqueous mercury exposure conditions. *Report for the CALFED Bay-Delta Agency*. 137 pp.

Slotton, D.G., and S.M. Ayers. 2004. Cache Creek Nature Preserve pilot mercury monitoring program: sixth and final semi-annual data report, spring - summer 2003, with three-year project overview. *Report for Yolo County*. 56 pp.

Slotton, D.G., and S.M. Ayers. 2013. Lower Cache Creek 2011-2012 Baseline Mercury Monitoring. *Report for Yolo County*. 66 pp.

Slotton, D.G., S.M. Ayers, and R.D. Weyand. (2015 edition). Quality Assurance Project Plan (QAPP) for UC Davis Biosentinel Mercury Monitoring, including Standard Operating Procedures (SOPs). 31 pp.

Slotton, D.G., and S.M. Ayers. 2017. Cache Creek Off-Channel Aggregate Mining Ponds – 2015 Mercury Monitoring; final draft May 2017. *Report for Yolo County*. 61 pp.

Slotton, D.G., and S.M. Ayers. 2018. Cache Creek Off-Channel Aggregate Mining Ponds – 2016 Mercury Monitoring; final draft March 2018. *Report for Yolo County*. 100 pp.

Yolo County Code, Title 10. Chapter 5 (Surface Mining Reclamation), Section 10.5.517. 1996. Mercury Bioaccumulation in Wildlife.

APPENDIX A

Yolo County, CA Code of Ordinances

Sec. 10-5.517. Mercury Bioaccumulation in Wildlife

Yolo County, CA Code of Ordinances.
Sec. 10-5.517. Mercury Bioaccumulation in Wildlife.

Prior to the approval of reclamation of aggregate mining areas to permanent lakes, the County shall commission a sampling and analysis program, to be implemented in one existing wet pit mining area within the OCMP planning area, to evaluate the potential for increased methylmercury production associated with wet pit mining and reclamation of mining areas to permanent lakes. The program shall include the sampling of water and sediments from the bottom of the existing pit and analysis of the samples for organic content; pH; dissolved oxygen content; dissolved carbon content; and total mercury. In addition, samples of predatory fish (preferably largemouth bass) shall be collected and analyzed for mercury and methylmercury content.

If the initial sampling indicates either of the following conditions, the County shall perform verification sampling:

(a) Average concentrations of total mercury in excess of 0.000012 milligrams per liter (mg/l) in the water; and

(b) Average mercury levels in fish samples in excess of 0.5 milligrams per kilogram (mg/kg).

If verification sampling indicates exceedance of these mercury criteria, the County shall approve the reclamation of mining areas to permanent lakes only if the average level of mercury in fish collected from the existing mining pits is shown to be equal to or less than ambient (background) mercury levels determined from a representative sample of similar species of fish (of similar size) collected in the Cache Creek channel within the planning area.

The determination of the ambient mercury level shall be performed by the County prior to the excavation of any new wet pit mine and at years ten (10), twenty (20) and thirty (30) in the permit time period, and shall be paid for by the mining permit operators on a fair-share basis. The County shall evaluate available data to determine any significant change in ambient concentrations of mercury in fish within the Cache Creek channel.

In the event of approval of reclamation of mined areas to permanent lakes, each mining area to be reclaimed to a permanent lake as part of each approved long-range mining plan shall be evaluated annually by the operator for five (5) years after creation of the lake for conditions that could result in significant methylmercury production.

An additional ten (10) years of biennial monitoring shall be performed after reclamation of each lake has been completed.

The evaluations shall be conducted by a qualified aquatic biologist or limnologist acceptable to the County and shall include the following analyses:

(c) Lake condition profiling during the period of June through September, including

measurements of pH; eH (or redox potential); temperature; dissolved oxygen; and total dissolved carbon.

(d) Collection of a representative sample of fish specimens (including a minimum of five (5) predator fish if available) and analysis of the specimens for mercury content. Sampling and analysis shall be conducted using methodologies which are consistent with the California State Water Resources Control Board Toxic Substances Monitoring Program procedures, or more stringent procedures.

(e) The results of the evaluation shall be summarized in a report and submitted to the County. The report shall include a comparison of the site-specific data to available data on the background concentrations of mercury in fish within the Cache Creek watershed. The County shall be responsible for submitting the data on mercury levels in fish to the California Department of Fish and Game and the Office of Environmental Health Hazard Assessment for a determination of whether a fish advisory should be issued.

(f) If a fish advisory is issued, the owner/operator shall be required to post warnings on fences surrounding the mining pit lakes which prohibit fishing in the lakes and describe the fish advisory.

If the average fish specimen mercury content exceeds the statistically verified ambient mercury concentrations for comparable fish species (of similar size) collected within the CCRMP planning area for two (2) consecutive years, wet pit mining on property controlled by the mining operator/owner shall be suspended and the owner/operator shall either:

(g) Present a revised reclamation plan to the Yolo County Community Development Agency which provides for filling the reclaimed lake to a level five (5') feet above the average seasonal high groundwater level with a suitable backfill material; or

(h) Present a mitigation plan to the Yolo County Community Development Agency which provides a feasible and reliable method or reducing methylmercury production or exposure to elevated mercury levels. Potential mitigation could include permanent aeration of the bottom levels of the lake, alteration of the water chemistry (increasing pH or dissolved organic carbon levels), control of anaerobic bacteria populations, or removal and replacement of affected fish populations. The mitigation plan would require review by the Regional Water Quality Control Board, California Department of Fish and Game, and the Yolo County Department of Environmental Health. (The removal and replacement of fish is not intended to be a long-term solution.)

The reclamation plan shall be modified such that the mitigation approved for methylmercury reduction shall be applied to all mining areas proposed for reclamation to permanent lakes within the reclamation plan. (§ 1, Ord. 1191, eff. September 5, 1996)

APPENDIX B

REPRESENTATIVE PHOTOS OF THE FALL 2017 MONITORING

FIELD WORK AND SITE PHOTOS

A1. Getting boat down to the pond; Teichert – Reiff

A2. Getting boat into the water

A3. Boat into Teichert – Storz Pond

A4. Teichert – Storz Pond

A5. Seining for small fish

A6. Muddy seining

A7. Seining with boat-assist; Cemex – Phase 1 (West) Pond

A8. Boat-assisted seining; Teichert – Reiff Pond

A9. Deploying a net; Cemex Phase 3-4 (East) Pond

A10. Towing a net

A11. Using a baited set-line to collect catfish

A12. Syar – West Pond

REPRESENTATIVE 2017 FISH SAMPLES

A13. Channel Catfish; Cemex – Phase 1 (West) Pond

A14. White Catfish; Teichert – Reiff Pond

A15. Largemouth Bass; Syar – West Pond

A16. Largemouth Bass; Cemex – Phase 3-4 (East) Pond

A17. Largemouth Bass; Teichert – Reiff Pond

A18. Carp; Teichert – Reiff Pond

A19. Mosquitofish Composites A, B, C, D; Mast Southeast

A20. Mosquitofish Composites; Mast Northwest

A21. Red Shiner Composites A, B, C, D; Reiff Pond


4DK8570