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# Pollutants of Concern Monitoring Data Report, Water Years 2021 and 2022


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## Executive Summary

Following the adoption of polychlorinated biphenyl (PCB) and mercury (Hg) TMDLs for San Francisco Bay (SFBRWQCB, 2006, 2007), which mandate significant reductions in stormwater loads by 2028–2030, the Regional Water Board issued the first Municipal Regional Stormwater Permit (MRP) in 2009. The permit included provisions to improve information on PCB and Hg sources and loads and to identify and abate areas contaminated with these pollutants. To support these provisions, the Regional Monitoring Program for the San Francisco Bay (RMP) has conducted stormwater quality monitoring in smaller watersheds with a history of older industrial land use through a reconnaissance-style sampling program, in which a composite sample from a single storm is collected at each site. This report presents findings from Water Years (WYs) 2021 and 2022 and builds on previous efforts from WYs 2015–2020.

Sampling during this period was disrupted by the COVID-19 pandemic. To improve cost efficiency, data from multiple years were grouped for processing rather than reported annually. These data represent the final phase of the reconnaissance sampling approach for PCBs and Hg. Future monitoring will shift toward fixed-station sampling to better support watershed load model calibration and load estimation for PCBs, total mercury (HgT), and Contaminants of Emerging Concern (CECs).

During WYs 2021 and 2022, seven sites were sampled, including two in Marin County, expanding the program's geographic scope. Drainage areas ranged from 0.51 to 16.2 km², with old industrial land use ranging from 0% to 18.8% of each watershed. Five sites were sampled manually, and two were sampled using remote suspended-sediment samplers.

Suspended sediment concentrations (SSC) at the five manually monitored sites ranged from 31 to 175 mg/L, consistent with previous Bay Area urban stormwater observations. Total PCB concentrations (sum of 40 congeners) ranged from 1.7 to 18 ng/L, with estimated particle concentrations (EPCs) between 55 and 265 ng/g, within the medium-to-low range of previous observations. Total Hg concentrations at four sites ranged from 32 to 57 ng/L, with EPCs from 200 to 1,192 ng/g. Kerner Pump Station had the highest HgT concentration and EPC; higher concentrations have only been recorded at three other RMP/SFEI sampling sites since WY 2003. Because the 0.51 km² Kerner watershed contains no old industrial land use, HgT sources are likely associated with newer industrial (18%) or older residential, commercial, and transportation areas. This finding may warrant follow-up by the Marin County Stormwater Program.

At Sunnyvale East Channel at Ahwanee Ave, a former fixed-station site (WYs 2012–2014), five discrete samples were collected during a single early-winter storm in WY 2022. Previous sampling at this location identified elevated PCB concentrations. PCB EPCs measured during the WY 2022 event were within the lower range observed during 2011–2014, suggesting a possible decline. However, given the complexity of watershed transport processes, additional sampling across a broader range of storm conditions would be needed to evaluate long-term trends.

This document focuses mostly on findings from WYs 2021–2022. A comprehensive summary of data collected through WY 2020 is available in the previous Progress Report (Gilbreath et al., 2021).

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## 1. Introduction

The San Francisco Bay PCB and mercury TMDLs (SFBRWQCB, 2006, 2007) require reducing stormwater PCB loads from 20 kg/year to 2 kg by 2030, and mercury loads from 160 kg to 80 kg by 2028. Following TMDL adoption, in 2009, the Regional Water Board issued the first Municipal Regional Stormwater Permit (MRP) for Phase I MS4 agencies (SFBRWQCB, 2009, 2011). MRP 1.0 included provisions for improved data on pollutant loads (C.8) and targeted reductions in Hg and PCBs (C.11, C.12) from urban tributaries. To support these requirements, four management questions were developed (SFEI, 2009), and revised in 2015 and 2024 (Gilbreath et al., 2024):

MQ1: What are the sources, pathways, and loadings of pollutants and sediment to the Bay?
MQ2: Which are the priority sources and pathways of pollutants that adversely impact or potentially adversely impact the Bay's environmental quality?
MQ3: What are the management actions that could be implemented in the region to address pollutant pathways and sources, and where would they have the greatest benefit?
MQ4: Are levels of individual pollutants or pollutant classes changing over time in the sources, pathways, and loadings? What factors or management interventions have contributed to the change?

Concerning MQ2, this report presents stormwater quality data on PCBs, HgT, and suspended sediment concentration (SSC) collected during Water Years (WYs) 2021 and 2022, as a continuation of the reconnaissance-style sampling program that had been ongoing since WY 2015 and first designed and used in WY 2011 (McKee et al., 2012). A comprehensive summary of data collected through WY 2020 is available in the 2021 Progress Report (Gilbreath et al., 2021); therefore, this document focuses exclusively on findings from the subsequent two water years.

The sampling efforts during WYs 2021 and 2022 were notably affected by the COVID-19 pandemic. Health and safety restrictions limited staff's ability to travel together to sampling sites, reduced opportunities for close collaboration in the field, and caused significant staffing challenges due to illness and remote-work constraints. These same challenges also affected sample handling upon return to SFEI, shipping, and laboratory operations, leading to delays in sample processing and analysis. In addition to pandemic-related disruptions, reporting was deferred to achieve cost savings by grouping a few samples collected each WY into a single dataset, with a total of seven sampling sites, for data formatting, quality assurance, and upload to the California Environmental Data Exchange Network (CEDEN).

In parallel, the RMP funded a data analysis project to mine and reinterpret existing stormwater PCB data to help guide management decisions (MQ3). The primary goal was to develop improved methods for identifying and ranking priority watersheds for further investigation and future sampling. Two methods were developed: a congener profile method (Davis & Gilbreath, 2019) and a loads and yields-based method (McKee et al., 2019), which were then applied to rank watersheds (McKee et al., 2022). The resulting ranking database will soon be updated with the additional data reported here (McKee and Gilbreath, in preparation).

These two years of additional reconnaissance data mark the final phase of the reconnaissance-style sampling effort for PCBs and Hg for the foreseeable future. However, ongoing sample capture using the reconnaissance sampling style continues for CECs, and PCBs and Hg may be included as CEC add-ons. For PCBs and Hg, there is a planned shift in focus back to a more intensive sampling approach at fixed stations (Gilbreath et al., 2016). The fixed station approach is designed to quantify within- and between-storm concentration variability, better support and refine watershed loading model calibration, support pollutant load estimation, and support trend analysis, as opposed to the reconnaissance sampling strategy of collecting a single sample from many sampling sites to assess the relative concentrations in relation to various stormwater pollutant sources.

# 2. Methods

## 2.1 Selecting Sampling Sites

Four objectives have been used as a basis for site selection for reconnaissance sampling, including:

1. Identifying potential high-leverage watersheds and catchments,
2. Sampling strategic large watersheds to support calibration of regional models,
3. Validating unexpected low (potential false negative) concentrations to address the possibility of a single storm composite poorly characterizing a sampling location, and
4. Filling data gaps along environmental gradients of land use distributions.

During WYs 2021 and 2022, the RMP selected seven sampling sites. Three were repeat sites to support regional modeling (Objective 2), and two were in Marin County to expand the sampled geography beyond the counties of previous focus (Contra Costa, Alameda, Santa Clara, and San Mateo) (Gilbreath et al., 2021). The drainage area for each sampling location ranged from 0.51 to 12 $km^2$ (Table 1; Figure 1). Together, residential and commercial land uses comprised 50% or more of each watershed. The percentage of old industrial[1] area in watersheds/catchments ranged from 0% to 18.8% (the land use dataset used in this analysis (ABAG 2006) is consistent with that used as input to the Regional Watershed Spreadsheet Model) (SFEI, 2018).

[1] To help Permittees identify potential POC sources and source areas, several GIS data layers were developed using historical and current land use and facility information for the Bay Area. These included: (1) a revised "Old Industrial" layer representing industrial areas present in 1968; (2) an "Old Urban" layer depicting urban development present by 1974 outside Old Industrial areas; (3) point locations of facilities that may currently have, or historically have had, PCBs on-site; and (4) historical and current rail lines that may have transported PCBs.

The Old Industrial layer was developed using three primary data sources: 2005 Association of Bay Area Governments (ABAG) land use data, 1968 aerial photographs from the USGS Earth Explorer website, and current County Assessor parcel data. Two supporting datasets were created: one identifying industrial areas visible in 1968 but not classified as industrial by ABAG, and another identifying areas classified as industrial by ABAG in 2005 that were non-industrial in 1968, most commonly agricultural lands later converted to industrial use.

Parcels identified as industrial in 1968 were visually reviewed and refined to improve accuracy. Where land use was uncertain, ABAG classifications were used. As a final quality check, 1968 and current aerial photographs were compared, and redeveloped parcels were attributed with their current land use.

## 2.2 Field Methods

### 2.2.1 Mobilization and Preparing to Sample

Mobilization for sampling was typically triggered by storm forecasts with a minimum rainfall of at least one-half inch[2] over 6 hours. Ideally, field teams reached the sampling site about one hour before rainfall began. Sampling sites were sampled by attaching laboratory-prepared trace-metal-clean Teflon sampling tubing to a painter's pole and a peristaltic pump with laboratory-cleaned silicone pump-roller tubing. During sampling, the tube was dipped into the channel or drainage line at mid-channel mid-depth (if shallow) or, if the depth allowed (>0.5m), the tube was passed up and down through the water column at an even rate until the sub-sample was completed.

### 2.2.2 Manual Time-paced Composite Stormwater Sampling Procedures

At four of the seven sampling sites, manual composite samples were collected using a variable number of sub-samples and approximately time-paced. Based on weather forecasts, on-site conditions, and weather radar, field staff estimated storm duration and selected aliquot size (0.1–0.5 L) and quantity to meet minimum volume requirements: HgT (0.25 L), SSC (0.3 L), and PCBs (1 L). Since bottle volumes exceeded these minimums, extra aliquots could be added if storms lasted longer than expected. Aliquot volume was set before the first sub-sample and fixed throughout; the interval between aliquots was set before the second sub-sample. All subsamples were collected into a single bottle, kept on ice, and refrigerated at 4 °C before lab transport. See Yee et al. (2017) for bottle, preservative, and hold time details.

### 2.2.3 Manual Discrete Stormwater Sampling Procedures

At Sunnyvale East Channel, discrete (non-composited) samples were collected and analyzed separately. Unlike composite sampling, field staff used judgment based on stage and turbidity to collect samples during the rising, peak, and falling stages of the hydrograph. Four discrete samples were collected on October 21st, 2021, and a fifth occurred just after midnight to complete a characterization of that one early winter storm. These data complement data previously collected at this site in WY 2011 (McKee et al., 2012) and in WYs 2012, 2013, and 2014 (Gilbreath et al., 2016).

### 2.2.4 Remote Sampler Sampling

In WY 2021, remote-sampling devices (Walling Tubes) were deployed at two Alameda County sampling sites (End of Eden Park Place and Zone 9 Line C at Juniper St.), following previously developed methods (Gilbreath et al., 2019). Of the two tested devices, the Walling Tube (Phillips et al., 2000) performed best under typical urban and small-tributary conditions in the San Francisco Bay. Deployed mid-channel and secured with hose clamps and rebar, the samplers trapped fine sediment. Collected water and sediment were decanted, split into lab containers, and analyzed as whole-water samples due to low sediment mass.

[2] This was relaxed in some years due to a lack of larger storms.

**Table 1.** Characteristics of the sampling sites sampled in WYs 2021 and 2022. Meeker Slough, Santa Fe Channel, and Sunnyvale East Channel watershed characteristics have been slightly altered since the WY 2020 report (Gilbreath et al., 2021) due to improved mapping data received from the corresponding cities.

| Watershed | County | Latitude | Longitude | Area (km2) | Open Space | Residential | Commercial | Industrial | Transportation |
|---|---|---|---|---|---|---|---|---|---|
| Kerner Pump Station | Marin | 37.9660 | -122.5073 | 0.51 | 2% | 22% | 33% | 18% | 26% |
| Canal Pump Station | Marin | 37.9673 | -122.4996 | 1.39 | 9% | 12% | 38% | 9% | 33% |
| Meeker Slough at Regatta Blvd. (Repeat) | Contra Costa | 37.9178 | -122.3383 | 7.01 | 4% | 44% | 12% | 9% | 32% |
| Santa Fe Channel Stormdrain at South 8th St. (Repeat) | Contra Costa | 37.9266 | -122.3620 | 2.15 | 3% | 44% | 18% | 5% | 31% |
| End of Eden Park Place | Alameda | 37.6102 | -122.0901 | 5.65 | 17% | 35% | 15% | 13% | 20% |
| Zone 9 Line C at Juniper St. | Alameda | 37.6927 | -122.1599 | 3.32 | 2% | 47% | 9% | 23% | 19% |
| Sunnyvale East Channel at Ahwanee Ave. (Repeat) | Santa Clara | 37.3947 | -122.0104 | 12.02 | 2% | 51% | 19% | 6% | 22% |

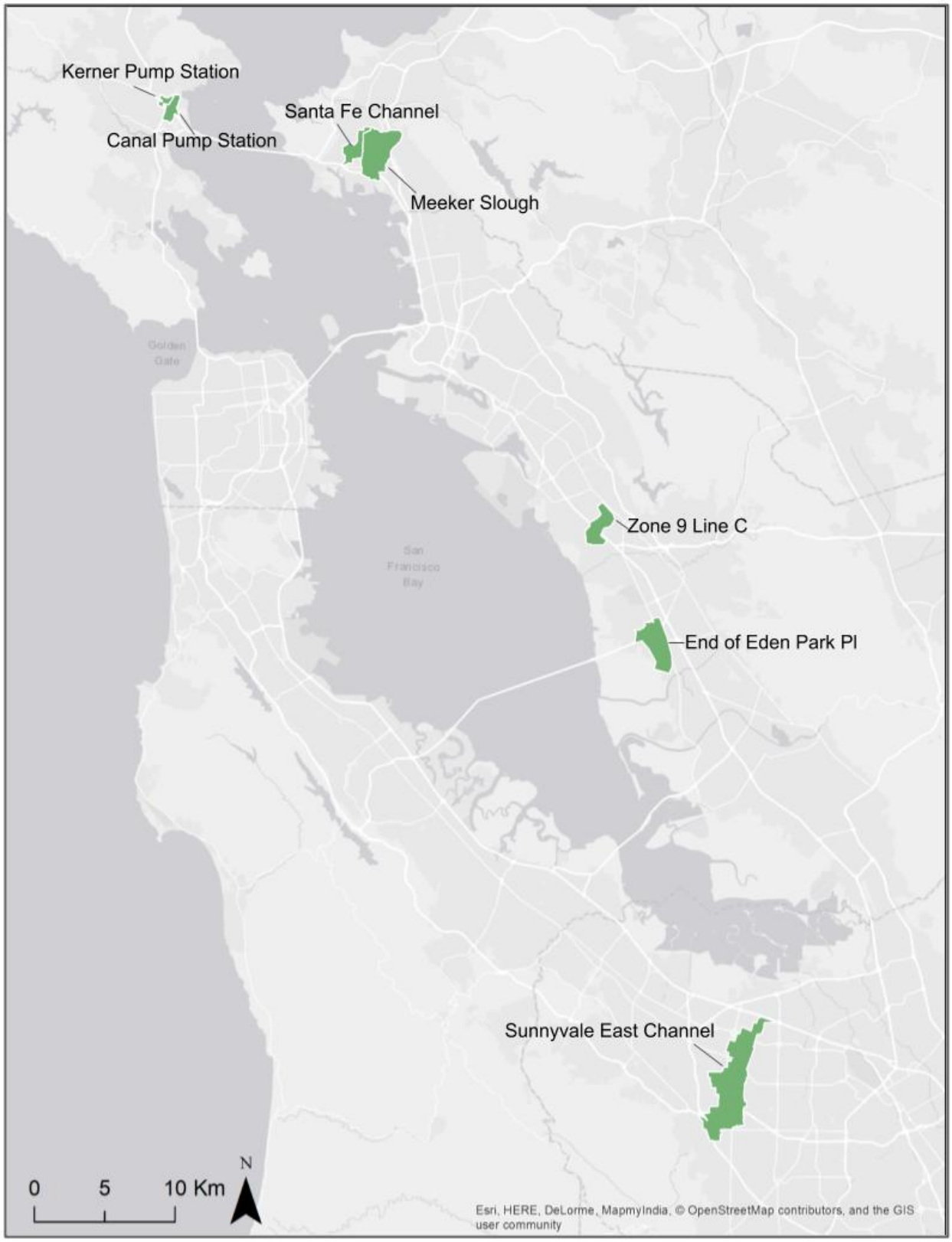



**Figure 1.** Watersheds/catchments sampled in Water Years 2021 and 2022.

## 2.3 Analytical Methods and Quality Assurance

### 2.3.1 Analytical Chemistry Methods and Contracted Analytical Laboratories

As noted earlier, samples were analyzed for PCBs, HgT, and SSC (Table 3). Methods were selected based on detection limits, accuracy, precision, and cost. PCB analysis included the 40 RMP-specified congeners or all 209 congeners, while HgT was sampled and analyzed using EPA-approved trace clean techniques. SSC was analyzed using EPA- or ASTM-approved methods, which are considered equivalent. Detailed methods and quality control procedures are outlined in the RMP Quality Assurance Program Plan (Yee et al., 2019).

**Table 2.** Laboratory analysis methods of whole water samples (no filtering).

| Analysis | Matrix | Analytical Method | Lab[3] | Field Preservation | Contract Lab / Preservation Hold Time |
|---|---|---|---|---|---|
| PCBs (40)[4]-Total | Water | SGS AXYS MLA-010 (EPA 1668) | SGS AXYS | NA | NA |
| PCBs (209)-Total | Water | SGS AXYS MLA-010 (EPA 1668) | SGS AXYS | NA | NA |
| Mercury-Total | Water | EPA 1631E | BAL | NA | BRL preservation with BrCl within 28 days |
| SSC | Water | ASTM D3977 | USGS | NA | NA |
| SSC | Water | EPA 160.2 M (modified) | SFEI | NA | NA |

### 2.3.2 Quality Assurance Results: PCBs WYs 2021 and 2022

The PCBs data were evaluated for quality assurance and were overall deemed acceptable. All WY21 data and eight of the WY22 field samples, along with three of the WY22 field blind duplicates were reported for 72 congeners; two of the WY22 field samples and one of the WY22 field blind duplicates were reported for all 209 congeners. PCB 063 had the lowest detection rate among WY21 PCB samples at 79%. PCB 014, PCB 023, PCB 034, PCB 038, PCB 054, PCB 057, PCB 058, PCB 073, PCB 078, PCB 080, PCB 081, PCB 104, PCB 106, PCB 111, PCB 112, PCB 120, PCB 121, PCB 123, PCB 126, PCB 127, PCB 142, PCB 145, PCB 148, PCB 161, PCB 165, PCB 169, PCB 186, PCB 192, and PCB 204 were all not detected in all WY 2022 samples that were reported for 209 congeners, though only eight of these were 100% ND for the whole batch (which included WY23 samples). About half of the target congeners appeared in lab or field blanks or both, but at low levels—typically <10× method detection limit (MDL) and all were <⅓ of field sample concentrations. No lab replicates were analyzed; only blind field duplicates were used, for which two analytes in the batch for PCB 40 analysis had relative percent difference (RPD) on field replicates outside the target 35% on average (PCB 008, which was about 15x MDL, with 113% RPD; PCB 194 with an average 36% target RPD). For the batch for PCB 209 analysis, for all congeners detected at least 3x the MDL, all had RPDs of 30% or less, within the target of 35%. Since field duplicates are rarely

[3] Labs and locations: SGS AXYS, British Columbia, Canada; Brooks Applied Labs, Bothell, WA; USGS, Santa Cruz, CA.
[4] Samples were analyzed for 40 PCB congeners (PCB-8, PCB-18, PCB-28, PCB-31, PCB-33, PCB-44, PCB-49, PCB-52, PCB-56, PCB-60, PCB-66, PCB-70, PCB-74, PCB-87, PCB-95, PCB-97, PCB-99, PCB-101, PCB-105, PCB-110, PCB-118, PCB-128, PCB-132, PCB-138, PCB-141, PCB-149, PCB-151, PCB-153, PCB-156, PCB-158, PCB-170, PCB-174, PCB-177, PCB-180, PCB-183, PCB-187, PCB-194, PCB-195, PCB-201, PCB-203).

perfectly concurrent, these challenges are typical of PCB analyses in RMP samples, not extreme, and thus the data were deemed acceptable.

#### 2.3.3 Quality Assurance Results: Total Mercury WY 2022

The HgT data were evaluated for quality assurance and were overall deemed acceptable. There was no HgT in the method blanks. There were no field blanks. HgT recovery in one laboratory control sample (LCSs) was good, with an error of just 7%, well below the measurement quality objective (MQO) of 35%. Precision for mercury was assessed using laboratory replicates of a field sample and matrix spike. The relative percent difference for both duplicates was 5%, again well below the 35% MQO. This level of data quality is overall excellent.

#### 2.3.4 Quality Assurance Results: SSC WYs 2021 and 2022

The SSC dataset was deemed acceptable, with successful detections in all field samples. In WY 2021, QA samples included one blind field duplicate and two lab blanks—all blanks were non-detects. Duplicate samples both measured 43 mg/L, yielding an RPD of 0%. In 2022, QA included one blind field duplicate and no lab blanks. Seven of eight laboratory control samples were within ±5 % of 100% recovery; one was at 70%. Duplicate concentrations were 46 and 50 mg/L, with an RPD of 8.3%. As is typical for SSC sampling and analysis, data quality was excellent.

### 2.4 Interpretive methods

The reconnaissance monitoring protocol collects a single composite whole-water sample per analyte during a single storm at each site to characterize stormflow concentrations. PCB and HgT concentrations can vary greatly between storms due to storm size, intensity, and prior conditions, and this variability isn't captured in a single sample. However, normalizing concentrations to SSC reduces variability by estimating pollutant levels associated with particles. This EPC, which represents the pollutant mass per sediment mass, exhibits less inter-storm variability than whole-water concentrations and is likely a more accurate indicator of site water quality for strongly sorbed pollutants (McKee et al., 2012, 2016; Rügner et al., 2013). Thus, EPC was calculated for each analyte and sample (Equation 1):

$$EPC\ (ng/mg) = \ (pollutant\ concentration\ (ng/L))/(SSC\ (mg/L)\ ) \quad (1)$$

In the case of Sunnyvale East Channel, where there were multiple discrete samples taken, the EPC was calculated following Equation 2:

$$EPC\ (ng/mg) = \ (\sum pollutant\ concentration\ (ng/L))/(\sum SSC\ (mg/L)\ ) \quad (2)$$

## 3. Results

### 3.1 Stormwater Suspended Sediment Concentrations

Suspended sediment concentrations from the five manual sampling sites ranged from 31 to 175 mg/L, with a median of 48 mg/L (Table 3). These concentrations fall within the range previously reported for Bay Area urban stormwater without agricultural influence, which spans from 16 to 671 mg/L with a median of 79 mg/L (Gilbreath et al., 2021).

### 3.2 Stormwater PCB Concentrations and Estimated Particle Concentrations

Total PCB concentrations across the five manually sampled sites ranged from 1.7 to 18 ng/L, representing approximately a 10-fold variation. Sunnyvale East Channel ranked highest for PCBs based on the average of discrete sample concentrations sampled there, versus the composited water concentrations at the other four manually sampled sites. EPCs ranged from 55 to 265 ng/g at all seven sites, a 5-fold variation. When ranked by EPCs, the Santa Fe Channel Stormdrain at South 8th Street and Zone 9 Line C, at Juniper Street exhibited notably elevated concentrations, with Sunnyvale East Channel ranking third. The 3.3 km² watershed upstream of Zone 9 Line C at Juniper Street consists of 23% industrial land use, and 19% is classified as old industrial. There may be source areas of interest within this industrial zone. Santa Fe Channel has previously been identified as having elevated EPCs (Gilbreath et al., 2021). Sunnyvale East Channel was initially identified as a watershed of interest in Water Year 2011, when an EPC of 298 ng/g was recorded for one of the discrete grab samples (McKee et al., 2012), and was subsequently selected as one of six load monitoring stations (Gilbreath et al., 2016). Meeker Slough has also been previously sampled in WY 2015 and 2018, and for those years exhibited a mean EPC of 140 ng/g, placing it in the upper quartile of previously sampled sites; this watershed is ~6% old industrial (Gilbreath et al., 2021).

### 3.3 Stormwater Total Mercury Concentrations and Estimated Particle Concentrations

Total mercury concentrations in composite water samples from four sampled sites ranged from 31.8 to 57.2 ng/L, a 2-fold variation (Table 3). Based on water concentrations, the highest-ranking site in both Water Years 2021 and 2022 was Kerner Pump Station, which had not been previously sampled. Total mercury EPCs showed greater variability, ranging from 200 to 1,192 ng/g, a 6-fold difference. Kerner Pump Station also exhibited the highest EPC, a value rarely observed, with only three other watershed stations reporting higher levels: Outfall at Gilman Street (2,201 ng/g), Guadalupe River at Highway 101 (3,600 ng/g), and Guadalupe River at Foxworthy Road/Almaden Expressway (4090 ng/g). The watershed upstream of Kerner Pump Station spans 0.51 km² and includes 18% industrial land use, though none is classified as old industrial.

However, 80% of the watershed area is characterized by older residential, commercial, and transportation land uses. Potential sources of HgT may therefore exist in either the newer industrial zone or these older developed areas. A concentration as high as that sampled may warrant additional attention and follow-up through the Marin County Stormwater Program. Notably, the EPC at Santa Fe Channel was lower during this sampling event compared to previous observations. This may be related to lower suspended sediment concentrations (SSC), potentially reflecting a lower-energy storm event with reduced mobilization of mercury sources. In contrast, Meeker Slough, which had also been sampled in earlier years, showed consistent EPCs across events. The average EPC from events sampled in Water Years 2015 and 2018 was 770 ng/g, and the most recent sampling yielded a comparable value of 863 ng/g, indicating relatively stable conditions or consistent source contributions over time.

Table 3. Concentrations and estimated particle concentrations in stormwater samples. The watershed characteristics of Meeker Slough, Santa Fe Channel, and Sunnyvale East Channel have been slightly altered since the WY 2020 report (Gilbreath et al., 2021) due to improved mapping data from the corresponding cities.

| Watershed | County | Water Year sampled | Total area (km2) | Impervious cover (%) | Polychlorinated biphenyls (PCBs) | | Total mercury (HgT) | | Suspended sediment concentration (SSC) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | (ng/g) | (ng/L) | (ng/g) | (ng/L) | (mg/L) |
| Canal Pump Station | Marin | 2022 | 1.39 | 67 | 55 | 1.7 | - | - | 31 |
| Kerner Pump Station | Marin | 2022 | 0.51 | 81 | 76 | 3.6 | 1,192 | 57.2 | 48 |
| Meeker Slough at Regatta Blvd. | Contra Costa | 2022 | 7.01 | 65 | 94 | 4.4 | 863 | 39.7 | 46 |
| Santa Fe Channel Stormdrain at South 8th St. | Contra Costa | 2022 | 2.15 | 70 | 233 | 12 | 612 | 31.8 | 52 |
| Sunnyvale East Channel at Ahwanee Ave. (averaged) | Santa Clara | 2022 | 12.02 | 60 | 102 | 18 | 200 | 34.9 | 175 |
| End of Eden Park Place | Alameda | 2021 | 5.65 | 60 | 85 | - | - | - | - |
| Zone 9 Line C at Juniper St. | Alameda | 2021 | 3.32 | 69 | 265 | - | - | - | - |

# 4. Discussion

## 4.1 Comparison of WYs 2021 and 2022 Reconnaissance Data to Data Collected Previously

The WY 2021 and 2022 data builds on extensive findings for PCBs from sampling conducted by the RMP and SFEI stormwater program[5]. PCB data have now been collected at 97 urban sites across the Bay Area, focusing on older industrial areas that historically included industries that used PCBs. With support from local stormwater programs, sampling for PCBs has been completed at 26 sites in Alameda County, 17 in Contra Costa, 2 in Marin, 24 in San Mateo, 27 in Santa Clara, and 1 in Solano. EPCs for PCBs range from 2 ng/g in Mount Diablo Creek (15% impervious surface cover and no old industrial use) to 8,222 ng/g in Pulgas Pump Station-South (87% impervious surface cover and 54% industrial land use) (Figure 2). Due to the elevated PCB concentrations measured at some sites, the 2021 and 2022 data added Zone 9 Line C at Juniper St. in San Leandro, a largely residential area with 19% industrial land in its upper watershed, as a site of moderate interest, and reaffirmed Sunnyvale East Channel and Santa Fe Channel (Richmond) as sites of high and moderate interest, respectively.

[5] BAMSC member programs conduct similar monitoring and also have extensive PCBs and HgT datasets that are not assessed as part of this report.

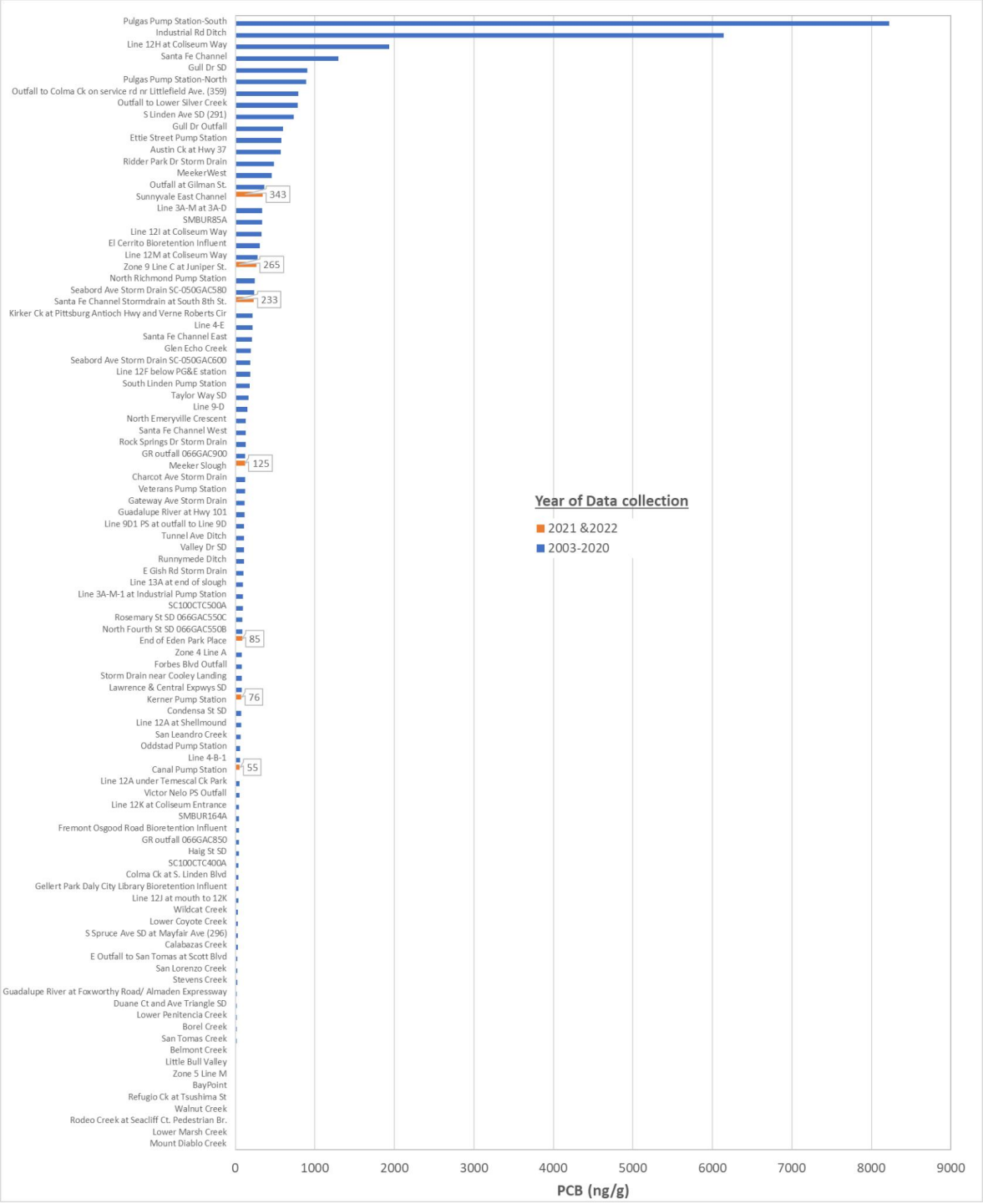



Figure 2. PCB EPCs for watershed and catchment sampling sites measured in WYs 2003-2022. Where more than one storm was sampled at a site, the reported concentration is the average of the storm composite samples.

Across all sampled watersheds, the arithmetic mean and median PCB concentrations were 30 ng/L and 9.8 ng/L, respectively, while SSC averaged 172 mg/L with a median of 93 mg/L. The corresponding PCB particle ratios yielded an arithmetic mean of 342 ng/g and a median of 96 ng/g. Because the sampling network is disproportionately skewed toward high-yield industrial watersheds, perhaps applying an area-weighted average would provide a more representative measure of central tendency for the urbanized Bay Area as a whole by giving greater weight to larger watersheds that integrate mixed land uses. On an area-weighted basis, the regional average PCB concentration is 12 ng/L, and the average PCB particle ratio is 59 ng/g.

The 2021 and 2022 data also build on earlier RMP and SFEI stormwater program findings for HgT, with sampling now completed at 94 urban Bay Area sites, mainly in older industrial areas. Sampling included 23 sites in Alameda County, 17 in Contra Costa County, 1 in Marin County, 24 in San Mateo County, 28 in Santa Clara County, and 1 in Solano County. HgT EPCs ranged from 70 ng/g in Walnut Creek (low impervious surface, no industrial history) to 4,090 ng/g in the Guadalupe River at Foxworthy Rd/Almaden Expy, downstream of the historic New Almaden Mining District (Figure 3). New data identified the Kerner Pump Station in San Rafael as a site of interest despite its lack of known industrial history. It also confirmed Meeker Slough and the Santa Fe Channel in Richmond as moderate-interest sites, and the Sunnyvale East Channel as a lower-interest site for HgT. Across all sampled watersheds with measurements, the arithmetic mean and median HgT concentrations were 53 ng/L and 37 ng/L, respectively, while the mean and median HgT particle ratios were 453 ng/g and 361 ng/g. As with PCBs, because the monitoring design was disproportionately skewed toward industrial land uses, applying area-weighted averages likely provides a more accurate representation of the central tendency of the data for the urbanized Bay Area by giving greater weight to larger integrative watersheds. On an area-weighted basis, the regional average Hg concentration was 57 ng/L (slightly higher than the arithmetic mean), and the average Hg particle ratio was 215 ng/g.

### 4.2 Exploration of PCB Water Quality Trends in Sunnyvale East Channel

Between WYs 2011–2014, 44 paired SSC and PCB samples were collected during storms at Sunnyvale East Channel at Ahwanee Avenue using depth-integrated grab sampling. The same method was used in WY 2022, enabling a comparison over time. Using SSC as a proxy for PCB transport, the 2022 concentrations fall within the lower range (Figure 4). Although this could be a sign of a decline due to watershed management, PCB transport in this watershed is known to be complex (Gilbreath et al, 2016), and five recent samples are probably insufficient to confirm a trend, as discussed below.

So far, 12 storms have been sampled. During 10 storms (one in WY 2011; two each in WYs 2012 and 2013; four in WY 2014; and one in WY 2022), we obtained 3–7 discrete samples; only one or two samples were obtained in the other two storms. Storm-averaged EPCs of less than 102 ng/g (the average concentration observed during the WY 2022 event) have been measured in March 2011 (the first event sampled) (82 ng/g)) and December 2012 (86 ng/g) (Table 4). The small storm of March 29, 2014, with just two samples, also exhibited a storm-averaged EPC of 79 ng/g. The remaining observed storms exhibited average EPCs ranging from 192 to 1,534 ng/g.  With one exception, there appears to be an

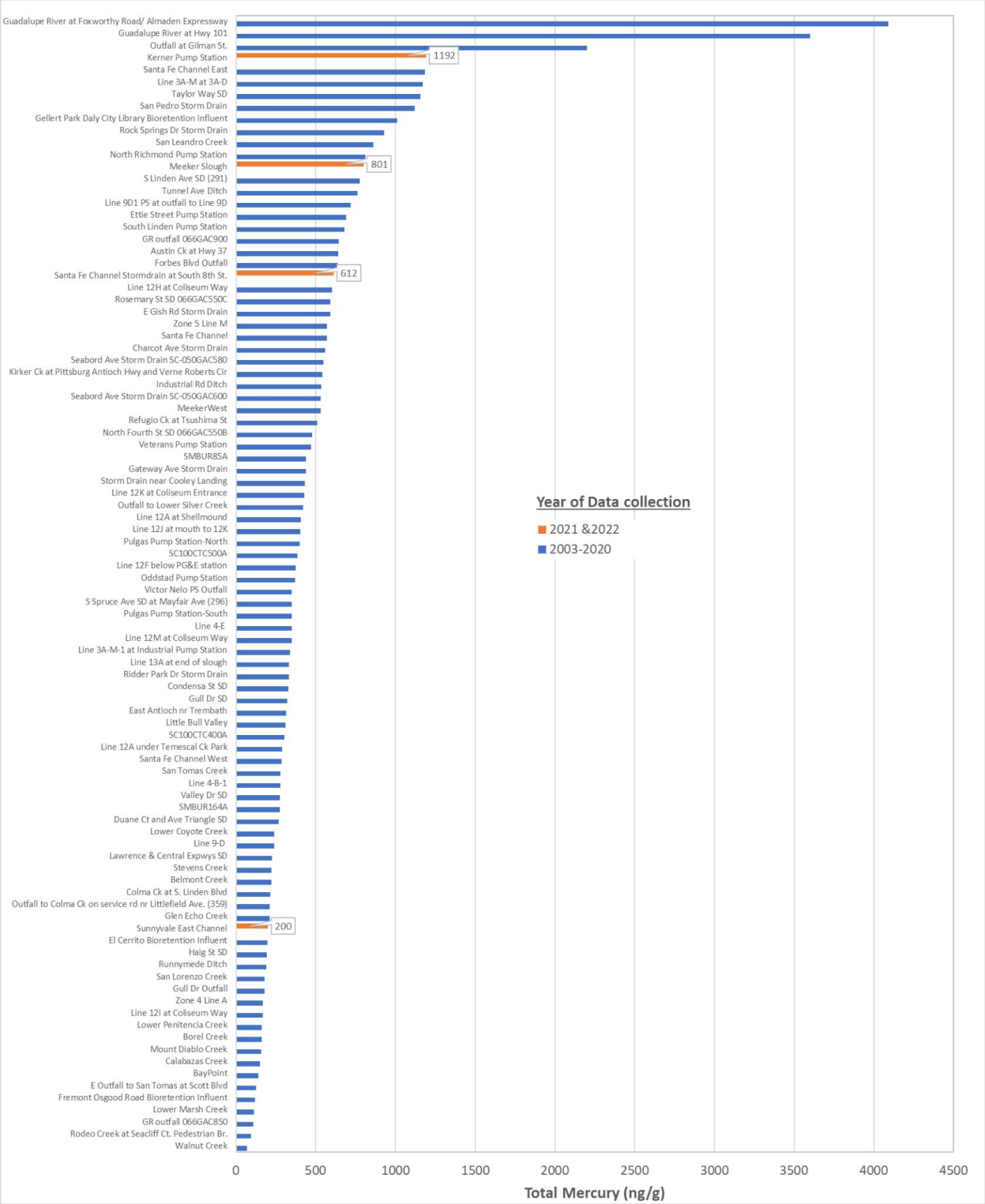



Figure 3. All sampling locations measured to date (WYs 2003-2022) ranked by HgT EPCs. Where more than one storm was sampled at a site, the reported concentration is the average of the storm composite samples.

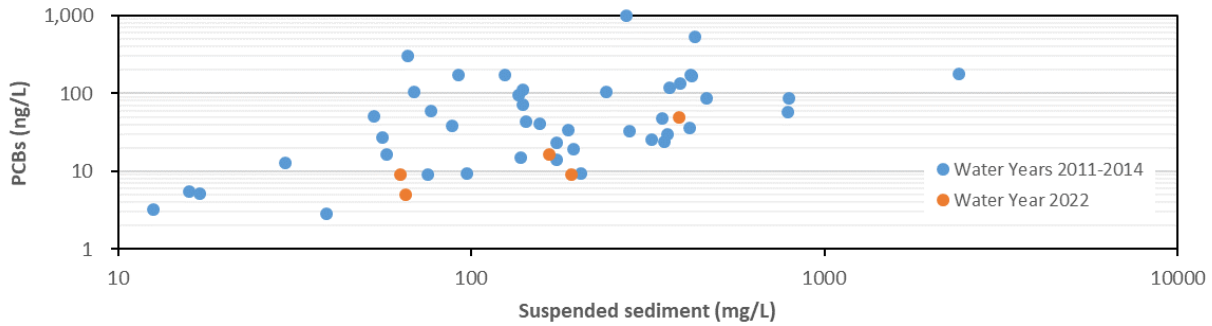



Figure 4. PCB concentrations relative to suspended sediments in Sunnyvale East Channel at Ahwanee Avenue from WY 2011-2022.

inverse correlation between rainfall intensity (measured at ValleyWater Gage 6048, Sunnyvale Wastewater Treatment Plant) and EPC, based on 1-, 2- or 3-hour rainfall intensities and total storm rainfall. Sixty-five percent of the variability in the data can be explained by relating 3-hour maximum rainfall intensity and storm-averaged EPC (the strongest inverse relationship) (Figure 5). However, which rainfall intensity best represents this relationship is uncertain and could be an artifact of a small data set. This inverse relationship, in exponential form, supports the hypothesis that one or more sources with a finite mass are released and transported as dilution occurs during storms with increasing rainfall intensity and total rainfall volume. Within the limits of what our low sample numbers within storms can indicate, during most storms, the highest PCB concentrations in water occurred at peak flows; EPCs were more variable.

The exception was the February 28, 2014 storm (storm 8), during which PCB concentrations peaked at 983 ng/L, with an EPC of 3,588 ng/g and a storm average of 1,534 ng/g. During this storm, both water and particle-bound concentrations followed an anticlockwise hysteresis pattern, rising on the hydrograph's rising limb, peaking after the flow peak, then dropping before rising again with a second, smaller flow peak (Figure 6). This response, along with very high concentrations in water and on sediment particles, suggests a unique source was mobilized during that storm that was not exhausted by its end. A similar anticlockwise hysteresis was observed during the next storm we sampled on March 31, 2014 (Storm 9), indicating that the same or a similar source was active and responding to runoff and sediment transport similarly. In contrast, a smaller storm on March 29, 2014 (just two samples), produced just 19 ng/L and an EPC of 79 ng/g, suggesting that the source was not triggered during that event, perhaps because the rainfall and runoff during this small event (just 4 mm of rainfall) were only sufficient to mobilize PCBs from local non-point sources. Thus, it appears that the source requires higher rainfall/saturation to mobilize contaminated fine sediments, but when this occurs, the runoff from that source arrives at the sampling location with a travel-time lag (anticlockwise hysteresis).

Table 4. Storm characteristics, measured flow, and PCB and SSC results for storms measured at Sunnyvale East Channel since Water Year 2011.

| Storm | Water Year | Date and time | Rainfall (mm) | | | | | Flow (cfs) | SSC (mg/L) | PCBs (ng/L) | PCB (ng/g) | SSC (mg/L) | PCB (pg/L) | PCB particle ratio (ng/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Year-to-date | Storm total | 1-hour | 2-hour | 3-hour | | | | | | | |
| 1 | 2011 | 19/03/2011 23:09 | 302 | 20 | 6 | 11 | 16 | No data | 352 | 23.8 | 68 | 423 | 34.7 | 82 |
| | | 19/03/2011 23:48 | | | | | | | 786 | 57.4 | 73 | | | |
| | | 20/03/2011 0:34 | | | | | | | 348 | 48.3 | 139 | | | |
| | | 20/03/2011 1:28 | | | | | | | 204 | 9.41 | 46 | | | |
| 2 | 2012 | 24/03/2012 19:59 | 115 | 13 | 3 | 5 | 8 | 29 | 17 | 5.23 | 308 | 25.7 | 7.69 | 299 |
| | | 24/03/2012 20:51 | | | | | | 30 | 16 | 5.54 | 346 | | | |
| | | 24/03/2012 23:04 | | | | | | 27 | 13 | 3.27 | 252 | | | |
| | | 25/03/2012 1:06 | | | | | | 85 | 57 | 16.7 | 293 | | | |
| 3 | | 13/04/2012 0:00 | 193 | 10 | 5 | 8 | 9 | 361 | 363 | 119 | 328 | 158 | 75 | 474 |
| | | 13/04/2012 0:44 | | | | | | 128 | 140 | 71.5 | 511 | | | |
| | | 13/04/2012 1:19 | | | | | | 61 | 77 | 58.5 | 760 | | | |
| | | 13/04/2012 1:53 | | | | | | 30 | 53 | 50.5 | 953 | | | |
| 4 | 2013 | 30/11/2012 5:01 | 48 | 32 | 7 | 12 | 15 | 155 | 325 | 25.3 | 78 | 255 | 49.1 | 192 |
| | | 30/11/2012 5:42 | | | | | | 187 | 360 | 29.8 | 83 | | | |
| | | 30/11/2012 6:40 | | | | | | 324 | 418 | 172 | 411 | | | |
| | | 30/11/2012 9:43 | | | | | | 99 | 97 | 9.42 | 97 | | | |
| | | 30/11/2012 11:06 | | | | | | 107 | 76 | 9.16 | 121 | | | |
| 5 | | 2/12/2012 8:56 | 94 | 27 | 12 | 19 | 23 | 307 | 416 | 36.1 | 87 | 807 | 69.4 | 86 |
| | | 2/12/2012 10:08 | | | | | | 527 | 2409 | 176 | 73 | | | |
| | | 2/12/2012 10:41 | | | | | | 350 | 792 | 87.7 | 111 | | | |
| | | 2/12/2012 11:23 | | | | | | 129 | 281 | 32.7 | 116 | | | |
| | | 2/12/2012 12:01 | | | | | | 81 | 138 | 14.9 | 108 | | | |
| 6 | 2014 | 6/02/2014 4:58 | 28 | 11 | 5 | 7 | 8 | 12 | 56 | 27.4 | 489 | 182 | 36.6 | 201 |
| | | 6/02/2014 6:08 | | | | | | 50 | 189 | 33.7 | 178 | | | |
| | | 6/02/2014 6:59 | | | | | | 193 | 463 | 85.6 | 185 | | | |
| | | 6/02/2014 7:35 | | | | | | 134 | 174 | 23.5 | 135 | | | |
| | | 6/02/2014 9:31 | | | | | | 22 | 30 | 12.7 | 423 | | | |
| 7 | | 26/02/2014 16:05 | 47 | 9 | 5 | 8 | 9 | 163 | 392 | 134 | 342 | 257 | 111 | 432 |
| | | 26/02/2014 16:46 | | | | | | 235 | 242 | 103 | 426 | | | |
| | | 26/02/2014 17:07 | | | | | | 129 | 136 | 95.8 | 704 | | | |
| 8 | | 28/02/2014 2:52 | 73 | 25 | 9 | 14 | 17 | 99 | 88 | 37.8 | 430 | 179 | 274 | 1534 |
| | | 28/02/2014 3:12 | | | | | | 226 | 157 | 40.5 | 258 | | | |
| | | 28/02/2014 3:54 | | | | | | 430 | 430 | 539 | 1253 | | | |
| | | 28/02/2014 4:22 | | | | | | 301 | 274 | 983 | 3588 | | | |
| | | 28/02/2014 5:07 | | | | | | 126 | 92 | 174 | 1891 | | | |
| | | 28/02/2014 6:08 | | | | | | 322 | 142 | 43.1 | 304 | | | |
| | | 28/02/2014 6:51 | | | | | | 135 | 69 | 103 | 1493 | | | |
| - | | 29/03/2014 12:29 | 117 | 4 | 4 | 4 | 4 | 3 | 39 | 2.9 | 74 | 107 | 8.43 | 79 |
| | | 29/03/2014 13:04 | | | | | | 17 | 174 | 14 | 80 | | | |
| 9 | | 31/03/2014 14:02 | 123 | 11 | 5 | 7 | 9 | 35 | 194 | 19 | 98 | 202 | 165 | 821 |
| | | 31/03/2014 14:48 | | | | | | 301 | 422 | 168 | 398 | | | |
| | | 31/03/2014 15:23 | | | | | | 108 | 124 | 170 | 1371 | | | |
| | | 31/03/2014 15:59 | | | | | | 42 | 66 | 305 | 4621 | | | |
| - | | 1/04/2014 17:51 | 134 | 3 | 2 | 3 | 3 | 135 | 140 | 111 | 793 | 140 | 111 | 794 |
| 10 | 2021 | 24/10/2021 18:45 | 7.9 | 48 | 9 | 16 | 21 | No data | 388 | 49.2 | 127 | 175 | 17.8 | 102 |
| | | 24/10/2021 20:30 | | | | | | | 166 | 16.7 | 101 | | | |
| | | 24/10/2021 22:10 | | | | | | | 192 | 9 | 47 | | | |
| | | 24/10/2021 23:15 | | | | | | | 63 | 9 | 143 | | | |
| | | 25/10/2021 0:10 | | | | | | | 65 | 5.1 | 78 | | | |

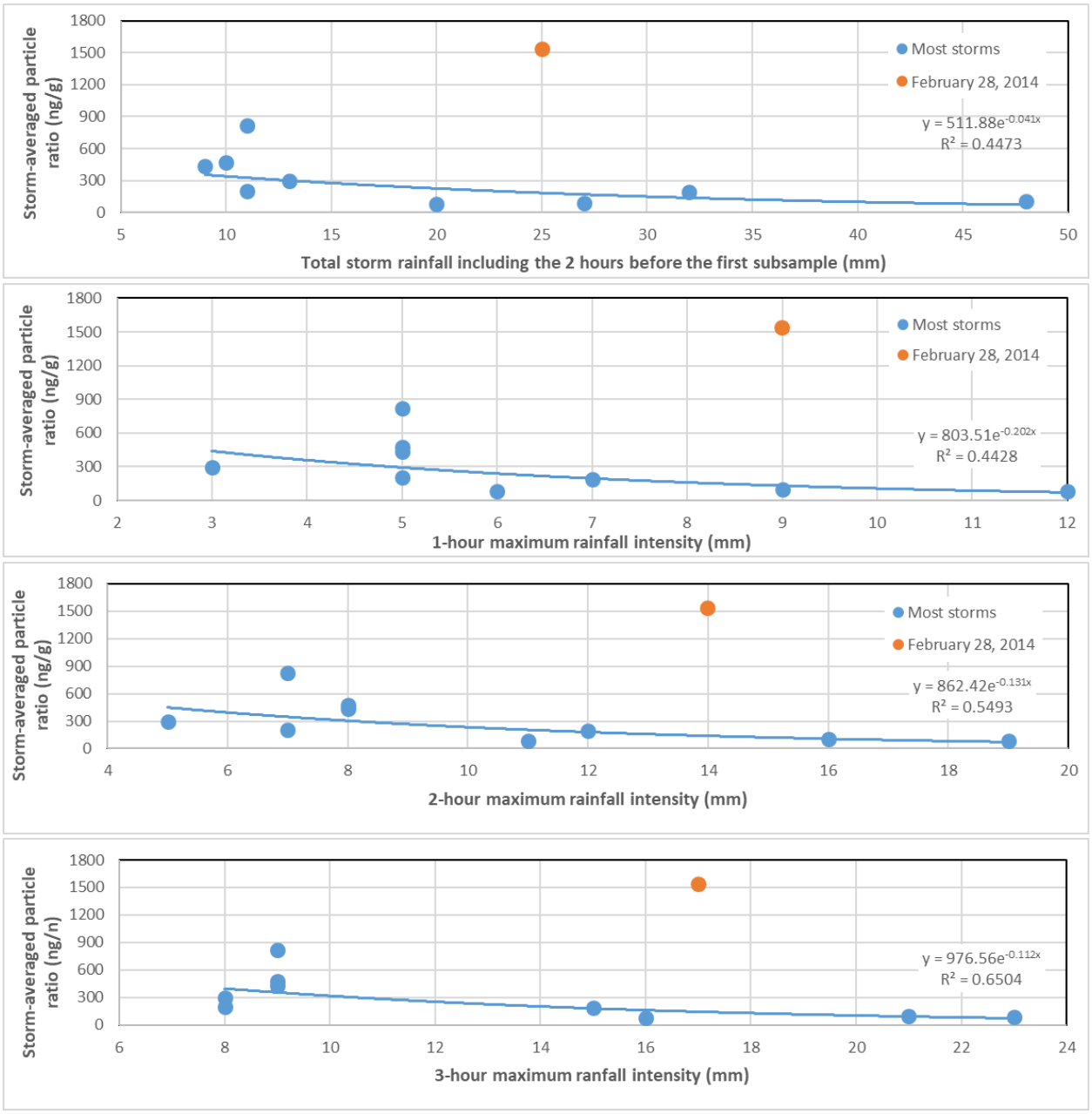



Figure 5. Inverse relationship between storm rainfall and estimated particle ratios for all storms measured to date, except for February 14, 2024. Note, the exponential nature of the curve-fit equations.

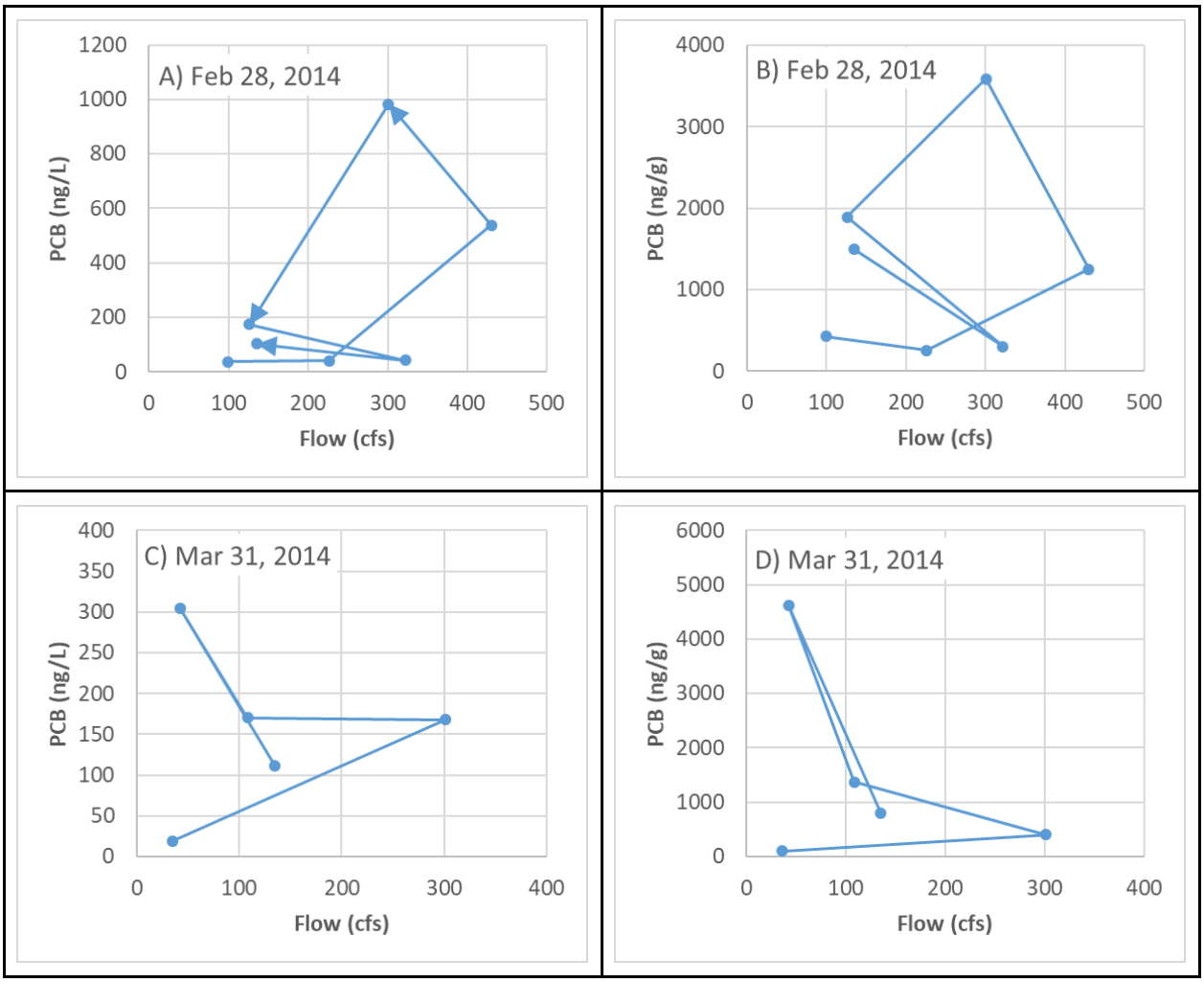



Figure 6. Comparisons of two sampled events and exploration of storm hysteresis to generate hypotheses about sources.

All the storms measured so far for this watershed were, for the most part, relatively small based on the 1-hour duration. Based on the 3-hour duration, just two storms, the February 12, 2012 and the October 24, 2021 storms, had a return frequency of between 2-5 years, and the unique February 28, 2014 storm had a return frequency of close to 2 years (Table 5). Despite this, the data set contains some interesting variability. As was explored in the previous paragraphs, the data are sufficient to start to build a series of interesting hypotheses about sources, release, and transport processes. If we were to couple this rainfall-runoff data with the continuous turbidity and congener data we have, the varying storm fingerprints could be used to develop a scientifically defensible statistical model of source-release transport processes for the watershed.

In summary, although the 2022 data show relatively low PCB concentrations compared to much of the data, the limited sampling (only one storm in WY 2022) is insufficient to confirm a downward trend,

especially since storms in the earlier period also exhibited similarly low EPCs. Additional sampling under storm conditions like those in WY 2014 would be needed to support a robust trend analysis. If stakeholders are interested, the existing data or an expanded data set could be explored in the future in more detail using statistical modeling to provide advanced evidence for source identification.

Table 5. Return frequency based on the NOAA 14 Atlas (Perica et al., 2011) using the Sunnyvale Wastewater Treatment Plant street address.

| Duration | Partial duration series-based precipitation frequency estimates | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 1 | 2 | 5 |
| | Rainfall (inch) | | | Rainfall (mm) | | |
| 1 hour | 0.326 | 0.402 | 0.51 | 8.3 | 10 | 13 |
| 2 hour | 0.477 | 0.587 | 0.742 | 12 | 15 | 19 |
| 3 hour | 0.597 | 0.736 | 0.93 | 15 | 19 | 24 |
| 1 day | 1.35 | 1.69 | 2.15 | 34 | 43 | 55 |

## 5. Conclusions

This report presents PCB, HgT, and SSC data collected during Water Years 2021 and 2022 at seven sites. At five locations, water samples were analyzed for the sum of 40 PCB congeners and SSC. At four of these, HgT was also measured. At two additional sites, sediment-water slurry samples were collected using a remote sampler and analyzed for PCBs and HgT, with results reported as particle-bound concentrations only.

SSC at the five sites ranged from 31 to 175 mg/L, within the typical range for Bay Area urban stormwater unaffected by agriculture. Total PCB concentrations ranged from 1.7 to 18 ng/L, with EPCs between 55 and 265 ng/g, both in the medium-to-low range of past observations. HgT concentrations in water samples from four sites ranged from 31.8 to 57.2 ng/L, with EPCs from 200 to 1,192 ng/g. Kerner Pump Station showed the highest HgT concentration and EPC; EPCs of 1,192 ng/g or greater have only been observed at five other watershed locations in all RMP/SFEI sampling to date, going back to WY 2003. The Kerner watershed (0.51 $km^2$) contains no old industrial land use. HgT sources must be within the newer industrial area (18%) or the older residential, commercial, and transportation zones.

Data from one storm in WY 2022 at Sunnyvale East Channel, collected using depth-integrated grab sampling, were compared to samples from previous storms in WYs 2011–2014. PCB EPCs in 2022 fell within the lower range of past concentrations, possibly indicating a downward trend. However, due to the complexity of source-release and transport processes in this watershed, sampling across a range of storm intensities would be needed to assess trends. Further source identification work could be done with the existing data using a statistical modeling approach that could include the possibility of fingerprinting the various source types.

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