Evaluation of PCBs in Caulk and Sealants in Public Roadway and Storm Drain Infrastructure

Project Report

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FINAL

August 16, 2018

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LIST OF ACRONYMS

ACCWP	Alameda Countywide Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
CCCWP	Contra Costa Clean Water Program
CEH	Center for Environmental Health
EPA	Environmental Protection Agency
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GC/MS-SIM	Gas Chromatography/Mass Spectroscopy-Selective Ion Monitoring
KLI	Kinnetic Laboratories, Inc.
LCS	Laboratory Control Sample
MDL	Method Detection Limit
MRL	Method Reporting Limits
MRP	Municipal Regional Stormwater NPDES Permit
MS	Matrix Spike
n/r	not reported
ND	Non-Detect
NPDES	National Pollutant Discharge Elimination System
PCBs	Polychlorinated Biphenyl
PMT	Project Management Team
POC	Pollutants of Concern
ppb	parts per billion
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
ROW	Right-of-Way
SAP	Sampling and Analysis Plan
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SFEI	San Francisco Estuary Institute
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
TMDL	Total Maximum Daily Loads
VSFCD	City of Vallejo and the Vallejo Sanitation and Flood Control District
XRF	X-ray Fluorescence

EXECUTIVE SUMMARY

The Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit (MRP; Order No. R2-2015-0049) implements the municipal stormwater portion of the polychlorinated biphenyls (PCBs) Total Maximum Daily Loads (TMDLs) for the San Francisco Bay. Provision C.12.e of the MRP requires Permittees collect at least 20 composite samples (throughout the permit area) to investigate PCBs concentrations in caulk and sealants from public roadway and storm drain infrastructure. To achieve compliance with this permit requirement, the Bay Area Stormwater Management Agencies Association (BASMAA[1]) implemented a regional sampling program on behalf of its member agencies. The goal of the ***BASMAA Regional Infrastructure Caulk and Sealant Sampling Program*** was to evaluate, at a limited screening level, whether and in what concentrations PCBs are present in caulks or sealants in public roadway and storm drain infrastructure in the portions of the Bay Area subject to the MRP. This sampling program also contributes to partial fulfillment of pollutants of concern (POC) monitoring required in Provision C.8.f of the MRP to address source identification, one of the five management information needs identified in the MRP. Source identification monitoring focuses on identifying which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff.

The ***BASMAA Regional Infrastructure Caulk and Sealant Sampling Program*** was conducted between February 2017 and August 2018 in the portion of the San Francisco Bay Area subject to the MRP. The sampling program was implemented by a project team comprised of EOA Inc., Kinnetic Laboratories, Inc. (KLI), and the San Francisco Estuary Institute (SFEI). A BASMAA Project Management Team (PMT) consisting of representatives from BASMAA stormwater programs and municipalities provided oversight and guidance to the project team throughout the sampling program. Anonymous municipal partners also provided assistance during sampling.

The sampling program was designed to specifically target roadway and storm drain structures that were constructed during the most recent time period when PCBs were potentially used in caulk and sealant materials (i.e., prior to 1980, with a focus on the 1960's and 1970's). Field reconnaissance was conducted in areas within participating municipalities that were developed during the time period of interest to identify structures with caulk or sealant applications. A total of 54 caulk and sealant samples were collected from ten different types of roadway and storm drain structures in the public right-of-way (ROW). Structures sampled included concrete bridges/overpasses, sidewalks, curbs and gutters, roadway surfaces, above and below ground storm drain structures (i.e., flood control channels and

[1] BASMAA is a 501(c)(3) non-profit organization that coordinates and facilitates regional activities of municipal stormwater programs in the San Francisco Bay Area. BASMAA programs support implementation of the MRP (Order No. R2-2015-0049). BASMAA is comprised of all 76 identified MRP municipalities and special districts, the Alameda Countywide Clean Water Program (ACCWP), Contra Costa Clean Water Program (CCCWP), the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), the Fairfield-Suisun Urban Runoff Management Program (FSURMP), the City of Vallejo and the Vallejo Sanitation and Flood Control District (VSFCD).

storm drains accessed from manholes), and electrical utility boxes or poles attached to concrete sidewalks. The individual samples were grouped by structure type and sample appearance (color and texture). The groups were combined into 20 composites. Composites were analyzed for the RMP-40 PCBs congeners[2] using a modified EPA Method 8270C (Gas Chromatography/Mass Spectroscopy-Selective Ion Monitoring, GC/MS-SIM), with a detection limit of ≤ 0.5 ppb (0.0005 ppm).

Total PCBs concentrations across the 20 composite samples ranged from non-detect (ND) to > 4,000 ppm. The majority of the composites had PCBs concentrations that were below 0.2 ppm. PCBs were not detected in ten of the composite samples, representing nearly 60% of the individual samples collected during this program. PCBs in twenty-five percent (5 of 20) of the composites were above 1 ppm. Of these, two composites had very high PCBs concentrations (> 1,000 ppm) that indicate PCBs were likely part of the original caulk or sealant formulations. Both of these composites were comprised of black, pliable joint filler materials that were collected from concrete bridges/overpasses. These results demonstrate that PCBs-containing caulks and sealants were used in some capacity on Bay Area roadway and storm drain infrastructure in the past, but the full extent and magnitude of this usage is unknown. The conclusions from this sampling program are primarily limited by the small number of structures that were sampled (n=54), compared with the vast number of roadway and storm drain structures throughout the Bay Area that were originally constructed during the peak period of PCBs production and use (1950 – 1980).

Given the limitations of the project, much more information would be needed to estimate the total mass of PCBs in infrastructure caulk and sealant materials, to better understand the fate and transport of PCBs in these materials, and to calculate stormwater loading estimates. Nevertheless, this screening-level sampling program was the first step towards understanding if infrastructure caulk and sealants are a potential source of PCBs to urban stormwater. Although limited by the small sample number, the results of this sampling program indicate:: (1) the majority of roadway and storm drain structure types that were sampled in this project did not have PCBs-containing caulks or sealants at concentrations of concern, and (2) only black, pliable joint fillers found on concrete bridges/overpasses sampled had PCBs concentrations of potential concern to stormwater. If further investigation is conducted, focus on this type of application may be a reasonable place to continue such efforts.

[2] The 40 individual congeners routinely quantified by the Regional Monitoring Program (RMP) for Water Quality in the San Francisco Estuary include: PCBs 8, 18, 28, 31, 33, 44, 49, 52, 56, 60, 66, 70, 74, 87, 95, 97, 99, 101, l05, 110, 118, 128, 132, 138, 141, 149, l51, 153, 156, 158, 170, 174, 177, 180, 183, 187, 194, 195, 201, and 203. These are referred to as the RMP-40 PCB congeners throughout this report.

1 INTRODUCTION

1.1 BACKGROUND

Until banned from production in 1979, polychlorinated biphenyls (PCBs) were commercially produced and used in a variety of products in the U.S., including caulk compounds and joint sealants. PCBs were added to these materials primarily to increase elasticity, but also to extend the lifespan of the materials and improve adherence to various structures (Kohler et al. 2005, Erickson and Kaley 2011). The use of PCBs in caulk and sealants is categorized as an open application that allows for potential release of PCBs into the environment during use, compared with closed applications (e.g., PCBs as dielectric fluid in transformers) that do not allow release to the environment during normal use (WHO 1993). Because of the open application of caulks and sealants in outdoor settings, exposed locations can come into direct contact with stormwater, and therefore has been identified as a potential direct source of PCBs in urban stormwater.

Globally, PCBs concentrations as high as 55% by mass have been measured in caulk or sealant materials that were used on the exteriors of public and private buildings constructed prior to 1979 (Herrick et al. 2004, Kohler et al. 2005, Robson et al. 2010). In the San Francisco Bay Area (Bay Area), PCBs have been measured in caulks used around the exterior of windows and door frames of tilt-slab style public and private buildings constructed prior to 1979 (Klosterhaus et al. 2014). PCBs-containing caulks and sealants have also been found on public roadway and storm drain infrastructure. In 2013, the City of Tacoma, Washington conducted a source-tracking program after elevated PCBs were detected in stormwater from a residential neighborhood that drains to the Thea Foss Waterway (City of Tacoma 2013, 2016). The City of Tacoma determined the source of PCBs was a black tar sealant in a storm drain catch basin. The sealant had been applied between asphalt and concrete surfaces in the catch basin during a 1975 road construction project. A sample of the sealant collected in 2013 had PCBs concentrations up to 260 parts per million (ppm). Although most of the sealant had worn away by 2013, residual PCBs likely contaminated the soil within the catch basin as the sealant material disintegrated over the years.

In the Bay Area, several open applications of PCBs-containing caulks have been identified in public infrastructure, including in the sealant that was used in the gaps between concrete slabs of the road deck on the old eastern span of the San Francisco-Oakland Bay Bridge (Caltrans 2013), and in caulk used in the joints of concrete drinking water storage reservoirs located in Alameda County (Sykes and Coate 1995). These examples represent the limited extent of local information that is currently available on PCBs in caulks and sealants used in storm drain and roadway infrastructure. There is no information available on PCBs concentrations in caulk or sealant applications on other local roadways, parking garages, bridges, dams, storm drain pipes, catch basins or inlets, or pavement joints (e.g., curb and gutter). Although the mass of PCBs contained in roadway and storm drain infrastructure caulks and sealants in the Bay Area is currently unknown (and we are not aware of any other published study that has completed an inventory in urban infrastructure in the U.S.), this potential PCBs source may warrant further investigation. .

1.2 PROJECT GOAL

The primary goal of this project was to evaluate, at a limited screening level, whether and in what concentrations PCBs are present in public roadway and storm drain infrastructure caulk and sealants in the portions of the Bay Area subject to the regulatory requirements of the Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit (MRP; Order No. R2-2015-0049). The MRP implements the municipal stormwater portion of the PCBs Total Maximum Daily Loads (TMDLs) for the San Francisco Bay. This project fulfills Provision C.12.e of the MRP that requires Permittees collect at least 20 composite samples (throughout the permit area) to investigate PCBs concentrations in caulk and sealants from public roadway and storm drain infrastructure. This project also contributes to partial fulfillment of pollutants of concern (POC) monitoring required in Provision C.8.f of the MRP to address source identification, one of the five management information needs identified in the MRP. Source identification monitoring focuses on identifying which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff.

To accomplish the project goal, the Bay Area Stormwater Management Agencies Association (BASMAA[3]) implemented a regional sampling program on behalf of its member agencies that included the following objectives:

- Collect caulk and sealant samples from up to 60 public roadway and storm drain infrastructure locations across the MRP area;
- Combine individual samples into 20 composites and analyze each for PCBs using laboratory methods that can detect a minimum PCBs concentration of 200 parts per billion (ppb, or µg/Kg); and
- Present the results of the sampling program in MRP Permittees' 2018 Annual Reports to the San Francisco Bay Regional Water Quality Control Board (Regional Water Board).

It is important to note that this regional sampling program was not designed to fully characterize the range of PCBs concentrations in Bay Area infrastructure caulk and sealants, but rather to provide a limited, screening level survey of concentrations of PCBs that may be found in roadway and storm drain infrastructure caulk and sealants. This limited screening level monitoring is a first step towards understanding if this is a potential source of PCBs to urban stormwater that may require further attention.

[3] BASMAA is a 501(c)(3) non-profit organization that coordinates and facilitates regional activities of municipal stormwater programs in the San Francisco Bay Area. BASMAA programs support implementation of the MRP (Order No. R2-2015-0049). BASMAA is comprised of all 76 identified MRP municipalities and special districts, the Alameda Countywide Clean Water Program (ACCWP), Contra Costa Clean Water Program (CCCWP), the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), the Fairfield-Suisun Urban Runoff Management Program (FSURMP), the City of Vallejo and the Vallejo Sanitation and Flood Control District (VSFCD).

This report presents the results of the ***BASMAA Regional Infrastructure Caulk and Sealant Sampling Program*** that was conducted during 2017 and 2018 in the portion of the San Francisco Bay Area subject to the MRP. The sampling program was implemented by a Project Team comprised of EOA Inc., Kinnetic Laboratories, Inc. (KLI), and the San Francisco Estuary Institute (SFEI). A BASMAA Project Management Team (PMT) consisting of representatives from BASMAA stormwater programs and municipalities provided oversight and guidance to the Project Team throughout the sampling program.

Section 2 of this report presents the overall approach and detailed methods that were used to implement the regional sampling program. Section 3 presents the results of the sampling program, including a summary of the types of locations where samples were collected and the measured PCBs concentrations. Section 4 summarizes the conclusions drawn from the results of the sampling program. Additional documents developed for this project, including the study design and the Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) are provided in Appendices A and B, respectively. Individual PCBs congener data are reported in Appendix C.

2 METHODS

This section presents the overall approach and methods that were used to implement the ***BASMAA Regional Infrastructure Caulk and Sealant Sampling Program***. Under the guidance and oversight of the PMT, the project team developed a study design (Appendix A) and a SAP/QAPP (Appendix B), which were followed throughout implementation of the sampling program.

2.1 Sampling Program Approach

The overall approach to the ***BASMAA Regional Infrastructure Caulk and Sealant Sampling Program*** was to work cooperatively with multiple Bay Area municipal agencies to identify public right-of-way (ROW) locations where PCBs were potentially used in caulk or sealant applications on roadway and storm drain infrastructure. These locations were identified primarily based on the time period that the infrastructure was originally constructed and/or repaired, with a focus on the 1970's- the most recent time period PCBs were still in widespread use. The project team collected 54 caulk or sealant samples from public infrastructure in these locations. Each sample was screened for chlorine content using portable X-ray Fluorescence (XRF) technology. This was done to evaluate whether this non-destructive, inexpensive, and portable screening technique could be applied to identify samples that contain high concentrations of PCBs. Following XRF screening, the Project Team then reviewed the information collected about each sample to determine how to group the samples for compositing prior to PCBs analysis. A total of 20 composite samples were then analyzed for PCBs concentrations. All municipal participants in the project remained anonymous. All chemical analyses and reporting were also conducted blind to the specific locations where caulk or sealant samples were collected. Additional details about the methods used to conduct this sampling program are provided below.

2.2 Recruitment of Municipal Partners

The first step of this sampling program was to recruit Bay Area municipal agencies to participate in the project. Participation in the project entailed assisting the project team to identify potential sample locations and allowing the project team to collect samples in public ROW areas within their jurisdictions.

As part of the study design development, the project team prepared a memorandum to help recruit municipalities to participate in the sampling program (Appendix A). The memo described the planned monitoring program, outlined desirable attributes for municipal partners, and described the roles of the monitoring program partners. The primary criterion for sampling program partners was municipalities that had public infrastructure that was constructed or repaired prior to 1980, when PCBs were still in common use. To identify appropriate partners, the project team identified the following desirable attributes:

- Cities that were significantly urbanized prior to 1980. All newer urban areas were excluded from sampling because they were not expected to contain PCBs in caulk or sealants.
- Cities that conducted their own road and storm drain infrastructure maintenance. Information about maintenance and repairs to all potential sample site locations, as well as site-specific information on potential structures was needed to identify appropriate sampling sites.
- Cities that had available records of structure installation or repair and/or knowledgeable staff that provided such information as far back as the 1970's. Site selection relied heavily on the availability of information about the age of existing roadway and storm drain infrastructure within partner jurisdictions.
- Cities that had the available resources and willingness to assist the project team in identifying potential sampling sites within their jurisdictions.

Stormwater Program staff from each of the five Bay Area counties subject to the MRP conducted outreach to their municipalities to recruit participants for the sampling program.

2.3 Screening Criteria for Sample Site Selection

The initial population of sampling sites included the universe of publicly maintained roadways, sidewalks and storm drain structures containing caulk or sealants located within participating Bay Area municipalities. Based on literature review and best professional judgement, the project team developed additional screening criteria for sample site selection to assist project partners in identifying locations that were more likely to contain caulk or sealants with PCBs. These criteria also accounted for logistical and safety considerations during sample collection. The screening criteria that were used to identify potential sample sites included the following:

1. **Public Property in Participating Jurisdictions**: All sample sites were located in public ROWs within the jurisdiction of a participating municipality.
2. **Structure Types**: The structures sampled included concrete and asphalt roadways, bridges and overpasses, sidewalks, pavement joints (e.g., curbs and gutters), below ground storm drain structures accessed through manholes, catch basins or inlets, storm drain outfalls, above ground storm drain structures (i.e., flood control channels), and utility boxes or poles attached to concrete sidewalks.
3. **Open Applications of Caulk/Sealant**: All sampled structures had open applications of caulk or sealants that were exposed and readily available for sample collection. Examples included: sites

of roadway or storm drain infrastructure repairs, such as filled cracks that had formed on the surface after installation; joints between concrete curbs and street pavement; joints between concrete paving; sidewalks or bridge decks; and joints between sections of storm drain pipes or culverts.

4. **Structure Age**: Preferred sampling sites included structures (or portions of structures) that were constructed prior to 1980, with a preference given to more recent structures. Although PCBs were likely present in caulk and sealants used throughout the 1950's, 1960's and 1970's (and possibly earlier), these materials are expected to break-down and disintegrate over time due to normal wear. The older caulks/sealants are more likely to have worn away and/or to have been replaced. To increase the likelihood of finding PCBs, this project focused on identifying structures that were constructed (or repaired) between the late 1960's through the late 1970's. This period is the most recent decade during which PCBs were still used regularly in caulks and sealants.

5. **Structure Repair Status**: Sampling sites were selected from structures (or portions of structures) that had not undergone repair since the 1980's. Because PCBs were not used from about 1980 onward, any structures, or portions of structures that were repaired after 1980, including removal and replacement of caulk/sealant, and/or addition of caulk/sealant, were excluded from sampling.

6. **Road Materials**: Portland cement concrete structures are more durable than asphalt-based pavements, thus less likely to have been replaced or resurfaced since 1980. Therefore, sample site selection favored concrete structures because they were more likely to contain PCBs in caulk/sealants.

7. **Accessibility**: Field personnel only collected samples from sites that were deemed to be safe and accessible for sample collection. None of the sites that were sampled required confined space entry or other special equipment. Traffic controls were implemented in the few locations that required such measures for safety reasons.

8. **Ongoing Capital Projects:** In-progress storm drain infrastructure repair, roadway repaving or repair projects could have provided an opportunity to collect caulk or sealant samples from locations that would otherwise not be safely accessible. However, no such projects were identified during the regional sampling program.

Participating municipal agency staff were asked to review the screening criteria above to help the project team identify potential sampling locations. The initial focus was on locations within participating municipalities that were developed during the 1950's through 1970's. The project team then worked with the municipal staff to further identify locations within these areas that met additional site selection criteria. Available information was reviewed, including GIS map layers, satellite imagery, or records from tracking systems used by cities to document roadway/storm drain infrastructure construction and/or repair dates. Knowledgeable municipal staff were queried for information about open applications of caulk or sealants. Existing records were used to verify the criteria above for a given location. However, because records for the time period of interest were not always available or complete, anecdotal

information from knowledgeable agency staff was also considered. The project team also conducted field reconnaissance within the areas of interest to further identify potential sample locations.

2.4 Sample Collection

All sample collection was conducted following the detailed methods and procedures described in the project SAP/QAPP (Appendix B). The project field teams visited the areas that had been identified as potential sample locations. In a number of cases, specific sampling sites that met the selection criteria were identified during field reconnaissance. However, for much of the sampling effort, the field crews had to search the appropriate roadway and storm drain structures within areas of interest to identify exposed applications of caulk or sealant that could be collected in a safe way. The types of applications that were sampled included the following:

- Materials used to fill cracks in concrete or asphalt roadways or sidewalk surfaces;
- Tar-like sealant materials within storm drain structures or on roadway surfaces;
- Caulking used between concrete structures and asphalt pavement, such as gutters and catch basins; and
- Fillers between the joints of concrete blocks on bridges and overpasses, roadways, or storm drain channels.

A variety of techniques were used to collect samples, depending on the specific location and the condition of the caulk or sealant material. Stainless steel knives/spoons were used as sample collection tools for scraping material from structure surfaces and inside cracks. Other collection techniques included carefully chiseling hardened material from surfaces or from within cracks/joints using appropriate tools. Field notes and photographs were taken to ensure proper documentation of collection method(s) used at each site, the structure type, the type of caulk or sealant usage, and other relevant factors. The field sampling form is available in the SAP/QAPP provided in Appendix B. To ensure all municipal partners remained anonymous, information that could be used to identify specific locations where individual samples were collected was not recorded by the field crews. All photographs avoided inclusion of any identifying features of the area such as road signs, heritage trees or other landmarks.

2.5 XRF Screening Procedures

Following collection, all samples were sent to the Center for Environmental Health (CEH) for XRF analysis to measure chlorine content. Because PCBs are highly chlorinated, samples with high chlorine content are more likely to contain PCBs. Previous projects have used portable XRF technology to evaluate the chlorine content of caulk samples (Klosterhaus et al. 2014). This screening was done to provide an additional factor that could be used to determine how to group individual samples for compositing. Moderate chlorine concentrations may provide information on whether the presence of chlorine is driven primarily by PCBs or instead by other chlorine containing compounds. Chlorine content as measured by XRF screening was one of several factors that was considered in determining how to group samples for compositing purposes prior to PCBs analysis.

2.6 Composite Grouping

Following XRF screening, the project team reviewed all of the information gathered about each sample to determine how individual samples would be grouped for compositing. The project team determined that combining samples with similar characteristics (e.g., structure type and sample appearance) into composites could potentially provide information on how PCBs concentrations vary across different types of structures, usage, etc. Although limited by the small sample size (i.e., 20 samples), this type of information was considered potentially important for future efforts to identify infrastructure caulk or sealants that are more likely to contain PCBs. The primary factors that were used to group individual samples for compositing included:

- Structure type,
- Caulk or sealant appearance and texture,
- Age of the infrastructure, and
- Chlorine content.

Other factors were also considered, but based on the information collected about each sample, the above four factors provided sufficient differentiation among the individual samples to create 20 composite samples.

2.7 Laboratory Methods

To prepare the samples for compositing, the laboratory first had to reduce the material in each sample to a very fine powder. The techniques used varied according to the character of each sample, but generally involved first drying the material if needed (oven-dry or freeze-dry), then grinding to the desired particle size using a pulverizer and ring and puck mill. Composite samples were created by combining equal masses of ground particles from individual samples using representative sub-sampling techniques. All composites were created according to the composite groupings assigned by the project team. Composite samples were then extracted using EPA Method 3540C and analyzed for the RMP-40 PCB congeners[4] using a modified EPA Method 8270C (Gas Chromatography/Mass Spectroscopy-Selective Ion Monitoring, GC/MS-SIM). Samples with high concentrations relative to calibration standards were diluted and reanalyzed as needed. Method Reporting Limits (MRLs) for each of the RMP-40 PCB Congeners was ≤ 0.5 ppb (0.0005 ppm). Additional details on the laboratory methods that were used, the data quality objectives, and procedures that were implemented to ensure data quality during laboratory analysis are provided in the project SAP/QAPP Appendix B.

2.8 Data Analysis and Reporting

As the final step of this sampling program, the results of the sampling effort, compositing decisions, and PCBs concentrations measured were analyzed and reported. PCBs concentrations in this report are presented as the sum of the RMP-40 congeners; individual congener data is available in Appendix C. The composite sample results were divided into five categories based on PCBs concentration ranges of

[4] The 40 individual congeners routinely quantified by the Regional Monitoring Program (RMP) for Water Quality in the San Francisco Estuary include: PCBs 8, 18, 28, 31, 33, 44, 49, 52, 56, 60, 66, 70, 74, 87, 95, 97, 99, 101, l05, 110, 118, 128, 132, 138, 141, 149, l51, 153, 156, 158, 170, 174, 177, 180, 183, 187, 194, 195, 201, and 203. These are referred to as the RMP-40 PCB congeners throughout this report.

interest. These categories were identified primarily based on the concentrations observed in caulk or sealants measured in other studies, and in public ROW surface soils and storm drain sediment from the Bay Area. The five PCBs concentration categories included the following:

1. **Very High (PCBs ≥1,000 ppm):** These concentrations (> 0.1% PCBs by weight) indicate PCBs were likely used in the original caulk or sealant formulation at concentrations high enough to impart the desired qualities of increased flexibility, durability, and adherence. PCB-containing caulks or sealants from building materials are typically greater than 10,000 ppm PCBs (i.e., 1 % PCBs).
2. **High (PCBs ≥ 50 ppm but < 1,000 ppm)**: These concentrations are above the federal hazardous waste threshold of 50 ppm but remain below the concentrations expected if PCBs were added to the original caulk or sealant formulations. More likely, this category includes materials that have been contaminated with PCBs. Removal of caulks or sealants with concentrations at or above 50 ppm requires hazardous waste handling and disposal procedures. However, no composites had PCBs concentrations in this category. Examples of materials in this category that were likely contaminated with PCBs include:
    a. Caulk/sealants that were in contact with older PCB-containing materials that remained in place when the newer caulks/sealants were applied over the existing material.
    b. Caulk/sealants that were in contact with surfaces that had residual PCBs left behind from PCB-containing materials used in the past. This could occur even if the original PCB-containing materials have largely disintegrated over time or were removed and replaced.
    c. Caulk/sealant materials that were in contact with unknown PCBs sources, which could include any past use or release of PCBs in the surrounding area.
3. **Moderate (PCBs ≥ 1 ppm but < 50 ppm):** As with the high PCBs category, materials with PCBs concentrations in this range more likely resulted from contamination, rather than addition of PCBs to the original formulation. BASMAA agencies currently use sediment PCBs concentrations above 1 ppm to identify watershed areas (both public ROW areas and private properties) that are potential sources of PCBs to stormwater. When PCB concentrations above 1 ppm are observed, further investigation and source abatement may be needed to protect stormwater quality. Caulks/sealants in this category have potentially been contaminated by the same sources that contribute to elevated soil/sediment concentrations in the surrounding area.
4. **Low (PCBs ≥ 0.2 ppm but < 1 ppm):** These PCBs concentrations are above the urban background concentration for PCBs that has been observed in Bay Area surface soils and storm drain sediment and may indicate proximity to a source. Caulks/sealants in this category likely result from contamination by other sources of PCBs, as described above.
5. **Very Low/Non-Detect (PCBs < 0.2 ppm):** This category includes all samples that had PCBs concentrations below < 0.2 ppm, including samples that did not detect any of the RMP-40 PCB congeners. Caulk or sealants in this category do not suggest proximity to a PCBs source. PCBs concentrations in Bay Area public ROW surface soils and storm drain sediment that are below 0.2 ppm suggest lack of proximity to a PCBs source (SCVURPPP 2018; SMCWPPP 2018).

Although compositing a mixture of higher and lower concentration samples can dilute the concentration detected in the composite sample, the number of samples included in each composite (8 at most)

suggests that none of the individual samples in a given composite has a concentration that is more than one PCBs concentration category higher than the composite.

The information gathered during sample collection for the individual samples included in each composite was further assessed. Features of the samples in each PCBs category were identified, including the types of structures sampled, the appearance of the caulk or sealant, etc. Although limited to a qualitative assessment due to the small sample number, this review was done to identify common factors (if any) about samples within each category that may suggest an association (or lack thereof) with elevated PCBs.

The XRF screening results were also compared with the measured PCBs concentrations to better understand the usefulness of XRF screening procedures in identifying PCBs-containing caulks or sealants. The infrastructure caulk/sealant concentrations observed during this project were then compared to PCBs concentrations measured in caulk or sealants in other studies, and to PCBs concentrations found in Bay Area public ROW surface soils and storm drain sediment.

3 RESULTS

This section presents the results of the ***BASMAA PCBs in Infrastructure Caulk and Sealant Sampling Program***. Although specific municipal partners remain anonymous in this report, at least ten different municipalities across the Bay Area participated in the project. Participants included one or more municipalities from each of the following countywide stormwater programs:

- Alameda Countywide Clean Water Program
- Contra Costa Clean Water Program
- Santa Clara Valley Urban Runoff Pollution Prevention Program
- San Mateo Countywide Water Pollution Prevention Program

3.1 Sample Collection And Compositing Decisions

Field sampling was conducted between September 2017 and January 2018. Prior to conducting field reconnaissance and sampling, the project team identified areas within participating municipalities that had been developed prior to 1980, with a focus on the 1960's and 1970's. The field team conducted reconnaissance in these areas and identified structures with caulk or sealant applications that could be sampled. This effort was both challenging and time consuming because of the lack of information available on specific structures where caulk or sealant applications were located. During reconnaissance, field crews noted that caulks and sealants were generally absent or rare in the targeted structures (i.e., a considerable effort was required to locate sampleable materials that met the criteria).

The sampling program collected a total of 54 individual caulk or sealant samples from public roadway and storm drain infrastructure within the jurisdictions of partner municipalities. Additional information about the samples that were collected, including the types and ages of structures sampled, the appearance and texture of the materials collected, the XRF screening results, and the results of the compositing scheme are presented below.

3.1.1 Structures Sampled

Samples were collected from ten different types of roadway or storm drain structures that were originally constructed prior to 1980, as presented in Table 3.1. The ten structure types sampled comprise a large portion of the existing roadway and storm drain infrastructure in the Bay Area. The majority of samples (65%) were collected from concrete structures, including bridges, sidewalks, storm drain manholes, and flood control channels.

Although the information on specific construction dates for each structure sampled was not always available, all of the structures sampled were located in areas that were originally developed prior to 1980. General construction time-frames could be approximated for most of the structures based on the time period when the surrounding neighborhood was initially developed. In most cases (61%), the structures sampled were constructed during the 1960's and 1970's. Approximately 19% of the structures sampled were constructed prior to 1960. The original construction dates for the remaining 20% of the structures sampled were unknown, although all areas selected for sampling were in older urban neighborhoods (i.e., developed prior to 1980).

Table 3.1 Sample counts collected from roadway and storm drain structures by structure type and original construction date for the BASMAA Regional Infrastructure Caulk and Sealant Sampling Program.

Structure Type	Original Construction Date of Structure			Total Sample Count
	Pre-1960	1960's - 1970's	Unknown (pre-1980)	
1. Asphalt Road Surface			1	**1**
2. Concrete Bridge/Overpass	5	6		**11**
3. Concrete Road Surface			5	**5**
4. Concrete sidewalk/curb/gutter	2	4	4	**10**
5. Below-ground Concrete Storm Drain Structure		1		**1**
6. Above-ground Concrete Storm Drain Structure (i.e., flood Control Channel)	1	7		**8**
7. Metal Electrical Utility Box attached to concrete sidewalk	2	6		**8**
8. Metal Outfall Pipe		4	1	**5**
9. Metal Pipes exposed at bridge crossing		3		**3**
10. Wood Electrical Utility Pole attached to concrete sidewalk		2		**2**
Total Sample Count	**10**	**33**	**11**	**54**

3.1.2 Appearance of Materials Sampled

The materials that were collected as part of this sampling program varied by color and texture as presented in Table 3.2. The caulk or sealant materials collected were black, white/gray, or brown in color. The textures of these materials ranged from pliable rubbery, foam, or fiber materials, to hard and brittle rock-like materials. The most common type of sample collected was a black material that had a very hard and brittle rock-like texture (43%).

Table 3.2 Caulk or sealant collected from roadway and storm drain infrastructure by sample color and texture for the BASMAA Regional Infrastructure Caulk and Sealant Sampling Program.

Sample Color	Sample Texture				Total Counts
	Pliable/Rubbery	*Pliable/Foam*	*Hard/Brittle*	*Fibrous*	
Black	7	2	23		**32**
White/Gray	8		10		**18**
Brown				4	**4**
Total Counts	**15**	**2**	**33**	**4**	**54**

3.1.3 XRF Screening of Individual Samples

The XRF screening of individual samples for chlorine content only identified 4 samples (out of the 54 collected) that had positive detection of chlorine. The XRF screening results for these four samples are presented in Table 3.3. The chlorine content measured by XRF in these samples ranged from 18,000 ppm up to nearly 500,000 ppm. Because of the limited number of positive chlorine results, XRF analysis could not be used for the majority of the samples as a factor in determining how to group samples for

compositing. All composites that included individual samples with positive chlorine detection by XRF are identified and discussed in more detail in Section 3.2.

Table 3.3 XRF chlorine screening results for samples collected for the BASMAA Regional Infrastructure Caulk and Sealant Sampling Program. Only samples with chlorine detected are included in this table.

Sample ID	Type of Structure	Structure Date	Caulk/Sealant Application	Sample Color and Texture	Chlorine Ion Concentration (ppm)
5	Wood Electrical Utility Pole attached to concrete sidewalk	1960-70's	Wood sealant	Black Hard/brittle	18,100 - 18,400
12	Concrete Bridge	<1960	Pre-fabricated joint filler	Black Pliable	159,500 - 189,100
48	Concrete Flood Control Channel	1960-70's	Pre-fabricated joint filler	White/Gray Hard/brittle	108,700 - 142,200
49	Concrete Flood Control Channel	1960-70's	Pre-fabricated joint filler	White/Gray Hard/brittle	95,900 - 489,800

3.1.4 Compositing Scheme

Based on the information recorded about the 54 individual samples that were collected, two major factors were identified that differentiated the majority of the samples, including: (1) the structure type the sample was collected from; and (2) the appearance of the sample, which was a combination of color and texture. The samples were grouped for compositing based primarily on these two factors, resulting in one to eight individual samples being included in each of the 20 composites. This compositing scheme resulted in grouping samples together that had similar caulk or sealant applications on specific structure types. Figure 3.1 presents the sample groupings included within each composite by structure type and sample appearance (color and texture). Each of the 20 composite samples was assigned a Composite ID which was a random letter designation from A to T. For three of the samples, the combination of structure type and sample appearance was unique enough to warrant analysis as an individual sample rather than a composite. Although XRF analysis results were limited, composites that contained individual samples with positive XRF results for chlorine were noted.

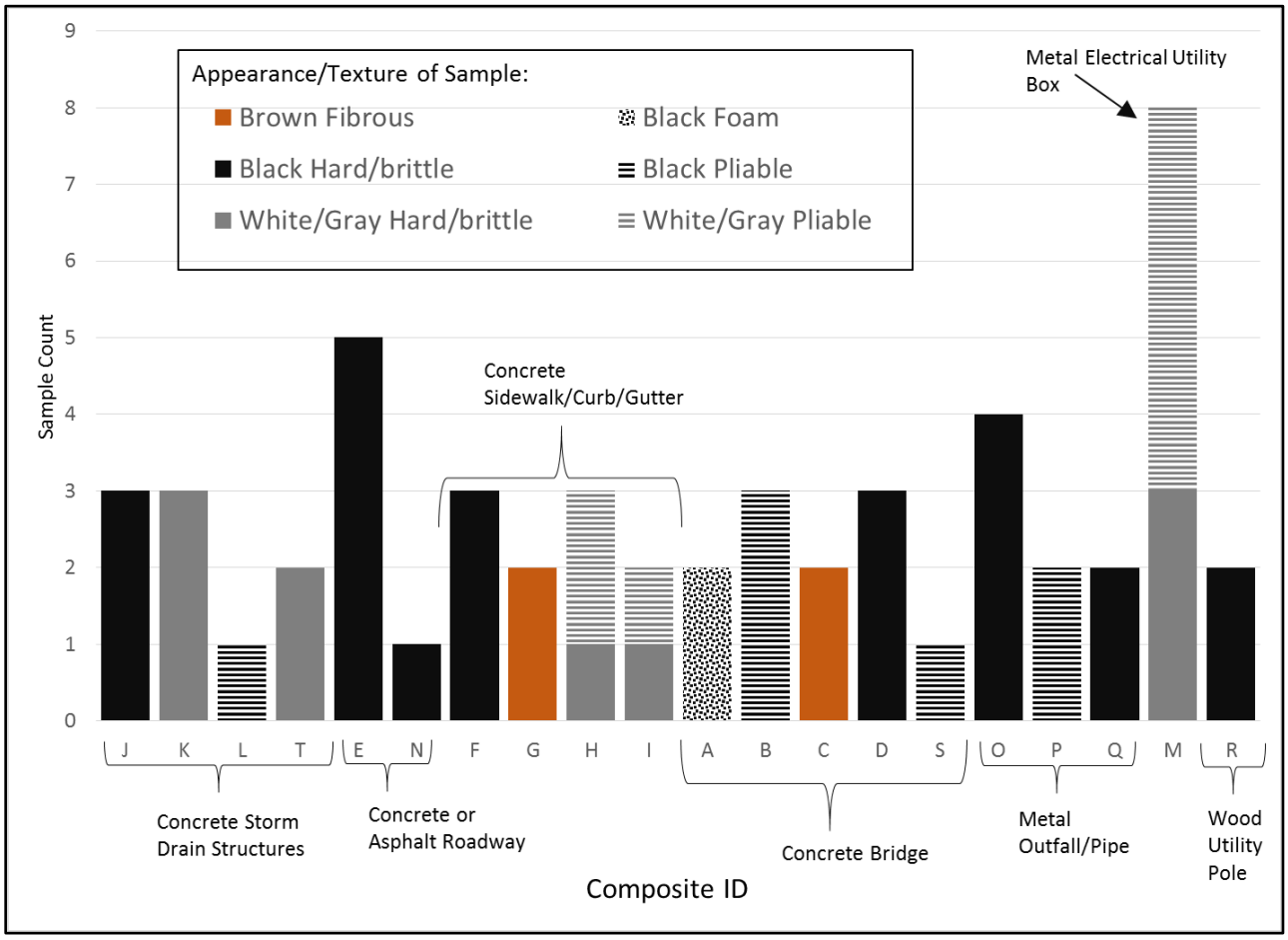

Figure 3.1 Structure types and sample appearance (color and texture) for the caulk and sealant samples included in each composite. Concrete Storm Drain Structures include samples collected from above ground flood control channels and below ground structures that were sampled via manhole access.

3.2 LABORATORY ANALYSIS

3.2.1 Quality Assurance and Quality Control

Data Quality Assurance (QA) and Quality Control (QC) was performed in accordance with the project's SAP/QAPP (Appendix B). The SAP/QAPP established Data Quality Objectives (DQOs) to ensure that data collected are sufficient and of adequate quality for their intended use. These DQOs include both quantitative and qualitative assessments of the acceptability of data. The qualitative goals include representativeness and comparability, and the quantitative goals include completeness, sensitivity (detection and quantization limits), precision, accuracy, and contamination. Measurement Quality Objectives (MQOs) are the acceptance thresholds or goals for the data.

The dataset included 20 composite field samples, with 1 blank, 1 laboratory control sample (LCS), and 2 matrix spikes (MSs), meeting the minimum number of QC samples required. All samples were analyzed within < 216 days, which is well within the recommended hold time of 1 year. Results were reported for the RMP 40 PCB congeners (with their coeluters). Two of the 40 congeners had poor recovery (>70% deviation from target values in LCS samples) and were rejected, so 95% of the field sample results were

reportable. In more than 50% of the samples, all PCBs congeners were non-detect (ND). Additionally, all congeners were ND in both MS samples, with consequent 0% recovery. Even adjusting for dilution factor, expected values of the target analytes were often < MDL reported. This suggests that MS samples were spiked at too low a level, and/or the method may have been insufficient to resolve interferences from the target analytes at the concentration ranges of interest. As the MS samples were the only ones analyzed in replicate, with all results ND, precision could not be calculated. The data, however, are usable for evaluating presence/absence or qualitative/order-of-magnitude comparison of concentration differences. However, due to highly uncertain measurement accuracy and no detectable replicate results to evaluate precision for any PCBs congeners, these data are not usable for finer differentiation. Additional details about the data quality review are presented below. The laboratory QA/QC data are available upon request.

Representativeness – The representativeness of data is the ability of the sampling locations and the sampling procedures to adequately represent the true condition of the sample sites. For this project, all samples are assumed to be representative as they were performed according to the protocols specified in the project SAP/QAPP (Appendix B). All field and laboratory personnel received and reviewed the SAP/QAPP and followed prescribed protocols, including laboratory methods, to ensure the collection of representative, uncontaminated samples.

Comparability – Comparability is the degree to which data can be compared directly to other relevant studies. Maximum concentrations were generally quite low in comparison to the maximums in the previous caulk study conducted in the region (Klosterhaus et. al 2014). However, the NDs/low spiking level/ 0% recovery in MSs mean that we do not have a good direct indicator of measurement accuracy in the caulk matrix.

Completeness – Completeness is the percentage of valid data collected and analyzed, compared to the total expected to be obtained under normal operating conditions. Overall completeness accounts for both sampling (in the field) and analysis (in the laboratory). In this project, the minimum number of field samples planned for collection was 40, which would be combined into 20 composite samples for PCBs analysis. The final dataset included 20 composites, comprised of 54 field samples, with 1 blank, 1 LCS, and 2 MSs, which achieves the number of samples planned for collection as part of the project (including QC samples). Data for two of the 40 PCBs congeners were rejected, so overall 95% of the field sample results were reportable.

Sensitivity – Different indicators of the sensitivity of an analytical method to measure a target parameter are often used including instrument detection limits (IDLs), method detection limits (MDLs), and reporting limits (RLs). For this Project, MDLs are the measurement of primary interest. The target MDL identified in MRP Provision C.12.e for PCBs analysis is 200 ppb (or µg/Kg). The PCBs analysis method that was used in this project (modified GC/MS-SIM) was selected to achieve this level of sensitivity. For this project, all samples that did not require dilution had MDLs well below the 200 ppb MDL target. For five samples that were analyzed at a secondary dilution, the MDL was elevated above this target. To evaluate the impact of the higher MDL on data interpretation (i.e., identifying the PCBs concentration category for each sample), ½ MDL was used for all congeners that were reported at ND in these samples, and a corrected total PCBs concentration was then calculated. In two of the five samples, the corrected PCBs concentration did not change the PCBs concentration category of the composite. For

the other three samples, the corrected PCBs concentration moved these composites from the low or very low category to the moderate PCBs category (< 50 ppm). The corrected concentrations did not result in any samples moving to the High or Very High PCBs categories.

Precision – Precision is used to measure the degree of agreement among individual measurements of the same property under prescribed similar conditions. Overall precision usually refers to the degree of agreement for the entire sampling, operational, and analysis system. For this project, precision was evaluated via matrix spikes and matrix spike duplicates (MS and MSD). The Project SAP/QAPP MQO for RPD is 25% for both laboratory and field duplicates. However, precision could not be evaluated, as no replicates of field samples were run, and all the MS results were ND.

Accuracy - Accuracy describes the degree of agreement between a measurement (or the average of measurements of the same quantity) and an acceptable reference or true value. For this project, accuracy of PCBs congener analysis was evaluated with MSs and laboratory control samples (LCS, spiked blanks). All congeners were ND in both MS samples. Thus, accuracy on MS samples could not be evaluated. LCS recoveries were within 70% relative to the target value for 38 of the 40 PCB congeners, which is an acceptable level of accuracy. However, LCS recoveries were >70% off (higher or lower) relative to the target value for two of the 40 PCBs congeners, and these results were rejected. The overall quantitativeness of the samples is therefore not robust.

Contamination - Blank samples help assure that analytes measured in samples originated from the target matrix in the sampled environment and are not contaminated artifacts of the analytical process. Per the Project SAP/QAPP, a method (laboratory) blank was run in the same batch as the samples and analyzed in a manner identical to the samples. The Project SAP/QAPP specifies that all blanks should not exceed the reporting limit. None of the target analytes were detected in the method blank.

3.2.2 PCBs Concentrations

Tables 3.4 – 3.6 present the PCBs concentrations measured in each composite during the ***BASMAA Regional Infrastructure Caulk and Sealant Sampling Program.*** The results are presented by PCBs category (Non-Detect/Very Low, Low, Moderate, High, and Very High). Additional information about the samples included in each composite is also presented, such as the structure type(s), sample appearance, and XRF screening results. Within each table, the composite results are presented in order of highest to lowest PCBs concentrations.

Total PCBs concentrations across the 20 composite samples ranged from non-detect (ND) to > 4,000 ppm (Tables 3.4-3.6). Twelve of the 20 composite samples (60%), had non-detect or very low PCBs concentrations that were well below the urban background for Bay Area public ROW surface soils and sediment (<0.2 ppm). In ten of the twelve composites with very low concentrations, all RMP-40 PCBs congeners were below detection limits. PCBs were detected above 0.2 ppm in the remaining eight composite samples, ranging from 0.43 ppm to 4,967 ppm. Composites A and B were in the Very High PCBs category (≥ 1,000 ppm). No composites were in the High PCBs category (≥50 ppm but <1,000 ppm). Composites Q, R and S were in the Moderate PCBs category (≥ 1 ppm but < 50 ppm). Composites C, D and K were in the Low PCBs category (≥ 0.2 ppm but < 1 ppm). Additional discussion about the types of samples in each PCBs concentration category is provided below.

3.2.2.1 No PCBs Detected

A total of 32 individual samples were included in the ten composite samples that had no PCBs detected (Table 3.4). The samples in these composites were collected from a variety of structure types, including asphalt and concrete roadway surfaces, concrete sidewalks, curbs and gutters, electrical utility boxes attached to concrete sidewalks, storm drain manholes, flood control channels, metal pipes and metal outfalls (Figure 3.2). The majority of these structures were constructed during the 1960's and 1970's. XRF screening did not detect any samples with chlorine in this category.

Table 3.4 Sample descriptions and PCBs concentrations for composites that had No PCBs Detected from the BASMAA Regional Infrastructure Caulk and Sealant Sampling Program. None of the RMP-40 PCB congeners were detected in any of the composite samples in this table.

Composite ID	Total PCBs (mg/Kg)	Type of Structure(s) Sampled	Caulk or Sealant Application	Sample Appearance (Color/ Texture)	# of Samples in Composite	Sample ID's in Composite	Structure Construction Date
E	ND	Concrete Roadway Surface	Caulk between expansion joints	Black Hard/brittle	5	35	<1980
						36	<1980
						37	<1980
						38	<1980
						39	<1980
F	ND	Concrete sidewalk	Caulk between joints	Black Hard/brittle	3	2	<1960
						7	<1960
						46	<1980
G	ND	Concrete sidewalk /curb/gutter	Caulk between joints	Brown Fibrous	2	16	1960-70's
						17	1960-70's
H	ND	Concrete sidewalk /curb/gutter	Crack Sealant	White/Gray Hard/brittle or Pliable	3	1	<1980
						8	1960-70's
						18	1960-70's
J	ND	Concrete Storm Drain Structure: Flood Control Channel	Caulk between joints	Black Hard/brittle	3	50	1960-70's
						53	1960-70's
						54	1960-70's
L	ND	Concrete Storm Drain Structure: Inside Manhole opening	Sealant between concrete surfaces	Black Pliable	1	34	1960-70's
M	ND	Metal Electrical Utility Box attached to concrete sidewalk	Caulk around base	White/Gray Pliable or White Hard/Brittle	8	11	<1960
						14	1960-70's
						15	1960-70's
						19	1960-70's
						21	1960-70's
						22	1960-70's
						25	<1960
						45	1960-70's
N	ND	Asphalt Roadway Surface	Surface adhesive	Black Hard/brittle	1	4	<1980
O	ND	Metal Outfall	Interior and Exterior Pipe Sealant	Black Hard/brittle	4	33	1960-70's
						41	1960-70's
						42	1960-70's
						43	1960-70's
P	ND	Metal Pipes adjacent to bridge and Metal Outfall	Exterior Pipe wrap	Black Pliable	2	3	1960-70's
						40	<1980

Figure 3.2 Examples of structures that were sampled and caulk or sealant materials that were included in the composites that had No PCBs Detected. Not all structures or samples included in the No PCBs Detected category are pictured here.

3.2.2.2 Very Low PCBs

A total of four individual samples were included in the two composites in the Very Low PCBs category (< 0.2 ppm, Table 3.5). The samples in these composites were collected from concrete sidewalks and concrete flood control channels (Figure 3.3). Samples in Composite T were collected from structures that were constructed in the 1960's and 1970's. The majority of these structures were constructed during the 1960's and 1970's. XRF screening detected chlorine concentrations in both samples included in Composite T, ranging from 100,000 to 500,000 ppm. However, chemical analysis results found PCBs in this composite were less than 0.02 ppm. The two samples included in this composite were both pre-fabricated materials that could have contained chlorine that was not from PCBs.

Table 3.5 Sample descriptions and PCBs concentrations for all composites in the Very Low PCBs concentration category (i.e., < 0.2 ppm) from the BASMAA Regional Infrastructure Caulk and Sealant Sampling Program. Results are presented in order from highest to lowest PCBs concentrations.

Composite ID	Total PCBs (mg/Kg)	Type of Structure(s) Sampled	Caulk/Sealant Application	Sample Appearance (Color/Texture)	# of Samples in Composite	Sample ID's included in Composite	Structure(s) Construction Date
I	0.06	Concrete sidewalk/curb/gutter	Surface adhesive	White Hard/brittle or White Pliable	2	23	<1980
						24	<1980
*T	0.03	Concrete Storm Drain Structure: Flood Control Channel	Pre-fabricated joint filler	White/Gray Hard/brittle	2	48	1960-70's
						49	1960-70's

*XRF screening estimated the chlorine content of these sample was 100,000 – 500,000 ppm. XRF screening did not identify chlorine content in any other samples in this table.

Figure 3.3 Examples of structures that were sampled and caulk or sealant materials that were included in composites that had Very Low PCBs (< 0.2 ppm). Not all structures or samples included in the Very Low PCBs category are pictured here.

3.2.2.3 Low PCBs

Three composite samples (Composites C, D and K) had low PCBs concentrations ranging from 0.43 ppm to 0.78 ppm. All of the materials within each of these composites were used as joint fillers in the gaps between concrete structures, including bridges and flood control channels (Figure 3.4). Composite C was comprised of samples of brown fibrous materials from concrete bridges. Composite D was comprised of black, hard/brittle materials from concrete bridges. Composite K was comprised of samples of gray, hard materials from concrete flood control channels. The observed PCBs concentrations suggest proximity to a PCBs source. However, given the relatively low concentrations, the PCBs in these samples likely resulted from contamination by a source other than the sampled materials. For example, older PCB-containing caulks or sealants may have been used previously at these locations, and there may be residual PCBs from these past sources.

Figure 3.3 Examples of structures that were sampled and caulk or sealant materials that were included in the composites that had Low PCBs (≥ 0.2 ppm and < 1 ppm). Not all structures or samples included in the Low PCBs category are pictured here.

Table 3.6 Sample descriptions and PCBs concentrations for all composite samples in the Very High, Moderate and Low PCBs concentration categories (i.e., above 0.2 ppm) from the BASMAA Regional Infrastructure Caulk and Sealant Sampling Program. None of the composites in this sampling program had PCBs concentrations in the High PCBs category. Results are presented in order from highest to lowest PCBs concentrations.

PCBs Category	Composite ID	Total PCBs (mg/Kg)	Type of Structure(s) Sampled	Caulk/Sealant Application	Sample Appearance (Color/ Texture)	# of Samples in Composite	Sample ID's in Composite	Structure Construction Date
VERY HIGH	A	4,967	Concrete Bridge	Caulk between expansion joints	Black Pliable Foam	2	10	1960-70's
							13	<1960
	B	4,150	Concrete Bridge	Caulk between expansion joints	Black Pliable	3	9	1960-70's
							30	1960-70's
							31	<1960
MODERATE	Q	24	Metal Pipes adjacent to bridge	Exterior Pipe Sealant	Black Hard/brittle	2	28	1960-70's
							44	1960-70's
	*R	2.8	Wood Electrical Utility Pole attached to concrete sidewalk	Wood sealant	Black Hard/brittle	2	5	1960-70's
							6	1960-70's
	*S	2.5	Concrete Bridge	Pre-fabricated joint filler	Black Pliable	1	12	<1960
LOW	C	0.78	Concrete Bridge	Caulk between expansion joints	Brown Fibrous	2	20	1960-70's
							26	1960-70's
	D	0.70	Concrete Bridge	Sealant between concrete surfaces or between concrete and wood surface	Black Hard/brittle	3	27	<1960
							29	1960-70's
							32	<1960
	K	0.43	Concrete Storm Drain Structure: Flood Control Channel	Caulk between joints	Gray Hard/brittle	3	47	1960-70's
							51	<1960
							52	1960-70's

*XRF screening chlorine content of these samples ranged from 18,000 ppm to 189,000 ppm. XRF screening did not identify chlorine content in any other samples in this table.

3.2.2.4 Moderate PCBs

Three composite samples (Composites Q, R and S) had Moderate PCBs concentrations, ranging from 2.5 ppm to 24 ppm (Table 3.6). Composite Q (24 ppm) was comprised of black, pliable sealant materials used on the exterior surfaces of exposed metal pipes (e.g., gas, water, or sewage pipelines) that ran adjacent to concrete bridges (Figure 3.5). Composite R was comprised of black sealant materials collected from wooden utility poles attached to concrete sidewalks. Composite S consisted of black filler materials used in expansion joints or between adjacent surfaces on concrete bridges. The concentrations found in these composites were all within the range of concentrations considered high for surface soil and storm drain sediments during investigations conducted to identify watershed-based PCBs sources, but much lower than the concentrations that would be expected if PCBs were a component of the caulk or sealant formulation. Given the elevated, but still relatively low concentrations, the sources of PCBs in these samples more likely result from contamination by residual PCBs remaining at these locations from past sources.

Figure 3.4 Examples of structures that were sampled and sealant materials that were included in the composites that had Moderate PCBs (≥ 1 ppm and < 50 ppm). Not all structures/samples in the Moderate PCBs category are pictured here.

3.2.2.5 Very High PCBs

Only two composite samples (Composites A and B), comprising 9% of the individual samples collected during this program had Very High PCBs concentrations (≥ 1,000 ppm). All of the samples within these composites were of black, pliable joint filler materials that were collected from concrete bridges (Figures 3.6 – 3.7). PCBs concentrations in this category indicate that PCBs were likely part of the original caulk or sealant formulations to impart desired characteristics such as elasticity. This finding is consistent with a previous sampling effort that found elevated PCBs in the black, pliable expansion joint filler that was used on the old eastern span of the San Francisco-Oakland Bay Bridge (Caltrans 2013).

Figure 3.5 Examples of structures that were sampled and caulk materials that were included in Composite A, which had Very High PCBs (≥ 1,000 ppm).

Figure 3.6 Examples of structures that were sampled and caulk materials that were included in Composite B, which had Very High PCBs (≥ 1,000 ppm).

3.2.3 Utility of XRF Screening

Composite R and S were the only samples that had PCBs above urban background and that also had chlorine detected by XRF analysis (Tables 3.3 and 3.6). However, given the 5 orders of magnitude difference between the chlorine concentration determined by XRF analysis and the PCBs concentrations determined by GC/MS analysis, even when chlorine is detected, the vast majority is often not from PCBs. More critically however, although all of the composites with no PCBs detected in this study also never had chlorine detected by XRF, some composites with very high PCBs (A & B), also had no detectable chlorine by XRF. Thus the results provided no evidence that XRF screening was useful for identifying samples with PCBs, nor for conclusively identifying samples that would not have PCBs.

3.2.4 Comparison with Other Studies

Table 3.7 presents a comparison of the PCBs concentrations measured in caulk and sealants collected during this sampling program with concentrations measured in caulk and sealants from previous studies in the Bay area, across the United States, and globally. Previous studies found very high, high and moderate concentrations of PCBs in caulk and sealant materials used on the exteriors of buildings, between concrete structures, in storm drain infrastructure, and in a drinking water reservoir (Sykes and Coates 1995, Herrick et al. 2004, Kohler et al. 2005, Robson et al. 2010, Tacoma 2013, 2016, Klosterhaus et al. 2014). PCBs concentrations detected in these studies ranged from the low parts per million up to 55% PCBs by mass. All of the PCBs concentrations detected in the current study are within the range of concentrations found in these other studies.

For additional context, Table 3.7 also includes the range of PCBs concentrations that have been measured to-date in public ROW surface soils and storm drain sediments in the Bay Area. In public ROW surface soils and sediments, PCBs above 1 ppm are considered high, and indicate proximity to a source. However, the highest concentrations that have been observed to date in public ROW surface soils and storm drain sediment in the Bay Area are below 200 ppm, or < 0.02% PCBs. By comparison, the highest concentrations found in caulks and sealants in this study were at least one order-of-magnitude greater than the highest storm drain sediment concentrations. Further, the highest concentrations of PCBs in caulks and sealants from this study were also one order-of-magnitude greater than the PCBs concentrations found in storm drain sealant in Tacoma, Washington (Tacoma 2013, 2016), and three orders-of-magnitude greater than the previous finding of PCBs in joint filler materials from the old eastern span of the San Francisco-Oakland Bay Bridge (Caltrans 2013).

About one-third of the samples of caulk or sealant materials collected during previous studies from building exteriors had PCBs concentrations above 50 ppm, which is the U.S. federal regulatory threshold for hazardous waste. In this BASMAA study, approximately one-tenth of the samples were above 50 ppm. The highest PCBs detected however, were much lower (one or two orders of magnitude lower) than the highest PCBs concentrations found in building caulks and sealants during previous studies. Compositing may have resulted in the dilution of higher concentration samples in the current study, however, at most this would result in dilution by one-half or one-third (given the number of samples included in each composite). Therefore, even accounting for potential dilution by one or more low concentration samples in each composite, the concentrations found in this study remain much lower than those observed in previous studies of PCBs in caulks or sealants from building exteriors.

Table 3.7 Comparison of PCBs concentrations measured in caulk and sealant materials collected from buildings and public roadway or storm drain infrastructure in the BASMAA Regional Infrastructure Caulk and Sealant Sampling Program, and other studies in the Bay Area, the United States and globally.

Study Location		Study Authors	Number of Samples	PCBs Concentrations	Materials Sampled
San Francisco Bay Area		*Numerous*[a]	*> 1,200*	*ND – 193 ppm*	*Public ROW surface soils or storm drain infrastructure sediment*
		BASMAA 2018	**20**[b]	**<4,967 ppm (up to 0.5%)**	**Caulk and sealants from public roadway/storm drain infrastructure**
		Klosterhaus et al. 2014	29	1 - 220,000 ppm (up to 22%)	Exterior building caulk
		Caltrans 2013	n/r[c]	0.7 - 3.7 ppm (0.0004%)	Black rubber sealant between expansion joints on old eastern span of San Francisco-Oakland Bay Bridge
		Sykes and Coate 1995	n/r	~200,000 ppm (20%)	Caulk lining a drinking water reservoir
Other Locations	**Tacoma, WA**	Tacoma 2013, 2016	n/r	260 ppm (0.026%)	Black tar sealant from a storm drain catch basin
	Boston, MA	Herrick et al. 2004	24	0.56-32,000 ppm (up to 3.2%)	Exterior building caulks
	Toronto, Canada	Robson et al. 2012	95	570-82,000 ppm (up to 8.2%)	Exterior building caulks
	Switzerland	Kohler et al. 2005	1,348	20-550,000 ppm (up to 55%)	Building joint sealants

[a]Gunther et al. 2001; KLI and EOA Inc. 2002; EOA Inc. 2002, 2004, 2007a, 2007b; City of San Jose and EOA Inc. 2003; SMSTOPPP 2002, 2003; Kleinfelder 2005, 2006; Salop et al. 2002a, 2002b; Yee and McKee 2010; SCVURPPP 2018; SMCWPPP 2018.

[b]The Samples were composites containing samples from 1 to 8 sites each.

[c]Not Reported (n/r)

4 CONCLUSIONS AND RECOMMENDATIONS

The ***BASMAA Regional Infrastructure Caulk and Sealant Sampling Program*** found PCBs at concentrations < 0.2 ppm for the majority of caulk and sealant samples collected from a variety of Bay Area public roadway and storm drain infrastructure. Forty percent (8 of 20) of the composite samples analyzed during this sampling program were above 0.2 ppm. Of these, only two composite samples had very high PCBs concentrations (> 1,000 ppm). Concentrations in this category indicate that PCBs were likely part of the original caulk or sealant formulations to impart desired characteristics such as elasticity. These results demonstrate that PCBs-containing caulks and sealants were used in some capacity on Bay Area roadway and storm drain infrastructure in the past, but the full extent and magnitude of this usage is unknown. All of the individual samples included within the two composite samples with very high PCBs consisted of black, pliable caulking materials that were used as joint fillers on concrete bridges or overpasses constructed prior to 1980. This finding, combined with previous findings in Tacoma and the Bay Area of PCBs in black filler materials, suggests that future characterization efforts might provide somewhat greater focus on these types of materials and applications.

No samples contained PCBs in the high category (50 - 1,000 ppm) and three composite samples only contained moderate (1 - 50 ppm) PCBs concentrations. For comparison purposes, soil/sediment samples collected in the public ROW that have concentrations within the moderate category (> 1 ppm), are typically investigated further and may indicate proximity to a PCBs "source property" that can be referred to the Regional Water Board for further evaluation. That said, the fate and transport processes of caulk/sealants in roadways and storm drain infrastructure likely differ greatly from sediment collected in public ROWs. Furthermore, the moderate concentrations observed during this study are well below the concentrations that would be expected if PCBs were a significant component of the original caulk/sealant material. The PCBs observed in samples with the moderate or low (>0.2 – 50 ppm) categories may be due to contamination from other sources, which could include residual PCBs associated with source materials that are no longer present. For example, the past use of PCBs-containing caulks or sealants that have since been removed or simply disintegrated over time may have left behind residual PCBs that contaminated surrounding surfaces.

Of the ten structure types that were sampled during this study, only concrete bridges/overpasses had PCBs at levels approaching the very high concentrations expected for PCBs-containing caulks and sealants. Thus, these results provide no indication that caulk and sealants present in the other nine types of structures that were sampled during this program would be expected to contain PCBs at levels above those observed in sediments/soils within the public ROW or on private properties in the Bay Area. There may be other types of materials that were not observed or collected during this sampling program that contain higher concentrations of PCBs.

The conclusions from this sampling program are limited by the small number of structures that were sampled (n=54), compared with the vast number of roadway and storm drain structures throughout the Bay Area that were originally constructed during the peak period of PCBs production and use (1950 – 1980). Many questions remain about infrastructure caulks and sealants as potential sources of PCBs to

stormwater. The data from this sampling program are not adequate to address these questions, including:

- Do PCBs migrate from infrastructure caulks and sealants into urban stormwater? If so, what are the processes involved?
- What are the PCBs concentrations of concern in infrastructure caulks and sealants?
- What is the mass of infrastructure caulk and sealants in the Bay Area that has PCBs concentrations of concern?
- How much PCBs mass is transported from infrastructure caulks and sealants to stormwater annually?

Given the limitations of the project, more information would be needed to estimate the mass of PCBs in infrastructure caulk and sealant materials, to better understand the fate and transport of PCBs in these materials, and to calculate stormwater loading estimates. Nevertheless, this screening-level sampling program was the first step towards understanding if infrastructure caulk and sealants are a potential source of PCBs to urban stormwater. Although limited by the small number of samples, the results of this sampling program indicate: (1) the majority of roadway and storm drain structure types that were sampled in this project did not have PCBs-containing caulks or sealants at concentrations of concern, and (2) only black, pliable joint fillers found on concrete bridges/overpasses sampled had PCBs concentrations of potential concern to stormwater. If further investigation is conducted, focusing on this type of application may be a reasonable place to continue such efforts.

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APPENDIX A: FINAL STUDY DESIGN

Evaluation of PCBs in Caulk and Sealants in Public Roadway and Storm Drain Infrastructure

Final Study Design

Prepared for:

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1 INTRODUCTION

1.1 BACKGROUND

Until banned from production in 1979, polychlorinated biphenyls (PCBs) were commercially produced and used in a variety of products in the U.S., including caulk compounds and joint sealants. In addition to uses in public and private buildings of tilt-slab style constructed prior to 1979 (Klosterhaus et al. 2014), PCBs-containing caulks and sealants may also be found between the expansion joints in public infrastructure such as roadways, parking garages, bridges, dams, storm drain pipes, and pavement joints (e.g., curb and gutter). PCB use in caulk or sealant is categorized as an open-ended application that allows potential release of PCBs to the environment during use, compared with closed applications (e.g., PCBs as dielectric fluid in transformers) that do not allow release to the environment during normal use (WHO, 1993). Because open application of caulks and sealants in such public roadway and storm drain infrastructure can come into direct contact with stormwater as it flows over and through these systems, this can be a direct source of PCBs in urban stormwater.

In 2013, the City of Tacoma conducted a source-tracing program after elevated PCBs were detected in stormwater from a residential neighborhood that drains to the Thea Foss Waterway (City of Tacoma 2013, 2016). The city determined that the source of PCBs was a black tar crack sealant in a storm drain catch basin in the neighborhood that was applied during a 1975 road construction project. A sample of the sealant collected between the asphalt and concrete catch basin had PCB concentrations up to 260 ppm. Although most of the sealant had worn away by 2013, the soil underneath the sealant was likely contaminated with PCBs as the sealant material disintegrated over the years.

In the Bay Area, several open applications of PCB-containing caulks have been identified previously, including caulks used around windows and door frames of buildings (Klosterhaus et al., 2014), in the sealant that was used in the gaps between concrete slabs of the road deck on the Old East Span of the San Francisco Oakland Bay Bridge, and in caulk used in the joints of concrete drinking water storage reservoirs located in Alameda County (Sykes and Coate, 1995). These examples represent the limited extent of local information that is currently available on PCBs in storm drain and roadway infrastructure, and demonstrate that additional monitoring data are needed to evaluate the importance of this potential source of PCBs to urban stormwater runoff. Although the reservoir of PCBs contained in roadway and storm drain infrastructure caulks and sealants in the Bay Area is currently unknown (and we are not aware of any other published study that has completed an inventory in urban infrastructure in the US), this source is potentially large enough to warrant further investigation.

1.2 REGULATORY REQUIREMENTS

Provision C.12 of the Municipal Regional Stormwater NPDES Permit (MRP; Order No. R2-2015-0049) implements the PCB Total Maximum Daily Loads (TMDLs) for the San Francisco Bay Area. Provision C.12.e of the MRP specifically requires that Permittees collect at least 20 composite samples (throughout the permit area) to investigate PCB concentrations in caulk and sealants from public roadway and storm drain infrastructure, and report the results in the 2018 Annual Report. Laboratory

analysis methods must be able to detect a minimum PCBs concentration of 200 parts per billion (ppb, or µg/Kg). To achieve compliance with Provision C.12.e, MRP Permittees have agreed to collectively conduct this sampling via the Bay Area Stormwater Management Agencies Association (BASMAA). This effort will also contribute to partial fulfillment of pollutants of concern (POC) monitoring required in Provision C.8.f of the MRP to address source identification, one of the five management information needs identified in the MRP. Source identification monitoring focuses on identifying which sources or watershed source areas provide the greatest opportunities for reductions of POCs in urban stormwater runoff.

1.3 Project Goal

The overall goal of this project is to evaluate, at a limited screening level, whether and in what concentrations PCBs are present in public roadway and storm drain infrastructure caulk and sealants in the Bay Area. To accomplish this goal, this study design presents a regional sampling plan to collect and analyze PCBs in 20 composite samples of caulk and sealants from public roadway and storm drain infrastructure. Implementation of this sampling plan will result in Permittee compliance with MRP Provision C.12.e, and partial fulfillment of the Provision C.8.f monitoring requirements aimed at finding PCBs sources. The results of this project will be reported in each countywide stormwater program's 2018 Annual Report, and will be used to guide next steps.

2 Study Design

2.1 Approach

The overall approach is to collect, analyze and report on PCB concentrations measured in Bay Area roadway and storm drain infrastructure caulk and sealants. The project team, in coordination with participating municipalities, will collect up to 50 samples of caulk and other sealants from storm drain structures and between concrete curbs and street pavement in public right-of-ways. These samples will be composited and a total of 20 composite samples will be analyzed for PCB concentrations. The results will be reported in the 2018 Annual Report.

Participation of Bay Area municipal partners is a critical factor for success of this project. To ensure willingness to participate, municipal partners will remain anonymous in all project reporting. Further, a blind sampling approach will be applied such that no information will be retained or reported that identifies the specific locations where PCB concentrations were measured. Only generic information that does not identify sample locations will be retained, including the type of structure or material collected, type of usage, age of structure, etc. These factors may be used to guide selection of samples for compositing and PCBs analysis. Moreover, this information may provide clues about where PCBs are more likely to be found in infrastructure caulk or sealants in the Bay Area. Additional information about each sampling site that may be useful for future efforts to estimate the PCBs inventory in these materials may also be documented, including crack dimensions, the length and/or width of the caulk bead sampled, spacing of expansion joints in a particular type of application, etc.,.

Over-sampling across multiple municipalities may also be conducted, as resources allow, such that only a subset of those samples, selected blind to their location, will be sent to the lab for PCBs analysis. This approach was deemed appropriate because the goal of this project is not to identify specific locations with elevated PCBs, but rather, to better understand if roadway/storm drain infrastructure caulk or sealants are potential sources of PCBs to urban stormwater runoff in the Bay Area. The regional sampling plan presented below is divided into two phases, including:

1. Identification of Structures for Sampling and Sample Collection
2. Selection of Samples for Compositing, PCBs Analysis and Reporting

Detailed descriptions of all sampling and analysis methods that will be used, the data quality objectives, and the procedures that will be implemented to ensure data quality during this project will be provided in the Quality Assurance Project Plan and Sampling and Analysis Plan (QAPP/SAP, *in preparation*). If PCBs are found to be present in infrastructure in the Bay Area, a protocol may be developed in the future to identify and manage PCBs-containing materials during infrastructure improvement projects to reduce potential discharges to the MS4. If PCBs are found, some municipalities may wish to perform immediate abatement rather than waiting for the next infrastructure improvement project at that location.

2.2 Phase 1: Identification of Structures for Sampling and Sample Collection

Phase 1 includes recruitment of Bay Area municipal partners, identification of structures within partner municipalities' jurisdictions for sampling, and sample collection. Each of the steps required to implement Phase 1 are described below.

2.2.1 Recruitment of Municipal Partners

The first step in implementing Phase I of this monitoring program is to recruit participation from Bay Area municipalities. Stormwater Program staff from each of the five Bay Area counties subject to the MRP will conduct outreach to municipalities in their countywide program and request participation in the project. The project team has prepared a memo that can be used to inform potential municipal partners about the project and request for participation. The role of the municipal partners will be to assist the project team in identifying appropriate structures for sampling, and to assist the monitoring contractor during sample collection, as needed. This assistance will entail working with the project team to identify appropriate sites by providing municipal staff that have working knowledge of roadways and storm drain infrastructure in the city, including the general condition and location of appropriate structures, maintenance and repair issues, and access to records or knowledge of the information needed to apply the screening criteria for sample site selection (defined below).

The municipal staff will be asked to review the screening criteria with the project team, provide information on the location of structures that may meet these criteria, and (as needed) accompany project team members during field visits to potential sample locations to verify structure conditions and identify specific locations where caulk/sealant are available for sample collection. Municipal staff may also be requested to provide logistical support to the monitoring contractor during sample collection, if needed, which may involve providing permits, traffic controls or other safety measures that may be required.

Interested municipal staff will be asked to look for opportunities (described in more detail in Sections 2.1.2 and 2.2) to collect caulk or sealant samples independent of the project monitoring contractor. All necessary information for municipal staff to perform such sample collection will be provided in the project QAPP/SAP (*in preparation*).

Desirable attributes of municipal partners include one or more of the following characteristics:

- Cities that were significantly urbanized prior to 1980. All newer urban areas will be excluded from sampling, as these are not expected to contain PCBs in caulk or sealants.
- Cities that conduct their own road and storm drain infrastructure maintenance. Information about maintenance and repairs to all potential sample site locations, as well as site-specific information on potential structures will be needed to identify appropriate sampling sites.
- Cities that have available records of structure installation or rehabilitation and/or knowledgeable staff that can provide such information as far back as the 1970's. Site selection will rely heavily on the knowledge of roadway and storm drain infrastructure provided by municipal staff.
- Cities that have the available resources and willingness to assist the project team in identifying sampling sites, and during sample collection. The project team will ask participating municipal staff to review the screening criteria for sample site selection (provided below) and identify potential locations that meet the criteria. Municipal staff will also be asked to participate in field reconnaissance during site selection and logistical support during sample collection, as described below.
- Larger cities are more likely to have the desirable attributes described above. However, cities of any size that have these attributes are also desirable municipal partners.

2.2.2 Sample Site Selection Criteria

The sample population for this project is the universe of publicly maintained roadways, sidewalks and storm drain structures containing caulk or sealants located within participating Bay Area municipalities. Based on literature review and best professional judgement, the screening criteria for sample site selection provided below were developed to target structures for sampling that are more likely to contain PCBs in caulk or sealants, while also balancing logistical and safety considerations for sample collection. After the municipal partners have been identified, these criteria may be modified or refined based on input from knowledgeable municipal staff and to address any municipal-specific issues. Any modifications to the initial screening criteria presented below will be documented in the final project report. Initial screening criteria for sample site selection include the following:

1. **Public Property**: All sample sites must be located within the public right-of-way
2. **Structure Types**: The following concrete or asphalt structures may be selected: roadways, parking lots, bridges, sidewalks, pavement joints (e.g, curbs and gutters), storm drain catch basins or inlets, and storm drain pipes or culverts.
3. **Structure Age**: Sampling will focus on structures (or portions of structures) installed or rehabilitated during the 1970's. Although PCBs were likely present in caulk and sealants used prior to the 1970's, these materials are expected to break-down and disintegrate over time due to normal wear. So, the older caulks/sealants are more likely to have worn away and/or to have

been replaced. To reduce this possibility, this project will focus on sampling efforts on the 1970's as the most recent decade during which PCBs were used in caulk and sealants.

4. **Structure Rehabilitation Age**: Sampling will focus on structures (or portions of structures) that have not undergone rehabilitation since the 1980's. Because PCBs were not used from at least 1980 onward, any structures, or portions of structures that were rehabilitated, including removal and replacement of caulk/sealant, and/or addition of caulk/sealant from 1980 onwards are excluded from sampling.
5. **Road Materials**: Portland cement concrete roads are more durable than asphalt-based pavement; thus, existing concrete roads are more likely to contain caulk/sealants applied during the 1970's because they are less likely to have been replaced or resurfaced since 1980.
6. **Open Application of Caulk/Sealant**: Sampling will focus on open applications of caulk or sealants that are exposed and available for sample collection. Examples include: sites of roadway or storm drain infrastructure repairs, such as filled cracks that formed on the surface after installation, joints between concrete curbs and street pavement, joints between concrete paving, sidewalks or bridge decks, and joints between sections of storm drain pipes or culverts.
7. **Accessibility**: All sample sites must be safely accessible to the monitoring team for sample collection. Sites that do not require confined space-entry or other special equipment are preferred.
8. **Ongoing Capital Projects:** Storm drain infrastructure rehabilitation or roadway repaving or repairs that are happening during the study period (July 2017 through December 2017) may provide an opportunity for municipal staff to collect samples of caulk or sealants (independent of the project monitoring contractor) that would otherwise not be accessible.
9. **Other Opportunities**: During field reconnaissance or sampling, additional unplanned/opportunistic sites may be identified that are good candidates for sampling, including locations observed to have older crack sealants that may be present from past repairs, locations where cracks between asphalt and concrete gutters may contain older caulks/sealants, etc. Municipal staff may have knowledge of such locations where old crack sealant may be present, or may identify such locations during their normal operation and maintenance activities throughout the course of the project.

The project team will work with municipal staff to identify potential sampling sites that meet the above criteria within the jurisdiction of each partner municipality. To identify sites, the first step will entail review of available information such as GIS map layers, satellite imagery, or records from tracking systems used by cities to document roadway/storm drain infrastructure construction and/or repairs to identify areas of interest within each partner municipality. Knowledgeable municipal staff will be queried for information about open applications of caulk or sealants based on their familiarity with municipal structures in the areas of interest. To the extent possible, the criteria above will be verified for a given location with existing records that document these factors. However, because records for the time period of interest may not be available or may be difficult to track, anecdotal information from knowledgeable municipal staff will also be considered during site selection.

2.2.3 Field Reconnaissance and Initial Sample Collection

The next step is to conduct field reconnaissance in the areas of interest to identify specific structures that meet all of the above criteria, and if feasible, to begin initial sample collection. Project team

members and appropriate municipal staff will work together, as needed, to conduct these visits. During field reconnaissance, the project team and/or municipal staff will identify specific structures that are sample site candidates within the areas of interest, document and confirm conditions at each site, identify specific areas of caulk or sealant that are available for collection, and collect caulk or sealant samples if feasible. If necessary, the logistics of collecting samples at a later date at sites that may require additional planning and/or equipment prior to sample collection (e.g., confined space entry sites) will be evaluated. Field notes and photo documentation will be used to record information gathered during the field reconnaissance and initial sample collection. Field sheets and instructions will be detailed in the project QAPP/SAP.

During these field visits, or at any time during the project sampling phase (July 2017 – December 2017), municipal staff will be asked to look for opportunities to collect caulk or sealant samples independent of the project monitoring contractor. For example, capital improvement projects that occur during the project sampling period may provide access to locations that would not otherwise be feasible for sample collection. Municipal staff may also observe caulk or sealant in roadway and storm drain infrastructure during the course of their regular operations and maintenance activities. All of the necessary information on how to collect caulk/sealant samples, the field notes and other documentation that should be recorded during sample collection, and all proper sample handling and storage procedures will be provided to municipal staff in the project QAPP/SAP. The project monitoring contractor will also be available to provide additional training on sample collection to any interested municipal staff during the initial field reconnaissance.

2.2.4 Follow-Up Sampling

The project team will review all of the information gathered during field reconnaissance and initial sample collection and identify any additional locations that are good candidates for follow-up sample collection. Follow-up sample site selection will be biased towards sites that are considered more likely to contain PCBs in caulk or sealants. Other factors considered will include the information on the types of samples already collected, the number of additional appropriate sites that have been identified, the type of structures identified, the types of caulk/sealant usages at the sites, logistical factors associated with sampling each structure, and available resources.

2.2.5 Field Sampling Methods

In-situ caulk or sealant samples will be collected from selected locations in public storm drain infrastructure or roadways following the methods and procedures detailed in the project QAPP/SAP. Materials that will be sampled include:

- caulk used to fill cracks in concrete or asphalt roadways or sidewalk surfaces,
- tar-like sealant material observed within storm drain structures or roadway surfaces,
- materials used to seal concrete structures such as gutters and catch basins to asphalt pavement,
- joint sealants between concrete blocks, etc.

Depending on the location and the condition of the caulk or sealant material available, samples may be collected using a variety of techniques ranging from stainless steel knives/spoons used to scrape material from structure surfaces or collect material from inside cracks, or by carefully chiseling hardened

material from surfaces or from within cracks/joints using appropriate tools. Field notes and photographs will be taken to document the sample collection method(s) used at each site, as well as to document the structure type, the type of caulk or sealant usage, and other relevant factors (but being careful to avoid any identifying features of the area such as road signs, heritage trees or other landmarks). Samples of caulk/sealant will be selected for compositing based on factors such as: structure type, structure age, particular caulk/sealant usage, multiple samples from a single structure, and percent chlorine based on XRF screening results (described below). Composite samples collected from multiple locations would allow PCBs analysis of caulk/sealant from across a wider geographic extent within the available analysis budget. All samples will be collected as one-time events.

2.3 Phase 2: Selection of Samples for Compositing, PCBs Analysis and Reporting

During Phase 2, the project team will review the information gathered on all samples that were collected, perform screening procedures in order to group samples for compositing purposes, select a sub-set of samples that will be sent to the laboratory for PCBs analysis, and report the results. Each of these steps are described in more detail below.

2.3.1 Selection of Samples for Compositing and PCBs Analysis

Once all the samples have been collected, the project team will decide which samples will be sent to the laboratory, and how those samples will be grouped for compositing prior to PCBs analysis. Selection of the sub-set of samples for PCBs analysis will not be random, but will remain blind to specific site location. Samples will be grouped for compositing based on a number of potential factors such as geographic area, structure type (e.g., catch basin, roadway, etc.), or material usage (e.g., sealant used to fill cracks on roadways, etc.). Multiple samples from a single structure may also be composited. Decisions on how samples will be composited will be made after the samples have been collected based on the types of sites that are sampled and other information gathered about each site. X-ray Fluorescence (XRF) technology will also be used to screen samples for chlorine content and guide selection and compositing decisions, as described below (Section 2.3.1.1). Composite samples will potentially allow the monitoring program to cover a greater geographic area with a limited number of samples that will be analyzed for PCBs, and may also provide some data on how concentrations vary across the different categories of structures, usage, etc. Although limited by the small sample size (i.e., 20 samples), this type of information may be important for future efforts to identify infrastructure caulk or sealants associated with PCBs.

2.3.2 XRF Screening Procedures

Because PCBs are highly chlorinated, samples with high chlorine content are more likely to contain PCBs. Previous projects have used portable XRF technology to evaluate the chlorine content of caulk samples (Klosterhaus et. al., 2014). Each sample collected in this project will be screened for chlorine content using portable XRF technology. Based on the range of chlorine content observed, the samples will be divided into high, moderate, and low chlorine content. Samples from the high and moderate chlorine content categories will be prioritized for PCBs analysis, as these have a higher probability of containing PCBs. Moderate chlorine concentrations may provide information on whether the presence of chlorine is driven primarily by PCBs or instead by other chlorine containing compounds. However, chlorine content as determined by XRF screening, will only be one of several factors that will be considered in

determining how to select samples for PCBs analysis and how to group those samples for compositing purposes. The XRF screening results will be compared with the PCBs analysis results to better understand the usefulness of this procedure in identifying PCB-containing caulks or sealants.

2.3.3 Laboratory Methods

Prior to PCBs analysis, the laboratory will composite samples per the direction of the project team. All composited samples will be analyzed for the RMP 40 PCBs following modified EPA Method 8270C (GCMS-SIM), which provides congener specific PCB concentrations at an acceptably low detection limit for the purposes of this project (MRL = 0.5 µg/Kg). All laboratory QA/QC procedures will follow the methods detailed in the project QAPP/SAP (*in preparation*).

2.3.4 Reporting

The range of total PCB concentrations measured in roadway and storm drain infrastructure caulk and sealant will be reported. If possible, PCBs concentrations will also be reported by appropriate sub-categories, such as structure type, age of installation/repair, caulk or sealant usage, percent chlorine, or other factors. The infrastructure caulk/sealant concentrations observed during this project may also be compared to PCB concentrations in other media, such as soil/sediment or caulk from building materials in the Bay Area. The project team will prepare a final project report of the sampling data that may also include recommendations for additional information needed to support future development of stormwater loading estimates and to develop appropriate control measures for this source. The final project report will be available for submittal to the Regional Water Board with the 2018 MRP Annual Reports due in September 2018.

2.4 Study Assumptions and Limitations

This regional sampling plan was not designed to characterize the full range of PCB concentrations in Bay Area caulk and sealants, but rather, to provide a limited, screening level survey of concentrations of PCBs that may be found in Bay Area roadway and storm drain infrastructure caulk in order to understand if this is a potential source to urban stormwater that requires further attention. Resources limit the project to collecting up to 50 samples, and only analyzing 20 composite samples for PCBs. The primary risk with such a small sample size is that the monitoring may not identify sites that have high concentrations of PCBs in caulk or sealants, even if such sites exist in the Bay Area. The study design attempts to minimize this limitation through targeted sample site selection, which focuses on locations that have a higher likelihood of containing PCBs in caulk and sealants. The assumption of this targeted sampling approach is that PCBs will not be found in high concentrations at sites that do not meet the site selection criteria identified in Section 2.2.2. XRF screening techniques may also increase the likelihood of selecting samples for lab analysis that have a higher likelihood of containing PCBs. Inclusion of composite samples can also extend the geographic coverage of the limited number of samples that will be analyzed for PCBs. However, given the small sample size and lack of definitive information on where PCB-containing caulks were used in Bay Area infrastructure, it is still possible that high concentrations will not be observed even if there are locations in the Bay Area that have high enough PCB concentrations in infrastructure caulk or sealants to warrant implementation of controls for this source of PCBs to urban stormwater.

3 SCHEDULE

- Draft and Final study design. (Draft Due May 2017; Final Due June 2017)
- Draft and Final Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP). (Draft Due June 2017; Final Due August 2017)
- Draft and Final Cost Estimates (Draft Due June 2017; Final Due August 2017)
- Project team discussions with municipal partners to facilitate information exchange and begin sample site selection (July/August, 2017)
- Field reconnaissance and Initial Sample Collection (August/September 2017)
- Additional Sample Collection (September 2017 – November 2017)
- XRF Screening (October - December 2017)
- Laboratory Analysis (December 2017 – February 2018)
- Data QA/QC Review (March 2018)
- Data Analysis and Reporting (April-May 2018)
- Final Summary Report (Draft due June 2018, Final Due September 2018)

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APPENDIX B: SAMPLING AND ANALYSIS PLAN AND QUALITY ASSURANCE PROJECT PLAN

BASMAA
Regional Monitoring Coalition

Pollutants of Concern Monitoring for Source Identification and Management Action Effectiveness, 2017-2018

Sampling and Analysis Plan and Quality Assurance Project Plan

Prepared for:

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Version 2
September 29, 2017

Title and Approval Sheet

Program Title	Pollutants of Concern (POC) Monitoring for Source Identification and Management Action Effectiveness
Lead Organization	Bay Area Stormwater Management Agencies Association (BASMAA) P.O. Box 2385, Menlo Park, CA 94026, 510-622-2326 info@basmaa.org
Primary Contact	Geoff Brosseau
Effective Date	September 29, 2017
Revision Number	Version 2

Approval Signatures:

A signature from the BASMAA Executive Director approving the BASMAA POC Monitoring for Source Identification and Management Action Effectiveness is considered approval on behalf of all Program Managers.

Geoff Brosseau _____ Date _____

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List of Acronyms

ACCWP	Alameda Countywide Clean Water Program
ALS	ALS Environmental Laboratory
BASMAA	Bay Area Stormwater Management Agencies Association
BSM	Bioretention Soil Media
CCCWP	Contra Costa Clean Water Program
CCV	continuing calibration verification
CEDEN	California Environmental Data Exchange Network
CEH	Center for Environmental Health
COC	Chain of Custody
Consultant-PM	Consultant Team Project Manager
CRM	Certified Reference Material
CSE	Confined Space Entry
ECD	Electron capture detection
EDD	Electronic Data Deliverable
EOA	Eisenberg, Olivieri & Associates, Inc.
EPA	Environmental Protection Agency (U.S.)
FD	Field duplicate
Field PM	Field Contractor Project Manager
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GC-MS	Gas Chromatography-Mass Spectroscopy
IDL	Instrument Detection Limits
ICV	initial calibration verification
KLI	Kinnetic Laboratories Inc.
LCS	Laboratory Control Samples
Lab-PM	Laboratory Project Manager
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MDL	Method Detection Limit
MQO	Measurement Quality Objective
MRL	Method Reporting Limit
MRP	Municipal Regional Permit
NPDES	National Pollutant Discharge Elimination System
OWP-CSUS	Office of Water Programs at California State University Sacramento
PCB	Polychlorinated Biphenyl
PM	Project Manager
PMT	Project Management Team
POC	Pollutants of Concern
QA	Quality Assurance
QA Officer	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
ROW	Right-of-way
RPD	Relative Percent Difference
RMC	Regional Monitoring Coalition
RMP	Regional Monitoring Program for Water Quality in the San Francisco Estuary
SFRWQCB	San Francisco Regional Water Quality Control Board (Regional Water Board)
SAP	Sampling and Analysis Plan
SCCVURPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SCVWD	Santa Clara Valley Water Department
SFEI	San Francisco Estuary Institute

SMCWPPP	San Mateo County Water Pollution Prevention Program
SOP	Standard Operating Procedure
SWAMP	California Surface Water Ambient Monitoring Program
TOC	Total Organic Carbon
TMDL	Total Maximum Daily Load
VSFCD	Vallejo Sanitation and Flood Control District

1. Problem Definition/Background

The Bay Area Stormwater Management Agencies Association (BASMAA) member agencies will implement a regional monitoring program for Pollutants of Concern (POC) Monitoring for Source Identification and Management Action Effectiveness (Monitoring Program). The Monitoring Program is intended to fulfill components of the Municipal Regional Stormwater NPDES Permit (MRP; Order No. R2-2015-0049), which implements the polychlorinated biphenyls (PCBs) and Mercury Total Maximum Daily Loads (TMDLs) for the San Francisco Bay Area. Monitoring for Source Identification and Management Action Effectiveness are two of five monitoring priorities for POCs identified in the MRP. Source identification monitoring is conducted to identify the sources or watershed source areas that provide the greatest opportunities for reductions of POCs in urban stormwater runoff. Management action effectiveness monitoring is conducted to provide support for planning future management actions or to evaluate the effectiveness or impacts of existing management actions.

BASMAA developed two study designs to implement each component of the Monitoring Program. The ***Evaluation of PCBs Presence in Public Roadway and Storm Drain Infrastructure Caulk and Sealants Study Design*** (BASMAA 2017a) addresses the source identification monitoring requirements of Provision C.8.f, as well as requirements of Provision C.12.e to investigate PCBs in infrastructure caulk and sealants. The ***POC Monitoring for Management Action Effectiveness Study Design*** (BASMAA 2017b) addresses the management action effectiveness monitoring requirements of Provision C.8.f. The results of the Monitoring Program will contribute to ongoing efforts by MRP Permittees to identify PCB sources and improve the PCBs and mercury treatment effectiveness of stormwater control measures in the Phase I permittee area of the Bay Area. This Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) was developed to guide implementation of both components of the Monitoring Program.

1.1. Problem Statement

Fish tissue monitoring in San Francisco Bay (Bay) has revealed bioaccumulation of PCBs and mercury. The measured fish tissue concentrations are thought to pose a health risk to people consuming fish caught in the Bay. As a result of these findings, California has issued an interim advisory on the consumption of fish from the Bay. The advisory led to the Bay being designated as an impaired water body on the Clean Water Act "Section 303(d) list" due to PCBs and mercury. In response, the California Regional Water Quality Control Board, San Francisco Bay Region (Regional Water Board) has developed TMDL water quality restoration programs targeting PCBs and mercury in the Bay. The general goals of the TMDLs are to identify sources of PCBs and mercury to the Bay and implement actions to control the sources and restore water quality.

Since the TMDLs were adopted, Permittees have conducted a number of projects to provide information that supports implementation of management actions designed to achieve the wasteload allocations described in the Mercury and PCBs TMDL, as required by Provisions of the MRP. The Clean Watersheds for a Clean Bay project (CW4CB) was a collaboration among BASMAA member agencies that pilot tested various stormwater control measures and provided estimates of the PCBs and mercury load reduction effectiveness of these controls (BASMAA, 2017c). However, the results of the CW4CB project identified a number of remaining data gaps on the load reduction effectiveness of the control measures

that were tested. In addition, MRP Provisions C.8.f. and C.12.e require Permittees to conduct further source identification and management action effectiveness monitoring during the current permit term.

1.2. Outcomes

The Monitoring Program will allow Permittees to satisfy MRP monitoring requirements for source identification and management action effectiveness, while also addressing some of the data gaps identified by the CW4CB project (BASMAA, 2017c). Specifically, the Monitoring Program is intended to provide the following outcomes:

1. Satisfy MRP Provision C.8.f. requirements for POC monitoring for source identification; and Satisfy MRP Provision C.12.e.ii requirements to evaluate PCBs presence in caulks/sealants used in storm drain or roadway infrastructure in public ROWs;
    a. Report the range of PCB concentrations observed in 20 composite samples of caulk/sealant collected from structures installed or rehabilitated during the 1970's;
2. Satisfy MRP Provision C.8.f. requirements for POC monitoring for management action effectiveness;
    a. Quantify the annual mass of mercury and PCBs captured in HDS Unit sumps during maintenance; and
    b. Identify bioretention soil media (BSM) mixtures for future field testing that provide the most effective mercury and PCBs treatment in laboratory column tests.

The information generated from the Monitoring Program will be used by MRP Permittees and the Regional Water Board to better understand potential PCB sources and better estimate the load reduction effectiveness of current and future stormwater control measures.

2. Distribution List and Contact Information

The distribution list for this BASMAA SAP/QAPP is provided in Table 2-1.

Table 2-1. BASMAA SAP/QAPP Distribution List.

Project Group	Title	Name and Affiliation	Telephone No.
BASMAA Project Management Team	BASMAA Project Manager, Stormwater Program Specialist	Reid Bogert, SMCWPPP	650-599-1433
	Program Manager	Jim Scanlin, ACCWP	510-670-6548
	Watershed Management Planning Specialist	Lucile Paquette, CCCWP	925-313-2373
	Program Manager	Rachel Kraai, CCCWP	925-313-2042
	Technical Consultant to ACCWP and CCCWP	Lisa Austin, Geosyntec Inc. CCCWP	510-285-2757
	Supervising Environmental Services Specialist	James Downing, City of San Jose	408-535-3500
	Senior Environmental Engineer	Kevin Cullen, FSURMP	707-428-9129
	Pollution Control Supervisor	Doug Scott, VSFCD	707-644-8949 x269
Consultant Team	Project Manager	Bonnie de Berry, EOA Inc.	510-832-2852 x123
	Assistant Project Manager SAP/QAPP Author and Report Preparer	Lisa Sabin, EOA Inc.	510-832-2852 x108
	Technical Advisor	Chris Sommers, EOA Inc.	510-832-2852 x109
	Study Design Lead and Report Preparer	Brian Currier, OWP-CSUS	916-278-8109
	Study Design Lead and Report Preparer	Dipen Patel, OWP-CSUS	
	Technical Advisor	Lester McKee, SFEI	415-847-5095
	Quality Assurance Officer	Don Yee, SFEI	510-746-7369
	Data Manager	Amy Franz, SFEI	510-746-7394
	Field Contractor Project Manager	Jonathan Toal, KLI	831-457-3950
Project Laboratories	Laboratory Project Manager	Howard Borse, ALS	360-430-7733
	XRF Laboratory Project Manager	Matt Nevins, CEH	510-655-3900 x318

3. Program Organization

3.1. Involved Parties and Roles

BASMAA is a 501(c)(3) non-profit organization that coordinates and facilitates regional activities of municipal stormwater programs in the San Francisco Bay Area. BASMAA programs support implementation of the MRP (Order No. R2-2015-0049), which implements the PCBs and Mercury TMDLs for the San Francisco Bay Area. BASMAA is comprised of all 76 identified MRP municipalities and special districts, the Alameda Countywide Clean Water Program (ACCWP), Contra Costa Clean

Water Program (CCCWP), the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), the Fairfield-Suisun Urban Runoff Management Program (FSURMP), the City of Vallejo and the Vallejo Sanitation and Flood Control District (VSFCD) (Table 3-1).

MRP Permittees have agreed to collectively implement this Monitoring Program via BASMAA. The Program will be facilitated through the BASMAA Monitoring and Pollutants of Concern Committee (MPC). BASMAA selected a consultant team to develop and implement the Monitoring Program with oversight and guidance from a BASMAA Project Management Team (PMT), consisting of representatives from BASMAA stormwater programs and municipalities (Table 3-1).

Table 3-1. San Francisco Bay Area Stormwater Programs and Associated MRP Permittees Participating in the BASMAA Monitoring Program.

Stormwater Programs	MRP Permittees
Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP)	Cities of Campbell, Cupertino, Los Altos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, Los Altos Hills, and Los Gatos; Santa Clara Valley Water District; and, Santa Clara County
Alameda Countywide Clean Water Program (ACCWP)	Cities of Alameda, Albany, Berkeley, Dublin, Emeryville, Fremont, Hayward, Livermore, Newark, Oakland, Piedmont, Pleasanton, San Leandro, and Union City; Alameda County; Alameda County Flood Control and Water Conservation District; and, Zone 7 Water District
Contra Costa Clean Water Program (CCCWP)	Cities of, Clayton, Concord, El Cerrito, Hercules, Lafayette, Martinez, , Orinda, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Walnut Creek, Danville, and Moraga; Contra Costa County; and, Contra Costa County Flood Control and Water Conservation District
San Mateo County Wide Water Pollution Prevention Program (SMCWPPP)	Cities of Belmont, Brisbane, Burlingame, Daly City, East Palo Alto, Foster City, Half Moon Bay, Menlo Park, Millbrae, Pacifica, Redwood City, San Bruno, San Carlos, San Mateo, South San Francisco, Atherton, Colma, Hillsborough, Portola Valley, and Woodside; San Mateo County Flood Control District; and, San Mateo County
Fairfield-Suisun Urban Runoff Management Program (FSURMP)	Cities of Fairfield and Suisun City
Vallejo Permittees (VSFCD)	City of Vallejo and Vallejo Sanitation and Flood Control District

3.2. BASMAA Project Manager (BASMAA-PM)

The BASMAA Project Manager (BASMAA-PM) will be responsible for directing the activities of the below-described PMT, and will provide oversight and managerial level activities, including reporting status updates to the PMT and BASMAA, and acting as the liaison between the PMT and the Consultant Team. The BASMAA PM will oversee preparation, review, and approval of project deliverables, including the required reports to the Regional Water Board.

3.3. BASMAA Project Management Team (PMT)

The BASMAA PMT will assist the BASMAA-PM and the below described Consultant Team with the design and implementation of all project activities. PMT members will assist the BASMAA-PM and Consultant Team to complete project activities within scope, on-time, and within budget by having specific responsibility for planning and oversight of project activities within the jurisdiction of the BASMAA agency that they represent. In addition, the PMT will coordinate with the municipal project partners and key regional agencies, including the Regional Water Board. The PMT is also responsible for reviewing and approving project deliverables (e.g., draft and final project reports).

3.4. Consultant Team Project Manager (Consultant-PM)

The Consultant Team Project Manager (Consultant-PM) will be responsible for ensuring all work performed during the Monitoring Program is consistent with project goals, and provide oversight of all day-to-day operations associated with implementing all components of the Monitoring Program, including scheduling, budgeting, reporting, and oversight of subcontractors. The Consultant-PM will ensure that data generated and reported through implementation of the Monitoring Program meet measurement quality objectives (MQOs) described in this SAP/QAPP. The Consultant -PM will work with the Quality Assurance Officer as required to resolve any uncertainties or discrepancies. The Consultant -PM will also be responsible for overseeing development of draft and final reports for the Monitoring Program, as described in this SAP/QAPP.

3.5. Quality Assurance Officer (QA Officer)

The role of the Quality Assurance Officer (QA Officer) is to provide independent oversight and review of the quality of the data being generated. In this role, the QA Officer has the responsibility to require data that is of insufficient quality to be flagged, or not used, or for work to be redone as necessary so that the data meets specified quality measurements. The QA Officer will oversee the technical conduct of the field related components of the Monitoring Program, including ensuring field program compliance with the SAP/QAPP for tasks overseen at the programmatic level.

3.6. Data Manager (DM)

The Data Manager will be responsible for receipt and review of all project related documentation and reporting associated with both field efforts and laboratory analysis. The Data Manager will also be responsible for storage and safekeeping of these records for the duration of the project.

3.7. Field Contractor Project Manager (Field-PM)

The Field Contractor Project Manager (Field-PM) will be responsible for conduct and oversight of all field monitoring- and reporting-related activities, including completion of field datasheets, chain of custodies, and collection of field measurements and field samples, consistent with the monitoring methods and procedures in the SAP/QAPP. The Field-PM will also be responsible for ensuring that personnel conducting monitoring are qualified to perform their responsibilities and have received appropriate training. The Field-PM will be responsible for initial receipt and review of all project related documentation and reporting associated with both field efforts and laboratory analysis.

The Field-PM will also be responsible for receiving all samples collected opportunistically by participating municipalities, including all caulk/sealant samples, initial review of sample IDs to ensure there are no duplicate sample IDs, and shipping the samples under COC to the appropriate laboratory (CEH for the caulk/sealant samples; ALS for all other samples). Participating municipalities should ship all samples they collect to the Field PM at the following address:

Jon Toal
Kinnetic Laboratories, Inc.
307 Washington Street
Santa Cruz, CA 95060
Reference: BASMAA POC Monitoring Project
(831)457-3950

3.8. Laboratory Project Manager (Lab-PM)

The Laboratory Project Manager (Lab-PM) and chemists at each analytical laboratory will be responsible for ensuring that the laboratory's quality assurance program and standard operating procedures (SOPs) are consistent with this SAP/QAPP, and that laboratory analyses meet all applicable requirements or explain any deviations. Each Lab-PM will also be responsible for coordinating with the Field-PM and other staff (e.g., Consultant -PM, Data Manager, QA Officer) and facilitating communication between the Field-PM, the Consultant -PM, and analytical laboratory personnel, as required for the project.

The Center for Environmental Health (CEH) will provide chlorine content screening of all caulk/sealant samples collected using X-Ray Fluorescence (XRF) technology to assist in selection of samples for further laboratory analysis of PCBs. This XRF-screening will also provide additional information on the utility of XRF in prioritizing samples for chemical PCBs analyses.

All other laboratory analyses will be provided by ALS Environmental.

3.1. Report Preparer

The Report Preparer (RP) will be responsible for developing draft and final reports for each of the following components of the Monitoring Program: (1) Source identification; and (2) Management action effectiveness. All draft reports will be submitted to the PMT for review and input prior to submission for approval by the BASMAA Board of Directors (BOD).

4. Monitoring Program Description

4.1. Work Statement and Program Overview

The Monitoring Program consists of the following three major tasks, each of which has a field sampling component:

- **Task 1. Evaluate presence and possible concentrations of PCBs in roadway and storm drain infrastructure caulk and sealants**. This task involves analysis of 20 composite samples of caulk/sealant collected from public roadway and storm drain infrastructure throughout the permit

area to investigate PCB concentrations. The goal of this task is to evaluate, at a limited screening level, whether and in what concentrations PCBs are present in public roadway and storm drain infrastructure caulk and sealants in the portions of the Bay Area under the jurisdiction of the Phase I Permittees identified in Table 3-1 (Bay Area).

- **Task 2. Evaluate Annual mass of PCBs and mercury captured in Hydrodynamic Separator (HDS) Unit sumps during maintenance.** This task involves collecting sediment samples from the sumps of public HDS unit during maintenance cleanouts to evaluate the mass of PCBs and mercury captured by these devices. The goal of this task is to provide data to better characterize the concentrations of POCs in HDS Unit sump sediment and improve estimates of the mass captured and removed from these units during current maintenance practices for appropriate TMDL load reduction crediting purposes.

- **Task 3. Bench-scale testing of the mercury and PCBs removal effectiveness of selected BSM mixtures enhanced with biochar.** This task involves collecting stormwater from the Bay Area that will then be used to conduct laboratory column tests designed to evaluate the mercury and PCBs treatment effectiveness of various biochar-amended BSM mixtures. Real stormwater will be used for the column tests to account for the effect of influent water quality on load removal. The goal of this task is to identify BSM mixtures amended with biochar that meet operational infiltration requirements and are effective for PCBs and mercury removal for future field testing.

All monitoring results and interpretations will be documented in BASMAA reports for submission to the Regional Water Board according to the schedule in the MRP.

4.2. Sampling Detail

The Monitoring Program includes three separate sampling tasks that involve collection and analysis of the following types of samples: caulk/sealants (Task 1); sediment from HDS units (Task 2); and stormwater collected and used for column tests in the lab (Task 3). Additional details specific to the sampling design for each task are provided below.

4.2.1. Task 1 - Caulk/Sealant samples

The PMT will recruit municipal partners from within each stormwater program to participate in this task. All caulk/sealant samples will be collected from locations within public roadway or storm drain infrastructure in the participating municipalities. Exact sample sites will be identified based on available information for each municipal partner, including: age of public infrastructure; records of infrastructure repair or rehabilitation (aiming for the late 1960s through the 1970s); and current municipal staff knowledge about locations that meet the site selection criteria identified in the study design (BASMAA, 2017a). Field crews led by the Field-PM and/or municipal staff will conduct field reconnaissance to further identify specific sampling locations and if feasible, will collect caulk/sealant samples during these initial field visits. Follow-up sampling events will be conducted for any sites that require additional planning or equipment for sample collection (e.g., confined space entry, parking controls, etc.). Sample locations will include any of the following public infrastructure where caulk/sealant are present: roadway or sidewalk surfaces, between expansion joints for roadways, parking garages, bridges, dams, or storm drain pipes, and/or in pavement joints (e.g., curb and gutter). Sampling will only occur during periods of dry weather when urban runoff flows through any structures that will be sampled are minimal, and do not

present any safety hazards or other logistical issues during sample collection. Sample collection methods are described further in Section 9.

As opportunities arise, municipal staff will also collect samples following the methods and procedures described in this SAP/QAPP during ongoing capital projects that provide access to public infrastructure locations with caulk/sealant that meet the sample site criteria. All samples collected by participating municipal staff will be delivered to the Field PM under COC. The Field-PM will be responsible for storing all caulk/sealant samples and shipping the samples under COC to CEH for XRF screening analysis.

All caulk/sealant samples collected will be screened for chlorine content using XRF technology described in Section 9. Samples will be grouped for compositing purposes as described in the study design (BASMAA, 2017a). Up to three samples will be included per composite and a total of 20 composite caulk/sealant samples will be analyzed for the RMP 40 PCB congeners[1]. All compositing and PCBs analysis will be conducted blind to the location where each sample was collected. Laboratory analysis methods must be able to detect a minimum PCBs concentration of 200 parts per billion (ppb, or µg/Kg). Laboratory analytical methods are described further in Section 12. The range of PCB concentrations found in caulk based on this documented sampling design will be reported to the Regional Water Board within the Permittees' 2018 Annual Reports.

4.2.2. Task 2 - Sediment samples from HDS Units

The PMT will recruit municipal partners that maintain public HDS units to participate in this task. All sediment samples will be collected from the sump of selected HDS units during scheduled cleaning and maintenance. Selection of the HDS units for sampling will be opportunistic, based on the units that are scheduled for maintenance by participating municipalities during the project period. Field crews led by the Field-PM and municipal maintenance staff will coordinate sampling with scheduled maintenance events. As needed, municipal staff will dewater the HDS unit sumps prior to sample collection, and provide assistance to field crews with access to the sump sediment as needed (e.g., confined space entry, parking controls, etc.). All sump sediment samples will be collected following the methods and procedures described in this SAP/QAPP. Sampling will only occur during periods of dry weather when urban runoff flows into the HDS unit sumps are minimal, and do not present any safety hazards or other logistical issues during sample collection. Sample collection methods are described further in Section 9.

All sediment samples collected will be analyzed for the RMP 40 PCB congeners, total mercury, total organic carbon (TOC), particle size distribution (PSD), and bulk density. Laboratory analytical methods are described further in Section 12. The range of PCB and mercury concentrations observed in HDS Unit sump sediments and the annual pollutant masses removed during cleanouts will be reported to the Regional Water Board in March 2019.

4.2.3. Task 3 - Storm Water and Column Test Samples

This task will collect stormwater from Bay Area locations that will then be used as the influent for column tests of biochar-amended BSM. Bay Area stormwater samples will be collected from locations

[1] The 40 individual congeners routinely quantified by the Regional Monitoring Program (RMP) for Water Quality in the San Francisco Estuary include: PCBs 8, 18, 28, 31, 33, 44, 49, 52, 56, 60, 66, 70, 74, 87, 95, 97, 99, 101, l05, 110, 118, 128, 132, 138, 141, 149, l51, 153, 156, 158, 170, 174, 177, 180, 183, 187, 194, 195, 201, and 203

within public roadway or storm drain infrastructure in participating municipalities. Field personnel lead by the Field PM will collect stormwater samples during three qualifying storm events and ensure all samples are delivered to the lab of OWP at CSUS within 24-hours of collection. Stormwater will be collected from one watershed that has a range of PCB concentrations and is considered representative of Bay Area watersheds (e.g. the West Oakland Ettie Street Pump Station watershed). Storms from the representative watershed should be targeted randomly without bias, thereby accounting for the effects of storm intensity and ensuring variability in contaminant concentration, proportion of dissolved contaminants, particle size, particle size distribution, and particle density. To achieve this, minimal mobilization criteria should be used to ensure predicted storm intensity and runoff volume are likely to yield the desired volume. Sample collection methods are described further in Section 9.

The stormwater collected will be used as the influent for column tests of various BSM mixtures amended with biochar. These tests will be implemented in three phases. First, hydraulic screening tests will be performed to ensure all amended BSM mixtures meet the MRP infiltration rate requirements of 12 in/h initial maximum infiltration or minimum 5 in/h long-term infiltration rate. Second, column tests will be performed using Bay Area stormwater to evaluate pollutant removal. Third, additional column tests will be performed using lower concentration (e.g., diluted) Bay Area stormwater to evaluate relative pollutant removal performance at lower concentrations. Further details about the column testing are provided in Section 9.3.

All influent and effluent water samples collected will be analyzed for the RMP 40 PCB congeners, total mercury, suspended sediment concentrations (SSC), TOC, and turbidity. Laboratory analytical methods are described further in Section 12. The range of PCB and mercury concentrations observed in influent and effluent water samples and the associated pollutant mass removal efficiencies for each BSM mixture tested will be reported to the Regional Water Board in March 2019.

4.3. Schedule

Caulk/sealant sampling (Task 1) will be conducted between July 2017 and December 2017. HDS Unit sampling (Task 2) will be conducted between July 2017 and May 2018. Stormwater sample collection and BSM column tests (Task 3) will occur between October 2017 – April 2018.

4.4. Geographical Setting

Field operations will be conducted across multiple Phase I cities in the San Francisco Bay region within the counties of San Mateo, Santa Clara, Alameda, and Contra Costa, and the City of Vallejo.

4.5. Constraints

Caulk/sealant sampling and HDS unit sampling will only be conducted during dry weather, when urban runoff flows through the sampled structures are minimal and do not present safety hazards or other logistical concerns. Caulk/sealant sampling will be limited to the caulk/sealant available and accessible at sites that meet the project site criteria (described in the Study Design, BASMAA 2017a). HDS unit sampling will be limited by the number of public HDS units that are available for maintenance during the project period. Extreme wet weather may pose a safety hazard to sampling personnel and may therefore impact wet season sampling.

5. Measurement Quality Objectives (MQO)

The quantitative measurements that estimate the true value or concentration of a physical or chemical property always involve some level of uncertainty. The uncertainty associated with a measurement generally results from one or more of several areas: (1) natural variability of a sample; (2) sample handling conditions and operations; (3) spatial and temporal variation; and (4) variations in collection or analytical procedures. Stringent Quality Assurance (QA) and Quality Control (QC) procedures are essential for obtaining unbiased, precise, and representative measurements and for maintaining the integrity of the sample during collection, handling, and analysis, as well and for measuring elements of variability that cannot be controlled. Stringent procedures also must be applied to data management to assure that accuracy of the data is maintained.

MQOs are established to ensure that data collected are sufficient and of adequate quality for the intended use. MQOs include both quantitative and qualitative assessment of the acceptability of data. The qualitative goals include representativeness and comparability, and the quantitative goals include completeness, sensitivity (detection and quantization limits), precision, accuracy, and contamination.

MQOs associated with representativeness, comparability, completeness, sensitivity, precision, accuracy, and contamination are presented below in narrative form.

5.1. Representativeness and Comparability

The representativeness of data is the ability of the sampling locations and the sampling procedures to adequately represent the true condition of the sample sites. The comparability of data is the degree to which the data can be compared directly between all samples collected under this SAP/QAPP. Field personnel, including municipal personnel that collect samples, will strictly adhere to the field sampling protocols identified in this SAP/QAPP to ensure the collection of representative, uncontaminated, comparable samples. The most important aspects of quality control associated with chemistry sample collection are as follows:

- Field personnel will be thoroughly trained in the proper use of sample collection equipment and will be able to distinguish acceptable versus unacceptable samples in accordance with pre-established criteria.
- Field personnel are trained to recognize and avoid potential sources of sample contamination (e.g., dirty hands, insufficient field cleaning).
- Samplers and utensils that come in direct contact with the sample will be made of non-contaminating materials, and will be thoroughly cleaned between sampling stations.
- Sample containers will be pre-cleaned and of the recommended type.
- All sampling sites will be selected according to the criteria identified in the project study design (BASMAA, 2017a)

Further, the methods for collecting and analyzing PCBs in infrastructure caulk and sealants will be comparable to other studies of PCBs in building material and infrastructure caulk (e.g., Klosterhaus et al., 2014). This SAP/QAPP was also developed to be comparable with the California Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance Program Plan (QAPrP, SWAMP 2013). All sediment

and water quality data collected during the Monitoring Program will be performed in a manner so that data are SWAMP comparable [2].

5.2. Completeness

Completeness is defined as the percentage of valid data collected and analyzed compared to the total expected to being obtained under normal operating conditions. Overall completeness accounts for both sampling (in the field) and analysis (in the laboratory). Valid samples include those for analytes in which the concentration is determined to be below detection limits.

Under ideal circumstances, the objective is to collect 100 percent of all field samples desired, with successful laboratory analyses on 100% of measurements (including QC samples). However, circumstances surrounding sample collections and subsequent laboratory analysis are influenced by numerous factors, including availability of infrastructure meeting the required sampling criteria (applies to both infrastructure caulk sampling and HDS Unit sampling), flow conditions, weather, shipping damage or delays, sampling crew or lab analyst error, and QC samples failing MQOs. An overall completeness of greater than 90% is considered acceptable for the Monitoring Program.

5.3. Sensitivity

Different indicators of the sensitivity of an analytical method to measure a target parameter are often used including instrument detection limits (IDLs), method detection limits (MDLs), and method reporting limits (MRLs). For the Monitoring Program, MRL is the measurement of primary interest, consistent with SWAMP Quality Assurance Project Plan (SWAMP 2013). Target MRLs for all analytes by analytical method provided in Section 13.

5.4. Precision

Precision is used to measure the degree of mutual agreement among individual measurements of the same property under prescribed similar conditions. Overall precision usually refers to the degree of agreement for the entire sampling, operational, and analysis system. It is derived from reanalysis of individual samples (laboratory replicates) or multiple collocated samples (field replicates) analyzed on equivalent instruments and expressed as the relative percent difference (RPD) or relative standard deviation (RSD). Analytical precision can be determined from duplicate analyses of field samples, laboratory matrix spikes/matrix spike duplicates (MS/MSD), laboratory control samples (LCS) and/or reference material samples. Analytical precision is expressed as the RPD for duplicate measurements:

$$RPD = ABS([X1 - X2] / [(X1 + X2) / 2])$$

Where: X1 = the first sample result
X2 = the duplicate sample result.

[2] SWAMP data templates and documentation are available online at http://waterboards.ca.gov/water_issues/programs/swamp/data_management_resources/templates_docs.shtml

Precision will be assessed during the Monitoring Program by calculating the RPD of laboratory replicate samples and/or MS/MSD samples, which will be run at a frequency of 1 per analytical batch for each analyte. Target RPDs for the Monitoring Program are identified in Section 13.

5.5. Accuracy

Accuracy describes the degree of agreement between a measurement (or the average of measurements of the same quantity) and its true environmental value, or an acceptable reference value. The "true" values of the POCs in the Monitoring Program are unknown and therefore "absolute" accuracy (and representativeness) cannot be assessed. However, the analytical accuracy can be assessed through the use of laboratory MS samples, and/or LCS. For MS samples, recovery is calculated from the original sample result, the expected value (EV = native + spike concentration), and the measured value with the spike (MV):

$$\% \text{ Recovery} = (MV-N) \times 100\% / (EV-N)$$

Where: MV = the measured value
EV = the true expected (reference) value
N = the native, unspiked result

For LCS, recovery is calculated from the concentration of the analyte recovered and the true value of the amount spiked:

$$\% \text{ Recovery} = (X/TV) \times 100\%$$

Where: X = concentration of the analyte recovered
TV = concentration of the true value of the amount spiked

Surrogate standards are also spiked into samples for some analytical methods (i.e., PCBs) and used to evaluate method and instrument performance. Although recoveries on surrogates are to be reported, control limits for surrogates are method and laboratory specific, and no project specific recovery targets for surrogates are specified, so long as overall recovery targets for accuracy (with matrix spikes) are achieved. Where surrogate recoveries are applicable, data will not be reported as surrogate-corrected values.

Analytical accuracy will be assessed during the Monitoring Program based on recovery of the compound of interest in matrix spike and matrix spike duplicates compared with the laboratory's expected value, at a frequency of 1 per analytical batch for each analyte. Recovery targets for the Monitoring Program are identified in Section 13.

5.6. Contamination

Collected samples may inadvertently be contaminated with target analytes at many points in the sampling and analytical process, from the materials shipped for field sampling, to the air supply in the analytical laboratory. When appropriate, blank samples evaluated at multiple points in the process chain help assure that compound of interest measured in samples actually originated from the target matrix in the sampled environment and are not artifacts of the collection or analytical process.

Method blanks (also called laboratory reagent blanks, extraction blanks, procedural blanks, or preparation blanks) are used by laboratory personnel to assess laboratory contamination during all stages of sample preparation and analysis. The method blank is processed through the entire analytical procedure in a manner identical to the samples. A method blank concentration should be less than the RL or should not exceed a concentration of 10% of the lowest reported sample concentration. A method blank concentration greater than 10% of the lowest reported sample concentration will require corrective action to identify and eliminate the source(s) of contamination before proceeding with sample analysis. If eliminating the blank contamination is not possible, all impacted analytes in the analytical batch shall be flagged. In addition, a detailed description of the likely contamination source(s) and the steps taken to eliminate/minimize the contaminants shall be included in narrative of the data report. If supporting data is presented demonstrating sufficient precision in blank measurement that the 99% confidence interval around the average blank value is less than the MDL or 10% of the lowest measured sample concentration, then the average blank value may be subtracted.

A field blank is collected to assess potential sample contamination levels that occur during field sampling activities. Field blanks are taken to the field, transferred to the appropriate container, preserved (if required by the method), and treated the same as the corresponding sample type during the course of a sampling event. The inclusion of field blanks is dependent on the requirements specified in the relevant MQO tables or in the sampling method.

6. Special Training Needs / Certification

All fieldwork will be performed by contractor staff that has appropriate levels of experience and expertise to conduct the work, and/or by municipal staff that have received the appropriate instruction on sample collection, as determined by the Field PM and/or the PMT. The Field-PM will ensure that all members of the field crew (including participating municipal staff) have received appropriate instructions based on methods described in this document (Section 9) for collecting and transporting samples. As appropriate, sampling personnel may be required to undergo or have undergone OSHA training / certification for confined space entry in order to undertake particular aspects of sampling within areas deemed as such.

Analytical laboratories are to be certified for the analyses conducted at each laboratory by ELAP, NELAP, or an equivalent accreditation program as approved by the PMT. All laboratory personal will follow methods described in Section 13 for analyzing samples.

7. Program Documentation and Reporting

The Consultant Team in consultation with the PMT will prepare draft and final reports of all monitoring data, including statistical analysis and interpretation of the data, as appropriate, which will be submitted to the BASMAA BOD for approval. Following approval by the BASMAA BOD, Final project reports will be available for submission with each stormwater program's Annual Report in 2018 (Task 1) or in the March 31, 2019 report to the Regional Water Board (Tasks 2 and 3). Procedures for overall management of project documents and records and report preparation are summarized below.

7.1. Field Documentation

All field data gathered for the project are to be recorded in field datasheets, and scanned or transcribed to electronic documents as needed to permit easy access by the PMT, the consultant team, and other appropriate parties.

7.1.1. Sampling Plans, COCs, and Sampling Reports

The Field-PM will be responsible for development and submission of field sampling reports to the Data Manager and Consultant-PM. Field crews will collect records for sample collection, and will be responsible for maintaining these records in an accessible manner. Samples sent to analytical laboratories will include standard Chain of Custody (COC) procedures and forms; field crews will maintain a copy of originating COCs at their individual headquarters. Analytical laboratories will collect records for sample receipt and storage, analyses, and reporting. All records, except lab records, generated by the Monitoring Program will be stored at the office of the Data Manager for the duration of the project, and provided to BASMAA at the end of the project.

7.1.2. Data Sheets

All field data gathered by the Monitoring Program will be recorded on standardized field data entry forms. The field data sheets that will be used for each sampling task are provided in Appendix A.

7.1.3. Photographic Documentation

Photographic documentation is an important part of sampling procedures. An associated photo log will be maintained documenting sites and subjects associated with photos. If an option, the date function on the camera shall be turned on. Field Personnel will be instructed to take care to avoid any land marks when taking photographs, such as street signs, names of buildings, road mile markers, etc. that could be used later to identify a specific location. A copy of all photographs should be provided at the conclusion of sampling efforts and maintained for project duration.

7.2. Laboratory Documentation

The Monitoring Program requires specific actions to be taken by contract laboratories, including requirements for data deliverables, quality control, and on-site archival of project-specific information. Each of these aspects is described below.

7.2.1. Data Reporting Format

Each laboratory will deliver data in electronic formats to the Field-PM, who will transfer the records to the Data Manager, who is responsible for storage and safekeeping of these records for the duration of the project. In addition, each laboratory will deliver narrative information to the QA Officer for use in data QA and for long-term storage.

The analytical laboratory will report the analytical data to the Field-PM via an analytical report consisting of, at a minimum:

1. Letter of transmittal
2. Chain of custody information
3. Analytical results for field and quality control samples (Electronic Data Deliverable, EDD)
4. Case narrative

5. Copies of all raw data.

The Field-PM will review the data deliverables provided by the laboratory for completeness and errors. The QA Officer will review the data deliverables provided by the laboratory for review of QA/QC. In addition to the laboratory's standard reporting format, all results meeting MQOs and results having satisfactory explanations for deviations from objectives shall be reported in tabular format on electronic media. SWAMP-formatted electronic data deliverable (EDD) templates are to be agreed upon by the Data Manager, QA Officer, and the Lab-PM prior to onset of any sampling activities related to that laboratory.

Documentation for analytical data is kept on file at the laboratories, or may be submitted with analytical results. These may be reviewed during external audits of the Monitoring Program, as needed. These records include the analyst's comments on the condition of the sample and progress of the analysis, raw data, and QC checks. Paper or electronic copies of all analytical data, field data forms and field notebooks, raw and condensed data for analysis performed on-site, and field instrument calibration notebooks are kept as part of the Monitoring Program archives for a minimum period of eight years.

7.2.2. Other Laboratory QA/QC Documentation

All laboratories will have the latest version of this Monitoring Program SAP/QAPP in electronic format. In addition, the following documents and information from the laboratories will be current, and they will be available to all laboratory personnel participating in the processing of samples:

1. Laboratory QA plan: Clearly defines policies and protocols specific to a particular laboratory, including personnel responsibilities, laboratory acceptance criteria, and corrective actions to be applied to the affected analytical batches, qualification of data, and procedures for determining the acceptability of results.

2. Laboratory Standard Operation Procedures (SOPs): Contain instructions for performing routine laboratory procedures, describing exactly how a method is implemented in the laboratory for a particular analytical procedure. Where published standard methods allow alternatives at various steps in the process, those approaches chosen by the laboratory in their implementation (either in general or in specific analytical batches) are to be noted in the data report, and any deviations from the standard method are to be noted and described.

3. Instrument performance information: Contains information on instrument baseline noise, calibration standard response, analytical precision and bias data, detection limits, scheduled maintenance, etc.

4. Control charts: Control charts are developed and maintained throughout the Program for all appropriate analyses and measurements for purposes of determining sources of an analytical problem or in monitoring an unstable process subject to drift. Control charts serve as internal evaluations of laboratory procedures and methodology and are helpful in identifying and correcting systematic error sources. Control limits for the laboratory quality control samples are ±3 standard deviations from the certified or theoretical concentration for any given analyte.

Records of all quality control data, maintained in a bound notebook at each workstation, are signed and dated by the analyst. Quality control data include documentation of standard calibrations, instrument

maintenance and tests. Control charts of the data are generated by the analysts monthly or for analyses done infrequently, with each analysis batch. The laboratory quality assurance specialist will review all QA/QC records with each data submission, and will provide QA/QC reports to the Field-PM with each batch of submitted field sample data.

7.3. Program Management Documentation

The BASMAA-PM and Consultant-PM are responsible for managing key parts of the Monitoring Program's information management systems. These efforts are described below.

7.3.1. SAP/QAPP

All original SAP/QAPPs will be held by the Consultant-PM. This SAP/QAPP and its revisions will be distributed to all parties involved with the Monitoring Program. Copies will also be sent to the each participating analytical laboratory's contact for internal distribution, preferably via electronic distribution from a secure location.

Associated with each update to the SAP/QAPP, the Consultant-PM will notify the BASMAA-PM and the PMT of the updated SAP/QAPP, with a cover memo compiling changes made. After appropriate distributions are made to affected parties, these approved updates will be filed and maintained by the SAP/QAPP Preparers for the Monitoring Program. Upon revision, the replaced SAP/QAPPs will be discarded/deleted.

7.3.2. Program Information Archival

The Data Manager and Consultant-PM will oversee the actions of all personnel with records retention responsibilities, and will arbitrate any issues relative to records retention and any decisions to discard records. Each analytical laboratory will archive all analytical records generated for this Program. The Consultant-PM will be responsible for archiving all management-level records.

Persons responsible for maintaining records for this Program are shown in Table 7-1.

Table 7-1. Document and Record Retention, Archival, and Disposition

Type	Retention (years)	Archival	Disposition
Field Datasheets	8	Data Manager	Maintain indefinitely
Chain of Custody Forms	8	Data Manager	Maintain indefinitely
Raw Analytical Data	8	Laboratory	Recycling
Lab QC Records	8	Laboratory	Recycling
Electronic data deliverables	8	Data Manager	Maintain indefinitely
Reports	8	Consultant-PM	Maintain indefinitely

As discussed previously, the analytical laboratory will archive all analytical records generated for this Program. The Consultant-PM will be responsible for archiving all other records associated with implementation of the Monitoring Program.

All field operation records will be entered into electronic formats and maintained in a dedicated directory managed by the BASMAA-PM.

7.4. Reporting

The Consultant team will prepare draft and final reports for each component of the Monitoring Program. The PMT will provide review and input on draft reports and submit to the BASMAA BOD for approval. Once approved by the BASMAA BOD, the Monitoring Program reports will be available to each individual stormwater program for submission to the Regional Water Board according to the schedule outlined in the MRP and summarized in Table 7.2.

Table 7-2. Monitoring Program Final Reporting Due Dates.

Monitoring Program Component	Task	MRP Reporting Due Date
Source Identification	Task 1 - Evaluation of PCB concentrations in roadway and storm drain infrastructure caulk and sealants	September 30, 2018
Management Action Effectiveness	Task 2 - Evaluation of the annual mass of PCBs and mercury captured in HDS Unit sump sediment	March 31, 2019
	Task 3 - Bench-scale testing of the mercury and PCBs removal effectiveness of selected BSM mixtures.	

8. Sampling Process Design

All information generated through conduct of the Monitoring Program will be used to inform TMDL implementation efforts for mercury and PCBs in the San Francisco Bay region. The Monitoring Program will implement the following tasks: (1) evaluate the presence and concentrations of PCB in caulk and sealants from public roadway and stormdrain infrastructure; (2) evaluate mass of PCBs and mercury removed during HDS Unit maintenance; and (3) evaluate the mercury and PCBs treatment effectiveness of various BSM mixtures in laboratory column tests using stormwater collected from Bay Area locations. Sample locations and the timing of sample collection will be selected using the directed sampling design principle. This is a deterministic approach in which points are selected deliberately based on knowledge of their attributes of interest as related to the environmental site being monitored. This principle is also known as "judgmental," "authoritative," "targeted," or "knowledge-based." Individual monitoring aspects are summarized further under Field Methods (Section 9) and in the task-specific study designs (BASMAA 2017a,b).

8.1. Caulk/Sealant Sampling

Caulk/sealant sampling will support the Monitoring Program's Task 1 to evaluate PCBs in roadway and stormdrain infrastructure caulk/sealant, as described previously (see Section 4). Further detail on caulk/sealant sampling methods and procedures are provided under Field Methods (Section 9).

8.2. Sediment Quality Sampling

Sediment sampling will support the Monitoring Program's Task 2 to evaluate the mass of mercury and PCBs removed during HDS unit maintenance, as described previously (see Section 4). Further detail on

sediment sampling methods and procedures are provided under Field Methods (Section 9).

8.3. Water Quality Sampling

Water sampling will support the Monitoring Program's Task 3 to evaluate the mercury and PCBs treatment effectiveness of various BSM mixtures, as described previously (see Section 4). Further detail on water sampling methods and procedures are provided under Field Methods (Section 9).

8.4. Sampling Uncertainty

There are multiple sources of potential sampling uncertainty associated with the Monitoring Program, including: (1) measurement error; (2) natural (inherent) variability; (3) undersampling (or poor representativeness); and (4) sampling bias (statistical meaning). Measures incorporated to address these areas of uncertainty are discussed below:

(1) Measurement error combines all sources of error related to the entire sampling and analysis process (i.e., to the measurement system). All aspects of dealing with uncertainty due to measurement error have been described elsewhere within this document.

(2) Natural (inherent) variability occurs in any environment monitored, and is often much wider than the measurement error. Prior work conducted by others in the field of stormwater management have demonstrated the high degree of variability in environmental media, which will be taken into consideration when interpreting results of the various lines of inquiry.

(3) Under- or unrepresentative sampling happens at the level of an individual sample or field measurement where an individual sample collected is a poor representative for overall conditions encountered given typical sources of variation. To address this situation, the Monitoring Program will be implementing a number of QA-related measures described elsewhere within this document, including methods refined through implementation of prior, related investigations.

(4) Sampling bias relates to the sampling design employed and whether the appropriate statistical design is employed to allow for appropriate understanding of environmental conditions. To a large degree, the sampling design required by the Monitoring Program is judgmental, which will therefore incorporate an unknown degree of sampling bias into the Project. There are small measures that have been built into the sampling design to combat this effect (e.g., homogenization of sediments for chemistry analyses), but overall this bias is a desired outcome designed to meet the goals of this Monitoring Program, and will be taken into consideration when interpreting results of the various investigations.

Further detail on measures implemented to reduce uncertainty through mobilization, sampling, sample handling, analysis, and reporting phases are provided throughout this document.

9. Sampling Methods

The Monitoring Program involves the collection of three types of samples: Caulk/sealants; sediment from HDS unit sumps; and water quality samples. Field collection will be conducted by field contractors or municipal staff using a variety of sampling protocols, depending on the media and parameter monitored. These methods are presented below. In addition, the Monitoring Program will utilize several field

sampling SOPs previously developed by the BASMAA Regional Monitoring Coalition identified in Table 9-3 (RMC, BASMAA, 2016).

9.1. Caulk/Sealant Sampling (Task 1)

Procedures for collecting caulk and sealant samples are not well established. Minimal details on caulk or sealant sample collection methodologies are available in peer-reviewed publications. The caulk/sealant sampling procedures described here were adapted from a previous study examining PCBs in building materials conducted in the Bay Area (Klosterhaus et al., 2014). The methods described by Klosterhaus et al. (2014) were developed through consultation with many of the previous authors of caulk literature references therein, in addition to field experience gained during the Bay Area study. It is anticipated that lessons will also be learned during the current study.

9.1.1. Sample Site Selection

Once a structure has been identified as meeting the selection criteria and permission is granted to perform the testing or collection of sealant samples, an on-site survey of the structure will be used to identify sealant types and locations on the structure to be sampled. It is expected that sealants from a number of different locations on each structure may sampled; however, inconspicuous locations on the structure will be targeted.

9.1.2. Initial Equipment Cleaning

The sampling equipment that is pre-cleaned includes:

- Glass sample jars
- Utility knife, extra blades
- Stainless-steel forceps

Prior to sampling, all equipment will be thoroughly cleaned. Glass sample containers will be factory pre-cleaned (Quality Certified™, ESS Vial, Oakland, CA) and delivered to field team at least one week prior to the start of sample collection. Sample containers will be pre-labeled and kept in their original boxes, which will be transported in coolers. Utility knife blades, forceps, stainless steel spoons, and chisels will be pre-cleaned with Alconox, Liquinox, or similar detergent, and then rinsed with deionized water and methanol. The cleaned equipment will then be wrapped in methanol-rinsed aluminum foil and stored in clean Ziploc bags until used in the field.

9.1.3. Field Cleaning Protocol

Between each use the tool used (utility knife blade, spoon or chisel) and forceps will be rinsed with methanol and then deionized water, and inspected to ensure all visible sign of the previous sample have been removed. The clean tools, extra blades, and forceps will be kept in methanol-rinsed aluminum foil and stored in clean Ziploc bags when not in use.

9.1.4. Blind Sampling Procedures

The intention of this sampling is to better determine whether sealants in road and storm drain infrastructure contain PCBs at concentrations of concern, and to understand the relative importance of PCBs in this infrastructure among the other known sources of PCBs that can affect San Francisco Bay. At this phase of the project, we are not seeking to identify specific facilities requiring mitigation (if PCBs are

identified, this could be a future phase). Therefore, in this initial round of sampling, we are not identifying sample locations, but instead implementing a blind sampling protocol, as follows:

- All samples will be collected without retaining any information that would identify structure locations. The information provided to the contractor on sampling locations will not be retained. Structure location information will not be recorded on any data sheets or in any data spreadsheets or other electronic computer files created for the Project. Physical sealant samples collected will be identified only by a sample identification (ID) designation (Section 4). Physical sealant sample labels will contain only the sample ID (see Section 4 and example label in Appendix A). Samples will be identified only by their sample ID on the COC forms.
- As an added precaution and if resources allow, oversampling will occur such that more samples will be collected than will be sent to the laboratory for compositing and analysis. In this case, the Project team would select a subset of samples for PCB analysis based on factors such as application type and/or chlorine content, but blind to the specific location where each sample was collected.
- Up to three individual sealant samples will be composited by the laboratory prior to analysis for PCBs, following instructions from the Consultant PM. This further ensures a blind sampling approach because samples collected at different locations will be analyzed together.

9.1.5. Caulk/Sealant Collection Procedures

At each sample location, the Field-PM, and/or municipal staff, will make a final selection of the most accessible sampling points at the time of sampling. From each point sampled, a one inch strip (aiming for about 10 g of material) of caulk or sealant will be removed from the structure using one of the following solvent-rinsed tools: a utility knife with a stainless-steel blade, stainless steel spoon to scrape off the material, or a stainless steel chisel. The Field-PM or municipal staff at the site will select the appropriate tool based on the conditions of the caulk/sealant at each sample point. Field personnel will wear nitrile gloves during sample collection to reduce potential sample contamination. The sample will then be placed in a labeled, factory-cleaned glass jar. For each caulk sample collected, field personnel will fill out a field data sheet at the time of sample collection, which includes the following information:

- Date and time of sample collection,
- sample identification designation,
- qualitative descriptions of relevant structure or caulk/sealant features, including use profile, color and consistency of material collected, surface coating (paint, oily film, masonry residues etc.)
- crack dimensions, the length and/or width of the caulk bead sampled, spacing of expansion joints in a particular type of application, and
- a description of any unusual occurrences associated with the sampling event (especially those that could affect sample or data quality).

Appendix A contains an example field data sheet. All samples will be kept in a chilled cooler in the field (i.e., at 4 ºC ± 2 ºC), and kept refrigerated pending delivery under COC to the Field PM at KLI. Further, the field data sheets will remain with the samples when they are shipped to KLI, and will then be maintained by the Field PM at KLI.

As needed, the procedure for replacement of the caulk/sealant will be coordinated with the appropriate municipal staff to help ensure that the sampling does not result in damage to the structure.

9.1.6. Sample ID Designation

Every sample must have a unique sample ID to ensure analytical results from each sample can be differentiated from every other sample. This information should follow the sample through the COC, analytical, and interpretation and reporting processes. For the infrastructure caulk/sealant samples, the sample ID must not contain information that can be used to identify where the sample was collected. The following 2-step process will be followed to assign sample IDs to the caulk/sealant samples.

1. Upon collection, the sample will be labeled according to the following naming convention:

   MMDDYYYY-TTTT-##

   Where:

MM	2 digit month of collection
DD	2 digit date of collection
YYYY	4 digit year of collection
TTTT	4 digit time of collection (military time)
##	Sequential 2-digit sample number (i.e., 01, 02, 03…etc.)

   For example, a sample collected on September 20, 2017 at 9 AM could be assigned the following sample ID: 09202017-0900-01.

2. This second step was added to avoid issues that could arise due to duplicate sample IDs, while maintaining the blind sampling approach. While the sample naming system identified above is unlikely to produce duplicate sample IDs, there is a chance that different groups may collect samples simultaneously. This second step will be implemented by the Field PM at KLI upon receipt of caulk/sealant samples from participating municipalities. The Field PM at KLI will review the sample IDs on the COC forms for all samples and compare the sample IDs to all caulk samples for this project already in storage at KLI. If any two samples have the same sample IDs, the Field PM will add a one-digit number to the end of one of the sample IDs, selected at random. This extra number will be added to the sample container label, the field data sheet, and the COC form for that sample.

9.2. HDS Unit Sampling Procedures (Task 2)

9.2.1. Sample Site Selection

Sample site selection will be opportunistic, based on the public HDS units that participating municipalities schedule for cleaning during the project. The project team will coordinate with participating municipalities to schedule sampling during HDS unit cleanouts.

9.2.2. Field Equipment and Cleaning

A list of potential sampling equipment for soil/sediment is presented in Table 5. The equipment list should be reviewed and tailored by field contractors to meet the needs of each individual sampling site. Appropriate sampling equipment is prepared in the laboratory a minimum of four days prior to sampling. Prior to sampling, all equipment will be thoroughly cleaned. Equipment is soaked (fully immersed) for three days in a solution of Alconox, Liquinox, or similar phosphate-free detergent and deionized water. Equipment is then rinsed three times with deionized water. Equipment is next rinsed with a dilute solution

(1-2%) of hydrochloric acid, followed by a rinse with reagent grade methanol, followed by another set of three rinses with deionized water. All equipment is then allowed to dry in a clean place. The cleaned equipment is then wrapped in aluminum foil or stored in clean Ziploc bags until used in the field.

Table 9-1 Field Equipment for HDS Unit Sampling.

Description of Equipment	Material (if applicable)
Sample scoops	Stainless steel or Kynar coated
Sample trowels	Stainless steel or Kynar coated
Compositing bucket	Stainless steel or Kynar coated
Ekman Dredge (as needed)	Stainless steel
Sample containers (with labels)	As coordinated with lab(s)
Methanol, Reagent grade (Teflon squeeze bottle with refill)	
Hydrochloric acid, 1-2%, Reagent grade (Teflon squeeze bottle)	
Liquinox detergent (diluted in DI within Teflon squeeze bottle)	
Deionized / reverse osmosis water	
Plastic scrub brushes	
Container for storage of sampling derived waste, dry	
Container for storage of sampling derived waste, wet	
Wet ice	
Coolers, as required	
Aluminum foil (heavy duty recommended)	
Protective packaging materials	Bubble / foam bags
Splash proof eye protection	
PPE for sampling personnel, including traffic mgmt as required	
Gloves for dry ice handling	Cotton, leather, etc.
Gloves for sample collection, reagent handling	Nitrile
Field datasheets	
COC forms	
Custody tape (as required)	
Shipping materials (as required)	
GPS	

9.2.3. Soil / Sediment Sample Collection

Field sampling personnel will collect sediment samples from HDS unit sumps using methods that minimize contamination, losses, and changes to the chemical form of the analytes of interest. The samples will be collected in the field into pre-cleaned sample containers of a material appropriate to the analysis to be conducted. Pre-cleaned sampling equipment is used for each site, whenever possible and/or when necessary. Appropriate sampling technique and measuring equipment may vary depending on the location, sample type, sampling objective, and weather. Additional safety measures may be necessary in some cases; for example, if traffic control or confined space entry is required to conduct the sampling.

Ideally and where a sufficient volume of soil/sediment allows, samples are collected into a composite container, where they are thoroughly homogenized, and then aliquoted into separate jars for chemical analysis. Sediment samples for metals and organics are submitted to the analytical laboratories in separate jars, which have been pre-cleaned according to laboratory protocol. It is anticipated that soil / solid media will be collected for laboratory analysis using one of two techniques: (1) Remote grab of submerged sediments within HDS unit sumps using Ekman dredge or similar; or (2) direct grab sampling of

sediments after dewatering HDS unit sumps using individual scoops, push core sampling, or similar. Each of these techniques is described briefly below.

- Soil and Sediment Samples, Submerged. Wet soil and sediment samples may be collected from within HDS unit sumps. Sample crews must exercise judgment on whether submerged samples can be collected in a manner that does not substantially change the character of the soil/sediment collected for analysis (e.g., loss of fine materials). It is anticipated that presence of trash within the sumps may interfere with sample collection by preventing complete grab closure and loss of significant portion of the sample. Field crews will have the responsibility to determine the best method for collection of samples within each HDS Unit sump. If sampling personnel determine that sample integrity cannot be maintained throughout collection process, it is preferable to cancel sampling operations rather than collect samples with questionable integrity. This decision making process is more fully described in Section 11, Field Variances.

- Soil and Sediment Samples, Dry. Soils / sediments may be collected from within the HDS unit sump after dewatering. Field crews will have the responsibility to identify areas of sediment accumulation within areas targeted for sampling and analysis, and determine the best method for collection of samples with minimal disturbance to the sampling media.

After collection, all soil/sediment samples for PCBs and mercury analyses will be homogenized and transferred from the sample-dedicated homogenization pail into factory-supplied wide-mouth glass jars using a clean trowel or scoop. The samples will be transferred to coolers containing double-bagged wet ice and chilled to 6°C immediately upon collection.

For each sample collected, field personnel will fill out a field data sheet at the time of sample collection. Appendix A contains an example field data sheet. All samples will be kept in a chilled cooler in the field, and kept refrigerated pending delivery under COC to the field-PM. The Field PM will be responsible for sending the samples in a single batch to CEH for XRF analysis under COC. Following XRF analysis, CEH will deliver the samples under COC to the Consultant-PM. The Consultant-PM will be responsible for working with the project team to group samples for compositing, and sending those samples to the analytical laboratory under COC.

9.2.4. Sample ID Designation

Every sample must have a unique sample ID so that the analytical results from each sample can be differentiated from every other sample. This information should follow the sample through the COC, analytical, and interpretation and reporting processes. Each sediment/soil sample collected from HDS units will be labeled according to the following naming convention:

MMM-UUU-##

where:

MMM	Municipal Abbreviation (i.e., SJC=San Jose; OAK=Oakland; SUN=Sunnyvale).
UUU	HDS Unit Catchment ID; this is the number provided by the municipality for a specific HDS unit.
##	Sequential Sample Number (i.e., 01, 02, 03…etc.)

9.3. Water Quality Sampling and Column Testing Procedures (Task 3)

For this task, monitoring will be conducted during three storm events. The stormwater collected during these events will then be used as the influent for the laboratory column tests of amended BSM mixtures. Four influent samples (i.e., one sample of Bay Area stormwater from each of the three monitored storm events plus one diluted stormwater sample) and 20 effluent samples from the column tests that includes 3 tests for each of the six columns, plus one test with the diluted stormwater in two columns (one test column and one control column) will be collected and analyzed for pollutant concentrations.

9.3.1. Sample Site Selection

Two stormwater collection sites have been selected based on influent PCB concentrations measured during CW4CB (BASMAA, 2017c). Both sites are near tree wells located on Ettie Street in West Oakland. The first site is the influent to tree well #6 (station code = TW6). During CW4CB, influent stormwater concentrations at this location were average to high, ranging from 30 ng/L to 286 ng/L. Stormwater collected from this site will be used as the influent for one of the main column tests and some water will be reserved for the dilution series column tests. The amount of dilution will be determined after results are received from the lab from the first run. The second site is the influent to tree well #2 (station code=TW2). During CW4CB, influent stormwater concentrations at this location were low to average, ranging from 6 ng/L to 39 ng/L. Stormwater collected from this site will be used for the remaining two main column tests..

9.3.2. Field Equipment and Cleaning

Field sampling equipment includes:

1. Borosilicate glass carboys
2. Glass sample jars
3. Peristaltic pump tubing

Prior to sampling, all equipment will be thoroughly cleaned. Glass sample containers and peristaltic pump tubing will be factory pre-cleaned. Prior to first use and after each use, glass carboys (field carboys and effluent collection carboys) will be washed using phosphate-free laboratory detergent and scrubbed with a plastic brush. After washing the carboy will be rinsed with methylene chloride, then de-ionized water, then 2N nitric acid, then again with de-ionized water. Glass carboys will be cleaned after each sample run before they are returned to the Field PM for reuse in the field.

9.3.3. Water Sampling Procedures

During each storm event, stormwater will be collected in six, five-gallon glass carboys. To fill the carboys, the Field PM will create a backwater condition in the gutter before the drain inlet at each site and use a peristaltic pump to pump the water into glass carboys. Field personnel will wear nitrile gloves during sample collection to prevent contamination. Carboys will be stored and transported in coolers with either wet ice or blue ice, and will be delivered to OWP within 24 hours of collection.

9.3.4. Hydraulic Testing

Based on the literature review and availability, the best five biochars will be mixed with the standard BSM to create biochar amended BSMs. Initially, each biochar will be mixed with standard BSM at a rate of 25% biochar by volume (the same as that at the CW4CB Richmond PG&E Substation 1st and Cutting

site). Hydraulic conductivity can be determined using the method stated in the BASMAA soil specification, method ASTM D2434.

1. Follow the directions for permeability testing in ASTM D2434 for the BSM.
2. Sieve enough of the sample biochar to collect at least 15 in^3 on a no. 200 sieve.
3. Mix the sieved biochar with standard BSM at a 1 to 4 ratio.
4. Thoroughly mix the soil.
5. Follow the directions for permeability testing in ASTM D2434.
6. If the soil mix is more than 1 in/hr different from the BSM, repeat steps 1-4 but on step 3, adjust the ratio as estimated to achieve the same permeability as the BSM.
7. Repeat steps 2-6 for each biochar.

9.3.5. Column Testing Procedures

Column Setup: Up to five biochar amended BSMs and one standard BSM will be tested (based on performance and availability of biochars). Six glass columns with a diameter of eight inches and a height of three feet will be mounted to the wall with sufficient height between the bottom of the columns and the floor to allow for effluent sample collection. Each column will be capped at the bottom and fitted with a spigot to facilitate sampling. Soil depth for all columns will be 18" after compaction, which is a standard depth used in bay area bioretention installations (see Figure 9-1 below). To retain soil the bottom of the soil layer will be contained by a layer of filter fabric on top of structural backing. Behind each column, a yardstick will be mounted to the wall so that the depth of water in the column can be monitored.

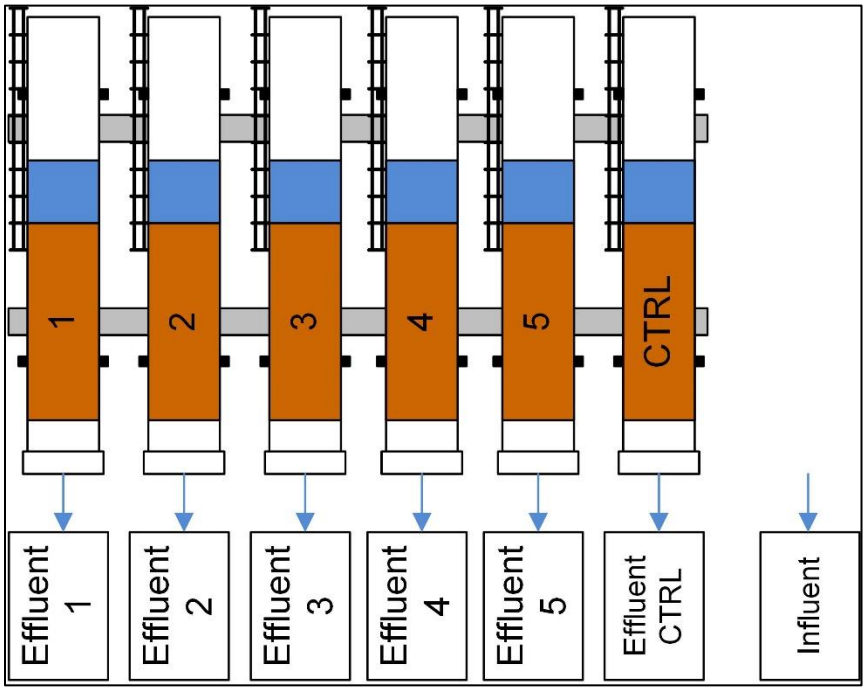

Figure 9-1. Column Test Setup

Dilution Run Column Setup: One of the existing biochar-amended BSM column and the standard BSM will be tested using diluted stormwater.

Testing procedure pre run setup: Before a sampling run begins a clean glass carboy will be placed under each soil column and labeled to match, this carboy will be sized to collect the full effluent volume

of the sample run. A glass beaker will also be assigned and labeled for each column of sufficient volume to accurately measure a single influent dose equivalent to 1 inch of depth in the column. An additional beaker will be prepared and labeled influent.

Media conditioning: Within 24 to 72 hours prior to the first column test run, pre-wet each column with a stormwater matrix collected from the CSUS campus by filling each column from the invert until water ponds above the media. Drain the water after 3 hours.

Sampling run: When the six glass carboys are delivered:

1. Inspect each carboy and fill out the Sample Receiving worksheet.
2. The runs will begin within 72 hours of delivery.
3. Select one carboy at random and fully mix it using a portable lab mixer for five minutes.
4. Turn off and remove the mixer, allow the sample to rest for one minute to allow the largest particles to settle to the bottom.
5. Fill each of the six dosing beakers and the one influent sample jar.
6. Pour each aliquot beaker into its respective column; record the time and height of water in each column.
7. Repeat steps 3-6 for each of the remaining carboys until a total of 18 inches of water is applied to each column. Before pouring an aliquot record the height of water in each column and the time. Pour each successive aliquot from the carboy when all columns have less than three inches of water above the soil surface. The water level should never be above 6 inches in any column at any time (6 inches is a standard ponding depth used in the bay area). Pour all aliquots from a single carboy into the columns at the same time.
8. Collect turbidity samples from the effluent of each column at the beginning, middle, and end of the sampling run. Fill the cuvettes for turbidity measurement directly from the effluent stream of each column and dispose of them after testing.
9. Collect mercury samples from the effluent of each column at the middle of the sample run using pre-labeled sample containers provided by the lab for that purpose.
10. Fill a pre-labeled sample jar from each columns effluent. The jar will be obtained from the laboratory performing the PCB analysis.
11. Pack each jar in ice and complete the lab COCs.
12. Ship the samples to the lab for analysis.

9.3.6.Sample ID Designations

Every sample must have a unique sample identification to ensure analytical results from each sample can be differentiated from every other sample. This information should follow the sample through the COC, analytical, and interpretation and reporting processes. Each influent and effluent water quality sample will be labeled according to the following naming convention:

SSS-TT-MMDDYYYY-##

Where:

SSS	Station code (see Table 9-2 for station codes)
TT	Sample Type (IN=influent; EF=Effluent)
MM	2 digit month of collection
DD	2 digit date of collection
YYYY	4 digit year of collection
##	Sequential 2-digit sample number (i.e., 01, 02, 03…etc.)

For example, a sample collected at the West Oakland Tree Well #2 site on October 20, 2017 and used for the influent sample for run #3 could be assigned the following sample ID: TW2-IN-09202017-03.

Table 9-2 Station Codes for Stormwater Influent Samples and Column Tests.

Station Code	Station Description
TW2	Stormwater sample collected from the West Oakland Tree Well #2
TW6	Stormwater sample collected from the West Oakland Tree Well #6
CO1	Effluent sample collected from column number 1
CO2	Effluent sample collected from column number 2
CO3	Effluent sample collected from column number 3
CO4	Effluent sample collected from column number 4
CO5	Effluent sample collected from column number 5
CO6	Effluent sample collected from column number 6

9.4. Collection of Samples for Archiving

Archive samples will not be collected for this Monitoring Program. The sample size collected will be enough to support additional analyses if QA/QC issues arise. Once quality assurance is certified by the QA Officer, the laboratory will be instructed to dispose of any leftover sample materials.

9.5. Waste Disposal

Proper disposal of all waste is an important component of field activities. At no time will any waste be disposed of improperly. The proper methods of waste disposal are outlined below:

9.5.1. Routine Garbage

Regular garbage (paper towels, paper cups, etc.) is collected by sampling personnel in garbage bags or similar. It can then be disposed of properly at appropriate intervals.

9.5.2. Detergent Washes

Any detergents used or detergent wash water should be collected in the field in a water-tight container and disposed of appropriately.

9.5.3. Chemicals

Methanol, if used, should be disposed of by following all appropriate regulations. It should always be collected when sampling and never be disposed in the field.

9.1. Responsibility and Corrective Actions

If monitoring equipment fails, sampling personnel will report the problem in the comments section of their field notes and will not record data values for the variables in question. Actions will be taken to replace or repair broken equipment prior to the next field use.

9.2. Standard Operating Procedures

SOPs associated with sampling and sample handling expected to be used as part of implementation of The Monitoring Program are identified in Table 9-3. Additional details on sample container information, required preservation, holding times, and sample volumes for all Monitoring Program analytes are listed

in Table 10-1 of Section 10.

Table 9-3. List of BASMAA RMC SOPs Utilized by the Monitoring Program.

RMC SOP #	RMC SOP	Source
FS-2	Water Quality Sampling for Chemical Analysis, Pathogen Indicators, and Toxicity	BASMAA 2016
FS-3	Field Measurements, Manual	BASMAA 2016
FS-4	Field Measurements, Continuous General Water Quality	BASMAA 2016
FS-5	Temperature, Automated, Digital Logger	BASMAA 2016
FS-6	Collection of Bedded Sediment Samples for Chemical Analysis and Toxicity	BASMAA 2016
FS-7	Field Equipment Cleaning Procedures	BASMAA 2016
FS-8	Field Equipment Decontamination Procedures	BASMAA 2016
FS-9	Sample Container, Handling, and Chain of Custody Procedures	BASMAA 2016
FS-10	Completion and Processing of Field Datasheets	BASMAA 2016
FS-11	Site and Sample Naming Convention	BASMAA 2016

In addition, contractor-specific plans and procedures may be required for specific aspects of the Monitoring Program implementation (e.g., health and safety plans, dry ice shipping procedures).

10. Sample Handling and Custody

Sample handling and chain of custody procedures are described in detail in RMC SOP FS-9 (Table 9-3) (BASMAA 2016). The Field-PM or designated municipal staff on site during sample collection will be responsible for overall collection and custody of samples during field sampling. Field crews will keep a field log, which will consist of sampling forms for each sampling event. Sample collection methods described in this document and the study designs (BASMAA 2017a, b) will be followed for each sampling task. Field data sheets will be filled out for each sample collected during the project. Example field data sheets are provided in Appendix A, and described further in Section 9.

The field crews will have custody of samples during field sampling, and COC forms will accompany all samples from field collection until delivery to the analyzing laboratory. COC procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of analytical results. Each laboratory will follow sample custody procedures as outlined in its QA plans.

Information on sampling containers, preservation techniques, packaging and shipping, and hold times is described below and summarized in Table 10.1.

10.1. Sampling Containers

Collection of all sample types require the use of clean containers. Factory pre-cleaned sample containers of the appropriate type will be provided by the contracted laboratory and delivered to field team at least one week prior to the start of sample collection. Individual laboratories will be responsible for the integrity of containers provided. The number and type of sample containers required for all analytes by media type for each sampling task are provided in Table 10.1.

10.2. Sample Preservation

Field Crews will collect samples in the field in a way that neither contaminates, loses, or changes the chemical form of the analytes of interest. The samples will be collected in the field into pre-cleaned sample containers of a material appropriate to the analysis to be conducted. Pre-cleaned sampling equipment is used for each site, whenever possible and/or when necessary. Appropriate sampling technique and measurement equipment may vary depending on the location, sample type, sampling objective, and weather.

In general, all samples will be packed in sufficient wet ice or frozen ice packs during shipment, so that they will be kept between 2 and 4º C (Table 10.1). When used, wet ice will be double bagged in Zip-top bags to prevent contamination via melt water. Where appropriate, samples may be frozen to prevent degradation. If samples are to be shipped frozen on dry ice, then appropriate handling procedures will be followed, including ensuring use of appropriate packaging materials and appropriate training for shipping personnel.

10.3. Packaging and Shipping

All samples will be handled, prepared, transported, and stored in a manner so as to minimize bulk loss, analyte loss, contamination, or biological degradation. Sample containers will be clearly labeled with an indelible marker. All caps and lids will be checked for tightness prior to shipping. Ice chests will be sealed with packing tape before shipping. Samples will be placed in the ice chest with enough ice or frozen ice packs to maintain between 2 and 4º C. Additional packing material will be added as needed. COC forms will be placed in a zip-top bag and placed inside of the ice chest.

10.4. Commercial Vehicle Transport

If transport of samples to the contracted laboratories is to be by commercial carriers, pickup will be pre-arranged with the carrier and all required shipping forms will be completed prior to sample pickup by the commercial carrier.

10.5. Sample Hold Times

Sample hold times for each analyte by media type are presented in Table 10-1.

Table 10-1 Sample Handling for the Monitoring Program Analytes by media type.

Analyte	Sample Media	Sample Container	Minimum Sample / Container Size[a]	Preservative	Hold Time (at 6º C)
PCBs (40-RMP Congeners)	Caulk or sealant	Pre-cleaned 250-mL glass sample container (e.g., Quality Certified™, ESS Vial, Oakland, CA)	10 g	Cool to 6° C within 24 hours, then freeze to ≤-20° C	1 year at -20º C; Samples must be analyzed within 14 days of collection or thawing.
	Sediment	Pre-cleaned 250-mL I-Chem 200 Series amber glass jar with Teflon lid liner	500 mL (two jars)	Cool to 6° C within 24 hours, then freeze to ≤-20° C	1 year at -20º C; Samples must be analyzed within 14 days of collection or thawing.
	Water	1000-mL I-Chem 200-Series amber glass bottle, with Teflon lid-liner	1000 mL/per individual analyses	Cool to 6º C in the dark.	1 year until extraction, 1 year after extraction
Total Mercury	Sediment	Pre-cleaned 250-mL I-Chem 200 Series amber glass jar with Teflon lid liner	100 g	Cool to 6º C and in the dark	1 year at -20º C; Samples must be analyzed within 14 days of collection or thawing.
	Water	250-mL glass or acid-cleaned Teflon bottle	250 mL	Cool to 6º C in the dark and acidify to 0.5% with pre-tested HCl within 48 hours	6 months at room temperature following acidification
Bulk Density	Sediment	250-mL clear glass jar; pre-cleaned	250 mL	Cool to 6º C	7 days
Grain Size and TOC	Sediment	250-mL clear glass jar; pre-cleaned	250 mL	Cool to 6º C, in the dark up to 28 days[2]	28 days at ≤6 ◦C; 1 year at ≤-20 ◦C
SSC	Water	125-mL amber glass jar or Polyethylene Bottles	125 mL	Cool to 6º C and store in the dark	7 days
Turbidity	Water				
Total Solids	Water	1 L HDPE	1 L	Cool to ≤6 ◦C	7 days
TOC	Water	40-mL glass vial	40 mL	Cool to 6º C and store in the dark. If analysis is to occur more than two hours after sampling, acidify (pH < 2) with HCl or H_2SO_4.	28 days
Particle Size Distribution	Water	1 L HDPE	2 L	Cool to 6º C and store in the dark	7 days

[a]QC samples or other analytes require additional sample bottles.

11. Field Health and Safety Procedures

All field crews will be expected to abide by their employer's (i.e., the field contractor's) health and safety programs. Additionally, prior to the fieldwork, field contractors are required to develop site-specific Health and Safety plans that include the locations of the nearest emergency medical services.

Implementation of the Monitoring Program activities may require confined space entry (CSE) to accomplish sampling goals. Sampling personnel conducting any confined space entry activities will be expected to be certified for CSE and to abide by relevant regulations.

12. Laboratory Analytical Methods

12.1. Caulk/Sealant Samples (Task 1)

12.1.1. XRF Chlorine analysis

XRF technology will be used in a laboratory setting to rank samples for chlorine content before sending the samples to the project laboratory for chemical analysis. Procedures for testing caulk or sealants using X-Ray fluorescence (XRF) and collecting caulk and sealant samples are not well described, and minimal detail on caulk or sealant sample collection is available in peer-reviewed publications. Sealant sampling procedures were adapted from the previous study examining PCBs in building materials (Klosterhaus et al., 2014).

An XRF analyzer will be used at the Center for Environmental Health (CEH) as a screening tool to estimate the concentration of chlorine (Cl) in collected caulk and sealant samples from various structures. Settings for the analyzer will be 'standardized' using procedures developed/ recommended by CEH each time the instrument is turned on and prior to any measurement. European plastic pellet reference materials (EC680 and EC681) will be used as 'check' standards upon first use to verify analyzer performance. A 30 second measurement in 'soil' mode will be used. CEH personnel will inspect the caulk/sealant surfaces and use a stainless steel blade to scrape off any paint, concrete chips, or other visible surface residue. The caulk/sealant surface to be sampled will then be wiped with a laboratory tissue to remove any remaining debris that may potentially interfere with the XRF analysis. At least two XRF readings will be collected from each sample switching the orientation or position of the sample between readings. If Cl is detected, a minimum of four additional readings will be collected on the same material to determine analytical variability. Each individual Cl reading and its detection limit will be recorded on the data sheet. After XRF analysis, all samples will be returned to their original sample container. Results of the XRF analysis will be provided to the project team as a table of ranked Cl screening results for possible selection for chemical (PCBs) analysis.

12.1.2. Selection of Samples for PCB analysis and Compositing

Once samples have been ranked for their chlorine content, primarily samples with the highest Cl will preferentially be selected for chemical analysis. About 75% of samples to be analyzed should be selected from samples with the top quartile Cl content. The remaining 25% should be selected from samples with medium (25 to 75th percentile) Cl, as the previous study using XRF screening showed inconsistent correlation between total Cl and PCB. Although samples with very low Cl seldom had much PCBs, samples with medium Cl on occasion had higher PCBs than samples with high Cl, and within the high Cl group, Cl content was not a good predictor of their ranks of PCB concentration.

In addition to Cl content, other factors about each sample that were recorded on the field data sheets at the time of sample collection, including the color or consistency of the sample, the type and/or age of the structure that was sampled, or the type of caulk or sealant application will be considered in selecting the samples that will be sent to the laboratory for PCBs analysis, as well as how the samples will be grouped for compositing purposes. Those factors are described in more detail in the study design (BASMAA, 2017a).

The Consultant PM will work with the project team to identify up to three samples for inclusion in each composite. A common composite ID will then be assigned to each sample that will be composited together (i.e., all samples the lab should composite together will be identified by the common composite ID). The composite ID will consist of a single letter designation and will be identical for all samples (up to 3 total) that will be composited together. The Consultant PM will add the composite ID to each sample container label, to each sample ID on all COC forms, and to each field data sheet for all samples prior to sending the samples to the laboratory for PCBs analysis.

12.1.3. Sample Preparation

The project laboratory will composite the samples prior to extraction and PCBs analysis according to the groupings identified by the common composite ID. Sample preparation will include removal of any paint, concrete chips, or other surface debris, followed by homogenization of the caulk/sealant material and compositing up to three samples per composite. Each sample will have a composite ID that will be used to identify which samples should be composited together. Samples with the same composite ID will be combined into a single composite sample. For example, all samples with composite ID = "A" will be composited together; all samples with composite ID = "B" will be composited together, etc. Sample preparation and compositing will follow the procedures outlined in the laboratory SOPs (Appendix B). After compositing, each composite sample will be assigned a new sample ID using the following naming convention:

X-MMDDYYYY

Where:

X	the single letter Composite ID that is common to all samples included in a given composite.
MM	2 digit month of composite preparation
DD	2 digit date of composite preparation
YYYY	4 digit year of composite preparation

For example, if three samples with the composite ID= "A" are combined into a single composite sample on December 12, 2017, the new (composite) sample ID would be the following: A-12122017.

12.1.4. PCBs Analysis

All composite caulk/sealant samples will be extracted by Method 3540C, and analyzed for the RMP-40 PCB congeners[3] using a modified EPA Method 8270C (GC/MS-SIM), in order to obtain positive

[3] The 40 individual congeners routinely quantified by the Regional Monitoring Program (RMP) for Water Quality in the San Francisco Estuary include: PCBs 8, 18, 28, 31, 33, 44, 49, 52, 56, 60, 66, 70, 74, 87, 95, 97, 99, 101, l05, 110, 118, 128, 132, 138, 141, 149, l51, 153, 156, 158, 170, 174, 177, 180, 183, 187, 194, 195, 201, and 203

identification and quantitation of PCBs. PCB content of these material covers an extremely wide range, so the subsampling of material should include sufficient material for quantification assuming that the concentration is likely to be around the median of previous results. There may be samples with much higher concentrations, which can be reanalyzed on dilution as needed. Method Reporting Limits (MRLs) for each of the RMP-40 PCB Congeners are 0.5 µg/Kg.

12.2. Sediment Samples Collected from HDS Units (Task 2)

All sediment samples collected from HDS units under Task 2 will be analyzed for TOC, grain size, bulk density, total mercury, and PCBs (RMP 40 Congeners1) by the methods identified in Table 12-1. All sediment samples (with the exception of grain size) will be sieved by the laboratory at 2 mm prior to analysis.

Table 12-1. Laboratory Analytical Methods for Analytes in Sediment

Analyte	Sampling Method	Recommended Analytical Method	Reporting Units
Total Organic Carbon (TOC)	Grab	EPA 415.1, 440.0, 9060, or ASTM D4129M	%
Grain Size	Grab	ASTM D422M/PSEP	%
Bulk Density	Grab	ASTM E1109-86	g/cm3
Mercury	Grab	EPA 7471A, 7473, or 1631	µg/kg
PCBs (RMP 40 Congeners)	Grab	EPA 1668	µg/kg

12.3. Water Samples – Stormwater and Column Tests (Task 3)

All water samples submitted to the laboratory will be analyzed for SSC, TOC, total mercury and PCBs (RMP-40 congeners) according to the methods identified in Table 12-2.

Table 12-2. Laboratory Analytical Methods for Analytes in Water

Analyte	Sampling Method	Recommended Analytical Method	Reporting Units
Suspended Sediment Concentration (SSC)	Grab	ASTM D3977-97 (Method C)	mg/L
Total Organic Carbon (TOC)	Grab	EPA 415.1 or SM 5310B	%
Mercury (Total)	Grab	EPA 1631	µg/L
PCBs (RMP 40 Congeners)	Grab	EPA 1668	ng/L

12.4. Method Failures

The QA Officer will be responsible for overseeing the laboratory implementing any corrective actions that may be needed in the event that methods fail to produce acceptable data. If a method fails to provide acceptable data for any reason, including analyte or matrix interferences, instrument failures, etc., then the involved samples will be analyzed again if possible. The laboratory in question's SOP for handling these types of problems will be followed. When a method fails to provide acceptable data, then the laboratory's

SOP for documenting method failures will be used to document the problem and what was done to rectify it.

Corrective actions for chemical data are taken when an analysis is deemed suspect for some reason. These reasons include exceeding accuracy or precision ranges and/or problems with sorting and identification. The corrective action will vary on a case-by-case basis, but at a minimum involves the following:

- A check of procedures.
- A review of documents and calculations to identify possible errors.
- Correction of errors based on discussions among analysts.
- A complete re-identification of the sample.

The field and laboratory coordinators shall have systems in place to document problems and make corrective actions. All corrective actions will be documented to the FTL and the QA Officer.

12.5. Sample Disposal

After analysis of the Monitoring Program samples has been completed by the laboratory and results have been accepted by QA Officer and the Field-PM, they will be disposed by laboratory staff in compliance with all federal, state, and local regulations. The laboratory has standard procedures for disposing of its waste, including left over sample materials

12.6. Laboratory Sample Processing

Field samples sent to the laboratories will be processed within their recommended hold time using methods agreed upon method between the Lab-PM and Field-PM. Each sample may be assigned unique laboratory sample ID numbers for tracking processing and analyses of samples within the laboratory. This laboratory sample ID (if differing from the field team sample ID) must be included in the data submission, within a lookup table linking the field sample ID to that assigned by the lab.

Samples arriving at the laboratory are to be stored under conditions appropriate for the planned analytical procedure(s), unless they are processed for analysis immediately upon receipt. Samples to be analyzed should only be removed from storage when laboratory staff are ready to proceed.

13. Quality Control

Each step in the field collection and analytical process is a potential source of contamination and must be consistently monitored to ensure that the final measurement is not adversely affected by any processing steps. Various aspects of the quality control procedures required by the Monitoring Program are summarized below.

13.1. Field Quality Control

Field QC results must meet the MQOs and frequency requirements specified in Tables 13-1 – 13-4 below.

13.1.1. Field Blanks

A field blank is collected to assess potential sample contamination levels that occur during field sampling activities. Field blanks are taken to the field, transferred to the appropriate container, preserved (if required by the method), and treated the same as the corresponding sample type during the course of a sampling event. The inclusion of field blanks is dependent on the requirements specified in the relevant MQO tables or in the sampling method or SOP.

Collection of caulk or sealant field blank samples has been deemed unnecessary due to the difficulty in collection and interpretation of representative blank samples and the use of precautions that minimize contamination of the samples. Additionally, PCBs have been reported to be present in percent concentrations when used in sealants; therefore any low level contamination (at ppb or even ppm level) due to sampling equipment and procedures is not expected to affect data quality because it would be many orders of magnitude lower than the concentrations deemed to be a positive PCB signal.

For stormwater samples, field blanks will be generated using lab supplied containers and clean matrices. Sampling containers will be opened as though actual samples were to be collected, and clean lab-supplied matrix (if any) will be transferred to sample containers for analysis.

13.1.2. Field Duplicates

Field samples collected in duplicate provide precision information as it pertains to the sampling process. The duplicate sample must be collected in the same manner and as close in time as possible to the original sample. This effort is to attempt to examine field homogeneity as well as sample handling, within the limits and constraints of the situation. These data are evaluated in the data analysis/assessment process for small-scale spatial variability.

Field duplicates will not be collected for caulk/sealant samples (Task 1), as assessment of within-structure variability of PCB concentrations in sealants is not a primary objective of the Project. Due to budget limitations, PCBs analysis of only one caulk/sealant sample per application will be targeted to maximize the number of Bay Area structures and structure types that may be analyzed in the Project. The selected laboratory will conduct a number of quality assurance analyses (see Section 13), including a limited number of sample duplicates, to evaluate laboratory and method performance as well as variability of PCB content within a sample.

For all sediment and water samples, 5% of field duplicates and/or column influent/effluent duplicates will be collected along with primary samples in order to evaluate small scale spatial or temporal variability in sample collection without specifically targeting any apparent or likely bias (e.g. different sides of a seemingly symmetrical unit, or offset locations in making a composite, or immediately following collection of a primary water sample would be acceptable, whereas collecting one composite near an inlet and another near the outlet, or intentionally collecting times with vastly different flow rates, would not be desirable).

13.1.3. Field Corrective Action

The Field PM is responsible for responding to failures in their sampling and field measurement systems. If monitoring equipment fails, personnel are to record the problem according to their documentation protocols. Failing equipment must be replaced or repaired prior to subsequent sampling events. It is the combined responsibility of all members of the field organization to determine if the performance

requirements of the specific sampling method have been met, and to collect additional samples if necessary. Associated data is to be flagged accordingly. Specific field corrective actions are detailed in Table 13-8.

13.2. Laboratory Quality Control

Laboratories providing analytical support to the Monitoring Program will have the appropriate facilities to store, prepare, and process samples in an ultra-clean environment, and will have appropriate instrumentation and staff to perform analyses and provide data of the required quality within the time period dictated by the Monitoring Program. The laboratories are expected to satisfy the following:

1. Demonstrate capability through pertinent certification and satisfactory performance in inter-laboratory comparison exercises.
2. Provide qualification statements regarding their facility and personnel.
3. Maintain a program of scheduled maintenance of analytical balances, laboratory equipment and instrumentation.
4. Conduct routine checking of analytical balances using a set of standard reference weights (American Society of Testing and Materials Class 3, NIST Class S-1, or equivalents). Analytical balances are serviced at six-month intervals or when test weight values are not within the manufacturer's instrument specifications, whichever occurs first.
5. Conduct routine checking and recording the composition of fresh calibration standards against the previous lot. Acceptable comparisons are within 2% of the precious value.
6. Record all analytical data in bound (where possible) logbooks, with all entries in ink, or electronically.
7. Monitor and document the temperatures of cold storage areas and freezer units on a continuous basis.
8. Verify the efficiency of fume/exhaust hoods.
9. Have a source of reagent water meeting specifications described in Section 8.0 available in sufficient quantity to support analytical operations.
10. Label all containers used in the laboratory with date prepared, contents, initials of the individual who prepared the contents, and other information as appropriate.
11. Date and safely store all chemicals upon receipt. Proper disposal of chemicals when the expiration date has passed.
12. Have QAPP, SOPs, analytical methods manuals, and safety plans readily available to staff.
13. Have raw analytical data readily accessible so that they are available upon request.

In addition, laboratories involved in the Monitoring Program are required to demonstrate capability continuously through the following protocols:

1. Strict adherence to routine QA/QC procedures.
2. Regular participation in annual certification programs.
3. Satisfactory performance at least annually in the analysis of blind Performance Evaluation Samples and/or participation in inter-laboratory comparison exercises.

Laboratory QC samples must satisfy MQOs and frequency requirements. MQOs and frequency requirements are listed in Tables 13-1 – 13-3. Frequency requirements are provided on an analytical batch

level. The Monitoring Program defines an analytical batch as 20 or fewer samples and associated quality control that are processed by the same instrument within a 24-hour period (unless otherwise specified by method). Target Method Reporting Limits are provided in Tables 13.4 – 13.8. Details regarding sample preparation are method- or laboratory SOP-specific, and may consist of extraction, digestion, or other techniques.

13.2.1. Calibration and Working Standards

All calibration standards must be traceable to a certified standard obtained from a recognized organization. If traceable standards are not available, procedures must be implemented to standardize the utilized calibration solutions (*e.g.*, comparison to a CRM – see below). Standardization of calibration solutions must be thoroughly documented, and is only acceptable when pre-certified standard solutions are not available. Working standards are dilutions of stock standards prepared for daily use in the laboratory. Working standards are used to calibrate instruments or prepare matrix spikes, and may be prepared at several different dilutions from a common stock standard. Working standards are diluted with solutions that ensure the stability of the target analyte. Preparation of the working standard must be thoroughly documented such that each working standard is traceable back to its original stock standard. Finally, the concentration of all working standards must be verified by analysis prior to use in the laboratory.

13.2.2. Instrument Calibration

Prior to sample analysis, utilized instruments must be calibrated following the procedures outlined in the relevant analytical method or laboratory SOP. Each method or SOP must specify acceptance criteria that demonstrate instrument stability and an acceptable calibration. If instrument calibration does not meet the specified acceptance criteria, the analytical process is not in control and must be halted. The instrument must be successfully recalibrated before samples may be analyzed.

Calibration curves will be established for each analyte covering the range of expected sample concentrations. Only data that result from quantification within the demonstrated working calibration range may be reported unflagged by the laboratory. Quantification based upon extrapolation is not acceptable; sample extracts above the calibration range should be diluted and rerun if possible. Data reported below the calibration range must be flagged as estimated values that are Detected not Quantified.

13.2.3. Initial Calibration Verification

The initial calibration verification (ICV) is a mid-level standard analyzed immediately following the calibration curve. The source of the standards used to calibrate the instrument and the source of the standard used to perform the ICV must be independent of one another. This is usually achieved by the purchase of standards from separate vendors. Since the standards are obtained from independent sources and both are traceable, analyses of the ICV functions as a check on the accuracy of the standards used to calibrate the instrument. The ICV is not a requirement of all SOPs or methods, particularly if other checks on analytical accuracy are present in the sample batch.

13.2.4. Continuing Calibration Verification

Continuing calibration verification (CCV) standards are mid-level standards analyzed at specified intervals during the course of the analytical run. CCVs are used to monitor sensitivity changes in the instrument during analysis. In order to properly assess these sensitivity changes, the standards used to perform CCVs must be from the same set of working standards used to calibrate the instrument. Use of a

second source standard is not necessary for CCV standards, since other QC samples are designed to assess the accuracy of the calibration standards. Analysis of CCVs using the calibration standards limits this QC sample to assessing only instrument sensitivity changes. The acceptance criteria and required frequency for CCVs are detailed in Tables 13-1 through 13-3. If a CCV falls outside the acceptance limits, the analytical system is not in control, and immediate corrective action must be taken.

Data obtained while the instrument is out of control is not reportable, and all samples analyzed during this period must be reanalyzed. If reanalysis is not an option, the original data must be flagged with the appropriate qualifier and reported. A narrative must be submitted listing the results that were generated while the instrument was out of control, in addition to corrective actions that were applied.

13.2.5. Laboratory Blanks

Laboratory blanks (also called extraction blanks, procedural blanks, or method blanks) are used to assess the background level of a target analyte resulting from sample preparation and analysis. Laboratory blanks are carried through precisely the same procedures as the field samples. For both organic and inorganic analyses, a minimum of at least one laboratory blank must be prepared and analyzed in every analytical batch or per 20 samples, whichever is more frequent. Some methods may require more than one laboratory blank with each analytical run. Acceptance criteria for laboratory blanks are detailed in Tables 13-1 through 13-3. Blanks that are too high require corrective action to bring the concentrations down to acceptable levels. This may involve changing reagents, cleaning equipment, or even modifying the utilized methods or SOPs. Although acceptable laboratory blanks are important for obtaining results for low-level samples, improvements in analytical sensitivity have pushed detection limits down to the point where some amount of analyte will be detected in even the cleanest laboratory blanks. The magnitude of the blanks must be evaluated against the concentrations of the samples being analyzed and against project objectives.

13.2.6. Reference Materials and Demonstration of Laboratory Accuracy

Evaluation of the accuracy of laboratory procedures is achieved through the preparation and analysis of reference materials with each analytical batch. Ideally, the reference materials selected are similar in matrix and concentration range to the samples being prepared and analyzed. The acceptance criteria for reference materials are listed in Tables 13-1 – 13-3. The accuracy of an analytical method can be assessed using CRMs only when certified values are provided for the target analytes. When possible, reference materials that have certified values for the target analytes should be used. This is not always possible, and often times certified reference values are not available for all target analytes. Many reference materials have both certified and non-certified (or reference) values listed on the certificate of analysis. Certified reference values are clearly distinguished from the non-certified reference values on the certificate of analysis.

13.2.7. Reference Materials vs. Certified Reference Materials

The distinction between a reference material and a certified reference material does not involve how the two are prepared, rather with the way that the reference values were established. Certified values are determined through replicate analyses using two independent measurement techniques for verification. The certifying agency may also provide “non-certified or “reference” values for other target analytes. Such values are determined using a single measurement technique that may introduce bias. When available, it is preferable to use reference materials that have certified values for all target analytes. This is not always an option, and therefore it is acceptable to use materials that have reference values for these

analytes. Note: Standard Reference Materials (SRMs) are essentially the same as CRMs. The term "Standard Reference Material" has been trademarked by the National Institute of Standards and Technology (NIST), and is therefore used only for reference materials distributed by NIST.

13.2.8. Laboratory Control Samples

While reference materials are not available for all analytes, a way of assessing the accuracy of an analytical method is still required. LCSs provide an alternate method of assessing accuracy. An LCS is a specimen of known composition prepared using contaminant-free reagent water or an inert solid spiked with the target analyte at the midpoint of the calibration curve or at the level of concern. The LCS must be analyzed using the same preparation, reagents, and analytical methods employed for regular samples. If an LCS needs to be substituted for a reference material, the acceptance criteria are the same as those for the analysis of reference materials..

13.2.9. Prioritizing Certified Reference Materials, Reference Materials, and Laboratory Control Samples

Certified reference materials, reference materials, and laboratory control samples all provide a method to assess the accuracy at the mid-range of the analytical process. However, this does not mean that they can be used interchangeably in all situations. When available, analysis of one certified reference material per analytical batch should be conducted. Certified values are not always available for all target analytes. If no certified reference material exists, reference values may be used. If no reference material exists for the target analyte, an LCS must be prepared and analyzed with the sample batch as a means of assessing accuracy. The hierarchy is as follows: analysis of a CRM is favored over the analysis of a reference material, and analysis of a reference material is preferable to the analysis of an LCS. Substitution of an LCS is not acceptable if a certified reference material or reference material is available, contact the Project Manager and QAO for approval before relying exclusively on an LCS as a measure of accuracy.

13.2.10. Matrix Spikes

A MS is prepared by adding a known concentration of the target analyte to a field sample, which is then subjected to the entire analytical procedure. The MS is analyzed in order to assess the magnitude of matrix interference and bias present. Because these spikes are often analyzed in pairs, the second spike is called the MSD. The MSD provides information regarding the precision of measurement and consistency of the matrix effects. Both the MS and MSD are split from the same original field sample. In order to properly assess the degree of matrix interference and potential bias, the spiking level should be approximately 2-5x the ambient concentration of the spiked sample. To establish spiking levels prior to sample analysis, if possible, laboratories should review any relevant historical data. In many instances, the laboratory will be spiking samples blind and will not meet a spiking level of 2-5x the ambient concentration. In addition to the recoveries, the relative percent difference (RPD) between the MS and MSD is calculated to evaluate how matrix affects precision. The MQO for the RPD between the MS and MSD is the same regardless of the method of calculation. These are detailed in Tables 13-1 – 13-3. Recovery data for matrix spikes provides a basis for determining the prevalence of matrix effects in the samples collected and analyzed. If the percent recovery for any analyte in the MS or MSD is outside of the limits specified in Tables 13-1 – 13-3, the chromatograms (in the case of trace organic analyses) and raw data quantitation reports should be reviewed. Data should be scrutinized for evidence of sensitivity shifts (indicated by the results of the CCVs) or other potential problems with the analytical process. If associated QC samples (reference materials or LCSs) are in control, matrix effects may be the source of

the problem. If the standard used to spike the samples is different from the standard used to calibrate the instrument, it must be checked for accuracy prior to attributing poor recoveries to matrix effects.

13.2.11.Laboratory Duplicates

In order to evaluate the precision of an analytical process, a field sample is selected and prepared in duplicate. Specific requirements pertaining to the analysis of laboratory duplicates vary depending on the type of analysis. The acceptance criteria for laboratory duplicates are specified in Tables 13-1 – 13-3.

13.2.12.Laboratory Duplicates vs. Matrix Spike Duplicates

Although the laboratory duplicate and matrix spike duplicate both provide information regarding precision, they are unique measurements. Laboratory duplicates provide information regarding the precision of laboratory procedures at actual ambient concentrations. The matrix spike duplicate provides information regarding how the matrix of the sample affects both the precision and bias associated with the results. It also determines whether or not the matrix affects the results in a reproducible manner. MS/MSDs are often spiked at levels well above ambient concentrations, so thus are not representative of typical sample precision. Because the two concepts cannot be used interchangeably, it is unacceptable to analyze only an MS/MSD when a laboratory duplicate is required.

13.2.13.Replicate Analyses

The Monitoring Program will adopt the same terminology as SWAMP in defining replicate samples, wherein replicate analyses are distinguished from duplicate analyses based simply on the number of involved analyses. Duplicate analyses refer to two sample preparations, while replicate analyses refer to three or more. Analysis of replicate samples is not explicitly required.

13.2.14.Surrogates

Surrogate compounds accompany organic measurements in order to estimate target analyte losses or matrix effects during sample extraction and analysis. The selected surrogate compounds behave similarly to the target analytes, and therefore any loss of the surrogate compound during preparation and analysis is presumed to coincide with a similar loss of the target analyte. Surrogate compounds must be added to field and QC samples prior to extraction, or according to the utilized method or SOP. Surrogate recovery data are to be carefully monitored. If possible, isotopically labeled analogs of the analytes are to be used as surrogates.

13.2.15.Internal Standards

To optimize gas chromatography mass spectrometry (GC-MS) analysis, internal standards (also referred to as "injection internal standards") may be added to field and QC sample extracts prior to injection. Use of internal standards is particularly important for analysis of complex extracts subject to retention time shifts relative to the analysis of standards. The internal standards can also be used to detect and correct for problems in the GC injection port or other parts of the instrument. The analyst must monitor internal standard retention times and recoveries to determine if instrument maintenance or repair or changes in analytical procedures are indicated. Corrective action is initiated based on the judgment of the analyst. Instrument problems that affect the data or result in reanalysis must be documented properly in logbooks and internal data reports, and used by the laboratory personnel to take appropriate corrective action. Performance criteria for internal standards are established by the method or laboratory SOP.

13.2.16.Dual-Column Confirmation

Due to the high probability of false positives from single-column analyses, dual column confirmation should be applied to all gas chromatography and liquid chromatography methods that do not provide definitive identifications. It should not be restricted to instruments with electron capture detection (ECD).

13.2.17.Dilution of Samples

Final reported results must be corrected for dilution carried out during the process of analysis. In order to evaluate the QC analyses associated with an analytical batch, corresponding batch QC samples must be analyzed at the same dilution factor. For example, the results used to calculate the results of matrix spikes must be derived from results for the native sample, matrix spike, and matrix spike duplicate analyzed at the same dilution. Results derived from samples analyzed at different dilution factors must not be used to calculate QC results.

13.2.18.Laboratory Corrective Action

Failures in laboratory measurement systems include, but are not limited to: instrument malfunction, calibration failure, sample container breakage, contamination, and QC sample failure. If the failure can be corrected, the analyst must document it and its associated corrective actions in the laboratory record and complete the analysis. If the failure is not resolved, it is conveyed to the respective supervisor who should determine if the analytical failure compromised associated results. The nature and disposition of the problem must be documented in the data report that is sent to the Consultant-PM. Suggested ccorrective actions are detailed in Table 13-9.

Table 13-1. Measurement Quality Objectives - PCBs.

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Tuning[2]	Per analytical method	Per analytical method
Calibration	Initial method setup or when the calibration verification fails	• Correlation coefficient (r^2 >0.990) for linear and non-linear curves • If RSD<15%, average RF may be used to quantitate; otherwise use equation of the curve • First- or second-order curves only (not forced through the origin) • Refer to SW-846 methods for SPCC and CCC criteria[2] • Minimum of 5 points per curve (one of them at or below the RL)
Calibration Verification	Per 12 hours	• Expected response or expected concentration ±20% • RF for SPCCs=initial calibration[4]
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analytes
Reference Material	Per 20 samples or per analytical batch	70-130% recovery if certified; otherwise, 50-150% recovery
Matrix Spike	Per 20 samples or per analytical batch, whichever is more frequent	50-150% or based on historical laboratory control limits (average±3SD)
Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	50-150% or based on historical laboratory control limits (average±3SD); RPD<25%
Surrogate	Included in all samples and all QC samples	Based on historical laboratory control limits (50-150% or better)
Internal Standard	Included in all samples and all QC samples (as available)	Per laboratory procedure
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	5% of total Project sample count (sediment and water samples only)	RPD<25% (n/a if concentration of either sample<RL)
Field Blank	Not required for the Monitoring Program	<RL for target analytes

Table 13-2. Measurement Quality Objectives – Inorganic Analytes.

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Continuing Calibration Verification	Per 10 analytical runs	80-120% recovery
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Reference Material	Per 20 samples or per analytical batch, whichever is more frequent	75-125% recovery
Matrix Spike	Per 20 samples or per analytical batch, whichever is more frequent	75-125% recovery
Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	75-125% recovery ; RPD<25%
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent	RPD<25% (n/a if concentration of either sample<RL)
Internal Standard	Accompanying every analytical run when method appropriate	60-125% recovery
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	5% of total Project sample count	RPD<25% (n/a if concentration of either sample<RL), unless otherwise specified by method
Field Blank, Equipment Field, Eqpt Blanks	Not required for the Monitoring Program	Blanks<RL for target analyte

Table 13-3. Measurement Quality Objectives – Conventional Analytes.

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Calibration Standard	Per analytical method or manufacturer's specifications	Per analytical method or manufacturer's specifications
Laboratory Blank	Total organic carbon only: one per 20 samples or per analytical batch, whichever is more frequent (n/a for other parameters)	80-120% recovery
Reference Material	One per analytical batch	RPD<25% (n/a if native concentration of either sample<RL)
Laboratory Duplicate	(TOC only) one per 20 samples or per analytical batch, whichever is more frequent (n/a for other parameters)	80-120% recovery
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	5% of total Project sample count	RPD<25% (n/a if concentration of either sample<RL)
Field Blank, Travel Blank, Field Blanks	Not required for the Monitoring Program analytes	NA

Consistent with SWAMP QAPP and as applicable, percent moisture should be reported with each batch of sediment samples. Sediment data must be reported on a dry weight basis.

Table 13-4. Target MRLs for Sediment Quality Parameters.

Analyte	MRL
Sediment Total Organic Carbon	0.01% OC
Bulk Density	n/a
%Moisture	n/a
%Lipids	n/a
Mercury	30 µg/kg

Table 13-5. Target MRLs for PCBs in Water, Sediment and Caulk

Congener	Water MRL (µg/L)	Sediment MRL (µg/kg)	Caulk/Sealant MRL (µg/kg)
PCB 8	0.002	0.2	0.5
PCB 18	0.002	0.2	0.5
PCB 28	0.002	0.2	0.5
PCB 31	0.002	0.2	0.5
PCB 33	0.002	0.2	0.5
PCB 44	0.002	0.2	0.5
PCB 49	0.002	0.2	0.5
PCB 52	0.002	0.2	0.5
PCB 56	0.002	0.2	0.5
PCB 60	0.002	0.2	0.5
PCB 66	0.002	0.2	0.5
PCB 70	0.002	0.2	0.5
PCB 74	0.002	0.2	0.5
PCB 87	0.002	0.2	0.5
PCB 95	0.002	0.2	0.5
PCB 97	0.002	0.2	0.5
PCB 99	0.002	0.2	0.5
PCB 101	0.002	0.2	0.5
PCB 105	0.002	0.2	0.5
PCB 110	0.002	0.2	0.5
PCB 118	0.002	0.2	0.5
PCB 128	0.002	0.2	0.5
PCB 132	0.002	0.2	0.5
PCB 138	0.002	0.2	0.5
PCB 141	0.002	0.2	0.5
PCB 149	0.002	0.2	0.5
PCB 151	0.002	0.2	0.5
PCB 153	0.002	0.2	0.5
PCB 156	0.002	0.2	0.5
PCB 158	0.002	0.2	0.5
PCB 170	0.002	0.2	0.5
PCB 174	0.002	0.2	0.5
PCB 177	0.002	0.2	0.5
PCB 180	0.002	0.2	0.5
PCB 183	0.002	0.2	0.5
PCB 187	0.002	0.2	0.5
PCB 194	0.002	0.2	0.5
PCB 195	0.002	0.2	0.5
PCB 201	0.002	0.2	0.5
PCB 203	0.002	0.2	0.5

Table 13-6. Size Distribution Categories for Grain Size in Sediment

Wentworth Size Category	Size	MRL
Clay	<0.0039 mm	1%
Silt	0.0039 mm to <0.0625 mm	1%
Sand, very fine	0.0625 mm to <0.125 mm	1%
Sand, fine	0.125 mm to <0.250 mm	1%
Sand, medium	0.250 mm to <0.5 mm	1%
Sand, coarse	0.5 mm to < 1.0 mm	1%
Sand, very coarse	1.0 mm to < 2 mm	1%
Gravel	2 mm and larger	1%

Table 13-7. Target MRLs for TOC, SSC, and Mercury in Water

Analyte	MRL
Total Organic Carbon	0.6 mg/L
Suspended Sediment Concentration	0.5 mg/L
Mercury	0.0002 µg/L

Table 13-8. Corrective Action – Laboratory and Field Quality Control

Laboratory Quality Control	Recommended Corrective Action
Calibration	Recalibrate the instrument. Affected samples and associated quality control must be reanalyzed following successful instrument recalibration.
Calibration Verification	Reanalyze the calibration verification to confirm the result. If the problem continues, halt analysis and investigate the source of the instrument drift. The analyst should determine if the instrument must be recalibrated before the analysis can continue. All of the samples not bracketed by acceptable calibration verification must be reanalyzed.
Laboratory Blank	Reanalyze the blank to confirm the result. Investigate the source of contamination. If the source of the contamination is isolated to the sample preparation, the entire batch of samples, along with the new laboratory blanks and associated QC samples, should be prepared and/or re-extracted and analyzed. If the source of contamination is isolated to the analysis procedures, reanalyze the entire batch of samples. If reanalysis is not possible, the associated sample results must be flagged to indicate the potential presence of the contamination.
Reference Material	Reanalyze the reference material to confirm the result. Compare this to the matrix spike/matrix spike duplicate recovery data. If adverse trends are noted, reprocess all of the samples associated with the batch.
Matrix Spike	The spiking level should be near the midrange of the calibration curve or at a level that does not require sample dilution. Reanalyze the matrix spike to confirm the result. Review the recovery obtained for the matrix spike duplicate. Review the results of the other QC samples (such as reference materials) to determine if other analytical problems are a potential source of the poor spike recovery.
Matrix Spike Duplicate	The spiking level should be near the midrange of the calibration curve or at a level that does not require sample dilution. Reanalyze the matrix spike duplicate to confirm the result. Review the recovery obtained for the matrix spike. Review the results of the other QC samples (such as reference materials) to determine if other analytical problems are a potential source of the poor spike recovery.
Internal Standard	Check the response of the internal standards. If the instrument continues to generate poor results, terminate the analytical run and investigate the cause of the instrument drift.
Surrogate	Analyze as appropriate for the utilized method. Troubleshoot as needed. If no instrument problem is found, samples should be re-extracted and reanalyzed if possible.
Field Quality Control	**Recommended Corrective Action**
Field Duplicate	Visually inspect the samples to determine if a high RPD between results could be attributed to sample heterogeneity. For duplicate results due to matrix heterogeneity, or where ambient concentrations are below the reporting limit, qualify the results and document the heterogeneity. All failures should be communicated to the project coordinator, who in turn will follow the process detailed in the method.
Field Blank	Investigate the source of contamination. Potential sources of contamination include sampling equipment, protocols, and handling. The laboratory should report evidence of field contamination as soon as possible so corrective actions can be implemented. Samples collected in the presence of field contamination should be flagged.

14. Inspection/Acceptance for Supplies and Consumables

Each sampling event conducted for the Monitoring Program will require use of appropriate consumables to reduce likelihood of sample contamination. The Field-PM will be responsible for ensuring that all supplies are appropriate prior to their use. Inspection requirements for sampling consumables and supplies are summarized in Table 14-1.

Table 14-1. Inspection / Acceptance Testing Requirements for Consumables and Supplies

Project-related Supplies	Inspection / Testing Specifications	Acceptance Criteria	Frequency	Responsible Person Sampling Containers
Sampling supplies	Visual	Appropriateness; no evident contamination or damage; within expiration date	Each purchase	Field Crew Leader

15. Non Direct Measurements, Existing Data

No data from external sources are planned to be used with this project.

16. Data Management

As previously discussed, the Monitoring Program data management will conform to protocols dictated by the study designs (BASMAA 2017a, b). A summary of specific data management aspects is provided below.

16.1. Field Data Management

All field data will be reviewed for legibility and errors as soon as possible after the conclusion of sampling. All field data that is entered electronically will be hand-checked at a rate of 10% of entries as a check on data entry. Any corrective actions required will be documented in correspondence to the QA Officer.

16.2. Laboratory Data Management

Record keeping of laboratory analytical data for the proposed project will employ standard record-keeping and tracking practices. All laboratory analytical data will be entered into electronic files by the instrumentation being used or, if data is manually recorded, then it will be entered by the analyst in charge of the analyses, per laboratory standard procedures.

Following the completion of internal laboratory quality control checks, analytical results will be forwarded electronically to the Field-PM. The analytical laboratories will provide data in electronic format, encompassing both a narrative and electronic data deliverable (EDD).

17. Assessments and Response Actions

17.1. Readiness Reviews

The Field-PM will review all field equipment, instruments, containers, and paperwork to ensure that everything is ready prior to each sampling event. All sampling personnel will be given a brief review of the goals and objectives of the sampling event and the sampling procedures and equipment that will be used to achieve them. It is important that all field equipment be clean and ready to use when it is needed. Therefore, prior to using all sampling and/or field measurement equipment, each piece of equipment will be checked to make sure that it is in proper working order. Equipment maintenance records will be checked to ensure that all field instruments have been properly maintained and that they are ready for use. Adequate supplies of all preservatives, bottles, labels, waterproof pens, etc. will be checked before each field event to make sure that there are sufficient supplies to successfully support each sampling event, and, as applicable, are within their expiration dates. It is important to make sure that all field activities and measurements are properly recorded in the field. Therefore, prior to starting each field event, necessary paperwork such as logbooks, chain of custody record forms, etc. will be checked to ensure that sufficient amounts are available during the field event. In the event that a problem is discovered during a readiness review it will be noted in the field log book and corrected before the field crew is deployed. The actions taken to correct the problem will also be documented with the problem in the field log book. This information will be communicated by the Field-PM prior to conducting relevant sampling. The Field-PM will track corrective actions taken.

17.2. Post Sampling Event Reviews

The Field-PM will be responsible for post sampling event reviews. Any problems that are noted will be documented along with recommendations for correcting the problem. Post sampling event reviews will be conducted following each sampling event in order to ensure that all information is complete and any deviations from planned methodologies are documented. Post sampling event reviews will include field sampling activities and field measurement documentation in order to help ensure that all information is complete. The reports for each post sampling event will be used to identify areas that may be improved prior to the next sampling event.

17.3. Laboratory Data Reviews

The Field-PM will be responsible for reviewing the laboratory's data for completeness and accuracy. The data will also be checked to make sure that the appropriate methods were used and that all required QC data was provided with the sample analytical results. Any laboratory data that is discovered to be incorrect or missing will immediately be reported to the both the laboratory and Consultant-PM. The laboratory's QA manual details the procedures that will be followed by laboratory personnel to correct any invalid or missing data. The Consultant-PM has the authority to request re-testing if a review of any of the laboratory data is found to be invalid or if it would compromise the quality of the data and resulting conclusions from the proposed project.

18. Instrument/Equipment Testing, Inspection and Maintenance

18.1. Field Equipment

Field measurement equipment will be checked for operation in accordance with manufacturer's specifications. All equipment will be inspected for damage when first employed and again when returned from use. Maintenance logs will be kept and each applicable piece of equipment will have its own log that documents the dates and description of any problems, the action(s) taken to correct problem(s), maintenance procedures, system checks, follow-up maintenance dates, and the person responsible for maintaining the equipment.

18.2. Laboratory Equipment

All laboratories providing analytical support for chemical or biological analyses will have the appropriate facilities to store, prepare, and process samples. Moreover, appropriate instrumentation and staff to provide data of the required quality within the schedule required by the program are also required. Laboratory operations must include the following procedures:

- A program of scheduled maintenance of analytical balances, microscopes, laboratory equipment, and instrumentation.
- Routine checking of analytical balances using a set of standard reference weights (American Society of Testing and Materials (ASTM) Class 3, NIST Class S-1, or equivalents).
- Checking and recording the composition of fresh calibration standards against the previous lot, wherever possible. Acceptable comparisons are < 2% of the previous value.
- Recording all analytical data in bound (where possible) logbooks, with all entries in ink, or electronic format.
- Monitoring and documenting the temperatures of cold storage areas and freezer units once per week.
- Verifying the efficiency of fume hoods.
- Having a source of reagent water meeting ASTM Type I specifications (ASTM, 1984) available in sufficient quantity to support analytical operations. The conductivity of the reagent water will not exceed 18 megaohms at 25°C. Alternately, the resistivity of the reagent water will exceed 10 mmhos/cm.
- Labeling all containers used in the laboratory with date prepared, contents, initials of the individual who prepared the contents, and other information, as appropriate.
- Dating and safely storing all chemicals upon receipt. Proper disposal of chemicals when the expiration date has passed.
- Having QAPP, SOPs, analytical methods manuals, and safety plans readily available to staff.
- Having raw analytical data, such as chromatograms, accessible so that they are available upon request.

Laboratories will maintain appropriate equipment per the requirements of individual laboratory SOPs and will be able to provide information documenting their ability to conduct the analyses with the required level of data quality. Such information might include results from interlaboratory comparison studies, control charts and summary data of internal QA/QC checks, and results from certified reference material analyses.

19. Instrument/Equipment Calibration and Frequency

19.1. Field Measurements

Any equipment used should be visually inspected during mobilization to identify problems that would result in loss of data. As appropriate, equipment-specific SOPs should be consulted for equipment calibration.

19.2. Laboratory Analyses

19.2.1. In-house Analysis – XRF Screening

A portable XRF analyzer will be used as a screening tool to estimate the chlorine concentration in each caulk sample. Since caulk often contains in excess of 1% PCBs and detection limits of portable XRF may be in the ppm range, the portable XRF may be able to detect chlorine within caulk containing PCBs down to about 0.1%. The analysis will be performed on the field samples using a test stand. The analyzer will be calibrated for chlorine using plastic pellet European reference materials (EC680 and EC681) upon first use, and standardized each time the instrument is turned on and prior to any caulk Cl analysis. The standardization procedure will entail a calibration analysis of the materials provided/recommended with the XRF analyzer. Analyses will be conducted in duplicate on each sample and notes kept. The mean will be used for comparison to GC–MS results.

19.2.2. Contract Laboratory Analyses

The procedures for and frequency of calibration will vary depending on the chemical parameters being determined. Equipment is maintained and checked according to the standard procedures specified in each laboratory's instrument operation instruction manual.

Upon initiation of an analytical run, after each major equipment disruption, and whenever on-going calibration checks do not meet recommended DQOs (see Section 13), analytical systems will be calibrated with a full range of analytical standards. Immediately after this procedure, the initial calibration must be verified through the analysis of a standard obtained from a different source than the standards used to calibrate the instrumentation and prepared in an independent manner and ideally having certified concentrations of target analytes of a CRM or certified solution. Frequently, calibration standards are included as part of an analytical run, interspersed with actual samples.

Calibration curves will be established for each analyte and batch analysis from a calibration blank and a minimum of three analytical standards of increasing concentration, covering the range of expected sample concentrations. Only those data resulting from quantification within the demonstrated working calibration range may be reported by the laboratory.

The calibration standards will be prepared from reference materials available from the EPA repository, or from available commercial sources. The source, lot number, identification, and purity of each reference material will be recorded. Neat compounds will be prepared weight/volume using a calibrated analytical balance and Class A volumetric flasks. Reference solutions will be diluted using Class A volumetric glassware. Individual stock standards for each analyte will be prepared. Combination working standards will be prepared by volumetric dilution of the stock standards. The calibration standards will be stored at -20º C. Newly prepared standards will be compared with existing standards prior to their use. All solvents

used will be commercially available, distilled in glass, and judged suitable for analysis of selected chemicals. Stock standards and intermediate standards are prepared on an annual basis and working standards are prepared every three months.

Sampling and analytical logbooks will be kept to record inspections, calibrations, standard identification numbers, the results of calibrations, and corrective action taken. Equipment logs will document instrument usage, maintenance, repair and performance checks. Daily calibration data will be stored with the raw sample data

20. Data Review, Verification, and Validation

Defining data review, verification, and validation procedures helps to ensure that Monitoring Plan data will be reviewed in an objective and consistent manner. Data review is the in-house examination to ensure that the data have been recorded, transmitted, and processed correctly. The Field-PM will be responsible for initial data review for field forms and field measurements; QA Officer will be responsible for doing so for data reported by analytical laboratories. This includes checking that all technical criteria have been met, documenting any problems that are observed and, if possible, ensuring that deficiencies noted in the data are corrected.

In-house examination of the data produced from the proposed Monitoring Program will be conducted to check for typical types of errors. This includes checking to make sure that the data have been recorded, transmitted, and processed correctly. The kinds of checks that will be made will include checking for data entry errors, transcription errors, transformation errors, calculation errors, and errors of data omission.

Data generated by Program activities will be reviewed against MQOs that were developed and documented in Section 13. This will ensure that the data will be of acceptable quality and that it will be SWAMP-comparable with respect to minimum expected MQOs.

QA/QC requirements were developed and documented in Sections 13.1 and 13.2, and the data will be checked against this information. Checks will include evaluation of field and laboratory duplicate results, field and laboratory blank data, matrix spike recovery data, and laboratory control sample data pertinent to each method and analytical data set. This will ensure that the data will be SWAMP-comparable with respect to quality assurance and quality control procedures.

Field data consists of all information obtained during sample collection and field measurements, including that documented in field log books and/or recording equipment, photographs, and chain of custody forms. Checks of field data will be made to ensure that it is complete, consistent, and meets the data management requirements that were developed and documented in Section 13.1.

Lab data consists of all information obtained during sample analysis. Initial review of laboratory data will be performed by the laboratory QA/QC Officer in accordance with the lab's internal data review procedures. However, upon receipt of laboratory data, the Lab-PM will perform independent checks to ensure that it is complete, consistent, and meets the data management requirements that were developed and documented in Section 13.2. This review will include evaluation of field and laboratory QC data and also making sure that the data are reported in compliance with procedures developed and documented in Section 7.

Data verification is the process of evaluating the completeness, correctness, and conformance / compliance of a specific data set against the method, procedural, or contractual specifications. The Lab-PM and Data Manager will conduct data verification, as described in Section 13 on Quality Control, in order to ensure that it is SWAMP-comparable with respect to completeness, correctness, and conformance with minimum requirements.

Data will be separated into three categories for use with making decisions based upon it. These categories are: (1) data that meets all acceptance requirements, (2) data that has been determined to be unacceptable for use, and (3) data that may be conditionally used and that is flagged as per US EPA specifications.

21. Verification and Validation Methods

Defining the methods for data verification and validation helps to ensure that Program data are evaluated objectively and consistently. For the proposed Program many of these methods have been described in Section 20. Additional information is provided below.

All data records for the Monitoring Program will be checked visually and will be recorded as checked by the checker's initials as well as with the dates on which the records were checked. Consultant Team staff will perform an independent re-check of at least 10% of these records as the validation methodology.

All of the laboratory's data will be checked as part of the verification methodology process. Each contract laboratory's Project Analyst will conduct reviews of all laboratory data for verification of their accuracy.

Any data that is discovered to be incorrect or missing during the verification or validation process will immediately be reported to the Consultant-PM. If errors involve laboratory data then this information will also be reported to the laboratory's QA Officer. Each laboratory's QA manual details the procedures that will be followed by laboratory personnel to correct any invalid or missing data. The laboratory's QA Officer will be responsible for reporting and correcting any errors that are found in the data during the verification and validation process.

If there are any data quality problems identified, the QA Officer will try to identify whether the problem is a result of project design issues, sampling issues, analytical methodology issues, or QA/QC issues (from laboratory or non-laboratory sources). If the source of the problems can be traced to one or more of these basic activities then the person or people in charge of the areas where the issues lie will be contacted and efforts will be made to immediately resolve the problem. If the issues are too broad or severe to be easily corrected then the appropriate people involved will be assembled to discuss and try to resolve the issue(s) as a group. The QA Officer has the final authority to resolve any issues that may be identified during the verification and validation process.

22. Reconciliation with User Requirements

The purpose of the Monitoring Program is to comply with Provisions of the MRP and provide data that can be used to identify sources of PCBs to urban runoff, and to evaluate management action effectiveness in removing POCs from urban runoff in the Bay Area. The objectives of the Monitoring Program are to provide the following outcomes:

1. Satisfy MRP Provision C.8.f. requirements for POC monitoring for source identification;

2. Satisfy MRP Provision C.12.e.ii requirements to evaluate PCBs presence in caulks/sealants used in storm drain or roadway infrastructure in public ROWs;
3. Report the range of PCB concentrations observed in 20 composite samples of caulk/sealant collected from structures installed or rehabilitated during the 1970's;
4. Satisfy MRP Provision C.8.f. requirements for POC monitoring for management action effectiveness;
5. Quantify the annual mass of mercury and PCBs captured in HDS Unit sumps during maintenance; and
6. Identify BSM mixtures for future field testing that provide the most effective mercury and PCBs treatment in laboratory column tests.

Information from field data reports (including field activities, post sampling events, and corrective actions), laboratory data reviews (including errors involving data entry, transcriptions, omissions, and calculations and laboratory audit reports), reviews of data versus MQOs, reviews against QA/QC requirements, data verification reports, data validation reports, independent data checking reports, and error handling reports will be used to determine whether or not the Monitoring Program's objectives have been met. Descriptions of the data will be made with no extrapolation to more general cases.

Data from all monitoring measurements will be summarized in tables. Additional data may also be represented graphically when it is deemed helpful for interpretation purposes.

The above evaluations will provide a comprehensive assessment of how well the Program meets its objectives. The final project reports will reconcile results with project MQOs.

23. References

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BASMAA 2017a. The Evaluation of PCBs Presence in Public Roadway and Storm Drain Infrastructure Caulk and Sealants Study Design. Prepared by EOA Inc. and the San Francisco Estuary Institute (SFEI). June 2017.

BASMAA 2017b. POC Monitoring for Management Action Effectiveness Study Design. Prepared by the Office of Water Programs, Sacramento State, CA, EOA Inc., and the San Francisco Estuary Institute (SFEI). July 2017.

BASMAA, 2017c. Clean Watershed for a Clean Bay (CW4CB) Final Report. Prepared for Bay Area Stormwater Management Agencies Association. Prepared by Geosyntec and EOA, Inc., May 2017.

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Surface Water Ambient Monitoring Program Quality Assurance Team, 2013. *SWAMP Quality Assurance Project Plan.* Prepared for the California State Water Quality Control Board. 2013.

24. Appendix A: Field Documentation

Caulk/Sealant Sampling Field Data Sheet	Composite ID:		Contractor:	Pg of Pgs
Sample ID:	Date (mm/dd/yyyy):		Personnel:	Failure Reason
Photos (Y / N)	ArrivalTime:	DepartureTime:		
Photo Log Identifier	**Land-Use at the Sample Location:**		Commercial (pre-1980; post 1980)	Open Space
	Industrial (pre-1980; post-1980)		Residential (pre 1980; post 1980)	Other:

Description of Structure: (Do not include any information on the location of the structure)							**Diagram of Structure (if needed) to identify where caulk/sealants were located in/on structure**
Structure Type:	Storm Drain Catch Basin	Roadway Surface		Sidewalk	Curb/Gutter	Bridge	
	Other:						
Structure Material:	Concrete	Asphalt	Other:				
Condition of Structure:	Good	Fair	Poor	Other:			
Year of Strucutre Construction							
Year of Repair							

Description of Caulk or Sealant Sample Collected:							
Application or Usage	Caulk	caulk between adjoing surfaces of same material (e.g., concrete-concrete); Describe:					
		caulk between adjoining surfaces of different types of material (e.g., concrete-asphalt); Describe:					
		Other:					
	Sealant	Crack Repair (describe):					
		Other:					
Color							
Texture	Hard/brittle	Soft/pliable	Other:				
Condition	Good (intact/whole)		Poor (crumbling/disintegrating)	Other:			
Location	Surface	Between Joints	Submerged	Exposed	At street level	Below street level	Other:
Amount of Caulk/Sealant observed on structure	Crack dimensions:				Spacing of expansion joints		
	Length&width of caulk bead sampled:				Other:		

Samples Taken	
COLLECTION DEVICE:	Equiptment type used:
SITE/SAMPLING DESCRIPTION AND COMMENTS:	

HDS Unit Sampling Field Data Sheet (Sediment Chemistry)			Contractor:	Pg of Pgs
City:	Date (mm/dd/yyyy):	/ /	*Contractor:	
HDS Catchment ID:	ArrivalTime:	DepartureTime:	*SampleTime (1st sample):	Failure Reason
	Personnel:			

Photos (Y / N)	*GPS/DGPS	**Lat (dd.ddddd)**	**Long (ddd.ddddd)**	Address, Location, and Sketches (if needed)
Photo Log Identifier	**Target (if known):**			
	***Actual:**			
	GPS Device:			

Estimate of Volume of Sediment in the HDS unit sump prior to cleanout:	
Estimate of Volume of Sediment REMOVED from the HDS unit sump during the cleanout:	

Env. Conditions		WIND DIRECTION (from):	N W E S	
SITE ODOR:	None,Sulfides,Sewage,Petroleum,Smoke,Other_____			
SKY CODE:	Clear, Partly Cloudy, Overcast, Fog, Smoky, Hazy			
PRECIP:	None, Fog, Drizzle, Rain			
PRECIP (last 24 hrs):	Unknown, <1", >1", None			
SOILODOR:	None, Sulfides, Sewage, Petroleum, Mixed, Other_____			
SOILCOLOR:	Colorless, Green, Yellow, Brown			
SOILCOMPOSITION:	Silt/Clay, Sand, Gravel, Cobble, Mixed, Debris			
SOILPOSITION	Submerged, Exposed			

Samples Taken (3 digit ID nos. of containers filled)	**Field Dup at Site? YES / NO:** (create separate datasheet for FDs, with unique IDs (i.e., blind samples)
COLLECTION DEVICE:	Equiptment type used: Scoop (SS / PC / PE), Core (SS / PC / PE), Grab (Van Veen / Eckman / Petite Ponar), Broom (nylon, natural fiber)

Sample ID (City-Catchment ID-Sample	DepthCollec (cm)	Composite / Grab (C / G)	Grain Size	PCBs	Hg	Bulk Density	TOC	OTHER		

SITE/SAMPLING DESCRIPTION AND COMMENTS:

Stormwater Field Data Sheet (Water Chemistry)						Entered in d-base (initial/date)				Pg of Pgs
***Station Code:**		*Date (mm/dd/yyyy):	/ /					*PurposeFailure:		*Agency:
Personnel:		ArrivalTime:	DepartureTime:							*Protocol:
		*GPS/DGPS	**Lat (dd.ddddd)**	**Long (ddd.ddddd)**		OCCUPATION METHOD: Walk-in Bridge R/V _____ Other				
GPS Device:		**Target:**		-						
Datum: NAD83	Accuracy (ft / m):	***Actual:**		-		Sampling Location (e.g., gutter at SW corner of 10th Street)				
Habitat Observations (CollectionMethod = Habitat_generic)			WADEABILITY: Y / N / Unk	BEAUFORT SCALE (see attachment)						
SITE ODOR:	None,Sulfides,Sewage,Petroleum,Smoke,Other____									
SKY CODE:	Clear, Partly Cloudy, Overcast, Fog, Smoky, Hazy		WIND DIRECTION (from):	N W E S		**PHOTOS** (RB & LB assigned when facing downstream; RENAME to StationCode_yyyy_mm_dd_uniquecode):				1: (RB / LB / BB / US / DS / ##)
OTHER PRESENCE:	Vascular,Nonvascular,OilySheen,Foam,Trash,Other_									
DOMINANT SUBSTRATE:	Bedrock, Concrete, Cobble, Boulder, Gravel, Sand, Mud, Unk, Other_____									
WATERCLARITY:	Clear (see bottom), Cloudy (>4" vis), Murky (<4" vis)		PRECIPITATION:	None, Fog, Drizzle, Rain, Snow						2: (RB / LB / BB / US / DS / ##)
WATERODOR:	None, Sulfides, Sewage, Petroleum, Mixed, Other___		PRECIPITATION (last 24 hrs):	Unknown, <1", >1", None						
WATERCOLOR:	Colorless, Green, Yellow, Brown									3: (RB / LB / BB / US / DS / ##)
OVERLAND RUNOFF (Last 24 hrs):	none, light, moderate / heavy, unknown									
OBSERVED FLOW:	NA, Dry Waterbody Bed, No Obs Flow, Isolated Pool, Trickle (<0.1cfs), 0.1-1cfs, 1-5cfs, 5-20cfs, 20-50cfs, 50-200cfs, >200cfs									

Field Samples (Record Time Sample Collected)

Carboy ID #	Start Sample Time	End Sample Time	Sample Type (Grab=G; Integrated = I)	Collection Depth (m)	Field Dup (Yes/No)	Indiv bottle (by hand, by pole, by bucket); Teflon tubing; Kemmer; Pole & Beaker; Other

COMMENTS:

Stormwater Influent Samples – Office of Water Programs

Sample Receiving							
Date (mm/dd/yy):		Time (24 hr) :			Team Member's Initial:		
Carboy	Temperature	pH	Observations				
1							
2							
3							
4							
5							
6							
7							

Stormwater Column Tests – Office of Water Programs

Sampling Run			
Date (mm/dd/yy):	Time (24 hr) :	Team Member's Initials:	Column ID:

During Test - Timed Measurements

Time	Water Depth	Media Condition	Other Observations

Grab Sample - Beginning of Run

Time	Water Depth	Turbidity (NTU)	Temp	pH	Other Observations

Grab Sample - Middle of Run

Time	Water Depth	Turbidity (NTU)	Temp	pH	Other Observations

Grab Sample - End of Run

Time	Water Depth	Turbidity (NTU)	Temp	pH	Other Observations

Grab Sample - Mercury

Time	Water Depth	Turbidity (NTU)	Temp	pH	Other Observations

25. Appendix B: Laboratory Standard Operating Procedures (SOPs)

APPENDIX C: PCBS CONGENERS CONCENTRATION DATA

PCBs Congener Concentrations Composites A-J (µg/kg dry weight). ND = non-detect (<0.05 µg/kg).

	Composite ID									
Congener	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
PCB 008	88000	44000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 018	300000	310000	ND	ND	ND	ND	ND	ND	6	ND
PCB 020+033	260000	320000	ND	80	ND	ND	ND	ND	6.6	ND
PCB 028	250000	400000	ND	ND	ND	ND	ND	ND	9	ND
PCB 031	240000	390000	26	ND	ND	ND	ND	ND	7.9	ND
PCB 043+049	370000	200000	ND	180	ND	ND	ND	ND	ND	ND
PCB 044	520000	310000	ND	ND	ND	ND	ND	ND	7	ND
PCB 052+069	420000	260000	18	50	ND	ND	ND	ND	ND	ND
PCB 056	250000	240000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 060	280000	160000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 061+074	320000	200000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 066	400000	380000	ND	ND	ND	ND	ND	ND	10	ND
PCB 070	410000	430000	17	ND	ND	ND	ND	ND	9	ND
PCB 086+097+117+125	52000	36000	61	ND	ND	ND	ND	ND	ND	ND
PCB 087+111+115	64000	41000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 089+090+101	120000	ND	32	81	ND	ND	ND	ND	ND	ND
PCB 093+095+098+102	66000	40000	27	ND	ND	ND	ND	ND	ND	ND
PCB 099	47000	27000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 105+127	72000	54000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 106+118	76000	57000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 110	100000	76000	47	ND	ND	ND	ND	ND	ND	ND
PCB 128	8300	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 132	5200	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 138	35000	28000	31	ND	ND	ND	ND	ND	ND	ND
PCB 139+149	28000	20000	19	ND	ND	ND	ND	ND	ND	ND
PCB 141	10000	11000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 151	8200	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 153	36000	28000	19	ND	ND	ND	ND	ND	ND	ND
PCB 156	7100	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 158+160	5700	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 170	18000	18000	480	310	ND	ND	ND	ND	ND	ND
PCB 174	14000	14000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 177	7700	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 180	34000	33000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 182+187	15000	12000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 183	7200	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 194	9500	11000	ND	ND	ND	ND	ND	ND	ND	ND
PCB 195	3400	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 196+203	9200	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 201	800	350	ND	ND	ND	ND	ND	ND	ND	ND

PCBs Congener Concentrations Composites K - T. (µg/kg dry weight). ND = non-detect (<0.05 µg/kg).

	Composite ID									
Congener	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**
PCB 008	ND	ND	ND	ND	ND	ND	250	ND	ND	ND
PCB 018	ND	ND	ND	ND	ND	ND	2400	ND	29	ND
PCB 020+033	ND	ND	ND	ND	ND	ND	2000	ND	43	ND
PCB 028	65	ND	ND	ND	ND	ND	2700	ND	100	ND
PCB 031	55	ND	ND	ND	ND	ND	2500	ND	67	ND
PCB 043+049	ND	ND	ND	ND	ND	ND	1100	ND	86	ND
PCB 044	ND	ND	ND	ND	ND	ND	1700	ND	130	ND
PCB 052+069	ND	ND	ND	ND	ND	ND	1400	2800	110	2.6
PCB 056	ND	ND	ND	ND	ND	ND	1100	ND	100	ND
PCB 060	ND	ND	ND	ND	ND	ND	700	ND	61	ND
PCB 061+074	ND	ND	ND	ND	ND	ND	980	ND	84	ND
PCB 066	ND	ND	ND	ND	ND	ND	2000	ND	190	ND
PCB 070	ND	ND	ND	ND	ND	ND	2100	ND	240	2.8
PCB 086+097+117+125	ND	ND	ND	ND	ND	ND	200	ND	59	ND
PCB 087+111+115	ND	ND	ND	ND	ND	ND	180	ND	79	ND
PCB 089+090+101	46	ND	ND	ND	ND	ND	400	ND	170	4.1
PCB 093+095+098+102	ND	ND	ND	ND	ND	ND	140	ND	71	ND
PCB 099	ND	ND	ND	ND	ND	ND	110	ND	52	ND
PCB 105+127	ND	ND	ND	ND	ND	ND	190	ND	72	ND
PCB 106+118	ND	ND	ND	ND	ND	ND	200	ND	110	ND
PCB 110	ND	ND	ND	ND	ND	ND	230	ND	160	3.8
PCB 128	ND	ND	ND	ND	ND	ND	24	ND	28	ND
PCB 132	ND	ND	ND	ND	ND	ND	71	ND	16	ND
PCB 138	40	ND	ND	ND	ND	ND	130	ND	110	3.8
PCB 139+149	29	ND	ND	ND	ND	ND	84	ND	72	3.2
PCB 141	ND	ND	ND	ND	ND	ND	30	ND	22	ND
PCB 151	ND	ND	ND	ND	ND	ND	23	ND	14	ND
PCB 153	ND	ND	ND	ND	ND	ND	28	ND	88	3.8
PCB 156	ND	ND	ND	ND	ND	ND	ND	ND	16	ND
PCB 158+160	ND	ND	ND	ND	ND	ND	ND	ND	18	ND
PCB 170	130	ND	ND	ND	ND	ND	760	ND	19	ND
PCB 174	ND	ND	ND	ND	ND	ND	46	ND	10	ND
PCB 177	ND	ND	ND	ND	ND	ND	35	ND	6.5	ND
PCB 180	41	ND	ND	ND	ND	ND	110	ND	20	3.9
PCB 182+187	26	ND	ND	ND	ND	ND	ND	ND	11	ND
PCB 183	ND	ND	ND	ND	ND	ND	21	ND	8.2	ND
PCB 194	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 195	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 196+203	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB 201	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND