4.0 DISCUSSION

This section discusses the results for each of the environmental media, i.e., sediment, water, and fish. Topics include chemical data quality; patterns of COC contamination; temporal trends of contamination; comparisons to cleanup criteria; and uncertainty in the sampling and testing.

4.1 SEDIMENT

Various efforts were made to validate the quality of chemical data gathered during this sampling event. These efforts are described below.

4.1.1 Data Quality Assessment

As previously discussed, analytical data were reviewed and validated following procedures specified in the sediment QAPP (ITSI Gilbane, 2013a). The Gilbane project chemist conducted an overall QC review after receiving data validation reports, and developed two Quality Control Summary Reports (QCSRs) to address the data for shelf-wide samples and the data for the OA samples. The QCSRs indicate that project data quality objectives (DQOs) were met. The qualified data are of acceptable quality, and should be considered usable to help determine whether the mass of contaminants is continuing to decrease. The rejected results, while not useable for their intended purposes, represent less than 0.1% of the total dataset. QCSRs for the shelf-wide and OA data sets are included in Appendix N.

Of the more than 29,000 primary sample results for the shelf-wide cores, five results (less than 0.1%) were rejected due to laboratory anomalies, rendering an analytical completeness factor of 99.9%, well exceeding the QAPP goal of 90%. Four shelf-wide samples were found to have insufficient volume for testing for various parameters; however, the field completeness was 99.6%, exceeding the QAPP goal of 90%.

Of the nearly 30,000 primary sample results for the OA cores, seventeen results (less than 0.1%) were rejected due to laboratory anomalies, rendering an analytical completeness factor of 99.9%, again exceeding the QAPP goal of 90%. Three samples were found to have insufficient volume for testing for various parameters (six tests in total); therefore, the field completeness was 99.8%, exceeding the QAPP goal of 90%.

4.1.1.1 Performance Evaluation Sample – Sediment Testing

EPA, with cooperation from the EPA Quality Assurance Technical Services (QATS) program, provided Eurofins CS with a sediment PE sample in May of 2014 to be analyzed and evaluated prior to analysis of project samples. For this sample, Eurofins CS performed the secondary cleanup step described in Section 2.1.6.2 for the analysis of DDTs. This comparison demonstrated that analytical results reported by Eurofins CS for all DDTs, PCBs, and TOC were acceptable, based on the confidence intervals developed for the sample. Results of the PE study are included in Appendix B.

4.1.2 Distribution of COCs

Figures 3-1 and 3-2 are current interpretations of the geometry of the DDT deposit in sediment at PV Shelf. This geometry is consistent with geometries previously reported or postulated by other investigators: the pattern of DDT contamination displays a center of mass near the Sanitation Districts' outfall diffusers, and the DDT concentrations generally diminish with distance from the diffusers. A significant deposit (hot spot) of Total DDTs appears in the 0-8-cm bed-depth interval along the 60-m isobath near the eastern diffuser of the 90-inch outfall. The bottom half of Figure 3-2 shows a cross section illustrating conditions of the sediment bed along the 60-m isobath, based on the 2013 data set. This image illustrates the difference between the 0-8-cm bed-depth interval (the bioactive zone at PV Shelf) and the bed below 8 cm: in the lower portion of the bed, the hot spot extends northwest of the outfalls. (It should be noted that the vertical images on Figures 3-2, 3-4, and 3-6 have a vertical scale factor of about 5,000, and in that regard, are exaggerations of conditions at PV Shelf.)

Figures 3-3 through 3-6 are current interpretations of the geometry of PCBs in sediment at PV Shelf. The pattern of PCBs in the 0-8-cm bed-depth interval shows areas of elevated concentrations in an elongated area that extends seaward (cross-shelf direction) from water depths shallower than 60 m to the PV Shelf break. The vertical profiles illustrate the difference between the 0-8-cm bed-depth interval and the bed below 8 cm, where PCBs appear in elevated concentrations along the 60-m isobath in areas northwest of the Sanitation Districts' outfalls, similar to the pattern of DDTs.

4.1.2.1 Dimensions of the EA Sediment Bed

Based on Figures 3-1 and 3-2, the EA sediment bed covers an area that extends in the along-shelf direction from approximately 3,000 m southeast of the 120-inch (southernmost) outfall to approximately 7,500 m northwest of the northernmost outfall, and in the cross-shelf direction from about the 40-m isobath to past the shelf break.

Appendix X presents a comparison of the 2009 and 2013 shelf-wide cores and OA cores, showing depth in the core versus values of BD_d and the three COC groupings (Total DDTs, Total DDT Compounds, and Total PCBs). The profiles for most cores appear to corroborate the three-layer model described previously (Section 1.2), in that distinct differences in the BD_d values and COC concentrations can be noticed with depth. The 2009 and 2013 profiles display similar patterns in many cores, including 4C, 6C, and 8C, where the highest contaminant concentrations in the two data sets were at nearly identical bed depths in the core.

As was done for the 2009 data set, the EA bed thickness was assumed to be equal to the core length. Using this approach for the 2013 data set, the MVS geostatistical model created a shape of the EA bed with an estimated volume of 15 million m^3, equivalent to the volume modeled in 2009.

4.1.2.2 Temporal Changes in the EA Deposit

Changes in Spatial Distribution of Contaminants

The general shape of the EA deposit does not appear to have changed appreciably since previous sediment sampling events. Location BA8C near the Sanitation Districts' diffusers appears to represent the most contaminated area on PV Shelf: for the 2013 data set, maximum concentrations of both Total DDT Compounds and Total PCBs were found in core BA8C.

Figure 4-1 illustrates the differences in DDT concentrations in the top 2 cm of the sediment bed between 2002/2004, 2009, and 2013. Figure 4-2 shows the comparison of DDTs in the 0-8-cm bed layer (the bioactive layer) between 2009 and 2013. Figures 4-3 and 4-4 present the corresponding data for PCBs.

For the top 2 cm of the sediment bed, concentrations of both DDTs and PCBs appear to have decreased significantly since 2002/2004, notably near the Sanitation Districts' outfall diffusers.

(It is acknowledged that different sampling methods were used for the 2002/2004 event than those used in 2009 and 2013). For the 0-8-cm bed-depth interval, concentrations of DDTs and PCBs show overall increases between 2009 and 2013 for a major portion of the sampled area. Possible contributing factors for the increases include: (1) lower RLs achieved by Eurofins CS for the 2013 event for DDT and PCBs as compared to RLs previously used; and (2) uncertainties in the chemical analysis and modeling (Sections 4.4.1.3 and 4.4.1.4); and (3) heterogeneity of the deposit, as indicated by the high variability seen in the field replicate evaluation (Appendix Y).

Average Concentrations and Mass of Contaminants

As previously noted, Table 3-7 presents estimates for the average concentrations of COC groupings for the entire data set and the OA data set, and Table 3-8 presents estimates of the mass of COCs for the entire data set and the OA data set. Results for both the 2009 and 2013 data sets are shown. The results indicate that significant amount of DDTs and PCBs remain in sediment at PV Shelf. Though average and mass values for 2013 were greater than corresponding values for 2009, overall, mass of COCs has decreased over time, when compared to previous mass calculations (prior to the IROD).

Regarding estimates of COC mass, previous researchers have focused on p,p'-DDE, as this isomer was regarded as the most prevalent DDT form on the shelf, and hence representative of contaminants in the sediment bed (Lee, 1994). Table 4-1 summarizes estimates of the masses of p,p'-DDE and PCBs by various researchers and indicates the wide differences between studies. The 30 MT value for p,p'-DDE calculated by the MVS model based on the 2013 data set is greater than the 9.7 MT and 13.8 MT values for p,p'-DDE calculated by the two separate MVS models based on the 2009 data set. However, as mentioned above, the mass values derived from the 2009 and 2013 sediment data sets were significantly lower than those for previous mass estimates. These differences may be associated with:

- Different data sets (previous data sets were generated as much as 30 years ago)
- Ongoing MNR processes (see Section 5.0)
- The reduced area evaluated by the MVS model relative to the areas previously examined
- Differences between the computational approaches used in the MVS model and those used in previous approaches

Both for 2013 and 2009, the OA cores as depicted in Figure 2-2 (and in the MVS model) were within 1.5 km of any outfall diffuser section. For the 0-8-cm bed-depth interval, based on the 2013 data set, the OA contains approximately 47% of the entire mass of each COC grouping (i.e., Total DDTs, Total DDT Compounds, and Total PCBs). For the same bed-depth interval, based on the 2009 data set, the OA contained about 53% of the COC mass.

4.1.3 Comparison of Sediment Data to Cleanup Goals

As previously described, the IROD established the following objectives of the interim isolation cap:

- The mean DDT concentration in surface sediment on the shelf will be reduced from 150 mg/kg OC to 78 mg/kg OC (in combination with MNR, the interim cleanup level of 46 mg/kg OC in surface sediment would be reached within 5 years of cap placement).
- Mean PCB concentrations in shelf surface sediment will be reduced to the cleanup level of 7 mg/kg OC.

As previously described, the 2013 sediment data set was input into the MVS geostatistical model; the model output included the average (mean) concentrations of COCs in the sediment bed (Table 3-7). For the 2013 data set, the mean value of Total DDTs OC in the 0-8-cm bed-depth interval was 77 mg/kg OC (77,000 ug/kg OC). This value is just under the cap placement objective of 78 mg/kg OC. For PCBs (short list), the model output mean value of 5 mg/kg OC (5,000 ug/kg OC), also is under the interim sediment cleanup level of 7 mg/kg OC.

4.1.4 Sediment Uncertainties and Possible Sources of Error

4.1.4.1 Coring Procedure

There are limitations inherent in collecting cores of a layered low-density (soft bottom) seabed at the ocean depths seen in this study. Some researchers have postulated that gravity corers provide incomplete samples of the surface of the sediment column (Lee, H.J., 1994; Lee et al., 2002). During the 2013 coring event, a camera mounted on the coring device, as described in Section 2.1.4, recorded the progress of the drop through the water column and into the sediment bed. Review of the videos (Appendix E) show that, though blowoff of fine sediment away from (external to) the coring device is evident at the moment of impact of the device into the seafloor, there is no evidence of advance blowoff (movement of sediment ahead of impact), and there is no evidence of sediment escaping from the coring device at impact. There is no evidence of incomplete cores, provided that the entry angle is plumb to the sediment bed surface.

Vertical profiles (Appendix X) indicate that the bottom of the EA bed may not have been reached in several cores, based on elevated COC concentrations reported for samples generated for the core bottom. However, this limitation is balanced by the fact that all cores were collected using the same methodology, for both the 2009 and 2013 events.

4.1.4.2 Spatial Uncertainty

The coring frequency of the shelf-wide sampling was 34 cores over a modeled area of 30 km^2, correlating to one core per 0.9 km^2. At the OA, the coring frequency (including the shelf-wide cores from Sanitation Districts Transects 6 through 9) was 51 cores over a modeled area of 11 km^2, correlating to one core per 0.2 km^2. The OA coring frequency was improved from the coverage of 0.3 km^2 achieved in the 2009 sampling event.

4.1.4.3 Laboratory Uncertainty

Aliquots of select samples from cores BA5B, BA6BC, BA9C, OA10, and OA11for the 2009 and 2013 sediment collections were retrieved from the Sanitation Districts' deep-freeze archive. The aliquots were extracted and analyzed in a single analytical batch by a single extraction technician and a single analyst at Eurofins CS in March 2017 (this approach was intended to minimize laboratory contribution to the uncertainty). Results of the analyses are presented in Table 4-2. The heterogeneity of the sample matrix is illustrated by R^2 values of 0.657 for p,p'-DDE and 0.627 for Total PCBs (short list) calculated for the 2009 versus the 2013 data sets (Appendix O). These R^2 values do not indicate a strong correlation for the two data sets. Another indication of the heterogeneity of the sample matrix is found in Appendix Z, which presents a graphical comparison of average p,p'-DDE concentrations for the 0-8-cm sediment layer between the 2009 and 2013 data sets.

4.1.4.4 Uncertainty in the Geostatistical Model

As described previously, Appendix C provides a detailed discussion of the MVS geostatistical modeling effort used on the sediment data set. The model output included values of mean (average) COC concentrations (OC normalized) and values of mass of COCs. The model also calculated values of "uncertainty" and "confidence" for the COC summations at each modeled node; the mean value of confidence for the entire sediment data set was reported as greater than 65%. The modeling report concludes that the site is well characterized for COCs.

To further bolster confidence in the sediment model, EPA sponsored a secondary geostatistical modeling effort independent of the primary effort, but using the identical sediment data set. The modeling was conducted by Sundance, Albuquerque, New Mexico. Sundance, in its model output, also produced values for average COCs OC normalized, and total COC mass, both for the entire sediment bed and for the 0-8-cm bed-depth interval. Appendix AA is a report that describes the modeling effort and the model output.

Table 4-3 summarizes model outputs from the primary and secondary geostatistical models, along with values of relative percent difference (RPD). As indicated, the secondary effort produced values of average concentrations that were generally about 20-to-30% lower than the primary model. Values of total COC mass in the entire (shelf-wide) bed were also lower in the output of the secondary model. The mass values for the 0-8-cm bed-depth interval varied slightly higher for Total DDTs and Total DDT Compounds, and slightly lower for Total PCBs. The RPD values for the model comparison are considered acceptable; as such, the secondary modeling effort validates the findings and output of the primary effort.

4.2 WATER COLUMN

4.2.1 Data Quality Assessment – Water Column (High Resolution)

Water sampling analytical data were reviewed and validated by an independent third-party validator following procedures specified in the water QAPP (Gilbane, 2014). Of the 6,850 primary sample results for the water sampling program, 13 results (less than 0.2%) in two samples, were rejected due to laboratory QC anomalies, for a data completeness of 99.8%, well above the QAPP goal of 90%.

The Gilbane project chemist conducted an overall QC review after receiving the data validation reports, and developed a QCSR to summarize the data quality anomalies for the water sampling program. The QCSR indicate that project DQOs were met and that all non-rejected data were usable for assessing vertical ocean water column concentrations. Laboratory reports and the QCSR for the high resolution water data set are presented in Appendix S.

4.2.2 Data Quality Assessment – Water Column (PSDs)

The PSD results were reviewed against the field QC requirements for PSD sampling presented in the PSD QAPP (Fluen Point Environmental, 2013) by the Gilbane project chemists. A total of

14 PED and four SPME field blanks were collected and analyzed. All were non-detected for both DDTs and PCBs. A minimum of three field replicates was required by the sampling design; each sample was deployed in triplicate. The results were reported as averages; therefore an evaluation of RPDs was not applicable.

The planned PSD sample collection total was 153 primary PEDs and 54 SPMEs. Several PEDs were lost during deployment: one surface sampler was missing from station 7C, all three surface samplers were missing from stations 8C and 9C, and one near-bottom sampler was missing from station W3. Also, an entire mooring line from station W5 was not recovered. All SPME samplers were recovered; however, two failed before they could be analyzed (one of three from near-bottom at station 4C and one of three from near-bottom at station 7C). Overall, this represents a combined PSD field sampling completeness of 90.8%.

4.2.3 Distribution of COCs in the Water Column

Figures 3-6 and 3-7 present concentrations of p,p'-DDE for the water column at each sampling location; Figures 3-8 and 3-9 show concentrations of Total DDTs for the same locations. The patterns of contamination were very similar; this similarity is expected, because the contribution of p,p'-DDE made up more than 70% of the concentrations of Total DDTs in most samples (Appendix Q). In general, the bottom and near-bottom samples had higher concentrations than mid-column samples, with some exceptions at locations BA3C, BA3DC, BA4B, and BA7C, where elevated mid-column concentrations were measured. All near-surface samples have low p,p'-DDE and Total DDTs concentrations.

Tables 3-10, 3-11, and 3-12 show results for Total DDT Compounds along the 150-m, 60-m, and 40-m isobaths, respectively; the sample locations were grouped by water depth, and by distance relative to the Sanitation Districts' outfall diffusers. In examining vertical trends, concentrations generally were highest either in the near-bottom or mid-column samples along all isobaths. Average concentrations were all greatest in the near-bottom locations, lower in mid-column samples (except in the vicinity of the outfall diffusers along the 60-m isobath), and always lowest for the near-surface samples.

For along-shelf trends, concentrations generally were highest down-current of the outfalls, with elevated Total DDT Compounds concentrations from transects BA7 through BA3, while up-current concentrations (transects BA9 and BA10) were relatively low. For cross-shelf trends between the 150-m, 60-m, and 40-m isobaths, the down-current concentration maxima and averages were similar at each sample depth, but in the vicinity of the outfall diffusers, the near-bottom concentrations along the 40-m isobath and the mid-column sample results along the 60-m isobath were greater.

Table 4-4 compares values for dissolved-phase DDTs from: (1) a SCCWRP event from 1999 (Zeng et al., 1999); (2) an EPA PSD sampling event from 2012 (Fernandez, 2012); (3) an EPA PSD sampling event from a draft data summary (Fernandez, 2015; see Appendix D); and (4) EPA's 2015 high resolution event described herein. In general, higher concentrations were measured in samples collected near the bottom of the water column (i.e., close to the sediment bed surface) during all sampling events. It also appears that the SCCWRP results are comparable to those from the PSD events. However, these results exceed by roughly an order of magnitude the results from the high resolution sampling event, for bottom and near-bottom samples.

Concentrations of dissolved-phase DDTs at PV Shelf would be expected to decline over time due to dispersion and mixing in the open ocean, and a net reduction of contaminated sediment exposed to the water column due to deposition of cleaner surface sediment. In that regard, the PSD results could be biased high. The high resolution grab sample results were significantly lower than the PSD results, but the general trend is similar in that elevated DDTs were detected in bottom or near-bottom samples at locations BA4C, BA5C, BA5DC, BA6DC, and BA7DC.

Figures 3-10 and 3-11 present high resolution concentrations of Total PCBs in water. In a pattern similar to that of p,p'-DDE, relatively high PCBs concentrations were reported for each transect from BA9 down-current through BA3. In general, the bottom and near-bottom samples had higher PCBs concentrations than mid-column samples, with some exceptions at locations BA3DC, BA4B, BA7C, BA8DC, and BA9DC, where elevated mid-column concentrations were measured. All near-surface samples have relatively low PCBs concentrations.

Tables 3-13, 3-14, and 3-15 show results for Total PCBs along the 150-m, 60-m, and 40-m isobaths, respectively, with the sample locations grouped by distance relative to the outfall diffusers. The vertical trends were similar to those for Total DDT Compounds, where concentrations generally were highest in the near-bottom or mid-column samples along all isobaths. Average concentrations were greatest in the near-bottom samples, lower for samples collected at mid-column depths (except in the vicinity of the outfall diffusers along the 60-m isobath and up-current of the diffusers along the 40-m isobath), and always lowest for the near-surface samples.

The along-shelf PCBs concentrations generally were highest down-current of the outfall diffusers, with elevated concentrations from transects BA9 through BA2; concentrations were relatively low for up-current transect BA10. For cross-shelf trends between the 150-m, 60-m, and 40-m isobaths, the down-current concentration maxima and averages were similar at each sample depth (similar to the Total DDT Compounds concentrations); but in the vicinity of the outfall diffusers, the near-bottom sample concentrations along the 40-m isobath and the mid-column results along the 60-m isobath are greater.

Table 4-5 compares dissolved-phase PCBs results from the various PV Shelf sampling events previously described for DDTs. Similar to the DDTs comparison, the concentrations of Total PCBs in the near-bottom and bottom samples were higher than those in mid-column and near-surface samples (with an exception for the near-surface sample at BA7C).

SCCWRP’s dissolved-phase results were higher than results for most other samples from similar depths, followed by results from near-bottom PEDs in 2013. The PED data from 2010 and shallower PED data from 2013 are generally comparable to the grab sample results from 2015. Dissolved-phase concentrations of PCBs, like those of DDTs, would be expected to decrease over time. SCCWRP’s bottom-sample concentrations were greater than the concentrations in the 2010 and 2013 PEDs, and a downward trend continues in the 2015 grab samples, showing an overall decreasing trend for PCBs. The high resolution sample results from 2015 generally were lower than those for the other sampling events, but still show elevated PCBs in many bottom or near-bottom samples, and in mid-column samples from locations BA6C, BA7C, BA8DC, and BA9DC. One near-surface grab sample at BA7C was also anomalously high.

Figure 4-5 shows near-bottom concentrations of Total DDTs in the water column along the 150-m, 60-m, and 40-m isobaths, in relation to concentrations in sediment in the 0-2-cm bed-depth interval. Elevated concentrations of DDTs in water samples extend from transect BA7, northwest (down-current) of the outfall diffusers, to beyond transect BA3 and the isobath boundaries, in a similar pattern to the elevated DDTs in the 0-2-cm sediment bed-depth interval.

Figure 4-6 is the equivalent figure for Total PCBs, and shows a widespread pattern of elevated concentrations, both in the near-bottom water column and in the 0-2-cm sediment bed-depth interval. The area of elevated PCBs extends from near location BA9B, down-current beyond location BA2B, and to the boundary of the sample coverage area.

4.2.4 Comparison of High Resolution Water Data to Cleanup Goals

For assessing possible risks to human and ecological health resulting from exposure to COCs in the water column, sample results (concentrations) were listed and compared to applicable cleanup goals on a point-by-point basis, as described below.

4.2.4.1 DDTs

The 2009 IROD established cleanup goals for DDTs in water, citing EPA's AWQC in effect at that time. The IROD AWQC as they apply to DDTs at PV Shelf are as follows:

- The human health AWQC is 0.22 ng/L for p,p'-DDE.[3]
- The ecological (saltwater aquatic life) AWQC is 1 ng/L for Total DDTs.

The high resolution results indicated that concentrations of p,p'-DDE exceeded the human health AWQC in 41 primary or replicate samples, and concentrations of Total DDTs exceeded the ecological AWQC in seven samples (Appendix Q). Locations of p,p-DDE exceedances are shown on Figures 3-6 and 3-7. Locations of exceedances for Total DDTs are shown on Figures 3-8 and 3-9. The patterns of p,p'-DDE and Total DDTs concentrations are similar since p,p'-DDE constitutes more than 70% of the Total DDTs result in most samples. Except for transect BA2, multiple AWQC (human health) exceedances of p,p'-DDE concentrations extend from transect BA8 down-current through BA1 (Figures 3-6 and 3-7). AWQC (ecological) exceedances for Total DDTs are limited to transects BA4 and BA7 (Figures 3-8 and 3-9).

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[3] For assessing possible human health impacts related to DDTs in the water column, the EPA used the AWQC for p,p'-DDE (0.22 ng/L). Use of this criterion is justified because, in terms of frequency and magnitude of detections, p,p'-DDE is the most prevalent DDT form in the water column (and in other media) at PV Shelf, and its AWQC value is more conservative than that for p,p'-DDD (0.31 ng/L) and equally conservative to that for p,p'-DDT (0.22 ng/L).

4.2.4.2 PCBs

The IROD established cleanup goals for PCBs in water, again citing EPA's AWQC. The IROD AWQC as they apply to PCBs at PV Shelf are as follows:

- The human health AWQC is 0.064 ng/L for Total PCBs.
- The ecological (saltwater aquatic life) AWQC is 30 ng/L for Total PCBs.

No other cleanup goals for PCBs in water were established in the IROD.

Concentrations of Total PCBs exceeded the AWQC for human health in 38 of 146 water samples. Appendix R presents all exceedances of the IROD AWQC for Total PCBs in shaded cells. Figures 3-10 and 3-11 present concentrations of Total PCBs in the water column. Similar to p,p'-DDE, Total PCBs at concentrations above the human health AWQC extend from transect BA9 down-current through BA3.

4.2.5 Water Column Uncertainties

4.2.5.1 Sampling Procedures

There are difficulties inherent in collecting ocean grab water samples at the depths and pressures attempted in this study. Samples were collected at sea directly into sample bottles; this approach was efficient in that it required no transfer of samples between bottles, and time-consuming decontamination procedures and associated handling of wastes were minimized.

Previous sampling events may have had the following sampling limitations: pumped samples required 1,100 to 2,300 L to be pumped through a filter and Teflon XAD-II resin column over several days for each sample (Zeng, 1999); and PSD samples required precise infusion of isotope-labelled compounds into each sampling device prior to each event, 30-day deployments for sampler equilibration allowing for sampler losses, and calculations for sampler concentrations based on variable water-polyethylene partitioning coefficients and temperature corrections (Fernandez, 2012, 2015).

The approach of grab sampling combined with high resolution analyses, by contrast, takes less labor and time; attains lower detection limits; and is representative of actual depth-specific water column conditions at the time of collection. For these reasons, this approach is recommended for future sampling at PV Shelf.

The two main sampling events for this MNR report were performed in March and September 2015, and this may lead to some temporal variability. The locations collected in March were BA8C, BA9DC, and W4. A review of the DDT and PCB results at these locations does not show any apparent anomalies or temporal bias between adjacent sampling locations. In Zeng's study, water column samples for DDTs and PCBs were collected in winter and summer 1997, but temporal trends were inconsistent and seasonal variability was not apparent (Zeng, 1999). Other possible variables that may affect COC concentrations in water include ocean currents, tidal influences, temperature and salinity cycles, and sedimentation patterns.

4.2.5.2 Laboratory Uncertainty

The high-resolution grab samples were filtered at the laboratory through glass fiber filters of nominal pore size of 0.7 um; this size was identical to the filters used by Zeng in the field (1999). Unlike Zeng, however, the filters were not analyzed to determine COC concentrations in the particulates retained on the filter. Colloids smaller than 0.7 um may be adsorbed (lost from the filtrate) to the surfaces of laboratory glassware. The filtrates were subjected to GPC and silica gel cleanup (SGC) to remove potential biological and hydrocarbon interferences, and this approach may also remove some colloids from the sample. These factors may affect the final reported concentrations of dissolved contaminants.

The values of target PCB congeners reported with co-elutions have a degree of uncertainty. For this water study, 14 target congeners had co-elutions (Table 2-3), and the reported values for these 14 congeners may have been biased high. For example, the PCB 70/74 results report the co-eluted target congeners, but also report non-target congeners PCB 61 and PCB 76.

4.2.5.3 Spatial Uncertainty

Horizontal accuracy using DGPS navigation was estimated to be within 3 m. However, during each sampler deployment, the propellers were stopped for variable amounts of time, leading to tidal drift and an estimated location error up to ±40 m. For each sampler deployment, the sample depth error is estimated as ±1.5 m, due to ocean swells and drift away from the vertical of the sampling device on the wire cable.

Horizontal and vertical location errors lead to changes in the exact grab sample location for consecutive sampler deployments for adjacent near-bottom and bottom samples, and for field replicates. Despite the temporal and spatial variability, the depth comparability of the DDTs and PCBs data sets were internally consistent at each location, the field replicate precision was good, and the results appear representative of the ocean water conditions at the time of sample collection.

4.3 FISH

The IROD established interim cleanup levels for environmental media. This section discusses the MNR results with respect to the cleanup levels.

4.3.1 Data Quality Assessment – Fish

The fish tissue analytical data were reviewed and validated by an independent third-party validator following procedures specified in the fish QAPP (Gilbane, 2016a). A total of 6,850 primary sample results was generated for the fish sampling program, and no data points were rejected; thus, the analytical completeness was 100%. The planned fish collection total was 340, and the actual number of fish caught over a 27-month period (from June 2014 through August 2016) was 301, for a field sampling completeness of 89%.

The Gilbane project chemist conducted an overall QC review after receiving the data validation reports, and developed a QCSR to summarize the data quality anomalies for the fish sampling program. The QCSR indicated that project DQOs were met and that all data were usable for assessing fish tissue concentrations. The QCSR for the fish data set is presented in Appendix W.

The laboratory RLs were evaluated by the project team prior to sample collection to confirm that the laboratory was able to attain the required sensitivity for the project. For the tests for pesticides and PCBs, the reporting approach was to report each DDT isomer and PCB congener to a sample-specific EDL. The level of sensitivity achieved by HRGC/HRMS analysis for DDTs and PCBs is the lowest technically achievable, and met project objectives. All fish data are useable, as qualified, for comparison to the IROD target fish tissue concentration goals.

4.3.2 Distribution of COCs in Fish

As previously mentioned, Figure 3-12 shows COC results for BSB and WC for each collection area, including minimum, average, and maximum concentrations of Total DDTs and Total PCBs.

4.3.2.1 DDTs

For BSB, there is an overall pattern of higher DDTs concentrations in samples of fish caught in EPA Zones 1 and 2 (near the Sanitation Districts' outfall diffusers). Samples of fish caught in the reference BSB collection area at Huntington Flats had elevated average and maximum concentrations of Total DDTs. The high maximum concentrations at the Huntington Flats reference area for DDTs in BSB may be indicative of individual fish having a significant contaminant load during summer spawning migration from PV Shelf or the ports of Los Angeles and Long Beach (ITSI Gilbane, 2013b), and do not appear to represent the local potential exposure of BSB to sediment conditions at Huntington Flats.

For WC, Figure 3-12 shows that the average and maximum Total DDTs values from Zones 1, 2, and 3 being higher than the corresponding values for the other collection areas. Significant concentrations of Total DDTs are also noted in the Breakwater Zone and Redondo Flats. The reference WC collection area at Ventura Flats has very low concentrations for DDTs. The widespread area of elevated DDTs concentrations in WC may be indicative of the fishes' wide range and mobility, and provide evidence of their apparent low site fidelity to the vicinity of the Sanitation Districts' outfalls area (Lowe, 2013).

4.3.2.2 PCBs

An overall pattern of higher PCBs concentrations in BSB from Zones 1 and 2 is apparent. BSB caught at reference collection area Huntington Flats also had elevated average and maximum concentrations of Total PCBs, comparable to Zone 2, but less than Zone 1. A small number of BSB from Huntington Flats (and to a lesser extent Redondo Flats and the Breakwater Zone) had high concentrations of PCBs, resulting in elevated maximum and average Total PCBs concentrations. The elevated concentrations of PCBs at Huntington Flats, like those of DDTs, may indicate that individual fish migrated from PV Shelf or the shipping harbors, and that these concentrations are not necessarily representative of sediment conditions at Huntington Flats.

For PCBs in WC, Zones 1, 2, and 3 all had maximum concentrations exceeding 150,000 pg/g. The collection area with the highest average value for PCBs was Zone 1 at the outfall diffusers. Redondo Flats (northwest of the diffusers) and the Breakwater Zone (east of the diffusers) both showed significant levels of PCBs when compared to the Ventura Flats reference area. It appears that elevated PCB concentrations in WC are more widespread than for BSB. This phenomenon may be related to the wide range and mobility of WC, as noted in previous studies (Lowe, 2013).

4.3.2.3 Time Trends

At this time, a meaningful analysis of time trends for fish at PV Shelf is difficult due to many factors, including fish mobility; differences in fish collection locations and depths by different researchers; differences in analyte lists; and differences in analytical procedures. Tables 4-6 and 4-7 show summaries of DDT and PCB data, respectively, generated from: NOAA's 2002/2004 study (NOAA/EPA, 2007); recent EPA studies from shallower pier fishing locations related to the ICs program (WC only; Gilbane, 2016b, 2017); the Sanitation Districts' 2012 (BSB) and 2015 (WC) data (Sanitation Districts, 2014, 2016); and this MNR study. An attempt was made to align locations of fish collections from these various efforts to examine time trends. There are more data available for WC than for BSB, as WC have been collected more consistently.

For DDTs, when comparing the NOAA 2002/2004 data set with the current MNR data set, the maximum and average DDTs results have decreased in both BSB and WC from 2002 to 2016 at all collection areas except the Breakwater Area. For WC at Zones 1, 2, and 3, where Sanitation Districts' data are available (collections in November and December 2015) and where comparisons can be made, the composited results for WC are notably higher than the averages from both the NOAA 2002/2004 study (Zones 1 and 2 only; collected from September 2002 to June 2004) and the 2014/2016 MNR study (October 2014 to July 2016 collections). For BSB at Zones 1, 2, and 3, the Sanitation Districts' results for DDTs for composited samples (collected from June to October 2012) are notably lower than the averages from the NOAA 2002/2004 study (Zones 1 and 3 only; collections from August 2002 to June 2003), and the 2014/2016 MNR study (Zones 1, 2, and 3; June 2014 to August 2016 collections). There are inadequate data to make more detailed observations.

For PCBs (collected concurrently with the DDTs), when comparing the NOAA 2002/2004 data set with the current MNR data set, the maximum and average PCBs results have decreased at all collection areas except Redondo Flats. For WC, decreases in average values were noted at Zones 1 and 2. For BSB at Zones 1, 2, and 3, the Sanitation Districts' results for total detectable Aroclors (total PCB congeners are not available) in composited samples, are consistent with the decreasing average concentrations trend from the higher NOAA 2002/2004 study (Zones 1 and 3 only), to the lower 2014/2016 MNR study. Due to incomplete and inconsistent data sets, there are no other discernable time trends that can be made at present.

The Sanitation Districts has generated data on DDTs and PCBs in WC routinely since the late 1990s. For the collection areas closest to the outfalls, the data set shows dramatic decreases for DDTs in WC samples. Concentrations of PCBs in WC have remained consistent, but at low concentrations relative to DDTs (EPA, 2009b; Sanitation Districts, 2016).

4.3.3 Comparison of Fish Data to Cleanup Goals

The IROD established the following cleanup goals for protection of human health from ingestion of WC (the IROD did not establish cleanup goals for ingestion of BSB):

- For DDTs, 400 ug/kg
- For PCBs, 70 ug/kg

For PV Shelf, the adopted approach is to derive a representative EPC specific to each EPA fish collection area. For this data set, for each collection area, ProUCL software (EPA, 2015) was used to calculate the 95% upper confidence limit (UCL) on the mean concentration; this value is regarded as the area-specific EPC. The use of the 95% UCL on the mean is widely recognized as a conservative estimate for representing an EPC. This approach is recommended when conducting quantitative exposure assessments of contaminants in environmental media including fish tissue (EPA, 1989), and has been applied for the ICs program at PV Shelf (Gilbane, 2016b, 2017).

Figure 3-12 shows that for Total DDTs, the EPCs exceeded the cleanup goal in fish collection areas EPA Zone 1, EPA Zone 2, and EPA Zone 3. For Total PCBs, the EPCs exceeded the cleanup goal in collection areas EPA Zone 1, EPA Zone 2, and Redondo Flats. The EPC for DDTs in EPA Zone 3 and the EPC for PCBs at Redondo Flats exceed the IROD cleanup goals. EPA Zone 3 and Redondo Flats are outside the CDFW commercial WC catch ban area.

4.3.4 Fish Uncertainties

4.3.4.1 Collection Procedures

The fish sampling design has an inherent and unknown degree of uncertainty, since it is not intended to ascertain the environments to which each fish collected during this task has been exposed in its life cycle. It is impossible to know where a fish has travelled, what its feeding habits are, and where it has received its contaminant body burden. Further, it is not possible to determine the degree to which direct sediment contaminant exposure has occurred for each fish.

A wide variety of fish lengths and weights were measured in each species; however, no evaluation of potential age biases to fish contaminant exposure uncertainties was made. Fish tend to absorb contaminants throughout their lifetimes. For future events, the age of each fish and/or body burden based on weights and measures, should be assessed.

Fish samples were prepared as skin-off filets, and estimated concentrations in whole fish were not generated. Also, while lipid results were generated for each sample (Appendix U), lipid normalization was not performed for this study, but could be calculated in future assessments. There is typically a linear relationship between fat content and organo-chlorine content in fish; lipid normalizing is an approach to assess whether changes (over time) in contaminant concentration indicate an actual trend or are attributable to changes in fat content in the fish (EPA, 2000b).

4.3.4.2 Spatial Uncertainty

Due to the limited availability of fish, the actual collection locations for several BSB at Breakwater Zone and Redondo Flats, for several WC at Redondo Flats, and for most fish at EPA Zone 1, EPA Zone 2, and EPA Zone 3, were outside the designated boundaries of the planned 5-km by 1-km collection areas indicated on Figures 2-5 and 3-12. All fish collection locations were recorded and are included in Appendix T.