Total Maximum Daily Loads for Mercury and PCBs, and Arsenic Analysis for Pago Pago Inner Harbor, Territory of American Samoa

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EXECUTIVE SUMMARY

Pago Pago Inner Harbor was included on the 2004 section 303(d) list of impaired waterbodies for American Samoa because of arsenic, mercury, and polychlorinated biphenyls (PCB) contamination in fish. The harbor was not supporting its designated use of recreational and subsistence fishing. Studies indicate that fish tissue contained elevated levels of arsenic, mercury, and PCBs and that the high concentrations in fish tissue could potentially cause adverse health effects in residents eating fish from the harbor. The studies resulted in a health advisory issued by the American Samoa Government in October 1991, warning residents not to eat any fish caught in the inner harbor (EnviroSearch 1994). A Tier 2 Fish Toxicity study was completed by Peshut and Brooks in 2005 and, based on the results, the fish consumption advisory continues to exist for fish and shellfish from the Pago Pago Inner Harbor.

While the Tier 2 Fish Toxicity study (Peshut and Brooks 2005) included arsenic in the toxicity assessment of fish tissue for the inner harbor, arsenic was considered to be of less importance as a risk driver, compared to mercury and PCBs (Peshut 2006). There are no data to suggest existing anthropogenic inputs of arsenic to the inner harbor. Arsenic found in fish tissue from the unimpacted coastal locations as well as the resulting calculated consumption limits for coastal sites were comparable to the values in fish from the inner harbor. Results of the analysis suggest that arsenic found in fish and shellfish from the inner harbor is likely from the volcanic parent material of the islands which naturally contains arsenic, and the arsenic levels in fish tissue from the inner harbor do not, by themselves, support a fish consumption advisory. Moreover, as American Samoa Water Quality Standards (ASWQS) contain a natural sources exclusion provision, the observed arsenic levels in Pago Pago Inner Harbor are not causing violations of the ASWQS. While this Total Maximum Daily Load (TMDL) report presents an inventory and analysis of the available arsenic data for Pago Pago Inner Harbor, the report establishes TMDLs only for mercury and PCBs, and not for arsenic.

The climate of American Samoa is tropical, characterized by high temperatures, high rainfall and high humidity in summer months. Pago Pago Harbor is located on the Island of Tutuila and receives an average of 200 inches of rainfall annually, but rainfall can vary considerably in the watershed. The harbor has a surface area of 2.4 mi^2, a length of approximately 15,000 feet and widths ranging from 1,000 to 3,000 feet in the inner harbor and 3,000 to 6,000 ft in the outer harbor. Because the drainage area is small relative to the harbor size (i.e., 4.9 mi^2 drainage area versus 2.4 mi^2 surface area), the harbor is typically marine-dominated with depressed salinity normally found only within close proximity of the stream mouths. The volume of stream flow entering the harbor following a rainstorm is probably less than the volume of direct precipitation onto the harbor. The residence time of water is approximately 34 days, indicating poor flushing within the harbor.

The Pago Pago Harbor area includes densely placed homes and businesses clustered near the water's edge and concentrated in the villages of Pago Pago, Fagatogo, Satala and Atu'u. Many small plantations and pig pens, operated mostly for family consumption, are found mixed with residential areas and extend up onto steep slopes of the watershed. For the last century, Pago Pago Harbor has been the center of the majority of light industrial, municipal, and military infrastructures in the territory. There may be areas where toxic military materials being abandoned in the past are polluting the watershed. Water quality in the harbor has improved dramatically since the two tuna canneries in the harbor began the segregation and removal of wastes in 1993.

Analysis of ambient conditions in the harbor indicates the harbor sediments are contaminated with mercury and PCBs and may be the principal source of elevated concentrations of mercury and PCBs found in the fish tissue. Since there is no apparent existing external source, sediments in the harbor likely bear a historical burden of mercury and PCBs from previous industrial and military activities in the watershed.

Numeric water quality criteria for mercury and PCBs exist for Pago Pago Harbor, although exceedances of these water quality criteria were not indicated as the basis for listing. The mercury and PCB listings were based solely on fish tissue levels. Therefore, the applicable water quality standards are not relevant targets for the mercury and PCB TMDLs.

Mercury and PCBs accumulated in marine sediments can result in mercury and PCB contamination of fish. Uptake of mercury and PCBs by fish can include direct contact and ingestion of contaminated bottom sediments and biomagnification through the food chain. Because of this sediment – fish tissue link, the Pago Pago Inner Harbor TMDLs were developed to meet and maintain the sediment ERLs (effects range low) for mercury and PCBs. It is anticipated that maintenance of these sediment targets will support the designated use of recreational and subsistence fishing by corresponding to levels of mercury, methylmercury and PCBs in sediment and fish that will not pose a human health risk. The TMDLs for mercury and PCBs for Pago Pago Inner Harbor are concentration-based due to the lack of sediment load data for the harbor.

To account for a margin of safety in this TMDL analysis, the TMDL target is established at a concentration 15 percent lower than the sediment ERL for mercury and PCBs. The resulting sediment targets for the mercury and PCB TMDLs for Pago Pago Inner Harbor are a sediment mercury concentration of 0.1275 mg/kg and a sediment PCB concentration of 0.0193 mg/kg. TMDLs are equal to the load allocation because the harbor sediments are currently the only likely source of mercury and PCBs contributing to the elevated levels of these pollutants in the fish tissue.

Table E-1 presents the wasteload allocations (WLAs) for the Satala Power Plant (NPDES AS0020044) and South West Marine (NPDES AS0020036), the only two facilities that hold NPDES permits in the area. Note that although the TMDL is based on sediment concentrations of mercury and PCBs, the WLAs are based on the effluent concentrations of mercury and PCBs from these two facilities. WLAs are capped at 0.0425 ug/L for mercury and 0.0000544 ug/L for PCBs, a reduction of 15% for margin of safety from the American Samoa Water Quality Standard for mercury and the USEPA National Recommended Water Quality Criterion for PCBs. In addition to the WLAs, point sources are required to develop and implement appropriate Pollutant Minimization Plans. Pollutants in sediments are reduced through natural attenuation and, if necessary and feasible, remedial actions.

Table E-1. Wasteload allocations for mercury and PCBs

Facility	PCB WLA*	Mercury WLA*
Satala Power Plant	0.0000544 ug/L	0.0425ug/L plus PMP
South West Marine	0.0000544 ug/L	0.0425 ug/L plus PMP

WLA – Wasteload allocation
PMP - Pollutant Minimization Plan
*15 percent MOS applied to the water quality criteria of 0.000064 ug/L for PCB (USEPA 2006) and 0.05 ug/L for mercury (ASWQS 2005)

Table E-2 presents the TMDLs, load allocations, and wasteload allocations for mercury and PCBs for the Pago Pago Inner Harbor.

Table E-2. TMDLs for mercury and PCBs for Pago Pago Inner Harbor

Pollutant of Concern	Existing Sediment Concentrations (mg/kg)	TMDL (mg/kg)	LA (mg/kg)	WLA (ug/L)	Pollutant Reduction (%)
Mercury	0.1631	0.1275	0.1275	0.0425 plus PMP	22
PCBs	0.1018	0.0193	0.0193	0.0000544 plus PMP	81

LA – Load allocation
WLA – Waste load allocation
PMP – Pollutant Minimization Plan
* Sediment concentration based on the average of all available dry-weight sediment data for Pago Pago Inner Harbor

1.0 INTRODUCTION

1.1 Problem Statement

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) Water Quality Management Regulations (40 CFR Part 130) require states and territories to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting water quality standards under technology-based controls. A TMDL establishes the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant. TMDLs provide the scientific basis for a state or territory to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's/territory's water resources (USEPA 1991a).

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. TMDL components are illustrated using the following equation:

$$TMDL = \Sigma\ WLAs + \Sigma$$

Pago Pago Inner Harbor was included on the 2004 section 303(d) list of impaired waterbodies for American Samoa because of arsenic, mercury and polychlorinated biphenyls (PCB) contamination in fish. There is currently a "no consumption" of fish or shellfish ban in effect for the general population for one or more fish/shellfish species in the inner harbor, or commercial fishing/shellfishing ban in effect. This fish and shellfish ban has resulted in the harbor not supporting its designated uses of recreational and subsistence fishing. A study conducted in 1994 (EnviroSearch 1994) evaluated the human health risk due to the consumption of contaminated fish in Pago Pago Harbor. The study indicated that fish tissue containing elevated levels of arsenic, mercury, and PCBs could potentially cause adverse health effects in residents eating fish from the harbor. The 1994 study supported previous studies (AECOS 1991, USEPA 1991b) that resulted in a health advisory issued by the American Samoa Government in October 1991, warning residents not to eat any fish caught in the inner harbor (EnviroSearch 1994). The 1994 EnviroSearch study suggested that a Tier 2 toxicity study be conducted focusing on the fish and shellfish species identified in the risk assessment and contaminants of concern that presented potential public health concern.

Based on the results of the Tier 2 Fish Toxicity study (Peshut and Brooks 2005), the fish consumption advisory continues to exist for fish and shellfish in Pago Pago Inner Harbor. The Tier 2 Toxicity study was conducted according to USEPA protocols. The results of this Tier 2 study confirmed the results of the 1994 study and previous studies indicating that mercury and PCBs are present in high enough concentrations in the fish and shellfish to justify continuing a general fish advisory for Pago Pago Inner Harbor.

While the Tier 2 Fish Toxicity study (Peshut and Brooks 2005) includes arsenic in the toxicity assessment of fish tissue for the inner harbor, arsenic was considered to be of less importance as a risk driver compared to mercury and PCBs (Peshut 2006). There are no data to suggest existing anthropogenic inputs of arsenic to the inner harbor. Arsenic found in fish tissue from the unimpacted coastal locations as well as the resulting calculated consumption limits for coastal sites were comparable to the values in fish from the inner harbor. Results of the analysis suggest that arsenic found in fish and shellfish from the inner harbor is likely from the volcanic parent material of the islands which naturally contains arsenic. American Samoa Water Quality Standards contain a provision that standards are not violated if elevated pollutant levels are caused solely by naturally occurring sources. Therefore, while this report presents an inventory and analysis of the available arsenic data for Pago Pago Inner Harbor, developing a TMDL for arsenic is not warranted. This report presents TMDLs only for mercury and PCBs.

1.2 Study Area

1.2.1 Pago Pago Harbor

The Territory of American Samoa lies in the South Pacific Ocean, about 1,000 miles south of the equator and 2,300 miles southwest of Hawaii. The principal islands are Tutuila, Aunu'u and the Manu'a Islands, a cluster of three islands: Ta'u, Ofu and Olosega. Also included in the territory are Swains Island and Rose Atoll. The islands are volcanic in origin with a maximum elevation of 3,180 feet.

Pago Pago Harbor is located on the Island of Tutuila which is the largest island in the territory with an area of 53 square miles (mi^2). The harbor has a surface area of 2.4 mi^2 with a length of approximately 15,000 feet (ft) and widths ranging from 1,000 to 3,000 ft in the inner harbor and 3,000 to 6,000 ft in the outer harbor (Figure 1-1). The outer harbor trends north-south while the inner harbor trends east-west. Maximum depths in the harbor range from less than 60 ft to over 200 ft with fringing reefs periodically exposed at low tide. Because the drainage area is small relative to the harbor size (i.e., 4.9 mi^2 drainage area versus 2.4 mi^2 surface area), the harbor is typically marine-dominated with depressed salinity normally found only within close proximity of the stream mouths.

Tides in the harbor are semi-diurnal with a range of about 2.5 ft with little diurnal inequality. The circulation in the harbor is mainly wind-driven with small tidal and freshwater influence. The residence time of water is approximately 34 days, indicating poor flushing within the harbor.

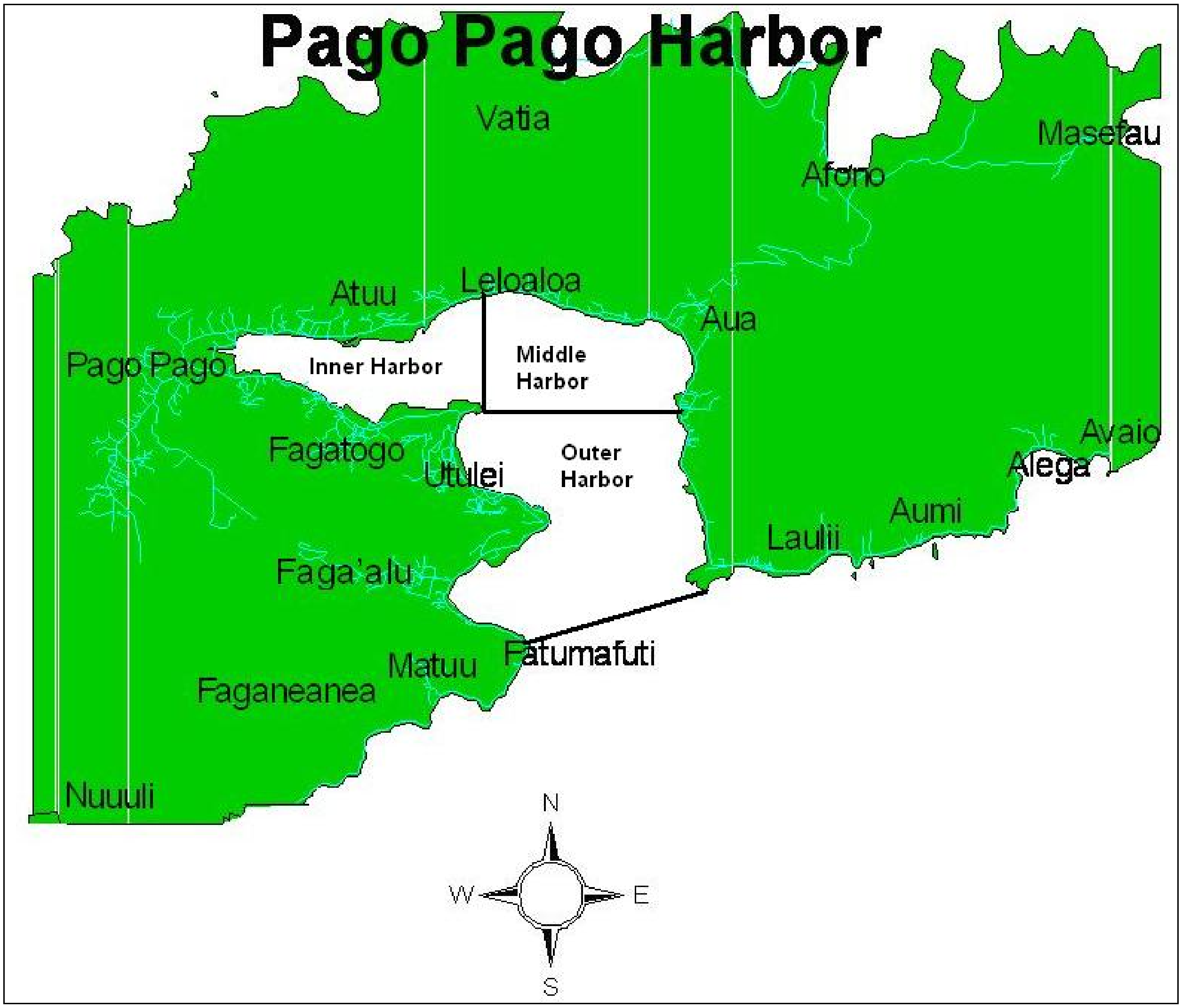

Figure 1-1. Location of Pago Pago Harbor

1.2.2 Pago Pago Harbor Watershed

The Pago Pago Harbor watershed is near the center of the Island of Tutuila. The watershed has an approximate area of 4 mi^2. North Pioa Mountain represents the eastern boundary of the watershed with Matautu Ridge, Palapalaloa Mountain and Fatifati Mountain making the south and west boundaries.

Hydrology

In the Pago Pago Harbor watershed, the average precipitation rate is 212 inches per year (Hydro Resources International 1989), but rainfall can vary considerably in watershed. There are approximately 27 streams draining into the Pago Pago Harbor. The watershed contributing runoff to the harbor is small relative to the size of the harbor (i.e., 4.9 mi^2 drainage area versus 2.4 mi^2 surface area). The volume of stream flow entering the harbor following a rainstorm is probably less than the volume of direct precipitation onto the harbor. The streams tributary to the harbor have small drainages with very steep average channel slopes ranging from 10 percent for the Vaipito and Fagaalu streams up to 65 percent for streams draining the south face of Alava Mountain which forms the north boundary of the watershed. Because precipitation is high and exhibits only mild seasonality and the soil remains near a saturated state at most times, streams respond quickly to rainfall.

Land Use

The American Samoa Watershed Protection Plan (Pedersen Planning Consultants 1998) indicates the existence of commercial, residential, agricultural and industrial land uses in the Pago Pago Harbor watershed. The Pago Pago Harbor area includes densely placed homes and businesses clustered near the water's edge and concentrated in the villages of Pago Pago, Fagatogo, Satala and Atu'u. Many small plantations and pig pens, operated mostly for family consumption, are found mixed with residential areas and extend up onto steep slopes of the watershed.

For the last century, Pago Pago Harbor has been the center of the majority of light industrial, municipal, and military infrastructures in the territory. Since association with the United States of America (U.S.) in 1900, the harbor was used as a coaling and repair station for the U.S. Navy. The military presence evolved over time, although the military significance of the harbor decreased dramatically as World War II progressed. Military activity in the harbor is now minimal; however there may be areas where toxic military materials being abandoned in the past are polluting the watershed. Historical records of placement and function of military installations are unclear.

For more than thirty years, tuna canneries have operated in the villages of Anua and Atua on the northern shore of the inner harbor. High strength waste from the canneries was disposed of at sea prior to 1992. Since 1992, low strength waste has been pumped to an outfall in the outer harbor. Water quality in the harbor has improved dramatically since the segregation and removal of wastes was completed. A large amount of boat traffic associated with the military and cannery operations has necessitated a shipyard for painting and repair that continues to operate as Southwest Marine of Samoa, Inc. in the village of Satala on the northern shore of the inner harbor. Another light industrial facility, also located in the similar vicinity, is a diesel fired electrical power generating plant.

Soils

Soils in the watershed include the Urban Land-Aua Leafu complex at 0 to 30 percent slopes, Aua Very Stony Silty Clay Loam (1) at 15 to 30 percent slopes, Aua Very Stony Silty Clay Loam (2) at 30 to 60 percent slopes and Fagasa Family-Lithic Hapludolls-Rock Outcrop Association in steeper upland areas. The Urban Land-Aua Leafu soils have limited to moderate potential for runoff with slight to moderate erosion potential. The Aua (1) soils have moderate potential for runoff and erosion while Aua (2) soils have high potential for runoff and erosion. The Fagasa Family soils also have high potential for surface runoff and erosion. The soils in the watershed have limited potential for agricultural production. The soils also are not desirable for onsite wastewater disposal systems due to their stoniness and their moderately rapid to rapid permeability.

Climate

The climate of American Samoa is tropical, characterized by high temperatures, high rainfall and high humidity in summer months. In winter months, Southern Hemisphere trade winds influence the weather, with prevailing southeasterly winds resulting in lower temperatures and less rainfall. The driest months are June through September and the wettest are December through March, but seasonal rainfall varies, and heavy showers and long rainy periods can occur in any month. Pago Pago receives an average of 200 inches of rainfall annually. The average annual temperature is about 80 degrees Fahrenheit with the hottest months being January through March.

1.3 Applicable Water Quality Standards

1.3.1 Designated Uses

The protected uses for the harbor listed in the American Samoa Water Quality Standards (ASWQS) (2005) include recreational and subsistence fishing; boat-launching and designated mooring areas; subsistence food gathering (e.g., shellfish harvesting); aesthetic enjoyment; whole and limited body contact recreation (e.g., swimming, snorkeling and scuba diving); support and propagation of marine life; industrial water supply; mariculture development; normal harbor activities (e.g., ship movements, docking, loading and unloading, marine railways and floating drydocks); and scientific investigations.

1.3.2 Water Quality Criteria

Section 24.0206(g)(3) of the ASWQS provides the applicable arsenic, mercury, and PCB water quality criteria for Pago Pago Harbor. The ASWQS (2005) state that for toxic substances in embayments, open coastal waters and ocean waters, “the concentration of toxic pollutants shall not exceed the more stringent of the aquatic life criteria for marine waters or the human health concentration criteria for consumption of organisms found in USEPA 2002 or the most recent version.” ASWQS specifically exclude the human health criteria for arsenic that are established by the USEPA. The ASWQS (2005) for protecting human health is 10 ug/L of arsenic in fresh water. In addition to the methylmercury criteria for human health established by USEPA, ASWQS also state that the water column concentration of total mercury shall not exceed 0.05 ug/L. There are no specific ASWQS identified for PCBs. Therefore, the *National Recommended Water Quality Criteria* (USEPA 2006) are applicable to PCBs. The human health criteria for consumption of organisms are more stringent than the aquatic life criteria for all three pollutants, therefore, human health criteria are applicable in the assessing and establishing TMDLs for Pago Pago Inner Harbor. The applicable arsenic, mercury and PCB water quality criteria are presented in Table 1-1.

Table 1-1. Applicable arsenic, mercury and PCB water quality criteria for Pago Pago Harbor

Priority Pollutant	Human Health Criteria (µg/L)	Notes	Source
Arsenic	0.018 (consumption of water and organism)	a	USEPA 2006
Arsenic	0.14 (consumption of organism only)	a	USEPA 2006
Arsenic	10	b	ASWQS 2005
Mercury	0.05	c	ASWQS 2005
Mercury	0.2 mg/kg (MeHg)	d	ASWQS 2005 USEPA 2006
Polychlorinated Biphenyls	0.000064	e	ASWQS 2005 USEPA 2006

[a]This recommended water quality criterion for arsenic refers to the inorganic form only (USEPA 2006). ASWQS exclude the human health criterion for arsenic established by USEPA (ASWQS 2005).
[b] For fresh water
[c]Water column concentration
[d]This fish tissue residue criterion for methylmercury (MeHg) is based on a total fish consumption rate of 32 g/day (see text below for further information).
[e]This criterion applies to total PCBs, (e.g., the sum of all congener or all isomer or homolog or Aroclor analyses.)

USEPA criteria guidance provides that national criterion for mercury in fish tissue should be revised to account for local fish consumption patterns where appropriate. For the TMDL analysis, local fish consumption rates were adjusted from the default consumption rate used to derive the default national criterion to account for the fact that recreational and subsistence fishing is an important beneficial use of Pago Pago Harbor.

The USEPA national default criterion of 0.3 mg/kg for mercury in fish is based on a fish consumption rate of 17.5 g/day. This represents the 90th percentile consumption rate for the general adult population in the United States which may not be representative of the recreational and subsistence consumption rate in the Pago Pago Harbor area. A detailed fish consumption study was completed for San Francisco Bay, California by the San Francisco Estuary Institute in 2000. This study evaluated the fish consumption rates for various ethnic groups, including Pacific Islanders living in the San Francisco Bay area. The 95th percentile consumption rate for recreational and subsistence anglers, including Pacific Islanders, living in the San Francisco Bay area was found to be 32 g/day. Since data are not available concerning the fish consumption rates of locally caught fish from Pago Pago Harbor, this fish consumption rate of 32 g/day is used to determine alternative numeric targets for fish tissue. If consumption data specific to Pago Pago Harbor becomes available, these targets should be reviewed and, if necessary, revised. Use of 32 g/day fish consumption rate results in a fish tissue water quality criterion of 0.2 mg/kg, slightly more stringent than USEPA's fish tissue criterion of 0.3 mg/kg based on the 17.5 g/day consumption rate for the general US population. A fish tissue criterion of 0.2 mg/kg is considered to be more appropriate for the recreational and subsistence consumption of fish in American Samoa.

2.0 MONITORING DATA ASSESSMENT

This section provides an inventory and analysis of the available arsenic, mercury, and PCB water quality, fish tissue, and sediment data for Pago Pago Inner Harbor. For greater detail on all data available for the harbor, refer to *Data Review to Support the Water Quality Monitoring Strategy for Pago Pago Harbor, American Samoa* (GDC 2003).

Review of arsenic data for Pago Pago is presented in this Section, however, as discussed in Section 1.1, water quality standards for arsenic in American Samoa are not violated and preparing a TMDL is not required. In this Section, presenting arsenic “exceedences” does not comprise violations of applicable water quality standards.

2.1 Inventory and Analysis of Available Monitoring Data

2.1.1 Water Quality Data

Arsenic

There are 55 total arsenic observations for Pago Pago Inner Harbor from October 1990 through February 2005 at six locations (Figure 2-1). Table 2-1 presents a summary of the available total arsenic data and Table A-1 in Appendix A presents all of the available total arsenic water quality data for Pago Pago Inner Harbor.

Table 2-1. Summary of total arsenic water quality observations in Pago Pago Inner Harbor

Station	Period of Record	Number of Observations	Min (µg/L)	Max (µg/L)	Average (µg/L)	Number of Exceedances[a]
Inner Harbor Site 1	October 1990	2	<10	<10	<10	NA[b]
Inner Harbor Site 4	October 1990	2	<10	<10	<10	NA[b]
11	March 2001-February 2005	18	1.0	2.8	1.70	18
13	March 2001-February 2005	27	0.73	10.1	1.78	27
12	October 2001	3	1.8	1.9	1.87	3
11A	October 2001	3	1.8	1.9	1.87	3

[a]Exceedances of the human health criterion for inorganic arsenic of 0.14 µg/L for consumption of organism only (USEPA 2006).
[b]The October 1990 data were not included in the data analysis because the detection limit was too high to obtain an accurate total arsenic observation.

There is no applicable ASWQS for arsenic in marine water. The human health water quality criterion recommended by USEPA (2006) is 0.14 ug/L for consumption of organism only. Since ASWQS exclude the USEPA human health water quality criterion for arsenic, the evaluation of inner harbor water quality data against the USEPA human health criterion is for information only. An exceedence of the USEPA water quality criterion does not constitute a violation of the ASWQS.

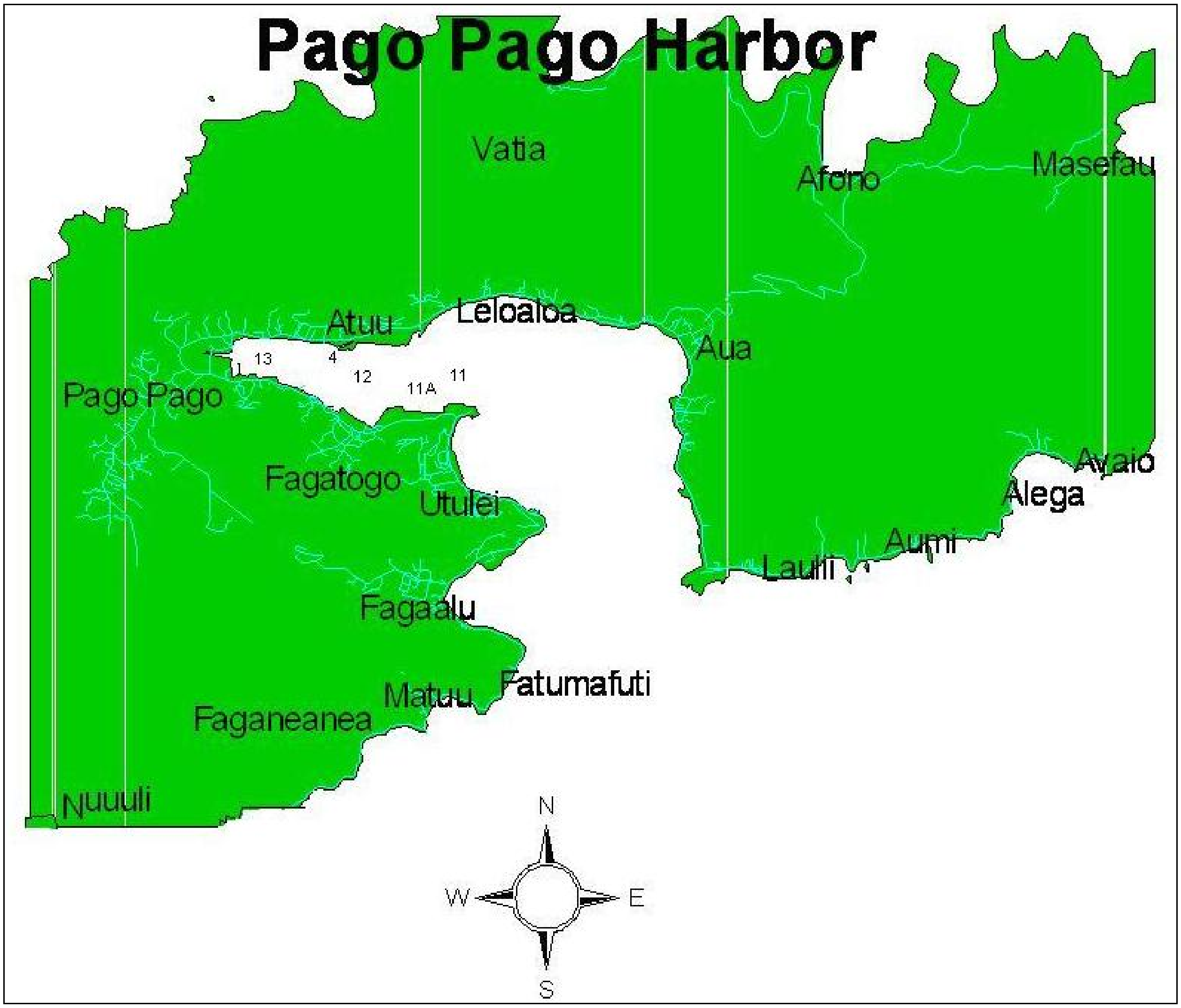

Figure 2-1. Location of water quality monitoring stations with relevant data in Pago Pago Inner Harbor

All of the available arsenic water quality data for the harbor are for total arsenic. USEPA (2006) indicates that the aquatic health criterion for arsenic is based on inorganic arsenic, but should be applied to total arsenic data as well. If this same approach is taken for the human health criterion, all of the total arsenic observations (100 percent of the 51 included samples) exceeded the inorganic human health arsenic criterion of 0.14 µg/L. Another option for comparing the total arsenic data to the inorganic criterion is to assume that a percentage of the total arsenic is inorganic. The arsenic in surface waters is typically mostly in the inorganic form (CH2M Hill 2004). A review of literature found that the typical arsenic V:total arsenic ratio in ocean water and saline bay water is 0.8:1 (CLS 1997). However, in addition to arsenic V, arsenic III is also a common component of inorganic arsenic. The ratio of arsenic V:arsenic III ranges from 0.1 to 10:1 (CLS 1997). Therefore, one can assume that inorganic arsenic (including both arsenic V and III) can account for more than 80 percent of total arsenic. To convert the total arsenic results to the inorganic form, which is directly comparable to the water quality criterion, 80 percent of the total arsenic results were assumed to represent the inorganic fraction (based on the ratios in CLS 1997). After applying the 80 percent conversion from total to inorganic arsenic, all 51 included observations (100 percent) exceeded the human health criterion for inorganic arsenic.

There are also 20 total arsenic observations available for five freshwater tributary streams to the harbor. As shown in Table 2-2, arsenic concentrations range from 0.3 to 11.7 µg/L. Table A-2 in Appendix A presents all of the available total arsenic water quality data for tributaries draining to the harbor. The ASWQS for arsenic in fresh water is 10 ug/L for protecting human health and the public health water quality criterion recommended by USEPA (2006) for consumption of water and organism is 0.018 ug/L. Similar to the evaluation of inner harbor water quality data, the evaluation of the water quality data for fresh water against the USEPA human health water quality criterion is for information only because ASWQS exclude the USEPA public health water quality criterion for arsenic. An exceedence of the USEPA water quality criterion does not constitute a violation of the ASWQS.

All of the total arsenic concentrations from the five freshwater streams exceed the USEPA total arsenic human health criterion of 0.018 ug/L for consumption of both water and organism. Only one of the samples exceeds ASWQS of 10 ug/L arsenic in fresh water.

Table 2-2. Summary of total arsenic water quality observations for streams draining to Pago Pago Harbor

Station	Period of Record	Number of Observations	Min (µg/L)	Max (µg/L)	Average (µg/L)	Number of Exceedances
S1	March 2003 - September 2004	4	0.3	0.5	0.39	4*/0**
S2	March 2003 - September 2004	4	1.05	2.33	1.75	4*/0**
S3	March 2003 - September 2004	4	0.5	0.69	0.565	4*/0**
S4	March 2003 - September 2004	4	0.37	1.4	0.788	4*/0**
S5	March 2003 - September 2004	4	0.8	11.7	3.86	4*/1**

*Exceedances of the human health criterion for total arsenic of 0.018 µg/L for consumption of water and organism (USEPA 2006).
** Exceedances of the human health criterion for fresh water of 10 µg/L (ASWQS 2005).

A summary of the comparison of the available arsenic water quality data to the water quality criteria is presented in Table 2-3.

Mercury

There are 55 total mercury observations in Pago Pago Inner Harbor's water column. All of these observations are at six locations in the inner harbor from October 1990 and March 2001 to February 2005 (Figure 2-1). Table 2-4 presents a summary of the available data and Table A-3 in Appendix A presents all of the available total mercury water quality data for Pago Pago Inner Harbor.

Table 2-3. Comparison of arsenic water quality data to water quality criteria for Pago Pago Inner Harbor

Pollutant	Water Quality Criteria	Number of Observations	Number of Exceedances	Percent Exceeding
Arsenic[a]	0.14 µg/L[bc]	51[f]	51[f]	100
Arsenic[d]	0.018µg/L[c]/10 ug/L[e]	20	20	100/5

[a]Samples taken from Pago Pago Inner Harbor
[b]Note that this criterion is for inorganic arsenic and all arsenic observations were total arsenic. It was assumed that 80% of total arsenic is inorganic for comparison to the water quality criterion (CLS 1997).
[c]Source: USEPA 2006
[d]Samples taken from freshwater tributaries to the harbor
[e]Source: ASWQS 2005
[f]October 1990 total arsenic observations were not included in this analysis because of high detection limits.

Table 2-4. Summary of total mercury water quality observations in Pago Pago Inner Harbor

Station	Period of Record	Number of Observations	Min (µg/L)	Max (µg/L)	Average (µg/L)	Number of Exceedances[a]
Inner Harbor Site 1	October 1990	2	<2	<10	<6	NA[b]
Inner Harbor Site 4	October 1990	2	<2	<10	<6	NA[b]
11	March 2001-February 2005	18	0.00188	0.0111	0.004214	0
13	March 2001-February 2005	27	0.001	0.0054	0.002721	0
12	October 2001	3	0.001	0.001	0.001	0
11A	October 2001	3	0.001	0.0012	0.0011	0

[a]Exceedances of the human health criterion for total mercury of 0.05 µg/L in water column (ASWQS 2005).
[b]The October 1990 data were not included in the data analysis because the detection limit was too high to obtain an accurate total mercury observation.

There are also 20 total mercury observations for five freshwater tributary streams that drain to the Harbor. The mercury concentrations range from 0.001 to 0.0067 µg/L. Table 2-5 presents a summary of the available stream data and Table A-4 in Appendix A presents all of the available total mercury water quality data for the tributaries to Pago Pago Inner Harbor.

Table 2-5. Summary of total mercury water quality observations for streams draining to Pago Pago Harbor

Station	Period of Record	Number of Observations	Min (µg/L)	Max (µg/L)	Average (µg/L)	Number of Exceedances*
S1	March 2003 - September 2004	4	0.001	0.0055	0.00385	0
S2	March 2003 - September 2004	4	0.0016	0.0023	0.00195	0
S3	March 2003 - September 2004	4	0.0032	0.0051	0.00435	0
S4	March 2003 - September 2004	4	0.0012	0.0067	0.00275	0
S5	March 2003 - September 2004	4	0.0011	0.0054	0.00238	0

*Exceedances of the human health criterion of 0.05 ug/L in water column (ASWQS 2005).

A comparison of the available water quality mercury data to the applicable human health criterion is presented in Table 2-6. None of the mercury concentrations in Pago Pago Inner Harbor and streams draining to Pago Pago Harbor exceeds the human health criterion. of 0.05 ug/L for mercury in water column (ASWQS 2005).

Table 2-6. Comparison of mercury water quality data to the water quality criteria for Pago Pago Harbor

Pollutant	Water Quality Criteria	Number of Observations	Number of Exceedances	Percent Exceeding
Mercury[a]	0.05 µg/L[b]	51[d]	0	0
Mercury[c]	0.05 µg/L[b]	20	0	0

[a]Samples taken from Pago Pago Inner Harbor
[b]Source: American Samoa human health criterion for mercury in water column (ASWQS 2005)
[c]Samples taken from freshwater tributaries to the harbor
[d]October 1990 total mercury observations were not included in this analysis because of high detection limits.

PCBs

There are no available water quality data for PCBs in Pago Pago Harbor. Due to the bioaccumulation and biomagnification potential of PCBs, the human health criterion is much more stringent than the criterion for protecting aquatic life. The applicable human health water quality criterion for PCBs is 0.000064 µg/L (USEPA 2006 and ASWQS 2005).

2.1.2 Fish Tissue Data

Sediment and water column heavy metals and PCBs may serve as a source of contamination to organisms that live in or on the sediments, and these organisms can in turn become a source of contamination to pelagic species. Because no human health criteria for arsenic or PCBs in fish tissue exist, it was necessary to determine a threshold to evaluate the fish tissue concentrations collected in Pago Pago Inner Harbor. The chosen fish tissue screening targets for arsenic and PCBs are based on USEPA (2000) and California's Office of Environmental Health Hazard Assessment (OEHHA) (1999) values, respectively. These targets, while not considered to be criteria, can be used as benchmarks in the future to help evaluate the progress toward reduced arsenic and PCB levels in fish from Pago Pago Harbor. The fish tissue target for mercury is based on USEPA's recommended human health criterion for fish tissue, taking into consideration of the fish consumption rate which is more relevant to recreational and subsistence fishing in American Samoa (USEPA 2006).

Arsenic

There are 18 available wet weight composite fish tissue samples (whole fish) for inorganic arsenic and 18 composite samples for total arsenic in Pago Pago Inner Harbor. Each composite sample consists of three to five individual fish. Table 2-7 presents a summary of the available arsenic wet weight fish tissue data and Table B-1 in Appendix B presents all of the available data for arsenic in fish tissue. Note that the total arsenic observations were converted to inorganic arsenic concentrations for comparison to the inorganic arsenic fish tissue target. This methodology is explained following Table 2-8.

Table 2-7. Summary of arsenic fish tissue data (wet weight) for Pago Pago Inner Harbor

Fish Type	Period of Record	Number of Observations	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Number of Exceedances*
Caranx papuensis	2005	12	0.00039	0.0935	0.02616	0
Megalaspis cordyla	2005	12	0.00019	0.253	0.09152	0
Mugilidae sp.	2005 and 2002	12	0.00221	0.1298	0.06549	0

*Exceedances of the USEPA (2000) inorganic arsenic fish tissue target of 1.2 mg/kg.

There were also six shellfish samples available for Pago Pago Inner Harbor. There are three inorganic arsenic samples and three total arsenic samples. Table 2-8 presents a summary of the available arsenic wet weight shellfish tissue data and Table B-2 in Appendix B presents all of the available arsenic data for shellfish tissue. Note that as with the fish tissue data, the total arsenic observations for shellfish were converted to inorganic arsenic concentrations for comparison to the inorganic arsenic shellfish tissue target. This methodology is explained following Table 2-8.

Table 2-8. Summary of arsenic shellfish tissue data (wet weight) for Pago Pago Inner Harbor

Fish Type	Period of Record	Number of Observations	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Number of Exceedances*
Asaphis violascens	2002	6	0.216	0.59	0.376	0

*Exceedances of the USEPA (2000) inorganic arsenic fish tissue target of 1.2 mg/kg.

None of the 18 inorganic arsenic samples exceed the 1.2 milligrams per kilogram (mg/kg) wet weight USEPA non-carcinogenic fish tissue target for inorganic arsenic (the screening value is for recreational fishers and is based on a consumption rate of 17.5 grams per day (g/day) and a body weight of 70 kilograms). In the *Draft Human Health Risk Assessment for Consumption of Fish and Shellfish Contaminated with Heavy Metals and Organochlorine Compounds in American Samoa* (EnviroSearch 1994), it was assumed that 10 percent of total arsenic in fish and shellfish was inorganic. The available total arsenic fish tissue data were converted to inorganic fraction using this 10 percent conversion rate (EnviroSearch 1994) and compared with the USEPA (2000) inorganic arsenic screening values. Using the converted results, none of the 18 samples exceed the USEPA's non-carcinogen screening value of 1.2 mg/kg.

The USEPA (2000) fish tissue screening values apply to both finfish and shellfish results; however, additional research was performed to further justify use of these screening values for shellfish. Additional studies determined that shellfish typically contain three to four times more inorganic arsenic than finfish (Donohue and Abernathy 1999). Finfish and shellfish generally have similar inorganic to total arsenic ratios (less than 10-15 percent for both) (Donohue and Abernathy 1999, USEPA 2003); however, some studies have described higher inorganic to total arsenic ratios for shellfish (USEPA 2003). The USEPA inorganic arsenic screening values are based on tissue consumption rates and average body weights.

None of the inorganic arsenic shellfish samples exceed USEPA's inorganic arsenic non-carcinogen screening value of 1.2 mg/kg wet weight. The total arsenic observations were converted to inorganic arsenic using the 10 percent conversion rate (EnviroSearch 1994) for comparison with the USEPA (2000) screening values. When this conversion was performed, none of the samples exceed the non-carcinogen screening value of 1.2 mg/kg.

Tables 2-9 and 2-10 present summaries of the arsenic fish and shellfish tissue data and comparisons with the potential fish and shellfish tissue targets. Results of this comparison indicate that arsenic is not a significant contributor to potential human health risks and thus not a significant contributor to the health advisory issued for consuming fish from Pago Pago Inner Harbor.

Table 2-9. Comparison of arsenic fish tissue data to the fish tissue target for Pago Pago Inner Harbor

Pollutant	Fish Tissue Targets	Number of Observations	Number of Exceedances	Percent Exceeding
Arsenic[a]	1.2 mg/kg[b,c]	18	0	0
Arsenic (converted)[a]	1.2 mg/kg[b,c]	18	0	0

[a]inorganic
[b]Source: USEPA 2000
[c]non-carcinogen target

Table 2-10. Comparison of arsenic shellfish tissue data to the shellfish tissue target for Pago Pago Inner Harbor

Pollutant	Shellfish Tissue Targets (wet wt.)	Number of Observations	Number of Exceedances	Percent Exceeding
Arsenic[a]	1.2 mg/kg[b,c]	3	0	0
Arsenic (converted)[a]	1.2 mg/kg[b,c]	3	0	0

[a]inorganic
[b]Source: USEPA 2000
[c]non-carcinogen target

Mercury

There are 20 total mercury wet weight composite samples for fish tissue. Each composite sample consists of three to five individual fish. There are no methylmercury measurements available. Table 2-11 presents a summary of the available total mercury wet weight fish tissue data and Table B-3 in Appendix B presents all of the available total mercury wet weight data for fish tissue in Pago Pago Inner Harbor.

There are also five wet weight total mercury samples available for shellfish (CH2M Hill 2002). Table 2-12 presents a summary of the total mercury concentrations in shellfish tissue and Table B-4 in Appendix B shows all of the available wet weight total mercury data in shellfish tissue from Pago Pago Inner Harbor.

Table 2-11. Summary of total fish tissue mercury data (wet weight) for Pago Pago Inner Harbor

Fish Type	Period of Record	Number of Observations	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Number of Exceedances
Caranx papuensis	2005	6	0.044	0.481	0.304	4* (3**)
Mugilidae spp.	2005	3	0.008	0.020	0.015	0* (0**)
Mugilidae spp.	2002	3	0.040	0.150	0.080	0* (0**)
Megalaspis cordyla	2005	6	0.098	0.208	0.141	1* (0**)
Serranidae spp.	2002	1	0.670	0.670	0.670	1* (1*)
Mullidae spp.	2002	1	0.400	0.400	0.400	1* (1**)

*Exceedances based on methylmercury fish tissue target of 0.2 mg/kg chosen for Pago Pago Inner Harbor. This fish tissue target is based on a consumption rate of 32 g/day (see Section 1.3.2).
** Exceedances based on default methylmercury fish tissue target of 0.3 mg/kg (USEPA 2006)

Table 2-12. Summary of Shellfish tissue total mercury data (wet weight) for Pago Pago Inner Harbor

Fish Type	Period of Record	Number of Observations	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Number of Exceedances
Asaphis violascens	2002	3	0.070	0.090	0.080	0
Trochus maculatus	2002	1	0.070	0.070	0.070	0
Octopus cyanea	2002	1	0.200	0.020	0.200	0

*Exceedances based on methylmercury fish tissue target of 0.2 mg/kg chosen for Pago Pago Inner Harbor or the default methylmercury fish tissue target of 0.3 mg/kg.

Available methylmercury targets for fish and shellfish tissue are for wet weight, so the results of the wet weight samples were compared to the methylmercury target for fish tissue of 0.2 mg/kg calculated for recreational and subsistence fish consumption in American Samoa (see Section 1.3.2). There are no methylmercury observations available. However, because mercury in fish and shellfish tissue is present primarily as methylmercury, total mercury is often analyzed and a conservative assumption is made that all mercury is present as methylmercury (USEPA 2000). When using this assumption, the data can be compared to the fish tissue target of 0.2 mg/kg. Table 2-13 presents a summary comparison with the chosen fish tissue target. Seven out of the twenty fish tissue samples (35%) have mercury concentration exceeding the target criterion. None of the five shellfish samples have mercury concentration greater than the target level of 0.2 mg/kg. Results of this comparison indicate that mercury is a significant contributor to potential human health risks and thus the health advisory issued for consuming fish from Pago Pago Inner Harbor.

Table 2-13. Comparison of fish and shellfish tissue mercury data (wet weight) to fish tissue target for Pago Pago Harbor

Pollutant	Fish Tissue Targets	Number of Observations	Number of Exceedances	Percent Exceeding
Mercury*	0.2 mg/kg	20	7	35
Mercury**	0.2 mg/kg	5	0	0

* Fish tissue samples
** Shellfish tissue samples

PCBs

The PCB data for fish tissue in Pago Pago Inner Harbor are reported as Aroclors 1254 and 1260. These data were summed to calculate total PCBs. This summation procedure is consistent with past studies, including those by National Oceanic and Atmospheric Association (NOAA), the Southern California Coastal Water Research Project (SCCWRP), and the data assessment associated with Los Angeles Harbor/Dominguez Channel TMDL development.

There are 20 fish tissue composite samples and five shellfish tissue samples being analyzed for PCBs. Summaries of the available PCB fish and shellfish data are presented in Tables 2-14 and 2-15, respectively. All available PCB data for fish and shellfish tissue are presented in Tables B-5 and B-7, respectively in Appendix B. The summed PCB data are presented in Tables B-6 and B-8.

Table 2-14. Summary of available PCB fish tissue data (wet weight)

Fish Type	Period of Record	Number of Observations	Min (µg/kg)	Max (µg/kg)	Average (µg/kg)	Number of Exceedances*
Serranidae spp.	2002	1	520	520	520	1
Mullidae spp.	2002	1	640	640	640	1
Mugilidae spp)	2002 and 2005	6	10	130	52	4
Caranx papuensis	2005	6	82	300	169	6
Megalaspis cordyla	2005	6	94	370	212	6

*Exceedances of the OEHHA and USEPA PCB fish tissue target of 20 ug/kg.

Table 2-15. Summary of available PCB shellfish tissue data (wet weight)

Fish Type	Period of Record	Number of Observations	Min (µg/kg)	Max (µg/kg)	Average (µg/kg)	Number of Exceedances*
Asaphis violascens	2002	3	5	5	5	0
Octopus cyanea	2002	1	50	50	50	1
Trochus maculatus	2002	1	5	5	5	0

*Exceedances of the OEHHA and USEPA PCB fish tissue target of 20 ug/kg.

The PCB data for fish tissue in Pago Pago Harbor are reported as Aroclors 1254 and 1260. These data were summed to calculate total PCBs. The available PCB tissue targets for total PCBs are 20 micrograms per kilogram (ug/kg) (OEHHA 1999 and USEPA 2000). This screening value applies to both finfish and shellfish (USEPA 2000) and is likely even more protective when comparing shellfish data because PCBs generally bioaccumulate in higher trophic level organisms.

Eighteen out of the 20 fish tissue samples (90%) detected PCBs at levels exceeding the OEHHA and USEPA PCB targets of 20 ug/kg. One of the five shellfish tissue samples (20%) had PCBs exceeding the 20 ug/kg target. Tables 2-16 and 2-17 present comparisons of the fish and shellfish data with the chosen fish and shellfish tissue targets, respectively. Results of this comparison indicate that PCBs are significant contributors to potential human health risks and thus the health advisory issued for consuming fish from Pago Pago Inner Harbor.

Table 2-16. Comparison of PCB fish tissue data to fish tissue target for Pago Pago Harbor

Pollutant	Fish Tissue Targets	Number of Observations	Number of Exceedances	Percent Exceeding
PCBs	20 ug/kg[a,b]	20	18	90

[a]Source: USEPA 2000
[b]Source: OEHHA 1999

Table 2-17. Comparison of PCB shellfish tissue data to shellfish tissue target for Pago Pago Harbor

Pollutant	Shellfish Tissue Targets (wet wt.)	Number of Observations	Number of Exceedances	Percent Exceeding
PCBs	20 ug/kg[a,b]	5	1	20

[a]Source: USEPA 2000
[b]Source: OEHHA 1999

2.1.3 Sediment Data

Monitoring data are also available for arsenic, mercury and PCBs in the sediments from Pago Pago Inner Harbor. An evaluation of these data is described below.

As stated earlier, heavy metals in the sediment may serve as a source of contamination to organisms that live in or on the sediments, and these organisms can in turn become a source of contamination to pelagic species. Because no human health criteria for arsenic, mercury or PCBs in sediment exist, it is necessary to select a threshold to evaluate concentrations detected in sediments collected from Pago Pago Inner Harbor. The chosen sediment targets (dry weight) for arsenic, mercury and PCBs are based on the Effects Range Low (ERL) values for aquatic organisms (Long et al. 1995). An ERL corresponds roughly to a 10% likelihood of observing toxicity in aquatic organisms. Adverse effects on organisms are rarely observed when concentrations fall below the ERL value. These sediment targets were chosen as the TMDL targets/endpoints for mercury and PCB in Pago Pago Inner Harbor. See Section 4.1 for more detail.

Note that the difference between the dry weight sediment samples and the dry weight core sediment samples for arsenic, mercury, and PCBs presented below is that the dry weight sediment samples were only collected at one depth at each sampling location while the dry weight core samples were collected at multiple depth intervals at each sampling location.

Arsenic

There are 40 dry weight arsenic sediment samples from Pago Pago Inner Harbor. These 40 samples do not include dry weight core samples, which are discussed below. Table 2-18 presents a summary of the available dry weight arsenic sediment samples and Table C-1 in Appendix C presents all of the available dry weight arsenic sediment data for Pago Pago Inner Harbor.

Table 2-18. Summary of available total arsenic sediment data (dry weight)

Station	Period of Record	Number of Observations	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Number of Exceedances*
4	October 2001	1	10	10	10	1
Fagatogo	1993	1	5.7	5.7	5.7	0
FD	October 2001	1	7.6	7.6	7.6	0
IH-1	October 1993 – February 2004	6	1.7	32.4	17.75	4
IH-1B	October 2001	1	8.1	8.1	8.1	0
IH-1C	October 2001	1	6.8	6.8	6.8	0
IH-2	October 1993 – February 2004	6	4.7	16.6	10.82	4
IH-3	October 1993 – February 2004	6	3.4	6.5	4.58	0
IH-3A	October 2001	1	7.1	7.1	7.1	0
Marine Sediment Station, SWM38	1997	1	15.2	15.2	15.2	1
Marine Sediment Station, SWM39	1997	1	15.5	15.5	15.5	1
Pago Pago	1993	1	7	7	7	0
STS-25	February 2004	1	9.1	9.1	9.1	1
STS-29	February 2004	1	16.6	16.6	16.6	1
STS-30	February 2004	1	32.4	32.4	32.4	1
STS-31	February 2004	1	10.9	10.9	10.9	1
STS-31A	February 2004	1	10.2	10.2	10.2	1
STS-34	February 2004	1	9.9	9.9	9.9	1
STS-42	February 2004	1	8.3	8.3	8.3	1
STS-43	February 2004	1	17.8	17.8	17.8	1
STS-43A	February 2004	1	11.3	11.3	11.3	1
STS-44A	February 2004	1	12.0	12.0	12.0	1
STS-48	February 2004	1	4.4	4.4	4.4	0
SW marine	1993 - October 2001	2	4.1	8.5	6.3	1

*Exceedances of the ERL arsenic sediment target of 8.2 mg/kg

Core sediment samples (dry weight) were also collected and analyzed for arsenic at 6 locations in the inner harbor in March 2005. Table 2-19 presents a summary of the dry weight arsenic core sample data and Table C-2 in Appendix C presents all of the available dry weight arsenic core sample data. A total of 24 core samples were collected at depths between 0 and 127 cm.

Data from the 40 dry weight arsenic sediment samples were compared to the effects range low (ERL) sediment target of 8.2 mg/kg (Long et al. 1995). Twenty two of the 40 (55%) dry weight sediment samples and 23 of the 24 (96%) dry weight core samples exceed the arsenic ERL of 8.2 mg/kg. Tables 2-20 and 2-21 present summaries of the comparison of available dry weight arsenic sediment data to the dry weight sediment target for arsenic.

Table 2-19. Summary of available core sample arsenic data for Pago Pago Inner Harbor (dry weight)

Station	Period of Record	Number of Observations	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Number of Exceedances*
STC-10A	March 2005	1	12.1	12.1	12.1	1
STC-10B	March 2005	1	11.8	11.8	11.8	1
STC-10C	March 2005	1	12.2	12.2	12.2	1
STC-11A	March 2005	1	10.3	10.3	10.3	1
STC-11B	March 2005	1	12.5	12.5	12.5	1
STC-11C	March 2005	1	9.58	9.58	9.58	1
STC-4A	March 2005	3	5.89	89	60.23	2
STC-4C	March 2005	1	9.17	9.17	9.17	1
STC-4E	March 2005	1	11.3	11.3	11.3	1
STC-5A	March 2005	1	9.8	9.8	9.8	1
STC-5B	March 2005	1	11.4	11.4	11.4	1
STC-5C	March 2005	1	13.3	13.3	13.3	1
STC-5D	March 2005	1	13.3	13.3	13.3	1
STC-5E	March 2005	1	12.1	12.1	12.1	1
STC-8A	March 2005	1	14.3	14.3	14.3	1
STC-8C	March 2005	1	9.23	9.23	9.23	1
STC-8E	March 2005	1	9.8	9.8	9.8	1
STC-9A	March 2005	3	10.5	116	45.93	3
STC-9B	March 2005	1	9.97	9.97	9.97	1
STC-9C	March 2005	1	11	11	11	1

*Exceedances of the ERL arsenic sediment target of 8.2 mg/kg

Table 2-20. Comparison of sediment arsenic data to sediment target for Pago Pago Inner Harbor (dry weight)

Pollutant	Sediment Targets	Number of Observations	Number of Exceedances	Percent Exceeding
Arsenic	8.2 mg/kg[a]	40	22	55

[a]ERL – effects range low (Long et al. 1995)

Table 2-21. Comparison of sediment core sample arsenic data to target for Pago Pago Inner Harbor (dry weight)

Pollutant	Sediment Targets	Number of Observations	Number of Exceedances	Percent Exceeding
Arsenic	8.2 mg/kg[a]	24	23	96

[a]ERL – effects range low (Long et al. 1995)

Mercury

Between 1993 and February 2004, there are a total of 32 dry weight sediment mercury samples being collected at 18 sampling locations in Pago Pago Inner Harbor. A summary of the available dry weight sediment mercury data is presented in Table 2-22 and all of the available dry weight mercury data for sediments in Pago Pago Inner Harbor are presented in Table C-3 in Appendix C.

Table 2-22. Summary of available sediment sample mercury data (dry weight)

Station	Period of Record	Number of Observations	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Number of Exceedances*
4	October 2001	1	0.084	0.084	0.084	0
Fagatogo	1993	1	<0.07	<0.07	<0.07	0
FD	October 2001	1	0.091	0.091	0.091	0
IH-1	October 1993 – October 2001	4	0.14	0.81	0.4235	3
IH-1B	October 2001	1	0.45	0.45	0.45	1
IH-1C	October 2001	1	0.33	0.33	0.33	1
IH-2	October 1993 – February 2004	6	0.083	0.33	0.1685	3
IH-3	October 1993 – February 2004	6	0.02	0.065	0.038	0
IH-3A	October 2001	1	0.054	0.054	0.054	0
Marine Sediment Station, SWM38	1997	1	0.38	0.38	0.38	1
Marine Sediment Station, SWM39	1997	1	0.22	0.22	0.22	1
Pago Pago	1993	1	<0.18	<0.18	<0.18	0
STS-25	February 2004	1	0.161	0.161	0.161	1
STS-29	February 2004	1	0.189	0.189	0.189	1
STS-42	February 2004	1	0.112	0.112	0.112	0
STS-44A	February 2004	1	0.178	0.178	0.178	1
STS-48	February 2004	1	0.036	0.036	0.036	0
SW marine	1993 - October 2001	2	0.13	0.31	0.22	1

*Exceedances of the ERL mercury sediment target of 0.15 mg/kg

A total of 24 dry weight sediment core samples for analysis of mercury were collected in March 2005 at depths ranging from 0 to 127 cm at 6 locations in Pago Pago Inner Harbor. Table 2-23 presents a summary of the available dry weight core sample mercury data and Table C-4 in Appendix C presents all of the available dry weight core sample mercury data for Pago Pago Inner Harbor. Note that there are some methylmercury data available, however, they are not included in Table 2-22 or Table C-4 because no methylmercury sediment targets are available for comparison.

Fourteen of the 32 sediment samples (44%) and seven of the 24 core samples (29%) detected mercury concentrations at levels exceeding the ERL of 0.15 mg/kg. Tables 2-24 and 2-25 present a comparison of available dry weight mercury sediment data to the chosen dry weight sediment target.

Table 2-23. Summary of available sediment core sample mercury data for Pago Pago Inner Harbor (dry weight)

Station	Period of Record	Number of Observations	Min (mg/kg)	Max (mg/kg)	Average (mg/kg)	Number of Exceedances*
STC-10A	March 2005	1	0.267	0.267	0.267	1
STC-10B	March 2005	1	0.057	0.057	0.057	0
STC-10C	March 2005	1	0.018	0.018	0.018	0
STC-11A	March 2005	1	0.217	0.217	0.217	1
STC-11B	March 2005	1	0.028	0.028	0.028	0
STC-11C	March 2005	1	0.01	0.01	0.01	0
STC-4A	March 2005	3	0.073	0.362	0.170333	1
STC-4C	March 2005	1	0.041	0.041	0.041	0
STC-4E	March 2005	1	0.031	0.031	0.031	0
STC-5A	March 2005	1	0.126	0.126	0.126	0
STC-5B	March 2005	1	0.33	0.33	0.33	1
STC-5C	March 2005	1	0.084	0.084	0.084	0
STC-5D	March 2005	1	0.112	0.112	0.112	0
STC-5E	March 2005	1	0.097	0.097	0.097	0
STC-8A	March 2005	1	0.368	0.368	0.368	1
STC-8C	March 2005	1	0.282	0.282	0.282	1
STC-8E	March 2005	1	0.008	0.008	0.008	0
STC-9A	March 2005	3	0.121	0.575	0.278667	1
STC-9B	March 2005	1	0.022	0.022	0.022	0
STC-9C	March 2005	1	0.008	0.008	0.008	0

*Exceedances of the ERL mercury sediment target of 0.15 mg/kg

Table 2-24. Comparison of sediment mercury data to the sediment target for Pago Pago Inner Harbor (dry weight)

Pollutant	Sediment Targets	Number of Observations	Number of Exceedances	Percent Exceeding
Mercury	0.15 mg/kg[a]	32	14	44

[a]ERL – effects range low (Long et al. 1995)

Table 2-25. Comparison of sediment core sample mercury data to the sediment target for Pago Pago Inner Harbor (dry weight)

Pollutant	Sediment Targets	Number of Observations	Number of Exceedances	Percent Exceeding
Mercury	0.15 mg/kg[a]	24	7	29

[a]ERL – effects range low (Long et al. 1995)

PCBs

The dry weight PCB data for sediment in Pago Pago Inner Harbor are reported as Aroclors (1016, 1221, 1232, 1242, 1248, 1254, and 1260). These data were summed to calculate total PCBs at each sample location. There are 15 dry weight PCB samples for sediment that were collected in October 2001, February 2004 and March 2005 at 9 sampling stations. Table 2-26 presents a summary of the available dry weight sediment PCB data for the Inner harbor and Table C-5 in Appendix C presents all of the available dry weight sediment PCB data for Pago Pago Inner

Harbor. Table C-6 presents the summed dry weight sediment PCB data.

Table 2-26. Summary of available PCB sediment data for Pago Pago Inner Harbor (dry weight)

Station	Period of Record	Number of Observations	Min (µg/kg)	Max (µg/kg)	Average (µg/kg)	Number of Exceedances*
FD	October 2001	1	43	43	43	1
IH-3	October 2001	2	37	59	48	2
IH-3A	October 2001	1	330	330	330	1
STS-11	February 2004	1	2.7	2.7	2.7	0
STS-25	February 2004	1	44	44	44	1
STS-34	February 2004	1	48	48	48	1
STS-42	February 2004	1	39	39	39	1
STS-44A	February 2004	1	85	85	85	1
STS-8A	March 2005	1	780	780	780	1
STS-8C	March 2005	1	18	18	18	0
STS-8E	March 2005	1	2.5	2.5	2.5	0
STS-9A	March 2005	1	34	34	34	1
STS-9B	March 2005	1	2.4	2.4	2.4	0
STS-9C	March 2005	1	2.3	2.3	2.3	0

*Exceedances of the ERL PCB sediment target of 22.7 ug/kg.

The chosen dry weight sediment target for total PCBs is ERL of 22.7 ug/kg. When compared to the target for PCBs in sediment, 10 of the 15 PCB sediment observations (67 percent) exceed the ERL target. Table 2-27 presents a summary of the comparison of available dry weight sediment PCB data to the chosen target.

Table 2-27. Comparison of PCB sediment data to the sediment target for Pago Pago Harbor (dry weight)

Pollutant	Sediment Targets	Number of Observations	Number of Exceedances	Percent Exceeding
PCBs	22.7 ug/kg[a]	15	10	67

[a]ERL – effects range low (Long et al. 1995)

3.0 SOURCE ASSESSMENT

This section provides an inventory and description of all potential point and nonpoint sources of mercury and PCBs in the Pago Pago Inner Harbor watershed. Note specific arsenic sources are not described in this section because the detected arsenic most likely comes from natural sources (volcanic parent material of American Samoa) and a TMDL was not developed for this chemical (see Section 1.1).

3.1 Assessment of Point Sources

For more than thirty years, the Star-Kist (AS0000019) and COS (AS0000027) tuna canneries have operated in the villages of Anua and Atua on the northern shore of the inner harbor. Prior to 1992, high strength waste from the canneries has been disposed of at sea. Since 1992, low strength waste has been pumped to an outfall in the outer harbor. Therefore, neither of the canneries currently discharges wastes to the inner harbor. Water quality in the harbor has improved dramatically since the segregation and removal of wastes was completed.

There are two facilities, the Satala Power Plant (SPP) and Southwest Marine of Samoa, Inc. (SMSI), that are permitted to discharge stormwater to the inner harbor. Current NPDES permits for SPP and SMSI became effective on May 8, 2004 and January 7, 2003, respectively, for five years. The SPP is considered a minor discharger and SMSI has been reclassified from a minor discharger to a discretionary major discharger due to the potential for toxic materials to enter the stormwater. There are no other NPDES or stormwater permitees in the watershed.

The Satala Power Plant (AS0020044). The Satala Power Plant discharges treated stormwater from two oil-water separators to Pago Pago Inner Harbor. There are few data for this facility and historically there is very rarely a discharge. When there is a discharge, it is very small. The Satala Power Plant does not have permit effluent limits for PCBs or mercury and does not currently monitor for PCBs or mercury.

Southwest Marine of Samoa, Inc. (AS0020036). A large amount of boat traffic associated with the military and cannery operations has necessitated a shipyard for painting and repairing being operated by the Southwest Marine of Samoa, Inc. in the village of Satala on the northern shore of the inner harbor. Activities at this facility include sandblasting and painting of ship hulls, as well as service and repair of ship engines. Wastes generated by the activities include spent sand blast grit, waste oil, and rubbish. This facility's current permit contains three discharge points to the Pago Pago Inner Harbor from the shoreline. Two of these are stormwater runoff from the ground and paved areas and one is from the oil-water separator that treats stormwater from the storage tank containment area. Discharging PCBs is not included in SWSI's permit, therefore, no effluent limit or monitoring of PCBs is required. SMSI's permit sets a daily maximum effluent limit for mercury at 2.1 ug/L and requires grab sampling quarterly. Data for this facility are sparse. Information submitted by the facility in their last permit application indicates that mercury of 1.0 ug/L was detected at the only Outfall 001 permitted under the previous permit.

3.2 Assessment of Nonpoint Sources

Data to evaluate nonpoint sources of mercury and PCBs in the Pago Pago Inner Harbor watershed are limited. There are no available PCBs water quality data and mercury is detected in the water column, but not in significant amounts. Review of the available data does not identify a definitive or active watershed source of mercury or PCBs to the harbor. These impairments are likely a legacy issue from past uses of the harbor and the land surrounding it. Volcanoes can also be a natural source of mercury. In addition to historical sources, atmospheric mercury is thought to be a potential source of mercury in American Samoa. There is currently an ASEPA study underway to characterize mercury contamination in the territory (Peshut and Brooks 2005).

It is assumed that the sediments in the harbor bear a historical burden of mercury and PCBs from previous industrial and military activities in the watershed as well as natural sources (volcanic soils) of mercury. Past activities in the watershed such as military uses and improper disposal of rubbish (e.g., batteries, etc.) are likely sources of historically accumulated mercury and PCBs.

Additionally, because the drainage area of the harbor is small compared to its size, it seems unlikely that the tributary inflows (of water or sediment) would noticeably influence harbor conditions beyond localized effects at stream mouths. Review of available stream data from the streams that discharge to Pago Pago Harbor do not show elevated concentrations of either of the pollutants of concern, indicating that the surrounding watershed does not contain the major source(s) of mercury or PCBs. Current watershed or tributary sources, if any, of mercury- or PCB-contaminated sediments are not believed to be the significant contributors responsible for the widespread contamination of harbor sediments. It is believed that the primary source of mercury and PCBs contaminating harbor fish is historically accumulated bottom sediments.

There are no specific identifiable sources of mercury or PCBs, and these two pollutants are likely either naturally occurring or legacy issues. It must be assumed that the contaminants of concern will naturally attenuate over time or can be removed through remedial actions. According to the Tier 2 Fish Toxicity study, Pago Pago Harbor’s sediment data indicate that some contaminants of concern appear to have peak concentrations below the sediment surface, suggesting decreased, if any, inputs in recent years (Peshut and Brooks 2005).

4.0 LINKAGE ANALYSIS

This section discusses the method for linking pollutant loading to the TMDL endpoint. The method establishes the cause-and-effect relationship between the TMDL endpoint and the pollutant sources using the available data. Identifying this relationship allows for the determination of the allowable pollutant load or concentration that can be assimilated by the waterbody while still meeting the applicable endpoint or targets.

4.1 Selection of TMDL Endpoints

The TMDL endpoint represents the numeric target for the pollutant(s) of concern. Pago Pago Inner Harbor was included on American Samoa's 2004 section 303(d) list due to an impairment of the designated use of recreational and subsistence fishing. The mercury and PCB listings were based solely on fish tissue levels. Therefore, the applicable water quality standard for PCBs is not an adequate target for the PCBs TMDLs. The Tier 2 toxicity study conducted by Peshut and Brooks (2005) supports the 2004 listing, indicating potential human health risks associated with the consumption of mercury and PCB-contaminated fish from the inner harbor.

Mercury and PCBs accumulated in marine sediments can result in methylmercury and PCB contamination of fish. Uptake of mercury and PCBs by aquatic organisms can include direct contact or ingestion of contaminated bottom sediments and biomagnification through the food chain. Because of this sediment – fish tissue link, the Pago Pago Inner Harbor TMDLs were developed to meet and maintain the sediment ERLs for mercury and PCBs. It is anticipated that maintenance of these sediment targets will support the designated uses of recreational and subsistence fishing by corresponding to levels of mercury and PCBs in sediment and fish that will not pose a human health risk.

To account for a margin of safety (see Section 5.3) in this TMDL analysis, the TMDL target/endpoint is established at a concentration 15 percent lower than the sediment ERL for mercury and PCBs. The resulting sediment targets for the mercury and PCB TMDLs for Pago Pago Inner Harbor are presented in Table 4-1.

Table 4-1. Sediment targets for mercury and PCB TMDLs in Pago Pago Inner Harbor

Pollutant of Concern	Sediment ERL	Sediment Target[a]
Mercury	0.15 mg/kg	0.1275 mg/kg
PCBs	22.7 ug/kg	19.295 ug/kg

ERL – Effect Range Low
[a]Sediment concentration that is 15 percent lower than the sediment ERL.

Since the section 303(d) listings for mercury and PCBs were based on fish tissue levels, not sediment levels or water quality exceedances, the fish tissue targets that were used to evaluate the tissue concentrations of fish collected from Pago Pago Inner Harbor can be used as alternate TMDL endpoints in addition to the endpoints based on sediment concentrations. The fish tissue targets can be used as benchmarks to help evaluate the progress toward reduced mercury and PCB levels in fish from Pago Pago Harbor. The fish tissue targets for mercury and PCBs are presented in Table 4-2 and are also discussed in Sections 1.3.2, and 2.1.2.

Table 4-2. Alternate TMDL endpoints for fish tissue

	Pollutant	
	Mercury (mg/kg)	**PCBs (ug/kg)**
Fish Tissue	0.2[a]	20[bc]

[a] An endpoint based on a fish consumption rate of 32 g/day.
[b] OEHHA 1999
[c] USEPA 2000

5.0 ALLOCATIONS

This section quantifies the wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources of mercury and PCBs to the inner harbor necessary for attainment of the sediment TMDL targets. This section also discusses the incorporation of a margin of safety and critical conditions in the TMDL analysis as well as the consideration of seasonality.

The TMDLs for mercury and PCBs for Pago Pago Inner Harbor are sediment concentration-based due to the lack of sediment load data for the harbor. The TMDLs for mercury and PCBs are presented in Table 5-1 and the allocations of the TMDL among the point and nonpoint sources are presented Sections 5.1 and 5.2. The existing average sediment concentration was based on the arithmetic mean f all available dry-weight mercury and PCB sediment and sediment core samples from Pago Pago Inner Harbor (see Tables C-3 through C-6 in Appendix C). The TMDL is equal to the TMDL targets for mercury and PCBs in sediment, based on mercury and PCB sediment ERLs minus a 15 percent for margin of safety (MOS). Table 5-1 shows a reduction of 22% and 81% is needed for mercury and PCBs in sediment, respectively.

Table 5-1. TMDLs for mercury and PCBs for Pago Pago Inner Harbor

Pollutant of Concern	Existing Average Sediment Concentration*	TMDL	Percent Reduction (%)
Mercury	0.1631 mg/kg	0.1275 mg/kg	22
PCBs	101.79 ug/kg	19.295 ug/kg	81

*Average sediment concentration based on the average of all available dry-weight sediment data for Pago Pago Inner Harbor

As mentioned in Section 4.1, mercury TMDL target can be alternatively established by using fish tissue target level of 0.2 mg/kg for human health protection. Based on the existing limited fish tissue data from the study by Peshut and Brooks (2005), the geometric mean mercury concentration in the larger fish species (i.e. Caranx papuensis) is 0.234 mg/kg. Using geometric mean is considered appropriate for a sample size that is relatively small (six composite samples with three fish in each composite). Based on this alternative approach, approximately 15% reduction in fish tissue mercury concentration is needed, compared to 22% reduction needed in sediment concentration, to achieve the target level. The two approaches that can be used in setting TMDL target levels are relatively consistent with each other, with sediment concentration-based target level chosen for Pago Pago Inner Harbor being more protective of human health than the fish tissue concentration-based target level.

5.1 Wasteload Allocations

There are two potential point sources of mercury and PCBs in Pago Pago Inner Harbor. These sources are the Satala Power Plant (SPP) (NPDES AS0020044) and Southwest Marine of Samoa, Inc. (SMSI) (NPDES AS0020036). SPP does not have permit limits for mercury or PCBs and does not monitor for either parameter. It is recommended that prior to the next NPDES permit renewal, this facility conduct adequate and appropriate mercury, including methylmercury, and PCB monitoring of their effluent to determine whether or not their discharge contains mercury and/or PCBs. SMSI has a daily maximum permit limit of 2.1 µg/L for mercury, but does not have a permit limit for PCBs and does not currently monitor for PCBs. As with the SPP, it is recommended that prior to the next NPDES permit renewal, SMSI conduct PCB, in addition to mercury and methylmercury, monitoring of their effluent to determine whether or not their discharge contains PCBs.

Wasteload allocations (WLAs) for the two point source facilities are derived from the concentration-based water quality criteria for mercury at 0.05 ug/L (ASWQS 2005) and PCBs at 0.000064 µg/L (USEPA 2006) minus a 15% margin of safety (MOS), resulting in WLAs of 0.0425 and 0.0000544 ug/L for mercury and PCBs, respectively. In addition, these facilities are required to develop and implement Pollutant Minimization Plans (PMPs). These WLAs are the monthly average effluent concentrations allowed for the discharges from the facilities. Monthly average effluent level is defined as the sum of all values obtained within a single month, divided by that number of values; if insufficient data exist, monthly averages may be further averaged over the previous 12 months of monthly values, as defined above**.** Since average monthly current effluent levels are unknown, monitoring data need to be obtained using relevant and appropriate USEPA Methods to determine the effluent value of mercury, methylmercury, and PCBs from each facility. Pollutant Minimization Plans should include the following as appropriate:

1. The identification and evaluation of current and potential sources of mercury and PCBs.
2. Monitoring to confirm current or potential sources of mercury and PCBs.
3. The identification of potential methods for reducing or eliminating mercury or PCBs, including requiring Best Management Practices (BMPs) or assigning limits to all potential sources of mercury or PCBs to a collection system, material substitution, materials recovery, spill control and collection, waste recycling, process modifications, housekeeping and laboratory use and disposal practices, and public education.
4. Implementation of appropriate minimization measures identified in the plan.
5. Monitoring to verify the results of pollution minimization efforts.

If it is determined through appropriate monitoring data using USEPA Methods that one or both of the facilities does not discharge quantifiable levels of mercury or PCBs, no further actions are required.

Note that although the TMDL is based on sediment concentrations of mercury and PCBs, the WLAs are based on the water concentrations of mercury and PCBs in facilities' effluent. It is assumed that these WLAs will support Pago Pago Harbor's water quality standards as well as the sediment TMDL targets. Table 5-2 presents the WLAs for the two NPDES facilities.

Table 5-2. Wasteload allocations for mercury and PCBs

Facility	PCB WLA*	Hg WLA*
Satala Power Plant	0.0000544 ug/L	0.0425ug/L plus PMP
Southwest Marine of Samoa, Inc.	0.0000544 ug/L	0.0425 ug/L plus PMP

PMP – Pollutant Minimization Plan
*15 percent MOS applied to the water quality criteria of 0.000064 ug/L for PCB (USEPA 2006) and 0.05 ug/L for mercury (ASWQS 2005)

5.2 Load Allocations

The load allocation (LA) is applied to the known existing nonpoint sources in the Pago Pago Inner Harbor watershed. The load allocations for mercury and PCBs are all allocated to bottom sediments of the harbor. The load allocations include any natural background loading of mercury. Currently, there are not enough data to determine mercury or PCB loading from the surrounding watershed. There is a very limited amount of mercury water quality data for tributaries to the harbor (four observations per tributary) and no water column data for PCBs in the harbor or the tributaries. Therefore, tributary inflows are not specifically accounted for in the TMDL analysis. Because the watershed drainage area is small relative to the size of the harbor, the likely effect of tributary inflows is small compared to in-harbor sources. It is assumed that the margin of safety used in setting the TMDL target is reasonable to account for any uncertainty in evaluating source loadings from streams draining to the inner harbor (see Section 5.3).

The LA is equal to the TMDL because the harbor sediments are currently the only likely source of mercury and PCBs contributing to the high levels of mercury and PCBs in fish tissue. Table 5-3 presents the LAs for mercury and PCBs in Pago Pago Inner Harbor.

Table 5-3. Load allocations for mercury and PCBs

Pollutant of Concern	Load Allocation
Mercury	0.1275 mg/kg
PCBs	19.295 ug/kg

A summary of the TMDLs, load allocations, and wasteload allocations for mercury and PCBs for the Pago Pago Inner Harbor is shown in Table 5-4.

Table 5-4. TMDLs for mercury and PCBs for Pago Pago Inner Harbor

Pollutant of Concern	TMDL (mg/kg)	LA (mg/kg)	WLA (ug/L)	Pollutant Reduction (%)
Mercury	0.1275	0.1275	0.0425 plus PMP	22
PCBs	0.0193	0.0193	0.0000544 plus PMP	81

LA – Load allocation
WLA – Waste load allocation
PMP – Pollutant Minimization Plan
* Sediment concentration based on the average of all available dry-weight sediment data for Pago Pago Inner Harbor

5.3 Margin of Safety

The margin of safety (MOS) accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and sediment quality. The MOS can either be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loadings). For the Pago Pago Inner Harbor TMDLs, the MOS was incorporated into conservative assumptions in establishing the ERLs as well as an explicit 15 percent MOS. .

The applicable sediment effects range low (ERLs) for mercury and PCBs in the inner harbor are 0.15 mg/kg and 22.7 ug/kg, respectively. To account for a MOS, the ERLs were reduced by 15%

to establish sediment targets of 0.1275 mg/kg for mercury and 19.295 ug/kg for PCBs. Tributary inflows are not specifically accounted for in the TMDL analysis. Because the watershed drainage area is small relative to the size of the harbor, the likely effect of tributary inflows is small compared to in-harbor sources. It is assumed that a 15% MOS used in setting the TMDL targets is reasonable to account for any uncertainty in evaluating source loadings from streams draining to the inner harbor.

An explicit 15% MOS was also applied to the WLAs for mercury and PCBs from the Satala Power Plant and Southwest Marine of Samoa, Inc. to account for any uncertainty in linking the water quality standard- and permit-based WLAs to the sediment TMDL. The applicable water quality standard or criterion for mercury and PCBs in the harbor is 0.05 ug/L and 0.000064 µg/L, respectively. These targets are reduced by 15% to provide the WLAs for mercury at 0.0425 ug/L and PCBs at 0.0000544 ug/L for both of these two NPDES facilities. WLAs for mercury and PCBs are based on monthly average effluent concentration plus development and implementation of Pollutant Minimization Plans (PMPs). Development and implementation of PMPs at the two point sources in the area will reduce loading, if any, of mercury and PCBs from these facilities.

5.4 Critical Conditions

Mercury and PCBs accumulated in bottom sediments can result in methylmercury and PCB contamination of fish. Uptake of mercury and PCBs by aquatic organisms, including fish, includes direct contact or ingestion of contaminated bottom sediments and biomagnification through the food chain. Because these uptake pathways and contamination mechanisms occur at any time, there is no specific critical condition related to the pathways of impairment.

5.5 Seasonality

Based on available data, there is no identifiable seasonal variation in mercury and PCB loadings, water quality, or sediment response or effects on designated uses for Pago Pago Inner Harbor.

6.0 IMPLEMENTATION

Due to the limited information to identify specific sources in the watershed, it is assumed that the historical accumulation of mercury and PCBs in harbor sediments is the primary source of mercury and PCBs in Pago Pago Inner Harbor. It is expected that mercury and PCB levels in the harbor will decline over time due to natural attenuation. Contaminated sediments will be covered with less contaminated sediments, reducing the availability of mercury and PCBs in the sediments. It is currently unknown how long this attenuation process will take, but continued sediment and fish tissue monitoring at the same locations over time in the harbor will provide a better understanding of the process (see section 6.1).

Waste load allocations to the Satala Power Plant (SPP) and Southwest Marine of Samoa, Inc. (SMSI) will be implemented through NPDES permits for these facilities and implementation of Pollutant Minimization Plans. Among others, the current NPDES permits set monitoring frequency and effluent limitations, and require the development and implementation of Best Management Practices. The American Samoa Environmental Protection Agency (ASEPA) and USEPA will ensure facilities' compliance with their respective NPDES permits. ASEPA and USEPA recommend that adequate monitoring of mercury and PCBs in effluent be conducted to ensure that concentration of these two pollutants does not exceed water quality standards. Furthermore, prior to the renewal of their respective permits, SPP and SMSI should conduct appropriate monitoring of mercury (including methylmercury) and PCBs to acquire adequate data of their monthly average effluent concentrations of these pollutants. Future permit renewal should set more stringent effluent concentration limits that correspond to the WLAs established in this TMDL document; include monitor of mercury, PCBs, and other potential pollutants of concern; and ensure consistency with the TMDLs and wasteload allocations established in this document.

In addition to updating, issuing and enforcing NPDES permits to ensure minimal discharge, if any, of mercury and PCBs from point sources, one can consider physical removal of contaminated sediments. However, removal of contaminated sediment may be infeasible at this time due to prohibited cost and concerns for contaminant resuspension. Removal options might be considered in the future when cost and technology are deemed feasible.

6.1 Follow-up Monitoring

ASEPA and USEPA's Pacific Island Office suggest continued monitoring of the sediment, water column and fish tissue for the marine environment of Pago Pago Inner Harbor. The work will be undertaken by ASEPA and a contractor. It is suggested that monitoring be conducted for the sediment, water column, and fish tissue in 2008, 2011 and 2014.

The contaminants to be monitored will include mercury, PCBs, and any other pollutants that deemed appropriate based on the on-going and continuing water quality and watershed monitoring, investigations and projects. In 2015, a comprehensive project report will be prepared that will contain results, discussion, and recommendations with regard to the TMDLs.

6.2 Public Participation

This TMDL was developed under contract to USEPA for the ASEPA. The ASEPA provided the TMDL for public review and comment for thirty (30) days on November 13, 2006. There were no comments and additional information submitted during this public comment period. ASEPA submits this final TMDL document to USEPA for approval. The ASEPA will implement the final TMDLs approved by USEPA.

7.0 REFERENCES

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APPENDIX A
Water Quality Data

Table A-1. Available total arsenic water quality data for Pago Pago Inner Harbor

Date	Station	Depth	Arsenic (µg/L)	Source
Oct-90	Inner Harbor Site 1	NA	<10	a
	Inner Harbor Site 1	NA	<10	a
	Inner Harbor Site 4	NA	<10	a
	Inner Harbor Site 4	NA	<10	a
Mar-01	11	1	1.30	b
	11	2	1.90	b
	11	3	1.50	b
	13	1	1.50	b
	13	2	1.30	b
	13	3	1.50	b
Oct-01	11	1	1.80	b
	11	2	2.10	b
	11	3	2.10	b
	12	1	1.80	b
	12	2	1.90	b
	12	3	1.90	b
	13	1	1.80	b
	13	2	10.10	b
	13	3	2.00	b
	11A	1	1.80	b
	11A	2	1.90	b
	11A	3	1.90	b
Mar-02	11	1	1.00	b
	11	2	1.01	b
	11	3	1.03	b
	13	1	1.03	b
	13	2	1.02	b
	13	3	1.10	b
Aug-02	11	1	2.70	b
	11	2	2.70	b
	11	3	2.80	b
	13	1	2.20	b
	13	2	3.10	b
	13	3	3.30	b
Mar-03	13	1	1.50	b
	13	2	1.50	b
	13	3	1.40	b
Aug-03	11	1	1.75	b
	11	2	1.52	b
	11	3	1.46	b
	13	1	1.47	b
	13	2	1.39	b
	13	3	1.60	b

Date	Station	Depth	Arsenic (µg/L)	Source
Feb-04	13	1	0.98	b
	13	2	1.13	b
	13	3	0.84	b
Sep-04	13	1	0.73	b
	13	2	0.89	b
	13	3	0.97	b
Feb-05	11	1	1.35	b
	11	2	1.31	b
	11	3	1.30	b
	13	1	1.20	b
	13	2	1.24	b
	13	3	1.26	b

[a]AECOS (1991) data from Table 3-20 in *Data Review to Support the Water Quality Monitoring Strategy for Pago Pago Harbor, American Samoa* (gdc 2003)
[b]Receiving Water Quality Monitoring Data (CH2M Hill 2006a)

Table A-2. Available total arsenic water quality data for tributaries to Pago Pago Harbor

Date	Station	Arsenic (µg/L)	Source
Mar-03	S1	0.50	*
	S2	1.30	*
	S3	0.50	*
	S4	1.40	*
	S5	0.80	*
Aug-03	S1	0.31	*
	S2	2.32	*
	S3	0.52	*
	S4	0.37	*
	S5	1.99	*
Feb-04	S1	0.45	*
	S2	1.05	*
	S3	0.55	*
	S4	0.63	*
	S5	0.93	*
Sep-04	S1	0.30	*
	S2	2.33	*
	S3	0.69	*
	S4	0.7	*
Sep-04	S5	11.70	*

* Receiving Water Quality Monitoring Data (CH2M Hill 2006a)

Table A-3. Available total mercury water quality data for Pago Pago Inner Harbor

Date	Station	Depth	Mercury (µg/L)	Source
Oct-90	Inner Harbor Site 1		<10	a
	Inner Harbor Site 1		<2	a
	Inner Harbor Site 4		<10	a
	Inner Harbor Site 4		<2	a
Mar-01	11	1	0.00260	b
	11	2	0.00310	b
	11	3	0.00360	b
	13	1	0.00140	b
	13	2	0.00160	b
	13	3	0.00180	b
Oct-01	11	1	0.00550	b
	11	2	0.00540	b
	11	3	0.00550	b
	12	1	0.00100	b
	12	2	0.00100	b
	12	3	0.00100	b
	13	1	0.00110	b
	13	2	0.00430	b
	13	3	0.00220	b
	11A	1	0.00110	b
	11A	2	0.00100	b
	11A	3	0.00120	b
Mar-02	11	1	0.00188	b
	11	2	0.00321	b
	11	3	0.00706	b
	13	1	0.00437	b
	13	2	0.00407	b
	13	3	0.00513	b
Aug-02	11	1	0.00260	b
	11	2	0.00380	b
	11	3	0.01110	b
	13	1	0.00280	b
	13	2	0.00520	b
	13	3	0.00320	b
Mar-03	13	1	0.00320	b
	13	2	0.00310	b
	13	3	0.00250	b
Aug-03	11	1	0.00310	b
	11	2	0.00370	b
	11	3	0.00530	b
	13	1	0.00190	b
	13	2	0.00210	b
	13	3	0.00220	b
Feb-04	13	1	0.00240	b
	13	2	0.00100	b
	13	3	0.00220	b
Sep-04	13	1	0.00340	b

Date	Station	Depth	Mercury (µg/L)	Source
	13	2	0.00290	b
	13	3	0.00540	b
Feb-05	11	1	0.00290	b
	11	2	0.00280	b
	11	3	0.00270	b
	13	1	0.00120	b
	13	2	0.00140	b
	13	3	0.00140	b

[a]AECOS (1991) data from Table 3-20 in *Data Review to Support the Water Quality Monitoring Strategy for Pago Pago Harbor, American Samoa* (gdc 2003)
[b]Receiving Water Quality Monitoring Data (CH2M Hill 2006a)

Table A-4. Available total mercury water quality data for tributaries to Pago Pago Harbor

Date	Station	Mercury (µg/L)	Source
Mar-03	S1	0.0055	*
	S2	0.0023	*
	S3	0.0051	*
	S4	0.0018	*
	S5	0.0017	*
Aug-03	S1	0.0038	*
	S2	0.0017	*
	S3	0.0040	*
	S4	0.0067	*
	S5	0.0013	*
Feb-04	S1	0.0051	*
	S2	0.0022	*
	S3	0.0051	*
	S4	0.0012	*
	S5	0.0054	*
Sep-04	S1	0.0010	*
	S2	0.0016	*
	S3	0.0032	*
	S4	0.0013	*
	S5	0.0011	*

[*]Receiving Water Quality Monitoring Data (CH2M Hill 2006a)

APPENDIX B
Fish and Shellfish Tissue Data

Table B-1. Available arsenic data for fish tissue in Pago Pago Inner Harbor

Date	Location	Fish Type	Constituent*	Arsenic (mg/Kg wet wt.)	Source
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(i)	0.00368	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(i)	0.0091	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(i)	0.00357	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(i)	0.00039	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(i)	0.0091	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(i)	0.0009	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(i)	0.00019	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(i)	0.0091	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(i)	0.0017	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(i)	0.0091	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(i)	0.0091	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(i)	0.0091	a
2005	Pago Pago Inner Harbor	*Mugilidae spp.*	As(i)	0.01639	a
2005	Pago Pago Inner Harbor	*Mugilidae spp.*	As(i)	0.00221	a
2005	Pago Pago Inner Harbor	*Mugilidae spp.*	As(i)	0.00535	a
2002	Pago Pago Inner Harbor	*Mugilidae spp.*	As(i)	0.12979	b
2002	Pago Pago Inner Harbor	*Mugilidae spp.*	As(i)	0.10979	b
2002	Pago Pago Inner Harbor	*Mugilidae spp.*	As(i)	0.09459	b

Date	Location	Fish Type	Constituent*	Arsenic (mg/Kg wet wt.)	Source
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(t)	0.311	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(t)	0.294	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(t)	0.675	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(t)	0.277	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(t)	0.38	a
2005	Pago Pago Inner Harbor	*Caranx papuensis*	As(t)	0.935	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(t)	2.04	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(t)	1.88	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(t)	2.53	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(t)	1.55	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(t)	1.17	a
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	As(t)	1.43	a
2005	Pago Pago Inner Harbor	*Mugilidae spp.*	As(t)	0.807	a
2005	Pago Pago Inner Harbor	*Mugilidae spp.*	As(t)	0.607	a
2005	Pago Pago Inner Harbor	*Mugilidae spp.*	As(t)	0.371	a
2002	Pago Pago Inner Harbor	*Mugilidae spp.*	As(t)	0.779	b
2002	Pago Pago Inner Harbor	*Mugilidae spp.*	As(t)	0.770	b
2002	Pago Pago Inner Harbor	*Mugilidae spp.*	As(t)	0.944	b
2002	Pago Pago Inner Harbor	*Serranidae spp.*	As(t)	59.5	a
2002	Pago Pago Inner Harbor	*Mullidae spp.*	As(t)	29.6	a

*As(i) refers to inorganic arsenic results and As(t) refers to total arsenic results
[a]Tier 2 Fish Toxicity Study (Peshut and Brooks 2005)
[b]Inner Harbor Fish Tissue Study (CH2M Hill 2002)

Table B-2. Available arsenic data for shellfish in Pago Pago Inner Harbor

Date	Location	Shellfish Type	Constituent*	Arsenic (mg/Kg wet wt.)	Source
2002	Inner Harbor	*Asaphis violascens*	As(i)	0.217	a
2002	Inner Harbor	*Asaphis violascens*	As(i)	0.212	a
2002	Inner Harbor	*Asaphis violascens*	As(i)	0.244	a

2002	Inner Harbor	*Asaphis violascens*	As(t)	4.70	a
2002	Inner Harbor	*Asaphis violascens*	As(t)	5.90	a
2002	Inner Harbor	*Asaphis violascens*	As(t)	5.08	a
2002	Inner Harbor	*Trochus maculatus*	As(t)	53.5	a
2002	Inner Harbor	*Octopus cyanea*	As(t)	190	a

*As(i) refers to inorganic arsenic results and As(t) refers to total arsenic results
[a]Inner Harbor Fish Tissue Study (CH2M Hill 2002)

Table B-3. Available mercury data for fish tissue in Pago Pago Inner Harbor (wet weight)[a]

Date	Location	Fish Type	Mercury (mg/Kg wet wt.)	Source
2005	Pago Pago Inner Harbor	*Caranx papuensis*	0.044	b
2005	Pago Pago Inner Harbor	*Caranx papuensis*	0.148	b
2005	Pago Pago Inner Harbor	*Caranx papuensis*	0.276	b
2005	Pago Pago Inner Harbor	*Caranx papuensis*	0.426	b
2005	Pago Pago Inner Harbor	*Caranx papuensis*	0.45	b
2005	Pago Pago Inner Harbor	*Caranx papuensis*	0.481	b
2005	Pago Pago Inner Harbor	*Mugilidae spp.*	0.008	b
2005	Pago Pago Inner Harbor	*Mugilidae spp.*	0.016	b
2005	Pago Pago Inner Harbor	*Mugilidae spp.*	0.02	b
2002	Pago Pago Inner Harbor	*Mugilidae spp.*	0.050	c
2002	Pago Pago Inner Harbor	*Mugilidae spp.*	0.150	c
2002	Pago Pago Inner Harbor	*Mugilidae spp.*	0.040	c
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	0.098	b
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	0.106	b
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	0.109	b
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	0.158	b
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	0.169	b
2005	Pago Pago Inner Harbor	*Megalaspis cordyla*	0.208	b
2002	Pago Pago Inner Harbor	*Serranidae spp.*	0.670	c
2002	Pago Pago Inner Harbor	*Mullidae spp.*	0.400	c

[a]Dry weight samples were not included because there are no mercury targets available for dry weight
[b]Tier 2 Fish Toxicity Study (Peshut and Brooks 2005)
[c]Inner Harbor Fish Tissue Study (CH2M Hill 2002)

Table B-4. Available mercury data for shellfish tissue in Pago Pago Inner Harbor (wet weight)[a]

Date	Location	Shellfish Type	Mercury (mg/Kg wet wt.)	Source
2002	Pago Pago Inner Harbor	*Asaphis violascens*	0.080	a
2002	Pago Pago Inner Harbor	*Asaphis violascens*	0.090	a
2002	Pago Pago Inner Harbor	*Asaphis violascens*	0.070	a
2002	Pago Pago Inner Harbor	*Trochus maculatus*	0.070	a
2002	Pago Pago Inner Harbor	*Octopus cyanea*	0.200	a

[a]Inner Harbor Fish Tissue Study (CH2M Hill 2002)

Table B-5. Available PCB data for fish tissue in Pago Pago Inner Harbor

Date	Location	Composite Number	Fish Type	Constituent	Arochlor (µg/Kg wet wt.)	Source
2005	Pago Pago Inner Harbor	C1MT	*Caranx papuensis*	Arochlor 1254	94	a
2005	Pago Pago Inner Harbor	C1MT	*Caranx papuensis*	Arochlor 1260	120	a
2005	Pago Pago Inner Harbor	C1MT	*Megalaspis cordyla*	Arochlor 1254	51	a
2005	Pago Pago Inner Harbor	C1MT	*Megalaspis cordyla*	Arochlor 1260	53	a
2005	Pago Pago Inner Harbor	C1MT	*Mugilidae spp.*	Arochlor 1254	10	a
2005	Pago Pago Inner Harbor	C1MT	*Mugilidae spp.*	Arochlor 1260	22	a
2002	Pago Pago Inner Harbor	C1WF	*Serranidae spp.*	Arochlor 1260	520	b
2002	Pago Pago Inner Harbor	C1WF	*Mullidae spp.*	Arochlor 1260	640	b
2005	Pago Pago Inner Harbor	C2MT	*Caranx papuensis*	Arochlor 1254	45	a
2005	Pago Pago Inner Harbor	C2MT	*Caranx papuensis*	Arochlor 1260	65	a
2005	Pago Pago Inner Harbor	C2MT	*Megalaspis cordyla*	Arochlor 1254	48	a
2005	Pago Pago Inner Harbor	C2MT	*Megalaspis cordyla*	Arochlor 1260	56	a
2005	Pago Pago Inner Harbor	C2MT	*Mugilidae spp.*	Arochlor 1260	10	a
2005	Pago Pago Inner Harbor	C3MT	*Caranx papuensis*	Arochlor 1254	61	a
2005	Pago Pago Inner Harbor	C3MT	*Caranx papuensis*	Arochlor 1260	85	a
2005	Pago Pago Inner Harbor	C3MT	*Megalaspis cordyla*	Arochlor 1254	42	a
2005	Pago Pago Inner Harbor	C3MT	*Megalaspis cordyla*	Arochlor 1260	52	a

Date	Location	Composite Number	Fish Type	Constituent	Arochlor (µg/Kg wet wt.)	Source
2005	Pago Pago Inner Harbor	C3MT	*Mugilidae spp.*	Arochlor 1260	11	a
2005	Pago Pago Inner Harbor	C4WF	*Caranx papuensis*	Arochlor 1254	110	a
2005	Pago Pago Inner Harbor	C4WF	*Caranx papuensis*	Arochlor 1260	190	a
2005	Pago Pago Inner Harbor	C4WF	*Megalaspis cordyla*	Arochlor 1254	130	a
2005	Pago Pago Inner Harbor	C4WF	*Megalaspis cordyla*	Arochlor 1260	190	a
2002	Pago Pago Inner Harbor	C4WF	*Mugilidae spp.*	Arochlor 1260	78	b
2005	Pago Pago Inner Harbor	C5WF	*Caranx papuensis*	Arochlor 1254	85	a
2005	Pago Pago Inner Harbor	C5WF	*Caranx papuensis*	Arochlor 1260	75	a
2005	Pago Pago Inner Harbor	C5WF	*Megalaspis cordyla*	Arochlor 1254	110	a
2005	Pago Pago Inner Harbor	C5WF	*Megalaspis cordyla*	Arochlor 1260	170	a
2002	Pago Pago Inner Harbor	C5WF	*Mugilidae spp.*	Arochlor 1260	130	b
2005	Pago Pago Inner Harbor	C6WF	*Caranx papuensis*	Arochlor 1254	41	a
2005	Pago Pago Inner Harbor	C6WF	*Caranx papuensis*	Arochlor 1260	41	a
2005	Pago Pago Inner Harbor	C6WF	*Megalaspis cordyla*	Arochlor 1254	150	a
2005	Pago Pago Inner Harbor	C6WF	*Megalaspis cordyla*	Arochlor 1260	220	a
2002	Pago Pago Inner Harbor	C6WF	*Mugilidae spp.*	Arochlor 1260	52	b

[a]Tier 2 Fish Toxicity Study (Peshut and Brooks 2005)
[b]Inner Harbor Fish Tissue Study (CH2M Hill 2002)

Table B-6. Summed PCB data for fish tissue in Pago Pago Inner Harbor

Date	Location	Composite Number	Fish Type	Summed PCBs (µg/Kg wet wt.)
2002[a]	Inner Harbor	C4WF	*Mugilidae spp.*	78
2002[a]	Inner Harbor	C5WF	*Mugilidae spp.*	130
2002[a]	Inner Harbor	C6WF	*Mugilidae spp.*	52
2002[a]	Inner Harbor	C1WF	*Serranidae spp.*	520
2002[a]	Inner Harbor	C1WF	*Mullidae spp.*	640
2005[b]	Pago Pago Inner Harbor	C1MT	*Caranx papuensis*	214
2005[b]	Pago Pago Inner Harbor	C1MT	*Megalaspis cordyla*	104
2005[b]	Pago Pago Inner Harbor	C1MT	*Mugilidae spp.*	32
2005[b]	Pago Pago Inner Harbor	C2MT	*Caranx papuensis*	110
2005[b]	Pago Pago Inner Harbor	C2MT	*Megalaspis cordyla*	104
2005[b]	Pago Pago Inner Harbor	C2MT	*Mugilidae spp.*	10
2005[b]	Pago Pago Inner Harbor	C3MT	*Caranx papuensis*	146
2005[b]	Pago Pago Inner Harbor	C3MT	*Megalaspis cordyla*	94
2005[b]	Pago Pago Inner Harbor	C3MT	*Mugilidae spp.*	11
2005[b]	Pago Pago Inner Harbor	C4WF	*Caranx papuensis*	300
2005[b]	Pago Pago Inner Harbor	C4WF	*Megalaspis cordyla*	320
2005[b]	Pago Pago Inner Harbor	C5WF	*Caranx papuensis*	160
2005[b]	Pago Pago Inner Harbor	C5WF	*Megalaspis cordyla*	280
2005[b]	Pago Pago Inner Harbor	C6WF	*Caranx papuensis*	82
2005[b]	Pago Pago Inner Harbor	C6WF	*Megalaspis cordyla*	370

[a]Inner Harbor Fish Tissue Study (CH2M Hill 2002)
[b]Tier 2 Fish Toxicity Study (Peshut and Brooks 2005)

Table B-7. Available PCB data for shellfish tissue in Pago Pago Inner Harbor[a]

Date	Shellfish Type	Constituent	Aroclor (µg/Kg wet wt.)	Source
2002	*Asaphis violascens*	Aroclor 1260	<5.0	a
2002	*Asaphis violascens*	Aroclor 1260	<5.0	a
2002	*Asaphis violascens*	Aroclor 1260	<5.0	a
2002	*Octopus cyanea*	Aroclor 1260	50	a
2002	*Trochus maculatus*	Aroclor 1260	<5.0	a

[a]Inner Harbor Fish Tissue Study (CH2M Hill 2002)

Table B-8. Summed PCB data for shellfish tissue in Pago Pago Inner Harbor[a]

Date	Shellfish Type	Constituent	Total PCBs (µg/Kg wet wt.)
2002	*Asaphis violascens*	Aroclor 1260	5
2002	*Asaphis violascens*	Aroclor 1260	5
2002	*Asaphis violascens*	Aroclor 1260	5
2002	*Octopus cyanea*	Aroclor 1260	50
2002	*Trochus maculatus*	Aroclor 1260	5

[a]Inner Harbor Fish Tissue Study (CH2M Hill 2002)

APPENDIX C
Sediment Data

Table C-1. Available dry weight arsenic data for sediment in Pago Pago Inner Harbor[a]

Date	Station	Arsenic (mg/Kg dry wt.)	Source
1993	Fagatogo	5.7	b
	Pago Pago	7	b
	SW Marine	8.5	b
1997	Native Soil Station, SWM37	0.36	c
	Native Soil Station, SWM40	0.57	c
	Marine Sediment Station, SWM38	15.2	c
	Marine Sediment Station, SWM39	15.5	c
	Native Soil Station, SWM36	<0.49	c
Oct-93	IH-1	<10	d
Oct-93	IH-2	<10	d
Oct-93	IH-3	<10	d
Mar-95	IH-1	11	d
Mar-95	IH-2	12	d
Mar-95	IH-3	<6.8	d
Mar-96	IH-1	1.7	d
Mar-96	IH-3	6.5	d
Mar-96	IH-2	10	d
10/25/01	SWM (South West Marine)	4.1	e
10/25/01	IH-2	4.7	e
10/25/01	IH-1C	6.8	e
10/25/01	IH-3A	7.1	e
10/25/01	FD (near fuel dock)	7.6	e
10/25/01	IH-1B	8.1	e
10/25/01	4 (Near Traders Point)	10	e
10/25/01	IH-1	24	e
10/26/01	IH-3	3.8	e
Feb-04	STS-48	4.4	f
Feb-04	STS-42	8.3	f
Feb-04	STS-25	9.1	f
Feb-04	STS-34	9.9	f
Feb-04	STS-31A	10.2	f
Feb-04	STS-31	10.9	f
Feb-04	STS-43A	11.3	f
Feb-04	STS-44A	12.0	f
Feb-04	STS-29	16.6	f
Feb-04	STS-43	17.8	f
Feb-04	STS-30	32.4	f
2/25/2004	IH-3	4.4	d
2/25/2004	IH-3	4.4	d
2/26/2004	IH-2	16.6	d

Date	Station	Arsenic (mg/Kg dry wt.)	Source
2/26/2004	IH-2	16.6	d
2/26/2004	IH-1	32.4	d
2/26/2004	IH-1	32.4	d

[a]Wet weight data are not included in this table because there are no wet weight targets to compare them to.
[b] These are USEPA (1993) data that were provided in Table 4-7 in *Data Review to Support the Water Quality Monitoring Strategy for Pago Pago Harbor, American Samoa* (gdc 2003)
[c] These are USEPA (1997) data that were provided in Table 4-8 in *Data Review to Support the Water Quality Monitoring Strategy for Pago Pago Harbor, American Samoa* (gdc 2003)
[d]Sediment Monitoring Report February 2004 Pago Pago Harbor, American Samoa (CH2M Hill 2004)
[e]Sediment Monitoring Report October 2001 Pago Pago Harbor, American Samoa (CH2M Hill 2003)
[f] Sediment Monitoring Data (CH2M Hill 2006b)

Table C-2. Available dry weight arsenic data for core sediment in Pago Pago Inner Harbor

Date	Station	Location (Interval cm)	Arsenic (mg/Kg dry wt.)
Mar-05	STC-10A	0-10	12.1
	STC-10B	38-44	11.8
	STC-10C	0-8	12.2
	STC-11A	0-16	10.3
	STC-11B	36-50	12.5
	STC-11C	85-110	9.58
	STC-4A	0-9	5.89
	STC-4A	0-9	85.8
	STC-4A	0-9	89
	STC-4C	58-64	9.17
	STC-4E	121-127	11.3
	STC-5A	0-7	9.8
	STC-5B	23-30	11.4
	STC-5C	40-47	13.3
	STC-5D	57-62	13.3
	STC-5E	?-87?	12.1
	STC-8A	3-16	14.3
	STC-8C	43-57	9.23
	STC-8E	87-100	9.8
	STC-9A	0-20	10.5
	STC-9A	0-20	11.3
	STC-9A	0-20	116
	STC-9B	58-72	9.97
	STC-9C	93-118	11

Data Source: Sediment Monitoring Data (CH2M Hill 2006b)

Table C-3. Available dry weight mercury data for sediment in Pago Pago Inner Harbor

Date	Station	Mercury (mg/kg dry wt.)	Source
10/25/01	4	0.084	c
1993	Fagatogo	<0.07	d
10/25/01	FD	0.091	c
Oct-93	IH-1	0.14	e
Mar-95	IH-1	0.194	e
Mar-96	IH-1	0.55	e
10/25/01	IH-1	0.81	c
10/25/01	IH-1B	0.45	c
10/25/01	IH-1C	0.33	c
Oct-93	IH-2	0.097	e
Mar-95	IH-2	0.123	e
Mar-96	IH-2	0.33	e
10/25/01	IH-2	0.083	c
2/26/2004	IH-2	0.189	e
2/26/2004	IH-2	0.189	e
Oct-93	IH-3	0.02	e
Mar-95	IH-3	0.065	e
Mar-96	IH-3	<0.18	e
10/26/01	IH-3	0.033	c
2/25/2004	IH-3	0.036	e
2/25/2004	IH-3	0.036	e
10/25/01	IH-3A	0.054	c
1997	Marine Sediment Station, SWM38	0.38	f
1997	Marine Sediment Station, SWM39	0.22	f
1993	Pago Pago	<0.18	d
Feb-04	STS-25	0.161	g
Feb-04	STS-29	0.189	g
Feb-04	STS-42	0.112	g
Feb-04	STS-44A	0.178	g
Feb-04	STS-48	0.036	g
1993	SW marine	<0.26	d
10/25/01	SWM	0.31	c

[a]Wet weight data are not included in this table because there are no wet weight targets to compare them to.
[b]Observations reported as < values were halved and compared to the targets.
[c] Sediment Monitoring Report October 2001 Pago Pago Harbor, American Samoa (CH2M Hill 2003)
[d] These are USEPA (1993) data that were provided in Table 4-7 in *Data Review to Support the Water Quality Monitoring Strategy for Pago Pago Harbor, American Samoa* (gdc 2003)
[e] Sediment Monitoring Report February 2004 Pago Pago Harbor, American Samoa (CH2M Hill 2004)
[f] These are USEPA (1997) data that were provided in Table 4-8 in *Data Review to Support the Water Quality Monitoring Strategy for Pago Pago Harbor, American Samoa* (gdc 2003)
[g] Sediment Monitoring Data (CH2M Hill 2006b)

Table C-4. Available dry weight mercury data for core sediment in Pago Pago Inner Harbor

Date	Station	Location (Interval cm)	Mercury (mg/Kg dry wt.)
Mar-05	STC-10A	0-10	0.267
	STC-10B	38-44	0.057
	STC-10C	0-8	0.018
	STC-11A	0-16	0.217
	STC-11B	36-50	0.028
	STC-11C	85-110	0.01
	STC-4A	0-9	0.073
	STC-4A	0-9	0.076
	STC-4A	0-9	0.362
	STC-4C	58-64	0.041
	STC-4E	121-127	0.031
	STC-5A	0-7	0.126
	STC-5B	23-30	0.33
	STC-5C	40-47	0.084
	STC-5D	57-62	0.112
	STC-5E	?-87?	0.097
	STC-8A	3-16	0.368
	STC-8C	43-57	0.282
	STC-8E	87-100	0.008
	STC-9A	0-20	0.121
	STC-9A	0-20	0.14
	STC-9A	0-20	0.575
	STC-9B	58-72	0.022
	STC-9C	93-118	0.008

Data Source: Sediment Monitoring Data (CH2M Hill 2006b)

Table C-5. Available dry weight PCB data for sediment in Pago Pago Inner Harbor

Date	Station	Location	Constituent	Aroclor (µg/Kg)[a]	Notes	Source
10/25/01	FD	Inner Harbor	Aroclor 1260	43		b
10/25/01	IH-3	Inner Harbor	Aroclor 1260	37		b
10/26/01	IH-3	Inner Harbor	Aroclor 1248	59		b
10/25/01	IH-3A	Inner Harbor	Aroclor 1254	180		b
10/25/01	IH-3A	Inner Harbor	Aroclor 1260	150		b
Feb-04	STS-11	Inner Harbor	Aroclor 1016	2.7	MDL[d] (2.7)	c
Feb-04	STS-11	Inner Harbor	Aroclor 1221	2.7	MDL[d] (2.7)	c
Feb-04	STS-11	Inner Harbor	Aroclor 1232	2.7	MDL[d] (2.7)	c
Feb-04	STS-11	Inner Harbor	Aroclor 1242	2.7	MDL[d] (2.7)	c
Feb-04	STS-11	Inner	Aroclor 1248	2.7	MDL[d] (2.7)	c

Date	Station	Location	Constituent	Aroclor (µg/Kg)[a]	Notes	Source
		Harbor				
Feb-04	STS-11	Inner Harbor	Aroclor 1254	2.7	MDL[d] (2.7)	c
Feb-04	STS-11	Inner Harbor	Aroclor 1260	2.7	MDL[d] (2.7)	c
Feb-04	STS-25	Inner Harbor	Aroclor 1016	3.4	MDL[d] (3.4)	c
Feb-04	STS-25	Inner Harbor	Aroclor 1221	3.4	MDL[d] (3.4)	c
Feb-04	STS-25	Inner Harbor	Aroclor 1232	3.4	MDL[d] (3.4)	c
Feb-04	STS-25	Inner Harbor	Aroclor 1242	3.4	MDL[d] (3.4)	c
Feb-04	STS-25	Inner Harbor	Aroclor 1248	3.4	MDL[d] (3.4)	c
Feb-04	STS-25	Inner Harbor	Aroclor 1254	3.4	MDL[d] (3.4)	c
Feb-04	STS-25	Inner Harbor	Aroclor 1260	44		c
Feb-04	STS-34	Inner Harbor	Aroclor 1016	4.7	MDL[d] (4.7)	c
Feb-04	STS-34	Inner Harbor	Aroclor 1221	4.7	MDL[d] (4.7)	c
Feb-04	STS-34	Inner Harbor	Aroclor 1232	4.7	MDL[d] (4.7)	c
Feb-04	STS-34	Inner Harbor	Aroclor 1242	4.7	MDL[d] (4.7)	c
Feb-04	STS-34	Inner Harbor	Aroclor 1248	4.7	MDL[d] (4.7)	c
Feb-04	STS-34	Inner Harbor	Aroclor 1254	4.7	MDL[d] (4.7)	c
Feb-04	STS-34	Inner Harbor	Aroclor 1260	48		c
Feb-04	STS-42	Inner Harbor	Aroclor 1016	4.9	MDL[d] (4.9)	c
Feb-04	STS-42	Inner Harbor	Aroclor 1221	4.9	MDL[d] (4.9)	c
Feb-04	STS-42	Inner Harbor	Aroclor 1232	4.9	MDL[d] (4.9)	c
Feb-04	STS-42	Inner Harbor	Aroclor 1242	4.9	MDL[d] (4.9)	c
Feb-04	STS-42	Inner Harbor	Aroclor 1248	4.9	MDL[d] (4.9)	c
Feb-04	STS-42	Inner Harbor	Aroclor 1254	4.9	MDL[d] (4.9)	c
Feb-04	STS-42	Inner Harbor	Aroclor 1260	39		c
Feb-04	STS-44A	Inner Harbor	Aroclor 1016	4.8	MDL[d] (4.8)	c
Feb-04	STS-44A	Inner Harbor	Aroclor 1221	4.8	MDL[d] (4.8)	c
Feb-04	STS-44A	Inner Harbor	Aroclor 1232	4.8	MDL[d] (4.8)	c

Date	Station	Location	Constituent	Aroclor (µg/Kg)[a]	Notes	Source
Feb-04	STS-44A	Inner Harbor	Aroclor 1242	4.8	MDL[d] (4.8)	c
Feb-04	STS-44A	Inner Harbor	Aroclor 1248	4.8	MDL[d] (4.8)	c
Feb-04	STS-44A	Inner Harbor	Aroclor 1254	4.8	MDL[d] (4.8)	c
Feb-04	STS-44A	Inner Harbor	Aroclor 1260	85		c
Mar-05	STS-8A	Inner Harbor	Aroclor 1016	2.8	ND[e]	c
Mar-05	STS-8A	Inner Harbor	Aroclor 1221	2.8	ND[e]	c
Mar-05	STS-8A	Inner Harbor	Aroclor 1232	2.8	ND[e]	c
Mar-05	STS-8A	Inner Harbor	Aroclor 1242	2.8	ND[e]	c
Mar-05	STS-8A	Inner Harbor	Aroclor 1248	130		c
Mar-05	STS-8A	Inner Harbor	Aroclor 1254	2.8	ND[e]	c
Mar-05	STS-8A	Inner Harbor	Aroclor 1260	650		c
Mar-05	STS-8C	Inner Harbor	Aroclor 1016	2.5	ND[e]	c
Mar-05	STS-8C	Inner Harbor	Aroclor 1221	2.5	ND[e]	c
Mar-05	STS-8C	Inner Harbor	Aroclor 1232	2.5	ND[e]	c
Mar-05	STS-8C	Inner Harbor	Aroclor 1242	2.5	ND[e]	c
Mar-05	STS-8C	Inner Harbor	Aroclor 1248	2.5	ND[e]	c
Mar-05	STS-8C	Inner Harbor	Aroclor 1254	2.5	ND[e]	c
Mar-05	STS-8C	Inner Harbor	Aroclor 1260	18		c
Mar-05	STS-8E	Inner Harbor	Aroclor 1016	2.5	ND[e]	c
Mar-05	STS-8E	Inner Harbor	Aroclor 1221	2.5	ND[e]	c
Mar-05	STS-8E	Inner Harbor	Aroclor 1232	2.5	ND[e]	c
Mar-05	STS-8E	Inner Harbor	Aroclor 1242	2.5	ND[e]	c
Mar-05	STS-8E	Inner Harbor	Aroclor 1248	2.5	ND[e]	c
Mar-05	STS-8E	Inner Harbor	Aroclor 1254	2.5	ND[e]	c
Mar-05	STS-8E	Inner Harbor	Aroclor 1260	2.5	ND[e]	c
Mar-05	STS-9A	Inner Harbor	Aroclor 1016	2.5	ND[e]	c
Mar-05	STS-9A	Inner	Aroclor 1221	2.5	ND[e]	c

Date	Station	Location	Constituent	Aroclor (µg/Kg)[a]	Notes	Source
		Harbor				
Mar-05	STS-9A	Inner Harbor	Aroclor 1232	2.5	ND[e]	c
Mar-05	STS-9A	Inner Harbor	Aroclor 1242	2.5	ND[e]	c
Mar-05	STS-9A	Inner Harbor	Aroclor 1248	9.9	MDL[d]	c
Mar-05	STS-9A	Inner Harbor	Aroclor 1254	2.5	ND[e]	c
Mar-05	STS-9A	Inner Harbor	Aroclor 1260	34		c
Mar-05	STS-9B	Inner Harbor	Aroclor 1016	2.4	ND[e]	c
Mar-05	STS-9B	Inner Harbor	Aroclor 1221	2.4	ND[e]	c
Mar-05	STS-9B	Inner Harbor	Aroclor 1232	2.4	ND[e]	c
Mar-05	STS-9B	Inner Harbor	Aroclor 1242	2.4	ND[e]	c
Mar-05	STS-9B	Inner Harbor	Aroclor 1248	2.4	ND[e]	c
Mar-05	STS-9B	Inner Harbor	Aroclor 1254	2.4	ND[e]	c
Mar-05	STS-9B	Inner Harbor	Aroclor 1260	2.4	ND[e]	c
Mar-05	STS-9C	Inner Harbor	Aroclor 1016	2.3	ND[e]	c
Mar-05	STS-9C	Inner Harbor	Aroclor 1221	2.3	ND[e]	c
Mar-05	STS-9C	Inner Harbor	Aroclor 1232	2.3	ND[e]	c
Mar-05	STS-9C	Inner Harbor	Aroclor 1242	2.3	ND[e]	c
Mar-05	STS-9C	Inner Harbor	Aroclor 1248	2.3	ND[e]	c
Mar-05	STS-9C	Inner Harbor	Aroclor 1254	2.3	ND[e]	c
Mar-05	STS-9C	Inner Harbor	Aroclor 1260	2.3	ND[e]	c

[a]Note that these are the raw PCB data. Aroclor values were summed to calculate total PCB concentrations that could be compared to the applicable PCB targets.
[b]Sediment Monitoring Report, October 2001 (CH2M Hill 2003)
[c]Sediment Monitoring Data (CH2M Hill 2006b)
[d]MDL = method detection limit
[e]ND = Non-detect; value reported is the detection limit

Table C-6. Summed dry weight PCB data for sediment in Pago Pago Inner Harbor

Date	Station	Location	Total PCBs (µg/Kg)
10/25/2001	FD	Inner Harbor	43
10/25/2001	IH-3	Inner Harbor	37
10/26/2001	IH-3	Inner Harbor	59
10/25/2001	IH-3A	Inner Harbor	330
Feb-04	STS-11	Inner Harbor	2.7
Feb-04	STS-25	Inner Harbor	44
Feb-04	STS-34	Inner Harbor	48
Feb-04	STS-42	Inner Harbor	39
Feb-04	STS-44A	Inner Harbor	85
Mar-05	STS-8A	Inner Harbor	780
Mar-05	STS-8C	Inner Harbor	18
Mar-05	STS-8E	Inner Harbor	2.5
Mar-05	STS-9A	Inner Harbor	34
Mar-05	STS-9B	Inner Harbor	2.4
Mar-05	STS-9C	Inner Harbor	2.3