United States
Environmental Protection
Agency

EPA/600/R-25/107 | September 2025 | www.epa.gov/research

Las Mareas Bay: Human Health Risk Assessment

Office of Research and Development
Center for Environmental Solutions
and Emergency Response

This page intentionally left blank.

United States
Environmental Protection
Agency

Las Mareas Bay Human Health Risk Assessment

by

Mindy Pensak[1], Jordan Welnetz[1], Mark Reiss[1], Diana Cutt[2], Daniel Sullivan[2], Rohit Warrier[3], Donna Womack[3], Anne Lutes[3], Katherine Bronstein[3], and David Gwisdalla[2]

[1]U.S. EPA Region 2
New York, New York 10007

[2]U.S. EPA Office of Research and Development
Washington, District of Columbia 20460

[3]RTI International
Research Triangle Park, North Carolina 27709

This page intentionally left blank.

Notice/Disclaimer

The U.S. Environmental Protection Agency (U.S. EPA), through its Office of Research and Development, funded and conducted the research described herein. It has been subjected to the Agency's peer and administrative review and approved for publication as a U.S. EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Mention of or referral to commercial products or services, and/or links to non-EPA sites does not imply official EPA endorsement of or responsibility for the opinions, ideas, data, or products presented at those locations, or guarantee the validity of the information provided. Mention of commercial products/services on non-EPA websites is provided solely as a pointer to information on topics related to environmental protection that may be useful to EPA staff and the public.

Acknowledgments

This report was prepared for the U.S. EPA Office of Research and Development (ORD), Center for Environmental Solutions and Emergency Response (CESER), Technical Support Coordination Division's Engineering Technical Support Center (ETSC) by RTI International under Contract No. 68HERC21D0004, Task Order 008, under Technical Direction No. 47. David Gwisdalla served as the EPA Task Order Manager and Technical Co-Lead. The project Quality Assurance Project Plan (QAPP) details the methods and approaches for sample collection and analysis and statistical data analysis. The project QAPP (QAPP ID: I-GLTED-0034299) can be made available upon request to David Gwisdalla. The other technical co-leads were Diana Cutt, the Region 2 Superfund and Technology Liaison (STL) and Mindy Pensak, the Region 2 Regional Science Liaison (RSL). Katherine Bronstein and Dr. Rohit Warrier, from RTI International, managed this work, helped coordinate field data collection, and provided technical content. Anne Lutes and Donna Womack, from RTI International, were the report's primary authors.

We would like to acknowledge those who conducted the technical and peer reviews of this document. Technical reviews were conducted by Marian Olsen, a Risk Assessor from EPA Region 2 and Charles Nace, an Eco-Risk Assessor from EPA Region 2. Peer reviews were conducted by Dr. Jacqueline MacDonald Gibson, Twisdale Family Civil, Construction, and Environmental Engineering Department Head and Professor, North Carolina State University; and Robert Hetes, Former Senior Policy Advisor, U.S. EPA Office of Air Quality Planning and Standards.

This report is a technical health risk assessment. Plain language communication pieces were also developed to accompany this document for use also by Regional staff and community members. The report was intended to be presented to the community for their use. Web links are provided for readers interested in additional information; these weblinks, while accurate at the time of publication, are subject to change.

As of the date of this publication, questions may be addressed to:

David Gwisdalla, Director
Engineering Technical Support Center (ETSC)
Technical Support Coordination Division (TSCD)
Center for Environmental Solutions and Emergency Response (CESER)
U.S. EPA Office of Research and Development (ORD)
26 W. Martin Luther King Drive, Mail-Stop 445
Cincinnati, Ohio 45268
513-569-7011
gwisdalla.david@epa.gov

Table of Contents

Figures

Tables

List of Abbreviations and Acronyms

µg	micrograms
ABS_d	absorption through the dermis
ABS_{GI}	absorption through the gastrointestinal tract
ATSDR	Agency for Toxic Substances and Disease Registry
BLRV	blood lead reference value
BTEX	benzene, toluene, ethylbenzene, xylenes
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^2	square centimeters
CSF	cancer slope factor
dL	deciliters
EFH	*Exposure Factors Handbook*
EPA	United States Environmental Protection Agency
ft	feet
g	grams
GPS	Global Positioning System
ha	hectares
HHRA	human health risk assessment
HQ	hazard quotient
hr	hours
IEUBK	Integrated Exposure Uptake Biokinetic Model
in	inches
IRIS	Integrated Risk Information System
JBNERR	Jobos Bay National Estuarine Research Reserve
kg	kilograms
Kp	absorption of chemicals through skin in water
L	liters
LM	Las Mareas Bay
LOAEL	lowest-observed-adverse-effect level
m	meters
mg	milligrams
mi	miles
mL	milliliters
MW	megawatts
NA	not applicable
ND	nondetect
NOAEL	no-observed-adverse-effect level

ORD	Office of Research and Development
oz	ounces
PA	Playa Arenas
PAH	polycyclic aromatic hydrocarbon
PPRTV	Provisional Peer-Reviewed Toxicity Values
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RDL	reporting detection limit
RfD	reference dose
RSL	Regional Screening Level

Executive Summary

The community of Laguna de las Mareas (Las Mareas Bay) in Guayama, Puerto Rico, expressed health concerns regarding the impact of industrial activities, such as coal and coal combustion residuals potentially released into Las Mareas Bay, in relation to recreating in (e.g., swimming, playing on the beach, wading) and consuming fish from Las Mareas Bay. It should be noted that Las Mareas Bay is surrounded by a variety of industrial activities, as discussed in **Section 3.2, Site Description**, and shown in **Figure 1,** Las Mareas Bay and nearby industrial activities. Further, as shown in **Figure 2**, potential sources of environmental contaminants in Las Mareas Bay are many, and thus it was subjected to a variety of potential contaminants from both past and present activities. The U.S. Environmental Protection Agency (EPA) performed a human health risk assessment (HHRA) to estimate the potential exposures and risks posed to individuals who recreate and consume fish in Las Mareas Bay. A four-step process shown in **Figure ES-1** following EPA standard methods was used to complete the HHRA. The results of the HHRA identify cancer risks and noncancer health hazards from the identified exposures.

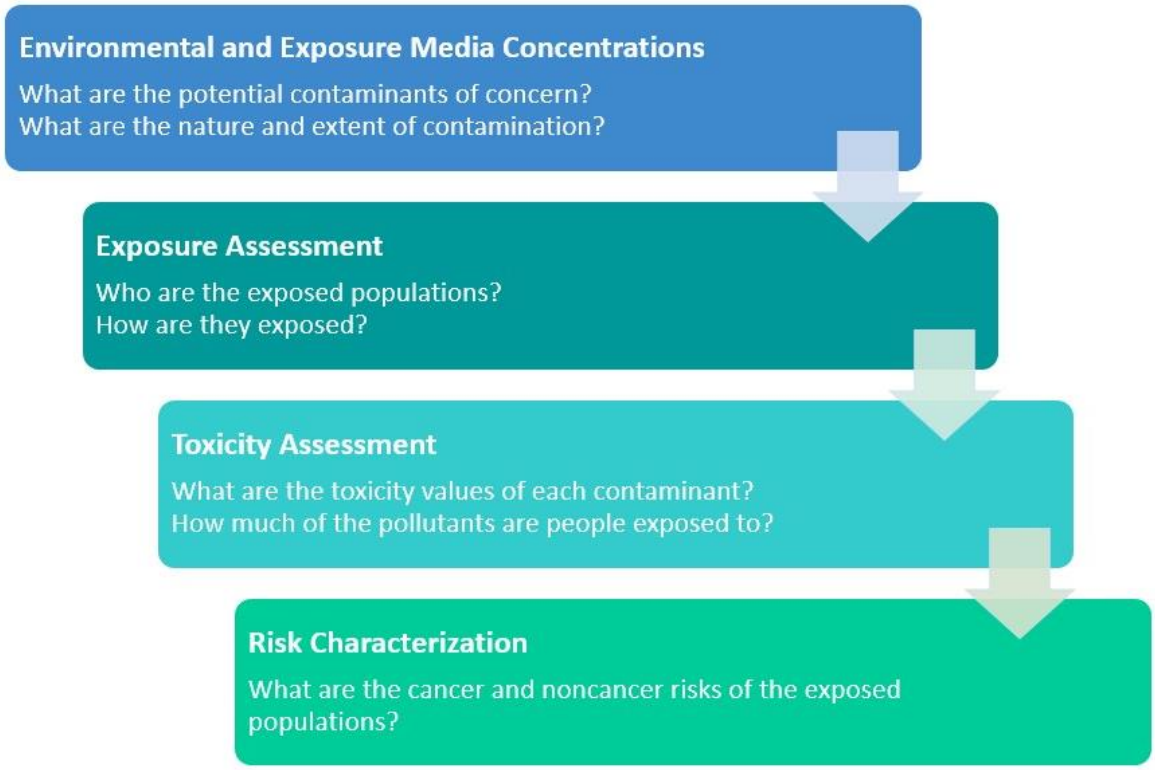

Figure ES-1. A four-step process, based on EPA methods, was used to complete the HHRA.

The HHRA is intended to be a tool to aid in the decision-making process by providing an assessment of the potential risk and hazard to human health. EPA uses risk assessment to inform decisions and characterize cancer risks and noncancer hazards associated with potential exposures. This assessment was not conducted under a specific regulatory program; rather, this document provides calculations of cancer risks and noncancer hazards for various receptors (e.g., adult and child recreators). The comparisons presented in this document provide context for the reader regarding the significance of the calculated cancer risks and noncancer hazards and are not designed to inform decisions under a specific regulatory program. EPA will evaluate the results and share the information with the community.

Environmental media and exposure media concentrations were determined through a combination of document review; meetings with the community to understand their concerns and learn about the site; and field sampling. In 2023, EPA met with the community to help scope the project, document how people recreate in Las Mareas Bay, and identify what type of fish are typically caught from the Bay for human consumption. The EPA team then identified locations to collect surface water, sand, sediment, and fish to determine the nature and extent of contamination in these media in Las Mareas Bay and at a background location outside the expected influence of the chemical emission sources near Las Mareas Bay. The background location serves as a reference point with which to compare findings. Later, a second background location was added due to technical issues with the first background location for some media (e.g., sand, sediment, surface water, fish).

Figure ES-2 shows the three sampling locations (Las Mareas Bay and the two background locations) relative to each other. The primary background location, Tropical Beach (in Naguabo) is approximately 30 miles northeast and upwind of Las Mareas Bay. Although 10 beach sand samples were collected from this location, due to unforeseen difficulties associated with road access while towing the boat to this site, surface water, sediment, and fish samples could not be collected at this location. Playa Arenas (in Salinas), which is approximately 7 miles west of Las Mareas Bay and does not have any large industrial activity, was selected as a second background location to collect surface water, sediment, and fish samples, as well as additional sand samples. Playa Arenas has several coves compared with Tropical Beach, which has a longer continuous sand shoreline. **Section 2** presents details on the sample collection methodology and results.

Figure ES-2. Surface water, sand, sediment, and fish samples were collected in 2024 at Las Mareas Bay. Sand samples were collected at Tropical Beach. Due to shallow, unnavigable waters at Tropical Beach, surface water, sediment, and fish samples were collected at Playa Arenas, along with additional sand samples. Source: Google Maps.

The surface water, sand, and sediment samples were analyzed for inorganic and organic constituents. For this HHRA, the EPA team analyzed 34 chemicals of potential concern, including 14 metals, mercury, and 19 organic chemicals (18 polycyclic aromatic hydrocarbons and sulfolane, a solvent used in petroleum refining). The metals included antimony, arsenic, barium, beryllium, boron, cadmium, total chromium, cobalt, lead, lithium, mercury, molybdenum, radium, selenium, silver, and thallium. These chemicals were selected for analysis because they are associated with coal combustion residuals and other industrial operations in the area.

Eight fish species were identified to cover the types of fish that Las Mareas Bay community is known to consume and were analyzed for the same 34 chemicals of potential concern as the surface water, sand, and sediment samples. The fish sample analysis included speciation of arsenic (total and inorganic) and mercury (total and methylmercury) to better reflect the forms of most concern in fish (inorganic arsenic and methylmercury). In early 2024, the community identified six fish species to EPA staff they commonly consume, which helped the EPA team develop the list of target fish species and sampling protocol. The six species the community identified include lane snapper (*Lutjanus synagris*), mutton snapper (*Lutjanus analis*), scaled sardine/herring (species not identified), yellowtail snapper (*Ocyurus chrysurus*), Spanish mackerel (*Scomberomorus maculatus*), and glass minnow/bay anchovy (species not identified). EPA staff added two additional fish species that were found in local markets—blue runner (*Caranx crysos*) and Atlantic bumper (*Chloroscombrus chrysurus*)—to the list of target species.

In general, exposure risk and bioaccumulation of chemicals in fish tissue will differ considerably across different fish species and environments. The variety of species collected for this HHRA provides a reasonable representation of contaminant exposure risks throughout the food web because they have overlapping feeding habits. For example, some species feed on zooplankton in the water column; some are bottom feeders; and others feed in pelagic, open-water conditions.

Water Sampling Results. Concentrations in Las Mareas Bay and the background location were compared against the Puerto Rico Water Quality Standards for coastal and estuarine waters (designated in the standards as "Class SB" waters) when those standards were based on human health endpoints.

Of the 34 chemicals analyzed, the same 9 metals were detected in both locations: arsenic, barium, boron, chromium, lead, lithium, mercury, molybdenum, and thallium. Chromium and thallium were detected at higher concentrations in Las Mareas Bay when compared with the detected background levels.

Concentrations in Las Mareas Bay were also compared to the Puerto Rico Water Quality Standards for coastal and estuarine (Class SB) waters, as shown in **Table ES-1**. Human-health based standards were available for only three of the inorganics evaluated (antimony, mercury, and thallium). Concentration values for antimony in surface water were not reported for either Las Mareas Bay or the background location, but both mercury and thallium were reported and detected at concentrations exceeding the water quality standard for coastal and estuarine waters in both locations.

Table ES-1. Sampled Water Concentrations Compared to Puerto Rico Water Quality Standards for Coastal and Estuarine Waters Based on Human Health Effects (all values µg/L)

Chemical	PR WQC for Class SB Waters	Las Mareas Bay			Background		
		Detection Frequency	50th Percentile Concentration	95th Percentile Concentration	Detection Frequency	50th Percentile Concentration	95th Percentile Concentration
Antimony	640	Not reported*					
Mercury	0.051	4 of 10 samples	0.1**	0.41	5 of 10 samples	0.16	0.68
Thallium	0.47	2 of 10 samples	0.5**	1.5	1 of 10 samples	0.5**	0.95

* The laboratory report did not report results for antimony in water.

** Value is half the reporting detection limit (RDL). Each non-detect value was replaced with half the RDL for the sample before computing the percentile statistics. A constituent with fewer than 50% detections may have a value half the RDL for 50th percentile but a measured value for 95th percentile.

Sand and Sediment Sampling Results. Concentrations in sand and sediment in Las Mareas Bay and the background locations were compared with the Regional Screening Levels (RSLs) for residential soil. RSLs are concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data. The RSL tables provide concentrations for ingestion, dermal exposure, and inhalation that are expected to result in a cancer risk of 1E-06 (or one in a million) or a noncancer hazard quotient (HQ) of 1. RSLs are considered by the Agency to be protective for humans (including sensitive groups) over a lifetime; however, RSLs are not always applicable to a particular location. Soil RSLs were available for seven chemicals (arsenic, boron, chromium, cobalt, lithium, molybdenum, and silver).

Of the 34 chemicals analyzed for, 8 were detected: arsenic, boron, chromium, cobalt (except in background sediment), lead, lithium (sediment only), molybdenum (except in Las Mareas Bay sand), and silver.

None of the results for sand and sediment exceeded the RSLs.

In the sand samples, arsenic, cobalt, lead, molybdenum, and silver concentrations were higher in Las Mareas Bay than in the background location (note molybdenum was not detected in the background location).

In the sediment samples, arsenic, chromium, cobalt, lead, and lithium concentrations in sediments were higher in Las Mareas Bay than in the background location (note cobalt was not detected in the background location).

Fish Sampling Results. Six fish species were caught in Las Mareas Bay and the background location (five of six species were the same in both locations). When multiple fish of a species were caught in a location, they were composited so that one composite sample was analyzed for each species caught in each location. All fish species were analyzed as whole fish and filets, except for the scaled sardines, which were only analyzed as whole fish because they are typically consumed whole.

The detected concentration distributions of inorganics and methylmercury in whole fish and filets at Las Mareas Bay are not significantly higher than the background sample concentrations reported.

Several inorganics such as cobalt, lithium, silver, and thallium that were found to have statistically higher means or medians between Las Mareas and background concentrations in sand, sediment, and surface water were detected in less than 50% of whole and filet samples from Las Mareas Bay.

Of the 19 organics analyzed, only naphthalene was detected in any samples from Las Mareas Bay or the background location. However, naphthalene was detected in only 1 of 5 fish filet samples and 1 of 6 whole fish samples from Las Mareas Bay, and in only 2 of 6 filet and whole fish samples in the background location. The 95th percentile concentrations of naphthalene in Las Mareas Bay (25 µg/kg in fish filet and 19 µg/kg in whole fish) were lower than the corresponding 95th percentile concentrations in the background location (42 and 43 µg/kg in filet and whole fish, respectively), suggesting that the industrial activities near Las Mareas Bay are not contributing significantly to naphthalene concentrations in the Bay.

The **exposure assessment** identified potentially exposed populations and estimated human chemical intake through exposure routes such as ingestion or skin contact. **Figure ES-3** shows a simplified overview of the exposures considered; more details on the exposure assessment methodology are presented in **Section 3**. The exposure routes considered for this study included the following:

- **Swimming**: dermal exposure to surface water and incidental ingestion of water while swimming (adults and children)
- **Playing in sand**: dermal exposure to sand and incidental ingestion of sand (children only)
- **Wading in sediments**: dermal exposure to sediment and incidental ingestion of sediment (children only)

- **Fish Consumption**: direct ingestion of fish by eating the fish directly or by consuming fish head stew; the former is quantified in the HHRA, whereas the latter is discussed in the risk characterization (adults and children).

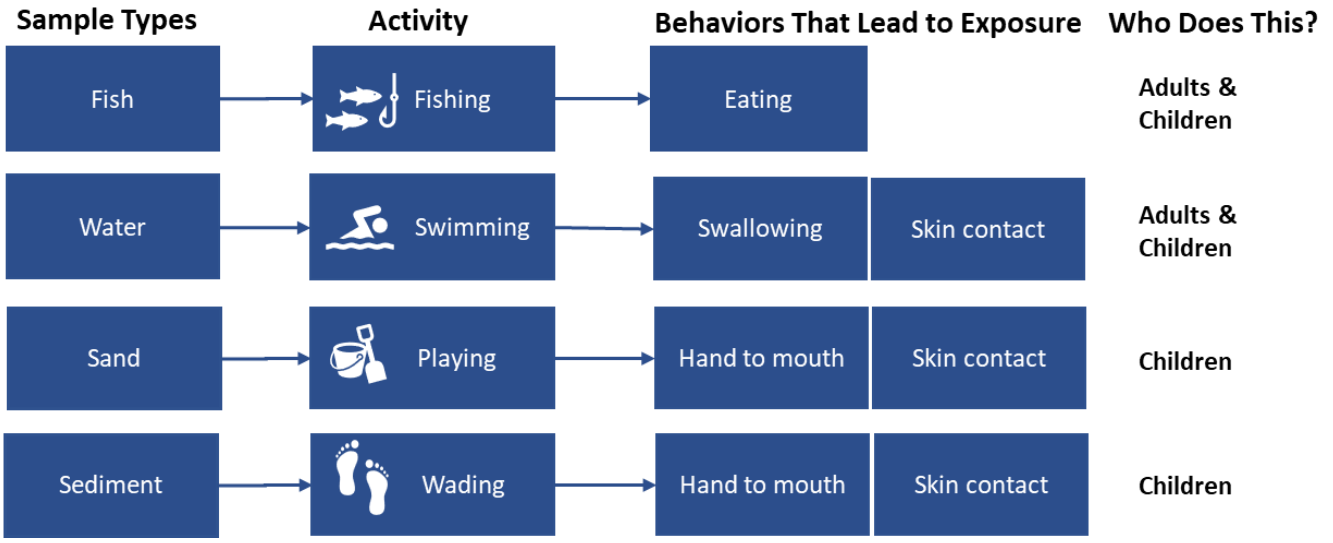

Figure ES-3. Overview of exposures considered in the HHRA.

The **toxicity assessment** evaluated chemical toxicity endpoints, including cancer and noncancer health effects from exposure to chemicals. Human health toxicity benchmarks are combined with exposure estimates to characterize the cancer risks and noncancer hazards. Human health toxicity benchmarks may be available for oral (ingestion) exposures but are not generally available for dermal exposure; therefore, *oral* toxicity values were used to evaluate dermal exposure. Details on the toxicity assessment methodology are presented in **Section 4**.

The **risk characterization** evaluated the likelihood and degree of chemical exposure and the possible adverse health effects associated with exposures to high-end (95th percentile) and median (50th percentile) concentrations. The hazards evaluated in this assessment include carcinogenic and noncarcinogenic endpoints. Details on the risk characterization methodology are presented in **Section 5**.

Risks and HQs were calculated for adults (21 to <70 years; swimming and fish consumption only) and the following child age cohorts: 1 to <2 years, 2 to <3 years, 3 to <6 years, 6 to <11 years, 11 to <16 years, and 16 to <21 years (swimming, sand, sediment, and fish consumption). For each type of exposure (swimming, sand, sediment, fish consumption), the child age cohort with the highest risks or HQs (i.e., the most sensitive age cohort) was identified; these typically differ for cancer and noncancer effects due to differences in the calculations and variables considered. The results were evaluated against a level of concern risk criteria of an HQ of 1 for noncarcinogens, or a cancer risk of 1 in 10,000 (10^{-4} or 1E-4).

Recreational Swimming Risks. Adults and children were evaluated for dermal exposure to surface water, as well as incidental ingestion of water while swimming. None of the results exceeded EPA's risk criteria (HQ=1 or cancer risk=1 in 10,000), and most were extremely low (<0.001 for noncancer HQ and on the order of 1E-8 [1 in 100,000,000] or lower for cancer) for all age groups. These results indicate that unacceptable hazards to swimming at the site are not expected from exposures to any of the chemicals included in this HHRA.

Recreational Playing in Sand Risks. Only children were evaluated for this pathway. Risks were calculated for incidental ingestion exposures, dermal exposures, and the total of incidental ingestion and dermal. Only arsenic and cadmium could be evaluated for dermal exposure because dermal absorption factors were not available for the other inorganics evaluated. There were no detections of cadmium in sand samples. Results indicate that noncancer hazards of recreational exposure to beach sand are less than EPA's criteria of an HQ of 1 for all chemicals. The results also indicate that cancer risks from recreational exposure to beach sand are all less than a risk of 1 in 10,000.

Recreational Wading in Sediment Risks. Only children were evaluated for this pathway. Risks were calculated for incidental ingestion exposures, dermal exposures, and the total of incidental ingestion and dermal. The results were similar to those for playing in sand, but none exceeded the risk criteria (HQ=1 or risk=1E-4 [1 in 10,000]). Dermal results for arsenic in sediment are lower than those for sand because the dermal adherence factor for sediment is considerably lower than that for sand, and less skin surface area is assumed to be exposed for sediment (hands, arms, legs, and feet vs. those same parts plus the torso for sand).

Fish Consumption. Results indicate that fish consumption hazards are all less than an HQ of 1 for all chemicals except thallium, which has an HQ of 1.2, slightly greater than 1, for one age group (children 1 to <2 years). Thallium was detected in only 1 of 5 fish samples from Las Mareas Bay, and the exceedance seems unlikely to reflect significant risk above background. The uncertainty factor applied to the thallium reference dose (directly used to calculate the noncancer hazard quotient) of 3,000 also highlights the large uncertainty in the risk result. The fish consumption cancer risks are all less than the goal of 1 in 10,000.

Lead. There is no accepted toxicity value for lead. Consistent with EPA policy, lead was evaluated using the Integrated Exposure Uptake Biokinetic (IEUBK) Model (U.S. EPA, 2024c), which estimates potential blood lead levels in children 7 years or younger (U.S. EPA, 2024d). These levels are compared to the Centers for Disease Control and Prevention (CDC) blood lead reference value (BLRV) of 3.5 micrograms per deciliter (µg/dL). The BLRV is a population-based measurement that reflects the 97.5 percentile of blood lead distribution in U.S. children aged 1–5 years and is not a health-based standard or a toxicity threshold.

Blood lead levels in children 1 to <2 years from consuming locally caught fish may slightly exceed the BLRV.

Conclusions

Only one exceedance was seen in the risk results: thallium in fish. The results for thallium in fish are based on a single detection in one fish species (Spanish mackerel); the single detected concentration from Las Mareas Bay is not higher than the single detected concentration from the background location (in Atlantic bumper). The exceedance is for children aged 1 to <2 years, for whom no fish consumption rate data were available, so the consumption rate for children 2 to <3 years was used. Consequently, this isolated fish exceedance is highly uncertain, and likely to be an overestimate.

1 Background

1.1 Introduction

This project aims to address community health concerns associated with fishing and recreational activities in Laguna de las Mareas (hereafter referred to as Las Mareas Bay) in Guayama, Puerto Rico. The community requested scientific support to improve understanding of how coal and coal combustion residuals potentially released into Las Mareas Bay from local industrial operations may impact the health of its residents. The community's concerns include impacts to the marine food web (including fish caught in Las Mareas Bay and consumed), along with direct human contact from recreation in and around Las Mareas Bay.

To address these concerns, the U.S. Environmental Protection Agency (EPA) completed a deterministic human health risk assessment (HHRA) to estimate potential exposures and risks posed to individuals in the community related to fishing and recreational activities that occur in Las Mareas Bay. A separate assessment is being conducted by EPA that considers groundwater and ambient air quality issues, so those issues are not covered in this assessment.

The assessment used sampling data from the Las Mareas area collected in 2024 for this study by EPA in conjunction with other EPA-approved data sources and methodologies to evaluate risk. The EPA developed and followed a Quality Assurance Project Plan (QAPP, QAPP ID: I-GLTED-0034299) to collect environmental samples (e.g., soil, sediment, fish) for laboratory analysis and data analysis to estimate exposure and risk in a subset of adults and children. The data were evaluated for compliance with the QAPP, and a determination was made that the data met the requirements outlined in the QAPP and were appropriate for use in the HHRA.

This report documents the sample collection activities, the sampling results, and the HHRA methodology and findings. The HHRA evaluates cancer risks and noncancer hazards from a subset of residents exposed to sand, sediment, and surface water, or ingesting fish caught in Las Mareas Bay.

The basic steps of the HHRA are as follows:

- **Data collection and analysis** determines the nature and extent of chemical contamination in environmental media, such as surface water, sand, sediment, and fish intended for human consumption.
- **Exposure assessment** identifies potentially exposed populations and estimates human chemical intake through exposure routes such as ingestion or skin contact.
- **Toxicity assessment** evaluates chemical toxicity endpoints, including cancer and noncancer health effects from exposure to chemicals.
- **Risk characterization** evaluates the likelihood and degree of chemical exposure and the possible adverse health effects associated with exposures to high-end (95th percentile) and median (50th percentile) concentrations.

The results of the HHRA identify cancer risks and noncancer health hazards from exposures to the media listed earlier. Although the HHRA uses methods and data developed by various regulatory programs at EPA (e.g., Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA], commonly known as Superfund; Resource Conservation and Recovery Act [RCRA]), it is important to note that Las Mareas Bay is not a Superfund or RCRA site, and the results of the HHRA presented in this report are informational and will not be used to support regulatory action. Risk managers and assessors will evaluate the information provided here to identify appropriate next steps. No regulatory decisions will be based on the results presented in this report.

1.2 Site Description

Las Mareas Bay, shown in **Figure 1**, is a human-made bay on the southern coast of Puerto Rico that was developed to ship materials to and from the island. The coal-powered AES power plant (hereafter referred to as AES) is located just north of the bay and currently uses the bay to receive coal and ship out fly ash, a residual of coal combustion. The bay is also home to a ship maintenance and docking facility and an abandoned fuel-oil terminal pier used by the Chevron Phillips Chemical Plant, which operated in the area from 1966 to 2008. The community uses the bay for recreational activities, including boating, swimming, and fishing.

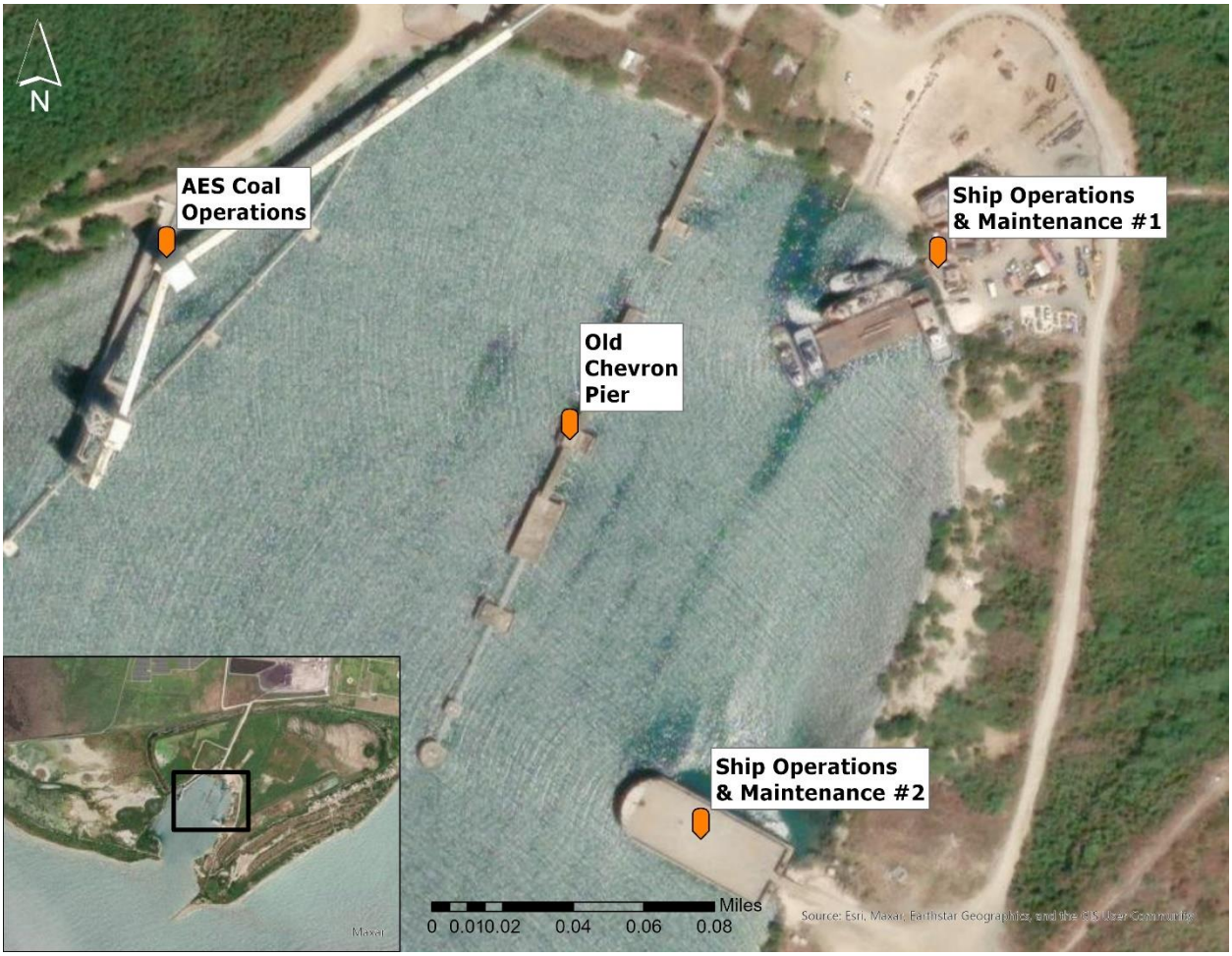

Figure 1. Las Mareas Bay and nearby industrial activities.

Las Mareas Bay is roughly 853 meters (m; 2,799 feet [ft]) long by 426 m (1,398 ft) wide, or about 36 hectares (ha) (0.53 miles [mi] by 0.26 mi; 90 acres). The navigable channel is dredged approximately every 10 years by the Puerto Rico Ports Authority. Anchorage and cargo pier depths range from 11 to 12.2 m (36–40 ft), whereas oil terminal depths range from 12.5 to 13.7 m (41–44.9 ft). The entrance channel is permitted to 11.6 m (38 ft). Outside of maintained areas, bathymetry data are limited, but depths outside the dredged areas are expected to be shallow because Las Mareas Bay is human made.[1]

[1] Depth data were provided by Mark Reiss, EPA Region 2 Water Division.

Source attribution was not the focus of this analysis; however, the area surrounding Las Mareas Bay includes several potential sources of environmental contaminants (see **Figure 2**). These include the following:

- AES, a coal-fired power plant (450 megawatts [MW]) that has a contract to produce energy until 2027
- Fibers Public Supply Wells Superfund site
- RCRA Corrective Action Sites
    - TAPI Puerto Rico
    - Chevron Phillips Chemicals
- Puerto Rico Aqueduct and Sewer Authority wastewater treatment plant
- Dredge spoils storage (runoff from the dredged material enters the bay during large storm events).

Further influencing environmental conditions in Las Mareas Bay (but not shown in Figure 2) are a ship maintenance and docking facility and an abandoned fuel-oil terminal.

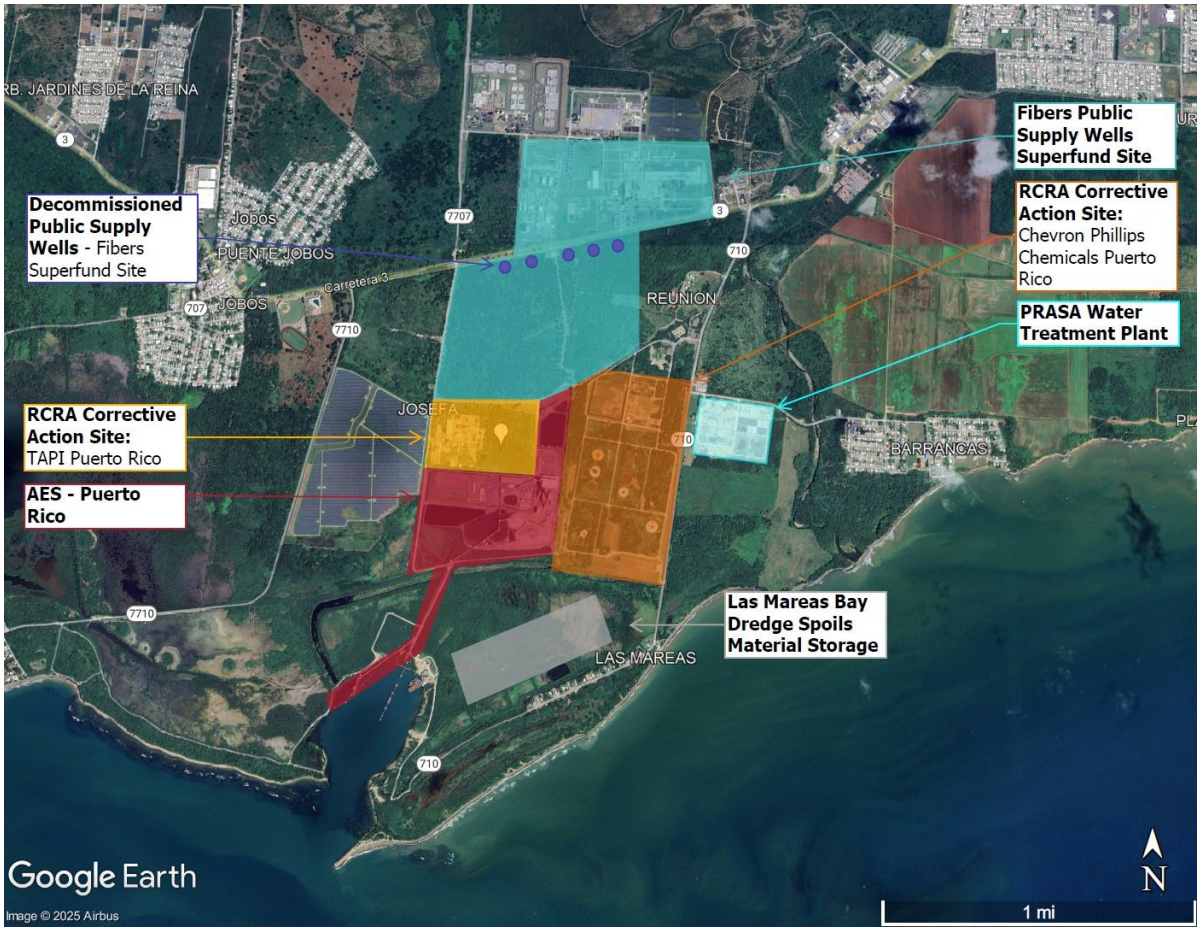

Figure 2. Potential sources of environmental contaminants in Las Mareas Bay.
Source: Figure created by EPA Region 2.

1.3 Chemicals Analyzed

The community's stated concerns regarding contaminants in the environment were related to the coal and fly ash from AES, which suggests metals, mercury, and polycyclic aromatic hydrocarbons (PAHs) as contaminants of potential concern. The coal used by AES is reportedly sourced from Colombia. Tewalt et al. (2006) provided data on the quality of coal from Colombia, including potential contaminants (although they note that the composition of the coal varies with location). The coal combustion residuals from AES are converted to a manufactured aggregate known as Agremax (a combination of 80% coal combustion fly ash and 20% bottom ash by weight;

Garrabrants et al. [2014]). The aggregate was previously used on the island and is shipped off the island for disposal. Coal plant operations require the offloading of coal and the loading of Agremax through the Mareas Bay terminal. AES's National Pollutant Discharge Elimination System (NPDES) permit includes levels for antimony, arsenic, barium, beryllium, boron, cadmium, total chromium, cobalt, lead, lithium, mercury, molybdenum, radium, selenium, silver, and thallium, as well as methylmercury due to the extensive pyritic sulfur (approximately 1% to 3%) in the coal where mercury may accumulate.

The Chevron Phillips RCRA Corrective Action site is another potential source of contamination. The Chevron Phillips Chemicals plant, which operated from 1966 and ceased operations in 2008, "*was constructed to process naphtha into a variety of refined hydrocarbon products including benzene, toluene, ethylbenzene, xylenes (BTEX), cyclohexanes, liquid petroleum gas, gasoline, and diesel fuels. Through inadvertent releases, BTEX was introduced into the soil and groundwater. In addition to BTEX, the chemical sulfolane was also released to soil and groundwater. Sulfolane is an organic solvent that was used as part of the petroleum refining process*" (U.S. EPA, 2017a). The sediment contaminants of concern from Chevron Phillips operations are chromium, copper, manganese, nickel, and zinc (U.S. EPA, 2017a).

Prior studies (Mansilla-Rivera & Rodríguez-Sierra, 2011; Agency for Toxic Substances and Disease Registry [ATSDR], 2013) evaluated contaminants in sediment, water, and fish near Las Mareas Bay[2] and found that elevated levels of mercury are persistent in the environment in areas surrounding coastal marine environments of Puerto Rico.

Table 1 lists the 34 chemicals of potential concern identified, including 15 inorganics and 19 organics (18 polycyclic aromatic hydrocarbons [PAHs] and sulfolane).

Table 1. Chemicals of Potential Concern Analyzed

Inorganics		Organics	
Antimony	Mercury*	Acenaphthene	Dibenzo(a,h)anthracene
Arsenic (inorganic)	Molybdenum	Acenaphthylene	Fluoranthene
Barium	Selenium	Anthracene	Fluorene
Beryllium	Silver	Benzo(a)anthracene	Indeno(1,2,3-cd)pyrene
Boron	Thallium	Benzo(a)pyrene	Methylnaphthalene, 2-
Cadmium		Benzo(b)fluoranthene	Naphthalene
Chromium		Benzo(g,h,i)perylene	Phenanthrene
Cobalt		Benzo(k)fluoroanthene	Pyrene
Lead		Biphenyl, 1,1'-	Sulfolane
Lithium		Chrysene	

* Includes methylmercury (fish) and inorganic mercury (other media).

1.4 Types of Fish Targeted for Sample Collection

The types of fish targeted for collection and analysis were primarily based on community input. Staff from EPA met with community members in 2023 and received feedback on fish species they typically consumed. The fish species include lane snapper (*Lutjanus synagris*), mutton snapper (*Lutjanus analis*), scaled sardine/herring (species not identified), yellowtail snapper (*Ocyurus chrysurus*), Spanish mackerel (*Scomberomorus maculatus*), and glass minnow/bay anchovy (species not identified). Many other fish species, including blue runner (*Caranx crysos*) and Atlantic bumper (*Chloroscombrus chrysurus*), are locally caught and marketed fresh for human

[2] Mansilla-Rivera and Rodríguez-Sierra (2011) evaluated metals in fish caught at Jobos Bay and La Parguera on the south coast of Puerto Rico about 3 and 30 miles west of Las Mareas Bay, respectively; ATSDR (2013) reviewed various environmental media at Vieques Island off the east coast of Puerto Rico.

consumption and may be used as bait. Therefore, blue runner and Atlantic bumper were included in the target list of fish species for sample collection. Blue runner are highly migratory and likely do not reflect environmental conditions at Las Mareas Bay or the background location; however, community members did possess blue runner from fishing, so the species was included in the laboratory analysis to consider the seasonal influence on community consumption/risk. **Table 2** provides basic characteristics of the eight fish species collected and analyzed for this project.

Bioaccumulation of chemicals in fish tissue (and thus exposure and risk) can differ considerably across fish species, due in part to different feeding strategies. Thus, the secondary rationale for collecting a variety of fish species was to provide a sample that would allow for characterization of exposure using species that have different life histories and foraging strategies. Most of the eight fish species collected have overlapping feeding habits; however, multiple species do feed in pelagic, open-water conditions compared with reef and coastal nearshore species. Likewise, small fish species such as scaled sardine/herring and glass minnow/bay anchovy, are planktonic and mostly feed on zooplankton in the water column. These differences are expected to provide representation of differing contaminant exposure risks throughout the food web.

Table 2. Typical Characteristics of the Eight Fish Species Sampled

Common Name	Blue Runner	Atlantic Bumper	Lane Snapper	Mutton Snapper	Scaled Sardine/ Herring	Yellowtail Snapper	Spanish Mackerel	Glass Minnow/ Bay Anchovy
Species	*Caranx crysos*	*Chloroscombrus chrysurus*	*Lutjanus synagris*	*Lutjanus analis*	Not identified	*Ocyurus chrysurus*	*Scomberomorus maculatus*	Not identified
Environment	Brackish, reef associated	Brackish, pelagic-neritic	Reef associated	Brackish, reef associated	Brackish/ hyper-saline estuaries, reef associated	Reef associated	Pelagic-neritic	Marine/ freshwater, brackish, pelagic-neritic
Requested by community?	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Migratory?	Highly migratory species	Short-distance migratory species	Localized migratory movements	Highly migratory species during life stage/ reproduction	Localized seasonal movements	Short-distance migratory species	Highly migratory species based on seasonality	Localized seasonal movements
Life cycle type	Oceanodromous	Oceanodromous	Oceanodromous	Oceanodromous	Anadromous	Oceanodromous	Oceanodromous	Anadromous
Depth (m)	0 to 100	0 to 110	10 to 400, usually 21 to 70	25 to 95	0 to 22, usually 1 to 5	0 to 180, usually 10 to 70	10 to 35	1 to 70, usually 1 to 36
Food	Fish, shrimp, other invertebrates	Fish, cephalopods, plankton detritus	Small fish, bottom-living crabs, shrimps, worms, gastropods, cephalopods	Fish, shrimp, crabs, cephalopods, gastropods	Plankton	Plankton, fish, crustaceans, worms, gastropods, cephalopods	Small fish (clupeoids, anchovies), shrimps, cephalopods	Zooplankton, primarily copepods
Avg. length at maturity (cm)	27.4	12.4	23.4	43.8	8.1	23.8	40.5	4.3
Avg. length at maturity (mm)	274	124	234	438	81	238	405	43
Range size (cm)	Not reported	10 to unknown	16 to 21.5	28 to 40	8 to 8.5	14 to 31	25 to 51.2	4 to 4.5

References: Allen, 1985; Collette & Nauen, 1983; Froese & Pauly, 2024; Smith-Vaniz et al., 1990; Whitehead et al., 1988.

2 Sample Collection

2.1 Sampling Locations

Figure 3 shows the three sampling locations (Las Mareas Bay and the two background locations) relative to each other. The background locations were chosen to be outside the expected influence of the chemical sources near Las Mareas Bay and serve as a reference point with which to compare findings. The primary background location, Tropical Beach (in Naguabo) is approximately 30 miles northeast and upwind of Las Mareas Bay. Although 10 beach sand samples were collected from this location, due to unforeseen difficulties associated with road access while towing the boat to this site, surface water, sediment, and fish samples could not be collected at this location. Playa Arenas (in Salinas), which is approximately 7 miles west of Las Mareas Bay and does not have any large industrial activity, was selected as a second background location to collect surface water, sediment, and fish samples, as well as additional sand samples. Playa Arenas has several coves compared with Tropical Beach, which has a longer continuous sand shoreline.

Figure 3. Surface water, sand, sediment, and fish samples were collected in 2024 at Las Mareas Bay. Sand samples were collected at Tropical Beach. Due to shallow, unnavigable waters at Tropical Beach, surface water, sediment, and fish samples were collected at Playa Arenas, along with additional sand samples.
Source: Google Maps

Figures 4 to **6** show the specific water, sand,[3] and sediment sampling locations in Las Mareas Bay, Tropical Beach, and Playa Arenas, respectively. The associated field data logs are provided in **Tables 3** to **5**. Fish collection field data logs are provided in **Tables 6** and **7** for Las Mareas Bay and Playa Arenas, respectively. No fish samples were collected from Tropical Beach.

[3] The areas sampled for sand for Las Mareas Bay (see Figure 4) are not readily accessible or regularly used for general beach recreation.

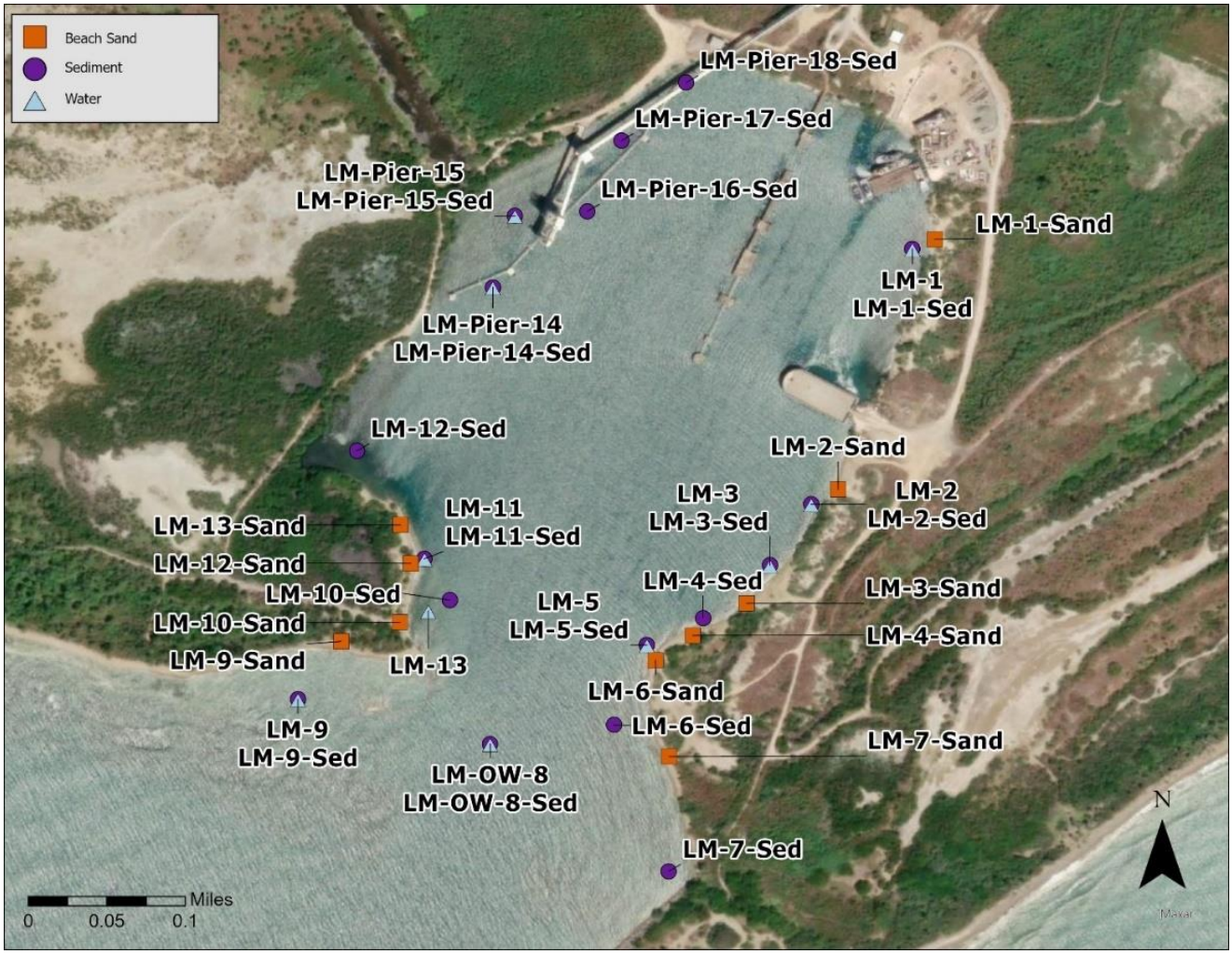

Figure 4. Sampling locations in Las Mareas Bay (Guayama, Puerto Rico).

Figure 5. Background sampling locations in Tropical Beach (Naguabo, Puerto Rico).

Figure 6. Background sampling locations in Playa Arenas (Salinas, Puerto Rico).

Table 3. Las Mareas Bay Water, Sand, and Sediment Sample IDs, Depths, Locations, and Descriptors

Sample ID	Matrix	Depth (ft)	Time	Latitude (DD)	Longitude (DD)	Notes/Description/Comments
LM-1-Sed	Sediment	2.5	10:45	17.9361879	-66.1558229	Dark gray/black mud and sand—coarse sand with fines; some organic material
LM-2-Sed	Sediment	3	11:07	17.9337092	-66.1568584	Dark gray/black; coarse sand with brown mud; some organic material
LM-3-Sed	Sediment	3.5	11:26	17.9332631	-66.1571352	Gray-black sand/mud with pieces of vegetation
LM-4-Sed	Sediment	3.5	11:38	17.9327808	-66.1577434	Gray mud, finer sand, lots of seagrass
LM-5-Sed	Sediment	3	12:00	17.9325790	-66.1581907	No sample on first grab; gray/black mud, lots of seagrass
LM-6-Sed	Sediment	3	12:36	17.9316296	-66.1583918	Coarse sand, packed; difficult to get good grab; took multiple drops before getting good grab
LM-7-Sed	Sediment	3	12:53	17.9304637	-66.1581823	Coarse sand, two grabs needed to collect enough sample; hard-packed sand, difficult grab
LM-OW-8-Sed	Sediment	50	13:20	See notes	See notes	GPS POI #8, did not log coordinates; thick, dark muck, fine, silty/mud
LM-9-Sed	Sediment	4.5	13:40	17.9321045	-66.1616236	Gritty, coarse gray sand; needed multiple grabs to get enough sample
LM-10-Sed	Sediment	3.5	13:57	17.9329919	-66.1601267	Coarse sand, some vegetation
LM-11-Sed	Sediment	1.5	14:54	17.9333480	-66.1603301	Very coarse sand
LM-12-Sed	Sediment	2.5	15:15	17.9343259	-66.1609153	Gritty mud, dark gray, lots of vegetation
LM-13-Sed	NA	NA	NA	NA	NA	At site #10 in sampling plan. No sample collected—rocky and thick vegetation; skipped sediment collection at this site, water sample only
LM-Pier-14-Sed	Sediment	35.5	15:30	17.9358291	-66.1596596	Thick dark, sticky, silty mud
LM-Pier-15-Sed	Sediment	4.5	16:10	17.9364971	-66.1595066	Thick dark mud with vegetation
LM-Pier-16-Sed	Sediment	36.5	16:21	17.9365335	-66.1587907	Thick, gloopy muck; gray mud; very different from other samples
LM-Pier-17-Sed	Sediment	2.5	16:35	17.9371768	-66.1585740	Thick clumps of gray clay-like material; clam shells; very sticky gray clay
LM-Pier-18-Sed	Sediment	9.5	16:55	17.9376488	-66.1578276	Clumps of gray clay-like material; gritty coarse sand mixed with fines/clays; lots of shell fragments
LM-Field Blank-Sed	Sediment	NA	17:20	NA	NA	Sediment sampler field blank—PAHs and sulfolane collected @ 17:25 using clean Ottawa sand
LM-Field Blank-Sed	Water	NA	17:25	NA	NA	Sediment sampler field blank—metals collected @ 17:20 using certified clean water
LM-1	Water	2.5	10:40	17.9361879	-66.1558229	Clear water, no color, no smell, no particulate
LM-2	Water	2.5	11:00	17.9338268	-66.1567660	Clear, no color/smell, no particulate
LM-3	Water	3.5	11:25	17.9332655	-66.1571360	Clear, no smell, color, or particulate
LM-5	Water	3.5	11:52	17.9325567	-66.1582609	Clear, no smell or particulate
LM-OW-8	Water	25*	13:15			Clear, nothing of note. *Sampled at 25 ft, midwater depth; water depth ~50 ft

(continued)

Table 3. Las Mareas Bay Water, Sand, and Sediment Sample IDs, Locations, and Descriptors (continued)

Sample ID	Matrix	Depth (ft)	Time	Latitude (DD)	Longitude (DD)	Notes/Description/Comments
LM-9	Water	4.5	13:33	17.9320365	-66.1615291	Nothing of note
LM-11	Water	2	15:02	17.9333885	-66.1603384	Clear water, no smell, color, small amount of particulate
LM-13	Water	3.5	15:54	17.9328076	-66.1602826	Water only collected from this site—collected at location #10 on the sampling plan
LM-Pier-14	Water	17*	15:28	17.9358380	-66.1596788	Clear water, no color/smell/particulate. *Water collected at 17 ft, midwater depth; water depth ~35.5 ft
LM-Pier-15	Water	4.5	16:08	17.9364971	-66.1595066	Clear water, no particulate
LM-Field Blank - Water	Water	NA	17:10	NA	NA	Water sampler field blank collected at 17:10 using laboratory-certified clean water. *PAH field blank water sample jar shattered in transit; only metals and sulfolane left and sent for analysis
LM-1-Sand	Beach sand	NA	12:12	17.9362649	-66.1556071	Sandy, few rocks/shells; collected ~10 ft above tidal zone (water line)
LM-2-Sand	Beach sand	NA	11:50	17.9339648	-66.1565025	Packed sand, some organic material; collected ~10 ft above tidal zone (water line)
LM-3-Sand	Beach sand	NA	11:23	17.9329231	-66.1573495	Coarser sand, more shell fragments, lighter/fluffier sand, shells; collected ~6 ft above tidal zone (water line)
LM-4-Sand	Beach sand	NA	11:10	17.9326214	-66.1578448	Slightly packed sand, more organic material, few small rocks; collected ~15 ft above tidal zone (water line)
LM-6-Sand	Beach sand	NA	10:35	17.9323714	-66.1582249	Fine sand; few small rocks; collected ~5 ft above tidal zone (water line)
LM-7-Sand	Beach sand	NA	10:59	17.9315036	-66.1580600	Fine sand; few small rocks/shells; collected ~8 ft above tidal zone (water line)
LM-9-Sand	Beach sand	NA	12:37	17.9325688	-66.1610859	Coarse and fine sand, mixed, few small rocks; collected ~15 ft above tidal zone (water line)
LM-10-Sand	Beach sand	NA	12:48	17.9327355	-66.1605308	Mixed sand, some rocks/shells; collected ~10 ft above tidal zone (water line)
LM-12-Sand	Beach sand	NA	13:00	17.9332323	-66.1604318	Mixed sand, finer, some organic material, light/fluffy, shell pieces; collected ~8 ft above tidal zone (water line)
LM-13-Sand	Beach sand	NA	13:08	17.9336456	-66.1605338	Mixed sand, finer, some organics, hard packed; collected ~12 ft above tidal zone (water line)
LM-Field Blank - Sand	Beach sand	NA	13:20	NA	NA	Las Mareas sand field blank collected at 13:20 using laboratory-prepared clean Ottawa sand
LM-2-Sand	Beach sand	NA	11:50	17.9339648	-66.1565025	Packed sand, some organic material; collected ~10 ft above tidal zone (water line)
LM-3-Sand	Beach sand	NA	11:23	17.9329231	-66.1573495	Coarser sand, more shell fragments, lighter/fluffier sand, shells; collected ~6 ft above tidal zone (water line)
LM-4-Sand	Beach sand	NA	11:10	17.9326214	-66.1578448	Slightly packed sand, more organic material, few small rocks; collected ~15 ft above tidal zone (water line)
LM-6-Sand	Beach sand	NA	10:35	17.9323714	-66.1582249	Fine sand; few small rocks; collected ~5 ft above tidal zone (water line)
LM-7-Sand	Beach sand	NA	10:59	17.9315036	-66.1580600	Fine sand; few small rocks/shells; collected ~8 ft above tidal zone (water line)

(continued)

Table 3. Las Mareas Bay Water, Sand, and Sediment Sample IDs, Locations, and Descriptors (continued)

Sample ID	Matrix	Depth (ft)	Time	Latitude (DD)	Longitude (DD)	Notes/Description/Comments
LM-9-Sand	Beach sand	NA	12:37	17.9325688	-66.1610859	Coarse and fine sand, mixed, few small rocks; collected ~15 ft above tidal zone (water line)
LM-10-Sand	Beach sand	NA	12:48	17.9327355	-66.1605308	Mixed sand, some rocks/shells; collected ~10 ft above tidal zone (water line)
LM-12-Sand	Beach sand	NA	13:00	17.9332323	-66.1604318	Mixed sand, finer, some organic material, light/fluffy, shell pieces; collected ~8 ft above tidal zone (water line)
LM-13-Sand	Beach sand	NA	13:08	17.9336456	-66.1605338	Mixed sand, finer, some organics, hard packed; collected ~12 ft above tidal zone (water line)
LM-Field Blank - Sand	Beach sand	NA	13:20	NA	NA	Las Mareas sand field blank collected at 13:20 using laboratory-prepared clean Ottawa sand

DD=decimal degrees; POI=point of interest.

Note: All Las Mareas Beach sand samples were collected on March 15, 2024. Surface water and sediment samples were collected on March 17, 2024. All samples were collected just below the surface, unless otherwise noted. See depths with an asterisk (*).

Table 4. Tropical Beach (Background Location) Sand Sample IDs, Locations, and Descriptors

Sample Name/No.	Matrix	Depth (ft)	Time	Lat (DD)	Long (DD)	Notes/Description/Comments
Ref-1-Sand	Beach sand	NA	14:49	18.1857330	-65.7285990	Coarse sand; collected from sandy area behind beach ~10 ft above water line near bridge/river
Ref-2-Sand	Beach sand	NA	15:05	18.1852029	-65.7287505	Coarse sand, some small shell fragments/small organic debris; collected from sand ~10 ft above ocean tidal zone, between ocean and river
Ref-3-Sand	Beach sand	NA	15:15	18.1861092	-65.7276413	Coarse sand; collected from sand ~10 ft above tidal zone (current water line)
Ref-4-Sand	Beach sand	NA	15:25	18.1836364	-65.7273021	Coarse sand; collected from sand ~15 ft above current water line (tidal zone)
Ref-5-Sand	Beach sand	NA	15:50	18.1868888	-65.7266374	Coarse sand, some small shell fragments; collected from sand ~15 ft above tidal zone (POI #6, disregard POI #5)
Ref-6-Sand	Beach sand	NA	16:05	18.1871216	-65.7262887	Coarse sand, some small vegetation roots, shell fragments; collected from ~15 ft above tidal zone
Ref-7-Sand	Beach sand	NA	16:18	18.1873975	-65.7259087	Coarse sand; collected from ~8 ft above tidal zone
Ref-8-Sand	Beach sand	NA	16:37	18.1877353	-65.7252759	Coarse sand; collected from ~15 ft above tidal zone, near bridge
Ref-9-Sand	Beach sand	NA	16:58	18.1883265	-65.7243912	Coarse sand; collected from ~15ft above tidal zone, eastern edge of beach on east side of bridge
Ref-10-Sand	Beach sand	NA	17:09	18.1885291	-65.7240340	Coarse sand, lots of small strands of organic vegetation in sand; collected from ~8 ft above tidal zone, furthest E[ast] sample along beach
Ref-Field Blank-Sand	Sand	NA	17:20	NA	NA	Field blank collected @ 17:20

DD=decimal degrees; POI=point of interest.

Note: All Tropical Beach sand samples were collected on March 16, 2024.

Table 5. Playa Arenas (Background Location) Water, Sand, and Sediment Sample IDs, Locations, and Descriptors

Sample Name/No.	Matrix	Depth (ft)	Time	Latitude (DD)	Longitude (DD)	Notes/Description/Comments
PA-Ref-1	Beach sand	NA	9:50	17.947473	-66.271558	Light-colored sand, coarse with lots of shell fragments, some small roots
PA-Ref-2	Beach sand	NA	10:20	17.947435	-66.273211	Sampled from upper part of tidal zone, no sand higher up beach; fine light-colored sand; texture of kinetic sand
PA-Ref-3	Beach sand	NA	11:20	17.948761	-66.275626	Coarse sand with lots of shells; light in color; GPS POI #6
PA-Ref-4	Beach sand	NA	11:30	17.948568	-66.276851	Medium/coarse sand, very light; lots of shell fragments; GPS POI #7
PA-Ref-5	Beach sand	NA	13:45	17.947501	-66.279830	Sampled in-shore of Ref-7 water/sediment sample; very coarse shell-dominated sand; GPS POI #12
PA-Ref-1-Sed	Sediment	3	9:40	17.947191	-66.271578	Lighter gray sandy sediment, shell fragments
PA-Ref-2-Sed	Sediment	3	10:10	17.947240	-66.273065	Lighter gray sandy, shell fragments, coarse
PA-Ref-3-Sed	Sediment	3	10:53	17.948438	-66.275990	Gray, soupy, sandy sediment, lots of vegetation on top; removed for sample
PA-Ref-4-Sed	Sediment	2.5	12:00	17.948483	-66.276423	Gray silty sand; more fine material here; vegetation present; had to repeat grab to get sample
PA-Ref-5-Sed	Sediment	2.5	12:22	17.948425	-66.276740	Gray gritty sand, lots of shell fragments; vegetation present
PA-Ref-6-Sed	Sediment	2.5	12:55	17.948253	-66.277146	Gray sandy mud with vegetation and shells
PA-Ref-7-Sed	Sediment	2	13:15	17.947176	-66.279700	Thick, dark gray silty mud, very soft
PA-Ref-8-Sed	Sediment	3	14:32	17.946731	-66.280378	Thick, dark gray silty/sticky mud; very soft
PA-Ref-9-Sed	Sediment	2	14:55	17.945971	-66.282053	Coarse, shelly sediment, gray; lots of shell fragments; calcareous algae
PA-Ref-10-Sed	Sediment	2	15:15	17.944716	-66.285050	Thick gray silty muck; completed sampling at 15:30
PA-Ref-Field Blank-Sed	Sediment	NA	15:45	NA	NA	Sediment field blanks collected @ 15:45; PAHs/sulfolane with clean sand
PA-Ref-Field Blank-Sed (metals)	Water	NA	15:45	NA	NA	Sediment field blanks collected @ 15:45; metals with clean DI water from laboratory
PA-Ref-1	Water	3	9:32	17.947191	-66.271578	Station @ furthest area east out from sandy beach area; collected just below surface; clear, no color/odor/particulate
PA-Ref-2	Water	3	10:02	17.947240	-66.273065	Station near next sandy areas west of Ref-1; manatees nearby; clear water
PA-Ref-3	Water	3	10:55	17.948438	-66.275990	Clear water, no small/particulate; manatee in water; stand down for a bit
PA-Ref-4	Water	2.5	11:50	17.948483	-66.276423	Clear water, no smell
PA-Ref-5	Water	2.5	12:20	17.948425	-66.276740	Slightly cloudy/murky no color/odor; some particulate; manatee mixing up sediment nearby; sampled on other side of boat

(continued)

Table 5. Playa Arenas (Background Location) Water, Sand, and Sediment Sample IDs, Locations, and Descriptors (continued)

Sample Name/No.	Matrix	Depth (ft)	Time	Latitude (DD)	Longitude (DD)	Notes/Description/Comments
PA-Ref-6	Water	2.5	12:50	17.948253	-66.277146	Clear water, no small or particulate
PA-Ref-7	Water	2	13:25	17.947176	-66.279700	Clear water, no small or particulate
PA-Ref-8	Water	3	14:30	17.946731	-66.280378	Clear water, no small or particulate
PA-Ref-9	Water	2	15:00	17.945971	-66.282053	Clear water
PA-Ref-10	Water	2	15:55	17.944716	-66.285050	Semi-cloudy water, some particulate
PA-Ref-Field Blank-Water	Water		15:40	NA	NA	Water field blank collected @ 15:40 with clean DI water from laboratory

DD=decimal degrees; DI=deionized; POI=point of interest.

Note: All Playa Arenas reference area samples were collected on March 19, 2024. All water samples were collected just below the surface, unless otherwise noted.

Table 6. Fish Field Sample Collection Logs for Las Mareas Bay

Sample ID	Common Name	Species	Length (cm)	Weight (g)	Date	Individuals	Latitude	Longitude
2024-LM-01	Blue runner	*Caranx crysos*	33.00	657.72	3/15/24	1	17.93439	-66.15865
2024-LM-02	Blue runner	*Caranx crysos*	30.50	489.89	3/15/24	1	17.93439	-66.15865
2024-LM-03	Blue runner	*Caranx crysos*	34.00	730.30	3/15/24	1	17.93439	-66.15865
2024-LM-04	Spanish mackerel	*Scomberomorus maculatus*	34.50	399.17	3/15/24	1	17.93508	-66.15786
2024-LM-05	Horse-eye jack	*Caranx latus*	52.00	3025.51	3/15/24	1	17.93439	-66.15865
2024-LM-06	Blue runner	*Caranx crysos*	31.00	544.32	3/15/24	1	17.93439	-66.15865
2024-LM-07	Blue runner	*Caranx crysos*	31.50	675.86	3/15/24	1	17.93439	-66.15865
2024-LM-08	Blue runner	*Caranx crysos*	30.50	612.36	3/15/24	1	17.93439	-66.15865
2024-LM-09	Horse-eye jack	*Caranx latus*	23.50	290.30	3/15/24	1	17.93439	-66.15865
2024-LM-10	Horse-eye jack	*Caranx latus*	22.00	263.09	3/15/24	1	17.93439	-66.15865
2024-LM-11	Horse-eye jack	*Caranx latus*	22.50	226.80	3/15/24	1	17.93439	-66.15865
2024-LM-12	Atlantic bumper	*Chloroscombrus chrysurus*	21.50	145.15	3/15/24	1	17.93363	-66.15959
2024-LM-13	Atlantic bumper	*Chloroscombrus chrysurus*	24.50	185.98	3/15/24	1	17.93363	-66.15959
2024-LM-14	Atlantic bumper	*Chloroscombrus chrysurus*	19.50	90.72	3/15/24	1	17.93363	-66.15959
2024-LM-15	Atlantic moonfish	*Selene setapinnis*	20.00	127.01	3/15/24	1	17.93363	-66.15959
2024-LM-16	Atlantic moonfish	*Selene setapinnis*	15.00	77.11	3/15/24	1	17.93363	-66.15959
2024-LM-17	Lane snapper	*Lutjanus synagris*	18.70	131.54	3/15/24	1	17.93363	-66.15959
2024-LM-18	Lane snapper	*Lutjanus synagris*	11.50	40.82	3/15/24	1	17.93363	-66.15959
2024-LM-19	Mutton snapper	*Lutjanus analis*	11.00	31.75	3/15/24	1	17.93480	-66.16058
2024-LM-20	Mutton snapper	*Lutjanus analis*	12.50	45.36	3/15/24	1	17.93480	-66.16058
2024-LM-21	Glass minnow	Not identified	5.50	18.14	3/15/24	11	17.93436	-66.15747
2024-LM-22	Scaled sardine/herring	Not identified	7.50	31.75	3/15/24	6	17.93436	-66.15747
2024-LM-23	Scaled sardine/herring	Not identified	8.50	36.29	3/15/24	6	17.93436	-66.15747
2024-LM-24	Mutton snapper	*Lutjanus analis*	17.50	140.62	3/16/24	1	17.93480	-66.16058
2024-LM-25	Mutton snapper	*Lutjanus analis*	19.00	195.05	3/16/24	1	17.93480	-66.16058
2024-LM-26	Mutton snapper	*Lutjanus analis*	17.90	127.01	3/16/24	1	17.93480	-66.16058
2024-LM-27	Lane snapper	*Lutjanus synagris*	16.00	104.33	3/16/24	1	17.93363	-66.15959
2024-LM-28	Lane snapper	*Lutjanus synagris*	9.50	18.14	3/16/24	1	17.93363	-66.15959

(continued)

Table 6. Fish Field Sample Collection Logs for Las Mareas Bay (continued)

Sample ID	Common Name	Species	Length (cm)	Weight (g)	Date	Individuals	Latitude	Longitude
2024-LM-29	Mutton snapper	*Lutjanus analis*	10.00	22.68	3/16/24	1	17.93480	-66.16058
2024-LM-30	Mutton snapper	*Lutjanus analis*	11.00	31.75	3/16/24	1	17.93480	-66.16058
2024-LM-31	Atlantic bumper	*Chloroscombrus chrysurus*	19.00	99.79	3/16/24	1	17.93363	-66.15959
2024-LM-32	Scaled sardine/herring	Not identified	7.30	9.07	3/16/24	2	17.93436	-66.15747
2024-LM-33	Blue runner	*Caranx crysos*	36.00	1034.21	3/16/24	1	17.93439	-66.15865
2024-LM-34	Lane snapper	*Lutjanus synagris*	12.00	45.36	3/17/24	1	17.93750	-66.15593
2024-LM-35	Scorpionfish	*Scorpaena plumieri*	15.50	163.30	3/17/24	1	17.93751	-66.15594

Table 7. Fish Field Sample Collection Logs for Playa Arenas Background Location (Salinas, Puerto Rico)

Sample ID	Common Name	Species	Length (cm)	Weight (g)	Date	Individuals	Latitude	Longitude
2024-PA-36	Lizardfish	Family: Synodontidae	23.90	131.54	3/19/24	1	17.94280	-66.28006
2024-PA-37	Yellowtail snapper	*Ocyurus chrysurus*	9.00	18.14	3/19/24	1	17.94280	-66.28006
2024-PA-38	Yellowtail snapper	*Ocyurus chrysurus*	14.70	63.50	3/19/24	1	17.94280	-66.28006
2024-PA-39	Yellowtail snapper	*Ocyurus chrysurus*	12.00	40.82	3/19/24	1	17.94280	-66.28006
2024-PA-40	Yellowtail snapper	*Ocyurus chrysurus*	15.00	72.58	3/19/24	1	17.94280	-66.28006
2024-PA-41	Yellowtail snapper	*Ocyurus chrysurus*	12.40	40.82	3/19/24	1	17.94280	-66.28006
2024-PA-42	Yellowtail snapper	*Ocyurus chrysurus*	7.50	9.07	3/19/24	1	17.94280	-66.28006
2024-PA-43	Jolthead porgy	*Calamus bajonado*	14.50	86.18	3/19/24	1	17.94280	-66.28006
2024-PA-44	Lane snapper	*Lutjanus synagris*	10.70	22.68	3/19/24	1	17.94280	-66.28006
2024-PA-45	Lane snapper	*Lutjanus synagris*	8.50	13.61	3/19/24	1	17.94280	-66.28006
2024-PA-46	Lane snapper	*Lutjanus synagris*	10.50	18.14	3/19/24	1	17.94280	-66.28006
2024-PA-47	Lane snapper	*Lutjanus synagris*	8.90	13.61	3/19/24	1	17.94280	-66.28006
2024-PA-48	Lane snapper	*Lutjanus synagris*	10.40	22.68	3/19/24	1	17.94280	-66.28006
2024-PA-49	Lane snapper	*Lutjanus synagris*	8.30	9.07	3/19/24	1	17.94280	-66.28006
2024-PA-50	Yellowtail snapper	*Ocyurus chrysurus*	8.10	9.07	3/19/24	1	17.94280	-66.28006
2024-PA-51	Mutton snapper	*Lutjanus analis*	23.00	300.00	3/20/24	1	17.93827	-66.28069
2024-PA-52	Spanish mackerel	*Scomberomorus maculatus*	36.00	444.00	3/20/24	1	17.93827	-66.28069
2024-PA-53	Blue runner	*Caranx crysos*	26.50	409.00	3/20/24	1	17.93827	-66.28069
2024-PA-54	Blue runner	*Caranx crysos*	30.10	506.00	3/20/24	1	17.93827	-66.28069
2024-PA-55	Blue runner	*Caranx crysos*	30.00	484.00	3/20/24	1	17.93827	-66.28069
2024-PA-56	Blue runner	*Caranx crysos*	36.00	760.00	3/20/24	1	17.93827	-66.28069
2024-PA-57	Blue runner	*Caranx crysos*	18.50	123.00	3/20/24	1	17.93827	-66.28069
2024-PA-58	Yellow jack	*Carangoides bartholomaei*	20.70	201.00	3/20/24	1	17.93827	-66.28069
2024-PA-59	Atlantic bumper	*Chloroscombrus chrysurus*	16.50	69.00	3/20/24	1	17.93827	-66.28069
2024-PA-60	Barracuda (great)	*Sphyraena barracuda*	26.00	123.00	3/20/24	1	17.93827	-66.28069
2024-PA-61	Barracuda (obtuse)	*Sphyraena obtusata*	33.00	195.00	3/20/24	1	17.93827	-66.28069
2024-PA-62	Bigeye scad	*Selar crumenophthalmus*	20.80	147.00	3/20/24	1	17.93827	-66.28069
2024-PA-63	Bigeye scad	*Selar crumenophthalmus*	20.70	152.00	3/20/24	1	17.93827	-66.28069

(continued)

Table 7. Fish Field Sample Collection Logs for Playa Arenas Background Location (Salinas, Puerto Rico) (continued)

Sample ID	Common Name	Species	Length (cm)	Weight (g)	Date	Individuals	Latitude	Longitude
2024-PA-64	Bigeye scad	*Selar crumenophthalmus*	18.50	106.00	3/20/24	1	17.93827	-66.28069
2024-PA-65	Bigeye scad	*Selar crumenophthalmus*	19.20	134.00	3/20/24	1	17.93827	-66.28069
2024-PA-66	Lane snapper	*Lutjanus synagris*	16.00	82.00	3/20/24	1	17.93827	-66.28069
2024-PA-67	Lane snapper	*Lutjanus synagris*	10.00	20.00	3/20/24	1	17.93827	-66.28069
2024-PA-68	Lane snapper	*Lutjanus synagris*	8.00	12.00	3/20/24	1	17.93827	-66.28069
2024-PA-69	Lane snapper	*Lutjanus synagris*	10.50	30.00	3/20/24	1	17.93827	-66.28069
2024-PA-70	Lane snapper	*Lutjanus synagris*	9.00	16.00	3/20/24	1	17.93827	-66.28069
2024-PA-71	Yellowtail snapper	*Ocyurus chrysurus*	14.50	66.00	3/20/24	1	17.93827	-66.28069
2024-PA-72	Yellowtail snapper	*Ocyurus chrysurus*	17.20	96.00	3/20/24	1	17.93827	-66.28069
2024-PA-73	Yellowtail snapper	*Ocyurus chrysurus*	8.20	13.00	3/20/24	1	17.93827	-66.28069
2024-PA-74	Yellowtail snapper	*Ocyurus chrysurus*	6.90	8.00	3/20/24	1	17.93827	-66.28069
2024-PA-75	Yellowtail snapper	*Ocyurus chrysurus*	10.00	21.00	3/20/24	1	17.93827	-66.28069
2024-PA-76	Yellowtail snapper	*Ocyurus chrysurus*	9.50	18.00	3/20/24	1	17.93827	-66.28069
2024-PA-77	Yellowtail snapper	*Ocyurus chrysurus*	9.90	20.00	3/20/24	1	17.93827	-66.28069
2024-PA-78	Yellowtail snapper	*Ocyurus chrysurus*	7.50	9.00	3/20/24	1	17.93827	-66.28069
2024-PA-79	Yellowtail snapper	*Ocyurus chrysurus*	7.20	9.00	3/20/24	1	17.93827	-66.28069
2024-PA-80	Yellowtail snapper	*Ocyurus chrysurus*	7.30	10.00	3/20/24	1	17.93827	-66.28069
2024-PA-81	Yellowtail snapper	*Ocyurus chrysurus*	6.90	8.00	3/20/24	1	17.93827	-66.28069
2024-PA-82	Yellowtail snapper	*Ocyurus chrysurus*	6.90	7.00	3/20/24	1	17.93827	-66.28069
2024-PA-83	Yellowtail snapper	*Ocyurus chrysurus*	9.90	21.00	3/20/24	1	17.93827	-66.28069
2024-PA-84	Yellowtail snapper	*Ocyurus chrysurus*	9.90	18.00	3/20/24	1	17.93827	-66.28069
2024-PA-85	Yellowtail snapper	*Ocyurus chrysurus*	10.00	22.00	3/20/24	1	17.93827	-66.28069
2024-PA-86	Yellowtail snapper	*Ocyurus chrysurus*	9.00	14.00	3/20/24	1	17.93827	-66.28069
2024-PA-87	Yellowtail snapper	*Ocyurus chrysurus*	12.50	40.00	3/20/24	1	17.93827	-66.28069

2.2 Sampling Protocols

Field sampling protocols generally followed the media-specific sampling procedures outlined in the project QAPP (I-GLTED-0034299; U.S. EPA, 2023), with minor deviations as described in this section. Water and sediment samples were generally taken from a depth of about 2–4 ft, although samples from open water or off the pier were taken from greater depths (17–25 ft for water, 35–50 ft for sediment). Sediment samples were collected from approximately the top 20 cm (8 inches [in]) of the sediment layer, or less depending on the bottom type (less penetration in areas with hard-packed sand). Beach sand was collected from the top 8 cm (3 in). Data collected under the QAPP were reviewed and a determination made that the data met project data quality objectives and were appropriate for use in the HHRA.

2.2.1 Sediment Sampling

Sediment samples were collected at each location using a 0.05 m^2 standard Ponar clamshell grab sampler. Before the first sample taken at each station, the sampler was thoroughly washed down with Alconox solution or liquid Joy (or other clean rinsing, non-phosphorus detergent) using a scrub brush and rinsed using ambient seawater. The sampler was rinsed thoroughly with seawater between drops made at the same station. Nitrile gloves were worn by all individuals while collecting and handling samples.

The sampler was deployed at each location from the sampling platform's davit. The grab sampler was slowly lowered through the water column to minimize the effects of bow wave disturbance to surficial sediments. Upon contact with the bottom, the rope was allowed to slack to allow the spring pin to eject and release the jaws of the grab sampler. The sampler was raised to the surface and placed on the deck of the boat, and each sample's location was recorded.

Before the sampler was opened, overlying water was allowed to drain, and the hinged top was inspected to determine whether the grab was acceptable or not. An acceptable grab is one having relatively level intact sediment over the entire area of the grab that fills at least 75% of the grab depth (see **Figure 7**). Grabs containing no sediments, partially filled grabs, or grabs with shelly substrates or grossly slumped surfaces were unacceptable. Grabs filled to where the sediment is in direct contact with the hinged top were also unacceptable. Samples identified as unacceptable were not included in the data analysis.

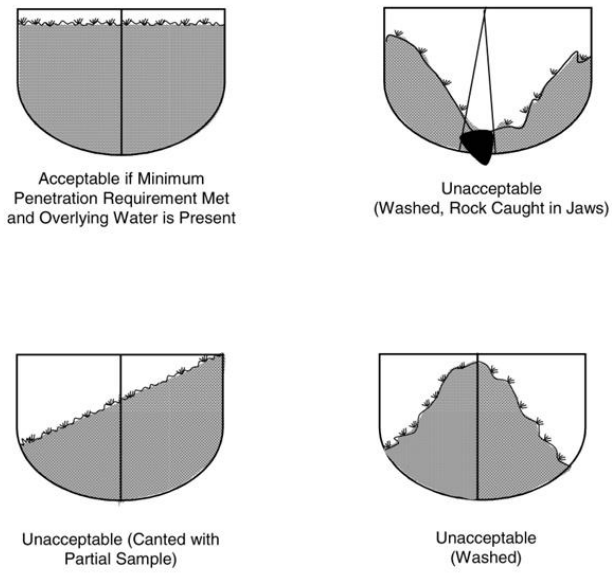

Figure 7. Illustration of acceptable and unacceptable grabs.
Source: U.S. EPA, 2001.

Upon obtaining an acceptable sample, the sampler was emptied into a clean Pyrex glass sampling pan, using a Teflon-coated sampling spoon to scoop sediment from the grab into the pan. Sediment for chemistry samples was taken directly from the grab and transferred to a clean Pyrex glass pan. Samples were homogenized by thoroughly mixing using the Teflon-coated spoon. Aliquots of the homogenized sediment sample were transferred to the appropriate prelabeled sample jars, leaving sufficient headspace to allow for sample expansion during freezing. The jar was then sealed and stored in a cooler on ice. Upon conclusion of the

sampling day, sediment samples for chemical analyses were transferred to a freezer for storage before shipment to the analytical laboratory.

2.2.2 Sand Sampling

Surface sand samples were collected at each location using a clean glass scoop and a Teflon-coated spoon. Before the first sample taken at each station, sampling and processing equipment were thoroughly washed with a clean rinsing, non-phosphorus detergent and rinsed with deionized water. Nitrile gloves were worn by all individuals while collecting and handling samples.

Sand samples were collected following these steps:

1. Clear the area to be sampled of surface debris (e.g., twigs, rocks, litter).
2. Collect the top 4-in layer of sand from a roughly 6-in diameter circle at each location with a precleaned glass scoop and transfer into a precleaned glass bowl.
3. Homogenize the sample by thoroughly mixing with a Teflon-coated spoon.
4. Transfer aliquots of homogenized sand into prelabeled sample jars, and place sealed samples into a cooler on ice.
5. Return unused sand to the excavation area, and level the area.

The following information was recorded at each station:

- Time of sample collection
- Latitude and longitude from a handheld Global Positioning System (GPS) unit for each accepted sample
- Visual description of any sand sampled (e.g., color, presence of shell fragments, grain size).

2.2.3 Surface Water Sampling

Water samples were collected using a 2.2-liter (L) acrylic Kemmerer bottle. Before the first sample taken at each station, sampling equipment was thoroughly washed down with a clean rinsing, non-phosphorus detergent and rinsed with seawater. Nitrile gloves were worn by all individuals while collecting and handling samples.

Water samples were taken by lowering the Kemmerer sampler to a depth approximately 1 ft below the surface of the water and triggering the bottle with a messenger weight.

Kemmerer bottle sampling procedures were as follows:

1. Using a properly decontaminated Kemmerer bottle, the sampling device was set so that the upper and lower stoppers were pulled away from the sampling tube, allowing water to enter the tube.
2. The preset sampling device was lowered to the predetermined depth (1 ft below surface).
3. When the Kemmerer bottle was at the required depth, the weighted messenger was sent down the suspension line, closing the sampling device.
4. The sampler was retrieved and the first 10–20 mL were discharged to clear potential contamination from the valve.
5. Each of the prelabeled sample jars was filled, and sealed samples were placed into a cooler on ice.

The following information was recorded at each station:

- Time of sample collection
- Sample depth
- Latitude and longitude from a handheld GPS unit from each attempted sample
- Visual description of any water sampled (e.g., color, clarity).

Table 8 summarizes the media sampled at each location (Las Mareas Bay locations and reference locations). A dot indicates that a sample was collected, and an “x” indicates that a sample was not collected at the location.

Table 8. Media Sampled at Each Sampling Location

Site Location	Station Number	Sample Types		
		Water	Sand	Sed.
Las Mareas Bay				
East shoreline	LM-1	●	●	●
East shoreline	LM-2	●	●	●
East shoreline	LM-3	●	●	●
East shoreline	LM-4	×	●	●
East shoreline	LM-5	●	×	●
East shoreline	LM-6	×	●	●
East shoreline	LM-7	×	●	●
Open water	LM-OW-8	●	×	●
West shoreline	LM-9	●	●	●
West shoreline	LM-10	×	●	●
West shoreline	LM-11	●	×	●
West shoreline	LM-12	×	●	●
West shoreline	LM-13	●	●	×
Pier	LM-Pier-14	●	×	●
Pier	LM-Pier-15	●	×	●
Pier	LM-Pier-16	×	×	●
Pier	LM-Pier-17	×	×	●
Pier	LM-Pier-18	×	×	●
Total samples (N)		*10*	*10*	*17*

Site Location	Station Number	Sample Types		
		Water	Sand	Sed.
Background Locations				
Playa Arenas	PA-1	●	●	●
Playa Arenas	PA-2	●	●	●
Playa Arenas	PA-3	●	●	●
Playa Arenas	PA-4	●	●	●
Playa Arenas	PA-5	●	●	●
Playa Arenas	PA-6	●	×	●
Playa Arenas	PA-7	●	×	●
Playa Arenas	PA-8	●	×	●
Playa Arenas	PA-9	●	×	●
Playa Arenas	PA-10	●	×	●
Tropical Beach	Ref-1	×	●	×
Tropical Beach	Ref-2	×	●	×
Tropical Beach	Ref-3	×	●	×
Tropical Beach	Ref-4	×	●	×
Tropical Beach	Ref-5	×	●	×
Tropical Beach	Ref-6	×	●	×
Tropical Beach	Ref-7	×	●	×
Tropical Beach	Ref-8	×	●	×
Tropical Beach	Ref-9	×	●	×
Tropical Beach	Ref-10	×	●	×
Total samples (N)		*10*	*15*	*10*

●=sample collected; ×=no sample collected.

2.2.4 Fish Sampling

Eight fish species required for the HHRA and identified by community leaders were collected in Las Mareas Bay and at the background location (Playa Arenas). The project QAPP (I-GLTED-0034299; U.S. EPA, 2023), incorporates a sampling plan for fish collection developed for this project that defines the use of collection methods developed by EPA using modifications to the 2008–2009 National Rivers and Streams Assessment Field Operations Manual. The sampling plan incorporates by reference two standard operating procedures describing the primary method for fish collection and processing and an alternative method developed by the U.S. Fish and Wildlife Service that can be used if needed based on supplies and availability of resources.

Seven of the eight fish species identified by the community and EPA (see **Section 1.4**) were selected for contaminant analysis: Atlantic bumper, blue runner, lane snapper, mutton snapper, scaled sardine/herring, Spanish mackerel, and yellowtail snapper. The eighth, glass minnow/bay anchovy, was omitted because only a single fish of this category was caught, insufficient for analysis. These fish are mostly trophic level 4 fish (i.e., top of the food chain), except sardines (trophic level 3). In total, 69 fish of these species were caught, 26 in Las Mareas Bay and 43 in Playa Arenas. As shown in **Table 9**, of the seven species, only five were caught in each location—no yellowtail snappers were caught in Las Mareas Bay, and no scaled sardines/herring were caught in Playa Arenas. The fish sampling logs for Las Mareas Bay and Playa Arenas are presented in Tables 6 and 7,

respectively; note those logs include 16 fish (7 in Las Mareas Bay and 9 in Playa Arenas) of other species not targeted and not included in Table 9.

Table 9. Locations Where Target Fish Species Were Caught

Target Fish Species	Las Mareas Bay	Playa Arenas
Atlantic bumper	4	1
Blue runner	7	5
Lane snapper	5	11
Mutton snapper	6	1
Scaled sardine/herring	3	0
Spanish mackerel	1	1
Yellowtail snapper	0	24

All fish species captured for laboratory analysis have greater fidelity to Las Mareas Bay and propensity to be exposed at or near the Bay than other species that could have been collected or at older ages. It is likely any exposure to blue runner would be very limited because this species is highly migratory, and there really is no certainty of how long they may have been in the background location or Las Mareas Bay before capture. Spanish mackerel are highly migratory based on season and age. The fish captured were within the range of maturity but smaller than average length, so it is possible these individuals may have spent a greater amount of time in these systems. Spanish mackerel captured in Las Mareas Bay were captured at the end of the loading pier in the Bay, so they may have been using it for an unknown period during growth. Mutton snapper are highly migratory at adult ages and move to deeper offshore environments as adults. All fish captured were juveniles based on reported lengths at maturity, which explains why they were likely in the Bay and the background location. These fish at juvenile age likely have greater site fidelity to the location in which they were captured. Based on length of fish, all other fish species likely were living in the sampling locations until they were collected.

From the individual fish collected, EPA developed a compositing and analytical scheme for filet and whole fish that met the minimum mass requirements for analysis of metals, mercury, PAHs, sulfolane, methylmercury, total and inorganic arsenic, lithium, and radium. This scheme is provided in **Table 10**. All fish samples were initially degilled, descaled, and gutted in the laboratory and further processed for compositing as shown in Table 10. For example, four Atlantic bumpers were caught in Las Mareas Bay (Sample IDs 2024-LM-12, -13, -14, and -31). Two of these (Sample IDs 2024-LM-12 and -13) were composited to create a single filet composite (Composite ID 2024-LM-AB-F-23), and the other two (Sample IDs 2024-LM-14 and -31) were composited to create a single whole body composite (Composite ID 2024-LM-AB-W-24). This produced two composites of sufficient mass for analysis, one for filet and one for whole fish. Separate composites were created for filet concentrations and whole fish concentrations whenever possible; however, if there was insufficient mass for two composites, a single composite was analyzed for both filet and whole. For example, only one Spanish Mackerel (2024-LM-04) was captured from Las Mareas Bay: a filet sample (2024-LM-SM-F-01) was processed to produce a filet concentration, and the remaining carcass was analyzed as the whole body sample (2024-LM-SM-W-02). Where this was done, the fish field sample ID in Table 10 is noted as “(filet” or “remaining carcass”.

Table 10. Summary of Fish Analytical Compositing Scheme for Filet and Whole Fish

Chemistry (Composite) ID	Filet or Whole	Common Name	Individual Fish Field Sample IDs Included in Composite		
Las Mareas Bay					
2024-LM-AB-F-23	Filet	Atlantic bumper	2024-LM-12	2024-LM-13	
2024-LM-AB-W-24	Whole	Atlantic bumper	2024-LM-14	2024-LM-31	
2024-LM-BR-F-19	Filet	Blue runner	2024-LM-01 2024-LM-03	2024-LM-07 2024-LM-33	
2024-LM-BR-W-20	Whole	Blue runner	2024-LM-02 2024-LM-06	2024-LM-08	
2024-LM-LS-F-07	Filet	Lane snapper	2024-LM-17 2024-LM-27	2024-LM-28	
2024-LM-LS-W-08	Whole	Lane snapper	2024-LM-18	2024-LM-34	
2024-LM-MS-F-11	Filet	Mutton snapper	2024-LM-24 2024-LM-25 2024-LM-26	2024-LM-20 2024-LM-29 2024-LM-30	
2024-LM-MS-W-12	Whole	Mutton snapper	2024-LM-30		
2024-LM-SS-W-18	Whole	Scaled sardine/herring	2024-LM-22 2024-LM-23	2024-LM-32	
2024-LM-SM-F-01	Filet	Spanish mackerel	2024-LM-04 (filet)		
2024-LM-SM-W-02	Whole	Spanish mackerel	2024-LM-04 (remaining carcass)		
Background (Playa Arenas)					
2024-PA-AB-F-25	Filet	Atlantic bumper	2024-PA-59 (filet)		
2024-PA-AB-W-26	Whole	Atlantic bumper	2024-PA-59 (remaining carcass)		
2024-PA-BR-F-21	Filet	Blue runner	2024-PA-53	2024-PA-54	2024-PA-56
2024-PA-BR-W-22	Whole	Blue runner	2024-PA-55		2024-PA-57
2024-PA-LS-F-09	Filet	Lane snapper	2024-PA-44 2024-PA-48	2024-PA-66 2024-PA-67	2024-PA-69
2024-PA-LS-W-10	Whole	Lane snapper	2024-PA-45 2024-PA-46	2024-PA-47 2024-PA-49	2024-PA-68 2024-PA-70
2024-PA-MS-F-14	Filet	Mutton snapper	2024-PA-51 (filet)		
2024-PA-MS-W-15	Whole	Mutton snapper	2024-PA-51 (remaining carcass)		
2024-PA-SM-F-04	Filet	Spanish mackerel	2024-PA-52 (filet)		
2024-PA-SM-W-05	Whole	Spanish mackerel	2024-PA-52 (remaining carcass)		
2024-PA-YS-F-17	Filet	Yellowtail snapper	2024-PA-37 2024-PA-38 2024-PA-39 2024-PA-40 2024-PA-41 2024-PA-42 2024-PA-50 2024-PA-71	2024-PA-72 2024-PA-73 2024-PA-74 2024-PA-75 2024-PA-76 2024-PA-77 2024-PA-78 2024-PA-79	2024-PA-80 2024-PA-81 2024-PA-82 2024-PA-83 2024-PA-84 2024-PA-85 2024-PA-86 2024-PA-87
2024-PA-YS-W-18	Whole	Yellowtail snapper	2024-PA-86		

Table 11 summarizes the filet and whole composites from Las Mareas Bay and the background location that resulted from this compositing scheme. Each composite in the table produced a set of analytical results for all the chemicals listed in **Section 1.3**.

Table 11. Summary of Fish Composites Analyzed

Fish Species	Composites Analyzed			
	Las Mareas Bay		Background (Playa Arenas)	
	Filet	Whole	Filet	Whole
Atlantic bumper	●	●	●	○
Blue runner	●	●	●	●
Lane snapper	●	●	●	●
Mutton snapper	●	●	●	○
Scaled sardine/herring	×	●	×	×
Spanish mackerel	●	○	●	○
Yellowtail snapper	×	×	●	●
Total Samples (N)	*5*	*6*	*6*	*6*

●=filet or complete whole body composite; ○=remaining carcass composite; ×=no composite

2.3 Sampling Results

Chemical-specific concentrations were obtained from sample analysis of surface water, sand, sediment, and fish. All chemical analyses were done according to the appropriate EPA method by an accredited contract laboratory. Detailed results, including method, detection limits, and reporting limits, are provided in a tabular format in **Appendix A**, and the original laboratory analytical reports are provided in **Appendix B**. Samples were collected and analyzed in accordance with the project QAPP (I-GLTED-0034299; EPA, 2023). The data collected were reviewed and a determination was made that the data met the Project Data Quality Objectives and quality assurance and quality control criteria and were appropriate for use in the HHRA. Analytical data received were reviewed and qualified to be acceptable for supporting this HHRA. These concentrations are representative of central tendency conditions and high-end conditions, respectively, and were selected and used in the exposure and risk calculations to provide a range of potential exposures.

When results were below the reporting detection limit (RDL), a value of half the RDL was substituted before summary statistics (50th and 95th percentiles) were calculated. The percentiles reflect the distribution of concentrations across specific sampling locations in either Las Mareas Bay or the background locations (water, sand, sediment; see Table 8 for the number of observations for each medium and overall location) or fish species from either Las Mareas Bay or the background location (see Table 11 for the number of observations for filet and whole fish in each overall location). Depending on the number of samples and the detection rates, in some cases, the 50th percentile value may be based on half the RDL, whereas the 95th is based on a detected measurement. The tables in this section present results for chemicals with at least one detection in a particular medium; tables including chemicals with no detections are provided in **Appendix C**. Values are flagged with an asterisk when they are based on half the RDL.

Section 2.3.1 summarizes the sampling results for water, sand, and sediment for the Las Mareas Bay and background sampling locations. **Appendix C.1** presents box plot comparisons of the concentration distributions for water, sand, and sediment between the Las Mareas Bay and background sampling values.

Section 2.3.2 summarizes the sampling results for fish (filet and whole) for the Las Mareas Bay and background sampling locations. **Appendix C.2** presents box plot comparisons of the concentration distributions for filet and whole fish between the Las Mareas Bay and background sampling values, as well as comparisons of filet and whole concentrations for all sampling locations.

2.3.1 Surface Water, Sand, and Sediment

Table 12 provides the detection frequency for the Las Mareas Bay and background sampling locations and RDLs for all constituents for the Las Mareas Bay sampling locations. RDLs varied only slightly across samples. Inorganics were generally detected in all samples or no samples, with some scattered exceptions. By contrast, organics were not detected in any samples. **Table 13** presents the sampling results (50th and 95th percentiles) for water, sand, and sediment. Concentrations are reported in the units provided by the laboratory doing the analysis, and the units differ for water versus sand and sediment and for inorganics versus organics; see the table subheadings for specific units. The plots in **Appendix C** provide a better overall view of the data distribution than isolated percentiles can. Because all organic concentrations were nondetects for water, sand, and sediment, EPA did not evaluate risk for organic compounds.

To determine whether the median or mean concentrations in Las Mareas Bay were greater from those in background locations for water, sand, and sediment at a statistically significant level, two-sample statistical tests (e.g., *t*-tests for means, Wilcoxon-Mann-Whitney test for medians) were used. Based on those tests, the following concentrations were found to be higher in Las Mareas Bay than in the background location at the 95% confidence level:

- **Water:** Chromium and thallium
- **Sand:** Arsenic, cobalt, lead, molybdenum, and silver
- **Sediment:** Arsenic, chromium, cobalt, lead, and lithium.

In addition to comparing the Las Mareas sampling results with the background sampling results, we also compared the results with available screening values.

- **Water:** Concentrations in Las Mareas Bay and background locations were compared with the Puerto Rico Water Quality Standards for coastal and estuarine waters (designated as Class SB waters in the standards) when those standards were based on human health endpoints (but not when based on protection of aquatic life). Only two chemicals with detections in water had such water quality criteria, mercury and thallium, and in both cases, 50th and 95th percentile concentrations in Las Mareas Bay and the background location exceeded the water quality criteria (see **Table 13**).
- **Sand and Sediment:** Concentrations in sand and sediment in Las Mareas Bay and background locations were compared with the Regional Screening Levels (RSLs) for residential soil at a hazard quotient (HQ) of 1.[4] Soil RSLs were available for seven chemicals (arsenic, boron, chromium, cobalt, lithium, molybdenum, and silver), and in no case did the 50th or 95th percentiles of the Las Mareas Bay or the background concentrations for sand or sediment exceed these RSLs (see **Table 13**).

[4] RSLs are screening values used by the Superfund program to promote national consistency in screening chemicals at Superfund sites; they are not cleanup standards. They are available for a variety of generic exposure scenarios, including the residential soil exposure scenario used here. The RSLs were not used directly in the risk assessment, but only to provide context for the concentration results. Additionally, the RSLs were last updated in November 2024; the toxicity values for arsenic were updated in January 2025 and are not reflected in the RSL values used here. However, the more up-to-date toxicity values were used in this assessment; see **Section 4.1**.

Table 12. Detection Frequency and Reporting Detection Limits (RDLs) in Water, Sand, and Sediment in Las Mareas Bay and Background Sampling Locations.

Constituent	Detections						RDL		
	Las Mareas Bay			Background			All Locations		
	Water (N=10)	Beach Sand (N=10)	Sediment (N=17)	Water (N=10)	Beach Sand (N=15)	Sediment (N=10)	Water	Beach Sand	Sediment
Inorganics (RDL for Water in µg/L, Sand and Sediment in mg/kg)									
Antimony	Not reported	0%	0%	Not reported	0%	0%	Not reported	1.9	2.6
Arsenic	100%	100%	100%	100%	80%	90%	1	0.75	1.0
Barium	100%	0%	0%	100%	0%	0%	1	9.4	13
Beryllium	0%	0%	0%	0%	0%	0%	1	0.28	0.43
Boron	100%	100%	100%	100%	100%	100%	50	0.94	1.4
Cadmium	0%	0%	0%	0%	0%	0%	1	0.28	0.43
Chromium	90%	100%	100%	80%	93%	100%	1	0.47	0.72
Cobalt	0%	100%	100%	0%	67%	0%	1	1.9	2.6
Lead	70%	100%	100%	10%	87%	80%	1	0.75	1.0
Lithium	100%	0%	82%	100%	0%	70%	20	3.8	5.2
Mercury	40%	0%	0%	50%	0%	0%	0.2	0.042	0.069
Molybdenum	100%	40%	29%	100%	0%	70%	1	0.94	1.3
Selenium	0%	0%	0%	0%	0%	0%	4	1.9	2.9
Silver	0%	90%	100%	0%	20%	30%	1	0.47	0.72
Thallium	20%	0%	0%	10%	0%	0%	1	1.9	2.6
Organics (RDL for Water in µg/L, Sand and Sediment in µg/kg)									
PAHs*	0%	0%	0%	0%	0%	0%	5	67	116
Sulfolane	0%	0%	0%	0%	0%	0%	8.2	34	58.5

Data for antimony in water were not reported by the analytical laboratory.* PAHs include acenaphthene; acenaphthylene; anthracene; benzo(a)anthracene; benzo(a)pyrene; benzo(g,h,i)perylene; benzo(k)fluoranthene; biphenyl, 1,1'-; chrysene; dibenzo(a,h)anthracene; fluoranthene; fluorene; indeno(1,2,3-cd)pyrene; methylnaphthalene, 2-; phenanthrene; and pyrene.

Table 13. Water, Sand, and Sediment Concentration Results in Las Mareas Bay and Background Sampling Locations (50th and 95th Percentiles)

	Las Mareas Bay						Background						Screening Comparisons	
	Water		Sand		Sediment		Water		Sand		Sediment		Water	Sand/Sed
Chemical	50th	95th	50th	95th	50th	95th	50th	95th	50th	95th	50th	95th	PR WQC	Soil RSL
Inorganics (Water in µg/L, Sand and Sediment in mg/kg)														
Antimony	No detections. See ***Appendix C*** for values based on half the RDL.												640	NA
Arsenic	2.1	2.4	6.8	8.5	8.5	13	2.3	3.7	4.6	5.6	4.1	6.2	NA	39
Barium	8.0	8.5	ND	ND	ND	ND	8.2	11	ND	ND	ND	ND	NA	NA
Beryllium	No detections. See ***Appendix C*** for values based on half the RDL.												NA	NA
Boron	5,100	ND	5.6	12	22	46	5,100	5,200	3.4	32	43	62	NA	16,000
Cadmium	No detections. See ***Appendix C*** for values based on half the RDL.												NA	NA
Chromium	2.8	ND	5.3	9.9	8.2	14	1.3	2.9	5.4	9.9	4.7	9.7	NA	70
Cobalt	ND	ND	4.9	9.5	6.0	10	ND	ND	2.8	3.5	1.6*	2.1*	NA	23
Lead	1.2	ND	2.0	3.2	3.3	7.7	0.5*	1.3	1.3	2.7	1.6	4.8	NA	NA
Lithium	340	ND	ND	ND	9.7	23	361	369	ND	ND	7.6	14	NA	160
Mercury	**0.1***	**0.41**	ND	ND	ND	ND	**0.16**	**0.68**	ND	ND	ND	ND	0.051	NA
Molybdenum	11	12	0.52*	1.1	0.61*	2.1	12	13	ND	ND	2.1	4.6	NA	390
Selenium	No detections. See ***Appendix C*** for values based on half the RDL.												NA	NA
Silver	ND	ND	1.0	1.9	0.92	1.9	ND	ND	0.25*	0.60	0.4*	1.9	NA	390
Thallium	**0.5***	**1.5**	ND	ND	ND	ND	**0.5***	**0.95**	ND	ND	ND	ND	0.47	NA
Organics (Water in µg/L, Sand and Sediment in µg/kg)														
PAHs†	No detections. See ***Appendix C*** for values based on half the RDL.												NA	NA
Sulfolane	No detections. See ***Appendix C*** for values based on half the RDL.												NA	NA

ND=nondetect (i.e., the specified percentile reflected a nondetect result). See ***Appendix C*** for values based on half the RDL. Data for antimony in water were not reported by the analytical laboratory.

NA = screening comparison value not available.

Bold indicates concentration exceeds the relevant screening value.

* Value is half the RDL. Individual values were replaced with half the RDL for the sample before computing the percentile statistics. A constituent with more than 50% nondetects may have a value half the RDL for 50th percentile but a measured value for the 95th percentile.

† PAHs include acenaphthene; acenaphthylene; anthracene; benzo(a)anthracene; benzo(a)pyrene; benzo(g,h,i)perylene; benzo(k)fluoranthene; biphenyl, 1,1'-; chrysene; dibenzo(a,h)anthracene; fluoranthene; fluorene; indeno(1,2,3-cd)pyrene; methylnaphthalene, 2-; phenanthrene; and pyrene.

2.3.2 Fish

All fish collected and analyzed were believed to be available locally and consumed locally as summarized in **Section 1.4**. **Table 14** provides the detection frequency and median method detection limits for all constituents for the Las Mareas Bay sampling locations for fish. The method detection limits did not vary significantly for inorganics. For organics, they varied somewhat more, for a minimum about half the median to a maximum about 7 times the median. Only a few organics were detected in the samples, whereas most inorganics were detected. **Table 15** presents the Las Mareas Bay sampling results (50th and 95th percentiles) for fish filet and whole fish. As noted in **Section 2.2.4**, when multiple fish of a species were caught in a location, they were composited so that one composite sample was analyzed for each species caught in each location (Las Mareas Bay and the background location, Playa Arenas). Six species were caught in each location, so these data reflect percentiles from those six values (or five values for filet, because one species, sardines, was too small to evaluate filets).

Results for inorganics are for total (e.g., total chromium), except arsenic and mercury. For arsenic, only inorganic forms were considered, because those are the most toxic to humans. Similarly, fish are known to convert environmental mercury exposures to methylmercury in fish tissue, and a separate reference dose (RfD) is provided specifically for fish that is based on methylmercury rather than other forms of mercury (Integrated Risk Information System [IRIS], U.S. EPA, 2024a). Consequently, fish samples were analyzed for methylmercury concentrations, and those are reported here. All concentrations are reported in the units provided by the laboratory doing the analysis, and the units differ for inorganics and organics in general and for specific chemicals in those categories (arsenic, mercury, sulfolane); see the table subheadings for specific units.

The data plots in **Appendix C** provide a better overall view of the data distribution than the isolated percentiles. The detected concentration distributions of inorganics and methylmercury in whole fish and fish filet at Las Mareas Bay are not significantly higher than the background/reference sample concentrations reported. Several inorganics such as cobalt, lithium, silver, and thallium that were found to have statistically higher means or medians between Las Mareas and background concentrations in sand (arsenic, cobalt, lead, molybdenum, silver), sediment (arsenic, chromium, cobalt, lead, lithium), and surface water (chromium, thallium) (see **Section 2.3.1**) were detected in less than 50% of samples in Las Mareas fish filet and whole fish. One exception is lithium, which was detected in greater than 50% of samples in sediments, surface water, and whole fish but not detected in fish filet. However, two-sample statistical tests (e.g., t-tests, Wilcoxon-Mann-Whitney test) confirmed that the median or mean concentrations of lithium in whole fish are similar in Las Mareas Bay when compared with the background samples at the 95% confidence level. Two-sample statistical tests (e.g., t-tests, Wilcoxon-Mann-Whitney test or Gehan test for inorganics with at least one nondetect) were also performed on remaining inorganics (inorganic arsenic, chromium, lead, methylmercury, and molybdenum) that were (1) detected in greater than 50% of fish filet and whole-body samples in Las Mareas Bay, and (2) found to have statistically higher means or medians between Las Mareas and background concentrations in sand, sediment, or surface water. These tests confirm that at the 95% confidence level, the median or mean concentrations of inorganic arsenic, chromium, lead, methylmercury, and molybdenum in fish filet and whole fish in Las Mareas Bay are similar to those concentrations in background samples.

Naphthalene is the only organic with any detected concentrations in Las Mareas Bay and the background location. However, detection frequency of naphthalene is less than 50% in filet and whole fish samples at Las Mareas Bay and the background location, and the detected concentrations are generally similar or slightly lower than the background sample concentrations reported.

Table 14. Detection Frequency and Reporting Detection Limits in Fish in Las Mareas Bay and Background Sampling Locations

Constituent	Detections				RDL
	Las Mareas Bay		Background		
	Fish Filet (N=5)*	Whole Fish (N=6)*	Fish Filet (N=6)†	Whole Fish (N=6)†	
Inorganics (MDLs in mg/kg except arsenic and methylmercury, which are µg/kg)					
Antimony	0%	33%	33%	0%	0.027
Arsenic (inorganic)	67%	100%	86%	100%	0.24
Barium	80%	100%	100%	83%	0.035
Beryllium	0%	0%	0%	0%	0.009
Boron	100%	100%	100%	100%	0.16
Cadmium	0%	17%	0%	0%	0.012
Chromium	100%	100%	100%	100%	0.039
Cobalt	0%	17%	0%	17%	0.024
Lead	100%	100%	100%	100%	0.006
Lithium	0%	100%	20%	100%	0.03
Methylmercury	100%	100%	100%	100%	1
Molybdenum	60%	100%	33%	83%	0.018
Selenium	100%	100%	100%	100%	0.12
Silver	0%	17%	0%	17%	0.011
Thallium	20%	17%	17%	17%	0.005
Organics (MDLs in µg/kg)					
Acenaphthene	0%	17%	0%	0%	5.8
Acenaphthylene	0%	0%	0%	0%	5.9
Anthracene	0%	0%	0%	0%	10
Benz(a)anthracene	0%	0%	0%	0%	7.3
Benzo(a)pyrene	0%	0%	0%	0%	4.3
Benzo(b)fluoranthene	0%	0%	0%	0%	7.2
Benzo(g,h,i)perylene	0%	0%	0%	0%	9.6
Benzo(k)fluoranthene	0%	0%	0%	0%	4.3
Chrysene	0%	0%	0%	0%	5.4
Dibenz(a,h)anthracene	0%	0%	0%	0%	8.9
Fluoranthene	0%	0%	0%	0%	6.9
Fluorene	0%	0%	0%	0%	8.8
Indeno(1,2,3-cd) pyrene	0%	0%	0%	0%	4.3
Methylnaphthalene, 2-	0%	0%	0%	0%	6.5
Naphthalene	20%	17%	33%	33%	5.9
Phenanthrene	0%	0%	0%	0%	9.6
Pyrene	0%	0%	0%	0%	8.2
Sulfolane	0%	0%	0%	0%	0.32

* N=6 for inorganic arsenic in fish filet; N=7 for inorganic arsenic and methylmercury in whole fish.

† N=7 for inorganic arsenic in fish filet and methylmercury in fish filet and whole fish; N=5 for lithium in fish filet and whole fish.

Table 15. Fish Concentration Results in Las Mareas Bay and Background Sampling Locations (50th and 95th Percentiles)

Constituent	Las Mareas Bay				Background			
	Fish Filet		Whole Fish		Fish Filet		Whole Fish	
	50th	95th	50th	95th	50th	95th	50th	95th
Inorganics (mg/kg, Except Inorganic Arsenic and Methylmercury, µg/kg)								
Antimony	ND	ND	0.2*	0.48	0.20*	0.23	ND	ND
Arsenic (inorganic)	0.28	1.5	1.5	41	0.44	2.7	2.3	4.4
Barium	0.25	0.30	0.57	0.72	0.27	0.37	0.37	0.55
Beryllium	No detections. See ***Appendix C*** for values based on half the RDL.							
Boron	1.0	1.2	1.5	2.6	1.1	1.2	1.4	1.9
Cadmium	ND	ND	0.023*	0.024	ND	ND	ND	ND
Chromium	0.094	0.15	0.15	0.47	0.098	0.18	0.13	0.26
Cobalt	ND	ND	0.056*	0.061	ND	ND	0.055*	0.059
Lead	0.069	0.092	0.12	0.38	0.075	0.098	0.096	0.33
Lithium	ND	ND	0.18	0.21	0.049*	0.050	0.20	0.45
Methylmercury	212	501	68	502	141	267	101	199
Molybdenum	0.021	0.057	0.039	0.14	0.051*	0.058	0.033	0.060
Selenium	0.35	0.55	0.50	0.67	0.37	0.44	0.53	0.74
Silver	ND	ND	0.059*	0.061	ND	ND	0.057*	0.059
Thallium	0.049*	0.057	0.055*	0.061	0.054*	0.058	0.053*	0.058
Organics (µg/kg Except Sulfolane, mg/kg)								
Acenaphthene	ND	ND	7.0*	19	ND	ND	ND	ND
Methylnaphthalene, 2-	ND	ND	ND	ND	7.7*	42	24*	43
Naphthalene	ND	25	6.1*	19	8.1*	42	19*	43
All other PAHs†	No detections. See ***Appendix C*** for values based on half the RDL.							
Sulfolane	No detections. See ***Appendix C*** for values based on half the RDL.							

ND=nondetect (i.e., the specified percentile reflected a nondetect result). See ***Appendix C*** for values based on half the RDL.

* Value is half the RDL. Individual values were replaced with half the RDL for the sample before computing the percentile statistics. A constituent with more than 50% nondetects may have a value half the RDL for 50th percentile, but a measured value for the 95th percentile.

† All other PAHs include acenaphthylene; anthracene; benzo(a)anthracene; benzo(a)pyrene; benzo(g,h,i)perylene; benzo(k)fluoranthene; biphenyl, 1,1'-; chrysene; dibenzo(a,h)anthracene; fluoranthene; fluorene; indeno(1,2,3-cd)pyrene; phenanthrene; and pyrene.

3 Exposure Assessment

3.1 Conceptual Model

The conceptual model, a component of the HHRA, identifies potential exposure routes via recreational activities (**Figure 8**) in Las Mareas Bay. The exposure routes considered include the following **recreational activities**:

- **Swimming:** dermal exposure to surface water and incidental ingestion of water while swimming (adults and children)
- **Playing in sand:** dermal exposure to sand and incidental ingestion of sand (children only)
- **Wading in sediment:** dermal exposure to sediment and incidental ingestion of sediment (children only).

Other recreational exposures may also occur but were not evaluated, including exposures to sand or sediment for adults and recreational fishing. The pathways considered were selected to be protective of these additional, unmodeled pathways. For example, the skin surface that would be exposed during recreational fishing would be considerably less than the whole-body exposure assumed for swimming, so the swimming pathway should have higher risks or hazards. Similarly, although adults may visit the beach, they are less likely to wade or play in the sand, resulting in lower sand or sediment exposures than for children.

A separate exposure pathway is the **consumption of fish** caught in local waters. Adults and children may be exposed by eating fish directly or by consuming fish head stew; the former is quantified in the HHRA, whereas the latter is discussed in the risk characterization. Although filet and whole-fish concentrations were reported from the laboratory analyses (and are provided in **Section 2.2.4**), for this assessment, people were assumed to consume fish filet. This pathway reflects a different exposure medium (fish) and route of exposure (ingestion). Thus, throughout the rest of this report, recreational exposures (and the related media concentrations) are discussed separately from fish exposures and concentrations.

3.2 Approach

The risk assessment was based on EPA-approved methods and the sampling data collected for this study, the statistical analyses in the project EPA QAPP (I-GLTED-0034299; U.S. EPA, 2023), and additional EPA-approved data sources. These methodology and data sources used include the following:

Methods

- EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, Part A* provides guidance on the human health evaluation activities that are conducted during the baseline risk assessment (U.S. EPA, 1989),
- EPA's *RAGS, Volume I: Human Health Evaluation Manual, Part E: Supplemental Guidance for Dermal Risk Assessment* provides methodology for all dermal pathways (swimming, wading, playing in sand) and selected inputs specific to those pathways (U.S. EPA, 2004).[5]
- RAGS documents provide an approach useful in the development of risk assessments that maybe useful to programs outside of Superfund Programs. The results of the assessment including cancer risks and non-cancer hazards from exposures maybe helpful in understanding the nature and extent of the risks and hazards that maybe used by other programs to determine next steps.

[5] Las Mareas Bay is not a Superfund site; nevertheless, the suite of documents that make up the RAGS are widely used in a variety of contexts. The dermal guidance is particularly useful because little other guidance on evaluating this route of exposure is available.

Additional Data

- EPA's *Exposure Factors Handbook (EFH)* describes exposure factors, including body weight, skin surface area, and activity factors relating to swimming, wading, and playing in sand, including incidental ingestion rates for water, sand, and sediment (U.S. EPA, 2011, 2017b, 2019).
- EPA's *Fish Consumption Report* describes consumption rates for marine fish (U.S. EPA, 2014a).

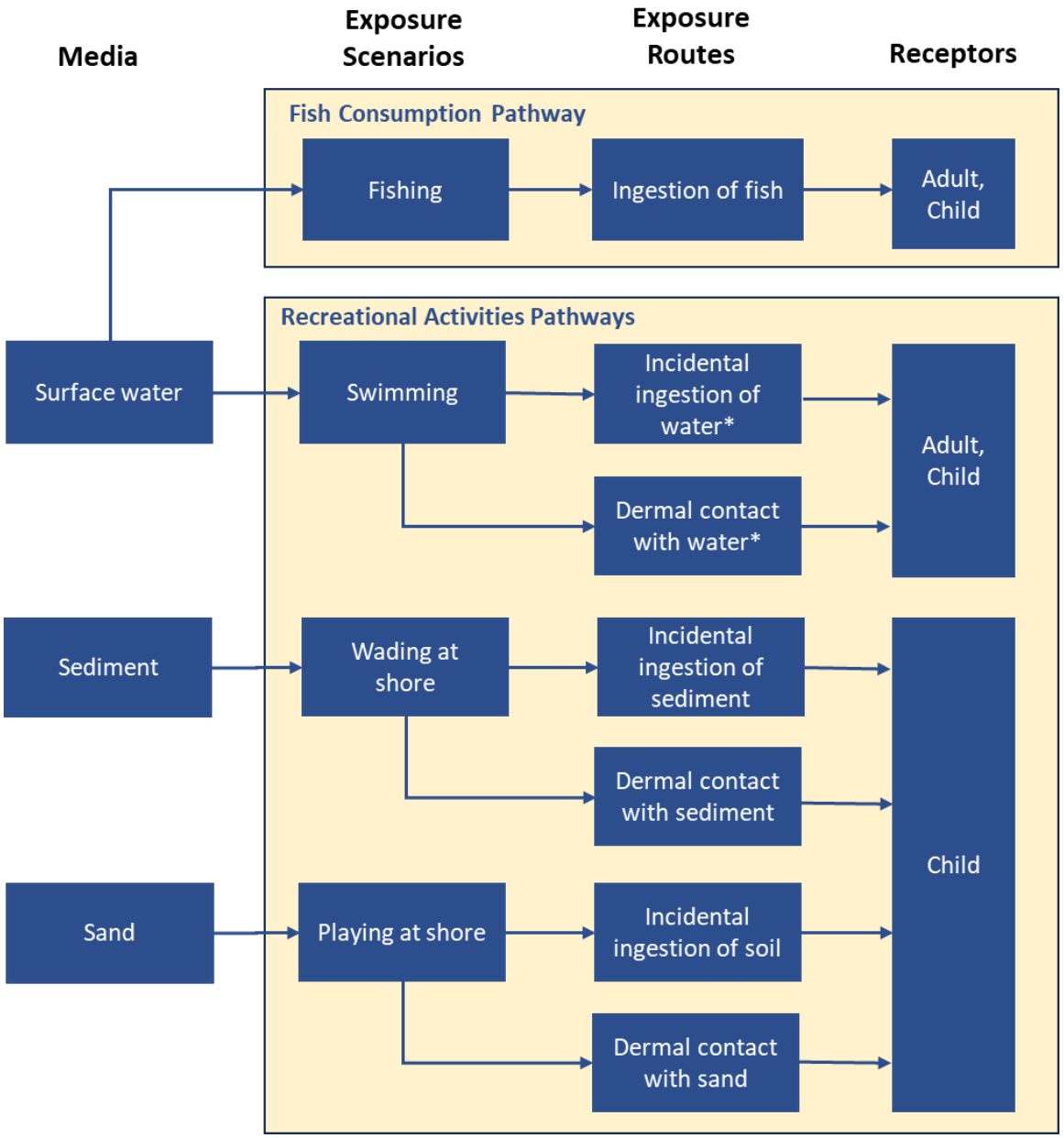

Figure 8. Conceptual model for the Las Mareas Bay HHRA.

Note: Adults were assumed to be 21 to <70 years; children were modeled for six age cohorts ranging from 1 to <21 years; see **Section 3.3** for details of age cohorts.

* Recreational anglers would also have these exposures, but the swimming scenario would be protective of anglers as well.

The generalized equation (based on the methods sources above) for calculating chemical exposures is as follows:

$$Exp = \frac{C \times CR \times EF \times ED \times CF}{BW \times AT} \quad \text{(Equation 1)}$$

where:

Exp = exposure (the amount of chemical at the exchange boundary) (mg/kg body weight/day)
C = exposure point concentration (the chemical concentration contacted over the exposure period at the exposure point [e.g., mg/kg in fish, sand, or sediment]) (mg/L in water; these values come from the sampling data)
CR = contact rate (the amount of affected medium contacted per unit time or event [e.g., fish consumption rate in g/day; for dermal exposures, this is generally a function of an absorption factor, the length of the event (for water) or an adherence factor (for solids), and the surface area of skin exposed])
EF = exposure frequency (describes how often exposure occurs) (days per year)
ED = exposure duration (describes how long exposure occurs) (year)
CF = conversion factor as necessary, depending on units of concentration and contact rate
BW = body weight (the average body weight over the exposure period) (kg)
AT = averaging time (period over which exposure is averaged) (days); for cancer risk, this is set to a lifetime (70 years); for noncancer hazard, it is set equal to the exposure duration.

Equation 1 is slightly modified for each pathway. Pathway-specific equations are provided in **Appendix D**.

Recreational exposures were evaluated for adults and children swimming and for children wading in sediment and playing in sand; adults were not evaluated for the sand and sediment exposures because children are the most at-risk population for those activities. These pathways include a dermal component and an incidental ingestion component. Incidental ingestion occurs while swimming and, for children, because of hand-to-mouth behavior while playing or wading in sand or sediments. For dermal exposures, the procedures laid out in the RAGS, Part E (U.S. EPA, 2004), for estimating exposure factors and calculating exposure and risk were followed.

Adults and children may be exposed by eating fish filet directly or by consuming fish head stew (in which they are not consuming fish directly, but contaminants may leach into the stew from the fish heads). Given the uncertainties and potential variability with the fish head stew recipe, the assessment focused on the fish filet ingestion pathway to represent the more conservative exposure levels. Values for whole fish were considered qualitatively in the context of local use of whole fish or fish heads in fish stew. Additional discussion is provided in **Section 5**.

For each of the potentially complete exposure pathways identified, 50th and 95th percentile estimates were calculated in the HHRA by using the 50th and 95th percentile exposure concentrations from the sampling data and mean or median exposure factor values. The 95th percentile estimates are intended to reflect the maximum exposure that is reasonably expected to occur at the exposure area.

3.3 Exposure Factors

In addition to the sampling concentrations, estimating exposure requires various exposure factors, including physical characteristics (e.g., body weight, skin surface area) and activity patterns (e.g., duration and frequency of swimming, consumption rates). Both types of exposure factors can vary significantly among the various stages of childhood; therefore, exposures for children were evaluated for six age groupings consistent with

recommendations in the EPA's *Guidance on Selecting Age Groups for Monitoring and Assessing Childhood Exposures to Environmental Contaminants* (U.S. EPA, 2005b):

- 1 to <2 years
- 2 to <3 years
- 3 to <6 years
- 6 to <11 years
- 11 to <16 years
- 16 to <21 years.

In addition, exposures for adults (21 to <70 years) were evaluated for some pathways.

A single point estimate was selected for each exposure factor and age group, and these values were used in the calculation of the cancer risks and noncancer hazards. In the absence of local activity/behavioral data, exposure parameters were selected from EPA's *Exposure Factors Handbook* (EFH) (U.S. EPA, 2011, 2017b, 2019) or other general sources. The median or mean was used to reflect the average person who might be exposed.

The rest of this section details the sources of the exposure factors used and, where relevant, how exposure factors used were derived from the source data. The pathway-specific exposure equations in **Appendix D** also provide the exposure factor values used and cross-reference the tables in this section.

3.3.1 Exposure Factors Used for All Pathways

Several exposure factors are used for all exposure pathways. These include averaging time, exposure duration, and body weight.

Exposure Duration and Averaging Time. The exposure duration is set to the length of the age group; these values are provided in **Table 16**. For estimating cancer risks, the averaging time is set to the value shown (and is the same for all age groups) but for estimating noncancer hazards, it is set equal to the age group–specific exposure duration (U.S. EPA, 1989).

Table 16. Exposure Duration and Averaging Time

Parameter	Age Group	Value	Units	Basis
Averaging time	All	70	Year	RAGS Part A (U.S. EPA, 1989)
Exposure duration	1 to <2 years	1	Year	Based on length of age group
	2 to <3 years	1		
	3 to <6 years	3		
	6 to <11 years	5		
	11 to <16 years	5		
	16 to <21 years	5		
	Adult 21 to <70 years	50		

Body Weight. Body weights were taken from the EFH and are provided in **Table 17**.

Table 17. Body Weight, by Age Group

Parameter	Age Group	Value	Units	Basis
Body weight	1 to <2 years	11.3	kg	*Exposure Factors Handbook* (U.S. EPA, 2011), Table 8-3, 50th percentile
	2 to <3 years	13.6		
	3 to <6 years	17.8		
	6 to <11 years	29.3		
	11 to <16 years	54.2		
	16 to <21 years	67.6		
	Adult 21 to <70 years	79		

3.3.2 Exposure Factors Used for Recreational Exposures

The key human exposure factors specific to recreational exposure include event and exposure frequency; duration of event; exposed skin surface area; adherence of solids (sand, sediment) to the skin; absorption fractions through the skin; and rates of incidental ingestion of water, sand, or sediment while swimming, playing, or wading.

Event and Exposure Frequency. RAGS, Part E, uses two parameters to evaluate frequency of dermal exposures: event frequency (events per day) and exposure frequency (days per year). To better correspond with the available data in the EFH (which were in events per year), these parameters were combined into a single frequency in events per year.

The most closely relevant activity data for estimating frequency of recreational activities at the shore in the EFH is frequency of swimming at a pool (EFH Table 16-39). This is the best available information for exposure; no exposure factor exists for swimming in a coastal beach area to the authors' knowledge. The EFH data are reported as number of respondents reporting they swam 1 time per month, 2 times per month, and so on up to 60 times per month. The respondents reporting more than 30 times per month (or more than once a day) accounted for less than 1% of all respondents, so they do not affect the 50th percentile data used. From these data, we reconstructed the distribution of responses and selected the 50th percentile.

Further, it was assumed that in Puerto Rico's climate, such recreational activities occur year-round, so the monthly value was multiplied by 12 months to obtain frequency in events per year. This same frequency value was applied for all recreational activities: swimming, playing in sand, and wading, as it seemed likely that children would engage in all three recreational activities during an excursion to the beach. **Table 18** includes the values used.

Table 18. Event / Exposure Frequency for Recreational Exposures

Parameter	Age Group	Value	Units	Basis
Event/exposure frequency	1 to <2 years	24	Events per year	*Exposure Factors Handbook* (U.S. EPA, 2011), Table 16-39, 50th percentile
	2 to <3 years	66		
	3 to <6 years	48		
	6 to <11 years	60		
	11 to <16 years	60		
	16 to <21 years	60		
	Adult 21 to <70 years	60		

Duration of Event. The most closely relevant activity data in the EFH for estimating the length of time swimming is swimming in pools (EFH Table 16-40). These data are presented in minutes per month. For this assessment, the median time swimming was combined with the median swimming events per month (as described earlier) to estimate the minutes per event. The minutes per event were then converted to hours per event. Values for event duration are provided in **Table 19**.

For playing in sand, data on time spent playing on sand or gravel were used (EFH Table 16-43). The data for playing in sand were presented in minutes per day, and one event per day was assumed. There were no data for anything like wading, so we also used the event duration for playing in sand for wading.

Table 19. Event Duration for Recreational Activities

Parameter	Age Group	Value	Units	Basis
Event duration (swimming)	1 to <2 years	0.88	hr	*Exposure Factors Handbook* (U.S. EPA, 2011), Table 16-40, 50th percentile; adult value based on 18 to 64 years
	2 to <3 years	0.36		
	3 to <6 years	0.75		
	6 to <11 years	0.6		
	11 to <16 years	0.6		
	16 to <21 years	0.6		
	Adult 21 to <70 years	0.15		
Event duration (wading in sediment, playing on sand)	1 to <2 years	0.5	hr	*Exposure Factors Handbook* (U.S. EPA, 2011), Table 16-43, 50th percentile, time spent playing on sand or gravel; used for sand and sediment
	2 to <3 years	0.5		
	3 to <6 years	1		
	6 to <11 years	1		
	11 to <16 years	1		
	16 to <21 years	1		
	Adult 21 to <70 years	Not evaluated		

Exposed Skin Surface Area. The EFH provides data on total skin surface area by age (EFH Table 7-1) and for various body parts—head, torso, arms, hands, legs, and feet—by age (EFH Table 7-2). The values for the whole body (median) are provided in **Table 20**, whereas the values for specific body parts (mean) are provided in **Table 21**. Note that values by body part do not sum to exactly the whole-body value for the same age group because the body part values are means, whereas the whole-body values are medians. The differences, however, are minor.

Table 20. Exposed Skin Surface Area: Whole Body

Parameter	Age Group	Value	Units	Basis
Skin surface area (total)	1 to <2 years	5,300	cm^2	*Exposure Factors Handbook* (U.S. EPA, 2011), Table 7-1, 50th percentile
	2 to <3 years	6,100		
	3 to <6 years	7,400		
	6 to <11 years	10,500		
	11 to <16 years	15,700		
	16 to <21 years	18,000		
	Adult 21 to <70 years	19,400		

Table 21. Exposed Skin Surface Area, by Body Part

Parameter	Age Group	Head	Trunk	Arms	Hands	Legs	Feet	Units	Basis
Skin surface area, by body part	1 to <2 years	870	1,880	690	300	1,220	330	cm^2	*Exposure Factors Handbook* (U.S. EPA, 2011), Table 7-2, mean
	2 to <3 years	510	2,500	880	280	1,540	380		
	3 to <6 years	610	3,130	1,060	370	1,950	490		
	6 to <11 years	660	4,280	1,510	510	3,110	730		
	11 to <16 years	730	6,300	2,270	720	4,830	1,050		
	16 to <21 years	750	7,590	2,690	830	5,430	1,120		
	Adult 21 to <70 years	Not evaluated							

Different recreational activities would not necessarily expose the same body parts. For this assessment, the following exposure assumptions were made for the purposes of calculating exposed skin surface area:

- **Swimming:** entire body (data from Table 20).
- **Playing in Sand:** face, lower arms, hands, lower legs, and feet. Data from Table 21 were used; to estimate face, lower arms, and lower legs (for which the EFH does not provide specific values), the assumptions used in RAGS, Part E (U.S. EPA, 2004) were used: face was estimated as one-third of head, lower arms were estimated as 45% of arms, and lower legs as 40% of legs (so, for example, the value for face for 1 to <2 years would be 870 [the value for head] divided by 3 = 290). The resulting total skin surface area values by age group are provided in **Appendix D**, Table D-3.
- **Wading in Sediment:** arms, hands, legs, and feet. (Although these body parts may also be exposed to water while wading, the swimming exposure scenario should be protective for exposure to the chemicals considered because it covers the greater surface area exposed to water compared with wading.)

The totals across body parts for skin surface area exposed for playing in sand and wading based on these assumptions are provided in **Appendix D** with the relevant equations.

Solids Adherence. The solids adherence factor reflects the extent to which different materials adhere to the skin and varies with the material and the body part. RAGS, Part E, recommends weighting the solids adherence factors for relevant body parts by the surface area of those body parts to establish a single weighted solids adherence factor for any given scenario. RAGS, Part E, provides body-part weighted values for children for dry soil, wet soil, and mud, all assuming exposure to face, lower arms, hands, lower legs, and feet. The EFH provides body-part specific values for mud and sediment, which can be weighted as desired by body part surface area. The mud values are consistent between the two sources.

Table 22 provides the values used. For the sand pathway, in the absence of data specifically for sand, the value for wet soil from RAGS, Part E, is the closest match to our scenario. RAGS, Part E, provides only the weighted value and it is not differentiated by age beyond "children." For the sediment pathway, the sediment values for different body parts from the EFH were used (which do not vary by age). A weighted average for arms, hands, legs, and feet was calculated for each age group based on the body part surface areas provided in Table 21; those weighted values by age group are shown in **Appendix D** with the relevant equations.

Table 22. Solids Adherence Factors

Parameter	Activity	Arms	Hands	Legs	Feet	Weighted Average	Units	Basis
	Playing in wet soil (sand)	Not provided				0.2	mg/cm^2	RAGS Part D (U.S. EPA, 2004), Exhibit 3-3

Parameter	Activity	Arms	Hands	Legs	Feet	Weighted Average	Units	Basis
Solids adherence factor	Playing in sediment	0.17	0.49	0.7	21	See App D		*Exposure Factors Handbook* (U.S. EPA, 2011), Table 7-4, mean

Dermal Absorption Factors. Dermal absorption factors are chemical specific. For water, the absorption factor is denoted as Kp (centimeters per hour [cm/hr]); for solids, it is denoted as ABS_d (fraction).

Experimental values for Kp for inorganics were available for cadmium, chromium, mercury, and silver; the rest of the inorganics were set to the default recommended in RAGS, Part E, (0.001). Kp values for organics can be estimated using a correlation equation but are complex to use due to interactions with the length of the exposure event, which varies by age. Because all organic concentrations were nondetects for water, sand, and sediment, we did not evaluate these at this time.

Data for ABS_d, the dermal absorption fraction for solids, are very sparse, and values were available in RAGS, Part E, for only arsenic and cadmium. RAGS, Part E, notes that for inorganics, the speciation of the compound is critical to the dermal absorption, and there are too little data to extrapolate a reasonable default value. Thus, no other inorganics were evaluated for this pathway.

Values used for Kp and ABS_d are provided in **Table 23**.

Table 23. Chemical-specific Absorption Factors for Dermal Exposures

	Water	Solids
Name	Kp (cm/hr)	ABS_d (fraction)
Antimony	0.001	No data available
Arsenic (inorganic)	0.001	0.03
Barium	0.001	No data available
Beryllium	0.001	No data available
Boron	0.001	No data available
Cadmium	0.001	0.001
Chromium (total)	0.000007	No data available
Cobalt	0.001	No data available
Lithium	0.001	No data available
Mercury	0.001	No data available
Molybdenum	0.001	No data available
Selenium	0.001	No data available
Silver	0.001	No data available
Thallium	0.001	No data available

Incidental Ingestion. The EFH provides data on incidental ingestion of water while swimming (EFH Table 3-7) and incidental ingestion of sediments for recreational activities at the shore (EFH Table 5-32). The latter were also used for sand. Both data sets provide mean only, in milliliters per hour (mL/hr) (water while swimming) or milligrams per hour (mg/hr) (sediment). For water, values were available for only age groups 6 to <11 years and up, so the values for 6 to <11 were used for the younger age groups as well. For sediment, the age groups for which data were provided differed from the standard age groups and were generally broader:

- 7 months to 4 years (used for 1 to <2 and 2 to <3)
- 5 to 11 years (used for 3 to <6 and 6 to <11)
- 12 to 19 years (used for 11 to <16 and 16 to <21).

The values used are provided in **Table 24**.

Table 24. Incidental Ingestion Rates During Recreational Activities

Parameter	Age Group	Value	Units	Basis
Incidental ingestion of water while swimming	1 to <2 years	38	mL/hr	*Exposure Factors Handbook* (EFH) (U.S. EPA, 2019), Table 3-7, mean
	2 to <3 years	38		
	3 to <6 years	38		
	6 to <11 years	38		
	11 to <16 years	44		
	16 to <21 years	33		
	Adult 21 to <70 years	28		
Incidental ingestion of sediment	1 to <2 years	72	mg/hr	EFH (U.S. EPA, 2017b), Table 5-32, mean of sediment consumption during recreational shore activities; used for sand and sediment
	2 to <3 years	72		
	3 to <6 years	57		
	6 to <11 years	57		
	11 to <16 years	18		
	16 to <21 years	18		
	Adult 21 to <70 years	Not eval.		

3.3.3 Exposure Factors Used for Fish Consumption

The key exposure factors specific to fish consumption are the consumption rate and the exposure frequency.

Fish Consumption Rate. For the purposes of this assessment, the fish consumption rate of interest is that of marine fish from the Atlantic Ocean. The EFH recommends marine fish consumption rates for recreational marine anglers but presents no other data specifically for marine fish. The recommendations for recreational marine anglers are presented by region (Atlantic, Gulf, Pacific) based on data from the 1990s for adults. Recommendations for children are estimated based on ratios of fish consumption for children in the general population (by age) to adults in the general population and do not include children younger than age 3.

The 2014 Fish Consumption Report (U.S. EPA, 2014a) presents more recent data from the National Health and Nutrition Examination Survey (2003–2010). Consumption rates for marine fish are presented for the same regions (Atlantic, Gulf, Pacific) and for adults and "youth" (all children <21 years). Data for all regions combined for children are also presented in finer age groups, including children 1 to <3. Thus, compared with the EFH, the Fish Consumption Report has the advantages of being more recent, based on actual data for children for marine fish, and covering a broader range of ages for children. Therefore, we chose to use this source for fish consumption rates.

To estimate consumption rates for just the Atlantic region for children, we used the ratio of Atlantic marine fish to all marine fish for youths <21 (this value is about 1.4 and is the only value provided for the under 21 group) and applied that to the all-marine fish consumption rates for each age group. The results are presented in **Table 25** in both grams (g) per day (the units needed for exposure calculations and as presented in the source) and in the equivalent ounces (oz) per month (for context). A meal for an adult would be about 4 oz, but that would probably be lower for younger children.

Table 25. Fish Consumption Rates: Marine Fish, Atlantic Region

Parameter	Age Group	Value (g/day)	Value (oz/month)	Basis
Fish consumption rate: marine fish, uncooked	1 to <2 years	2.4	2.5	Fish Consumption Report (U.S. EPA, 2014a), Table E-2, scaled by ratio of Atlantic to all regions for all youth (<21) from Table 21b
	2 to <3 years	2.4	2.5	
	3 to <6 years	3.2	3.4	
	6 to <11 years	4.4	4.7	
	11 to <16 years	4.3	4.6	
	16 to <21 years	6.7	7.1	
	Adult 21 to <70 years	13.1	14	Fish Consumption Report (U.S. EPA, 2014a), Table 10b

Exposure Frequency. The fish consumption rates are presented on a per-day, not per-eating occasion, so it seems reasonable to assume the exposure frequency is the entire year. It is set to 350 days per year for all ages, assuming 2 weeks away from home, per EPA policy (U.S. EPA, 2014b). **Table 26** provides the data for exposure frequency for fish consumption.

Table 26. Exposure Frequency for Fish Consumption

Parameter	Age Group	Value	Units	Basis
Exposure frequency (fish consumption)	All	350	day/ yr	U.S. EPA, 2014b

3.4 Exposure Results

Exposures are expressed as the amount of chemical at the exchange boundary (in mg/kg body weight/day). The exposure values are provided in **Appendix D** for each chemical, pathway, and age group. Results for noncancer and cancer endpoints are reported separately; these differ only in the averaging time applied (equal to the exposure duration for noncancer and 70 years for cancer).

4 Calculation of Risk and Hazard

Risks (for carcinogens) and HQs (for noncarcinogens) were calculated as follows:

$$Risk = Exp \times \text{CSF} \quad \text{(Equation 2)}$$

$$HQ = \frac{Exp}{RfD} \quad \text{(Equation 3)}$$

where:

Risk = incremental cancer risk to an individual (unitless)
HQ = noncancer hazard quotient (unitless)
Exp = exposure (the amount of chemical at the exchange boundary) (mg/kg body weight/day)
CSF = cancer slope factor, the toxicity endpoint for carcinogens; see **Section 4.1.1** (per mg/kg per day)
RfD = reference dose, the toxicity endpoint for noncarcinogens; see **Section 4.1.2** (mg/kg per day).

Results were calculated for all child age groups and, where relevant, adults. The results are reported in **Section 5** for adults and the child age group with the greatest exposure for a given pathway, and only for chemicals with at least one detection in the relevant medium. **Appendix E** provides the results for all age groups and chemicals.

The key input to the calculation of risk or hazard other than exposure is the toxicity value. This section describes the oral toxicity endpoints that are used in the assessments of cancer and noncancer health effects (**Section 4.1**), the data sources that were used to obtain values for these endpoints (**Section 4.2**), the values selected for this assessment (**Section 4.3**), and adjustments to those values to account for dermal exposures (**Section 4.4**).

4.1 Toxicity Endpoints

EPA classifies the toxicity of chemicals based on health effects, including cancer and noncancer health effects, depending on the available toxicity data. Human health toxicity benchmarks are combined with exposure estimates to characterize the cancer risks and noncancer hazards. Human health toxicity benchmarks may be available for oral (ingestion) exposures and inhalation exposures, depending on the chemical and available data. Benchmarks specific to dermal exposures are not generally available, so oral toxicity values are typically used to evaluate dermal exposures. Inhalation exposures were not considered in this assessment; thus, only oral toxicity endpoints were used.

4.1.1 Carcinogens

Consistent with EPA's *Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 2005c), EPA classifies chemicals based on the weight of evidence for carcinogenicity using the following standard descriptors:

- Carcinogenic to humans
- Likely to be carcinogenic to humans
- Suggestive evidence of carcinogenic potential
- Inadequate information to assess carcinogenic potential
- Not likely to be carcinogenic to humans.

Cancer slope factors (CSFs) are developed for chemicals classified as known, probable, or possible human carcinogens for which there are sufficient data available of acceptable quality. Oral CSFs are combined with exposure estimates to calculate cancer risks.

4.1.2 Noncarcinogens

The chronic oral RfD represents an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime.[6]

EPA derives RfDs by first identifying the highest dose level that does not cause observable adverse effects (no-observed-adverse-effect level [NOAEL]). If a NOAEL was not identified, a lowest-observed-adverse-effect level (LOAEL), may be used. This dose level is then divided by uncertainty factors to calculate an RfD. Four standard uncertainty factors can be used when calculating an RfD:

- An up-to-10-fold factor to account for the variation in sensitivity among members of the human population
- An up-to-10-fold factor to account for the uncertainty involved in extrapolating from animal data to humans
- An up-to-10-fold factor to account for the uncertainty involved in extrapolating from less-than-chronic NOAELs to chronic NOAELs
- An up-to-10-fold factor to account for the uncertainty involved in extrapolating from LOAELs to NOAELs.

An additional modifying factor can also be applied to the calculation of the RfD. The modifying factor is an additional uncertainty factor that is greater than zero and less than or equal to 10. The magnitude of the modifying factor depends on an assessment of the scientific uncertainties of the study and the database used in deriving the RfD that are not explicitly treated above (e.g., completeness of the overall database and number of species tested).

4.1.3 Lead

There is no accepted toxicity value for lead. Consistent with EPA policy, lead is evaluated using the Integrated Exposure Uptake Biokinetic (IEUBK) Model (U.S. EPA, 2024c), which estimates potential blood lead levels in children 7 years or younger (U.S. EPA, 2024d).

4.2 Data Sources

Toxicity values were selected according to the hierarchy established in the 2003 Office of Solid Waste and Emergency Response Directive 9285.7-53 (U.S. EPA, 2003), which encourages the prioritization of toxicity values from sources that are current, transparent, and publicly available, and that have been peer reviewed. The sources used for this assessment are as follows:

- EPA IRIS (U.S. EPA, 2024a)
- Provisional Peer-Reviewed Toxicity Values (PPRTV) for Superfund (U.S. EPA, 2024b)
- ATSDR minimal risk levels (ATSDR, 2024).

EPA-developed values were preferred (IRIS and PPRTV; these do not generally overlap as the PPRTVs cross-reference IRIS when values are available there). Values from non-EPA sources but based on similar methods (ATSDR) were only used if EPA values were not available.

4.3 Selected Toxicity Values

Table 27 shows the oral CSF values identified and the carcinogen weight of evidence classification; only chemicals with a weight of evidence classification of "Suggestive Evidence of Carcinogenic Potential" or higher are included. **Table 28** provides the oral RfDs for noncarcinogens and the target organ system. Four constituents

[6] https://www.epa.gov/iris/basic-information-about-integrated-risk-information-system

have no toxicity values in any of the above sources: lead, acenaphthylene, benzo(g,h,i)perylene, and phenanthrene.

Table 27. Cancer Slope Factors and Cancer Weight of Evidence for Analyzed Chemicals with Carcinogenic Effects

Name	Cancer Slope Factor (per mg/kg-day)	Source	Weight of Evidence Classification
Inorganics			
Arsenic (inorganic)	32	IRIS	Carcinogenic to humans
Chromium VI	0.16	IRIS	Carcinogenic to humans
Organics			
Benzo(a)pyrene	1	IRIS	Carcinogenic to humans
Benzo(a)anthracene	0.1	IRIS†	B2—Probable human carcinogen
Benzo(b)fluoranthene	0.1	IRIS†	B2—Probable human carcinogen
Benzo(k)fluoranthene	0.01	IRIS†	B2—Probable human carcinogen
Biphenyl, 1,1'-	0.008	IRIS	Suggestive evidence of carcinogenic potential
Chrysene	0.001	IRIS†	B2—Probable human carcinogen
Dibenzo(a,h)anthracene	1.0	IRIS†	B2—Probable human carcinogen
Indeno(1,2,3-cd)pyrene	0.1	IRIS†	B2—Probable human carcinogen

* EPA cancer toxicity values were obtained from the Integrated Risk Information Management System (IRIS) database on April 2, 2025.

† PAHs, listed under Organics, include chemicals with similar toxicological properties. Potency equivalency factors are used to calculate the overall carcinogenicity of PAHs based on the relative potency of the individual chemical to Benzo(a)pyrene. The relative potency factor for Benzo(a)fluoranthene was obtained from: https://www.epa.gov/sites/default/files/2015-11/documents/pah-rpfs.pdf.

Table 28. Reference Doses and Target Organs for Analyzed Chemicals with Noncarcinogenic Effects

Name	Reference Dose (mg/kg-day)	Uncertainty Factor	Target Organ	Source
Inorganics				
Antimony	0.0004	1000	Hematologic	IRIS
Arsenic (inorganic)	0.00006	3	Endocrine, cardiovascular	IRIS
Barium	0.2	300	Urinary	IRIS
Beryllium	0.002	300	Gastrointestinal	IRIS
Boron	0.2	66	Developmental	IRIS
Cadmium	0.0005 (water) 0.001 (food)	10 10	Urinary	IRIS
Chromium VI	0.0009	100	Gastrointestinal	IRIS
Cobalt	0.0003	3000	Thyroid	PPRTV
Lithium	0.002	1000	Adverse effect in several organs and systems	PPRTV
Mercuric chloride*	0.0003	1000	Immune, urinary	IRIS
Methylmercury*	0.0004	10	Nervous, developmental	IRIS
Molybdenum	0.005	30	Urinary	IRIS
Selenium	0.005	3	Nervous, hematologic, dermal	IRIS
Silver	0.005	3	Dermal	IRIS
Thallium	0.00001	3000	Not specified	PPRTV
Organics				
Acenaphthene	0.06	3000	Hepatic	IRIS
Anthracene	0.3	3000	No Observed Adverse Effects Level	IRIS
Benzo(a)pyrene	0.0003	300	Developmental	IRIS
Biphenyl, 1,1'-	0.5	30	Urinary	IRIS
Fluoranthene	0.04	3000	Hepatic, urinary	IRIS
Fluorene	0.04	3000	Hematologic	IRIS
Methylnaphthalene, 2-	0.004	1000	Respiratory	IRIS
Naphthalene	0.02	3000	Other	IRIS
Pyrene	0.03	3000	Urinary	IRIS
Sulfolane	0.001	3000	Hematologic	PPRTV

Note: Toxicity values are not available for lead; see Section 4.1.3.

* Value for mercuric chloride used for dermal exposures and incidental ingestion of water, sand, or sediment. Value for methylmercury used for fish consumption.

4.4 Adjustment of Toxicity Factors for Absorbed Dose

For dermal exposures, the doses calculated are absorbed dose. However, most oral toxicity factors are based on administered dose. Thus, the RAGS Part E Dermal Guidance recommends adjusting those toxicity factors to absorbed dose by dividing by the fraction absorbed in the gastrointestinal tract (ABS_{GI}). These adjustments are medium specific, and those provided for the inorganics of interest are all based on administered doses in an aqueous medium, so they are applicable only to the dermal exposures to water. **Table 29** provides the values recommended in RAGS Part E (specifically in Exhibit 4.1 of that reference). Chemicals missing from the table had no recommended value, and this adjustment was not made.

Table 29. Recommended Values for Absorption in the Gastrointestinal Tract from an Aqueous Medium

Name	ABS_{GI} (fraction)
Antimony	0.15
Arsenic (inorganic)	0.95
Barium	0.07
Beryllium	0.007
Cadmium	0.05
Chromium (VI)	0.025
Mercury	0.07
Selenium	0.3
Silver	0.04
Thallium	1

5 Risk Characterization

The hazards evaluated in this assessment include carcinogenic and noncarcinogenic chemicals and lead.

Carcinogenic (cancer-causing) chemicals. The level of concern was defined as an excess lifetime cancer risk to individuals above a risk of 1 in 10,000 (this is generally expressed as 10^{-4} for brevity) for chemicals with a carcinogen weight of evidence of Carcinogenic to Humans, Likely to Be Carcinogenic to Humans, or Suggestive Evidence of Carcinogenic Potential or higher. **Table 27** lists the Weight of Evidence Classifications for chemicals classified as carcinogens.

Noncarcinogenic chemicals (i.e., that cause other health effects). The level of concern was defined as an HQ above 1. The HQ is a ratio of predicted intake levels to safe intake levels, typically expressed in units of mg/kg-day. **Table 28** lists the target organ system for noncancer health effects identified for the chemicals evaluated in this assessment.

Lead. The level of concern for lead is the Centers for Disease Control and Prevention (CDC) blood lead reference value (BLRV) of 3.5 micrograms per deciliter (µg/dL). The BLRV is a population-based measurement that reflects the 97.5 percentile of blood lead distribution in U.S. children aged 1–5 years. The BLRV is not a health-based standard or a toxicity threshold. CDC indicates that the "BLRV is used to guide and determine recommended follow-up and prioritize communities with the need for exposure prevention" (CDC, 2024). The BLRV was updated in April 2024, falling from 5 µg/dL to 3.5 µg/dL.

5.1 Recreational Exposures

Risks and HQs were calculated for adults (21 to <70 years; swimming only) and the following child age groups: 1 to <2 years, 2 to <3 years, 3 to <6 years, 6 to <11 years, 11 to <16 years, and 16 to <21 years (swimming, sand, sediment). For each type of exposure (swimming, sand, sediment), the child age group with the highest exposures based on median exposure factors was identified. The tables in this section present the noncancer and cancer risk estimates by pathway for adults (if evaluated) and the child age group with the highest exposures among those evaluated for the exposure pathway and endpoint for chemicals with at least one detection in the relevant medium. Results for all child age groups and all chemicals (evaluated at half the RDL if there were no detections) are provided in **Appendix E**. In no case was a result that exceeded risk criteria presented only in **Appendix E**.

Values that exceed the level of concern risk criteria (cancer risk of 10^{-4} or HQ of 1) are shown in **bold** and discussed in the text.

5.1.1 Recreational Swimming Risks

Tables 30 and **31** present noncancer HQs and cancer risks, respectively, for recreational swimming. Results are shown for incidental ingestion exposures, dermal exposures, and the total of ingestion and dermal, for the 50th and 95th percentile concentration results. Adults (21 to <70 years) and children were evaluated for this pathway. For noncancer, the child age group with the highest exposures (based on median exposure factors) is 3 to <6 years, whereas for cancer, it is children 6 to <11 years. None of these results exceed the risk criteria (HQ=1 or risk=1E-4 [1 in 10,000]), and most are extremely low (<0.001 for noncancer HQ and on the order of 1E-8 [1 in 100,000,000] or lower for cancer).

Table 30. Results Indicate That Recreational Swimming Hazards Are All Less Than an HQ of 1.

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal	Total	Ingestion	Dermal	Total
Arsenic (inorganic)	Child (3 to <6 years)	0.007	0.001	0.009	0.008	0.002	0.01
Arsenic (inorganic)	Adult (21 to <70 years)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	Child (3 to <6 years)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	Adult (21 to <70 years)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	Child (3 to <6 years)	0.005	0.001	0.006	0.006	0.001	0.007
Boron	Adult (21 to <70 years)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (VI)	Child (3 to <6 years)	<0.001	<0.001	<0.001	0.012	<0.001	0.01
Chromium (VI)	Adult (21 to <70 years)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	Child (3 to <6 years)	0.04	0.007	0.04	0.04	0.007	0.05
Lithium	Adult (21 to <70 years)	0.002	0.001	0.003	0.002	0.001	0.003
Mercury (total)	Child (3 to <6 years)	*<0.001*	*<0.001*	*<0.001*	<0.001	<0.001	0.001
Mercury (total)	Adult (21 to <70 years)	*<0.001*	*<0.001*	*<0.001*	<0.001	<0.001	<0.001
Molybdenum	Child (3 to <6 years)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	Adult (21 to <70 years)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	Child (3 to <6 years)	*0.01*	*0.002*	*0.01*	0.03	0.006	0.04
Thallium	Adult (21 to <70 years)	*<0.001*	*<0.001*	*<0.001*	0.001	<0.001	0.002

Noncancer Results (Hazard Quotients) based on the 50th and 95th percentile concentrations for adults and the child age group with the highest exposures based on median exposure factors for recreational exposure while swimming by incidental ingestion and dermal contact.

Note: Values in *italics* and pale-yellow shading are based on a nondetect concentration set to half the detection limit. Results are shown only for chemicals with some detections; results based on half the detection limit for chemicals with no detects can be found in Appendix E.

Table 31. Results Indicate That Recreational Swimming Cancer Risks Are All Less Than 1 in 10,000.

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal	Total	Ingestion	Dermal	Total
Arsenic (inorganic)	Child (6 to <11 years)	6E-07	2E-07	8E-07	7E-07	2E-07	9E-07
Arsenic (inorganic)	Adult (21 to <70 yrs)	4E-07	3E-07	7E-07	5E-07	3E-07	8E-07
Chromium (VI)	Child (6 to <11 years)	4E-09	3E-10	4E-09	7E-08	6E-09	8E-08
Chromium (VI)	Adult (21 to <70 yrs)	3E-09	5E-10	3E-09	5E-08	1E-08	6E-08

Cancer Risks based on the 50th and 95th percentile concentrations for adults and the child age group with the highest exposures based on median exposure factors for recreational exposure while swimming by incidental ingestion and dermal contact.

Note: Values in *italics* and pale-yellow shading are based on a nondetect concentration set to half the detection limit. Results are shown only for chemicals with some detections; results based on half the detection limit for chemicals with no detects can be found in Appendix E.

5.1.2 Recreational Playing in Sand Risks

Tables 32 and **33** present noncancer HQs and cancer risks, respectively, for recreational exposures while playing in sand. Results are shown for incidental ingestion exposures, dermal exposures, and the total of ingestion and dermal, for the 50th and 95th percentile concentration results. Only children were evaluated for this pathway. For noncancer, the child age group with the highest exposures is 2 to <3 years, whereas for cancer, it is children 6 to <11 years. Only arsenic and cadmium could be evaluated for dermal exposure because dermal absorption

factors are not available for the other inorganics (see **Table 23**). Further, there were no detections of cadmium in sand samples, so the results for cadmium (including dermal) for half the RDL are provided in **Appendix E**.

The results are generally higher than those for swimming but still do not exceed the risk criteria (HQ=1 or risk of 1E-4 [1 in 10,000]).

Table 32. Results Indicate That Recreational Exposure to Beach Sand Hazards Are All Less Than an HQ of 1.

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal*	Total	Ingestion	Dermal*	Total
Arsenic (inorganic)	Child (2 to <3 years)	0.05	0.02	0.07	0.07	0.02	0.09
Boron	Child (2 to <3 years)	<0.001	NA	<0.001	<0.001	NA	<0.001
Chromium (VI)	Child (2 to <3 years)	0.003	NA	0.003	0.005	NA	0.005
Cobalt	Child (2 to <3 years)	0.008	NA	0.008	0.02	NA	0.02
Molybdenum	Child (2 to <3 years)	*<0.001*	*NA*	*<0.001*	<0.001	NA	<0.001
Silver	Child (2 to <3 years)	<0.001	NA	<0.001	<0.001	NA	<0.001

Noncancer Results (Hazard Quotients) based on the 50th and 95th percentile concentrations for the child age group with the highest exposures based on median exposure factors for recreational exposure to beach sand by incidental ingestion and dermal contact.

Note: Values in *italics* and pale-yellow shading are based on a nondetect concentration set to half the detection limit. Results are shown only for chemicals with some detections; results based on half the detection limit for chemicals with no detections can be found in Appendix E.

* Dermal results are not available for chemicals without a recommended dermal absorption fraction in *Risk Assessment Guidance for Superfund*, Part E.

Table 33. Results Indicate That Recreational Exposure to Beach Sand Cancer Risks Are All Less Than 1 in 10,000.

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal*	Total	Ingestion	Dermal*	Total
Arsenic (inorganic)	Child (6 to <11 years)	5E-06	2E-06	7E-06	6E-06	2E-06	7E-06
Chromium (VI)	Child (6 to <11 years)	2E-08	NA	2E-08	4E-08	NA	4E-08

Cancer Risks based on the 50th and 95th percentile concentrations for the child age group with the highest exposures based on median exposure factors for recreational exposure to beach sand by incidental ingestion and dermal contact.

Note: Values in *italics* and pale-yellow shading are based on a nondetect concentration set to half the detection limit. Results are shown only for chemicals with some detections; results based on half the detection limit for chemicals with no detections can be found in Appendix E.

* Dermal results are not available for chemicals without a recommended dermal absorption fraction in *Risk Assessment Guidance for Superfund*, Part E.

5.1.3 Recreational Wading in Sediment Risks

Tables 34 and **35** present noncancer HQs and cancer risks, respectively, for recreational exposures while wading in sediment. Results are shown for incidental ingestion exposures, dermal exposures, and the total of ingestion and dermal, for the 50th and 95th percentile concentration results. Only children were evaluated for this pathway. For noncancer, the child age group with the highest exposures is 2 to <3 years, whereas for cancer, it is children 6 to <11 years. Only arsenic and cadmium could be evaluated for dermal exposure because dermal absorption factors are not available for the other inorganics (see **Table 23**). Further, there were no detections of cadmium in sediment samples, so the results for cadmium (including dermal) for half the RDL are provided in **Appendix E**.

The results are similar to those for playing in sand, but none exceed the risk criteria (HQ=1 or risk=1E-4 [1 in 10,000]).

Table 34. Results Indicate That Recreational Exposure to Sediment Hazards Are All Less Than an HQ of 1.

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal*	Total	Ingestion	Dermal*	Total
Arsenic (inorganic)	Child (2 to <3 years)	0.07	0.5	0.6	0.1	0.8	0.9
Boron	Child (2 to <3 years)	<0.001	NA	<0.001	<0.001	NA	<0.001
Chromium (VI)	Child (2 to <3 years)	0.004	NA	0.004	0.008	NA	0.008
Cobalt	Child (2 to <3 years)	0.01	NA	0.01	0.02	NA	0.02
Lithium	Child (2 to <3 years)	0.002	NA	0.002	0.005	NA	0.005
Molybdenum	Child (2 to <3 years)	*<0.001*	*NA*	*<0.001*	<0.001	NA	<0.001
Silver	Child (2 to <3 years)	<0.001	NA	<0.001	<0.001	NA	<0.001

Noncancer Results (Hazard Quotients) based on the 50th and 95th percentile concentrations for the child age group with the highest exposures based on median exposure factors for recreational exposure to sediment by incidental ingestion and dermal contact.

Note: Values in **bold** exceed the risk criterion of hazard quotient=1. Values in *italics* and pale-yellow shading are based on a nondetect concentration set to half the detection limit. Results are shown only for chemicals with some detections; results based on half the detection limit for chemicals with no detections can be found in ***Appendix E***.

* Dermal results are not available for chemicals without a recommended dermal absorption fraction in *Risk Assessment Guidance for Superfund*, Part E.

Table 35. Results Indicate That Recreational Exposure to Sediment Cancer Risks Are All Less Than 1 in 10,000.

Chemical	Receptor	50th Percentile			95th Percentile		
		Ingestion	Dermal*	Total	Ingestion	Dermal*	Total
Arsenic (inorganic)	Child (6 to <11 years)	6E-06	6E-05	7E-05	1E-05	9E-05	1E-04
Chromium (VI)	Child (6 to <11 years)	3E-08	NA	3E-08	5E-08	NA	5E-08

Cancer Risks based on the 50th and 95th percentile concentrations for the child age group with the highest exposures based on median exposure factors for recreational exposure to sediment by incidental ingestion and dermal contact.

Note: Values in *italics* and pale-yellow shading are based on a nondetect concentration set to half the detection limit. Results are shown only for chemicals with some detections; results based on half the detection limit for chemicals with no detections can be found in ***Appendix E***.

* Dermal results are not available for chemicals without a recommended dermal absorption fraction in *Risk Assessment Guidance for Superfund*, Part E.

5.2 Fish Consumption

Tables 36 and **37** present the noncancer HQs and cancer risks, respectively, for fish consumption for the 50th and 95th percentile concentration results. Fish consumption was evaluated for adults and children. For noncancer, the child age group with the highest exposures is 1 to <2 years, whereas for cancer, it is children 6 to <11 years. Values that exceed the level of concern risk criteria (cancer risk of 1E-04, or 1 in 10,000, or HQ of 1) are shown in **bold**.

The only exceedance for fish consumption is for thallium (noncancer), where the HQ for children 1 to <2 yrs is just over 1 at the 95th percentile concentration and is equal to 1 at the 50th percentile concentration. However, thallium was detected in only one of five fish samples in Las Mareas Bay (Spanish mackerel) and only one of six samples in the background location (Atlantic bumper), so in both cases, the 50th percentile concentration is based on half the detection limit, and the 95th percentile concentration represents a single detection. The single detection from Las Mareas Bay is effectively equal to the single detection from the background location (0.057 vs. 0.058 mg/kg). Thus, risk in the background location would be the same as the risk in Las Mareas Bay. Further, the RfD for thallium is uncertain because the calculation of the RfD includes an uncertainty factor of 3,000. Finally, the fish consumption rate for children 1 to <2 years was based on the value for children 2 to <3 years, as no value was available for children 1 to <2 years. This is likely also an overestimate. The HQ for children 2 to <3 is 1, which is at the criterion, but not an exceedance, and is still subject to the other uncertainties above. For all these reasons, this isolated, borderline exceedance seems unlikely to reflect significant risk.

Table 36. Results Indicate That Fish Consumption Hazards Are All Less Than 1 for All Chemicals Except Thallium, Which Has Hazards Potentially Slightly Greater Than the Goal of 1 for Children 1 to <2 Years.

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Arsenic (inorganic)	Child (1 to <2 years)	<0.001	0.005
Arsenic (inorganic)	Adult (21 to <70 years)	<0.001	0.004
Barium	Child (1 to <2 years)	<0.001	<0.001
Barium	Adult (21 to <70 years)	<0.001	<0.001
Boron	Child (1 to <2 years)	0.001	0.001
Boron	Adult (21 to <70 years)	<0.001	<0.001
Chromium (VI)	Child (1 to <2 years)	0.02	0.03
Chromium (VI)	Adult (21 to <70 years)	0.02	0.03

(continued)

Table 37. Results Indicate That Fish Consumption Hazards Are All Less Than and HQ of 1 for All Chemicals Except Thallium, Which Has Hazards Potentially Slightly Greater Than the Goal of 1 for Children 1 to <2 Years (continued).

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Methylmercury	Child (1 to <2 years)	0.4	1.0
Methylmercury	Adult (21 to <70 years)	0.3	0.8
Molybdenum	Child (1 to <2 years)	<0.001	0.002
Molybdenum	Adult (21 to <70 years)	<0.001	0.002
Selenium	Child (1 to <2 years)	0.01	0.02
Selenium	Adult (21 to <70 years)	0.01	0.02
Thallium	Child (1 to <2 years)	*1*	**1.2**
Thallium	Adult (21 to <70 years)	*0.8*	0.9

Noncancer Results (Hazard Quotients) based on the 50th and 95th percentile concentrations for adults and the child age group with the highest exposures based on median exposure factors for fish consumption

Note: Values in **bold** exceed the risk criterion of hazard quotient=1. Values in *italics* and pale-yellow shading are based on a nondetect concentration set to half the detection limit. Results are shown only for chemicals with some detections; results based on half the detection limit for chemicals with no detections can be found in Appendix E.

Table 38. Results Indicate That Fish Consumption Cancer Risks Are All Less Than 1 in 10,000.

Chemical	Receptor	Ingestion Risk	
		50th Percentile Concentration	95th Percentile Concentration
Arsenic (inorganic)	Child (6 to <11 years)	9E-08	5E-7
Arsenic (inorganic)	Adult (21 to <70 years)	1E-06	5E-6
Chromium (VI)	Child (6 to <11 years)	2E-07	2E-07
Chromium (VI)	Adult (21 to <70 years)	2E-06	3E-06

Cancer Risks) based on the 50th and 95th percentile concentrations for adults and the child age group with the highest exposures based on median exposure factors for fish consumption

Note: Values in *italics* and pale-yellow shading are based on a nondetect concentration set to half the detection limit. Results are shown only for chemicals with some detections; results based on half the detection limit for chemicals with no detections can be found in Appendix E.

5.3 Lead Exposures

For lead, a screening criteria concentration (i.e., action level in water [U.S. EPA, 2008]) was used to approximate human health risk (for incidental ingestion of water while swimming) because a human health benchmark is not currently available. In addition, lead exposures were assessed with the IEUBK Model Version 2 (U.S. EPA, 2021). The action level for lead in drinking water is 0.015 mg/L, or 15 µg/L. This was developed on the assumption of daily consumption of drinking water and is therefore likely overprotective for intermittent, incidental ingestion of small amounts of water while swimming. Overprotectiveness aside, the 50th and 95th percentile water concentrations for lead at Las Mareas Bay are 1.2 and 3.2 µg/L (see **Table 13**), both well below the action level.

For fish consumption, EPA's IEUBK Model was used to evaluate lead exposures to children. The IEUBK Model considers four sources of lead: air, drinking water, soil and dust, and diet. The defaults are based on national distributions of these exposures. However, certain diet categories can be revised to reflect the consumption of locally caught fish, game, or homegrown fruits or vegetables. Other diet categories (e.g., dairy) cannot readily be altered. For the purposes of this assessment, we ran the IEUBK for all default assumptions, then a scenario in which 100% of the child's meat consumption is locally caught fish filet. The difference between these is

indicative of the incremental increase in blood lead due to the fish consumption. The median and 95th percentile fish filet concentrations for lead (shown in **Table 15**) were evaluated.

The IEUBK outputs a geometric mean blood lead level for children aged 6–12 months and aged 1–7 years in 1-year age ranges. Additional percentiles of the blood lead distribution can be estimated using the EPA-recommended geometric standard deviation of 1.6 (U.S. EPA, 2021, p. 42; White et al., 1998) and the assumption of a log-normal distribution.

Table 38 presents the results of IEUBK modeling for fish consumption. Values that exceed the CDC BLRV of 3.5 µg/dL are shown in bold. As noted in **Section 5.1**, this is a population-based measurement that reflects the 97.5 percentile of blood lead distribution in U.S. children aged 1–5 years. It is not a health-based standard or a toxicity threshold. Further, in interpreting these results, it is useful to consider whether the addition of locally caught fish moves a child from a blood lead level below the reference value to above. For the mean blood lead levels, only the 1 to <2 years age group has an estimated blood lead level over 3.5 µg/dL when locally caught fish are assumed to make up all meat consumption (50th and 95th percentile concentrations).[7] However, as noted in **Section 2.3.2**, there was no statistically significant difference between the fish concentrations of lead from Las Mareas Bay and those from the background location.

[7] IEUBK has a built-in default diet; this is more general than the fish consumption rates for fish specified in Table 25. For the purposes of this assessment, all meat consumption in IEUBK's default diet is assumed to come from locally caught fish. This is likely an overestimate.

Table 39. IEUBK Mean Blood Lead Levels for Fish Consumption at 50th and 90th Percentile Concentrations

Age (years)	Lead Intake from Various Sources (µg/day)									Geometric Mean Blood Lead Level (µg/dL)		
	Nondietary (Defaults)			Dietary*			Total†					
	Air	Water	Soil & Dust	Default Diet	Local Filet (50th Percentile Concentration)	Local Filet (90th Percentile Concentration)	Default Diet	Local Filet (50th Percentile Concentration)	Local Filet (90th Percentile Concentration)	Default Diet	Local Filet (50th Percentile Concentration)	Local Filet (90th Percentile Concentration)
Child (1 to <2 years)	0.057	0.179	4.496	2.363	4.275	4.738	7.172	9.007	9.452	3.0	**3.7**	**3.9**
Child (2 to <3 years)	0.075	0.216	3.257	2.491	4.909	5.494	6.102	8.458	9.027	2.4	3.2	3.4
Child (3 to <4 years)	0.093	0.23	3.087	2.59	5.272	5.921	6.056	8.682	9.317	2.1	3.0	3.2
Child (4 to <5 years)	0.102	0.244	3.295	2.724	5.748	6.48	6.424	9.39	10.108	2.1	3.0	3.2
Child (5 to <6 years)	0.111	0.259	2.578	2.936	5.995	6.738	5.926	8.943	9.675	1.9	2.8	3
Child (6 to <7 years)	0.118	0.272	2.734	2.897	6.013	6.77	6.064	9.138	9.885	1.7	2.6	2.8

* The default diet is the Integrated Exposure Uptake Biokinetic Model default. Local filet (50th percentile) and local filet (90th percentile) reflect the default diet for everything but meat and 100% of meat from local fish filet at the 50th (or 90th) percentile concentration from the sampling data.

† Total includes air, water, soil and dust, and one of the three diet scenarios (default, 50th, 90th percentile.

6 Uncertainty

EPA typically classifies the major areas of uncertainty in risk assessments as scenario uncertainty, model uncertainty, and parameter uncertainty:

- Scenario uncertainty refers to missing or incomplete information needed to define exposure and dose fully.
- Model uncertainty relates to uncertainty about how well the model or algorithm simulates reality.
- Parameter uncertainty is a lack of knowledge regarding the true value of a parameter used in the assessment.

In general, this risk assessment was designed to provide a range of risks by applying 50th and 95th percentile pollutant concentrations in the face of uncertainty.

6.1 Scenario Uncertainty

Sources of scenario uncertainty include the assumptions that are made to represent an exposure scenario. The assessment is based on a single conceptual site model that characterizes exposures and risk based on EPA-approved methods, as well as additional EPA-approved data sources and parameters. The lack of location-specific information to define and assess actual exposure conditions introduces uncertainty into this assessment including potential overestimates of cancer risk and non-cancer hazards.

The hypothetical recreational and fish consumption scenarios are a source of uncertainty in this assessment: The exposure modeling relies heavily on default assumptions and parameters concerning population activity patterns, mobility, dietary habits, body weights, and other factors. Although some of these, such as body weight or skin surface area by age group, are likely similar in the vicinity of Las Mareas Bay, others are plausibly more site specific; therefore, the absence of site-specific exposure factors is a source of uncertainty.

Fish Consumption: The fish consumption rates, although based on consumption of Atlantic marine fish, are not specific to Puerto Rico, which may have higher fish consumption rates because it is an island. This uncertainty would tend to underestimate risk, and the underestimate could be as much as a factor of 10 if residents eat fish nearly every day.

Furthermore, the fish consumption pathway is based on consumption of fish filet. However, other preparations, such as fish head stew, have not been modeled. Adequate models are not available to estimate the amount of chemical that cooks out of a fish head and into the edible portion of a stew. Nor did the fish sampling evaluate fish head concentrations specifically, and these may be different from whole fish or filet concentrations. The magnitude of this uncertainty is unknown, but it seems likely that eating fish filet directly is protective of the fish head stew scenario, in which probably not all of the chemical leaches out of the fish head. The differences between filet and whole fish concentrations in the samples collected for this study were not typically large, so it seems reasonable to assume that fish head concentrations are also not significantly different.

Exposure Frequency for Recreational Exposures: Not only are the data for exposure frequency not specific to Puerto Rico (which, being an island, may have higher frequencies of visiting the beach than other locations), but they are also not specific to a beach environment. The only data available in the EFH for frequency of swimming are explicitly based on swimming in a pool, not at the shore. No data are available on frequency of playing on sand or in sediments, and the values for swimming (in pools) were used. This uncertainty may underestimate the frequency of swimming and other recreational exposures at Las Mareas Bay.

Time of Exposure for Recreational Exposures: The only data the EFH provides for time of exposure are for swimming in pools and time spent playing in sand/gravel (which is not specific to a beach scenario and likely includes playgrounds and sandboxes). The values used range from about half an hour to an hour per day, so it seems unlikely the underestimate could be more than a factor of 10.

Body Parts Exposed: For swimming, the assumption that the entire body is exposed is reasonable and protective of scenarios in which less of the body might be exposed. For sand, the assumption that the torso, upper arms, and upper legs would be covered (i.e., not exposed) is consistent with a child wearing a short-sleeved sun-shirt and shorts. For sediment, the face was also excluded. These are realistic assumptions that should not over- or underestimate risk.

Most of these might be expected to underestimate risk, but most of the risk results are very, very low. Even an order of magnitude underestimate would not change the conclusion that risks and hazards are, in most cases, well below the risk criteria established. Despite the uncertainty, the assumptions (hence, the assessment) are reasonable and protective.

6.2 Model Uncertainty

The risk calculation essentially compares the predicted media concentration with a human health benchmark, represented as a point estimate. Although the health benchmarks are derived with some consideration of intraspecies variability in toxicological sensitivity, the risk calculation does not explicitly simulate these differences. Given the differences in child sensitivity to chemicals and the research on latency of effects, the lack of child-specific treatment of health effects is recognized as a limitation of the risk model. EPA routinely accounts for uncertainty in its development of toxicity values such as RfDs and other human health benchmarks. For example, if certain toxicological data are missing from the overall toxicological database (e.g., reproductive data), EPA may account for this by applying an uncertainty factor in the development of the toxicity values. These uncertainty factors are designed to be protective, so they would be more likely to overestimate risk than underestimate it. **Table 28** provides the overall uncertainty that was applied in the derivation of the RfD; the larger this factor, the more uncertain the result and the greater the likelihood that the risk is overestimated.

The only chemicals with results within an order of magnitude of the risk criteria are arsenic (sand exceeds criteria; sediment does not but values are 0.4–0.9) and thallium (fish exceeds criteria). The RfD for thallium is highly uncertain because it includes an uncertainty factor of 3,000. Arsenic, on the other hand, has a relatively low uncertainty factor of 3.

Another uncertainty in the toxicity model is the use of oral toxicity values for dermal exposures. Although the model uses adjustment factors to account for the difference in absorption between gut and skin, where available, this remains an uncertainty of indeterminate direction (could under- or overestimate risk). However, because dermal toxicity values are not available, it is the best approximation available.

Finally, there are no health-based toxicity values for lead. The only available criterion for evaluating lead is a reference blood lead level, which is a value that reflects the top 2.5% of national blood lead levels. This does not mean that levels below that are “safe,” just that they are not among the highest 2.5% in the population. This value is intended to prioritize situations in which blood lead levels are among the highest observed.

6.3 Parameter Uncertainty

Parameter uncertainty encompasses the sampling data and some of the exposure factors.

Sampling data for water, sand, and sediment: The sampling data for water, sand, and sediment are based on 10–15 samples in various locations and typically span a range of less than an order of magnitude from lowest to highest value. The pattern and rate of detections do not differ much between Las Mareas Bay and the background location. Only half the inorganics had higher concentrations in Las Mareas Bay compared with background (arsenic, chromium, cobalt, and lead in more than one medium, and lithium, molybdenum, silver, and thallium in a single medium). Values for arsenic in sand (the one chemical with an exceedance for recreational exposures) were higher than in the background location at a 95% confidence level. Thus, although there is always some uncertainty in sampling data, the data for water, sand, and sediment seem consistent, and the uncertainty is not likely to be greatly reduced by more sampling.

Sampling data for fish: The sampling data for fish are based on a relatively small number of composited samples (five or six). Each data point represents a single fish species and, depending on the species, could reflect a single fish or a composite of up to 17 fish. Many of the inorganics detected in fish were not detected at higher concentrations in Las Mareas Bay as compared with background at the 95% confidence limit. Further, the results for thallium, which do exceed that risk criterion for fish consumption, were detected in only one of five fish filet samples (so a detection rate of 20%), so the 95th percentile concentration (and thus risk) represents a single detection.

In addition to the general uncertainties around the fish data, a potential upper-tail outlier of inorganic arsenic concentrations was identified for a single whole-fish sample (a composite of three scaled sardines from Las Mareas Bay). The inorganic arsenic concentration for this sample was 56 µg/kg. Filet samples were not analyzed for this fish sample due to small size and weight of sardines. Therefore, it is unclear why the whole-fish arsenic concentration is elevated for this single composite sample from Las Mareas, and that is a source of uncertainty. However, the risks from fish for arsenic are low (HQ ≤ 0.005, risk ≤ 5E-6), so this uncertainty is not likely significant.

Dermal absorption factors for solids: Absorption factors for inorganics in solids are scarce and highly uncertain. Consequently, the dermal pathway for sand and sediment could be evaluated for only arsenic and cadmium. Given that all cadmium samples were nondetects in sand and sediment, this means that effectively, only arsenic could be evaluated for the dermal route. Those results for arsenic are about 100 times higher than the incidental ingestion route, which was evaluated for all the inorganics. Further, the dermal arsenic in sand results are one of the two exceedances seen in the entire assessment. Although the sediment results for arsenic were below the risk criterion, they are only just below (values of 0.4 to 0.9 at the 95th percentile concentration). Arsenic has a relatively high absorption factor (0.03) relative to cadmium (0.001), which is still a concerning data gap for the remaining chemicals for dermal exposures to sand and sediment.

Solids adherence factor: This factor accounts for how well solids adhere to the skin. The EFH has a value for sediment, but not for wet sand; however, the RAGS has a value for wet sand which was used. The EFH factor for playing in sediment are specific to various body parts, including arms, hands, legs, and feet. The RAGS factor only presents a weighted average. The RAGS value for wet sand is considered reasonable and likely overestimates risk, but is somewhat uncertain.

Incidental sand ingestion rate: The EFH has incidental ingestion rates for only sediment (at the recreational shore). The same value was used for sand, which seems reasonable but is somewhat uncertain.

Other exposure factors: the exposure factors (e.g., body weight, skin surface area, amounts consumed, duration of exposure) are based on median values to reflect the average exposed person. However, these factors can vary considerably from person to person, and to the extent that the values for a particular individual are far from the median, this could result in either and over- or underestimate of that person's risk.

7 Conclusions

This risk assessment is based on sampling data in water, sand, sediment, and fish collected from Las Mareas Bay and background locations specifically identified for this project (see **Section 2**). These samples were analyzed for a variety of metals, polycyclic aromatic hydrocarbons (PAHs), and sulfolane. The organic analytes were nondetects in nearly all samples, so only metals were evaluated for risk.

Several studies and sampling efforts have been conducted in the general vicinity of Las Mareas Bay over the last two decades (Aldarondo-Torres et al., 2010; Mansilla-Rivera et al., 2011; Whitall et al., 2011; Apeti et al., 2012; Sastre et al., 2015; Salgado-Ramírez et al., 2017; DRNA, 2017; and Rodríguez-Sierra et al., 2019). These studies focused on the area designated as Bahía de Jobos which is part of the Reserva Natural de Investigación Estuarina de Bahía de Jobos (or Jobos Bay National Estuarine Research Reserve[8] [JBNERR]). Jobos Bay is located approximately 3 miles west of Las Mareas Bay. The concentration data from the Jobos Bay studies are consistent with the sampling data from Las Mareas Bay where media and concentrations overlap. The Las Mareas Bay sampling data cover more media (e.g., water, sand) and more metals and chemicals than any of the published Jobos Bay data. Given the purpose of this project and community concerns specific to Las Mareas Bay and chemicals related to coal combustion residuals, the report authors believe using the sampling data collected from Las Mareas Bay for the HHRA is reasonable. The Jobos Bay data, while not used in the Las Mareas Bay HHRA, confirm the findings from Las Mareas Bay are as might be expected.

Human exposures at Las Mareas Bay were evaluated for fish consumption and for dermal exposure and incidental ingestion of water, sand, or sediment via three recreational pathways (swimming, playing in sand, and wading in sediment). Exposures at the 50th and 95th percentile sampling concentrations were estimated for adults (fish and swimming) and children in seven age groups (all pathways) using standard (not site-specific) exposure factors (see **Section 3**).

Exposure concentrations at the 50th and 95th percentiles were compared to toxicity values for cancer and noncancer to estimate risk and noncancer hazard. For lead, in the absence of an accepted toxicity value, blood lead levels were estimated using the IEUBK Model and the results compared to the CDC BLRV (see **Section 4**).

Only one exceedance was seen in the risk results - thallium in fish. In addition, blood lead levels in children 1 to <2 years from consuming locally caught fish may slightly exceed the BLRV. No other exceedances of noncancer or cancer risk criteria were calculated.

The results for thallium in fish are highly uncertain. The thallium RfD has large uncertainty factor (3,000) and is based on a single detection. Furthermore, the single detected concentration from Las Mareas Bay is not higher than the single detected concentration from the background location. Finally, the fish consumption rate for children 1 to <2 years was based on the value for children 2 to <3 years, as no value was available for children 1 to <2 years. This is likely also an overestimate. Given these uncertainties (which likely overestimate the risk) and that the HQ exceedance is very small (1.2), it seems unlikely that this exceedance reflects a significant concern.

[8] See the Jobos Bay National Estuarine Research Reserve website for more information: https://coast.noaa.gov/nerrs/reserves/jobos-bay.html.

8 References

Aldarondo-Torres J.X., Samara, F., Mansilla-Rivera I., Aga D.S., Rodríguez-Sierra C.J. (2010). *Trace metals, PAHs, and PCBs in sediments from the Jobos Bay area in Puerto Rico*. Mar Pollut Bull. 60(8):1350-8. doi: *10.1016/j.marpolbul.2010.06.006*

Allen, G. R. (1985). *FAO species catalogue: Vol. 6. Snappers of the world. An annotated and illustrated catalogue of lutjanid species known to date*. Food and Agriculture Organization of the United Nations. https://www.fao.org/4/ac481e/ac481e00.htm

Apeti, D.A., Whitall, D.R., Pait, A.S., Dieppa, A., Zitello, A.G., and Lauenstein, G.G. (2012). *Characterization of land-based sources of pollution in Jobos Bay, Puerto Rico: status of heavy metal concentration in bed sediment*. Env. Mon. and Ass., 184: 811–830. doi: *10.1007/s10661-011-2003-0*

ATSDR (Agency for Toxic Substances and Disease Registry). (2013). *An evaluation of environmental, biological, and health data from the Island of Vieques, Puerto Rico*. Division of Community Health Investigations. https://www.atsdr.cdc.gov/hac/pha/vieques/Vieques_Summary_Final_Report_English_2013.pdf

ATSDR (Agency for Toxic Substances and Disease Registry). (2024, February). *Minimal risk levels (MRLs) for hazardous substances*. https://www.atsdr.cdc.gov/mrls/index.html

CDC (Centers for Disease Control and Prevention). (2024). *CDC updates blood lead reference value*. https://www.cdc.gov/lead-prevention/php/news-features/updates-blood-lead-reference-value.html

Collette, B. B., & Nauen, C. E. (1983). *FAO species catalogue: Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date*. Food and Agriculture Organization of the United Nations. https://www.fishbase.se/references/FBRefSummary.php?ID=168

Departamento de Recursos Naturales y Ambientales (DRNA). (2017). Jobos Bay National Estuarine Research Reserve Management Plan 2017-2022. 193 pp. Available at: *https://www.drna.pr.gov/jbnerr/pm-jbnerr/jobos-bay-national-estuarine-research-reserve-management-plan-2017-2022/*

Froese, R., & Pauly, D. (2024). *FishBase*. www.fishbase.org

Garrabrants, A. C., Kosson, D. S., DeLapp, R., & van der Sloot, H. A. (2014). Effect of coal combustion fly ash use in concrete on the mass transport release of constituents of potential concern. *Chemosphere*, *103*, 131–139. https://doi.org/10.1016/j.chemosphere.2013.11.048

Mansilla-Rivera, I., & Rodríguez-Sierra, C. J. (2011). Metal levels in fish captured in Puerto Rico and estimation of risk from fish consumption. *Archives of Environmental Contamination and Toxicology*, *60*(1), 132–144. https://doi.org/10.1007/s00244-010-9538-x

Rodríguez-Sierra, C.J., Adelman, D., Vojta, Š. et al. (2019). *Passive Sampling of Persistent Organic Pollutants in Four Coastal Aquatic Systems of Puerto Rico: A Pilot Study*. Bull Environ Contam Toxicol **103**, 770–775. doi: *https://doi.org/10.1007/s00128-019-02731-w*

Salgado-Ramírez, C.A., Mansilla-Rivera, I., Rodríguez-Sierra, C.J. (2017). *Comparison of trace metals in different fish tissues of Scomberomorus spp. ("sierra") and Lutjanus synagris ("arrayado") from Jobos Bay and La Parguera coastal areas in Southern Puerto Rico*. Reg. Stud. Mar. Sci. 13, 1-11. doi: *https://doi.org/10.1016/j.rsma.2017.03.006*

Sastre, M.P., Collado, E., Mansilla-Rivera, I. and Rodríguez-Sierra, C.J. (2015). *DNA damage and heavy metal content in the mussel, Brachiodontes exustus (Linnaeus, 1758) (Mollusca: Mytilidae), from the Jobos Bay*

National Estuarine Research Reserve (JBERR), Salinas and Guayama, Puerto Rico. Life: The Excitement of Biology, 3 (1): 3–14. doi: *10.9784/LEB3(1)Sastre.01*

Smith-Vaniz, W. F., Quéro, J. C., & Desoutter, M. (1990). Carangidae. In J. C. Quero, J. C. Hureau, C. Karrer, A. Post, & L. Saldanha (Eds.), *Check-list of the fishes of the eastern tropical Atlantic (CLOFETA)* (pp. 729–755). JNICT, SEI, and UNESCO. https://www.fishbase.se/references/FBRefSummary.php?ID=7097

Tewalt, S. J., Finkelman, R. B., Torres, I. E., & Simoni, F. (2006). World coal inventory: Colombia. In A. W. Karlsen, S. J. Tewalt, L. J. Bragg, & R. B. Finkelman (Eds.), *World coal quality inventory: South America*. U.S. Geological Survey Open File Report 2006-1241. https://pubs.usgs.gov/of/2006/1241/Chapter%205-Colombia.pdf

U.S. EPA (Environmental Protection Agency). (1989). *Risk assessment guidance for Superfund. Volume I: Human health evaluation manual (Part A)* (Interim Final). EPA/540/1-89/002. Prepared by U.S. EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). (2001). *Methods for collection, storage, and manipulation of sediments for chemical and toxicological analyses: Technical manual, chapter 3: Collection of whole sediments*. EPA-823-B-01-002. Office of Water. https://www.epa.gov/sites/default/files/2015-09/documents/collectionmanual.pdf

U.S. EPA (U.S. Environmental Protection Agency). (2003). *OSWER Directive 9285.7-53 Human health toxicity values in Superfund risk assessments*. Office of Solid Waste and Emergency Response. https://www.regulations.gov/document/EPA-HQ-OLEM-2018-0524-0022

U.S. EPA (U.S. Environmental Protection Agency). (2004). *Risk assessment guidance for Superfund volume I: Human health evaluation manual (Part E, supplemental guidance for dermal risk assessment)*. Office of Superfund Remediation and Technology Innovation. https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part-e

U.S. EPA (U.S. Environmental Protection Agency). (2005b). *Guidance on selecting age groups for monitoring and assessing childhood exposures to environmental contaminants*. EPA/630/P-03/003F. https://www.epa.gov/sites/default/files/2013-09/documents/agegroups.pdf

U.S. EPA (U.S. Environmental Protection Agency). (2005c). *Guidelines for carcinogen risk assessment*. EPA/630/P-03/001F. Available at: https://www.epa.gov/risk/guidelines-carcinogen-risk-assessment

U.S. EPA (U.S. Environmental Protection Agency). (2008). *Lead and copper rule: A quick reference guide*. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=60001N8P.txt

U.S. EPA (U.S. Environmental Protection Agency). (2011). *Exposure factors handbook: 2011 edition*. EPA/600/R-090/052F. Office of Research and Development. https://www.epa.gov/expobox/about-exposure-factors-handbook

U.S. EPA (U.S. Environmental Protection Agency). (2014a). *Estimated fish consumption rates for the U.S. population and selected subpopulations (NHANES 2003-2010)*. Final Report. EPA-820-R-14-002.

U.S. EPA (U.S. Environmental Protection Agency). (2014b). *Human health evaluation manual, supplemental guidance: Update of standard default exposure factors*. OSWER Direction 9200.1-120, February 6.

U.S. EPA (U.S. Environmental Protection Agency). (2017a). *Statement of basis final remedy decision, Chevron Phillips Chemical Puerto Rico Core, L.L.C*. EPA ID Number: PRD991291972. https://www.epa.gov/sites/default/files/2018-04/documents/final_remedy_decision-cpcprc-sb-v.1.pdf.

U.S. EPA (U.S. Environmental Protection Agency). (2017b). *Update for Chapter 5 of the Exposure Factors Handbook: Soil and dust ingestion*. EPA/600/R-17/384F. Office of Research and Development.

U.S. EPA (U.S. Environmental Protection Agency). (2019). *Update for Chapter 3 of the Exposure Factors Handbook: Ingestion of water and other select liquids*. EPA/600/R-18/259F. Office of Research and Development.

U.S. EPA (U.S. Environmental Protection Agency). (2021). *User's guide for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) version 2.0*. https://semspub.epa.gov/work/HQ/400700.pdf

U.S. EPA (U.S. Environmental Protection Agency). (2023). *QAPP: EPA Journey to Justice (J2J): Evaluation of health risks associated with fishing and recreational activities in Laguna De Las Mareas Bay, Guayama, Puerto Rico*. QAPP ID: I-GLTED-0034299.

U.S. EPA (U.S. Environmental Protection Agency). (2024a). *Integrated Risk Information System (IRIS)*. National Center for Environmental Assessment, Office of Research and Development. http://www.epa.gov/iris/

U.S. EPA (U.S. Environmental Protection Agency). (2024b). *Superfund provisional peer-reviewed toxicity values*. https://hhpprtv.ornl.gov/

U.S. EPA (U.S. Environmental Protection Agency). (2024c). *Lead at Superfund sites: Software and users' manuals (IEUBK Model)*. https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals

U.S. EPA (U.S. Environmental Protection Agency). (2024d). *Updated residential soil lead guidance for CERCLA site and RCRA corrective action facilities, January 2024*. https://www.epa.gov/superfund/updated-soil-lead-guidance-cercla-sites-and-rcra-corrective-action-facilities

Whitall, D.R., B.M. Costa, L.J. Bauer, A. Dieppa, and S.D. Hile (eds.). (2011). *A Baseline Assessment of the Ecological Resources of Jobos Bay, Puerto Rico*. NOAA Technical Memorandum NOS NCCOS 133. Silver Spring, MD. 188 pp. *https://repository.library.noaa.gov/view/noaa/669*

White, P., Van Leeuwen, P., Davis, B., Maddaloni, M., Hogan, K., Marcus, A., & Elias, R. (1998). The conceptual structure of the Integrated Exposure Uptake Biokinetic Model for lead in children. *Environmental Health Perspectives*, *106*(Suppl. 6), 1513. https://doi.org/10.1289/ehp.98106s61513

Whitehead, P. J. P., Nelson, G. J., & Wongratana, T. (1988). *FAO species catalogue: Vol. 7. Clupeoid fishes of the world (suborder Clupeoidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings*. Food and Agriculture Organization of the United Nations. https://www.fishbase.se/references/FBRefSummary.php?ID=189

Quality Assurance Statement

This document followed the requirements outlined in the Quality Assurance Project Plan (QAPP) number, I-GLTED-0034299; U.S. EPA, 2023.

Appendix A. Analytical Results Tables

The compiled analytical results are included in Appendix_A_Analytical Results_Tables.pdf. These tables include key sampling characteristics (e.g., the site name where samples were collected from, the sample ID, date of sampling); analytical details (e.g., the method used, analytical results, qualifiers, detection limits by method); and the quantitation limit (i.e., the QL, or the lowest concentration that can be measured with acceptable accuracy and precision using the specified laboratory method), and the computed one-half of the QL, which was used in statistical analyses in place of non-detect values.

The analytical results are organized by the following tables:

- A1. Compiled Analytical Results for Water Samples Collected at Las Mareas Bay
- A2. Compiled Analytical Results for Sediment Samples Collected at Las Mareas Bay
- A3. Compiled Analytical Results for Sand Samples Collected at Las Mareas Bay
- A4. Compiled Analytical Results for Water Samples Collected at Playa Arenas
- A5. Compiled Analytical Results for Sediment Samples Collected at Playa Arenas
- A6. Compiled Analytical Results for Sand Samples Collected at Playa Arenas
- A7. Compiled Analytical Results for Sand Samples Collected at Tropical Beach, Naguabo
- A8. Compiled Analytical Results for the Fish Tissue Samples Collected at Las Mareas Bay and Playa Arenas

The abbreviations in each table are defined as follows:

Qualifiers:

- U = the analyte was analyzed but undetected
- J = the analyte was detected, but the reported concentration is an estimate

Site Names:

- LM = Las Mareas
- PA = Playa Arenas
- F = Fillet
- W = Whole Fish

Units:

- ug/kg = microgram per kilogram
- ug/L = microgram per liter

Appendix B. Laboratory Analytical Reports

The laboratory reports are included in Appendix_B_Laboratory_Analytical_Reports.pdf.

Five different analytical laboratories were contracted with to analyze the suite of chemicals and media collected for this project. Table B-1 summarizes which media and chemicals each laboratory was contracted for and the location in Appendix B where each laboratory's original report can be found.

As noted in Section 2.3 (Sampling Results) of the main report, all chemical analyses were done according to the appropriate method by an accredited laboratory. Samples were analyzed in accordance with the project QAPP (I-GLTED-0034299; EPA, 2023).

Table B-1. Summary of Media, Chemicals Analyzed, and Analytical Methods Used by the Laboratories

Laboratory	Media Analyzed	Chemicals Analyzed	Methods Used	Applicable Appendix B PDF Page Numbers
EPA Region 2 Laboratory	Sand, Sediment and Surface Water	Metals ICP TAL	EPA 200.7 SOP C-109 Rev 3.7	Appendix B, pages 3 to 158
		Metals ICPMS + Minerals & Iron TAL	EPA 200.8 SOP C-112 Rev 3.9	
		Mercury	EPA 245.1 SOP C-110 Rev 2.8	
		Organics, volatiles	EPA 625.1 SOP C-90 Rev 3.9	
		Sulfolane	EPA 625.1 SOP C-90 Rev 3.9	
		Organic Carbon	SM 5310B SOP C-88 Rev 2.10	
Alpha Analytical	Fish Tissue	Organics	EPA 3570	Appendix B, 160 to 195
		Metals	EPA 6020B	Appendix B, 197 to 234
		Inorganics & Miscellaneous (moisture and lipids)	EPA 2540G	Appendix B, 236 to 284
Pace Analytical – Green Bay	Fish Tissue	Lithium	EPA 6020B	Appendix B, 286 to 298
		Radium-226, Radium-228	EPA 901.1	Appendix B, 307 to 325
Brooks Applied Labs	Fish Tissue	Inorganic Arsenic	SOP BAL-4101	Appendix B, 329 to 345
		Methylmercury	EPA 1630 Modified	
Eurofins Pensacola	Fish Tissue	Sulfolane	SW846 8270E	Appendix B, 346 to 395

Appendix C. Detailed Sampling Results

C.1 Sand, Sediment, and Water

Table C-1 provides full concentration results including values based on half the reported detection limit (RDL) for chemicals with no detections at any sampling location for a particular medium.

Figures C-1 through **C-16** present box plots comparing results at Las Mareas Bay sampling locations with those at background sampling locations, by chemical. For some chemicals, two plots are presented, one with detections only and one with nondetects included at half the reporting limit.

- Figure C-1. Arsenic
- Figure C-2. Boron
- Figure C-3. Chromium (detections only)
- Figure C-4. Chromium (nondetects included at half reporting limit)
- Figure C-5. Cobalt (detections only)
- Figure C-6. Cobalt (nondetects included at half reporting limit)
- Figure C-7. Lead (detections only)
- Figure C-8. Lead (nondetects included at half reporting limit)
- Figure C-9. Lithium (detections only)
- Figure C-10. Lithium (nondetects included at half reporting limit)
- Figure C-11. Molybdenum (detections only)
- Figure C-12. Molybdenum (nondetects included at half reporting limit)
- Figure C-13. Silver (detections only)
- Figure C-14. Silver (nondetects included at half reporting limit)
- Figure C-15. Thallium (detections only)
- Figure C-16. Thallium (nondetects included at half reporting limit)

Table C-1. Full Water, Sand, and Sediment Concentration Results

Chemical	Las Mareas Bay						Background					
	Water		Sand		Sediment		Water		Sand		Sediment	
	50th	95th	50th	95th	50th	95th	50th	95th	50th	95th	50th	95th
Inorganics (Water in µg/L, Sand and Sediment in mg/kg)												
Antimony	Not reported		0.95**	1.0**	1.2**	1.6**	Not reported		0.94**	1.4**	1.6**	2.1**
Arsenic	2.1	2.4	6.8	8.5	8.5	13	2.3	3.7	4.6	5.6	4.1	6.2
Barium	8.0	8.5	4.7**	5.2**	6.1**	8.2**	8.2	11	4.7**	7.2**	8.0**	10**
Beryllium	0.5**	0.5**	0.14**	0.16**	0.18**	0.25**	0.5**	0.5**	0.14**	0.22**	0.24**	0.31**
Boron	5100	5300	5.6	12	22	46	5100	5200	3.4	32	43	62
Cadmium	0.5**	0.50**	0.14**	0.16**	0.18**	0.25**	0.5**	0.5**	0.14**	0.22**	0.24**	0.31**
Chromium	2.8	51	5.3	9.9	8.2	14	1.3	2.9	5.4	9.9	4.7	9.7
Cobalt	0.5**	0.5**	4.9	9.5	6.0	10	0.5**	0.5**	2.8	3.5	1.6**	2.1**
Lead	1.2	3.2	2.0	3.2	3.3	7.7	0.5*	1.3	1.3	2.7	1.6	4.8
Lithium	340	360	1.9**	2.1**	9.7	23	361	369	1.9**	2.9**	7.6	14
Mercury	0.1*	0.41	0.02**	0.023**	0.028**	0.04**	0.16	0.68	0.023**	0.033**	0.039**	0.055**
Molybdenum	11	12	0.52*	1.1	0.61*	2.1	12	13	0.47**	0.72**	2.1	4.6
Selenium	2.0**	2.0**	0.95**	1.0**	1.2**	1.6**	2.0**	2.0**	0.94**	1.4**	1.6**	2.1**
Silver	0.5**	0.5**	1.0	1.9	0.92	1.9	0.5**	0.5**	0.25*	0.60	0.4*	1.9
Thallium	0.5*	1.5	0.95**	1.0**	1.2**	1.6**	0.5*	0.95	0.94**	1.4**	1.6**	2.1**
Organics (Water in µg/L, Sand and Sediment in µg/kg)												
PAHs†	2.5**	2.6**	33**	35**	46**	70**	2.5**	2.6**	34**	43**	71**	80**
Sulfolane	4.1**	4.4**	17**	17**	25**	36**	4.1**	4.4**	17**	25**	36**	42**

* At least some samples were detections. Value is half the RDL. Individual values were replaced with half the RDL for the sample before computing the percentile statistics. A constituent with more than 50% nondetects may have a value half the RDL for 50th percentile, but a measured value for the 95th percentile.

** All samples were nondetects. Value is half the RDL. Individual values were replaced with half the RDL for the sample before computing the percentile statistics. 50th and 95th percentiles may differ slightly due to variation in the RDLs for different samples.

† PAHs include acenaphthene; acenaphthylene; anthracene; benzo(a)anthracene; benzo(a)pyrene; benzo(g,h,i)perylene; benzo(k)fluoranthene; biphenyl, 1,1'-; chrysene; dibenzo(a,h)anthracene; fluoranthene; fluorene; indeno(1,2,3-cd)pyrene; methylnaphthalene, 2-; naphthalene; phenanthrene; and pyrene.

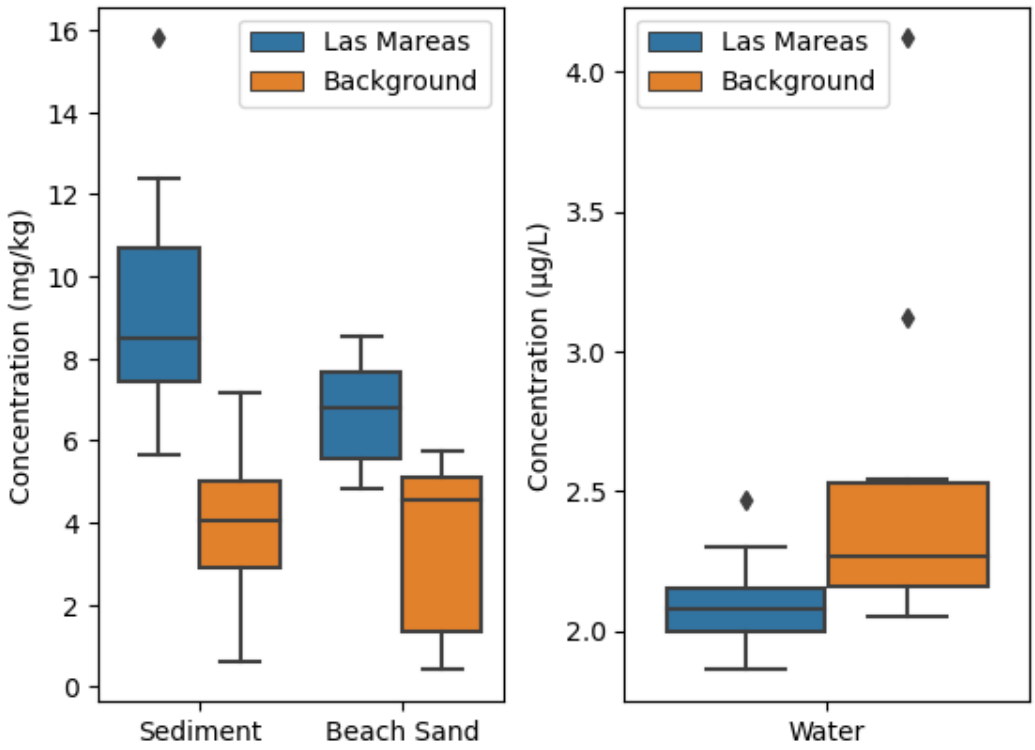

Figure C-1. Arsenic concentrations in sediment, sand, and water.

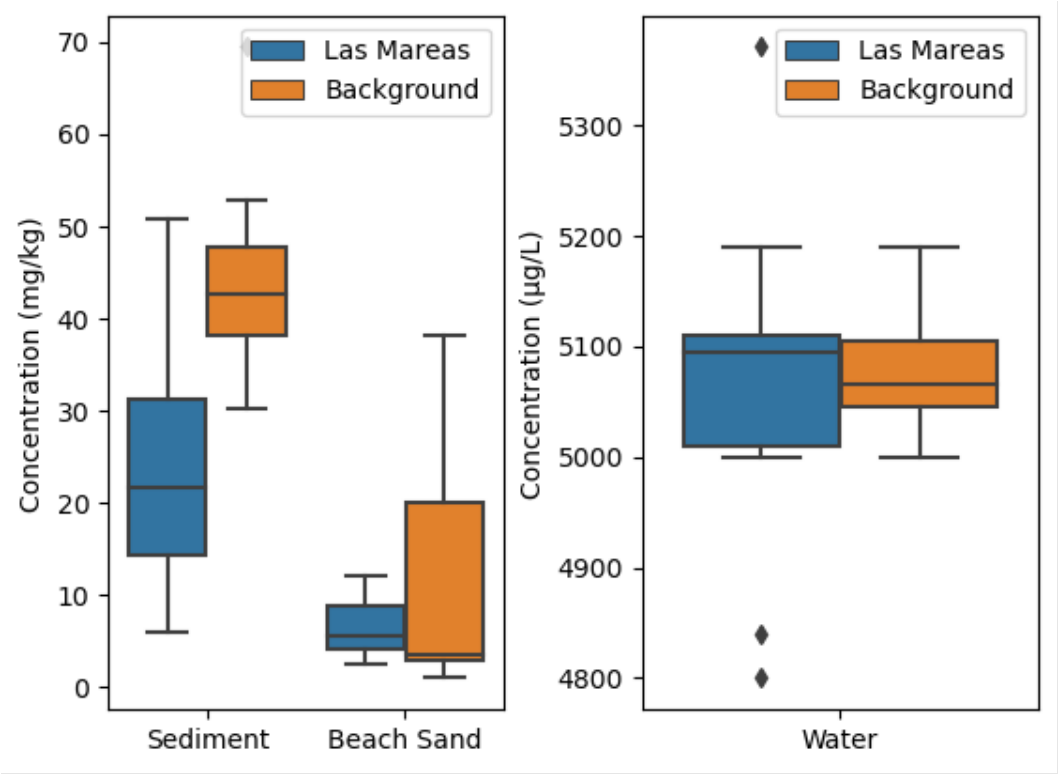

Figure C-2. Boron concentrations in sediment, sand, and water.

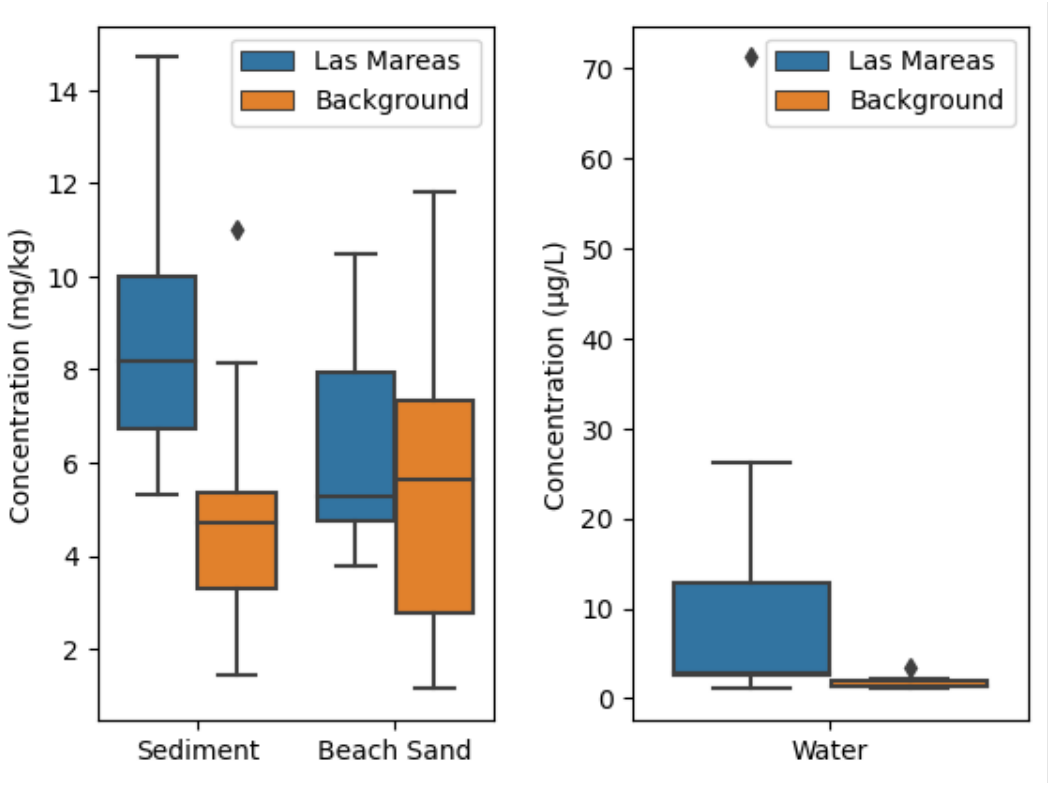

Figure C-3. Chromium concentrations in sediment, sand, and water (detections only).

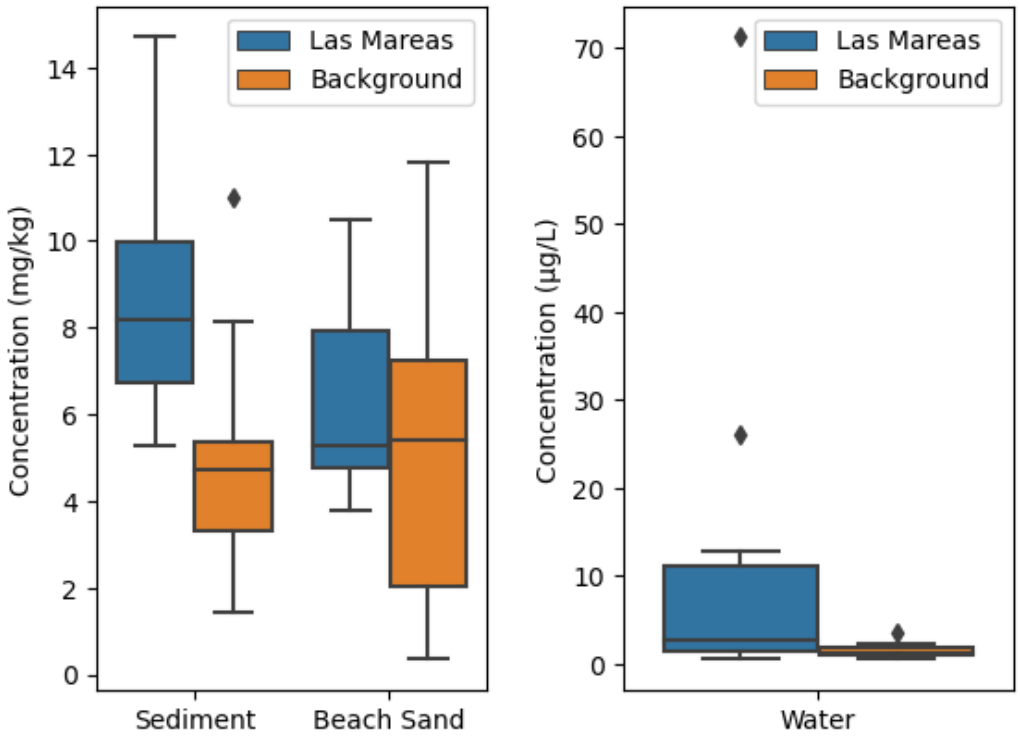

Figure C-4. Chromium concentrations in sediment, sand, and water (nondetects included at half reporting limit).

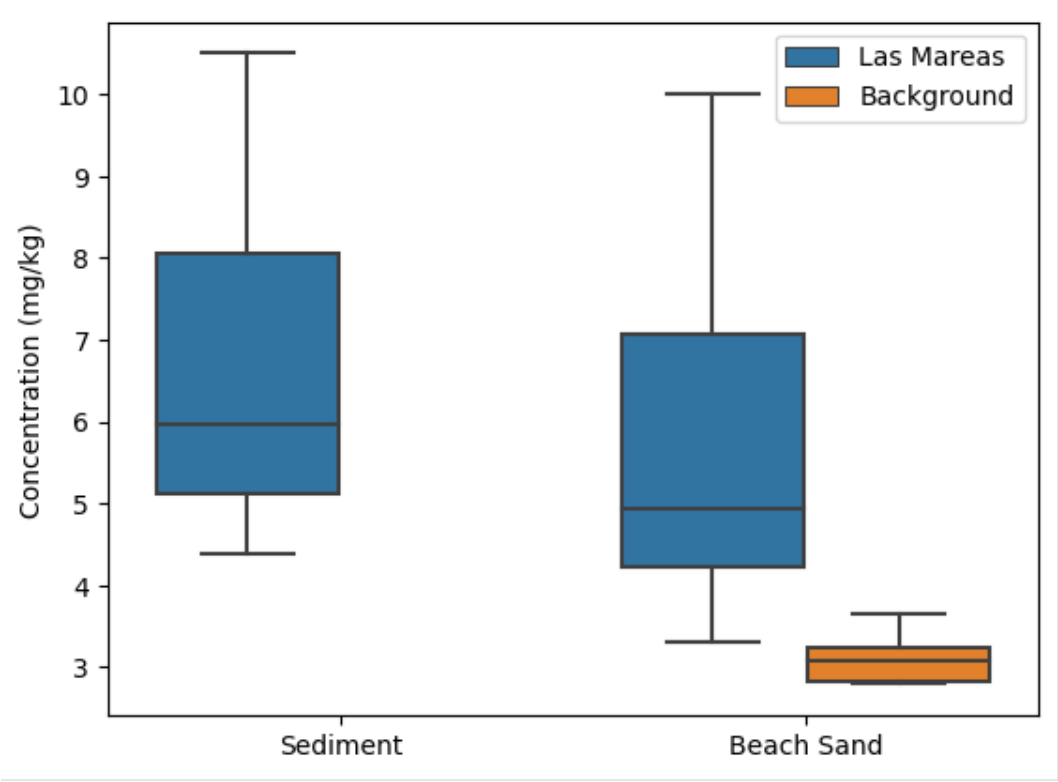

Figure C-5. Cobalt concentrations in sediment and sand, (detections only).

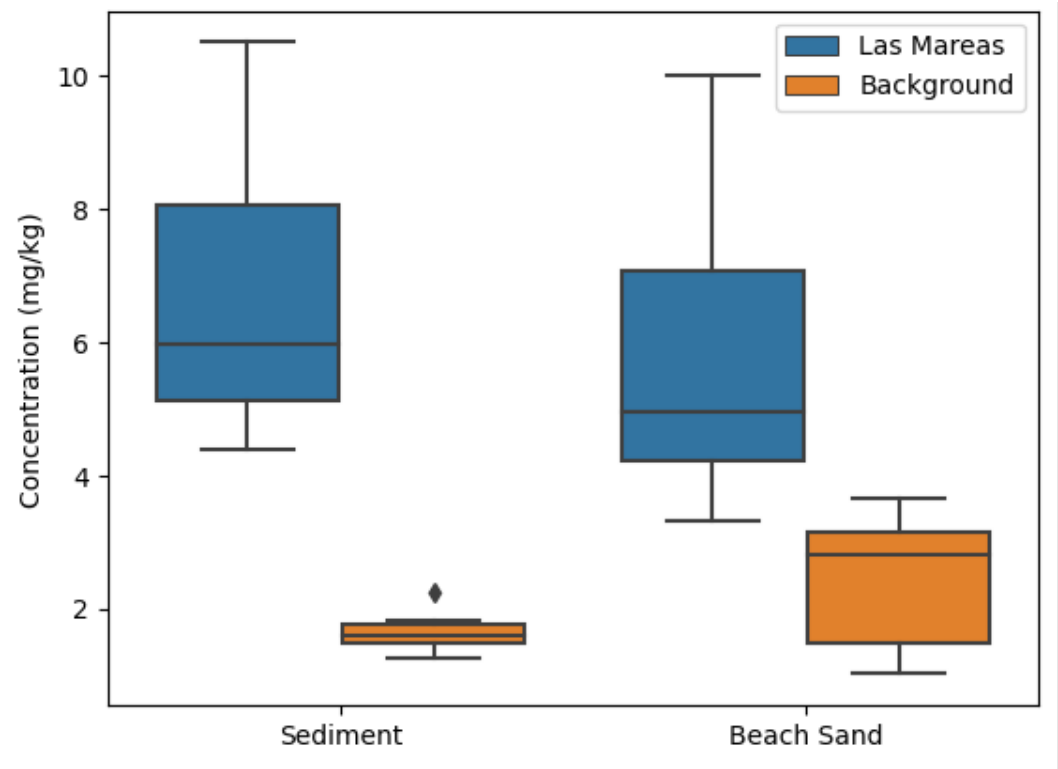

Figure C-6. Cobalt concentrations in sediment and sand (nondetects included at half reporting limit).

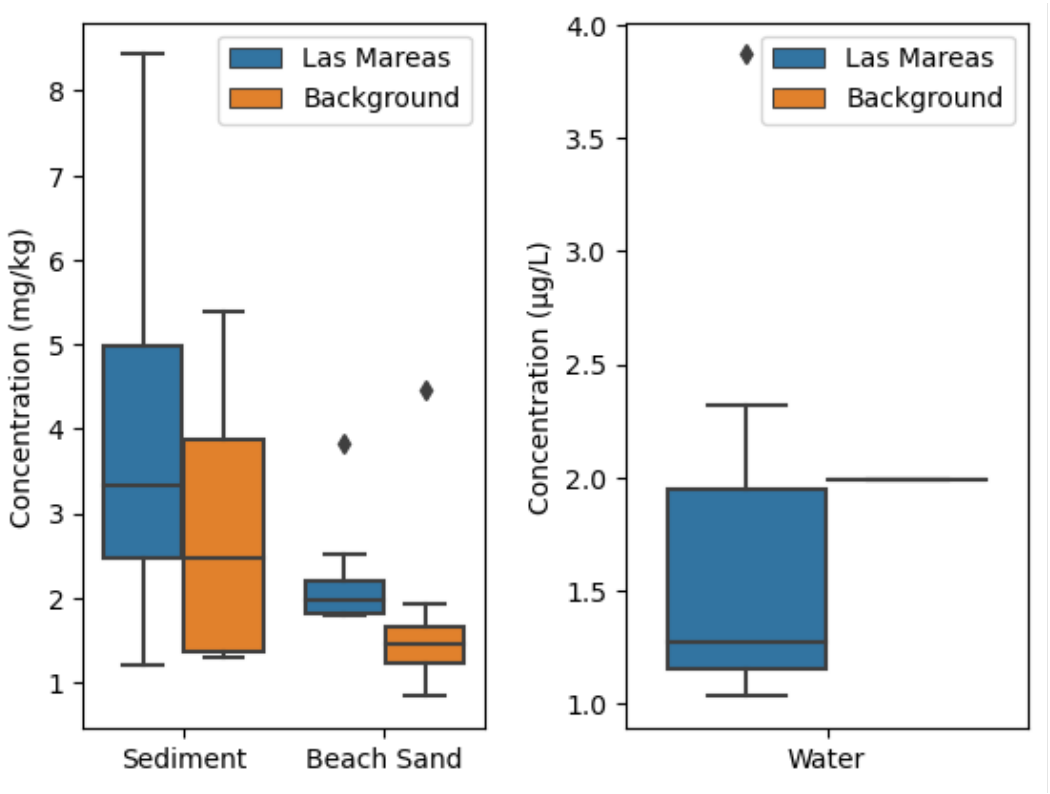

Figure C-7. Lead concentrations in sediment, sand, and water (detections only).

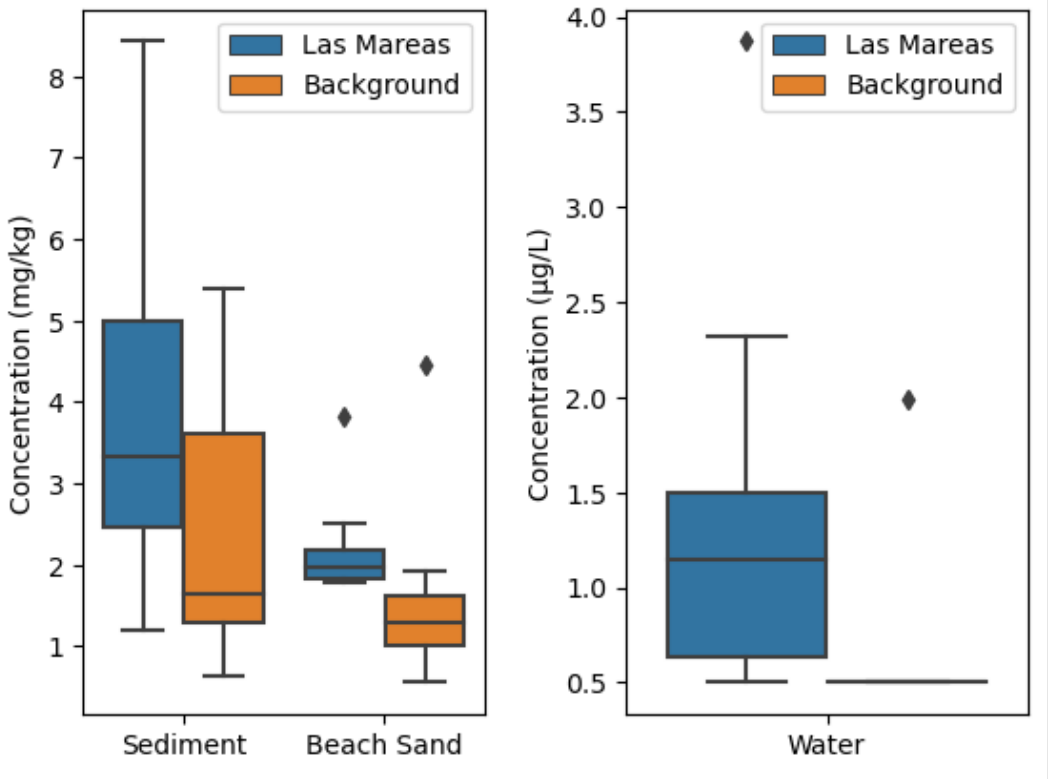

Figure C-8. Lead concentrations in sediment, sand, and water (nondetects included at half reporting limit).

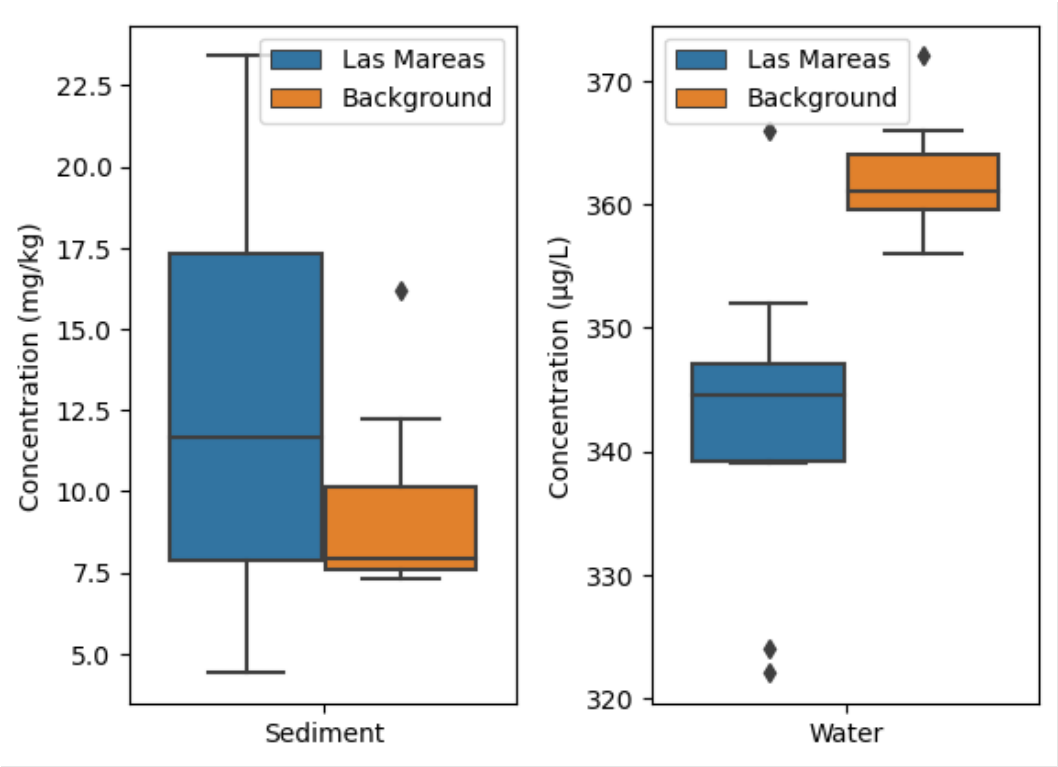

Figure C-9. Lithium concentrations in sediment and water (detections only).

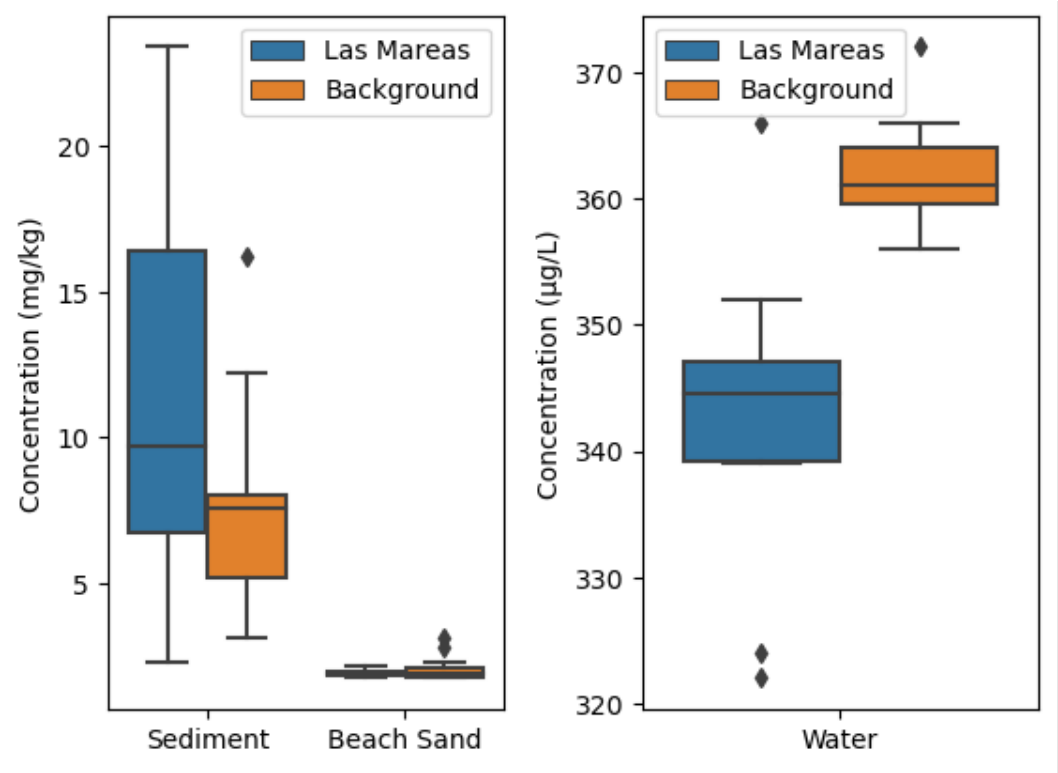

Figure C-10. Lithium concentrations in sediment, sand, and water (nondetects included at half reporting limit).

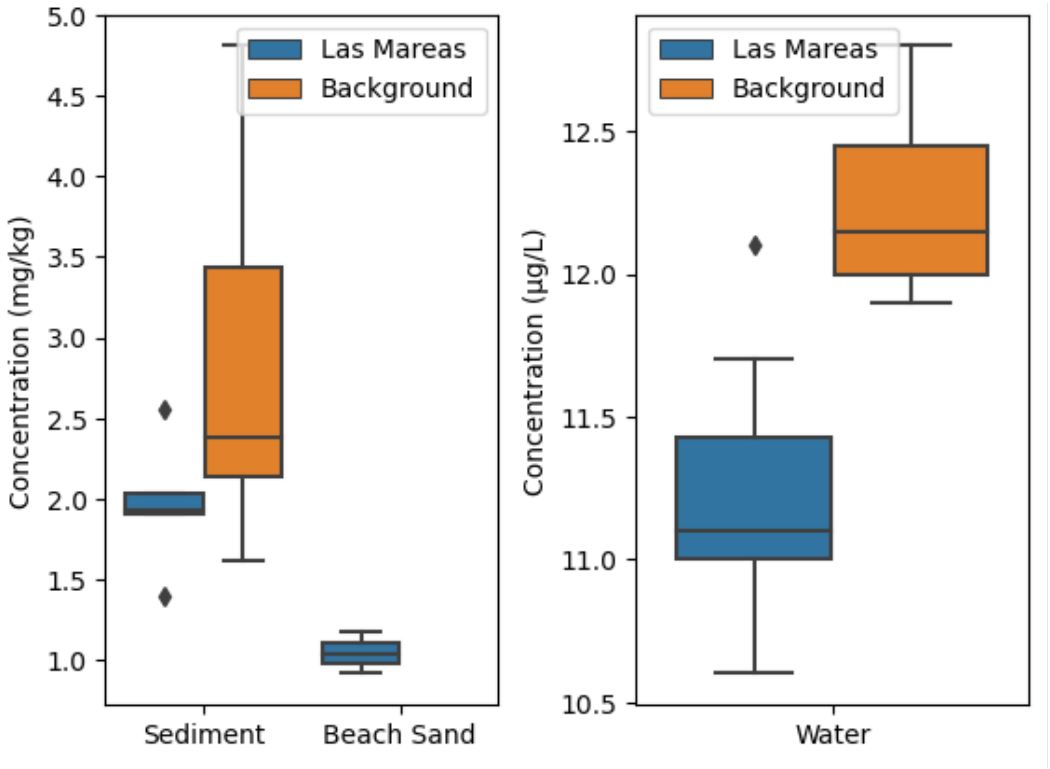

Figure C-11. Molybdenum concentrations in sediment, sand, and water (detections only).

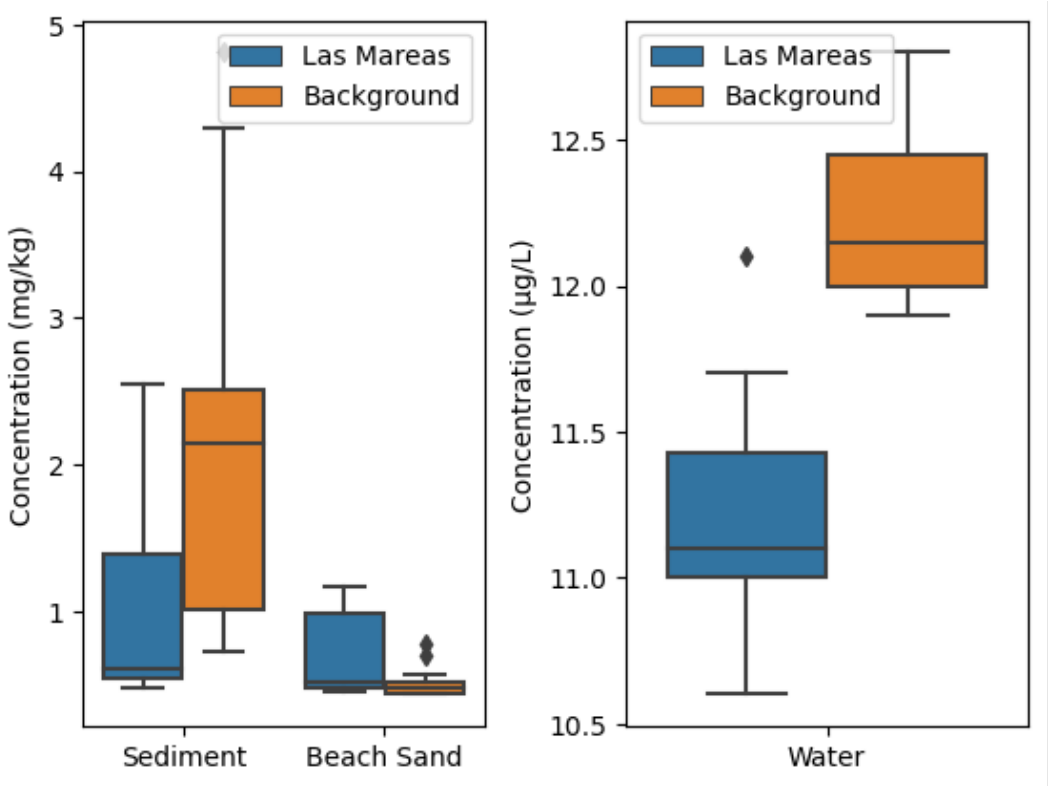

Figure C-12. Molybdenum concentrations in sediment, sand, and water (nondetects included at half reporting limit).

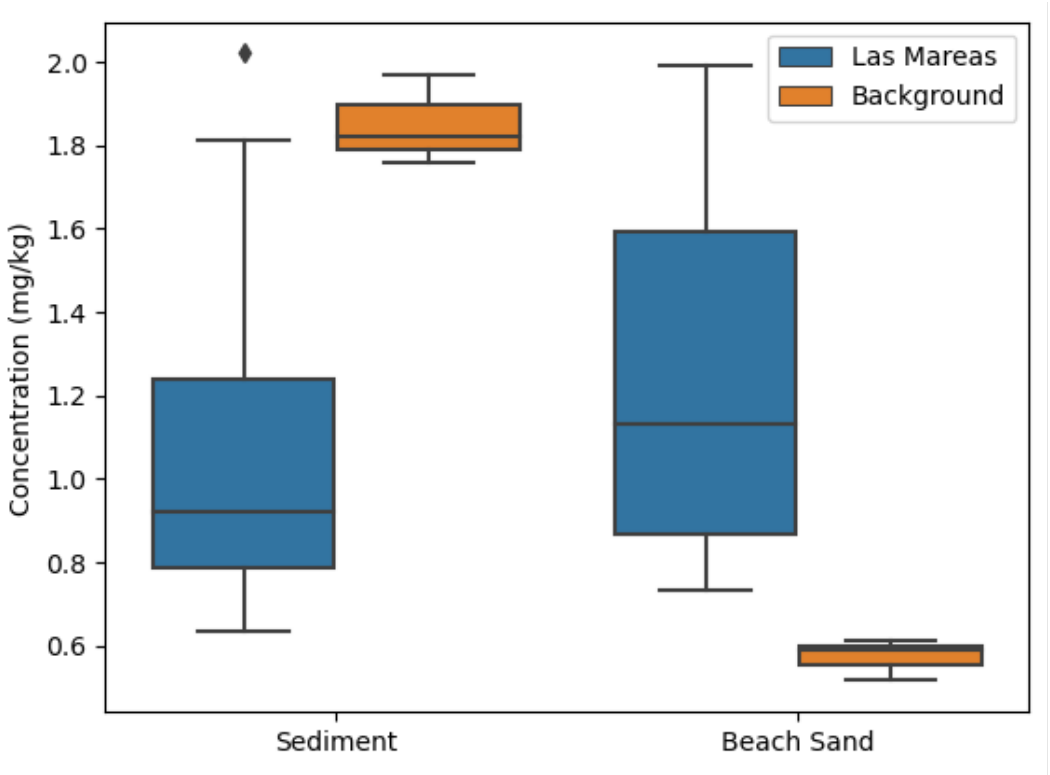

Figure C-13. Silver concentrations in sediment and sand (detections only).

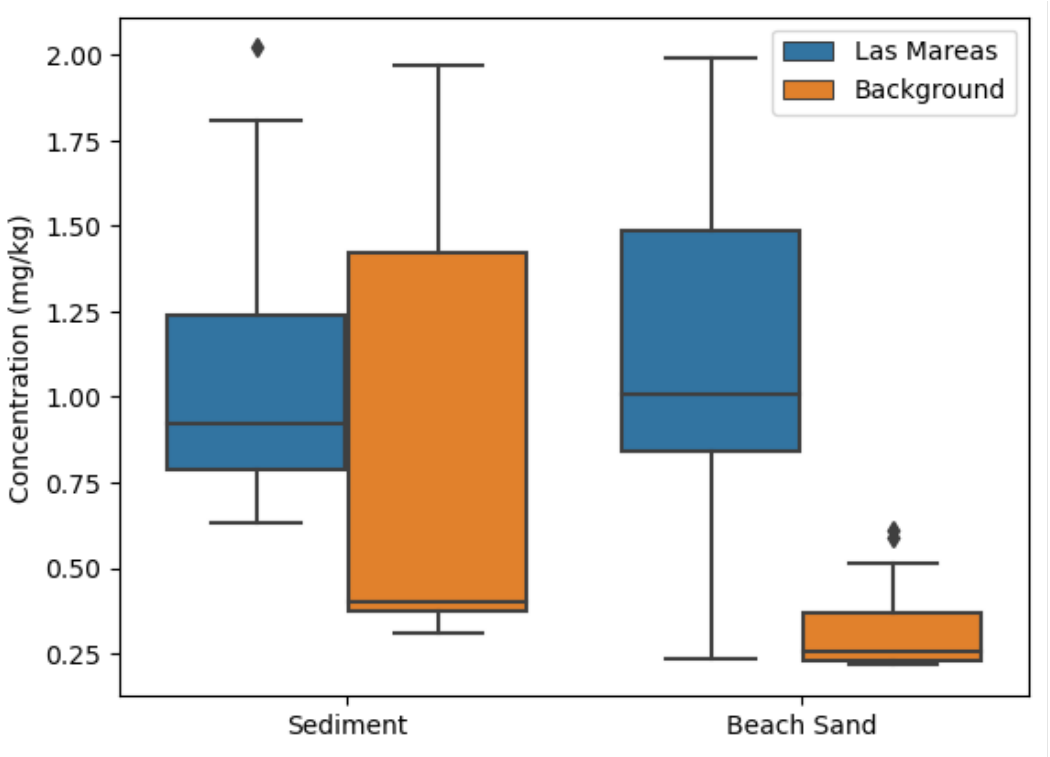

Figure C-14. Silver concentrations in sediment and sand (nondetects included at half reporting limit).

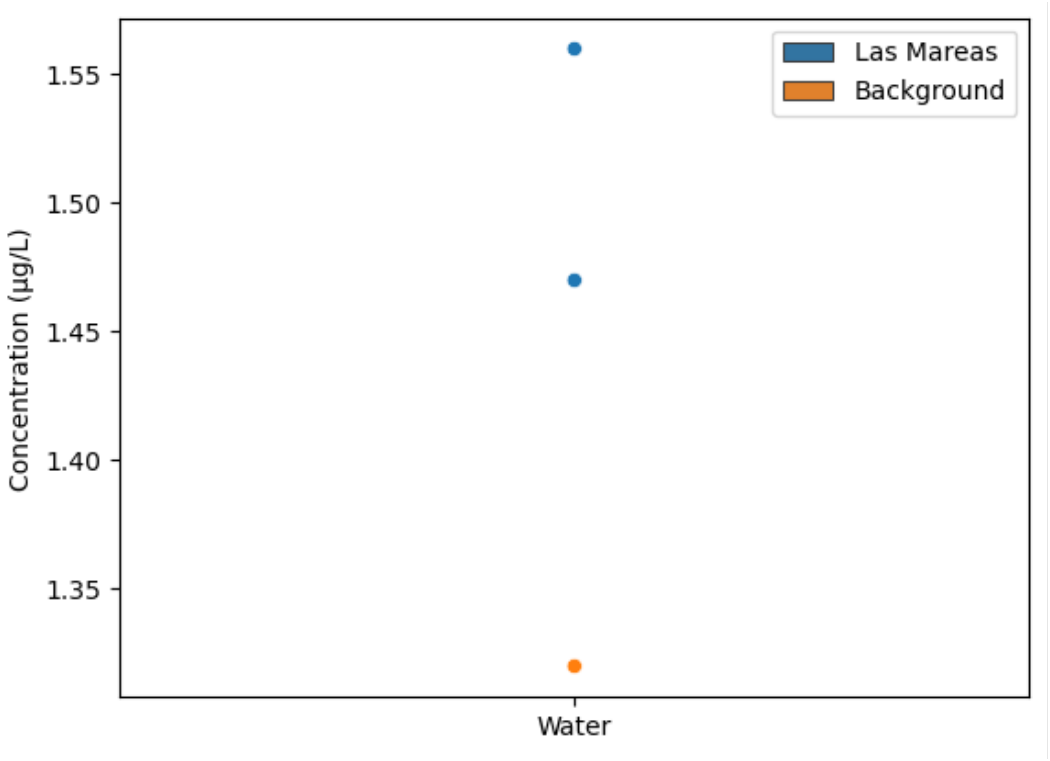

Figure C-15. Thallium concentrations in sediment, sand, and water (detections only).

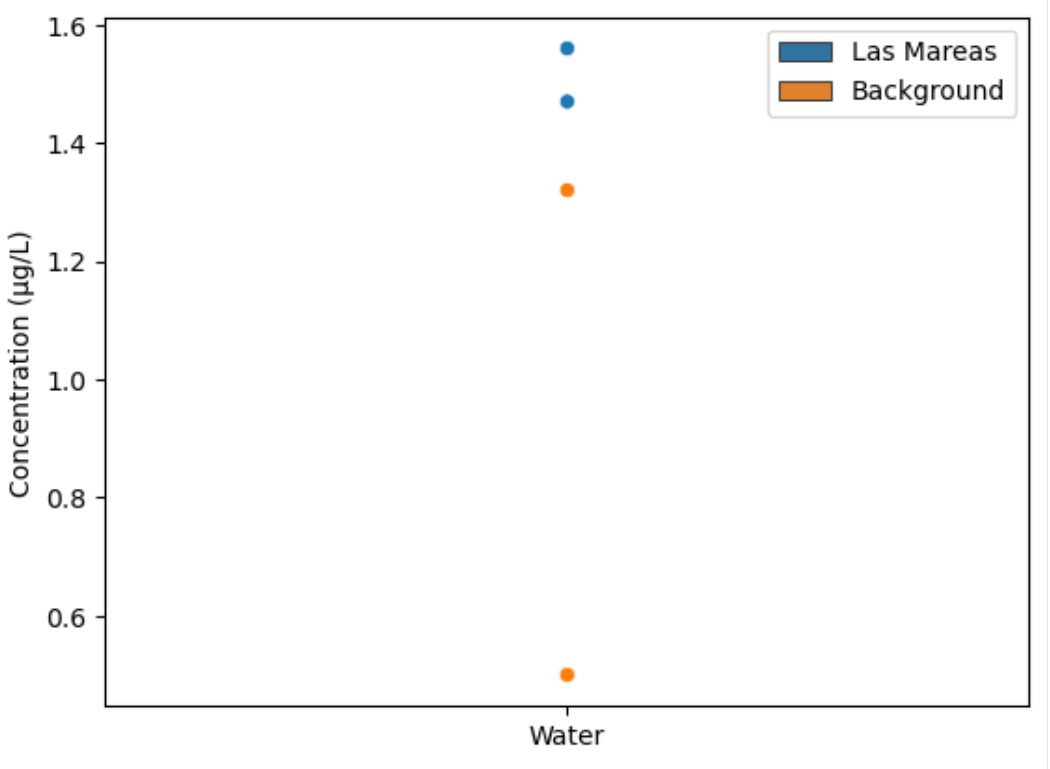

Figure C-16. Thallium concentrations in sediment, sand, and water (nondetects included at half reporting limit).

C2. Filet and Whole Fish

Table C-2 provides full concentration results for fish, including values based on half the reported detection limit (RDL) for chemicals with no detections at any sampling location for a particular medium.

Figures C-17 through **C-25** present box plots comparing fish concentration results at Las Mareas Bay sampling locations with those at background sampling locations, by chemical:

- Figure C-17. Antimony
- Figure C-18. Arsenic (inorganic)
- Figure C-19. Barium
- Figure C-20. Boron
- Figure C-21. Chromium
- Figure C-22. Lead
- Figure C-23. Lithium
- Figure C-24. Methylmercury
- Figure C-25. Molybdenum

Table C-2. Full Fish Concentration Results

Constituent	Las Mareas Bay				Background			
	Fish Filet		Whole Fish		Fish Filet		Whole Fish	
	50th	95th	50th	95th	50th	95th	50th	95th
Inorganics (mg/kg, except inorganic arsenic and methylmercury, µg/kg)								
Antimony	0.01**	0.23**	0.02*	0.48	0.20*	0.23	0.22**	0.24**
Arsenic (inorganic)	0.28	1.5	1.5	41	0.44	2.7	2.3	4.4
Barium	0.25	0.30	0.57	0.72	0.27	0.37	0.37	0.55
Beryllium	0.033**	0.035**	0.034**	0.037**	0.034**	0.035**	0.033**	0.035**
Boron	1.0	1.2	1.5	2.6	1.1	1.2	1.4	1.9
Cadmium	0.022**	0.023**	0.023*	0.024	0.023**	0.023**	0.022**	0.023**
Chromium	0.094	0.15	0.15	0.47	0.098	0.18	0.13	0.26
Cobalt	0.055**	0.058**	0.056*	0.061	0.056**	0.058**	0.055*	0.059
Lead	0.069	0.092	0.12	0.38	0.075	0.098	0.096	0.33
Lithium	0.049**	0.05**	0.18	0.21	0.049*	0.050	0.20	0.45
Methylmercury	212	501	68	502	88	267	101	199
Molybdenum	0.021	0.057	0.039	0.14	0.051*	0.058	0.033	0.060
Selenium	0.35	0.55	0.50	0.67	0.37	0.44	0.53	0.74
Silver	0.06**	0.06**	0.059*	0.061	0.058**	0.06**	0.057*	0.059
Thallium	0.049*	0.057	0.055*	0.061	0.054*	0.058	0.053*	0.058
Organics (µg/kg except sulfolane, mg/kg)								
Acenaphthene	3.9**	19**	7.0*	19	5.7**	42**	19**	43**
Methylnaphthalene, 2-	3.9**	19**	5.7**	19**	7.7*	42	24*	43
Naphthalene	3.9*	25	6.1*	19	8.1*	42	19*	43
All other PAHs†	3.9**	19**	5.7**	19**	5.7**	42**	19**	43**
Sulfolane	0.14**	0.16**	0.28**	0.41**	0.08**	0.35**	0.40**	0.41**

* At least some samples were detections. Value is half the RDL. Individual values were replaced with half the RDL for the sample before computing the percentile statistics. A constituent with more than 50% nondetects may have a value half the RDL for 50th percentile, but a measured value for the 95th percentile.

** All samples were nondetects. Value is half the RDL. Individual values were replaced with half the RDL for the sample before computing the percentile statistics. 50th and 95th percentiles may differ slightly due to variation in the RDLs for different samples.

† All other PAHs include acenaphthylene; anthracene; benzo(a)anthracene; benzo(a)pyrene; benzo(g,h,i)perylene; benzo(k)fluoranthene; biphenyl, 1,1'-; chrysene; dibenzo(a,h)anthracene; fluoranthene; fluorene; indeno(1,2,3-cd)pyrene; phenanthrene; and pyrene.

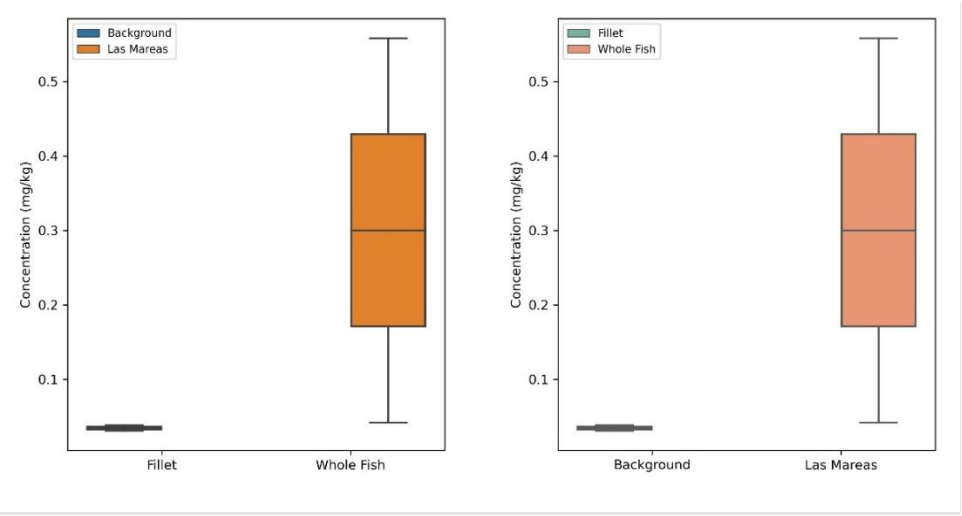

Figure C-17. Antimony concentrations in fish.

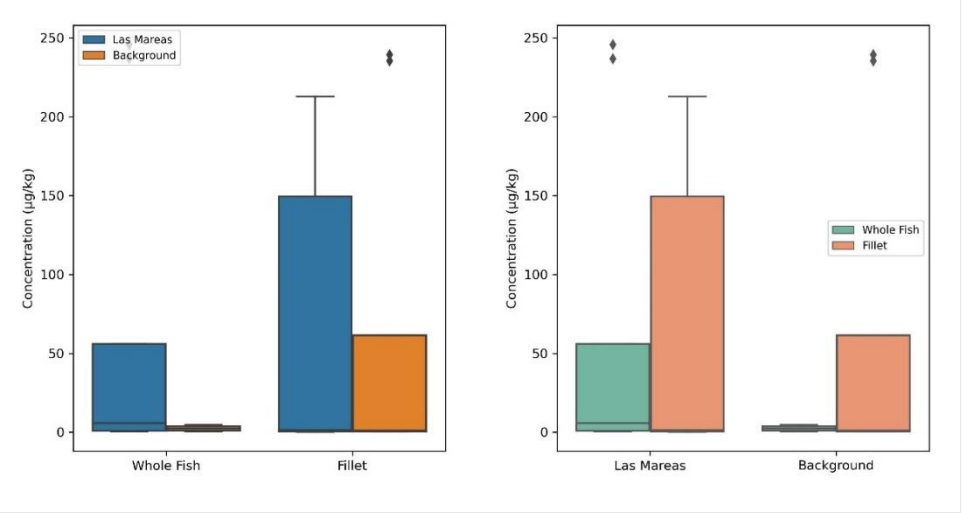

Figure C-18. Arsenic (inorganic) concentrations in fish.

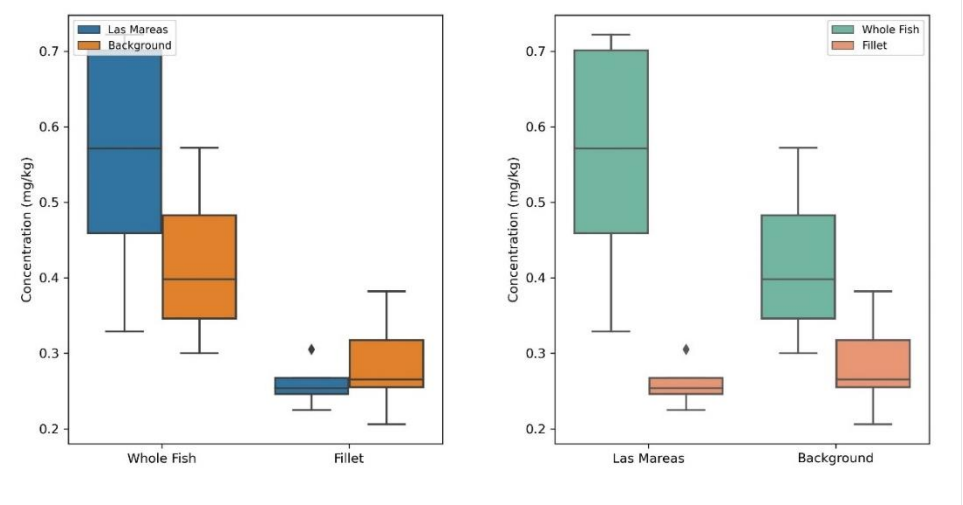

Figure C-19. Barium concentrations in fish.

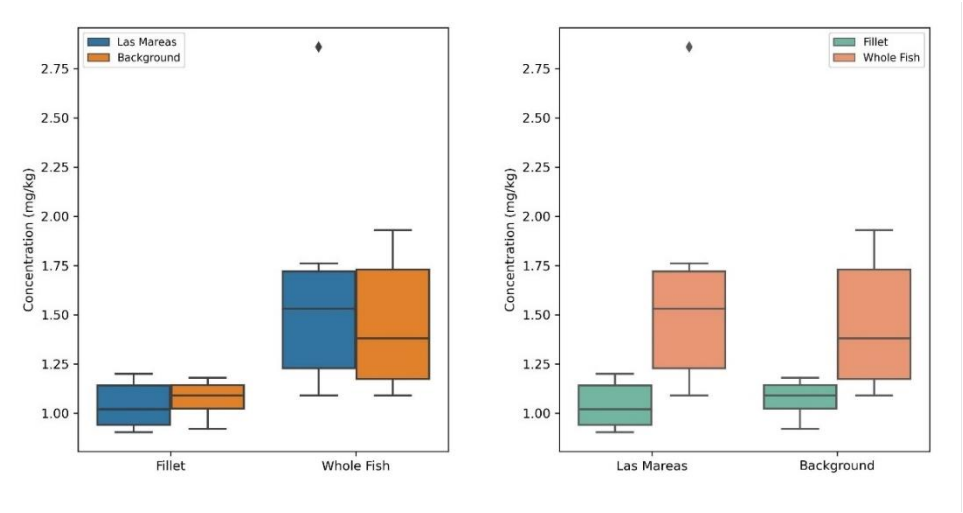

Figure C-20. Boron concentrations in fish.

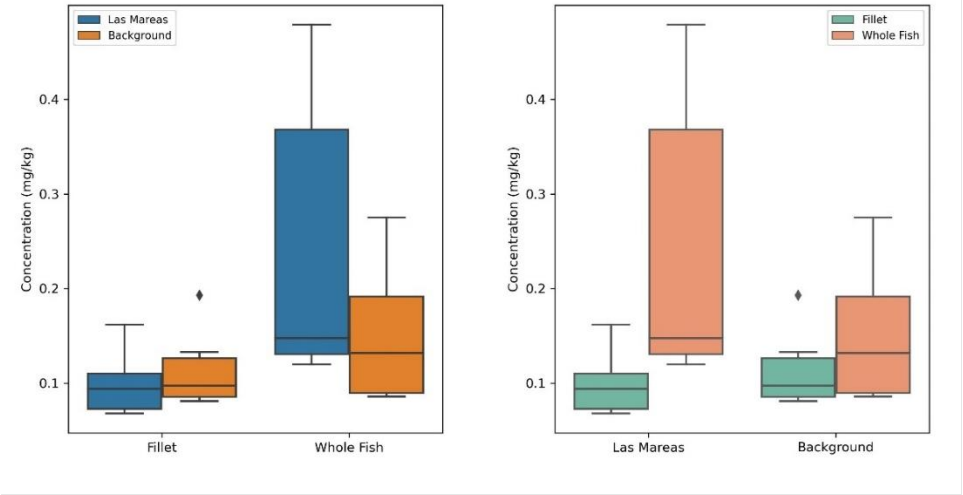

Figure C-21. Chromium concentrations in fish.

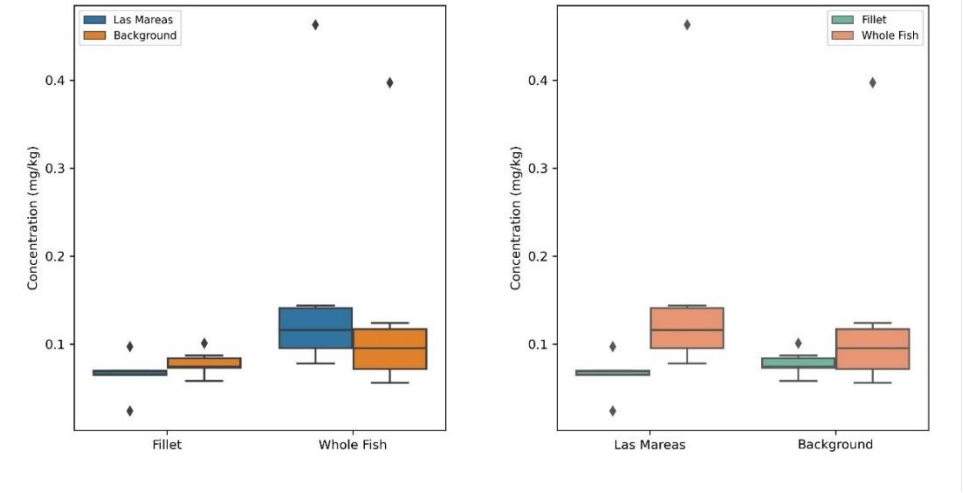

Figure C-22. Lead concentrations in fish.

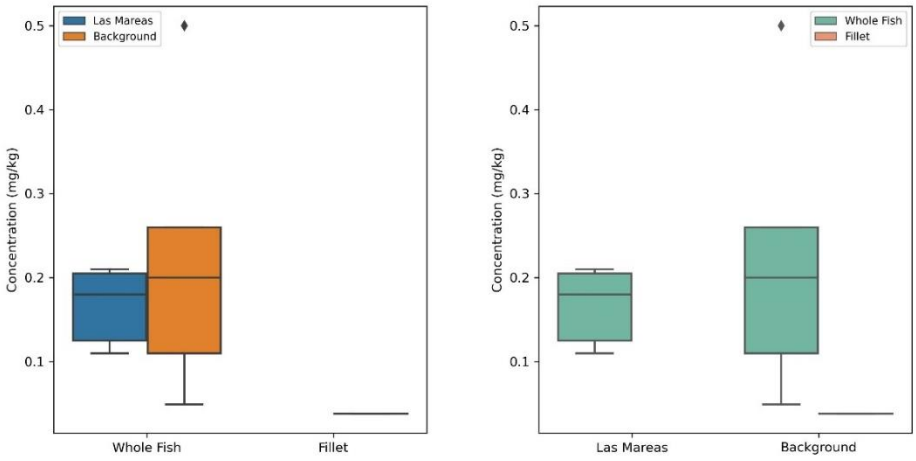

Figure C-23. Lithium concentrations in fish.

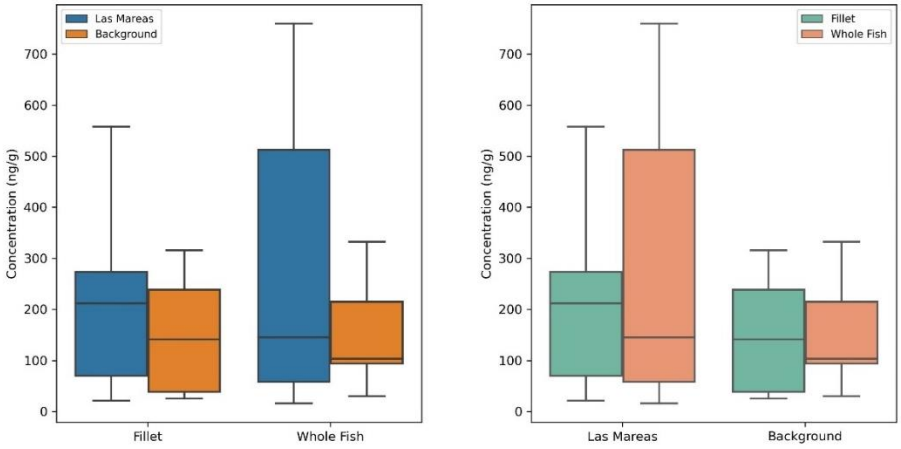

Figure C-24. Methylmercury concentrations in fish.

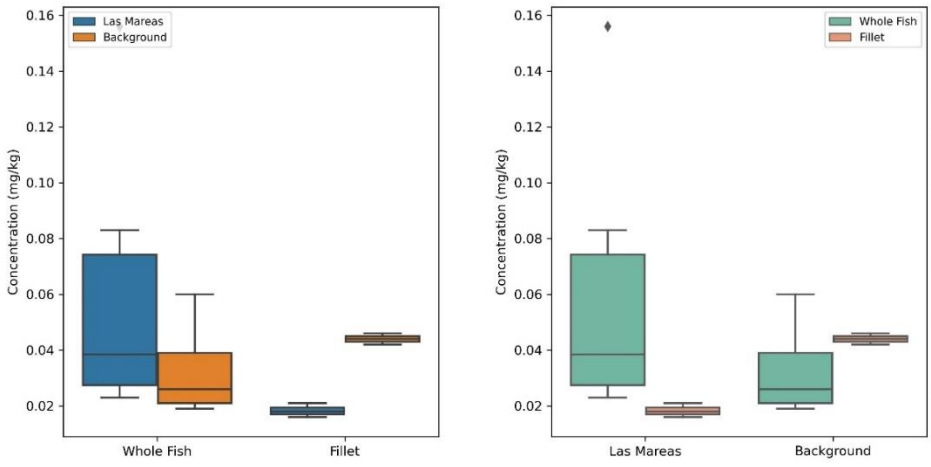

Figure C-25. Molybdenum concentrations in fish.

Appendix D. Exposure Calculations and Detailed Results

This appendix presents the equations and inputs used to calculate exposures and the exposure results for noncancer and cancer calculations for all age groups.

D.1 Exposure Calculations

The equations and inputs used to calculate exposures are shown in **Tables D-1** through **D-7**:

- **Table D-1:** Swimming—Dermal
- **Table D-2:** Swimming—Incidental Ingestion
- **Table D-3:** Playing in Sand—Dermal
- **Table D-4:** Playing in Sand—Incidental Ingestion
- **Table D-5:** Wading in Sediment—Dermal
- **Table D-6:** Wading in Sediment—Incidental Ingestion.
- **Table D-**7: Fish Consumption.

Table D-1. Equation and Inputs for Calculating Dermal Exposures from Swimming

Dermal Absorbed Dose Due to Swimming (mg/kg-day)

$$DA_{event} = C_{water} \times 0.001\ L/cm^3 \times K_p \times t_{event}\ \textit{(inorganics only)}$$

$$DAD_{swim} = DA_{event} \times EV \times SA \times \frac{EF \times ED}{BW \times AT}$$

Parameter	Description	Units	Value by Age Group							Source
			1 to <2	2 to <3	3 to <6	6 to <11	11 to <16	16 to <21	21 to <70	
C_{water}	Concentration in water	mg/L	Chemical- and percentile-specific							see **Table 13**
Kp	Dermal permeability coefficient	cm/hr	Chemical-specific							See **Table 23**
t_{event}	Duration of event (swimming)	hr/event	0.88	0.36	0.76	0.6	1	0.6	0.15	See **Table 19**
DA_{event}	Dermal absorbed dose per event	mg/cm^2-event	Calculated (intermediate value)							
EV	Event frequency	event/day	1	1	1	1	1	1	1	Assumption
SA	Skin surface area exposed	cm^3	5,300	6,100	7,400	10,500	15,700	18,000	19,400	See **Table 20**
EF	Exposure frequency (swimming)	days/year	24	66	48	60	36	60	60	See **Table 18**
ED	Exposure duration	year	1	1	3	5	5	5	50	See **Table 16**
BW	Body weight	kg	11.3	13.6	17.8	29.3	54.2	67.6	79	See **Table 17**
AT*	Averaging time	days	25,550 365	25,550 365	25,550 1,095	25,550 1,825	25,550 1,825	25,550 1,825	25,550 18,250	See **Table 16**

* Averaging times on the top row in each cell are for cancer calculations and are equivalent to 70 years for all ages; values on the bottom row are for noncancer calculations and are equal the exposure duration in days.

Table D-2. Equation and Inputs for Calculating Incidental Ingestion Exposures from Swimming

Intake Due to Incidental Ingestion of Water While Swimming (mg/kg-day)

$$I_{water} = C_{water} \times IR_{water} \times t_{event} \times 0.001\ L/mL \times \frac{EF \times ED}{BW \times AT}$$

Parameter	Description	Units	Value by Age Group							Source
			1 to <2	2 to <3	3 to <6	6 to <11	11 to <16	16 to <21	21 to <70	
C_{water}	Concentration in water	mg/L	Chemical- and percentile-specific							see **Table 13**
IR_{water}	Incidental consumption of water while swimming	mL/hr	38	38	38	38	44	33	28	See **Table 24**
t_{event}	Duration of event (swimming)	hr	0.88	0.36	0.76	0.6	1	0.6	0.15	See **Table 19**
EF	Exposure frequency (swimming)	days/year	24	66	48	60	36	60	60	See **Table 18**
ED	Exposure duration	year	1	1	3	5	5	5	50	See **Table 16**
BW	Body weight	kg	11.3	13.6	17.8	29.3	54.2	67.6	79	See **Table 17**
AT*	Averaging time	days	25,550 365	25,550 365	25,550 1,095	25,550 1,825	25,550 1,825	25,550 1,825	25,550 18,250	See **Table 16**

* Averaging times on the top row in each cell are for cancer calculations and are equivalent to 70 years for all ages; values on the bottom row are for noncancer calculations and are equal the exposure duration in days.

Table D-3. Equation and Inputs for Calculating Dermal Exposures from Playing in Sand

Dermal Absorbed Dose Due to Sand Adherence (mg/kg-day)

$$DA_{event} = C_{sand} \times 10^{-6}\ kg/mg \times AF \times ABS_d$$

$$DAD_{sand} = DA_{event} \times EV \times SA \times \frac{EF \times ED}{BW \times AT}$$

Parameter	Description	Units	Value by Age Group							Source
			1 to <2	2 to <3	3 to <6	6 to <11	11 to <16	16 to <21	21 to <70	
C_{sand}	Concentration in sand	mg/kg	Chemical- and percentile-specific							see **Table 13**
AF	Adherence factor of sand to skin	mg/cm^2-event	0.2	0.2	0.2	0.2	0.2	0.2	Not eval.	See **Table 22**
ABS_d	Dermal absorption fraction	fraction	Chemical-specific							See **Table 23**
DA_{event}	Dermal absorbed dose per event	mg/cm^2-event	Calculated (intermediate value)							
EV	Event frequency	event/day	1	1	1	1	1	1	Not eval.	Assumption
SA	Skin surface area exposed*	cm^3	1,720	1,840	2,320	3,380	4,970	5,580	Not eval.	See **Table 21**
EF	Exposure frequency	days/year	24	66	48	60	36	60	Not eval.	See **Table 18**
ED	Exposure duration	year	1	1	3	5	5	5	Not eval.	See **Table 16**
BW	Body weight	kg	11.3	13.6	17.8	29.3	54.2	67.6	Not eval.	See **Table 17**
AT**	Averaging time	days	25,550 365	25,550 365	25,550 1,095	25,550 1,825	25,550 1,825	25,550 1,825	Not eval.	See **Table 16**

* Exposed skin surface area includes face (assuming 1/3 of head), lower arms (assuming 45% of arms), hands, lower legs (assuming 40% of legs), and feet

** Averaging times on the top row in each cell are for cancer calculations and are equivalent to 70 years for all ages; values on the bottom row are for noncancer calculations and are equal the exposure duration in days.

Table D-4. Equation and Inputs for Calculating Incidental Ingestion Exposures from Playing in Sand

Intake Due to Incidental Ingestion of Sand While Playing (mg/kg-day)

$$I_{sand} = C_{sand} \times IR_{sand} \times t_{event} \times 0.001\ L/mL \times \frac{EF \times ED}{BW \times AT}$$

Parameter	Description	Units	Value by Age Group							Source
			1 to <2	2 to <3	3 to <6	6 to <11	11 to <16	16 to <21	21 to <70	
C_{sand}	Concentration in sand	mg/kg	Chemical- and percentile-specific							see **Table 13**
IR_{sand}	Incidental consumption of sand	mg/hr	72	72	57	57	18	18	Not eval.	See **Table 24**
t_{event}	Duration of event	hr	0.5	0.5	1	1	1	1.4	Not eval.	See **Table 19**
EF	Exposure frequency	days/year	24	66	48	60	36	60	Not eval.	See **Table 18**
ED	Exposure duration	year	1	1	3	5	5	5	Not eval.	See **Table 16**
BW	Body weight	kg	11.3	13.6	17.8	29.3	54.2	67.6	Not eval.	See **Table 17**
AT*	Averaging time	days	25,550 365	25,550 365	25,550 1,095	25,550 1,825	25,550 1,825	25,550 1,825	Not eval.	See **Table 16**

* Averaging times on the top row in each cell are for cancer calculations and are equivalent to 70 years for all ages; values on the bottom row are for noncancer calculations and are equal the exposure duration in days.

Table D-5. Equation and Inputs for Calculating Dermal Exposures from Wading in Sediment

Dermal Absorbed Dose Due to Sand Adherence (mg/kg-day)

$$DA_{event} = C_{sand} \times 10^{-6}\ kg/mg \times AF \times ABS_d$$

$$DAD_{sand} = DA_{event} \times EV \times SA \times \frac{EF \times ED}{BW \times AT}$$

Parameter	Description	Units	Value by Age Group							Source
			1 to <2	2 to <3	3 to <6	6 to <11	11 to <16	16 to <21	21 to <70	
C_{sed}	Concentration in sediment	mg/kg	Chemical- and percentile-specific							see **Table 13**
AF	Adherence factor of sediment to skin	mg/cm^2-event	3.2	3	3.1	3.1	3	2.8	Not eval.	See **Table 22**
ABS_d	Dermal absorption fraction	fraction	Chemical-specific							See **Table 23**
DA_{event}	Dermal absorbed dose per event	mg/cm^2-event	Calculated (intermediate value)							
EV	Event frequency	event/day	1	1	1	1	1	1	Not eval.	Assumption
SA	Skin surface area exposed*	cm^3	2,540	3,080	3,870	5,860	8,870	10,070	Not eval.	See **Table 21**
EF	Exposure frequency	days/year	24	66	48	60	36	60	Not eval.	See **Table 18**
ED	Exposure duration	year	1	1	3	5	5	5	Not eval.	See **Table 16**
BW	Body weight	kg	11.3	13.6	17.8	29.3	54.2	67.6	Not eval.	See **Table 17**
AT**	Averaging time	days	25,550 365	25,550 365	25,550 1,095	25,550 1,825	25,550 1,825	25,550 1,825	Not eval.	See **Table 16**

* Exposed skin surface area includes arms, hands, legs, and feet

** Averaging times on the top row in each cell are for cancer calculations and are equivalent to 70 years for all ages; values on the bottom row are for noncancer calculations and are equal the exposure duration in days.

Table D-6. Equation and Inputs for Calculating Incidental Ingestion Exposures from Wading in Sediment

Intake Due to Incidental Ingestion of Sediment While Wading (mg/kg-day)

$$I_{sed} = C_{sed} \times IR_{sed} \times t_{event} \times 0.001\ L/mL \times \frac{EF \times ED}{BW \times AT}$$

Parameter	Description	Units	Value by Age Group							Source
			1 to <2	2 to <3	3 to <6	6 to <11	11 to <16	16 to <21	21 to <70	
C_{sed}	Concentration in sediment	mg/kg	Chemical- and percentile-specific							see **Table 13**
IR_{sed}	Incidental consumption of sediment	mg/hr	72	72	57	57	18	18	Not eval.	See **Table 24**
t_{event}	Duration of event (same as playing in sand)	hr	0.5	0.5	1	1	1	1.4	Not eval.	See **Table 19**
EF	Exposure frequency (same as swimming)	days/year	24	66	48	60	36	60	Not eval.	See **Table 18**
ED	Exposure duration	year	1	1	3	5	5	5	Not eval.	See **Table 16**
BW	Body weight	kg	11.3	13.6	17.8	29.3	54.2	67.6	Not eval.	See **Table 17**
AT*	Averaging time	days	25,550 365	25,550 365	25,550 1,095	25,550 1,825	25,550 1,825	25,550 1,825	Not eval.	See **Table 16**

* Averaging times on the top row in each cell are for cancer calculations and are equivalent to 70 years for all ages; values on the bottom row are for noncancer calculations and are equal the exposure duration in days.

Table D-7. Equation and Inputs for Calculating Fish Consumption Exposures

Intake Due to Ingestion of Fish Filet (mg/kg-day)

$$I_{filet} = C_{filet} \times CR_{fish} \times 0.001\ kg/g \times \frac{EF \times ED}{BW \times AT}$$

Parameter	Description	Units	Value by Age Group							Source
			1 to <2	2 to <3	3 to <6	6 to <11	11 to <16	16 to <21	21 to <70	
C_{filet}	Concentration in fish filet	mg/kg	Chemical- and percentile-specific							see **Table 15**
CR_{fish}	Consumption rate of fish	g/day	2.4	2.4	3.2	4.4	4.3	6.7	13.1	See **Table 25**
EF	Exposure frequency	days/year	350	350	350	350	350	350	350	See **Table 26**
ED	Exposure duration	year	1	1	3	5	5	5	50	See **Table 16**
BW	Body weight	kg	11.3	13.6	17.8	29.3	54.2	67.6	79	See **Table 17**
AT*	Averaging time	days	25,550 365	25,550 365	25,550 1,095	25,550 1,825	25,550 1,825	25,550 1,825	25,550 18,250	See **Table 16**

* Averaging times on the top row in each cell are for cancer calculations and are equivalent to 70 years for all ages; values on the bottom row are for noncancer calculations and are equal the exposure duration in days.

D.2 Exposure Results

The following tables present the exposures that correspond to the risks in **Tables E-1** to **E-8** to E in **Appendix E**:

- **Table D-8:** noncancer exposures for recreational swimming (corresponds to Table E-1)
- **Table D-9:** cancer exposures for recreational swimming (Table E-2)
- **Table D-10:** noncancer exposures for recreational exposure to beach sand (Table E-3)
- **Table D-11:** cancer exposures for recreational exposure to beach sand (Table E-4)
- **Table D-12:** noncancer exposures for recreational exposure to sediment (Table E-5)
- **Table D-13:** cancer exposures for recreational exposure to sediment (Table E-6)
- **Table D-14:** noncancer exposures for fish consumption (Table E-7)
- **Table D-15:** cancer exposures for fish consumption (Table E-8).

The noncancer and cancer exposure values differ only in the averaging time applied (equal to the exposure duration for noncancer and 70 years for cancer).

Antimony is omitted from Tables D-8 and D-9 (exposures for recreational swimming) because concentration results were not reported for antimony in water. Tables D-9, D-11, D-13, and D-15 present results for only arsenic and chromium, as these were the only chemicals evaluated that had cancer toxicity endpoints (cancer slope factors).

Table D-8. Noncancer Exposures (mg/kg-day) for Recreational Swimming

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Arsenic (inorganic)	Child (1 to <2 yrs)	4E-07	6E-08	5E-07	6E-08
Arsenic (inorganic)	Child (2 to <3 yrs)	4E-07	6E-08	4E-07	7E-08
Arsenic (inorganic)	Child (3 to <6 yrs)	4E-07	9E-08	5E-07	1E-07
Arsenic (inorganic)	Child (6 to <11 yrs)	3E-07	7E-08	3E-07	8E-08
Arsenic (inorganic)	Child (11 to <16 yrs)	2E-07	6E-08	2E-07	7E-08
Arsenic (inorganic)	Child (16 to <21 yrs)	1E-07	5E-08	1E-07	6E-08
Arsenic (inorganic)	Adult (21 to <70 yrs)	2E-08	1E-08	2E-08	1E-08
Barium	Child (1 to <2 yrs)	2E-06	2E-07	2E-06	2E-07
Barium	Child (2 to <3 yrs)	1E-06	2E-07	2E-06	2E-07
Barium	Child (3 to <6 yrs)	2E-06	3E-07	2E-06	3E-07
Barium	Child (6 to <11 yrs)	1E-06	3E-07	1E-06	3E-07
Barium	Child (11 to <16 yrs)	6E-07	2E-07	7E-07	2E-07
Barium	Child (16 to <21 yrs)	4E-07	2E-07	4E-07	2E-07
Barium	Adult (21 to <70 yrs)	7E-08	5E-08	7E-08	5E-08
Beryllium	Child (1 to <2 yrs)	1E-07**	1E-08**	1E-07**	1E-08**
Beryllium	Child (2 to <3 yrs)	9E-08**	1E-08**	9E-08**	1E-08**
Beryllium	Child (3 to <6 yrs)	1E-07**	2E-08**	1E-07**	2E-08**
Beryllium	Child (6 to <11 yrs)	6E-08**	2E-08**	6E-08**	2E-08**
Beryllium	Child (11 to <16 yrs)	4E-08**	1E-08**	4E-08**	1E-08**
Beryllium	Child (16 to <21 yrs)	2E-08**	1E-08**	2E-08**	1E-08**
Beryllium	Adult (21 to <70 yrs)	4E-09**	3E-09**	4E-09**	3E-09**
Boron	Child (1 to <2 yrs)	1E-03	1E-04	1E-03	1E-04
Boron	Child (2 to <3 yrs)	9E-04	1E-04	1E-03	2E-04

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Boron	Child (3 to <6 yrs)	1E-03	2E-04	1E-03	2E-04
Boron	Child (6 to <11 yrs)	7E-04	2E-04	7E-04	2E-04
Boron	Child (11 to <16 yrs)	4E-04	1E-04	4E-04	2E-04
Boron	Child (16 to <21 yrs)	2E-04	1E-04	3E-04	1E-04
Boron	Adult (21 to <70 yrs)	4E-05	3E-05	5E-05	3E-05
Cadmium	Child (1 to <2 yrs)	1E-07**	1E-08**	1E-07**	1E-08**
Cadmium	Child (2 to <3 yrs)	9E-08**	1E-08**	9E-08**	1E-08**
Cadmium	Child (3 to <6 yrs)	1E-07**	2E-08**	1E-07**	2E-08**
Cadmium	Child (6 to <11 yrs)	6E-08**	2E-08**	6E-08**	2E-08**
Cadmium	Child (11 to <16 yrs)	4E-08**	1E-08**	4E-08**	1E-08**
Cadmium	Child (16 to <21 yrs)	2E-08**	1E-08**	2E-08**	1E-08**
Cadmium	Adult (21 to <70 yrs)	4E-09**	3E-09**	4E-09**	3E-09**
Chromium (VI)	Child (1 to <2 yrs)	5E-07	5E-10	1E-05	1E-08
Chromium (VI)	Child (2 to <3 yrs)	5E-07	6E-10	9E-06	1E-08
Chromium (VI)	Child (3 to <6 yrs)	6E-07	8E-10	1E-05	1E-08
Chromium (VI)	Child (6 to <11 yrs)	4E-07	7E-10	7E-06	1E-08
Chromium (VI)	Child (11 to <16 yrs)	2E-07	6E-10	4E-06	1E-08
Chromium (VI)	Child (16 to <21 yrs)	1E-07	5E-10	2E-06	9E-09
Chromium (VI)	Adult (21 to <70 yrs)	2E-08	1E-10	4E-07	2E-09
Cobalt	Child (1 to <2 yrs)	1E-07**	1E-08**	1E-07**	1E-08**
Cobalt	Child (2 to <3 yrs)	9E-08**	1E-08**	9E-08**	1E-08**
Cobalt	Child (3 to <6 yrs)	1E-07**	2E-08**	1E-07**	2E-08**
Cobalt	Child (6 to <11 yrs)	6E-08**	2E-08**	6E-08**	2E-08**
Cobalt	Child (11 to <16 yrs)	4E-08**	1E-08**	4E-08**	1E-08**
Cobalt	Child (16 to <21 yrs)	2E-08**	1E-08**	2E-08**	1E-08**
Cobalt	Adult (21 to <70 yrs)	4E-09**	3E-09**	4E-09**	3E-09**
Lithium	Child (1 to <2 yrs)	7E-05	9E-06	7E-05	1E-05
Lithium	Child (2 to <3 yrs)	6E-05	1E-05	7E-05	1E-05
Lithium	Child (3 to <6 yrs)	7E-05	1E-05	8E-05	1E-05
Lithium	Child (6 to <11 yrs)	4E-05	1E-05	5E-05	1E-05
Lithium	Child (11 to <16 yrs)	3E-05	1E-05	3E-05	1E-05
Lithium	Child (16 to <21 yrs)	2E-05	9E-06	2E-05	9E-06
Lithium	Adult (21 to <70 yrs)	3E-06	2E-06	3E-06	2E-06
Mercury (total)	Child (1 to <2 yrs)	2E-08*	3E-09*	8E-08*	1E-08*
Mercury (total)	Child (2 to <3 yrs)	2E-08*	3E-09*	8E-08*	1E-08*
Mercury (total)	Child (3 to <6 yrs)	2E-08*	4E-09*	9E-08*	2E-08*
Mercury (total)	Child (6 to <11 yrs)	1E-08*	4E-09*	5E-08*	1E-08*
Mercury (total)	Child (11 to <16 yrs)	8E-09*	3E-09*	3E-08*	1E-08*
Mercury (total)	Child (16 to <21 yrs)	5E-09*	3E-09*	2E-08*	1E-08*
Mercury (total)	Adult (21 to <70 yrs)	9E-10*	6E-10*	4E-09*	3E-09*
Molybdenum	Child (1 to <2 yrs)	2E-06	3E-07	2E-06	3E-07
Molybdenum	Child (2 to <3 yrs)	2E-06	3E-07	2E-06	3E-07
Molybdenum	Child (3 to <6 yrs)	2E-06	5E-07	3E-06	5E-07
Molybdenum	Child (6 to <11 yrs)	1E-06	4E-07	2E-06	4E-07
Molybdenum	Child (11 to <16 yrs)	9E-07	3E-07	1E-06	3E-07
Molybdenum	Child (16 to <21 yrs)	5E-07	3E-07	6E-07	3E-07

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Molybdenum	Adult (21 to <70 yrs)	1E-07	7E-08	1E-07	7E-08
Selenium	Child (1 to <2 yrs)	4E-07**	5E-08**	4E-07**	5E-08**
Selenium	Child (2 to <3 yrs)	4E-07**	6E-08**	4E-07**	6E-08**
Selenium	Child (3 to <6 yrs)	4E-07**	8E-08**	4E-07**	8E-08**
Selenium	Child (6 to <11 yrs)	3E-07**	7E-08**	3E-07**	7E-08**
Selenium	Child (11 to <16 yrs)	2E-07**	6E-08**	2E-07**	6E-08**
Selenium	Child (16 to <21 yrs)	1E-07**	5E-08**	1E-07**	5E-08**
Selenium	Adult (21 to <70 yrs)	2E-08**	1E-08**	2E-08**	1E-08**
Silver	Child (1 to <2 yrs)	1E-07**	8E-09**	1E-07**	8E-09**
Silver	Child (2 to <3 yrs)	9E-08**	9E-09**	9E-08**	9E-09**
Silver	Child (3 to <6 yrs)	1E-07**	1E-08**	1E-07**	1E-08**
Silver	Child (6 to <11 yrs)	6E-08**	1E-08**	6E-08**	1E-08**
Silver	Child (11 to <16 yrs)	4E-08**	9E-09**	4E-08**	9E-09**
Silver	Child (16 to <21 yrs)	2E-08**	8E-09**	2E-08**	8E-09**
Silver	Adult (21 to <70 yrs)	4E-09**	2E-09**	4E-09**	2E-09**
Thallium	Child (1 to <2 yrs)	1E-07*	1E-08*	3E-07	4E-08
Thallium	Child (2 to <3 yrs)	9E-08*	1E-08*	3E-07	4E-08
Thallium	Child (3 to <6 yrs)	1E-07*	2E-08*	3E-07	6E-08
Thallium	Child (6 to <11 yrs)	6E-08*	2E-08*	2E-07	5E-08
Thallium	Child (11 to <16 yrs)	4E-08*	1E-08*	1E-07	4E-08
Thallium	Child (16 to <21 yrs)	2E-08*	1E-08*	7E-08	4E-08
Thallium	Adult (21 to <70 yrs)	4E-09*	3E-09*	1E-08	9E-09

* At least some samples were detections. Value is based on a concentration that is half the RDL.

** All samples were nondetects. Value is based on a concentration that is half the RDL.

Table D-9. Cancer Exposures (mg/kg-day) for Recreational Swimming

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Arsenic (inorganic)	Child (1 to <2 yrs)	6E-09	8E-10	7E-09	9E-10
Arsenic (inorganic)	Child (2 to <3 yrs)	5E-09	9E-10	6E-09	1E-09
Arsenic (inorganic)	Child (3 to <6 yrs)	2E-08	4E-09	2E-08	4E-09
Arsenic (inorganic)	Child (6 to <11 yrs)	2E-08	5E-09	2E-08	6E-09
Arsenic (inorganic)	Child (11 to <16 yrs)	1E-08	4E-09	1E-08	5E-09
Arsenic (inorganic)	Child (16 to <21 yrs)	7E-09	4E-09	8E-09	4E-09
Arsenic (inorganic)	Adult (21 to <70 yrs)	1E-08	9E-09	1E-08	1E-08
Chromium (VI)	Child (1 to <2 yrs)	8E-09	8E-12	1E-07	1E-10
Chromium (VI)	Child (2 to <3 yrs)	7E-09	8E-12	1E-07	1E-10
Chromium (VI)	Child (3 to <6 yrs)	3E-08	3E-11	5E-07	6E-10
Chromium (VI)	Child (6 to <11 yrs)	3E-08	5E-11	5E-07	9E-10
Chromium (VI)	Child (11 to <16 yrs)	2E-08	4E-11	3E-07	7E-10
Chromium (VI)	Child (16 to <21 yrs)	1E-08	4E-11	2E-07	7E-10
Chromium (VI)	Adult (21 to <70 yrs)	2E-08	8E-11	3E-07	2E-09

Table D-10. Noncancer Exposures (mg/kg-day) for Recreational Exposure to Sand

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Antimony	Child (1 to <2 yrs)	2E-07**	NA	2E-07**	NA
Antimony	Child (2 to <3 yrs)	5E-07**	NA	5E-07**	NA
Antimony	Child (3 to <6 yrs)	4E-07**	NA	4E-07**	NA
Antimony	Child (6 to <11 yrs)	3E-07**	NA	3E-07**	NA
Antimony	Child (11 to <16 yrs)	5E-08**	NA	6E-08**	NA
Antimony	Child (16 to <21 yrs)	4E-08**	NA	5E-08**	NA
Arsenic (inorganic)	Child (1 to <2 yrs)	1E-06	4E-07	2E-06	5E-07
Arsenic (inorganic)	Child (2 to <3 yrs)	3E-06	1E-06	4E-06	1E-06
Arsenic (inorganic)	Child (3 to <6 yrs)	3E-06	7E-07	4E-06	9E-07
Arsenic (inorganic)	Child (6 to <11 yrs)	2E-06	8E-07	3E-06	1E-06
Arsenic (inorganic)	Child (11 to <16 yrs)	4E-07	6E-07	5E-07	8E-07
Arsenic (inorganic)	Child (16 to <21 yrs)	3E-07	6E-07	4E-07	7E-07
Barium	Child (1 to <2 yrs)	1E-06**	NA	1E-06**	NA
Barium	Child (2 to <3 yrs)	2E-06**	NA	2E-06**	NA
Barium	Child (3 to <6 yrs)	2E-06**	NA	2E-06**	NA
Barium	Child (6 to <11 yrs)	2E-06**	NA	2E-06**	NA
Barium	Child (11 to <16 yrs)	3E-07**	NA	3E-07**	NA
Barium	Child (16 to <21 yrs)	2E-07**	NA	2E-07**	NA
Beryllium	Child (1 to <2 yrs)	3E-08**	NA	3E-08**	NA
Beryllium	Child (2 to <3 yrs)	7E-08**	NA	8E-08**	NA
Beryllium	Child (3 to <6 yrs)	6E-08**	NA	7E-08**	NA
Beryllium	Child (6 to <11 yrs)	5E-08**	NA	5E-08**	NA
Beryllium	Child (11 to <16 yrs)	8E-09**	NA	9E-09**	NA
Beryllium	Child (16 to <21 yrs)	6E-09**	NA	7E-09**	NA
Boron	Child (1 to <2 yrs)	1E-06	NA	3E-06	NA
Boron	Child (2 to <3 yrs)	3E-06	NA	6E-06	NA
Boron	Child (3 to <6 yrs)	2E-06	NA	5E-06	NA
Boron	Child (6 to <11 yrs)	2E-06	NA	4E-06	NA
Boron	Child (11 to <16 yrs)	3E-07	NA	7E-07	NA
Boron	Child (16 to <21 yrs)	2E-07	NA	5E-07	NA
Cadmium	Child (1 to <2 yrs)	3E-08**	3E-10**	3E-08**	3E-10**
Cadmium	Child (2 to <3 yrs)	7E-08**	7E-10**	8E-08**	8E-10**
Cadmium	Child (3 to <6 yrs)	6E-08**	5E-10**	7E-08**	5E-10**
Cadmium	Child (6 to <11 yrs)	5E-08**	5E-10**	5E-08**	6E-10**
Cadmium	Child (11 to <16 yrs)	8E-09**	4E-10**	9E-09**	5E-10**
Cadmium	Child (16 to <21 yrs)	6E-09**	4E-10**	7E-09**	4E-10**
Chromium (VI)	Child (1 to <2 yrs)	1E-06	NA	2E-06	NA
Chromium (VI)	Child (2 to <3 yrs)	3E-06	NA	5E-06	NA
Chromium (VI)	Child (3 to <6 yrs)	2E-06	NA	4E-06	NA
Chromium (VI)	Child (6 to <11 yrs)	2E-06	NA	3E-06	NA
Chromium (VI)	Child (11 to <16 yrs)	3E-07	NA	5E-07	NA
Chromium (VI)	Child (16 to <21 yrs)	2E-07	NA	4E-07	NA
Cobalt	Child (1 to <2 yrs)	1E-06	NA	2E-06	NA
Cobalt	Child (2 to <3 yrs)	2E-06	NA	5E-06	NA

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Cobalt	Child (3 to <6 yrs)	2E-06	NA	4E-06	NA
Cobalt	Child (6 to <11 yrs)	2E-06	NA	3E-06	NA
Cobalt	Child (11 to <16 yrs)	3E-07	NA	5E-07	NA
Cobalt	Child (16 to <21 yrs)	2E-07	NA	4E-07	NA
Lithium	Child (1 to <2 yrs)	4E-07**	NA	4E-07**	NA
Lithium	Child (2 to <3 yrs)	9E-07**	NA	1E-06**	NA
Lithium	Child (3 to <6 yrs)	8E-07**	NA	9E-07**	NA
Lithium	Child (6 to <11 yrs)	6E-07**	NA	7E-07**	NA
Lithium	Child (11 to <16 yrs)	1E-07**	NA	1E-07**	NA
Lithium	Child (16 to <21 yrs)	8E-08**	NA	9E-08**	NA
Mercury (total)	Child (1 to <2 yrs)	4E-09**	NA	5E-09**	NA
Mercury (total)	Child (2 to <3 yrs)	1E-08**	NA	1E-08**	NA
Mercury (total)	Child (3 to <6 yrs)	8E-09**	NA	1E-08**	NA
Mercury (total)	Child (6 to <11 yrs)	6E-09**	NA	7E-09**	NA
Mercury (total)	Child (11 to <16 yrs)	1E-09**	NA	1E-09**	NA
Mercury (total)	Child (16 to <21 yrs)	9E-10**	NA	1E-09**	NA
Molybdenum	Child (1 to <2 yrs)	1E-07*	NA	2E-07	NA
Molybdenum	Child (2 to <3 yrs)	2E-07*	NA	5E-07	NA
Molybdenum	Child (3 to <6 yrs)	2E-07*	NA	5E-07	NA
Molybdenum	Child (6 to <11 yrs)	2E-07*	NA	4E-07	NA
Molybdenum	Child (11 to <16 yrs)	3E-08*	NA	6E-08	NA
Molybdenum	Child (16 to <21 yrs)	2E-08*	NA	5E-08	NA
Selenium	Child (1 to <2 yrs)	2E-07**	NA	2E-07**	NA
Selenium	Child (2 to <3 yrs)	5E-07**	NA	5E-07**	NA
Selenium	Child (3 to <6 yrs)	4E-07**	NA	4E-07**	NA
Selenium	Child (6 to <11 yrs)	3E-07**	NA	3E-07**	NA
Selenium	Child (11 to <16 yrs)	5E-08**	NA	6E-08**	NA
Selenium	Child (16 to <21 yrs)	4E-08**	NA	5E-08**	NA
Silver	Child (1 to <2 yrs)	2E-07	NA	4E-07	NA
Silver	Child (2 to <3 yrs)	5E-07	NA	9E-07	NA
Silver	Child (3 to <6 yrs)	4E-07	NA	8E-07	NA
Silver	Child (6 to <11 yrs)	3E-07	NA	6E-07	NA
Silver	Child (11 to <16 yrs)	5E-08	NA	1E-07	NA
Silver	Child (16 to <21 yrs)	4E-08	NA	8E-08	NA
Thallium	Child (1 to <2 yrs)	2E-07**	NA	2E-07**	NA
Thallium	Child (2 to <3 yrs)	5E-07**	NA	5E-07**	NA
Thallium	Child (3 to <6 yrs)	4E-07**	NA	4E-07**	NA
Thallium	Child (6 to <11 yrs)	3E-07**	NA	3E-07**	NA
Thallium	Child (11 to <16 yrs)	5E-08**	NA	6E-08**	NA
Thallium	Child (16 to <21 yrs)	4E-08**	NA	5E-08**	NA

NA = not available because dermal absorption fraction for solids was not available for this chemical.

* At least some samples were detections. Value is based on a concentration that is half the RDL.

** All samples were nondetects. Value is based on a concentration that is half the RDL.

Table D-11. Cancer Exposures (mg/kg-day) for Recreational Exposure to Sand

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Arsenic (inorganic)	Child (1 to <2 yrs)	2E-08	6E-09	3E-08	7E-09
Arsenic (inorganic)	Child (2 to <3 yrs)	5E-08	1E-08	6E-08	2E-08
Arsenic (inorganic)	Child (3 to <6 yrs)	1E-07	3E-08	2E-07	4E-08
Arsenic (inorganic)	Child (6 to <11 yrs)	2E-07	6E-08	2E-07	7E-08
Arsenic (inorganic)	Child (11 to <16 yrs)	3E-08	4E-08	3E-08	5E-08
Arsenic (inorganic)	Child (16 to <21 yrs)	2E-08	4E-08	3E-08	5E-08
Chromium (VI)	Child (1 to <2 yrs)	2E-08	NA	3E-08	NA
Chromium (VI)	Child (2 to <3 yrs)	4E-08	NA	7E-08	NA
Chromium (VI)	Child (3 to <6 yrs)	1E-07	NA	2E-07	NA
Chromium (VI)	Child (6 to <11 yrs)	1E-07	NA	2E-07	NA
Chromium (VI)	Child (11 to <16 yrs)	2E-08	NA	4E-08	NA
Chromium (VI)	Child (16 to <21 yrs)	2E-08	NA	3E-08	NA

NA = not available because dermal absorption fraction for solids was not available for this chemical.

Table D-12. Noncancer Exposures (mg/kg-day) for Recreational Exposure to Sediment

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Antimony	Child (1 to <2 yrs)	3E-07**	NA	3E-07**	NA
Antimony	Child (2 to <3 yrs)	6E-07**	NA	8E-07**	NA
Antimony	Child (3 to <6 yrs)	5E-07**	NA	7E-07**	NA
Antimony	Child (6 to <11 yrs)	4E-07**	NA	5E-07**	NA
Antimony	Child (11 to <16 yrs)	7E-08**	NA	9E-08**	NA
Antimony	Child (16 to <21 yrs)	5E-08**	NA	7E-08**	NA
Arsenic (inorganic)	Child (1 to <2 yrs)	2E-06	1E-05	3E-06	2E-05
Arsenic (inorganic)	Child (2 to <3 yrs)	4E-06	3E-05	6E-06	5E-05
Arsenic (inorganic)	Child (3 to <6 yrs)	4E-06	2E-05	6E-06	3E-05
Arsenic (inorganic)	Child (6 to <11 yrs)	3E-06	3E-05	4E-06	4E-05
Arsenic (inorganic)	Child (11 to <16 yrs)	5E-07	2E-05	7E-07	3E-05
Arsenic (inorganic)	Child (16 to <21 yrs)	4E-07	2E-05	6E-07	3E-05
Barium	Child (1 to <2 yrs)	1E-06**	NA	2E-06**	NA
Barium	Child (2 to <3 yrs)	3E-06**	NA	4E-06**	NA
Barium	Child (3 to <6 yrs)	3E-06**	NA	3E-06**	NA
Barium	Child (6 to <11 yrs)	2E-06**	NA	3E-06**	NA
Barium	Child (11 to <16 yrs)	3E-07**	NA	4E-07**	NA
Barium	Child (16 to <21 yrs)	3E-07**	NA	4E-07**	NA
Beryllium	Child (1 to <2 yrs)	4E-08**	NA	5E-08**	NA
Beryllium	Child (2 to <3 yrs)	9E-08**	NA	1E-07**	NA
Beryllium	Child (3 to <6 yrs)	8E-08**	NA	1E-07**	NA
Beryllium	Child (6 to <11 yrs)	6E-08**	NA	8E-08**	NA
Beryllium	Child (11 to <16 yrs)	1E-08**	NA	1E-08**	NA
Beryllium	Child (16 to <21 yrs)	8E-09**	NA	1E-08**	NA
Boron	Child (1 to <2 yrs)	5E-06	NA	1E-05	NA

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Boron	Child (2 to <3 yrs)	1E-05	NA	2E-05	NA
Boron	Child (3 to <6 yrs)	9E-06	NA	2E-05	NA
Boron	Child (6 to <11 yrs)	7E-06	NA	1E-05	NA
Boron	Child (11 to <16 yrs)	1E-06	NA	3E-06	NA
Boron	Child (16 to <21 yrs)	9E-07	NA	2E-06	NA
Cadmium	Child (1 to <2 yrs)	4E-08**	9E-09**	5E-08**	1E-08**
Cadmium	Child (2 to <3 yrs)	9E-08**	2E-08**	1E-07**	3E-08**
Cadmium	Child (3 to <6 yrs)	8E-08**	2E-08**	1E-07**	2E-08**
Cadmium	Child (6 to <11 yrs)	6E-08**	2E-08**	8E-08**	3E-08**
Cadmium	Child (11 to <16 yrs)	1E-08**	1E-08**	1E-08**	2E-08**
Cadmium	Child (16 to <21 yrs)	8E-09**	1E-08**	1E-08**	2E-08**
Chromium (VI)	Child (1 to <2 yrs)	2E-06	NA	3E-06	NA
Chromium (VI)	Child (2 to <3 yrs)	4E-06	NA	7E-06	NA
Chromium (VI)	Child (3 to <6 yrs)	3E-06	NA	6E-06	NA
Chromium (VI)	Child (6 to <11 yrs)	3E-06	NA	5E-06	NA
Chromium (VI)	Child (11 to <16 yrs)	4E-07	NA	8E-07	NA
Chromium (VI)	Child (16 to <21 yrs)	4E-07	NA	6E-07	NA
Cobalt	Child (1 to <2 yrs)	1E-06	NA	2E-06	NA
Cobalt	Child (2 to <3 yrs)	3E-06	NA	5E-06	NA
Cobalt	Child (3 to <6 yrs)	3E-06	NA	4E-06	NA
Cobalt	Child (6 to <11 yrs)	2E-06	NA	3E-06	NA
Cobalt	Child (11 to <16 yrs)	3E-07	NA	6E-07	NA
Cobalt	Child (16 to <21 yrs)	3E-07	NA	4E-07	NA
Lithium	Child (1 to <2 yrs)	2E-06	NA	5E-06	NA
Lithium	Child (2 to <3 yrs)	5E-06	NA	1E-05	NA
Lithium	Child (3 to <6 yrs)	4E-06	NA	1E-05	NA
Lithium	Child (6 to <11 yrs)	3E-06	NA	7E-06	NA
Lithium	Child (11 to <16 yrs)	5E-07	NA	1E-06	NA
Lithium	Child (16 to <21 yrs)	4E-07	NA	1E-06	NA
Mercury (total)	Child (1 to <2 yrs)	6E-09**	NA	8E-09**	NA
Mercury (total)	Child (2 to <3 yrs)	1E-08**	NA	2E-08**	NA
Mercury (total)	Child (3 to <6 yrs)	1E-08**	NA	2E-08**	NA
Mercury (total)	Child (6 to <11 yrs)	9E-09**	NA	1E-08**	NA
Mercury (total)	Child (11 to <16 yrs)	2E-09**	NA	2E-09**	NA
Mercury (total)	Child (16 to <21 yrs)	1E-09**	NA	2E-09**	NA
Molybdenum	Child (1 to <2 yrs)	1E-07*	NA	4E-07	NA
Molybdenum	Child (2 to <3 yrs)	3E-07*	NA	1E-06	NA
Molybdenum	Child (3 to <6 yrs)	3E-07*	NA	9E-07	NA
Molybdenum	Child (6 to <11 yrs)	2E-07*	NA	7E-07	NA
Molybdenum	Child (11 to <16 yrs)	3E-08*	NA	1E-07	NA
Molybdenum	Child (16 to <21 yrs)	3E-08*	NA	9E-08	NA
Selenium	Child (1 to <2 yrs)	3E-07**	NA	3E-07**	NA
Selenium	Child (2 to <3 yrs)	6E-07**	NA	8E-07**	NA
Selenium	Child (3 to <6 yrs)	5E-07**	NA	7E-07**	NA
Selenium	Child (6 to <11 yrs)	4E-07**	NA	5E-07**	NA
Selenium	Child (11 to <16 yrs)	7E-08**	NA	9E-08**	NA

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Selenium	Child (16 to <21 yrs)	5E-08**	NA	7E-08**	NA
Silver	Child (1 to <2 yrs)	2E-07	NA	4E-07	NA
Silver	Child (2 to <3 yrs)	4E-07	NA	9E-07	NA
Silver	Child (3 to <6 yrs)	4E-07	NA	8E-07	NA
Silver	Child (6 to <11 yrs)	3E-07	NA	6E-07	NA
Silver	Child (11 to <16 yrs)	5E-08	NA	1E-07	NA
Silver	Child (16 to <21 yrs)	4E-08	NA	8E-08	NA
Thallium	Child (1 to <2 yrs)	3E-07**	NA	3E-07**	NA
Thallium	Child (2 to <3 yrs)	6E-07**	NA	8E-07**	NA
Thallium	Child (3 to <6 yrs)	5E-07**	NA	7E-07**	NA
Thallium	Child (6 to <11 yrs)	4E-07**	NA	5E-07**	NA
Thallium	Child (11 to <16 yrs)	7E-08**	NA	9E-08**	NA
Thallium	Child (16 to <21 yrs)	5E-08**	NA	7E-08**	NA

NA = not available because dermal absorption fraction for solids was not available for this chemical.

* At least some samples were detections. Value is based on a concentration that is half the RDL.

** All samples were nondetects. Value is based on a concentration that is half the RDL.

Table D-13. Cancer Exposures (mg/kg-day) for Recreational Exposure to Sediment

Chemical	Receptor	50th Percentile Concentration		95th Percentile Concentration	
		Ingestion	Dermal	Ingestion	Dermal
Arsenic (inorganic)	Child (1 to <2 yrs)	3E-08	2E-07	4E-08	3E-07
Arsenic (inorganic)	Child (2 to <3 yrs)	6E-08	4E-07	9E-08	7E-07
Arsenic (inorganic)	Child (3 to <6 yrs)	2E-07	1E-06	2E-07	1E-06
Arsenic (inorganic)	Child (6 to <11 yrs)	2E-07	2E-06	3E-07	3E-06
Arsenic (inorganic)	Child (11 to <16 yrs)	3E-08	1E-06	5E-08	2E-06
Arsenic (inorganic)	Child (16 to <21 yrs)	3E-08	1E-06	4E-08	2E-06
Chromium (VI)	Child (1 to <2 yrs)	2E-08	NA	4E-08	NA
Chromium (VI)	Child (2 to <3 yrs)	6E-08	NA	1E-07	NA
Chromium (VI)	Child (3 to <6 yrs)	1E-07	NA	3E-07	NA
Chromium (VI)	Child (6 to <11 yrs)	2E-07	NA	3E-07	NA
Chromium (VI)	Child (11 to <16 yrs)	3E-08	NA	6E-08	NA
Chromium (VI)	Child (16 to <21 yrs)	3E-08	NA	4E-08	NA

NA = not available because dermal absorption fraction for solids was not available for this chemical.

Table D-14. Noncancer Exposures (mg/kg-day) for Fish Consumption

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Inorganics			
Antimony	Child (1 to <2 yrs)	4E-05**	5E-05**
Antimony	Child (2 to <3 yrs)	4E-05**	4E-05**
Antimony	Child (3 to <6 yrs)	4E-05**	4E-05**
Antimony	Child (6 to <11 yrs)	3E-05**	3E-05**
Antimony	Child (11 to <16 yrs)	2E-05**	2E-05**
Antimony	Child (16 to <21 yrs)	2E-05**	2E-05**
Antimony	Adult (21 to <70 yrs)	3E-05**	4E-05**
Arsenic (inorganic)	Child (1 to <2 yrs)	6E-08	3E-07
Arsenic (inorganic)	Child (2 to <3 yrs)	5E-08	3E-07
Arsenic (inorganic)	Child (3 to <6 yrs)	5E-08	3E-07
Arsenic (inorganic)	Child (6 to <11 yrs)	4E-08	2E-07
Arsenic (inorganic)	Child (11 to <16 yrs)	2E-08	1E-07
Arsenic (inorganic)	Child (16 to <21 yrs)	3E-08	1E-07
Arsenic (inorganic)	Adult (21 to <70 yrs)	4E-08	2E-07
Barium	Child (1 to <2 yrs)	5E-05	6E-05
Barium	Child (2 to <3 yrs)	4E-05	5E-05
Barium	Child (3 to <6 yrs)	4E-05	5E-05
Barium	Child (6 to <11 yrs)	4E-05	4E-05
Barium	Child (11 to <16 yrs)	2E-05	2E-05
Barium	Child (16 to <21 yrs)	2E-05	3E-05
Barium	Adult (21 to <70 yrs)	4E-05	5E-05
Beryllium	Child (1 to <2 yrs)	7E-06**	7E-06**
Beryllium	Child (2 to <3 yrs)	6E-06**	6E-06**
Beryllium	Child (3 to <6 yrs)	6E-06**	6E-06**
Beryllium	Child (6 to <11 yrs)	5E-06**	5E-06**
Beryllium	Child (11 to <16 yrs)	3E-06**	3E-06**
Beryllium	Child (16 to <21 yrs)	3E-06**	3E-06**
Beryllium	Adult (21 to <70 yrs)	5E-06**	6E-06**
Boron	Child (1 to <2 yrs)	2E-04	2E-04
Boron	Child (2 to <3 yrs)	2E-04	2E-04
Boron	Child (3 to <6 yrs)	2E-04	2E-04
Boron	Child (6 to <11 yrs)	1E-04	2E-04
Boron	Child (11 to <16 yrs)	8E-05	9E-05
Boron	Child (16 to <21 yrs)	1E-04	1E-04
Boron	Adult (21 to <70 yrs)	2E-04	2E-04
Cadmium	Child (1 to <2 yrs)	4E-06**	5E-06**
Cadmium	Child (2 to <3 yrs)	4E-06**	4E-06**
Cadmium	Child (3 to <6 yrs)	4E-06**	4E-06**
Cadmium	Child (6 to <11 yrs)	3E-06**	3E-06**

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Cadmium	Child (11 to <16 yrs)	2E-06**	2E-06**
Cadmium	Child (16 to <21 yrs)	2E-06**	2E-06**
Cadmium	Adult (21 to <70 yrs)	3E-06**	4E-06**
Chromium (VI)	Child (1 to <2 yrs)	2E-05	3E-05
Chromium (VI)	Child (2 to <3 yrs)	2E-05	3E-05
Chromium (VI)	Child (3 to <6 yrs)	2E-05	3E-05
Chromium (VI)	Child (6 to <11 yrs)	1E-05	2E-05
Chromium (VI)	Child (11 to <16 yrs)	7E-06	1E-05
Chromium (VI)	Child (16 to <21 yrs)	9E-06	1E-05
Chromium (VI)	Adult (21 to <70 yrs)	1E-05	2E-05
Cobalt	Child (1 to <2 yrs)	1E-05**	1E-05**
Cobalt	Child (2 to <3 yrs)	9E-06**	1E-05**
Cobalt	Child (3 to <6 yrs)	9E-06**	1E-05**
Cobalt	Child (6 to <11 yrs)	8E-06**	8E-06**
Cobalt	Child (11 to <16 yrs)	4E-06**	4E-06**
Cobalt	Child (16 to <21 yrs)	5E-06**	6E-06**
Cobalt	Adult (21 to <70 yrs)	9E-06**	9E-06**
Lithium	Child (1 to <2 yrs)	1E-05**	1E-05**
Lithium	Child (2 to <3 yrs)	8E-06**	8E-06**
Lithium	Child (3 to <6 yrs)	8E-06**	9E-06**
Lithium	Child (6 to <11 yrs)	7E-06**	7E-06**
Lithium	Child (11 to <16 yrs)	4E-06**	4E-06**
Lithium	Child (16 to <21 yrs)	5E-06**	5E-06**
Lithium	Adult (21 to <70 yrs)	8E-06**	8E-06**
Methylmercury	Child (1 to <2 yrs)	4E-05	1E-04
Methylmercury	Child (2 to <3 yrs)	4E-05	8E-05
Methylmercury	Child (3 to <6 yrs)	4E-05	9E-05
Methylmercury	Child (6 to <11 yrs)	3E-05	7E-05
Methylmercury	Child (11 to <16 yrs)	2E-05	4E-05
Methylmercury	Child (16 to <21 yrs)	2E-05	5E-05
Methylmercury	Adult (21 to <70 yrs)	3E-05	8E-05
Molybdenum	Child (1 to <2 yrs)	4E-06	1E-05
Molybdenum	Child (2 to <3 yrs)	4E-06	1E-05
Molybdenum	Child (3 to <6 yrs)	4E-06	1E-05
Molybdenum	Child (6 to <11 yrs)	3E-06	8E-06
Molybdenum	Child (11 to <16 yrs)	2E-06	4E-06
Molybdenum	Child (16 to <21 yrs)	2E-06	5E-06
Molybdenum	Adult (21 to <70 yrs)	3E-06	9E-06
Selenium	Child (1 to <2 yrs)	7E-05	1E-04
Selenium	Child (2 to <3 yrs)	6E-05	9E-05
Selenium	Child (3 to <6 yrs)	6E-05	9E-05

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Selenium	Child (6 to <11 yrs)	5E-05	8E-05
Selenium	Child (11 to <16 yrs)	3E-05	4E-05
Selenium	Child (16 to <21 yrs)	3E-05	5E-05
Selenium	Adult (21 to <70 yrs)	6E-05	9E-05
Silver	Child (1 to <2 yrs)	1E-05**	1E-05**
Silver	Child (2 to <3 yrs)	1E-05**	1E-05**
Silver	Child (3 to <6 yrs)	1E-05**	1E-05**
Silver	Child (6 to <11 yrs)	9E-06**	9E-06**
Silver	Child (11 to <16 yrs)	5E-06**	5E-06**
Silver	Child (16 to <21 yrs)	6E-06**	6E-06**
Silver	Adult (21 to <70 yrs)	1E-05**	1E-05**
Thallium	Child (1 to <2 yrs)	1E-05*	1E-05
Thallium	Child (2 to <3 yrs)	8E-06*	1E-05
Thallium	Child (3 to <6 yrs)	8E-06*	1E-05
Thallium	Child (6 to <11 yrs)	7E-06*	8E-06
Thallium	Child (11 to <16 yrs)	4E-06*	4E-06
Thallium	Child (16 to <21 yrs)	5E-06*	5E-06
Thallium	Adult (21 to <70 yrs)	8E-06*	9E-06
Organics			
Methylnapthalene, 2-	Child (1 to <2 yrs)	8E-04**	4E-03**
Methylnapthalene, 2-	Child (2 to <3 yrs)	7E-04**	3E-03**
Methylnapthalene, 2-	Child (3 to <6 yrs)	7E-04**	3E-03**
Methylnapthalene, 2-	Child (6 to <11 yrs)	6E-04**	3E-03**
Methylnapthalene, 2-	Child (11 to <16 yrs)	3E-04**	1E-03**
Methylnapthalene, 2-	Child (16 to <21 yrs)	4E-04**	2E-03**
Methylnapthalene, 2-	Adult (21 to <70 yrs)	6E-04**	3E-03**
Naphthalene	Child (1 to <2 yrs)	8E-04**	5E-03**
Naphthalene	Child (2 to <3 yrs)	7E-04**	4E-03**
Naphthalene	Child (3 to <6 yrs)	7E-04**	4E-03**
Naphthalene	Child (6 to <11 yrs)	6E-04**	4E-03**
Naphthalene	Child (11 to <16 yrs)	3E-04**	2E-03**
Naphthalene	Child (16 to <21 yrs)	4E-04**	2E-03**
Naphthalene	Adult (21 to <70 yrs)	6E-04**	4E-03**

* At least some samples were detections. Value is based on a concentration that is half the RDL.

** All samples were nondetects. Value is based on a concentration that is half the RDL.

Table D-15. Cancer Exposures (mg/kg-day) for Fish Consumption

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Arsenic (inorganic)	Child (1 to <2 yrs)	8E-10	4E-09
Arsenic (inorganic)	Child (2 to <3 yrs)	7E-10	4E-09
Arsenic (inorganic)	Child (3 to <6 yrs)	2E-09	1E-08
Arsenic (inorganic)	Child (6 to <11 yrs)	3E-09	2E-08
Arsenic (inorganic)	Child (11 to <16 yrs)	1E-09	8E-09
Arsenic (inorganic)	Child (16 to <21 yrs)	2E-09	1E-08
Arsenic (inorganic)	Adult (21 to <70 yrs)	3E-08	2E-07
Chromium (VI)	Child (1 to <2 yrs)	3E-07	4E-07
Chromium (VI)	Child (2 to <3 yrs)	2E-07	4E-07
Chromium (VI)	Child (3 to <6 yrs)	7E-07	1E-06
Chromium (VI)	Child (6 to <11 yrs)	1E-06	2E-06
Chromium (VI)	Child (11 to <16 yrs)	5E-07	8E-07
Chromium (VI)	Child (16 to <21 yrs)	6E-07	1E-06
Chromium (VI)	Adult (21 to <70 yrs)	1E-05	2E-05

Appendix E. Detailed Risk and Hazard Results

This appendix presents noncancer hazard and cancer risk results for all age groups modeled and includes numerical results that were based on a nondetect concentration set to half the RDL. Throughout, tables are presented in the same order as the abbreviated tables in Section 4 (which contain results for only the child age group with the highest exposures based on median exposure factors and omit results based on half the RDL). In all tables, a result that exceeds the risk or hazard criterion (as defined in **Section 4.1**) are bolded.

E.1 Recreational Exposures to Water, Sand, and Sediment

The following tables correspond to **Tables 30** to **35** in **Section 5.2**:

- **Table E-1:** noncancer hazard for recreational swimming
- **Table E-2:** cancer risks for recreational swimming
- **Table E-3:** noncancer hazards for recreational exposure to beach sand
- **Table E-4:** cancer risks for recreational exposure to beach sand
- **Table E-5:** noncancer hazards for recreational exposure to sediment
- **Table E-6:** cancer risks for recreational exposure to sediment

Antimony is omitted from the Table E-1 because there were no concentration data for water. Tables E-2, E-4, and E-6 present results for only arsenic and chromium, as these were the only chemicals evaluated that had cancer toxicity endpoints (cancer slope factors).

Results exceeded the risk criteria for only one chemical/pathway: dermal exposure to arsenic in sand. HQs for this pathway exceeded 1 for all ages at both the 50th and 95th percentile of concentration in sand. At the 50th percentile, the HQs range from 1.9 (children 1 to <2 years) up to 5.3 (children 2 to <3 years). At the 95th percentile, the HQs range from 2.4 to 6.6 (for the same age groups). Ingestion HQs are considerably lower, so the total HQ is generally equal to the dermal HQ. Cancer risks for this pathway exceeded the risk criteria of 1E-4 for ages 3 to <6 years and older at the 50th percentile (risk ranging from 3E-04 to 6E-04) and for ages 2 to <3 years and older at the 95th percentile (risk ranging from 2E-04 to 7E-04).

Table E-1. Full Noncancer Results (HQs) for Recreational Swimming

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal	Total	Ingestion	Dermal	Total
Arsenic (inorganic)	Child (1 to <2 yrs)	0.007	<0.001	0.008	0.008	0.001	0.009
Arsenic (inorganic)	Child (2 to <3 yrs)	0.006	0.001	0.007	0.007	0.001	0.008
Arsenic (inorganic)	Child (3 to <6 yrs)	0.007	0.001	0.009	0.008	0.002	0.01
Arsenic (inorganic)	Child (6 to <11 yrs)	0.004	0.001	0.006	0.005	0.001	0.007
Arsenic (inorganic)	Child (11 to <16 yrs)	0.003	0.001	0.004	0.003	0.001	0.004
Arsenic (inorganic)	Child (16 to <21 yrs)	0.002	<0.001	0.003	0.002	0.001	0.003
Arsenic (inorganic)	Adult (21 to <70 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	Child (1 to <2 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	Child (2 to <3 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	Child (3 to <6 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	Child (6 to <11 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	Child (11 to <16 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	Child (16 to <21 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal	Total	Ingestion	Dermal	Total
Barium	Adult (21 to <70 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	Child (1 to <2 yrs)	<0.001**	<0.001**	0.001**	<0.001**	<0.001**	0.001**
Beryllium	Child (2 to <3 yrs)	<0.001**	0.001**	0.001**	<0.001**	0.001**	0.001**
Beryllium	Child (3 to <6 yrs)	<0.001**	0.001**	0.002**	<0.001**	0.001**	0.002**
Beryllium	Child (6 to <11 yrs)	<0.001**	0.001**	0.001**	<0.001**	0.001**	0.001**
Beryllium	Child (11 to <16 yrs)	<0.001**	0.001**	0.001**	<0.001**	0.001**	0.001**
Beryllium	Child (16 to <21 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Beryllium	Adult (21 to <70 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Boron	Child (1 to <2 yrs)	0.005	<0.001	0.006	0.005	<0.001	0.006
Boron	Child (2 to <3 yrs)	0.005	<0.001	0.005	0.005	<0.001	0.006
Boron	Child (3 to <6 yrs)	0.005	0.001	0.006	0.006	0.001	0.007
Boron	Child (6 to <11 yrs)	0.003	<0.001	0.004	0.003	<0.001	0.004
Boron	Child (11 to <16 yrs)	0.002	<0.001	0.003	0.002	<0.001	0.003
Boron	Child (16 to <21 yrs)	0.001	<0.001	0.002	0.001	<0.001	0.002
Boron	Adult (21 to <70 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	Child (1 to <2 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cadmium	Child (2 to <3 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cadmium	Child (3 to <6 yrs)	<0.001**	<0.001**	0.001**	<0.001**	<0.001**	0.001**
Cadmium	Child (6 to <11 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cadmium	Child (11 to <16 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cadmium	Child (16 to <21 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cadmium	Adult (21 to <70 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Chromium (VI)	Child (1 to <2 yrs)	<0.001	<0.001	<0.001	0.01	<0.001	0.01
Chromium (VI)	Child (2 to <3 yrs)	<0.001	<0.001	<0.001	0.01	<0.001	0.01
Chromium (VI)	Child (3 to <6 yrs)	<0.001	<0.001	<0.001	0.01	<0.001	0.01
Chromium (VI)	Child (6 to <11 yrs)	<0.001	<0.001	<0.001	0.007	<0.001	0.008
Chromium (VI)	Child (11 to <16 yrs)	<0.001	<0.001	<0.001	0.005	<0.001	0.005
Chromium (VI)	Child (16 to <21 yrs)	<0.001	<0.001	<0.001	0.003	<0.001	0.003
Chromium (VI)	Adult (21 to <70 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	Child (1 to <2 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cobalt	Child (2 to <3 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cobalt	Child (3 to <6 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cobalt	Child (6 to <11 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cobalt	Child (11 to <16 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cobalt	Child (16 to <21 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Cobalt	Adult (21 to <70 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Lithium	Child (1 to <2 yrs)	0.03	0.005	0.04	0.03	0.005	0.04
Lithium	Child (2 to <3 yrs)	0.03	0.005	0.04	0.03	0.005	0.04
Lithium	Child (3 to <6 yrs)	0.04	0.007	0.04	0.04	0.007	0.05
Lithium	Child (6 to <11 yrs)	0.02	0.006	0.03	0.02	0.006	0.03
Lithium	Child (11 to <16 yrs)	0.01	0.005	0.02	0.01	0.005	0.02
Lithium	Child (16 to <21 yrs)	0.008	0.005	0.01	0.009	0.005	0.01
Lithium	Adult (21 to <70 yrs)	0.002	0.001	0.003	0.002	0.001	0.003
Mercury (total)	Child (1 to <2 yrs)	<0.001*	<0.001*	<0.001*	<0.001	<0.001	<0.001
Mercury (total)	Child (2 to <3 yrs)	<0.001*	<0.001*	<0.001*	<0.001	<0.001	<0.001
Mercury (total)	Child (3 to <6 yrs)	<0.001*	<0.001*	<0.001*	<0.001	<0.001	0.001

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal	Total	Ingestion	Dermal	Total
Mercury (total)	Child (6 to <11 yrs)	<0.001*	<0.001*	<0.001*	<0.001	<0.001	<0.001
Mercury (total)	Child (11 to <16 yrs)	<0.001*	<0.001*	<0.001*	<0.001	<0.001	<0.001
Mercury (total)	Child (16 to <21 yrs)	<0.001*	<0.001*	<0.001*	<0.001	<0.001	<0.001
Mercury (total)	Adult (21 to <70 yrs)	<0.001*	<0.001*	<0.001*	<0.001	<0.001	<0.001
Molybdenum	Child (1 to <2 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	Child (2 to <3 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	Child (3 to <6 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	Child (6 to <11 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	Child (11 to <16 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	Child (16 to <21 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	Adult (21 to <70 yrs)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	Child (1 to <2 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Selenium	Child (2 to <3 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Selenium	Child (3 to <6 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Selenium	Child (6 to <11 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Selenium	Child (11 to <16 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Selenium	Child (16 to <21 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Selenium	Adult (21 to <70 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Silver	Child (1 to <2 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Silver	Child (2 to <3 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Silver	Child (3 to <6 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Silver	Child (6 to <11 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Silver	Child (11 to <16 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Silver	Child (16 to <21 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Silver	Adult (21 to <70 yrs)	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**
Thallium	Child (1 to <2 yrs)	0.01*	0.001*	0.01*	0.03	0.004	0.03
Thallium	Child (2 to <3 yrs)	0.009*	0.001*	0.01*	0.03	0.004	0.03
Thallium	Child (3 to <6 yrs)	0.01*	0.002*	0.01*	0.03	0.006	0.04
Thallium	Child (6 to <11 yrs)	0.006*	0.002*	0.008*	0.02	0.005	0.02
Thallium	Child (11 to <16 yrs)	0.004*	0.001*	0.005*	0.01	0.004	0.02
Thallium	Child (16 to <21 yrs)	0.002*	0.001*	0.004*	0.007	0.004	0.01
Thallium	Adult (21 to <70 yrs)	<0.001*	<0.001*	<0.001*	0.001	<0.001	0.002

No values exceed the risk criterion of HQ = 1.

* At least some samples were detections. Value is based on a concentration that is half the RDL.

** All samples were nondetects. Value is based on a concentration that is half the RDL.

Table E-2. Full Cancer Risk Results for Recreational Swimming

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal	Total	Ingestion	Dermal	Total
Arsenic (inorganic)	Child (1 to <2 yrs)	2E-07	3E-08	2E-07	2E-07	3E-08	2E-07
Arsenic (inorganic)	Child (2 to <3 yrs)	2E-07	3E-08	2E-07	2E-07	3E-08	2E-07
Arsenic (inorganic)	Child (3 to <6 yrs)	6E-07	1E-07	7E-07	7E-07	1E-07	8E-07
Arsenic (inorganic)	Child (6 to <11 yrs)	6E-07	2E-07	8E-07	7E-07	2E-07	9E-07
Arsenic (inorganic)	Child (11 to <16 yrs)	4E-07	1E-07	5E-07	4E-07	2E-07	6E-07
Arsenic (inorganic)	Child (16 to <21 yrs)	2E-07	1E-07	4E-07	3E-07	2E-07	4E-07
Arsenic (inorganic)	Adult (21 to <70 yrs)	4E-07	3E-07	7E-07	5E-07	3E-07	8E-07
Chromium (VI)	Child (1 to <2 yrs)	1E-09	5E-11	1E-09	2E-08	9E-10	2E-08
Chromium (VI)	Child (2 to <3 yrs)	1E-09	5E-11	1E-09	2E-08	1E-09	2E-08
Chromium (VI)	Child (3 to <6 yrs)	4E-09	2E-10	4E-09	7E-08	4E-09	8E-08
Chromium (VI)	Child (6 to <11 yrs)	4E-09	3E-10	4E-09	7E-08	6E-09	8E-08
Chromium (VI)	Child (11 to <16 yrs)	3E-09	3E-10	3E-09	5E-08	5E-09	5E-08
Chromium (VI)	Child (16 to <21 yrs)	2E-09	2E-10	2E-09	3E-08	4E-09	3E-08
Chromium (VI)	Adult (21 to <70 yrs)	3E-09	5E-10	3E-09	5E-08	1E-08	6E-08

No values exceed the risk criterion of risk = 1E-4.

Table E-3. Full Noncancer Results (HQs) for Recreational Exposure to Beach Sand

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal†	Total	Ingestion	Dermal†	Total
Antimony	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Antimony	Child (2 to <3 yrs)	0.001**	NA	0.001**	0.001**	NA	0.001**
Antimony	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	0.001**	NA	0.001**
Antimony	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Antimony	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Antimony	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Arsenic (inorg.)	Child (1 to <2 yrs)	0.02	0.007	0.03	0.03	0.009	0.04
Arsenic (inorg.)	Child (2 to <3 yrs)	0.05	0.02	0.07	0.07	0.02	0.09
Arsenic (inorg.)	Child (3 to <6 yrs)	0.05	0.01	0.06	0.06	0.01	0.07
Arsenic (inorg.)	Child (6 to <11 yrs)	0.04	0.01	0.05	0.05	0.02	0.06
Arsenic (inorg.)	Child (11 to <16 yrs)	0.006	0.01	0.02	0.008	0.01	0.02
Arsenic (inorg.)	Child (16 to <21 yrs)	0.005	0.009	0.01	0.006	0.01	0.02
Barium	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (2 to <3 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (2 to <3 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal†	Total	Ingestion	Dermal†	Total
Beryllium	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Boron	Child (1 to <2 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (2 to <3 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (3 to <6 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (6 to <11 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (11 to <16 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (16 to <21 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Cadmium	Child (1 to <2 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (2 to <3 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (3 to <6 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (6 to <11 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (11 to <16 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (16 to <21 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Chromium (VI)	Child (1 to <2 yrs)	0.001	NA	0.001	0.002	NA	0.002
Chromium (VI)	Child (2 to <3 yrs)	0.003	NA	0.003	0.005	NA	0.005
Chromium (VI)	Child (3 to <6 yrs)	0.002	NA	0.002	0.005	NA	0.005
Chromium (VI)	Child (6 to <11 yrs)	0.002	NA	0.002	0.004	NA	0.004
Chromium (VI)	Child (11 to <16 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Chromium (VI)	Child (16 to <21 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Cobalt	Child (1 to <2 yrs)	0.003	NA	0.003	0.007	NA	0.007
Cobalt	Child (2 to <3 yrs)	0.008	NA	0.008	0.02	NA	0.02
Cobalt	Child (3 to <6 yrs)	0.007	NA	0.007	0.01	NA	0.01
Cobalt	Child (6 to <11 yrs)	0.005	NA	0.005	0.01	NA	0.01
Cobalt	Child (11 to <16 yrs)	<0.001	NA	<0.001	0.002	NA	0.002
Cobalt	Child (16 to <21 yrs)	<0.001	NA	<0.001	0.001	NA	0.001
Lithium	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Lithium	Child (2 to <3 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Lithium	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Lithium	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Lithium	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Lithium	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (2 to <3 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Molybdenum	Child (1 to <2 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal†	Total	Ingestion	Dermal†	Total
Molybdenum	Child (2 to <3 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Molybdenum	Child (3 to <6 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Molybdenum	Child (6 to <11 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Molybdenum	Child (11 to <16 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Molybdenum	Child (16 to <21 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Selenium	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (2 to <3 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Silver	Child (1 to <2 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (2 to <3 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (3 to <6 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (6 to <11 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (11 to <16 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (16 to <21 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Thallium	Child (1 to <2 yrs)	0.02**	NA	0.02**	0.02**	NA	0.02**
Thallium	Child (2 to <3 yrs)	0.05**	NA	0.05**	0.05**	NA	0.05**
Thallium	Child (3 to <6 yrs)	0.04**	NA	0.04**	0.04**	NA	0.04**
Thallium	Child (6 to <11 yrs)	0.03**	NA	0.03**	0.03**	NA	0.03**
Thallium	Child (11 to <16 yrs)	0.005**	NA	0.005**	0.006**	NA	0.006**
Thallium	Child (16 to <21 yrs)	0.004**	NA	0.004**	0.005**	NA	0.005**

No values exceed the risk criterion of HQ = 1.

* At least some samples were detections. Value is based on a concentration that is half the RDL.

** All samples were nondetects. Value is based on a concentration that is half the RDL.

† Dermal results are not available for chemicals without a recommended dermal absorption fraction in RAGS Pt E.

Table E-4. Full Cancer Risk Results for Recreational Exposure to Beach Sand

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentation		
		Ingestion	Dermal†	Total	Ingestion	Dermal†	Total
Arsenic (inorganic)	Child (1 to <2 yrs)	7E-07	2E-07	8E-07	8E-07	2E-07	1E-06
Arsenic (inorganic)	Child (2 to <3 yrs)	1E-06	5E-07	2E-06	2E-06	6E-07	2E-06
Arsenic (inorganic)	Child (3 to <6 yrs)	4E-06	1E-06	5E-06	5E-06	1E-06	6E-06
Arsenic (inorganic)	Child (6 to <11 yrs)	5E-06	2E-06	7E-06	6E-06	2E-06	8E-06
Arsenic (inorganic)	Child (11 to <16 yrs)	8E-07	1E-06	2E-06	1E-06	2E-06	3E-06
Arsenic (inorganic)	Child (16 to <21 yrs)	7E-07	1E-06	2E-06	9E-07	2E-06	2E-06
Chromium (VI)	Child (1 to <2 yrs)	3E-09	NA	3E-09	5E-09	NA	5E-09
Chromium (VI)	Child (2 to <3 yrs)	6E-09	NA	6E-09	1E-08	NA	1E-08
Chromium (VI)	Child (3 to <6 yrs)	2E-08	NA	2E-08	3E-08	NA	3E-08
Chromium (VI)	Child (6 to <11 yrs)	2E-08	NA	2E-08	4E-08	NA	4E-08
Chromium (VI)	Child (11 to <16 yrs)	3E-09	NA	3E-09	6E-09	NA	6E-09
Chromium (VI)	Child (16 to <21 yrs)	3E-09	NA	3E-09	5E-09	NA	5E-09

No values exceed the risk criterion of risk = 1E-4.

† Dermal results are not available for chemicals without a recommended dermal absorption fraction in RAGS Pt E.

Table E-5. Full Noncancer Results (HQs) for Recreational Exposure to Sediment

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal†	Total	Ingestion	Dermal†	Total
Antimony	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Antimony	Child (2 to <3 yrs)	0.001**	NA	0.001**	0.002**	NA	0.002**
Antimony	Child (3 to <6 yrs)	0.001**	NA	0.001**	0.002**	NA	0.002**
Antimony	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	0.001**	NA	0.001**
Antimony	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Antimony	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Arsenic (inorg.)	Child (1 to <2 yrs)	0.03	0.2	0.2	0.05	0.3	0.4
Arsenic (inorg.)	Child (2 to <3 yrs)	0.07	0.5	0.6	0.1	0.8	0.9
Arsenic (inorg.)	Child (3 to <6 yrs)	0.06	0.4	0.4	0.09	0.6	0.7
Arsenic (inorg.)	Child (6 to <11 yrs)	0.05	0.4	0.5	0.07	0.7	0.7
Arsenic (inorg.)	Child (11 to <16 yrs)	0.008	0.3	0.3	0.01	0.5	0.5
Arsenic (inorg.)	Child (16 to <21 yrs)	0.006	0.3	0.3	0.01	0.4	0.5
Barium	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (2 to <3 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Barium	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (2 to <3 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal†	Total	Ingestion	Dermal†	Total
Beryllium	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Beryllium	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Boron	Child (1 to <2 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (2 to <3 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (3 to <6 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (6 to <11 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (11 to <16 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Boron	Child (16 to <21 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Cadmium	Child (1 to <2 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (2 to <3 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (3 to <6 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (6 to <11 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (11 to <16 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Cadmium	Child (16 to <21 yrs)	<0.001**	<0.001	<0.001**	<0.001**	<0.001	<0.001**
Chromium (VI)	Child (1 to <2 yrs)	0.002	NA	0.002	0.003	NA	0.003
Chromium (VI)	Child (2 to <3 yrs)	0.004	NA	0.004	0.008	NA	0.008
Chromium (VI)	Child (3 to <6 yrs)	0.004	NA	0.004	0.007	NA	0.007
Chromium (VI)	Child (6 to <11 yrs)	0.003	NA	0.003	0.005	NA	0.005
Chromium (VI)	Child (11 to <16 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Chromium (VI)	Child (16 to <21 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Cobalt	Child (1 to <2 yrs)	0.004	NA	0.004	0.007	NA	0.007
Cobalt	Child (2 to <3 yrs)	0.01	NA	0.01	0.02	NA	0.02
Cobalt	Child (3 to <6 yrs)	0.008	NA	0.008	0.01	NA	0.01
Cobalt	Child (6 to <11 yrs)	0.006	NA	0.006	0.01	NA	0.01
Cobalt	Child (11 to <16 yrs)	0.001	NA	0.001	0.002	NA	0.002
Cobalt	Child (16 to <21 yrs)	<0.001	NA	<0.001	0.001	NA	0.001
Lithium	Child (1 to <2 yrs)	0.001	NA	0.001	0.002	NA	0.002
Lithium	Child (2 to <3 yrs)	0.002	NA	0.002	0.005	NA	0.005
Lithium	Child (3 to <6 yrs)	0.002	NA	0.002	0.005	NA	0.005
Lithium	Child (6 to <11 yrs)	0.002	NA	0.002	0.004	NA	0.004
Lithium	Child (11 to <16 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Lithium	Child (16 to <21 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Mercury (total)	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (2 to <3 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Mercury (total)	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Molybdenum	Child (1 to <2 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Molybdenum	Child (2 to <3 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal†	Total	Ingestion	Dermal†	Total
Molybdenum	Child (3 to <6 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Molybdenum	Child (6 to <11 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Molybdenum	Child (11 to <16 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Molybdenum	Child (16 to <21 yrs)	<0.001*	NA	<0.001*	<0.001	NA	<0.001
Selenium	Child (1 to <2 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (2 to <3 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (3 to <6 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (6 to <11 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (11 to <16 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Selenium	Child (16 to <21 yrs)	<0.001**	NA	<0.001**	<0.001**	NA	<0.001**
Silver	Child (1 to <2 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (2 to <3 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (3 to <6 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (6 to <11 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (11 to <16 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Silver	Child (16 to <21 yrs)	<0.001	NA	<0.001	<0.001	NA	<0.001
Thallium	Child (1 to <2 yrs)	0.03**	NA	0.03**	0.03**	NA	0.03**
Thallium	Child (2 to <3 yrs)	0.06**	NA	0.06**	0.08**	NA	0.08**
Thallium	Child (3 to <6 yrs)	0.05**	NA	0.05**	0.07**	NA	0.07**
Thallium	Child (6 to <11 yrs)	0.04**	NA	0.04**	0.05**	NA	0.05**
Thallium	Child (11 to <16 yrs)	0.007**	NA	0.007**	0.009**	NA	0.009**
Thallium	Child (16 to <21 yrs)	0.005**	NA	0.005**	0.007**	NA	0.007**

No values exceed the risk criterion of HQ = 1.

* At least some samples were detections. Value is based on a concentration that is half the RDL.

** All samples were nondetects. Value is based on a concentration that is half the RDL.

† Dermal results are not available for chemicals without a recommended dermal absorption fraction in RAGS Pt E.

Table E-6. Full Cancer Risk Results for Recreational Exposure to Sediment

Chemical	Receptor	50th Percentile Concentration			95th Percentile Concentration		
		Ingestion	Dermal†	Total	Ingestion	Dermal†	Total
Arsenic (inorganic)	Child (1 to <2 yrs)	8E-07	5E-06	6E-06	1E-06	8E-06	1E-05
Arsenic (inorganic)	Child (2 to <3 yrs)	2E-06	1E-05	2E-05	3E-06	2E-05	2E-05
Arsenic (inorganic)	Child (3 to <6 yrs)	5E-06	3E-05	4E-05	8E-06	5E-05	6E-05
Arsenic (inorganic)	Child (6 to <11 yrs)	6E-06	6E-05	7E-05	1E-05	9E-05	1E-04
Arsenic (inorganic)	Child (11 to <16 yrs)	1E-06	5E-05	5E-05	2E-06	7E-05	7E-05
Arsenic (inorganic)	Child (16 to <21 yrs)	8E-07	4E-05	4E-05	1E-06	6E-05	6E-05
Chromium (VI)	Child (1 to <2 yrs)	4E-09	NA	4E-09	7E-09	NA	7E-09
Chromium (VI)	Child (2 to <3 yrs)	9E-09	NA	9E-09	2E-08	NA	2E-08
Chromium (VI)	Child (3 to <6 yrs)	2E-08	NA	2E-08	4E-08	NA	4E-08
Chromium (VI)	Child (6 to <11 yrs)	3E-08	NA	3E-08	5E-08	NA	5E-08
Chromium (VI)	Child (11 to <16 yrs)	5E-09	NA	5E-09	9E-09	NA	9E-09
Chromium (VI)	Child (16 to <21 yrs)	4E-09	NA	4E-09	7E-09	NA	7E-09

No values exceed the risk criterion of risk = 1E-4.

† Dermal results are not available for chemicals without a recommended dermal absorption fraction in RAGS Pt E.

E.2 Fish Consumption

The following tables correspond to **Tables 36** and **37** in **Section 5.3**:

- **Table E-7:** noncancer hazard for fish consumption
- **Table E-8:** cancer risks for fish consumption

Table E-8 presents results for only arsenic and chromium, as these were the only chemicals evaluated that had cancer toxicity endpoints (cancer slope factors).

Results exceeded the risk criteria only for thallium at the 95th percentile of concentration in fish filet for children 1 to <2 years, where the HQ is 1.2. All other HQs were less than 1, and all cancer risks were less than 1E-4.

Table E-7. Full Noncancer Results (HQs) for Fish Consumption

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Inorganics			
Antimony	Child (1 to <2 yrs)	0.1**	0.1**
Antimony	Child (2 to <3 yrs)	0.09**	0.1**
Antimony	Child (3 to <6 yrs)	0.09**	0.1**
Antimony	Child (6 to <11 yrs)	0.08**	0.08**
Antimony	Child (11 to <16 yrs)	0.04**	0.04**
Antimony	Child (16 to <21 yrs)	0.05**	0.06**
Antimony	Adult (21 to <70 yrs)	0.09**	0.09**
Arsenic (inorganic)	Child (1 to <2 yrs)	<0.001	0.005
Arsenic (inorganic)	Child (2 to <3 yrs)	<0.001	0.004
Arsenic (inorganic)	Child (3 to <6 yrs)	<0.001	0.004
Arsenic (inorganic)	Child (6 to <11 yrs)	<0.001	0.004
Arsenic (inorganic)	Child (11 to <16 yrs)	<0.001	0.002
Arsenic (inorganic)	Child (16 to <21 yrs)	<0.001	0.002
Arsenic (inorganic)	Adult (21 to <70 yrs)	<0.001	0.004
Barium	Child (1 to <2 yrs)	<0.001	<0.001
Barium	Child (2 to <3 yrs)	<0.001	<0.001
Barium	Child (3 to <6 yrs)	<0.001	<0.001
Barium	Child (6 to <11 yrs)	<0.001	<0.001
Barium	Child (11 to <16 yrs)	<0.001	<0.001
Barium	Child (16 to <21 yrs)	<0.001	<0.001
Barium	Adult (21 to <70 yrs)	<0.001	<0.001
Beryllium	Child (1 to <2 yrs)	0.003**	0.004**
Beryllium	Child (2 to <3 yrs)	0.003**	0.003**
Beryllium	Child (3 to <6 yrs)	0.003**	0.003**
Beryllium	Child (6 to <11 yrs)	0.002**	0.003**
Beryllium	Child (11 to <16 yrs)	0.001**	0.001**
Beryllium	Child (16 to <21 yrs)	0.002**	0.002**
Beryllium	Adult (21 to <70 yrs)	0.003**	0.003**
Boron	Child (1 to <2 yrs)	0.001	0.001

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Boron	Child (2 to <3 yrs)	<0.001	0.001
Boron	Child (3 to <6 yrs)	<0.001	0.001
Boron	Child (6 to <11 yrs)	<0.001	<0.001
Boron	Child (11 to <16 yrs)	<0.001	<0.001
Boron	Child (16 to <21 yrs)	<0.001	<0.001
Boron	Adult (21 to <70 yrs)	<0.001	<0.001
Cadmium	Child (1 to <2 yrs)	0.009**	0.009**
Cadmium	Child (2 to <3 yrs)	0.007**	0.008**
Cadmium	Child (3 to <6 yrs)	0.008**	0.008**
Cadmium	Child (6 to <11 yrs)	0.006**	0.007**
Cadmium	Child (11 to <16 yrs)	0.003**	0.003**
Cadmium	Child (16 to <21 yrs)	0.004**	0.004**
Cadmium	Adult (21 to <70 yrs)	0.007**	0.007**
Chromium (VI)	Child (1 to <2 yrs)	0.02	0.03
Chromium (VI)	Child (2 to <3 yrs)	0.02	0.03
Chromium (VI)	Child (3 to <6 yrs)	0.02	0.03
Chromium (VI)	Child (6 to <11 yrs)	0.02	0.02
Chromium (VI)	Child (11 to <16 yrs)	0.008	0.01
Chromium (VI)	Child (16 to <21 yrs)	0.01	0.02
Chromium (VI)	Adult (21 to <70 yrs)	0.02	0.03
Cobalt	Child (1 to <2 yrs)	0.04**	0.04**
Cobalt	Child (2 to <3 yrs)	0.03**	0.03**
Cobalt	Child (3 to <6 yrs)	0.03**	0.03**
Cobalt	Child (6 to <11 yrs)	0.03**	0.03**
Cobalt	Child (11 to <16 yrs)	0.01**	0.01**
Cobalt	Child (16 to <21 yrs)	0.02**	0.02**
Cobalt	Adult (21 to <70 yrs)	0.03**	0.03**
Lithium	Child (1 to <2 yrs)	0.005**	0.005**
Lithium	Child (2 to <3 yrs)	0.004**	0.004**
Lithium	Child (3 to <6 yrs)	0.004**	0.004**
Lithium	Child (6 to <11 yrs)	0.004**	0.004**
Lithium	Child (11 to <16 yrs)	0.002**	0.002**
Lithium	Child (16 to <21 yrs)	0.002**	0.002**
Lithium	Adult (21 to <70 yrs)	0.004**	0.004**
Methylmercury	Child (1 to <2 yrs)	0.4	1.0
Methylmercury	Child (2 to <3 yrs)	0.4	0.8
Methylmercury	Child (3 to <6 yrs)	0.4	0.9
Methylmercury	Child (6 to <11 yrs)	0.3	0.7
Methylmercury	Child (11 to <16 yrs)	0.2	0.4
Methylmercury	Child (16 to <21 yrs)	0.2	0.5
Methylmercury	Adult (21 to <70 yrs)	0.3	0.8

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Molybdenum	Child (1 to <2 yrs)	<0.001	0.002
Molybdenum	Child (2 to <3 yrs)	<0.001	0.002
Molybdenum	Child (3 to <6 yrs)	<0.001	0.002
Molybdenum	Child (6 to <11 yrs)	<0.001	0.002
Molybdenum	Child (11 to <16 yrs)	<0.001	<0.001
Molybdenum	Child (16 to <21 yrs)	<0.001	0.001
Molybdenum	Adult (21 to <70 yrs)	<0.001	0.002
Selenium	Child (1 to <2 yrs)	0.01	0.02
Selenium	Child (2 to <3 yrs)	0.01	0.02
Selenium	Child (3 to <6 yrs)	0.01	0.02
Selenium	Child (6 to <11 yrs)	0.01	0.02
Selenium	Child (11 to <16 yrs)	0.005	0.008
Selenium	Child (16 to <21 yrs)	0.007	0.01
Selenium	Adult (21 to <70 yrs)	0.01	0.02
Silver	Child (1 to <2 yrs)	0.002**	0.002**
Silver	Child (2 to <3 yrs)	0.002**	0.002**
Silver	Child (3 to <6 yrs)	0.002**	0.002**
Silver	Child (6 to <11 yrs)	0.002**	0.002**
Silver	Child (11 to <16 yrs)	<0.001**	<0.001**
Silver	Child (16 to <21 yrs)	0.001**	0.001**
Silver	Adult (21 to <70 yrs)	0.002**	0.002**
Thallium	Child (1 to <2 yrs)	1*	**1.2**
Thallium	Child (2 to <3 yrs)	0.8*	1
Thallium	Child (3 to <6 yrs)	0.8*	1
Thallium	Child (6 to <11 yrs)	0.7*	0.8
Thallium	Child (11 to <16 yrs)	0.4*	0.4
Thallium	Child (16 to <21 yrs)	0.5*	0.5
Thallium	Adult (21 to <70 yrs)	0.8*	0.9
Organics			
Methylnapthalene, 2-	Child (1 to <2 yrs)	0.2**	0.9**
Methylnapthalene, 2-	Child (2 to <3 yrs)	0.2**	0.8**
Methylnapthalene, 2-	Child (3 to <6 yrs)	0.2**	0.8**
Methylnapthalene, 2-	Child (6 to <11 yrs)	0.1**	0.7**
Methylnapthalene, 2-	Child (11 to <16 yrs)	0.1**	0.4**
Methylnapthalene, 2-	Child (16 to <21 yrs)	0.09**	0.4**
Methylnapthalene, 2-	Adult (21 to <70 yrs)	0.2**	0.7**
Naphthalene	Child (1 to <2 yrs)	0.04**	0.2**
Naphthalene	Child (2 to <3 yrs)	0.03**	0.2**
Naphthalene	Child (3 to <6 yrs)	0.03**	0.2**
Naphthalene	Child (6 to <11 yrs)	0.03**	0.2**
Naphthalene	Child (11 to <16 yrs)	0.01**	0.09**

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Naphthalene	Child (16 to <21 yrs)	0.02**	0.1**
Naphthalene	Adult (21 to <70 yrs)	0.03**	0.2**

Values in **bold with yellow shading** exceed the risk criterion of HQ = 1.

* At least some samples were detections. Value is based on a concentration that is half the RDL.

** All samples were nondetects. Value is based on a concentration that is half the RDL.

Table E-8. Full Cancer Risk Results for Fish Consumption

Chemical	Receptor	50th Percentile Concentration	95th Percentile Concentration
Arsenic (inorganic)	Child (1 to <2 yrs)	3E-08	1E-07
Arsenic (inorganic)	Child (2 to <3 yrs)	2E-08	1E-07
Arsenic (inorganic)	Child (3 to <6 yrs)	7E-08	4E-07
Arsenic (inorganic)	Child (6 to <11 yrs)	9E-08	5E-07
Arsenic (inorganic)	Child (11 to <16 yrs)	5E-08	3E-07
Arsenic (inorganic)	Child (16 to <21 yrs)	6E-08	3E-07
Arsenic (inorganic)	Adult (21 to <70 yrs)	1E-06	5E-06
Chromium (VI)	Child (1 to <2 yrs)	4E-08	7E-08
Chromium (VI)	Child (2 to <3 yrs)	4E-08	6E-08
Chromium (VI)	Child (3 to <6 yrs)	1E-07	2E-07
Chromium (VI)	Child (6 to <11 yrs)	2E-07	2E-07
Chromium (VI)	Child (11 to <16 yrs)	8E-08	1E-07
Chromium (VI)	Child (16 to <21 yrs)	1E-07	2E-07
Chromium (VI)	Adult (21 to <70 yrs)	2E-06	3E-06

No values exceed the risk criterion of risk = 1E-4.

PRESORTED STANDARD
POSTAGE & FEES PAID
EPA
PERMIT NO. G-35

Office of Research and Development (8101R)
Washington, DC 20460

Official Business
Penalty for Private Use
$300