United States
Environmental Protection
Agency

2022 EPA Guam Deep Ocean Disposal Site Monitoring and Assessment Report

Prepared by:

The Marine Protection, Research and Sanctuaries Act Program

USEPA Region 9

San Francisco, CA

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1 EXECUTIVE SUMMARY

In the United States, dredged material is currently the primary material disposed into the ocean. Dredged material is sediment excavated or otherwise removed in order to maintain safe navigation channels in the navigable waters of the United States. Under the Marine Protection, Research, and Sanctuaries Act (MPRSA), the U.S. Environmental Protection Agency (EPA) is responsible for designating and managing ocean disposal sites for the permitted disposal of materials. EPA Region 9 manages 12 ocean disposal sites along the California coast and throughout the Pacific Islands for disposal of suitable dredged material.

EPA designated the Guam Deep Ocean Disposal Site (G-DODS) in 2010, offshore of Apra Harbor, Guam. In May of 2022, EPA conducted the first comprehensive monitoring survey at the G-DODS since its designation. The monitoring was intended to verify that permitted disposal does not cause unanticipated or significant adverse effects and that all the terms of MPRSA permits are met. For this survey, EPA collected sediment profile images (SPI) and plan view images (PV) to evaluate dredged sediment deposition and benthic habitat condition, as well as sediment samples for grain size and chemistry.

Based on the results, it appears that the pre-disposal sediment testing program has protected the G-DODS and surrounding areas from adverse contaminant loading. The bulk of the dredged material disposed in the last decade appears to have been deposited properly within the site boundaries. There are minor and localized physical impacts from dredged material disposal, as expected, but no significant adverse impacts are apparent to the benthic environment outside of site boundaries. Continued use of the G-DODS, under an updated Site Management and Monitoring Plan (SMMP), is recommended.

2 INTRODUCTION

2.1 Site Description

The EPA-designated Guam Deep Ocean Disposal Site (G-DODS) is located approximately 11.1 nautical miles (NM; 20.6 kilometers [km]) offshore of Guam, northwest of the entrance to Apra Harbor, at a depth of 2,680 meters (m) (Figure 2-1). The G-DODS is circular in shape with a diameter of 3 NM (5.6 km) on the seafloor, centered at 13° 35.500’ N and 144° 28.733’ E (NAD 1983). The 2022 survey covered an area of approximately 12 NM^2, oriented within and around the disposal site and including the G-DODS reference site (Figure 2-2).

The G-DODS was designated for the disposal of dredged material, primarily from port and naval facilities in Apra Harbor and other locations around Guam. Prior to the 2022 survey, the G-DODS had only received approximately 138,000 cy of material, from a single project in 2017.

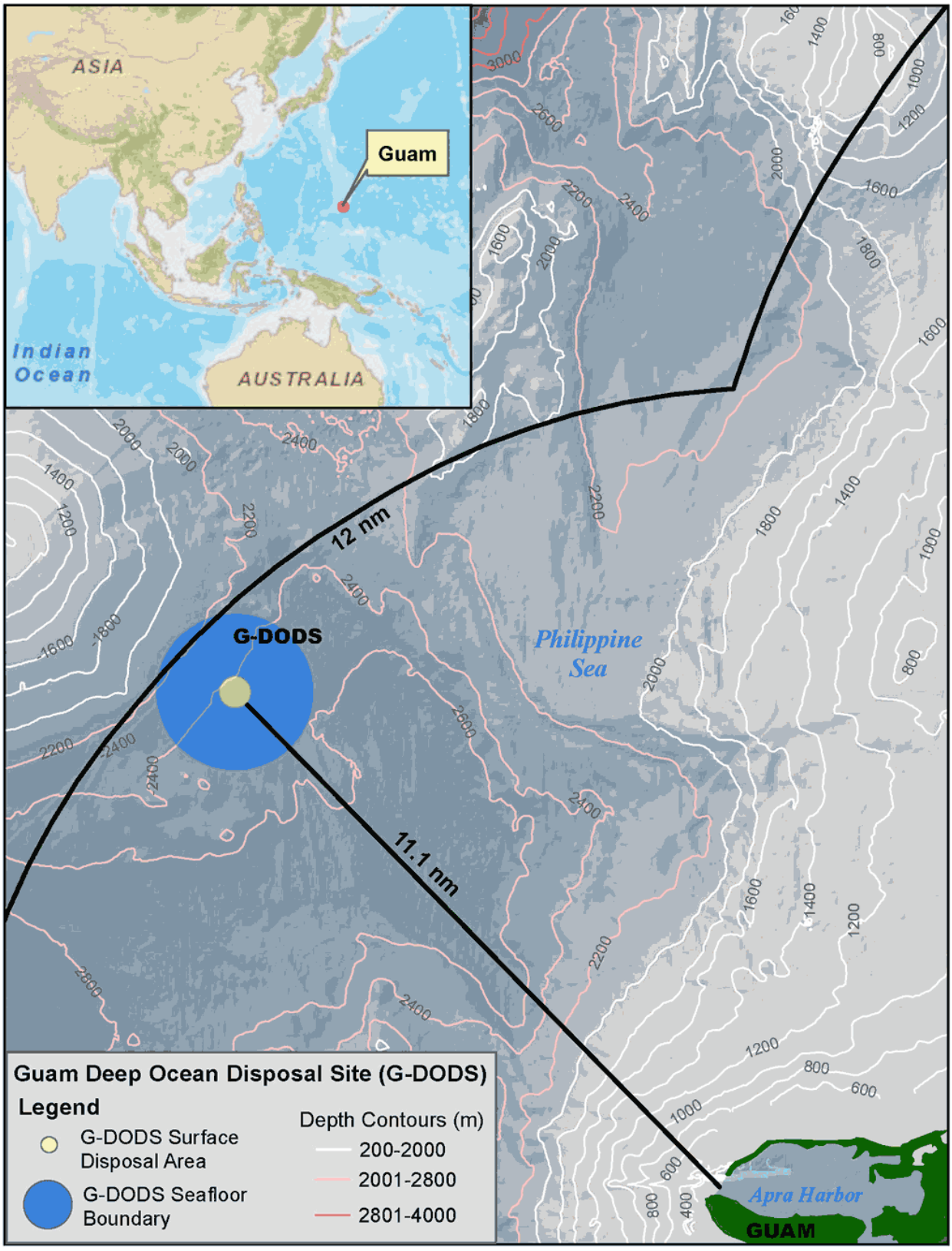

Figure 2-1. Topographic overview map of Guam Deep Ocean Disposal Site (G-DODS) in relation to Apra Harbor.

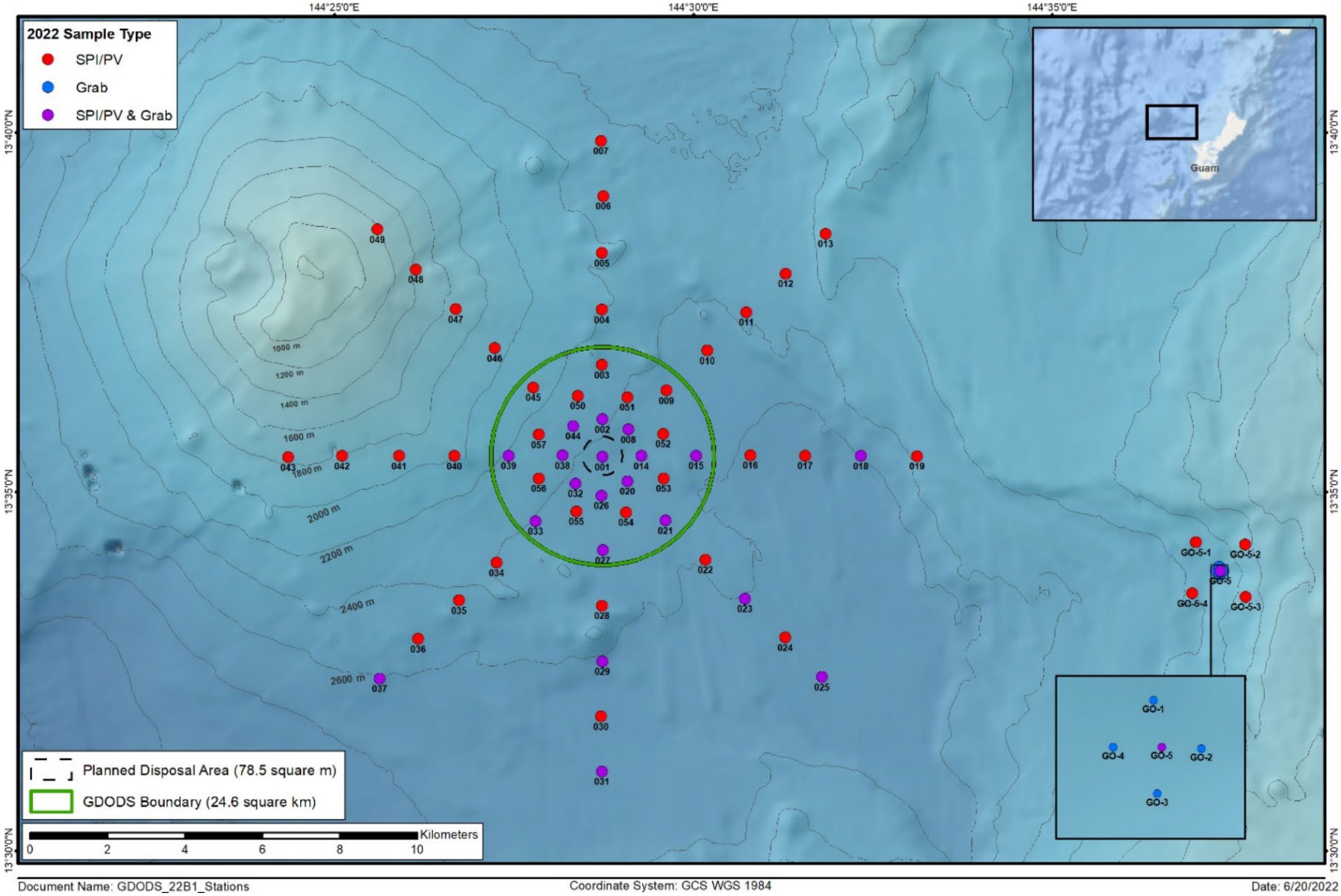

Figure 2-2. Map depicting the area covered during the 2022 G-DODS monitoring survey.

2.2 Previous Monitoring

The 2022 survey was the first time the G-DODS had been monitored since its designation in 2010. The only monitoring conducted prior to the 2022 survey was for the site designation, as described in the Final Environmental Impact Statement (FEIS) (USEPA, 2010) and the baseline surveys conducted for site designation (US Navy, 2009). The baseline surveys conducted for site designation included several field efforts: current meters were placed in January 2008 and retrieved in December 2008; water, sediment, benthic and fish community samples were collected in April 2008 (US Navy, 2009). The 2008 field studies covered two potential alternative disposal areas, and the results predominantly pertaining to the area encompassing the current G-DODS (referred to as the Northwest Alternative in the FEIS) are described in more detail below.

Oceanographic Current Evaluation (January – December 2008)

Two oceanographic current meter arrays were moored to the seafloor in between the two alternative areas (the North and Northwest Alternatives) to collect in situ current data, and the commonalities are outlined in the paragraphs below. Current data was then used to confirm modelling results and further evaluate the area of sediment deposits on the seafloor.

Surface currents (at 25 m) varied throughout the study period, shifting from a west-southwesterly direction from January to April, to a predominantly westerly direction in May and in a west, southwesterly direction in June. The months of July and August showed the greatest variability in current direction, trending from northeast to northwest to southwest, and these months also had the highest measured current velocities (0.54 m/s). The currents then shifted from a predominantly southwest direction in September to an almost exclusively west, southwesterly direction from October to early December. Surface current directions at 50 m to 150 m often ran counter to the directions of currents at 25 m.

Mid-water currents (at ~300 m) generally flowed predominantly in a northerly, northeasterly direction from mid-February to April and in a southerly direction from June to July. Mid-water currents (at ~1,000 m) flowed predominantly in a southeasterly to southwesterly direction throughout the majority of the year. The current direction was generally erratic during the months of January, April, and November and corresponded to periods in which below average current velocities were recorded. During the months of May, October, and most of July and August, currents consistently flowed in a southerly or southwesterly direction. Throughout the months of June and September, the currents trended in a northeasterly to northwesterly direction. Mid-water currents (at ~1,700 m) were generally less organized than those observed at other depths, flowing predominantly in either a northerly, northwesterly, or southwesterly direction for the majority of the year. The directions varied between the two arrays. During all other times of the year, current flow was disorganized and erratic, rarely flowing in the same direction for longer than two or three days at a time.

Bottom currents (at ~2,200 m) were somewhat organized, flowing in a north, northwesterly direction approximately 60-70% of the year. The currents then shifted between northerly and southerly between the months of May to October, depending on the location of the array. The currents returned to trending in a northerly direction in November. Average yearly current velocities were 0.018 m/s at 2,285 m in depth. The months of March and January had the

highest average current velocity (0.024 m/s and 0.039 m/s, respectively, depending on the array location).

Water Column Sampling (April 2008)

A Seabird Electronics SBE 9*plus* conductivity/temperature/depth (CTD) was deployed to measure full oceanographic profiles of physical water quality parameters such as conductivity, temperature, dissolved oxygen, transmissivity, and turbidity. Water samples were collected by interfacing a Seabird Electronics SBE 11*plus* V2 deck unit with a Seabird Electronics SBE 32 Carousel outfitted with 24 General Oceanics 10-L Niskin water samplers.

Transmissivity and turbidity values were relatively constant throughout the entire water column with minor changes. Transmissivity measurements in surface waters were fairly constant at 85.2% and increased slightly to 85.7% approaching the mid-water column, remaining elevated through to the bottom water. Turbidity averaged 43.9 NTU. Minimum turbidity values were measured just below the thermocline, averaging about 42.2 NTU. Turbidity increased slightly through the remainder of the water column, reaching an average value of 44.9 NTU near the seafloor.

Dissolved oxygen concentrations were greatest near the surface (averaging 5.98 mg/L at 15 m and reaching a maximum of 6.16 mg/L at 80m), decreasing to a minimum at about 550 m (2.21 mg/L). Dissolved oxygen concentrations then slowly increased to 3.92 mg/L near the seafloor.

Temperature remained relatively constant in the surface layer (around 28.2 °C), then decreased rapidly through the thermocline layer. The top of the thermocline was located between approximately 125 and 150 m, and approximately 240 m thick, with an average temperature of 27.2 °C. Below the thermocline, temperatures gradually decreased from an average of 10.5 °C to an average of 1.8°C at the ocean floor (at ~100 m above the bottom at all stations).

Salinity concentrations also remained constant in the mixed surface layer at 34.5 ppth, then increased sharply near the top of the thermocline, to a maximum concentration of 35.1 ppth at about 170 m. Salinity then decreased to a minimum concentration of 34.3 ppth near the bottom of the thermocline (425 m). Below the thermocline, salinity remained constant, having an average concentration of 34.6 ppth near the seafloor.

Conventional and chemical analyses were also performed on water samples from four discrete depths in the Northwest Alternative area. Analyses included nitrogen (ammonia, nitrate, nitrite), dissolved orthophosphate, total organic carbon (TOC), dissolved trace metals, and organic pollutants such as polycyclic aromatic hydrocarbons (PAHs), chlorinated pesticides, and polychlorinated biphenyls (PCBs). In the dissolved form, all trace metals from the Northwest Alternative area were detected above the method detection limit (MDL) in the four depth samples with the exception of aluminum, beryllium, iron, mercury and tin. Throughout the water column, dissolved metals concentrations were consistent with other deep ocean reference samples. All of the dissolved metals concentrations were one to three orders below their respective Criteria Continuous Concentration (CCC)[1] values. PAHs were below the MDL with the exception of 2-methylnaphthalene, naphthalene, and perylene. Perylene and 2-

[1] CCC = Criteria Continuous Concentration, synonymous with "chronic " based on EPA Ambient Water Quality Criteria (AWQC).

methylnapthalene were both detected below the reporting limit (RL), and napthalene was detected above the RL, but five orders of magnitude below the Criteria Maximum Concentration (CMC)[2]. All pesticides were non-detect, apart from 4,4'-DDT, which was detected below the RL and well below the CMC. All PCBs were non-detect.

Sediment Sampling (April 2008)

Sediments were collected from the Northwest Alternative area using an Ocean Instruments 20-inch MK-III spade-type boxcore capable of collecting cores to 24 in below the sediment surface. Sediment samples were primarily sand and silt with some clay. The major sand fraction averaged 52.05 %, with a range of 42.57 % to 63.44 %. The minor silt fraction averaged 39.48 %, with a range of 30.33 % to 47.79 %. The lesser clay fraction averaged 8.47 %, with a range of 6.22 % to 9.64 %. No gravel fraction was detected in the collected sediments. Sediment samples collected at the Northwest Alternative reference site similarly had a distribution that consisted of primarily sand (57.2%), followed by silt (33.96%), and clay (8.75%).

Conventional parameters analyzed in sediment samples were detected in low concentrations. TOC averaged 0.28%, TON averaged 89.01 mg/dry kg, and Ammonia-N averaged 0.24 mg/dry kg. These ammonia-N averages were approximately 2 orders of magnitude lower than biologically toxic concentrations (30 ppm).

Cadmium, zinc, mercury, arsenic, chromium, lead and silver concentrations in the Northwest Alternative area were below Effects Range Low (ER-L) levels. Average copper concentrations slightly exceeded the ER-L but at concentrations well below the Effects Range Median (ER-M). Average nickel concentrations were more than 2 times the ER-L and slightly less than the ER-M. Sediment metal levels in the Northwest Alternative area were below average oceanic crustal abundances available for barium, cobalt, copper, iron, lead, manganese, nickel, titanium, vanadium, and zinc. Average aluminum concentrations were an order of magnitude greater than, while average chromium concentrations were more than double, the oceanic crustal abundance values. Average strontium only slightly exceeds the oceanic crustal abundance values measured in the central Pacific Ocean (Wen et al., 1997).

PAHs, chlorinated pesticides, PCBs, and organotins were all non-detect. Dioxins and furans were detected, but in low concentrations. Further sediment chemistry results are discussed in Section 4 of this document, and summary results are available in Table 7-1 (Appendix).

Invertebrate Sampling (Benthic Communities) (April 2008)

Macroinfauna and meiofauna samples were subsampled from the boxcore samples collected in the Northwest Alternative area. Results indicated that the invertebrate community found in the Northwest Alternative is typical of the deep offshore environment. A total of 30 different species were collected in the Northwest Alternative. At all stations, the majority of the benthic populations were comprised of polychaetes. There were no mollusks nor echinoderms present in any of the stations. No meiofaunal nematodes nor harpactacoid copepods were present.

[2] CMC = Criteria Maximum Concentration, synonymous with "acute," based on EPA Ambient Water Quality Criteria (AWQC).

Fish Community Surveys (April 2008)

Sampling for fish community consisted of three methods: beam trawl surveys, fish trap deployments, and underwater video and digital still camera deployments. The beam trawl surveys, were conducted across the entire sampling area. Unlike sampling for water or sediment samples which occur at discrete points, fish community surveys were conducted by towing a beam trawl along a planned transect. Due to a low abundance of demersal organisms in the beam trawls, baited fish traps were deployed in an effort to collect additional fish or epifaunal invertebrates for tissue chemistry analyses. Fish traps were deployed at two stations in each of the two proposed alternative areas. For the underwater video and digital camera deployments, a DTS6000 underwater video and digital still camera was deployed at every station except for one. The results indicated that deep-sea demersal species in the Northwest Alternative and surrounding area were typical of the deep offshore environment in the vicinity of either alternative disposal area. Between all three methods, one demersal cuskeel (*Bassogigas gillii*), three water column bristlemouths (*Cyclothone pallida*), one small Ophidiiform, two hagfish, and five Ophidiiforms were observed throughout the Northwest Alternative sampling locations.

Bioassay Analyses

Bioassay testing was performed on the proposed reference site composite sample and the three individual grab samples that comprised the proposed reference site composite sample. Toxicity testing for this project included three solid phase (SP) toxicity tests and two bioaccumulation potential tests. The SP tests were conducted on the two amphipod species, *Ampelisca abdita* and *Eohaustorius estuarius*, and the polychaete worm *Neanthes arenaceodentata*. Bioaccumulation tests were conducted on the polychaete worm *Nephtys caecoides* and the bivalve *Macoma nasuta*. Testing and analysis were performed in accordance with the guidelines provided in the Ocean Testing Manual (OTM; USEPA/U.S. Army Corps of Engineers [USACE], 1991); the Inland Testing Manual (ITM; USEPA/USACE, 1998) was used as guidance for more specific methodologies and test conditions.

With the exception of silver, several PAHs, and 4,4'-DDT, all chemical concentrations in *N. caecoides* tissue were similar to day zero concentrations. With the exception of several metals, PAHs, and total detectable dioxins, all chemical concentrations in *M. nasuta* tissue were similar to day zero concentrations. Further results are available in the field report for the baseline studies (US Navy, 2009).

2.3 Survey Objectives

EPA conducted a monitoring survey at and around the G-DODS from May 17th – 26th, 2022, aboard the *RV Bold Horizon*. This field survey was the first time the G-DODS had been monitored since its designation in 2010. The overall survey area was circular with an approximate diameter of 12 NM, with the G-DODS in the center. Stations were located along orthogonal transect lines as well as the G-DODS reference site (Figure 2-2).

The 2022 G-DODS monitoring survey involved two field efforts: (1) sediment profile image/plan view (SPI/PV) sampling to identify the dredged material deposit footprint and provide visual parameters of benthic habitat condition; and (2) boxcore sediment sampling for analysis of

grain size and chemical contaminants in the different impact zones (dredged material, trace dredged material, and unimpacted/ambient/native) identified by the SPI/PV sampling**.** EPA conducted SPI/PV sampling at 62 stations (25 within G-DODS, 32 outside the G-DODS, and 5 at the reference site) (Figure 2-2). EPA also collected sediment from 25 stations (14 stations within the ODMDS, 6 outside of the ODMDS, and 5 at the reference site) (Figure 2-2).

The general objectives for the survey were to collect SPI/PV and sediments in and around the G-DODS and the reference site to evaluate the short- and long-term fates of the material disposed at the G-DODS, as well as the short and long-term environmental impacts of disposal of material at the G-DODS.

An additional objective of the survey was to collect sediments from the G-DODS ocean reference site for physical and chemical analyses and 10-day acute toxicity bioassays. These sediment chemistry and toxicity data will be added to the ocean reference database[3].

3 METHODS

EPA conducted the 2022 survey aboard the *R/V Bold Horizon*. The objective of the survey was to evaluate the short and long-term fate of the material deposited the G-DODS. To address this objective, EPA evaluated the footprint of disposed dredged material, as well as the chemical and physical composition of sediments, and the habitat quality of stations inside and outside of the dredged material footprint. The survey involved two field efforts: (1) sediment profile image/plan view (SPI/PV); and (2) boxcore sediment sampling. The 2022 sampling followed the approved methods and approaches defined in the *Final Quality Assurance Project Plan (QAPP) for the 2022 Guam Deep Ocean Disposal Site (G-DODS) Monitoring Survey* (USEPA, 2022). All planned stations were occupied, and all samples were successfully collected. Additional SPI/PV images were collected to further delineate dredged material footprint boundaries based on real-time image analysis.

3.1 Sediment Profile Images – Plan View Images

EPA collected SPI and PV to assess the overall condition of the benthic habitat at the ODMDS and surrounding areas. SPI and PV were collected at a total of 62 stations throughout the survey area, including 25 stations within the G-DODS, 32 stations outside of the G-DODS, and five stations at the G-DODS reference site.

SPI/PV imaging has been shown to be a powerful reconnaissance tool that can efficiently map gradients in sediment type, biological communities, or disturbances from physical forces, anthropogenic input, or organic enrichment. The SPI-PV system provides a surface and cross-sectional photographic record of selected locations on the seafloor to allow a general description of conditions both on and off dredged material deposits (Figure 3-1).

With resolution on the order of millimeters, the SPI system is useful for identifying a number of features, including the spatial extent and thickness of the dredged material footprint over the native sediments of the seabed, the level of disturbance and recolonization as indicated by the

[3] The ocean reference database provides reference sediment results for the pre-disposal sediment testing evaluation conducted for dredged sediments proposed for disposal at the G-DODS.

depth of bioturbation, the apparent depth of the redox discontinuity (aRPD)[4], and the presence of certain classes of benthic organisms. PV is useful for identifying surface features in the vicinity of where the SPI photos are taken, thereby providing important surface context for the vertical profiles at each station. The SPI and PV were collected in a radial sampling design, allowing for sampling to occur both within and outside of the G-DODS (Figure 2-2). A radial sampling design is selected to mimic the dispersion pattern of dredged material on the seafloor, as dredged material is required to be disposed of within a limited Surface Disposal Zone (SDZ) at the center of the G-DODS.

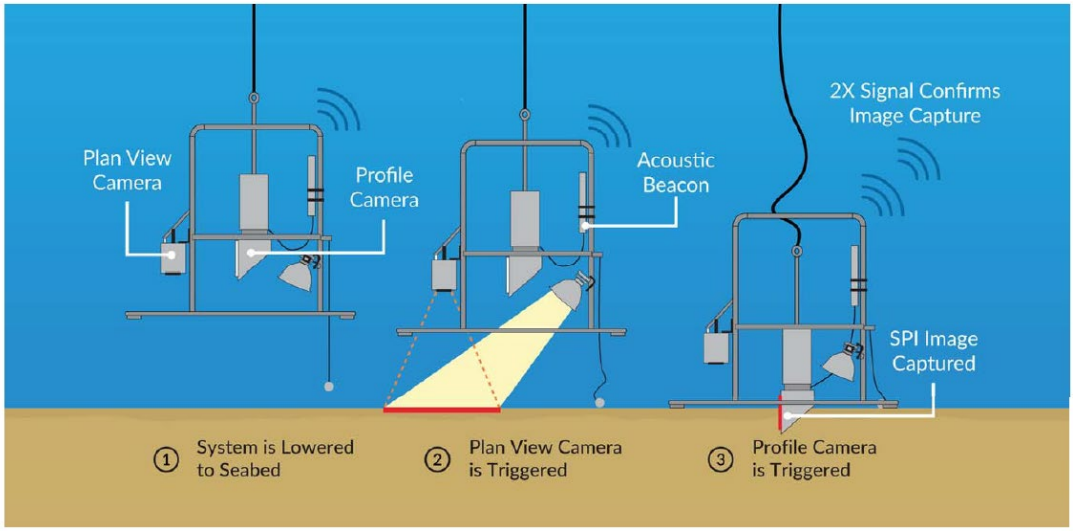

Figure 3-1.Schematic of deployment and collection of SPI and PV.

Sediment Profile Images

The SPI technique involved deploying an underwater camera system to photograph a cross-section of the sediment–water interface. High-resolution SPI images were acquired using a Nikon® D7200 digital single-lens reflex (DSLR) camera mounted inside an Ocean Imaging® Model 3731 pressure housing. The pressure housing sat atop a wedge-shaped steel prism with a plexiglass front faceplate and a back mirror that was mounted at a 45° angle. The camera lens looked down at the mirror, which reflected the image from the faceplate. The prism had an internal strobe mounted inside at the back of the wedge to provide illumination for the image; this chamber was filled with distilled water, so the camera always had an optically clear path. The descent of the prism into the sediment was controlled by a hydraulic piston. As the prism penetrated the seafloor, a trigger activated a time-delayed circuit that fired the internal strobe to obtain a cross-sectional image of the upper 15–20 centimeters (cm) of the sediment column (Figure 3-1). The camera remained on the seafloor for approximately 20 seconds to ensure that successful images were obtained.

Prior to field operations, the internal clock in the digital SPI system was synchronized with the vessel's navigational global positioning system (GPS). Each image was assigned a unique time stamp in the digital file attributes by the camera's data logger and cross-checked with the time

[4] The aRPD is the depth of transition from oxygenated to anoxic conditions in sediment. It is used as a relative measure of sediment oxygen content and habitat quality.

stamp in the navigational system's computer data file. Test exposures of a Color Calibration Target were also made on deck at the beginning of the survey to verify that all internal electronic systems were working to design specifications and to provide a color standard against which final images could be checked for proper white balance. Test images were also captured to confirm proper camera settings for site conditions. Images were checked periodically throughout the survey to confirm that the initial camera settings were still resulting in the highest quality images possible.

When the camera was brought back on board (typically after every fifth to eighth station), the frame counter was checked to ensure that the requisite number of replicates had been obtained. In addition, a prism penetration depth indicator on the camera frame was checked to verify that the optical prism had penetrated the bottom to a sufficient depth. Time of image acquisition, water depth, frame stop-collar position, and the number of weights used were recorded in the field log for each replicate image.

Plan View Images

An Ocean Imaging® Model DSC24000 plan view underwater camera system with two Ocean Imaging® Model 400-37 Deep Sea Scaling lasers was attached to the sediment profile camera frame and used to collect PV images of the seafloor surface. Both SPI and PV images were collected during each "drop" of the system. The PV system consisted of a Nikon® D-7100 DSLR camera encased in a titanium housing, a 24 volts direct current autonomous power pack, a 500 W strobe, and a bounce trigger. A weight was attached to the bounce trigger with a stainless-steel cable so that the weight hung below the camera frame; the scaling lasers projected two red dots that were separated by a constant distance (26 cm) regardless of the field of view of the PV system. The field of view can be varied by increasing or decreasing the length of the trigger wire and, thereby the camera height above the bottom when the picture is taken. As the SPI/PV camera system was lowered to the seafloor, the weight attached to the bounce trigger contacted the seafloor prior to the camera frame reaching the seafloor and triggered the PV camera (Figure 3-1).

Prior to field operations, the internal clock in the digital PV system was synchronized with the vessel's GPS navigation system and the SPI camera. During set-up and testing of the PV camera, the positions of lasers on the PV camera were checked and calibrated to ensure consistent separation. Test images were also captured to confirm proper camera settings for site conditions. Images were checked periodically throughout the survey to confirm that the initial camera settings were still resulting in the highest quality images possible. All camera settings and any setting changes were recorded in the field log.

The ability of the PV system to collect usable images is dependent on the clarity of the water column. Bottom-water clarity during this survey allowed use of a 2.4 m trigger, however due to the sea state, the trigger wire was decreased to 1.8 m, resulting in a predominant mean image width of 1.3 m and a mean field of view of 1.2 m^2.

Image Conversion and Calibration

Following completion of field operations, the raw image files were color calibrated in Adobe Camera Raw® by synchronizing the raw color profiles to the Color Calibration Target that was

photographed prior to field operations with the SPI camera. The raw SPI and PV were then converted to high-resolution Photoshop Document (PSD) format files, using a lossless conversion file process and maintaining an Adobe RGB (1998) color profile. The PSD images were then calibrated and analyzed in Adobe Photoshop®. Length and area measurements were recorded as number of pixels and converted to scientific units using the calibration information.

3.2 Box Core Sediment Samples

EPA also collected box core sediment samples to assess the sediment chemistry and grain size, both inside and outside of the G-DODS boundaries. In total, EPA collected sediment from 25 stations, including 14 stations within the G-DODS, six stations outside of the G-DODS, and five stations at the reference site (Figure 2-2).

Physical and Chemical Sampling and Analysis

Sediment samples for physical and chemical analyses were collected with a 0.25 m^2 box core sampler (Figure 3-2). Once a successful box core sample was brought on board, the sample was photographed, and the five best subcores were selected for subsampling for physical and chemical analysis. Cores were chosen based on adequate penetration (>10 cm) and undisturbed sediment surface, as evidenced by overlying water. The selected subcores were extruded, and the top 10 cm of sediment was collected, homogenized, and distributed to the appropriate sample containers. The sediment samples were stored refrigerated at ~4°C or frozen at ~-20°C, as outlined in the G-DODS Quality Assurance Project Plan (USEPA, 2022).

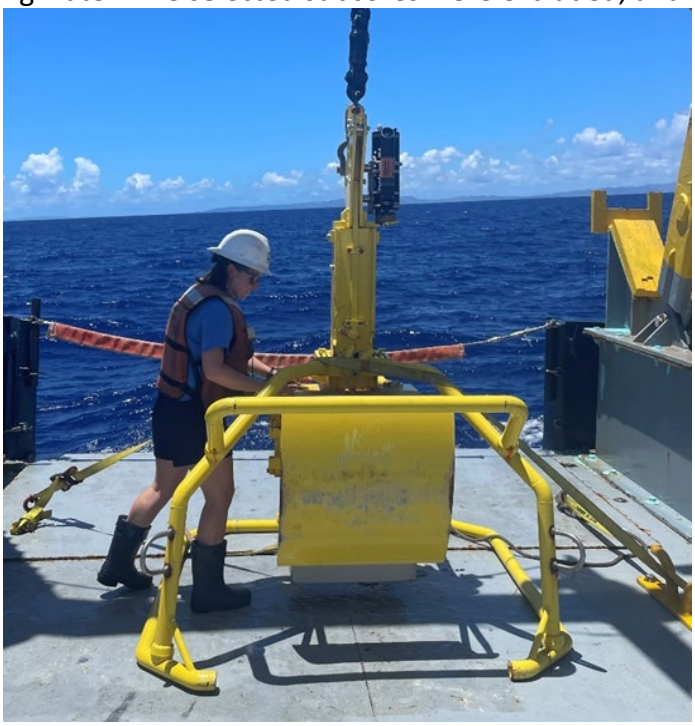

Figure 3-2. EPA scientist checking the box core sampler.

Sediments were analyzed for a number of conventional parameters, such as grain size, TOC, and total solids, as well as chemical analytes, including metals, PAHs, PCBs, dioxins and furans, and butyltins. Analytical tests for physical and chemical parameters were conducted according to the G-DODS Quality Assurance Project Plan (USEPA, 2022). All parameters were analyzed by ALS laboratories.

Bioassay Sampling and Analysis

Sediment samples for the bioassay tests were also collected from separate subcores from each of the five reference site stations. A minimum of five liters of sediment was collected for each bioassay. The samples were placed into clean plastic bags and double bagged. The samples were placed on a gel ice product to bring the temperature to ≤ 6°C and stored at 4°±2°C prior to shipment. The samples were then shipped to the Pacific EcoRisk laboratory upon arrival at

shore. Upon receipt of the samples in the laboratory, each sample was logged in, and then placed in the refrigerator at 4°C. The samples were tested within the eight week holding times.

The acute toxicity bioassays were conducted by Pacific EcoRisk of Fairfield, California. Pacific EcoRisk conducted the acute sediment toxicity tests according to the EPA/USACE OTM (1991) and ITM (1998) Guidelines, PN 01-01. The methods followed ASTM Method 1367-03 Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Invertebrates (2014) and EPA's Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods (USEPA, 1994).

The solid phase toxicity tests were run on the amphipod *Leptocheirus plumulosus* for each of the five reference site samples provided. The sediments were thoroughly homogenized prior to use, and the sediment in each replicate was deep enough to meet the biological needs of the test organisms. The tests were conducted as 10-day (acute) static exposures, with five replicates per treatment, and 20 randomly selected test organisms per replicate.

A control was concurrently performed with the test organisms' native sediments, as well as a reference toxicant test. Measurements of water quality parameters, including dissolved oxygen, temperature, pH, and salinity were taken immediately prior to the tests and daily during the tests. In addition, ammonia and sulfides were measured immediately prior to testing, as well as routinely on appropriate test fractions to ensure appropriate levels according to the testing protocols.

4 RESULTS

4.1 Sediment Profile Images – Plan View Images

EPA collected SPI/PV from 62 stations in and around the G-DODS: 25 stations within the disposal site boundary, 32 stations distributed radially from the disposal site boundary, and five stations at the reference site (Figure 2-2). Measured depths at stations sampled in the G-DODS study area ranged from 1,196 m to 2,697 m. The results of the SPI/PV analyses are described below. Tables and figures pertaining to the SPI/PV results are available in Section 7 (Appendix; Tables 7-2 – 7-5).

Grain Size

Sediments across the entire study area, with some exceptions, were predominantly composed of silt/clay and very fine sand with a pinkish brown hue (Figure 4-1; Tables 7-2, 7-3). Stations located west and northwest of the site boundary were characterized as medium sand, and stations located north of the site boundary were composed of a variable sediment type of silt/clay and eroded volcanic grain fraction (Figure 4-1: "varies" on the map). Stations inside the G-DODS and south of the site boundary were predominantly clay or fine sand. Stations in the reference site were a mix of silt/clay, very fine sand, and volcanic rock**.** In and around the G-DODS boundary and at the reference site, volcanic rock and eroded volcanic rock, as coarse black grains, were a notable feature of the sediment**.** At some locations, the entirety of the seabed was volcanic rock with a thin depositional drape of fine sediment**.** At locations where the sediment type was indeterminate due to a lack of prism penetration, the seabed in the PV image appeared to be predominantly volcanic rock**.**

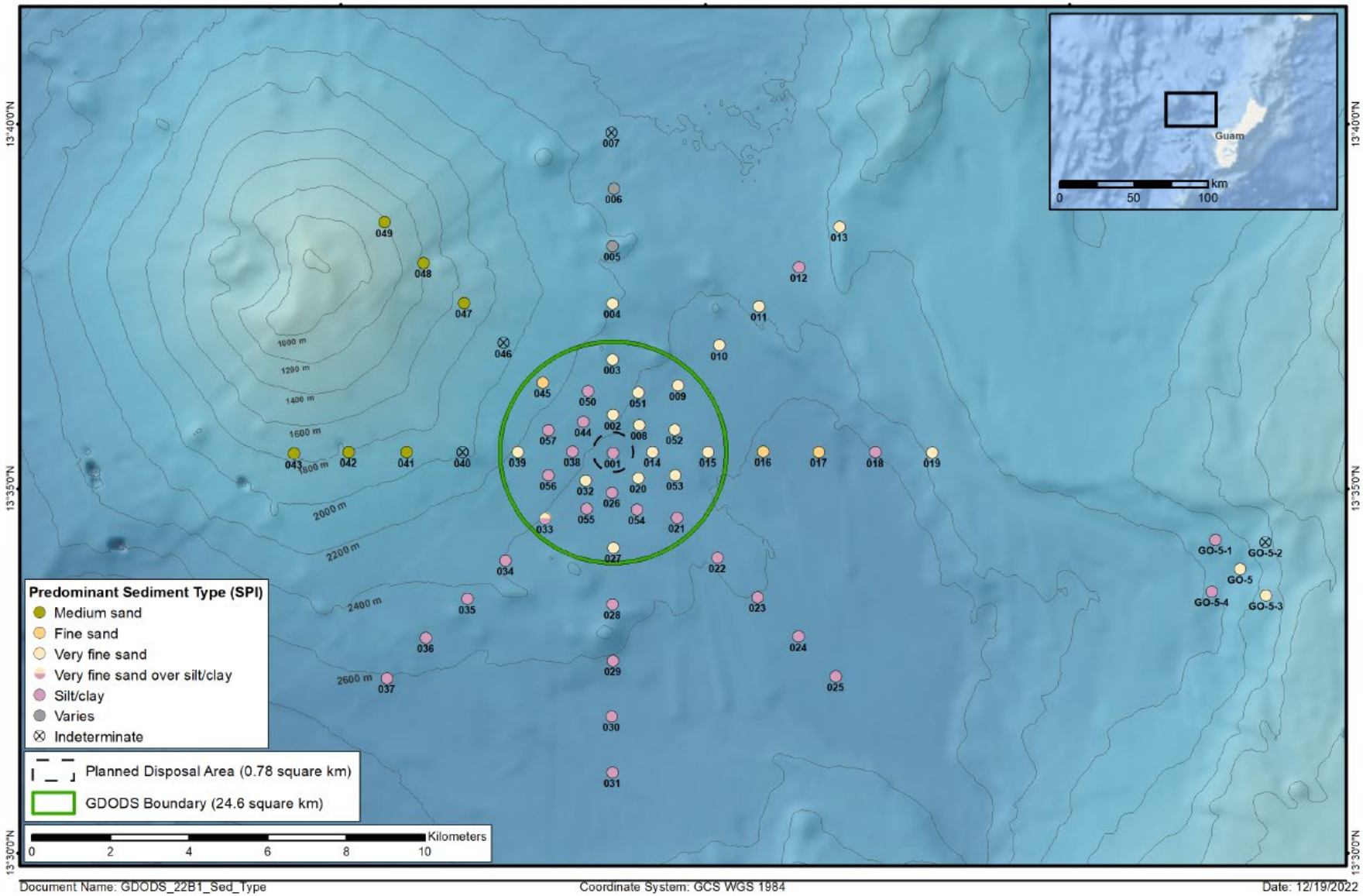

Figure 4-1. Sediment type in the G-DODS survey area.

Dredged Material

Dredged material was observed predominantly within the boundary of the G-DODS and was concentrated around the SDZ projected on the seafloor. The optical characteristics of the dredged material was a whitish gray clay that, when present, was observed as a distinct layer in the profile images or blanketing the sediment surface in the PV images (Figure 4-2). The thickness and prevalence of dredged material was most prominent at Station 001, which was located in the center of the SDZ. Dredged material was also documented in trace concentrations as loosely scattered clasts on the sediment surface or as non-continuous clay inclusions in the sediment profiles. Only one station located outside of the G-DODS boundary contained traces of dredged material: Station 023 located approximately 2.3 km to the southeast of the ODMDS boundary (Figure 4-3). No dredged material was observed in the profile images at Station 023, but in at least two plan view replicates a few medium sized pale-gray clay clasts were observed on the sediment surface (Table 7-2). No dredged material was observed at the reference site stations (Table 7-3).

In all instances when dredged material was observed, it was found to be a surface layer (i.e., not buried below the sediment water interface), indicating that the material was recently deposited relative to the local rate of natural sediment deposition. When dredged material was present in a discrete layer, the thickness of the layer was measured. Dredged material thickness throughout the survey area ranged from 0.0 to 7.8 cm with a mean of 0.8 cm (standard deviation [SD] ±2.1) (Tables 7-2 – 7-3). The layer of dredged material was thickest at Station 001, the only station located within the SDZ.

Figure 4-2. Presence of dredged material (pale gray sediment) in SPI and PV images at Station 001.

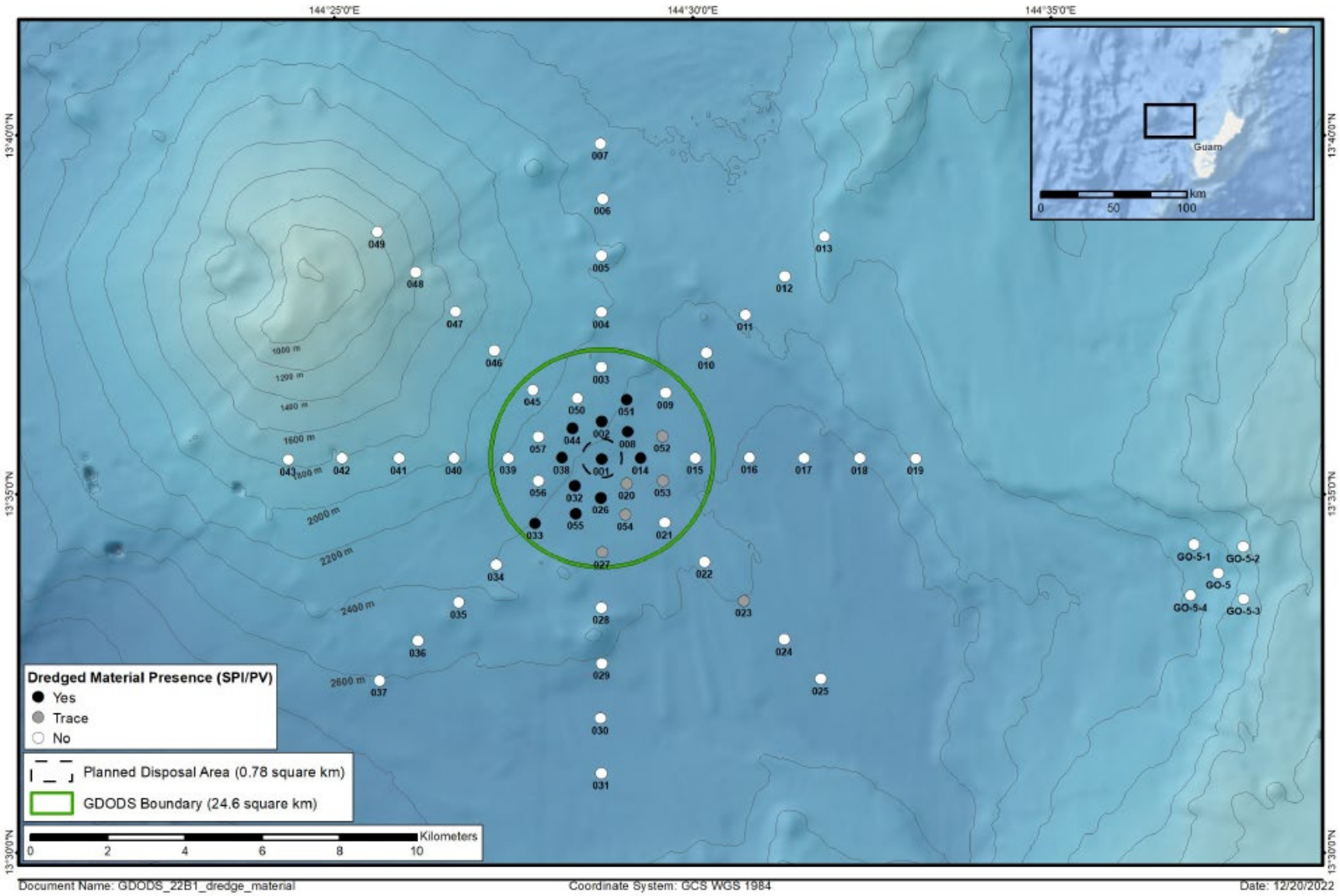

Figure 4-3. Presence/absence of dredged material in the G-DODS survey area.

Prism Penetration

Prism penetration depth was not a reliable indicator of the bearing strength or compaction of the sediment, because the weight settings on the camera frame had to be changed throughout the survey due to the variability in grain size throughout the survey area. Mean station prism penetration values in and around the G-DODS ranged from 0.0 to 14.4 cm, with an overall mean of 6.3 cm (±3.4) (Table 7-2). At the reference site, mean station prism penetration values ranged from 0.0 to 11.0 cm, with an overall mean across the reference site of 5.5 cm (SD±4.0) (Table 7-3). Large standard deviations indicated high variability in sediment shear strength across the surveyed area. However, lower prism penetrations were predominantly observed at stations located to the north and west of the ODMDS, and these observations corresponded with areas where coarser sediment grains were documented.

Surface Boundary Roughness

Surface boundary roughness (sediment surface relief) was determined by measuring the vertical distance between the highest and lowest points of the sediment–water interface. The camera must be level to record accurate boundary roughness measurements. The surface boundary roughness measured over the width of sediment profile images typically ranges from 0 to 4 cm and may be related to either physical structures (ripples, rip-up structures) or biogenic features (burrow openings, fecal mounds, foraging depressions). In sandy sediments, boundary roughness can be a measure of sand wave height. On silt–clay bottoms, boundary roughness values often reflect biogenic features such as fecal mounds or surface burrows. Biogenic roughness may change seasonally and is related to the interaction of bottom turbulence and bioturbation. The size and scale of boundary roughness values can have dramatic effects on both sediment erodibility and localized oxygen penetration into subsurface sediments.

Small-scale boundary roughness of the seafloor surface did not vary spatially within the study area. Mean station boundary roughness in and around the ODMDS ranged from 0.4 cm to 2.7 cm with an overall mean of 1.2 cm (SD ± 0.5) (Table 7-2). The small-scale topography at most stations in and around the ODMDS was small with roughness values averaging less than 2.5 cm. Station 007 (the furthest north station in the study area, located outside of the G-DODS) was the only location where boundary roughness values exceeded 2.5 cm. At the reference site, mean station boundary roughness ranged from 0.9 cm to 2.2 cm with a mean of 1.3 cm (SD ± 0.6) (Table 7-3).

ARPD Depth

The aRPD is the depth of transition from oxygenated to anoxic conditions in sediment. It is used as a relative measure of sediment oxygen content and habitat quality. The aRPD depth was indeterminate at all the stations surveyed in and around the ODMDS and reference site (Tables 7-4 – 7-5). Indeterminate aRPD designations were due to shallow prism penetrations at some stations, however at most stations they were due to there not being an optically discernable aRPD in the light-colored sediments of the G-DODS study area.

Successional Stage

Infaunal and epifaunal communities at the G-DODS study area were documented to be robust and generally characteristic of the environment (Figure 4-4). Infaunal successional stage, a measure of the status of the functional biological community inhabiting the seafloor, was found to be variable; there was a mix of advanced, intermediate, and early stage succession throughout the survey area. Inside the G-DODS, there appeared to be a general pattern where Stage 1 taxa were more prevalent to the south and southeast within the ODMDS boundary, and Stage 3 taxa were predominantly present in the north and northeast (Table 7-4). Evidence of advanced Stage 3 taxa was observed at a few stations within the G-DODS, often in one or two replicate images. Evidence of the presence of Stage 3 fauna included feeding voids within the sediment column; when present there was often only one void per image. There were frequent designations of Stage 2 succession inside the G-DODS, evidenced by the presence of medium-sized tubes at the sediment–water interface. In contrast, tiny tubes documented at the sediment–water interface indicated early Stage 1 succession.

The reference site was identified as Stage 2 or in a transitory state between Stage 1 and 2 (identified as Stage 1->2) (Table 7-5). This designation was due to the presence of small to medium sized tubes and shallow burrowing. Stage 1 and Stage 2->3 were also documented in a single replicate at Stations GO-5-4 and GO-5, respectively. At most stations throughout the survey area where successional stage was indeterminate, the stations had shallow prism penetration, preventing successional stage designations from being determined.

Epifaunal taxa were infrequently observed throughout the study area and included predominantly burrowing anemones. Gorgonians, brittle stars, crinoids, tunicates, and other epifauna were also observed (Table 7-4). The only documented epifauna at the reference site was a small crinoid (Table 7-5).

Methane Bubbles

The presence of subsurface methane bubbles is an indicator of organic enrichment in marine environments. Methane bubbles are indicative of very high sediment oxygen demand (SOD) and usually seen only in sediments with very high organic loading. There was no evidence of sedimentary methane or of low dissolved oxygen conditions in the water column or at the benthic boundary layer in any of the SPI or PV images analyzed in and around the ODMDS or reference site. This observation contributed to the qualitative assessment of SOD, which was classified as low at all stations surveyed in and around the G-DODS and reference site (Tables 7-4 – 7-5).

Anthropogenic Debris

Anthropogenic debris including a Styrofoam cup, an aluminum can, plastic bags, and other unidentifiable plastic objects were observed at several stations across the survey area (Tables 7-2 – 7-3). Anthropogenic debris was documented at a total of nine stations across the survey area including at the G-DODS and reference site. The presence of anthropogenic debris appeared haphazard and often did not correspond with the presence of dredged material.

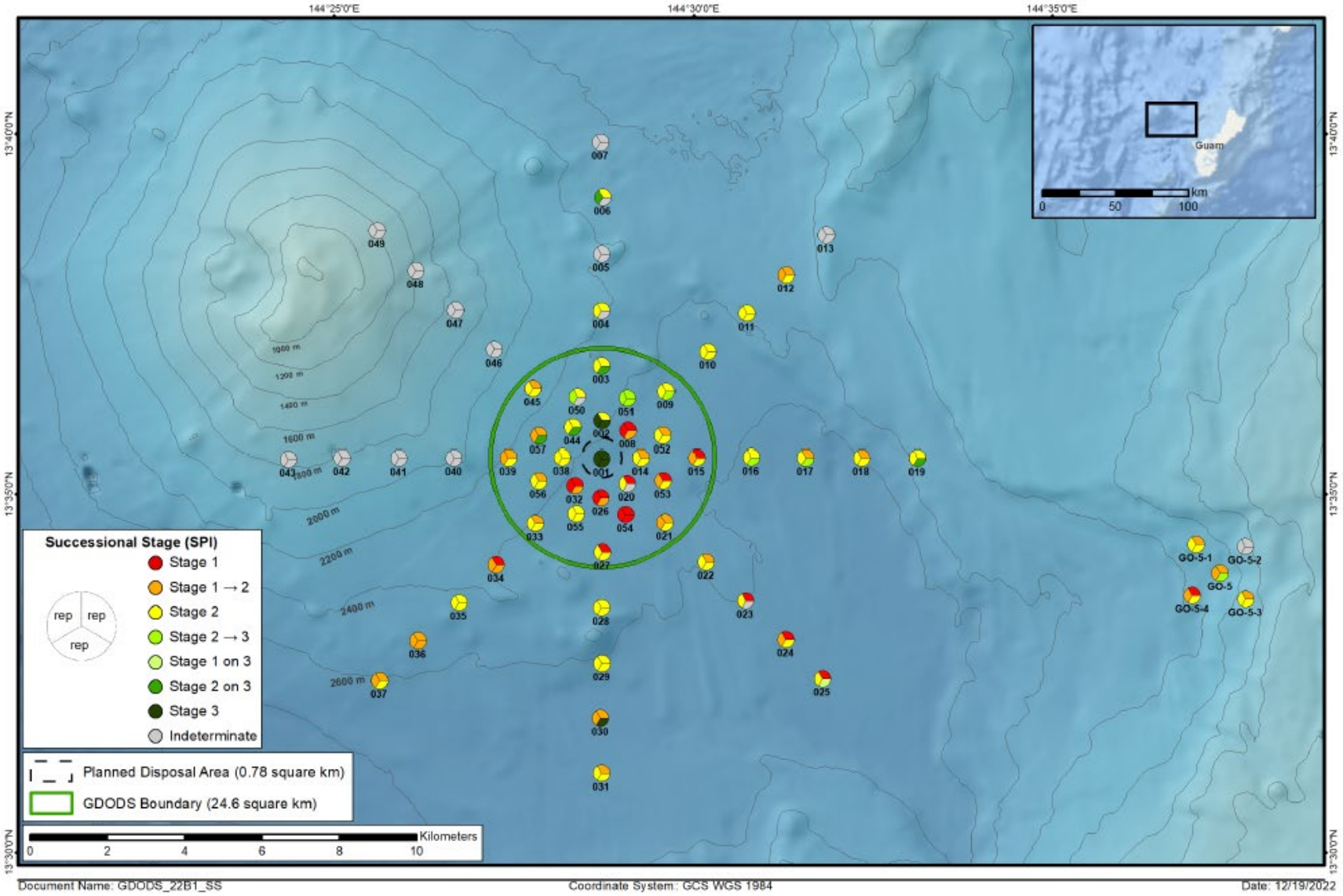

Figure 4-4. Infaunal succession stage in the G-DODS survey area.

4.2 Sediment Physical Parameters and Chemistry

Sediment Physical Parameters

Grain Size: Overall, sediment grain size distribution from stations inside of the G-DODS was similar to that of stations outside of the G-DODS and at the reference site (Figure 4-5; Table 4-1 –Table 4-4; Tables 7-6 – 7-7). Average grain size results for all stations both inside and outside of the G-DODS show the sediments are comprised primarily of silt (~ 40%) followed by clay (~ 38%) then sand (predominantly fine sand: 17% within G-DODS, and 12% outside of G-DODS, respectively). The reference site was similarly composed primarily of silt (39%), followed by clay (32%), and subsequently fine sand (19%). However, sediment at the reference site was composed of a slightly higher percentage of gravel (average of 8%) than inside and outside the G-DODS (0.6% and 0.1% gravel, respectively).

There was some variability within the G-DODS as well: Station 001, located at the center of the SDZ, was predominantly composed of clay (51%), followed by silt (26%), gravel (8%), and coarse/medium sand (5%). Sediments from the southern and western areas inside the G-DODS (stations 032, 033, 038, 039, and 044) also contained slightly more gravel and clay than the northern and eastern areas inside the G-DODS (stations 002, 008, 014, 015, 020, 021, 026, and 027), which contained slightly higher percentages of silt.

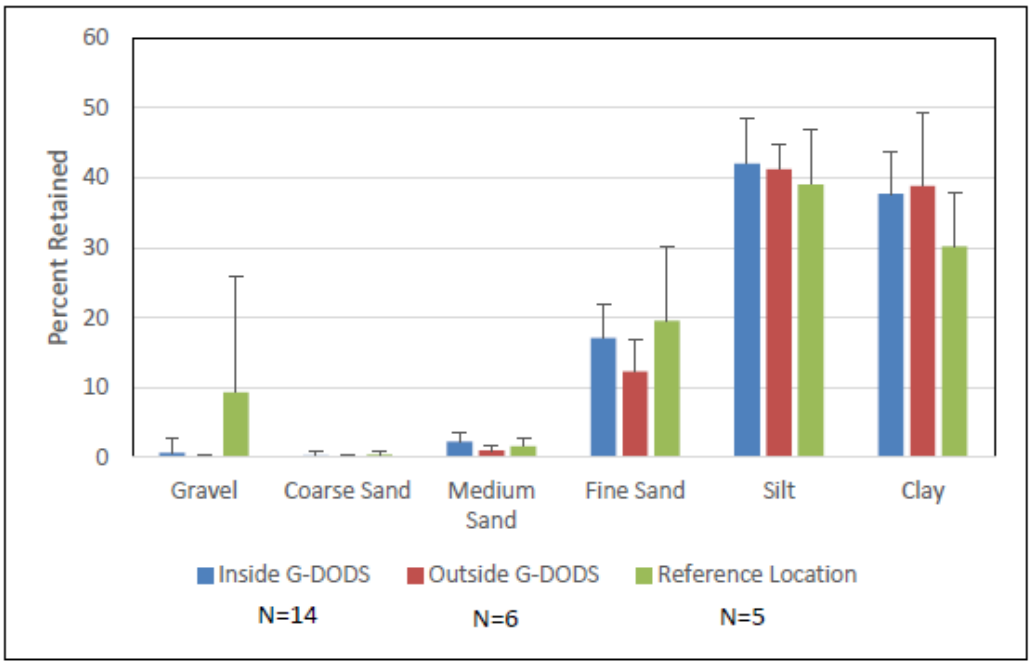

Figure 4-5.Average grain size and standard deviation by location: inside the G-DODS, outside the G-DODS, and the reference site.

Total Organic Carbon

The average TOC concentration was very similar inside (0.273%) and outside (0.285%) of the G-DODS and slightly higher at the reference site (0.345%) (Table 4-1 –Table 4-4; Tables 7-6 – 7-7). TOC values for the stations inside of the G-DODS ranged from 0.21% to 0.54%, and TOC for stations outside of the G-DODs ranged from 0.26% to 0.32%. TOC values for the reference site ranged from 0.27% to 0.37%.

Sediment Chemistry

Metals: Samples collected inside and outside of the G-DODS contained similar concentrations of metals (Table 4-1 –Table 4-4; Tables 7-8 – 7-10). Concentrations of metals (except copper and nickel) at all stations were below the ER-L values. Copper concentrations from all sediment samples, including outside of the G-DODS and at the reference site, surpassed the ER-L (34 mg/kg) and ranged from 37.9 to 57.6 mg/kg across the entire survey area (Table 4-1 –Table 4-4). Averages and ranges of copper inside the G-DODS, outside the G-DODS, and at the reference site were fairly similar, with the stations outside of the G-DODS having the highest average copper concentration (51.68 mg/kg). No copper concentrations were reported above the ER-M (270 mg/kg).

Nickel concentrations from all sediment samples, including outside of the G-DODS and at the reference site, surpassed the ER-L (20.9 mg/kg) (Table 4-1 –Table 4-4; Tables 7-8 – 7-10). Three locations inside of the G-DODS (008, 014, and 044) surpassed the ER-M (51.6 mg/kg), ranging from 53.9 to 80.8 mg/kg. However, average concentrations of nickel in sediment samples were similar inside and outside of the G-DODS and at the reference site.

Average chromium concentrations were slightly lower inside the G-DODS (38.09 mg/kg) than outside of the G-DODS (41.60 mg/kg) and at the reference site (54.73 mg/kg) (Table 4-1 –Table 4-4; Tables 7-8 – 7-10). All concentrations of chromium from samples throughout the survey area were below the ER-L.

Pesticides: Pesticides across the entire survey area were non-detect, except for certain pesticides in 11 samples. The only pesticides detected above the reporting limit (RL) in the survey area were pep'-DDE or p, p'-DDT (Table 4-1 –Table 4-4; Tables 7-11 – 7-13). Six of the samples were located within the G-DODS, one sample outside G-DODS, and four samples at the reference. Detected concentrations above the RLs ranged from 0.95 to 26 µg/kg, with the highest concentration located within the G-DODS (at Station 026; Table 7-11). Nine of the 11 samples detected had concentrations of total DDT exceeding the ER-L value (1.58 µg/kg), however all concentrations were well below the ER-M (46.1 µg/kg).

Polychlorinated Biphenyls: Total PCBs (both aroclors and congeners) were summarized based on the sum of all detected values above the MDL and applying zero to the non-detect compounds (i.e., not detected above the MDL; Table 4-1 –Table 4-4; Tables 7-11 – 7-13). PCB congeners were detected at or above the MDL in sediment from 12 of the 25 stations sampled: six stations inside G-DODS, one station outside G-DODS, and in all five stations within the reference site. Total PCB congeners ranged from 0.16 to 131 µg/kg throughout the survey area. Congener PCB-1 was reported as 130 µg/kg in sample XAB-024 from station GO-5, however this may have been an artefact of laboratory error[5]. With the suspect data excluded, total PCB

[5] A peak was detected on both columns in their respective retention time windows, however, the relative percentage difference (RPD) between the two values was greater than 40% and the retention times of the peaks identified as PCB-1 were shifted slightly between the sample and the standard. While these peaks were observed within the expected retention time (RT) windows for PCB-1, the shift in RT and the high RPD in concentrations between the two columns, along with the fact that no other PCB congeners were detected, make this value suspect as an actual PCB and have been qualified as such.

congeners within the G-DODS ranged from 0.16 µg/kg (Station 014) to 18.6 µg/kg (Station 001), which are all below the ER-L value (22.7 µg/kg). Overall, very few congeners were detected above the RL at any stations (Station 001 had five PCB congeners that were detected above the RL [Table 7-11]; three reference site locations each had one PCB congener detected above the RL [Table 7-13]).

PCB Aroclors were detected above the RL at five of the 25 sediment stations, with total Aroclors ranging from 5 µg/kg (GO-4) to 28.8 µg/kg (Station 001) (Tables 7-11 –7-13). At Station 001, Aroclors 1242 and 1260 were detected above the RL. Aroclor 1242 was detected in two locations inside the G-DODS (001 and 018) and in three reference site locations (GO-3, 4, and 5). No PCB Aroclor concentrations exceeded the MDL across the survey area.

Polycyclic Aromatic Hydrocarbons: Total PAH values were calculated based on the sum of all detections above the MDL and using zero for non-detect compounds (Table 4-1 –Table 4-4). Four stations within the G-DODS (001, 025, 037, and 038) had at least one PAH compound detected above the MDL, and two reference site stations (GO-2 and GO-4) had at least one PAH compound detected above the MDL (Tables 7-14 – 7-16). Total PAHs were all below the ER-L value (4,022 µg/kg). The average total PAH value inside the G-DODS was 4.73 µg/kg, with a range of 0.7-27.5 µg/kg, and the average total PAH value outside the G-DODS was 8.01 µg/kg, with a range of 1.15-37.6 µg/kg. The average total PAH value at the reference site was 4.46 µg/kg with a range of 1.57 – 10.00 µg/kg. The stations with the highest PAH levels were station 001 (within G-DODS), station 025 (outside the G-DODS), and station GO-4 (in the reference site). Stations with the lowest PAH levels were seen at station 044 (within the G-DODS), station 023 (outside of the G-DODS), and station GO-2 (field duplicate in the reference site).

Dioxins and Furans: Eight stations (001, 002, 008, 021, 026, 029, 031, 038) and four reference stations (GO-1, -2, -3, and -5) had detected concentrations of OCDD (Tables 7-17 – 7-19). Stations 001, 008, 029, and GO-2 had detected concentrations of a few other dioxin/furan compounds. All other data were either not detected or detected below the RLs. There are no ER-L or ER-M values to compare to for dioxin/furan compounds, but total toxicity equivalency quotients (TEQs) were calculated using toxicity equivalency factors (TEFs). TEQs were calculated using both zero and half the detection limit for non-detect compounds. The average total TEQ concentrations using zero for non-detect compounds was 0.383 ng/kg TEQ inside the G-DODS, 0.407 ng/kg TEQ outside the G-DODS, and 0.172 ng/kg TEQ at the reference site (Table 4-1 – Table 4-4). The range of total TEQ concentrations using zero for non-detect compounds in samples was 0.023 - 1.57 ng/kg inside the G-DODS, 0.008 – 1.89 ng/kg outside of the G-DODS, and 0.079 – 0.416 ng/kg at the reference site. The average total TEQ concentrations using half the detection limit for non-detect compounds was 0.979 ng/kg TEQ inside the G-DODS, 1.09 ng/kg TEQ outside the G-DODS, and 0.430 ng/kg TEQ at the reference. The range of total TEQ concentrations using half the detection limit for non-detect compounds in samples was 0.410-2.10ng/kg TEQ inside the G-DODS, 0.536-2.21 ng/kg TEQ outside the G-DODS, and 0.292-0.677 ng/kg TEQ at the reference site.

Butyltins: There were no butyltins detected in any of the 25 samples (Table 4-1 –Table 4-4).

Table 4-1. Summary of physical parameters and chemistry of sediments from inside the dredged material footprint.

		Survey Station:														
Analytes	**Units (dw)**	001	002	008	014	015	020	021	026	026 DUP*	027	032	033	038	039	044
Gravel	%	8.27	0	0	0	0	0	0	0	0.01	0	0.02	0.01	0.47	0.06	0.47
Sand	%	14.83	28.92	21.85	24.26	25.88	16.54	10.69	14.34	13	20.05	13.62	14.24	21.4	24.45	23.32
Silt	%	25.66	40.61	47.22	43.32	43.42	44.65	51.7	50.98	43.87	43.44	41.07	44.01	38.55	35.94	37.81
Clay	%	51.24	30.47	30.93	32.42	30.7	38.81	37.61	34.68	43.12	36.51	45.29	41.74	39.58	39.55	38.4
Total Organic Carbon	%	0.54	0.23	0.26	0.23	0.21	0.28	0.31	0.31	0.26	0.23	0.26	0.26	0.26	0.21	0.24
Arsenic	mg/kg	7.4	6.14	6.49	7.34	5.6	6.07	6.49	6.54	5.66	5.59	5.94	5.09	5.67	7.03	7.96
Cadmium	mg/kg	0.158	0.187	0.183	0.239	0.161	0.156	0.156	0.157	0.137	0.152	0.176	0.155	0.171	0.223	0.228
Chromium	mg/kg	49.2	35.4	38.9	36.6	36.8	44.7	45.4	43.1	36.4	38.7	38.5	33.2	32.9	27.5	34
Copper	mg/kg	47.1	48.8	51.5	55.4	42.7	52.1	49.7	51.2	47.1	48.5	51	44.6	46.3	45.9	54.8
Lead	mg/kg	7.81	8.98	8.63	12.4	6.46	6.53	5.76	6.39	5.62	5.65	6.36	5.77	7.3	13.1	15.1
Mercury	ug/kg	64.4	35.3	58	41.6	47.2	58.1	77.2	74.2	86.2	44.5	60.8	43.3	40.3	29.4	28.6
Nickel	mg/kg	40.4	47.9	53.9	80.8	44.6	47.7	45.2	45.2	40.5	43.7	42.7	37.7	40.2	49.6	68.8
Selenium	mg/kg	0.4	0.3	0.2	0.2	0.1	ND	0.2	0.2	ND	ND	ND	ND	ND	0.2	0.2
Silver	mg/kg	0.037	0.024	0.032	0.03	0.03	0.039	0.044	0.038	0.027	0.031	0.033	0.031	0.022	0.026	0.023
Zinc	mg/kg	48.1	41.8	43.8	47.3	38.2	44.8	42.8	43.2	39.4	41.5	42.5	37	38.5	40	45.1
Total Organotins	ug/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total PAHs	ug/kg	27.45	2.76	0.93	2.93	3.18	2.13	1.99	5.22	4.38	0.96	0.87	4.05	13.28	0.69	0.17
Total PCB Aroclors	ug/kg	28.8	1.8	ND	ND	ND	ND	ND	1.4	ND	ND	ND	ND	ND	ND	ND
Total PCB Congeners	ug/kg	18.61	0.18	ND	0.16	0.24	ND	0.51	ND	ND	ND	ND	0.24	ND	ND	ND
Total DDTs	ug/kg	ND	ND	ND	1.7	1	2.4	4.3	26	ND	ND	ND	0.95	ND	ND	ND
Dioxins - Total TEQ[1]	ng/kg	1.40	0.521	0.145	0.065	0.027	0.552	0.146	0.043	0.023	0.047	0.095	0.061	1.571	0.058	0.987
Dioxins - Total TEQ[2]	ng/kg	2.10	0.980	0.848	0.411	0.741	1.013	0.923	0.612	1.37	0.466	0.764	0.410	1.85	0.616	1.59
Dioxin-Like PCBs - Total TEQ	ug/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

"Inside" stations are both within the disposal site boundary AND on the dredged material deposit as determined by the SPI-PVP survey. "Outside" stations are both outside the site boundary AND off the dredged material deposit. Green highlight indicates above ER-L; yellow highlight indicates above ER-M.

* Field duplicate sample from a separate grab taken at a different time at the same station

[1] Using ND= 0

[2] Using ND= 1/2 DL

Table 4-2. Summary of physical parameters and chemistry of sediments from outside of the dredged material footprint.

		Survey Station:					
Analyte	**Units (dw)**	018	023	025	029	031	037
Gravel	%	0	0	0	0.73	0	0.01
Sand	%	19.26	13.38	11.3	13.33	5.04	18.04
Silt	%	44.85	44.53	40	43.69	36.04	38.53
Clay	%	35.89	42.09	48.7	42.25	58.92	43.42
Total Organic Carbon	%	0.26	0.26	0.32	0.28	0.31	0.28
Arsenic	mg/kg	6.33	5.6	6.86	6.64	6.09	5.8
Cadmium	mg/kg	0.18	0.132	0.166	0.185	0.132	0.163
Chromium	mg/kg	46.9	39.8	48.1	43.5	35.8	35.5
Copper	mg/kg	50.9	45.2	52.6	57.6	50.7	53.1
Lead	mg/kg	5.77	4.71	5.7	6.8	6.22	7.35
Mercury	ug/kg	39.9	58	66.1	35.2	82.6	58.1
Nickel	mg/kg	49.2	39.3	47.5	47.5	36.1	38.8
Selenium	mg/kg	0.2	0.1	0.2	0.2	0.2	0.2
Silver	mg/kg	0.042	0.028	0.042	0.023	0.028	0.032
Zinc	mg/kg	44.5	37.6	44.3	47	39.1	40.7
Total Organotins	ug/kg	ND	ND	ND	ND	ND	ND
Total PAHs	ug/kg	1.22	1.15	37.59	2.7	2.26	3.12
Total PCB Aroclors	ug/kg	7.9	ND	ND	ND	ND	ND
Total PCB Congeners	ug/kg	ND	ND	ND	ND	ND	0.18
Total DDTs	ug/kg	ND	ND	3.8	ND	ND	ND
Dioxins - Total TEQ[1]	ng/kg	0.309	0.008	0.008	1.893	0.034	0.189
Dioxins - Total TEQ[2]	ng/kg	0.536	0.964	0.994	2.21	1.27	0.569
Dioxin-Like PCBs - Total TEQ	ug/kg	ND	ND	ND	ND	ND	ND

"Inside" stations are both within the disposal site boundary AND on the dredged material deposit as determined by the SPI-PVP survey. "Outside" stations are both outside the site boundary AND off the dredged material deposit. Green highlight indicates above ER-L; yellow highlight indicates above ER-M.

* Field duplicate sample from a separate grab taken at a different time at the same station

[1] Using ND= 0

[2] Using ND= 1/2 DL

Table 4-3. Summary of physical parameters and chemistry of sediments from the reference site.

		Survey Station:					
Analyte	**Units (dw)**	GO-1	GO-2	GO-2 DUP*	GO-3	GO-4	GO-5
Gravel	%	8.33	38.06	0.2	0	0	0.02
Sand	%	14.44	10.93	18.63	18.15	25.49	38.37
Silt	%	37.17	27.18	37.45	48.02	42.4	40.59
Clay	%	40.06	23.83	43.72	33.83	32.11	21.02
Total Organic Carbon	%	0.37	0.35	0.36	0.36	0.36	0.27
Arsenic	mg/kg	6.97	7.26	6.72	5.96	6.57	7.25
Cadmium	mg/kg	0.157	0.156	0.157	0.139	0.151	0.157
Chromium	mg/kg	54.7	57.1	55.1	50	53.2	58.3
Copper	mg/kg	49.8	46.4	43.4	37.9	40.1	41.6
Lead	mg/kg	5.27	5.46	5.25	4	4.59	4.88
Mercury	ug/kg	68.7	49.8	48.4	43.1	44.1	36.3
Nickel	mg/kg	47.9	49.6	48	43.8	45.7	50.2
Selenium	mg/kg	0.2	0.3	0.3	0.2	0.2	0.2
Silver	mg/kg	0.053	0.056	0.047	0.047	0.043	0.046
Zinc	mg/kg	44.6	44.9	41.7	39.4	40.6	42.7
Total Organotins	ug/kg	ND	ND	ND	ND	ND	ND
Total PAHs	ug/kg	1.77	5.06	1.57	4.34	10.01	3.98
Total PCB Aroclors	ug/kg	ND	3.1	ND	14	5	6.4
Total PCB Congeners	ug/kg	0.63	0.77	1.3	0.25	2.3	0.92
Total DDTs	ug/kg	ND	1.8	ND	2	15	1.8
Dioxins - Total TEQ[1]	ng/kg	0.113	0.416	0.134	0.089	0.079	0.203
Dioxins - Total TEQ[2]	ng/kg	0.392	0.677	0.377	0.292	0.347	0.494
Dioxin-Like PCBs - Total TEQ	ug/kg	ND	ND	ND	ND	ND	ND

"Inside" stations are both within the disposal site boundary AND on the dredged material deposit as determined by the SPI-PVP survey. "Outside" stations are both outside the site boundary AND off the dredged material deposit. Green highlight indicates above ER-L; yellow highlight indicates above ER-M.

* Field duplicate sample from a separate grab taken at a different time at the same station

[1] Using ND= 0

[2] Using ND= 1/2 DL

Table 4-4. Summary of physical parameters and chemistry ranges and averages of sediments from inside the dredged material footprint, outside the footprint, and at the reference site.

Analyte	Units (dw)	ER-L	ER-M	Range Inside	Range Outside	Range Reference	Average Inside	Average Outside	Average Reference
Gravel	%	--	--	0 - 8.27	0 - 0.73	0 - 38.06	0.62	0.12	7.77
Sand	%	--	--	10.69 - 28.92	5.04 - 19.26	10.93 - 38.37	19.16	13.39	21.00
Silt	%	--	--	25.66 - 51.7	36.04 - 44.85	27.18 - 48.02	42.15	41.27	38.80
Clay	%	--	--	30.47-51.24	35.89 - 58.92	21.02 - 43.72	38.07	45.21	32.43
Total Organic Carbon	%	--	--	0.21 - 0.54	0.26 - 0.32	0.27 - 0.37	0.27	0.29	0.35
Arsenic	mg/kg	8.2	70	5.09 - 7.96	5.6 - 6.86	5.96 - 7.26	6.33	6.22	6.79
Cadmium	mg/kg	1.2	9.6	0.137 - 0.239	0.132 - 0.185	0.139 - 0.157	0.18	0.16	0.15
Chromium	mg/kg	81	370	27.5 - 49.2	35.5 - 48.1	50 - 58.3	38.09	41.60	54.73
Copper	mg/kg	34	270	42.7 - 55.4	45.2 - 57.6	37.9 - 49.8	49.11	51.68	43.20
Lead	mg/kg	46.7	218	5.62 - 15.1	4.71 - 7.35	4 - 5.46	8.12	6.09	4.91
Mercury	ug/kg	150	710	28.6 - 86.2	35.2 - 82.6	36.3 - 68.7	52.61	56.65	48.40
Nickel	mg/kg	20.9	51.6	37.7 - 80.8	36.1 - 49.2	43.8 - 50.2	48.59	43.07	47.53
Selenium	mg/kg	--	--	0.1 - 0.4	0.1 - 0.2	0.2 - 0.3	0.22	0.18	0.23
Silver	mg/kg	1	3.7	0.022 - 0.044	0.023 - 0.042	0.043 - 0.056	0.03	0.03	0.05
Zinc	mg/kg	150	410	37 - 48.1	37.6 - 47	39.4 - 44.9	42.27	42.20	42.32
Total Organotins	ug/kg	--	--	ND	ND	ND	ND	ND	ND
Total PAHs	ug/kg	4022	44792	0.17 - 27.5	1.15 - 37.6	1.57 - 10.0	4.73	8.01	4.46
Total PCB Aroclors	ug/kg	--	--	1.4 - 28.8	7.9 - 7.9	3.1 - 14	10.67	7.90	7.13
Total PCB Congeners	ug/kg	22.7	180	0.16 - 18.6	0.18 - 0.18	0.25 - 2.3	3.32	0.18	1.03
Total DDTs	ug/kg	1.58	46.1	0.95 - 26	3.8 - 3.8	1.8 - 15	6.06	3.80	5.15
Dioxins - Total TEQ[1]	ng/kg	--	--	0.023 - 1.57	0.008 - 1.89	0.079 - 0.416	0.38	0.41	0.17
Dioxins - Total TEQ[2]	ng/kg	--	--	0.410 - 2.10	0.536 - 2.21	0.292 - 0.677	0.98	1.09	0.43
Dioxin-Like PCBs - Total TEQ	ug/kg	--	--	ND	ND	ND	ND	ND	ND

"Inside" stations are both within the disposal site boundary AND on the dredged material deposit as determined by the SPI-PVP survey. "Outside" stations are both outside the site boundary AND off the dredged material deposit.

* Field duplicate sample from a separate grab taken at a different time at the same station

[1] Using ND= 0

[2] Using ND= 1/2 DL

4.3 Acute Toxicity Bioassays

A 10-day sediment amphipod survival test with *Leptocheirus plumulosus* test was performed for each site composite sample from the reference site. The concentration-response relationship for the reference toxicant test was evaluated as per EPA guidelines (EPA-821-B-00-004) and was determined to be acceptable. There was 97% survival in the Lab Control sediment, indicating an acceptable survival response by the test organisms. The survival in XAB-025 was significantly less than the Lab Control response ($p < 0.05$). Due to the statistical observation that survival in the XAB-025 sample was significantly less than the Lab Control treatment response at $p < 0.05$, further statistical analyses were performed comparing the survival result in XAB-025 to the remaining sediment samples results. These analyses indicated that the XAB-025 survival results were not statistically lower than the survival results in the XAB-023, XAB-024, and XAB-026 sediment samples, but they were statistically lower than the survival results in the XAB-027 sediment sample (Table 4-5).

Table 4-5. Leptocheirus plumulosus survival in the reference site sediments.

Sediment Site	Laboratory Sample ID	% Survival in Test Replicates					Mean % Survival
		Rep A	Rep B	Rep C	Rep D	Rep E	
Lab Control	Lab Control	95	95	95	100	100	97
XAB-023	GDODS-1	95	90	90	100	85	92
XAB-024	GDODS-2	100	90	80	90	100	92
XAB-025	GDODS-3	95	90	80	85	85	**87***
XAB-026	GDODS-4	95	90	90	85	100	92
XAB-027	GDODS-5	100	95	90	95	90	94

* The response at this test treatment was significantly less than the Control treatment response at $p < 0.05$

5 CONCLUSIONS AND RECOMMENDATIONS

The objectives of the 2022 G-DODS survey were met. Based on analyses of SPI/PV, sediment grain size, and sediment chemistry, it appears that the pre-disposal sediment testing program has protected the G-DODS and surroundings from any adverse environmental impacts. The bulk of the dredged material disposed in the last decade appears to have been deposited properly within the site boundaries. There are minor and localized physical impacts from dredged material disposal, as expected, but no significant adverse impacts are apparent to the benthic environment.

5.1 Sediment Profile Images – Plan View Images

The SPI/PV collected successfully mapped the dredged material footprint and characterized the benthic community status. Dredged material placement has occurred at this ODMDS since 2010, however disposal volumes have been limited. The only disposal activity at G-DODS occurred in 2017 and included approximately 138,000 yd^3 of dredged material originating from the U.S. Navy Base located in Apra Harbor, Guam (USACE, 2022).

The dredged material, observed as sediment layers and patches of material in the sediment column, was optically distinct from the native sediment. The SPI/PV results indicate that dredged material disposal efforts were successful in containing the majority of the material within the site boundary. Dredged material was documented only within the site boundary, with one exception: one station outside of the G-DODS was documented as having traces of dredged material. This station was located southeast of the G-DODS, generally along the route from Apra Harbor. It appears that the outlier dredge material is potentially the result of incidental leakage from the disposal scowl, as the trace dredged material was only found at one station outside the site, and that station is within the transit route from the harbor to the G-DODS. Compliance reports indicate that there was no substantial leakage from the disposal scow during any transit during the single project that disposed at the G-DODS, therefore this leakage is minor and not expected to have had adverse impacts to the area in which it was found.

In terms of environmental effects, the presence of dredged material did not appear to correspond with biological impairment. The deep sea is generally considered to be oligotrophic (Thiel 1979; Grassle and Grassle, 1994). As such, the baseline sediment community is one of small shallow burrowers (Rex and Etter, 2010), or early to intermediate stage succession. Dredged material tends to be organically rich due to its origin from harbors and coastal waterways. The placement of dredged material in deep-sea organically poor basins can artificially enrich the deep seafloor promoting secondary productivity (Wilber and Clarke, 1998). Advanced successional taxa were documented at stations where dredged material was present, including Station 001 at the center of the SDZ, where Stage 3 taxa were observed in each of the three replicate images. It is possible that dredged material placement in G-DODS promoted secondary benthic production at these stations.

Since the single project disposing at the G-DODS consisted of low volumes and occurred five years prior to the most recent survey, sufficient recovery has been observed inside the G-DODS. However, there does not seem to be a consistent recovery pattern within the G-DODS, as there is variability in infaunal successional stages. The same variability is also present outside of the G-DODS and reference site; locations with dredged material had both early and late-stage succession and, locations without dredged material also had both early and late-stage succession. This variability in benthic recovery is believed to be due to the natural variability of the native environment, as the unimpacted areas seem to demonstrate similar variability to the variability found inside the G-DODS.

Other potential impacts such as anthropogenic debris and adverse organic enrichment were also evaluated through the SPI-PV. Anthropogenic debris was observed in several PV images dispersed throughout the survey area, including at the reference site. The presence of this debris often did not appear to coincide with the presence of dredged material**.** The haphazard distribution of anthropogenic debris in and around the G-DODS disposal site suggests that direct placement of dredged material is not the sole contributing cause of anthropogenic debris. The SPI/PV also demonstrated that there were no indications of adverse organic enrichment, and the benthic community in the G-DODS surveyed area was not found to be in an impaired state. At all the stations surveyed in and around the G-DODS, the sediment was qualitatively assessed as having low SOD, indicating that the seafloor was not experiencing

deleterious levels of enrichment. Similarly, the presence of anthropogenic debris was not found to be associated with any level of impaired state of the benthic community.

5.2 Sediment Physical Parameters and Chemistry

Sediment Physical Parameters

Grain Size: Minor and localized impacts within the G-DODS were expected following the disposal event in 2017. Average grain size results from the 2022 survey for all stations both inside and outside of G-DODS show sediments are comprised primarily of silt, followed by clay, and fine sand**.** However, slight variability was observed within the G-DODS: gravel and coarser sands were present in the southern and western areas inside the G-DODS, although the percentage composition of these grain size classes remained low. Additionally, the center of the SDZ contained higher percentages of gravel, coarse sand, and clay clasts, and lower percentages of silt in comparison to other stations inside the G-DODS. This higher percentage of clay and gravel compared to other areas of the site is likely due to the dredged material disposed in the SDZ. Larger sediments, such as gravel and clay casts, tend to fall quickly to the bottom of the SDZ and remain centralized, as opposed to finer sediments which tend to disperse and settle outside the SDZ.

Grain size distribution found during this latest survey slightly varied compared to what was observed during the baseline designation survey of the G-DODS. Sediment samples collected from the Northwest Alternative area and reference site in 2008 were primarily composed of sand, followed by silt and clay. During the most recent survey, average grain size results from stations inside and outside the G-DODS, including at the reference site, indicate that sediments are comprised primarily of silt, clay, and fine sand. Therefore, since designation, it appears that the silt fraction has remained relatively consistent, however the clay fraction has increased, and the sand fraction has decreased. While there has been an observed change in grain size distribution within and outside of the G-DODS since its designation, this trend can be seen across the survey area including the reference site. This implies that the change in grain size distribution is not limited to the boundaries of the G-DODS and is likely the result of a factor external to dredging, such as potentially differing grain size classifications.

Total Organic Carbon: The results from the 2022 survey indicate that average TOC was very similar inside and outside the G-DODS and slightly higher at the reference site. TOC from stations within the G-DODS also appear to be relatively consistent between the designation studies and the most recent survey in both average concentration and range.

Sediment Chemistry

Metals: Metal concentrations at stations inside the G-DODS, outside the G-DODS, and at the reference site were very similar. Arsenic, cadmium, mercury, selenium, silver, and zinc all had very similar averages and ranges and were all below the ER-L at all stations throughout the survey area. Copper exceeded the ER-L at all stations within the study area, however levels both within and outside of the G-DODS boundaries were similar. Nickel concentrations were above the ER-L for every station sampled within and outside of the G-DODS, however nickel concentrations only surpassed the ER-M at three stations (located on the northeast portion of

the G-DODS). Despite these exceedances of the ER-M within the G-DODS, the average nickel concentrations were very similar between the areas inside the G-DODS, outside the G-DODS, and at the reference site. Further, although exceeding the ER-M may indicate potential toxicity, such concentrations of nickel are naturally occurring in Guam.

There were slight differences in lead and chromium concentrations throughout the survey area, with slightly higher lead concentrations inside the G-DODS in comparison to outside and at the reference site, and slightly lower chromium concentrations inside the G-DODS in comparison to the reference site. However, all lead and chromium values were well below the ER-L.

Overall, stations within and outside the G-DODS and at the reference site had similar concentrations of metals as those observed during the site designation surveys, with the exception of selenium and silver. Selenium concentrations increased by approximately seven-fold from the site designation surveys to the 2022 survey. Despite this increase in selenium concentration, selenium concentrations from the 2022 survey were nearly identical across the stations within the G-DODS, outside the G-DODS, and at the reference site. This indicates that this increase in selenium concentration across the survey area is likely not due to disposal material deposited at the G-DODS, but rather an overall change in the natural environment or external factor such as laboratory evaluations. Furthermore, average concentrations across the 2022 study area were far below the Apparent Effects Threshold (AET) of (1000 mg/kg) for selenium. Silver, on the other hand, appeared to be approximately three times lower across the 2022 survey area, in comparison to the baseline designation studies. Therefore, dredged material disposal has not resulted in adverse metal concentrations inside the G-DODS.

Pesticides: Individual pesticide concentrations within the G-DODS during the most recent survey were mainly non-detect. However, total DDTs exceeded the ER-L at four stations inside the G-DODS (at the southeast), one station outside the G-DODS (also at the southeast), and four stations at the reference site. Overall, the average total DDT was similar between the G-DODS and reference site, and all values were well below the ER-L, except for four stations where concentrations of total DDTs surpassed the ER-L but were well below the ER-M.

Pesticide concentrations within the Northwest Alternative area during the site designation surveys were non all non-detect. The increase in pesticide levels from the designation surveys to 2022 appears to be primarily concentrated at the southeast of the survey study area, with increases seen inside the G-DODS, outside the G-DODS, and at the reference site. Because this increase in pesticide concentrations was seen across all three areas (i.e., inside, outside, and reference) in the 2022 survey, such increases are likely not due to disposal of dredged material.

Polychlorinated Biphenyls: During the most recent survey, total PCB Aroclor and total Congener concentrations were slightly elevated inside the G-DODS, in comparison to outside the G-DODS and at the reference site. However, all total PCB Congener values were well below the ER-L[6].

During the site designation survey, both PCB Congeners and Aroclors were non-detect throughout the Northwest Alternative area. During the most recent survey, most stations had

[6] No ER-L or ER-M values are available for PCB Aroclors.

non-detect levels of total PCB Congeners and Aroclors throughout the G-DODS survey area, with the exception of a few stations. Although there were increases in PCB Congeners and Aroclors from the designation surveys to 2022, those increases were minor and were generally consistent across the entire survey area. Therefore, dredged material disposal has not resulted in adverse PCB concentrations inside the G-DODS.

Polycyclic Aromatic Hydrocarbons: During the most recent survey, total PAH concentrations were similar inside the G-DODS and at reference site. Although the total PAH concentrations were slightly higher outside the G-DODS than inside the G-DODS and at the reference site, the ranges of total PAH concentrations were similar across all three areas. It appears that the higher level of PAHs outside of the G-DODS was primarily driven by one station (025) at the southeast, and further removed from the G-DODS. Further, all total PAH concentrations were well below the ER-L.

Concentrations of PAHs reported from site designation survey had overall non detect levels throughout the Northwest Alternative area and the reference site. Although total PAH concentrations in 2022 were slightly elevated compared to the baseline studies, the increase is minor, all values are well below the ER-L, and the greatest increases were seen outside of the G-DODS. Therefore, dredged material disposal has not resulted in adverse PAH concentrations inside the G-DODS.

Dioxins and Furans: Dioxins and furans during both surveys were calculated as TEQs. TEQ values reported within G-DODS during the most recent survey were similar inside the G-DODS and outside the G-DODS, and both of these values were slightly elevated in comparison to the reference site.

During site designation, TEQ^1 concentrations in the Northwest Alternative area averaged 0.043 ng/kg TEQ, with a range of 0.026 to 0.053 ng/kg TEQ, and TEQ^2 averaged 3.086 ng/kg TEQ, with a range of 3.06 to 3.16 ng/kg TEQ. Although TEQ values observed during the designation surveys in the Northwest Alternative area were quite different to those seen inside and outside the G-DODS and at the reference site during the 2022 survey, these differences are most likely due to differences in MDLs between the two surveys. MDLs for dioxins and furans were 2 ng/kg during the designation surveys, whereas they were predominantly under 1 ng/kg during the 2022 survey. Therefore, there were several lower concentrations of dioxins and furans (below 1 ng/kg) identified during the 2022 survey that would have been considered non-detect for TEQ^1 calculations during the designation surveys, resulting in a higher TEQ^1 value for the 2022 survey than the site designation surveys. Alternatively, because the MDLs were higher during the designation surveys, the TEQ^2, which uses ½ of the MDL for non-detect values, resulted in a much higher TEQ^2 value during the designation surveys than the 2022 survey. Importantly, the results of the 2022 survey indicate that both TEQ^1 and TEQ^2 values were similar inside and outside of the G-DODS, therefore dredged material disposal has not resulted in adverse dioxin and furan concentrations inside the G-DODS.

Organotins: Organotins were non-detect across the 2022 survey area. Similarly, organotins were non-detect across the Northwest Alternative area and the reference site during the designation studies.

5.3 Acute Toxicity Bioassays

The 10-day sediment amphipod survival test with *Leptocheirus plumulosus* test was deemed to be acceptable, and the results will be added to the G-DODS Ocean Reference Database.

5.4 Recommendations

EPA conducted the 2022 monitoring survey to assess the conditions and performance of the EPA-designated G-DODS. Since its designation in 2010, the G-DODS has received disposals from a singular dredging project. EPA analyzed the data collected during the 2022 survey to identify whether any adverse impacts of dredged material disposal occurred and to compare the results to the baseline conditions seen during the 2008 survey of the Northwest Alternative area.

Based on the results, it appears that the pre-disposal sediment testing program has protected the G-DODS and surrounding areas from any adverse contaminant loading. The bulk of the dredged material disposed appears to have been deposited properly within the site boundaries. There are minor and localized physical impacts from dredged material disposal, as expected, but no significant adverse impacts are apparent to the benthic environment outside of site boundaries. Continued use of the G-DODS, under an updated SMMP, is recommended.

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7 APPENDIX

Table 7-1. Sediment chemistry from the Northwest Alternative and reference site (US Navy, 2009).

Analyte	Units	MDL	RL	Proposed Reference Site (GO-5)	Northwest Alternative (GO-6 - GO-8)			ER-L	ER-M	Oceanic Crustal Abundance[3]
Grain Size										
Gravel	%	-	-	0	0	0	0	-	-	-
Sand	%	-	-	57.30	63.44	50.13	42.57	-	-	-
Silt	%	-	-	33.96	30.33	40.33	47.79	-	-	-
Clay	%	-	-	8.75	6.22	9.54	9.64	-	-	-
Silt-Clay	%	-	-	42.70	36.56	49.87	57.43	-	-	-
General Chemistry										
Total Organics Carbon (TOC)	Percent	0.01	0.02	0.8	0.2	0.3	0.4	-	-	-
Total Organic Nitrogen (TON)[1]	mg/dry kg	-						-	-	-
Total Kjeldahl Nitrogen (TKN)		7.6	10	220	180	190	140	-	-	-
Ammonia-N	mg/dry kg	0.03	0.03	0.5	0.2	0.24	0.29	-	-	-
Total Sulfides	mg/dry kg	0.2	0.4	0.78	0.51	0.53	0.56	-	-	-
Percent Solids	Percent	0.1	0.1	53.3	53.8	51.5	52.2	-	-	-
Trace Metals										
Aluminum (Al)	µg/dry g	1	5	26720	21460	23380	17280	-	-	-
Antimony (Sb)	µg/dry g	0.025	0.05	0.152	0.168	0.156	0.2	-	-	-
Arsenic (As)	µg/dry g	0.025	0.05	6.012	5.954	6.092	5.639	8.20	70.00	-
Barium (Ba)	µg/dry g	0.025	0.05	176.4	223.4	387.5	368.4	-	-	1497
Beryllium (Be)	µg/dry g	0.025	0.05	0.154	0.172	0.183	0.131	-	-	-
Cadmium (Cd)	µg/dry g	0.025	0.05	0.11	0.139	0.136	0.159	1.20	9.60	-
Chromium (Cr)	µg/dry g	0.025	0.05	61.2	45.7	48.62	31.38	81.00	370.00	17
Cobalt (Co)	µg/dry g	0.025	0.05	13.81	15.82	14.94	14.06	-	-	6324
Copper (Cu)	µg/dry g	0.025	0.05	39.02	49.55	52.83	43.99	34.00	270.00	799
Iron (Fe)	µg/dry g	1	5	26310	26070	27010	20990	-	-	-
Lead (Pb)	µg/dry g	0.025	0.05	3.05	6.047	5.564	7.572	46.70	218.00	874
Manganese (Mn)	µg/dry g	0.025	0.05	487.5	1191	1068	1420	-	-	-

Analyte	Units	MDL	RL	Proposed Reference Site (GO-5)	Northwest Alternative (GO-6 - GO-8)			ER-L	ER-M	Oceanic Crustal Abundance[3]
Mercury (Hg)	µg/dry g	0.01	0.02	0.06	0.05	0.06	0.04	0.15	0.71	-
Molybdenum (Mo)	µg/dry g	0.025	0.05	0.402	0.667	0.56	0.59	-	-	-
Nickel (Ni)	µg/dry g	0.025	0.05	46.36	51.53	47.2	38.31	20.90	51.60	4960
Selenium (Se)	µg/dry g	0.025	0.05	0.111	0.062	0.089	0.053	-	-	-
Silver (Ag)	µg/dry g	0.025	0.05	0.111	0.103	0.095	0.118	1.00	3.70	-
Strontium (Sr)	µg/dry g	0.025	0.05	2531	1437	1440	1167	-	-	1253
Thallium (Tl)	µg/dry g	0.025	0.05	0.038J	0.187	0.121	0.175	-	-	-
Tin (Sn)	µg/dry g	0.025	0.05	0.345	0.278	0.345	0.211	-	-	-
Titanium (Ti)	µg/dry g	0.025	0.05	688.9	644.6	668.7	586.2	-	-	-
Vanadium (V)	µg/dry g	0.025	0.05	70.85	67.76	74.58	58.11	-	-	600
Zinc (Zn)	µg/dry g	0.025	0.05	35.97	41.31	41.58	34.89	150.00	410.00	654
Acid Volatile Sulfides-Simultaneously Extracted Metals (AVS-SEM)										
Acid Volatile Sulfides (AVS)	mg/dry kg	0.05	0.1	2.01	1.03	1.16	1.52	-	-	-
Cadmium (Cd) - SEM	µmol/dry g	0.0018	0.0036	<0.0018	<0.0018	<0.0018	<0.0018	-	-	-
Copper (Cu) - SEM	µmol/dry g	0.0062	0.0124	0.0569	0.0435	0.0745	0.113	-	-	-
Lead (Pb) - SEM	µmol/dry g	0.0002	0.0004	0.0003J	<0.0002	0.0002J	0.0013	-	-	-
Nickel (Ni) - SEM	µmol/dry g	0.0033	0.0066	0.0126	0.008	0.0077	0.0107	-	-	-
Silver (Ag) - SEM	µmol/dry g	0.0047	0.0094	<0.0047	<0.0047	<0.0047	<0.0047	-	-	-
Zinc (Zn) - SEM	µmol/dry g	0.0015	0.003	0.0533	0.0557	0.058	0.0841	-	-	-
Polynuclear Aromatic Hydrocarbons (PAHs)										
1-Methylnaphthalene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
1-Methylphenanthrene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
2,3,5-Trimethylnaphthalene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
2,6-Dimethylnaphthalene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
2-Methylnaphthalene	ng/dry g	1	5	<1	<1	<1	<1	70	670	-
Acenaphthene	ng/dry g	1	5	<1	<1	<1	<1	16	500	-
Acenaphthylene	ng/dry g	1	5	<1	<1	<1	<1	44	640	-
Anthracene	ng/dry g	1	5	<1	<1	<1	<1	85.3	1100	-

Analyte	Units	MDL	RL	Proposed Reference Site (GO-5)	Northwest Alternative (GO-6 - GO-8)			ER-L	ER-M	Oceanic Crustal Abundance[3]
Benz[a]anthracene	ng/dry g	1	5	<1	<1	<1	<1	261	1600	-
Benzo[a]pyrene	ng/dry g	1	5	<1	<1	<1	<1	430	1600	-
Benzo[b]fluoranthene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Benzo[e]pyrene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Benzo[g,h,i]perylene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Benzo[k]fluoranthene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Biphenyl	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Chrysene	ng/dry g	1	5	<1	<1	<1	<1	384	2800	-
Dibenz[a,h]anthracene	ng/dry g	1	5	<1	<1	<1	<1	63.4	260	-
Dibenzothiophene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Fluoranthene	ng/dry g	1	5	<1	<1	<1	<1	600	5100	-
Fluorene	ng/dry g	1	5	<1	<1	<1	<1	19	540	-
Indeno[1,2,3-c,d]pyrene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Naphthalene	ng/dry g	1	5	<1	<1	<1	<1	160	2100	-
Perylene	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Phenanthrene	ng/dry g	1	5	<1	<1	<1	<1	240	1500	-
Pyrene	ng/dry g	1	5	<1	<1	<1	<1	665	2600	-
Chlorinated Pesticides										
2,4'-DDD	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
2,4'-DDE	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
2,4'-DDT	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
4,4'-DDD	ng/dry g	1	5	<1	<1	<1	<1	2	20	-
4,4'-DDE	ng/dry g	1	5	<1	<1	<1	<1	2.2	27	-
4,4'-DDT	ng/dry g	1	5	<1	<1	<1	<1	1	7	-
Aldrin	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
BHC-alpha	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
BHC-beta	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
BHC-delta	ng/dry g	1	5	<1	<1	<1	<1	-	-	-

Analyte	Units	MDL	RL	Proposed Reference Site (GO-5)	Northwest Alternative (GO-6 - GO-8)			ER-L	ER-M	Oceanic Crustal Abundance[3]
BHC-gamma	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Chlordane-alpha	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Chlordane-gamma	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
DCPA (Dacthal)	ng/dry g	5	10	<5	<5	<5	<5	-	-	-
Dicofol	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Dieldrin	ng/dry g	1	5	<1	<1	<1	<1	0.02	8	-
Endosulfan Sulfate	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Endosulfan-I	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Endosulfan-II	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Endrin	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Endrin Aldehyde	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Endrin Ketone	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Heptachlor	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Heptachlor Epoxide	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Methoxychlor	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Mirex	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Oxychlordane	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Perthane	ng/dry g	5	10	<5	<5	<5	<5	-	-	-
Toxaphene	ng/dry g	10	50	<10	<10	<10	<10	-	-	-
cis-Nonachlor	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
trans-Nonachlor	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Total Chlordane	ng/dry g	-	-	<1	<1	<1	<1	0.5	6	-
Polychlorinated Biphenyls (PCBs) Congeners										
PCB003	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB008	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB018	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB028	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB031	ng/dry g	1	5	<1	<1	<1	<1	-	-	-

Analyte	Units	MDL	RL	Proposed Reference Site (GO-5)	Northwest Alternative (GO-6 - GO-8)			ER-L	ER-M	Oceanic Crustal Abundance[3]
PCB033	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB037	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB044	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB049	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB052	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB056/060	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB066	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB070	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB074	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB077	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB081	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB087	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB095	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB097	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB099	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB101	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB105	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB110	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB114	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB118	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB119	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB123	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB126	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB128	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB138	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB141	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB149	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB151	ng/dry g	1	5	<1	<1	<1	<1	-	-	-

Analyte	Units	MDL	RL	Proposed Reference Site (GO-5)	Northwest Alternative (GO-6 - GO-8)			ER-L	ER-M	Oceanic Crustal Abundance[3]
PCB153	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB156	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB157	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB158	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB167	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB168+132	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB169	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB170	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB174	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB177	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB180	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB183	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB187	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB189	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB194	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB195	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB200	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB201	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB206	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
PCB209	ng/dry g	1	5	<1	<1	<1	<1	-	-	-
Total PCBs	ng/dry g	-	-	<1	<1	<1	<1	22.7	180	-
Aroclor PCBs										
Aroclor 1016	ng/dry g	10	20	<10	<10	<10	<10	-	-	-
Aroclor 1221	ng/dry g	10	20	<10	<10	<10	<10	-	-	-
Aroclor 1232	ng/dry g	10	20	<10	<10	<10	<10	-	-	-
Aroclor 1242	ng/dry g	10	20	<10	<10	<10	<10	-	-	-
Aroclor 1248	ng/dry g	10	20	<10	<10	<10	<10	-	-	-
Aroclor 1254	ng/dry g	10	20	<10	<10	<10	<10	-	-	-

Analyte	Units	MDL	RL	Proposed Reference Site (GO-5)	Northwest Alternative (GO-6 - GO-8)			ER-L	ER-M	Oceanic Crustal Abundance[3]
Aroclor 1260	ng/dry g	10	20	<10	<10	<10	<10	-	-	-
Organotins										
Dibutyltin	ng/dry g	1	3	<1	<1	<1	<1	-	-	-
Monobutyltin	ng/dry g	1	3	<1	<1	<1	<1	-	-	-
Tetrabutyltin	ng/dry g	1	3	<1	<1	<1	<1	-	-	-
Tributyltin	ng/dry g	1	3	<1	<1	<1	<1	-	-	-
Dioxins/Furans[2]										
2,3,7,8-Tetra CDD	pg/g	2.00	10	< 0.13	< 0.10	< 0.12	< 0.12	-	-	-
1,2,3,7,8-Penta CDD	pg/g	2.00	10	< 0.13	< 0.10	< 0.12	< 0.11	-	-	-
1,2,3,4,7,8-Hexa CDD	pg/g	2.00	10	< 0.16	< 0.17	< 0.13	< 0.14	-	-	-
1,2,3,6,7,8-Hexa CDD	pg/g	2.00	10	< 0.13	< 0.14	0.17 J	< 0.11	-	-	-
1,2,3,7,8,9-Hexa CDD	pg/g	3.00	10	< 0.16 (1)	< 0.15	< 0.19 (1)	< 0.12	-	-	-
1,2,3,4,6,7,8-Hepta CDD	pg/g	3.00	10	< 1.4 (1)	1.07 J	0.76 J	< 0.44 (1)	-	-	-
Octa CDD	pg/g	5.00	100	20.1	12.6	15.8	11.4	-	-	-
Total Tetra CDD	pg/g	-	-	< 0.33 (1)	< 0.34 (1)	0.3	< 0.12	-	-	-
Total Penta CDD	pg/g	-	-	2.67	3.25	1.47	2.4	-	-	-
Total Hexa CDD	pg/g	-	-	< 2.4 (1)	0.95	0.17	< 1.8 (1)	-	-	-
Total Hepta CDD	pg/g	-	-	1.48	2.33	1.6	0.47	-	-	-
2,3,7,8-Tetra CDF	pg/g	2.00	10	0.30 J	0.20 J	0.23 J	0.22 J	-	-	-
1,2,3,7,8-Penta CDF	pg/g	2.00	10	< 0.18	< 0.12	< 0.12	< 0.11	-	-	-
2,3,4,7,8-Penta CDF	pg/g	2.00	10	< 0.19	< 0.13	< 0.25 (1)	< 0.12	-	-	-
1,2,3,4,7,8-Hexa CDF	pg/g	2.00	10	< 0.13	< 0.19 (1)	< 0.12	< 0.12 (1)	-	-	-
1,2,3,6,7,8-Hexa CDF	pg/g	2.00	10	< 0.12	0.16 J	< 0.11	< 0.11	-	-	-
2,3,4,6,7,8-Hexa CDF	pg/g	2.00	10	< 0.14	< 0.13	< 0.13	< 0.13	-	-	-
1,2,3,7,8,9-Hexa CDF	pg/g	2.00	10	< 0.17	< 0.15	< 0.15	< 0.15	-	-	-
1,2,3,4,6,7,8-Hepta CDF	pg/g	3.00	10	< 1.9 (1)	< 0.71 (1)	< 0.26 (1)	< 0.20 (1)	-	-	-
1,2,3,4,7,8,9-Hepta CDF	pg/g	2.00	10	< 0.14	< 0.16	< 0.14	< 0.11	-	-	-
Octa CDF	pg/g	5.00	100	1.55 J	0.64 J	0.63 J	0.35 J	-	-	-

Analyte	Units	MDL	RL	Proposed Reference Site (GO-5)	Northwest Alternative (GO-6 - GO-8)			ER-L	ER-M	Oceanic Crustal Abundance[3]
Total Tetra CDF	pg/g	-	-	0.69	0.42	0.52	0.39	-	-	-
Total Penta CDF	pg/g	-	-	< 0.41 (1)	< 1.2 (1)	< 0.25 (1)	< 0.11	-	-	-
Total Hexa CDF	pg/g	-	-	0.55	0.68	0.13	< 0.12 (1)	-	-	-
Total Hepta CDF	pg/g	-	-	< 1.9 (1)	< 0.71 (1)	< 0.26 (1)	< 0.20 (1)	-	-	-
Gross Alpha/Beta										
Gross Alpha	pCi/g	3	-	6.45	12.1	10.8	11.6	-	-	-
Gross Beta	pCi/g	2.3	-	2.17	5.86	2.46	1.61	-	-	-

J = estimated value above the MDL and below the RL

[1] TON = TKN -Ammonia

[2] Dioxin/furan results reported down to sample-specific laboratory EDL instead of MDL

[3] Wen *et al*., 1997

(1) = EMPC / NDR - Peak detected does not meet ratio criteria and has resulted in an elevated detection limit