ENVIRONMENTAL ASSESSMENT

PROPOSED HOTEL WHARF AND ACCESS ROAD
MAINTENANCE AND REPAIR PROJECT
Apra Harbor, Guam

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and

U.S. DEPARTMENT OF TRANSPORTATION
MARITIME ADMINISTRATION
As lead Federal Agency pursuant to the National Environmental Policy Act of 1969

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LIST OF ABBREVIATIONS

AMEC	AMEC Environment & Infrastructure, Inc.
APE	Area of Potential Effect
BMP	best management practice
dB	decibel
BMUS	bottomfish management unit species
CALTRANS	California Department of Transportation
cm	centimeter(s)
CMUS	crustacean management unit species
CFR	Code of Federal Regulations
CHCRT	currently harvested coral reef taxa
CRE-MUS	coral reef ecosystem species
DAWR	Division of Aquatic and Wildlife Resources
DCA	Duenas, Camacho & Associates, Inc.
DOT	U.S. Department of Transportation
DPS	distinct population segment
EA	Environmental Assessment
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FEP	Fishery Ecosystem Plan
ft	feet
FWCA	Fish and Wildlife Coordination Act
HAPC	Habitat Areas of Particular Concern
m	meter
MARAD	Maritime Administration
MLLW	mean lower low water
mph	miles per hour
MSA	Magnuson-Stevens Act
MSL	mean sea level
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic & Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PAG	Port Authority of Guam

LIST OF ABBREVIATIONS (continued)

PHCRT	potentially harvested coral reef taxa
PIP	Port Improvement Project
PTS	permanent threshold shift
RO/RO	roll-on/roll-off
sq. ft	square feet
sq. m	square meter
TTS	temporary threshold shift
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish & Wildlife Service
UXO	unexploded ordnance
WPRFMC	Western Pacific Regional Fishery Management Council

1. INTRODUCTION

The Port Authority of Guam (PAG, Port) was awarded funding through the Transportation Investment Generating Economic Recovery (TIGER) Discretionary Grant No. DTMA91G1600007. Maritime Administration (MARAD), as the operating administration on behalf of the Department of Transportation (DOT), proposes to fund the reconstruction of the Hotel Wharf and Access Road Maintenance and Repair Project in Apra Harbor, Guam.

This Environmental Assessment (EA) is prepared in accordance with the following: U.S. Department of Transportation (DOT) Order 5610.1C, "Procedures for Considering Environmental Impacts"; MARAD Maritime Administrative Order 600-1, dated July 23, 1985; and the National Environmental Policy Act of 1969 (NEPA), as implemented by the Council on Environmental Quality (CEQ) regulations found in Code of Federal Regulations (CFR) Title 40, Parts 1500 to 1508 (40 CFR §§ 1500 - 1508).

1.1 Project Location

The Proposed Action is located on Cabras Island, Apra Harbor, Guam (Appendix A, Figure 1). Guam is an unincorporated United States (U.S.) territory and the southernmost island in the Mariana Archipelago. Cabras Island extends from the western coast of Guam to form the northern limit of Apra Harbor, the largest U.S. deep-water harbor in the western Pacific, and the busiest port in Micronesia (Porter 2005).

1.2 Summary of Proposed Action

The proposed action is the Hotel Wharf and Access Road Maintenance and Repair Project. The proposed action would entail the following tasks:

- Repair and improve approximately one mile of access road serving the wharf and other Cabras Island facilities;
- Install or replace underground utilities in the access road and wharf areas, including water, sewer, electricity, stormwater, and data transmission;
- Reconstruct the existing wharf and bulkhead to include a new sheet pile bulkhead with approximately 4,396 cubic yards (cu. yds) of clean fill to increase the in-water footprint by approximately 4,577 square feet (sq. ft);
- Construct structural components on the wharf and road, including mooring bollards and concrete decking/pavement;
- Demolish the dilapidated structures, including fencing, cleats, rubber fenders, and mooring bollards, and asphalt and concrete pavement, and a portion of the concrete cap atop the existing sheet pile bulkhead.

2. PURPOSE AND NEED

2.1 Existing Conditions

Hotel Wharf is a 500-ft long waterfront structure along its south face that was originally constructed in 1948. The wharf has progressively deteriorated over the years since it was transferred to the PAG in 1989. Damage to the facility includes asphalt surface deterioration; corrosion of sheet piles and bulkhead; and deterioration of bollards, cleats, tie rods, and wharf fender system (Parsons Brinckerhoff (PB) 2018). It is not known whether the existing facility was designed for earthquake loading, but the wharf is located in Universal Building Code Seismic Zone 3 and sustained earthquake damage in 1993. The original draft depth of the wharf was approximately -34 ft mean lower low water (MLLW). The existing mudline along the wharf bulkhead varies between -28.6 and -33.6 MLLW.

Hotel Wharf has not been used as a commercial wharf since December 2001 as the facility is structurally unsound. The wharf consists of an aging seawall structure with concrete decking and an asphalt center section. In past years, the PAG leased the facility for various commercial activities including cruise ship operations, administrative functions, fishing support operations, and recreational activities. It has also been used directly by the PAG for scrap metal handling and vehicle import operations when space at the Jose D. Leon Guerrero Commercial Port of Guam (Commercial Port) facility was temporarily restricted. The Commercial Port marine facilities include the Marine Industrial Terminal and the Cargo Terminal (Figure 1B). The Marine Industrial Terminal includes wharf F-1 (liquid bulk and liquid petroleum gas operations); wharf F-2 (fishing fleet repair); and Golf Pier (liquid bulk tankers). The Cargo Terminal includes wharf F-3 (general cargo, passenger vessels, and fishing vessels), and wharves F-4 through F-6 (container and general cargo); the types of operations are summarized in Table 1.

Table 1. Types and Volume of Operations at the Commercial Port Cargo Terminal

Types of Operations	FY2019 YTD	FY2018	FY2017	FY2016	FY2015	FY2014	FY2013
Bulk Operation Tons	11604	35378	30300	20843	12569	42608	33477
BB Transhipment Tons	148	4201	6639	2526	4031	1108	1434
BB Unitized Tons	339	962	362	792	847	1142	803
Tuna Fishing Tons	563	1301	1516	1628	2579	2677	2327
RO/RO Total Vehicles	2852	5027	7216	7766	9291	6075	5972
RO/RO (Over 6,000 Pounds[1]) Tons	4761	9094	0	0	0	0	0
RO/RO BB Tons	608	1232	617	666	2444	1899	1509
RO/RO Unitized Tons	214	597	430	442	704	291	288
Research Vessel Visits	16	52	52	3	12	10	2
Cruise Vessel Visits	3	3	6	4	3	5	7

Source: PAG. Notes: FY = Fiscal Year; YTD = Year to Date; RO/RO = Roll-on/Roll-off; BB = Break Bulk; 1 = Trucks, Heavy Lift, Boats, Others.

Bulk cargo refers to dry good commodities that can be shipped in bulk (non-unitized) form, such as sand, aggregates, and scrap metal. Break bulk cargo are commodities that cannot fit into containers, including those that can be shipped on a pallet as an individual unit (unitized). Roll-on/roll-off (RO/RO) cargo is a type of break bulk cargo that is rolled or driven on/off ships, such as automobiles. Containerized cargo is handled with land-based gantry cranes, while self-sustaining vessels have their own cranes to lift containers onto the wharf. Cruise and research vessel berthing also takes place at Commercial Port.

The Port has received 31 passenger cruise vessel visits, and 147 research vessel visits since Fiscal Year 2013 (Table 1). During each visit, the vessels are temporarily berthed at F-3 in the Commercial Port, which must shut down its normal cargo handling operations for security reasons.

Hotel Wharf has recently transitioned from being a leased facility to one that will be used directly by the PAG. The PAG anticipates that future construction in the Cargo Terminal will create an increased need for overflow and contingency operations at Hotel Wharf during Commercial Port reconfiguration and a potential increase in cargo flow as a result of the normal economic growth. Consequently, maintenance and repair of Hotel Wharf is now a high priority project for the PAG.

2.2 Purpose and Need for Proposed Action

The purpose of the proposed project is to restore valuable PAG property to safe and efficient operational status. The site layout will remain open and suitable for multi-purpose use. The facility is currently unusable for large vessel mooring and deck surface loading, hence, repairs to the facility are needed to obtain U.S. Coast Guard certification for compliance as a waterfront facility (PB 2018). The project is needed to support PAG's overflow and emergency break bulk and bulk cargo handling operations, container operations on self-sustaining vessels, and cruise and research vessel mooring, and passenger screening operations. The proposed action is expected to help provide alternative offload and staging areas for specific project cargos, provide flexible cargo/passenger handling acreage as the Port transitions between different modes of operation at the main cargo terminal, and provide for easier management of spikes in cargo activity (PB 2018). The ability to berth cruise and research vessels at Hotel Wharf would shift this activity from the Cargo Terminal, thereby avoiding a disruption of cargo handling operations, and ensuring that the flow of commerce continues unimpeded.

3. ALTERNATIVES CONSIDERED

This section describes the alternatives that were considered, including the proposed action, which is the preferred alternative, and the no action alternative. This section also describes other alternatives that were eliminated from further consideration.

3.1 Proposed Action

The proposed action is the Hotel Wharf and Access Road Maintenance and Repair Project.

Access Road. Approximately one mile of the existing roadway will be repaired to improve access to Hotel Wharf and other Cabras Island facilities. While the roadway and shoulder areas will be improved in the same location, there will be minor adjustments to grade and alignment of both to achieve better performance for traffic and the environment. The proposed project will not increase capacity or vehicle miles traveled on the access roadway.

Stormwater Outfalls. In the process of repairing the road, stormwater management components will be installed that do not currently exist. In total, seven new stormwater outfalls will be installed in the project construction footprint to discharge surface water runoff into Apra Harbor (Figures 2A-2C). Surface runoff from Hotel Wharf will be treated through two oily water separators and a filtration system before discharging via two outfalls into Apra Harbor. In addition, surface runoff from the roadway will be directed to a grass-lined bioswale along the north side of the road for natural filtration prior to being discharged into Apra Harbor through a series of underground stormwater pipes, catch basins and five outfalls on the south side of the road. These five outfalls will be installed adjacent to the roadway and will discharge runoff onto existing energy-dissipating riprap. The easternmost outfall (S-107) will also have an oily water separator to pre-treat stormwater prior to discharge. The proposed action would not install new riprap in waters of Apra Harbor.

Utilities. Both the wharf and roadway maintenance and repair activities will involve the placement or replacement of underground utilities. Utilities in the road will include water line replacement, stormwater piping, and empty data transmission conduit and sanitary sewer. Utilities in the wharf will include electrical for power and lighting, potable water with capped stubouts to support future construction, a fire main with supporting tank and pump station, stormwater pipes with oily water separators, sanitary lines with holding tank and manholes to support future construction, and empty data communications conduit terminating in handholes to support future construction. Site electrical will originate from existing roadway power poles and proceed underground to a new load center situated on the wharf close to the access road. Underground electrical lines from the load center will feed low mast perimeter wharf lighting and site power

requirements. Conduit and manholes will be positioned to support future construction at both the northwest and northeast corners of the wharf adjacent to the access road.

Wharf Reconstruction. Hotel Wharf maintenance and repair activities include construction of a new sheet pile bulkhead retaining wall at an offset from the existing sheet pile bulkhead wall of 8.0 ft from the west side, 6.25 ft from the south side and 9.75 ft from the east side. The new bulkhead wall be approximately 717.5 ft long (inclusive of east and west return bulkheads at approximately 101.8 ft each), and will increase the size of the in-water wharf footprint by approximately 4,577 sq. ft, which will increase the area of shading by a maximum of 10,128 sq. ft (941 sq. m) for morning hours, and by a maximum of 16,996 sq. ft (1,579 sq. m) for afternoon hours, based on a shade analysis (Figures 5-7). The new bulkhead wall will be constructed to accommodate new structural components without causing the existing wharf to collapse during construction. Wharf structural components will include new sheet pile retaining wall bulkheads held in place by new sheet pile "deadman" walls, batter piles, and tie-rods. Pile driving would likely occur both off of barge structures in the water and land-based pile driving rigs. Water-borne pile driving rigs would require the use of containment booms and silt curtains. Ecological disturbance is expected to be lessened with the driving of new sheetpile into native sediments without the attendant disturbance and cleanup that would be associated with removing existing piles first.

Additional structural components include mooring bollards on the wharf, two mooring bollards along the roadway's edge east and west of the wharf, and concrete decking/pavement for the first 100 ft adjacent to the pierhead line in the ship unloading zone. Structural fill will be placed in the area between the existing and new bulkheads. All parts of the Hotel Wharf surface will be impervious with the area outside the 100-ft ship unloading zone consisting of asphalt pavement.

Fill Activities. Clean material from an on-island upland source will be used to backfill the area between the existing and new bulkhead walls, for a total of 4,396 cu. yds of fill material. There would be no off-site cumulative impact as a result of the amount of fill to be placed at this site. Fill material placed between the existing bulkhead and the new sheet pile wall will be contained and will not be in contact with open water, thereby minimizing potential impacts. No dredging is proposed as part of project activities.

Demolition. Project demolition components include the removal of surface facilities and dilapidated structures such as fencing, cleats, rubber fenders, and mooring bollards. It also includes the removal of asphalt and concrete pavement, and the partial demolition of the concrete cap atop the existing sheet pile bulkhead.

3.2 No Action Alternative

The no action alternative would not involve new construction, hence, there would be no rehabilitative upgrades to Hotel Wharf and no improvements to the adjacent access road. This alternative would leave these facilities in their current condition. Hotel Wharf would remain idle and inactive because the structure is unsound. The access road would remain unimproved with no stormwater infrastructure. Stormwater runoff would continue to sheet flow untreated into the receiving waters of Apra Harbor. The potential economic benefits of reactivating commercial operations at Hotel Wharf would not be realized by the Government of Guam.

3.3 Alternatives Considered and Dismissed

The Port considered the following alternatives to the proposed action alternative.

3.3.1 Demolition of Existing Hotel Wharf and Full Reconstruction

The Port considered the demolition of the existing wharf bulkhead, and then reconstruction of the bulkhead in place to provide a structurally sound facility. This alternative was dismissed from further consideration because it was anticipated to result in greater disturbance to the receiving waters and ecosystem of Apra Harbor than the proposed action alternative.

3.3.2 F-6 Wharf Improvements

The Port's 1990 Master Plan considered the extension of the wharf face of Berth F-6, approximately 900 ft to the east of Hotel Wharf, to ultimately allow three full container berths along this face (Figure 1B) (TAMS Consultants, Inc. and J. Agi & Associates, Inc. 1990). Initially, this additional berth would benefit the various combinations of vessels and inter-island vessels calling at the Port. This alternative, in combination with the expansion of the container yard to provide 37 to 40 acres, would increase the practical operating capacity of the Port to approximately 3,000,000 revenue tons annually.

This alternative was dismissed from further consideration because it was anticipated to result in greater disturbance to the receiving waters and ecosystem of Apra Harbor than the proposed action alternative. The activities associated with this alternative included the need to dredge a new berth (from 35 ft to 40 ft water depth), construction of a 900 ft long extension of the wharf (including bulkhead, ship services, crane rails and paving to the rear of the cranes), and expansion of the container yard by approximately 13 acres. The cost in 1990 to implement this action, with contingencies and engineering design, was estimated at approximately $29,830,000 (TAMS Consultants, Inc. and J. Agi & Associates, Inc. 1990).

4. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

4.1 Resources Considered in this Environmental Assessment

4.1.1 Soil, Geology, Seismicity

Soils. The proposed Hotel Wharf project is located entirely on an extension of Cabras Island upon a manmade breakwater comprising Urban land-Ustorthents complex soils. Urban land consists of impervious areas containing paved roads, parking lots and buildings overlaying crushed coral fill or limestone substrate (Young 1988). Stormwater runoff is rapid over these impermeable Urban land areas. Ustorthents consist of quarried fill material, commonly with crushed coral gravel and cobbles; permeability is moderately rapid, and stormwater runoff is slow (Young 1988).

Geology. The Port of Guam is located on the west side of Cabras Island just north of the Orote Peninsula. The Port was built as an extension of Cabras Island, a naturally occurring carbonate platform associated with the reef facies of the Mariana limestone (PB 2014). The Mariana limestone unit near the site is massive, generally compact, porous and cavernous white limestone of reef origin, with corals in a growth position in a matrix of encrusting calcareous algae (Siegrist and Reagan 2008). The Port facilities include a breakwater extending to the west on the north side of the harbor just over 2 miles from the western end of Cabras Island. The wide coral bank of Luminao Reef forms the foundation for the Glass Breakwater (Tracey et al. 1964), upon which Hotel Wharf and the adjacent access road are situated. In addition to the Pliocene and Pleistocene Mariana limestone, modern reefs are present near the Port. Limestone is exposed at the surface on Cabras Island, east of the Port of Guam, and is typically found relatively close to the surface in the portions of the Port that were originally part of Cabras Island (PB 2014). In other locations, including Hotel Wharf and the access road, near-surface man-made fill material, marine salty sands, and coralline gravels typically comprise the graphic sequence that overlays the limestone rock (PB 2014).

Seismicity. The Hotel Wharf facility has progressively deteriorated over the years since it was originally constructed shortly after World War II, and then transferred to the Port in 1989 (PB 2014). It is unknown whether it was originally designed for earthquake loading (PB 2014). Evaluations conducted in the mid 1990's have suggested that it is currently susceptible to damage during Uniform Building Code (UBC) Level 3 and 4 earthquakes. It is located in UBC Seismic Zone 3 and is known to have actually sustained earthquake damage in 1993.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on soils, geology, soils and seismicity.

Proposed Action Alternative. In order to construct the road improvements and install utilities, the proposed action would disturb the soils at the site, which comprise permeable crushed coral fill in the unpaved areas. On-site material may be used as an aggregate base course provided that it meets the required aggregate gradations. The proposed horizontal and vertical alignments will also follow the existing conditions as much as possible, keeping within applicable codes and standards. Temporary erosion and sedimentation control measures shall be provided to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and water bodies. The finished road would be asphalt-paved, adding to the impervious surfaces of the project site. The access road will be sloped to the north at 2 percent, and roadway runoff would be collected and treated in a bioswale and piped back under the road to a new stormwater outfall. Best management practices (BMPs) will be employed to minimize dust and sedimentation from earthmoving activities. The underlying limestone geology of the project site would not be altered by the proposed action.

The repaired wharf facility will be designed to sustain applicable earthquake loading along with the mooring and docking loads of larger vessels and multi-purpose deck surface loading associated with bulk cargo, break-bulk cargo, and loaded container cargo stacked two-high (PB 2014). The proposed asphaltic concrete pavement and base on the wharf and repaired road will be designed to handle bulk, break-bulk, and cargo handling equipment loads on the wharf, and future vehicle traffic (cruise passenger buses and bulk/break-bulk transport vehicles) on both the wharf and road (PB 2014).

The repaired access road will accommodate traffic associated with break bulk and bulk cargo operations currently performed in the Commercial Port. Use of the standards applied for the Defense Access Road Program and, in particular, for the recently completed Route 11 improvements are assumed sufficient to address military mobilization requirements (PB 2014).

4.1.2 Air Quality

The National Ambient Air Quality Standards (NAAQS) are pollutant concentration limits established by U.S. Environmental Protection Agency (USEPA) under the Clean Air Act (CAA) to protect human health and welfare, including sensitive populations, such as children and the elderly. The NAAQS encompass the following criteria air pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter less than 10 and 2.5 microns (PM_{10}, $PM_{2.5}$), lead (Pb) and ozone (O_3). Pursuant to section 107(d) of the CAA, USEPA has designated a 6.074-kilometer (km) (3.77-mile) radius around the Cabras Island/Piti Power Plant in the Municipality of Piti as a SO_2 non-attainment area under the 2010 NAAQS. A non-attainment designation indicates a certain air region has not met the NAAQS based on ambient air quality monitoring data.

The CAA includes provisions that ensure federal actions do not obstruct local efforts to control air pollution. Section 176(c) of the CAA prohibits federal agencies from engaging

in, supporting, licensing, of approving any action that does not conform to an approved state or federal implementation plan. Conformity includes Transportation Conformity (wherein federal highway projects must comply with the Transportation Improvement Plan for an area) and General Conformity (wherein projects with non-road components (e.g., marine vessels) must conform to the State Implementation Plan for the area). Conformity to an implementation plan's purpose of eliminating or reducing the severity and number of violations of the NAAQS and achieving expeditious attainment of such standards; and that such activities will not a) cause or contribute to any new violation of any standard in any area; b) increase the frequency or severity of any existing violation of any standard in any area; or c) delay timely attainment of any standard or any required interim emission reductions or other milestones in any area.

The Hotel Wharf project site is located entirely within the Cabras Island/Piti Power Plant SO_2 non-attainment area. The power plant facility, located approximately 2.2 miles from Hotel Wharf, is the main stationary emission source in the project vicinity (Figure 1B). The existing mobile emission sources in the vicinity include official Port and personal vehicles; cargo handling equipment, including 10-ton and 20-ton forklifts, top-lifters (which stack and transfer containerized cargo), and yard tractors; commercial and private trucks; buses and vans; and marine vessels (such as tankers, cargo ships, and cruise vessels). The nearest existing sensitive land uses in the project vicinity and their distances include Hoover Park (1.9 miles), Pedro Santos Park (2 miles), Outhouse Beach (0.003 mile), Family Beach (0.095 miles); Piti Village and the Jose Rios Elementary School are 2 or more miles from the project site (Figure 1B). The nearest medical facility, U.S. Naval Hospital, is over 5 miles away from the project limits.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on existing air quality.

Proposed Action Alternative. ***Construction Phase:*** Heavy equipment would be used to bring construction materials and equipment to the project site (including aggregate fill material), and haul construction debris away. Marine vessels may be used for some transportation of materials and equipment during construction. The proposed action would involve earthmoving and construction activities that require the use of heavy equipment, such as dump trucks, cranes, bulldozers, excavators, backhoes, and pavers. Small motorized boats may be used during the installation and removal of the turbidity curtain. A crane-mounted barge would be used during pile-driving activities. These road and non-road activities would generate emissions, such as fugitive dust (PM_{10}) during earthmoving and the unloading of fill material, and heavy equipment and marine vessel exhaust ($PM_{2.5}$, CO, oxides of nitrogen (NO_x), and SO_2) during transportation and construction.

The Port Modernization EA included an estimated annual emissions inventory in tons per year for operation of heavy equipment (based on 8 hours per day, 5 days per week)

during the 2013-2014 construction period for the following pollutants: CO, volatile organic carbons (VOC), NO_X, SO_X, PM_{10}, and $PM_{2.5}$; these estimates were all well below the USEPA General Conformity *de minimis* thresholds for these pollutants (EA 2012). The Hotel Wharf project is also anticipated to occur over a two-year period (2019-2021), within a much smaller footprint (7.68 acres) than the Port Modernization project (71 acres) but using similar construction equipment. The Hotel Wharf project is anticipated to generate similar types of emissions as the Port Modernization project, and, given the smaller footprint, these emissions are anticipated to fall below USEPA General Conformity *de minimis* thresholds, and no further conformity analysis would be needed.

The Hotel Wharf project emissions generated during construction activities are expected to be minor adverse effects; however, these would be temporary and concentrated within the immediate vicinity of the project site. The nearest sensitive land uses are Outhouse Beach, located adjacent to the access road, and Family Beach, located 0.095 miles (501 ft) to the west of the westernmost extent of the project where the access road would be improved, and located 0.188 miles (992 ft) from Hotel Wharf. While the proposed project would have short-term adverse effects on air quality during construction, with the implementation of standard BMPs to control dust and particulates, these effects are not anticipated to be significant.

Operation Phase: The proposed project does not include expansion of capacity on the wharf access road. There will be an increase in vehicle traffic on this road, much of it local and driven by the shifting of overflow operations from the Commercial Port to Hotel Wharf. This traffic on the wharf and access road would include bulk/break-bulk transport vehicles, such as commercial and private trucks. Very minimal cargo handling equipment would be needed at Hotel Wharf, since container operations would remain confined to the Cargo Terminal. Cruise passenger buses, taxis and rental vehicles would be used during the occasional port calls from cruise ships and research vessels. The emissions related to cargo operations and cruise/research vessel berthing are existing uses that already occur at the Cargo Terminal that would be shifted to Hotel Wharf. These existing activities would not cause an exceedance of the SO_2 NAAQS. Therefore, the proposed action would be in conformity with the CAA General Conformity Rule since there would be no significant emission sources from the proposed activity above the existing conditions.

4.1.3 Hazardous Materials and Waste Management

Since Hotel Wharf is a former U.S. Navy ammunition wharf, Unitek Environmental Guam, Inc. (UEG) (2013) performed scans down to the 30 ft water depth to identify obstructions, manmade debris and search for hazardous materials and/or unexploded ordnance (UXO) or munitions and explosives of concern (MEC). UEG (2013) documented extensive debris, but found no UXOs or MEC. The south side of Hotel Wharf contained the largest area of metal debris, including various amounts of large equipment tires, large cables from mooring systems, gang planks, manmade trash, and large batteries. The east side of Hotel

Wharf contained barrels, concrete-filled barrels, a large amount of equipment tires, cables and chains, a large mooring buoy, various amounts of abandoned pipes and assorted trash. UEG (2013) concluded that all of the metal and debris discovered was indicative of battle damage of vessels during World War II, and also indicative of human littering from previous use of the Navy/Military Sealift Command at the Hotel Wharf site.

During underwater surveys in March 2019, Dr. William Jeffery, Maritime Archaeologist and Assistant Professor, Anthropology, University of Guam (UOG), found the southern face littered with material associated with the use of the wharf that has been dumped, thrown, or has fallen onto the seabed. This debris included: rubber tires of various sizes, wharf fenders, a considerable amount of rope of various thicknesses as well as metal cable, thin strand wire, the rear section of a heavy duty forklift, a large scrap metal cube, two large concrete columns, various size shackles, a hand-trolley, sand bags, sections of various diameter pipe, metal plating, a small number of bottles and cans, fragmentary timber piles, and a few ceramics (one whole plate, a few ceramic sherds similar to the plate, and a cup) (Jeffery, 2019). The eastern and western faces contained very little debris, which is indicative of these sections of the wharf not being used in loading or unloading people or cargo (Jeffery 2019). A UXO dive team was present throughout the maritime survey; however, no MEC or Material Potentially Presenting an Explosive Hazard (MPPH) were found (UEG 2019).

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on hazardous materials and waste management.

Proposed Action Alternative. The proposed action would not have a significant effect on the environment relative to hazardous materials and waste management. Prior to construction, the debris within the project footprint would be removed if it poses an obstacle to pile-driving or is unsuitable to remain in place prior to backfilling behind the new sheetpiles. These unsuitable materials include marine batteries, rubber tires, and metal cables. The installation of sheetpiles for the bulkhead extension would be performed with a UXO team involved to ensure the safety of the work and avoidance of any MEC or MPPH. All debris removed from the project area prior to pile-driving would be disposed properly at an approved disposal site by the Port's salvage contractor.

4.1.4 Noise and Vibration

Based on USEPA guidance, the exterior noise L_{dn} (day-night noise level) of 65 A-weighted decibels (dBA) was used as a threshold for construction and operational noise, wherein noise levels above 65 dBA are considered to have an adverse effect on sensitive receptors (such as schools, parks, hospitals, or nature preserves). A-weighted decibels are denoted by dBA, which is a weighted scale representing the range and characteristics of human hearing. L_{dn} denotes the day-night sound level that averages all events over a 24-hour

period, measured in dBA. The Guam Department of Public Work Traffic Noise Abatement Policy (2009) sets noise threshold levels for traffic noise, as shown in Table 2.

Table 2. Activity Categories and Noise Abatement Criteria

Activity Category	L_{eq}(h) dBA	Description of Activity Category
A	57 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, places of worship, libraries, and hospitals.
C	72 (Exterior)	Developed lands, properties, or activities not included in Categories A or B.
D	--	Undeveloped lands.
E	52 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, and auditoriums.

Note: Leq (h) is the equivalent continuous sound level over one hour.

The wharf access road is considered a low-volume road, with traffic generated mainly by private and commercial entities accessing recreational areas to the east and west of Hotel Wharf. Aside from commercial and industrial vessel traffic, the harbor supports tourist-related recreational activities. Immediately adjacent and west of Hotel Wharf is a commercial jet ski and banana boat activity based on shore that operates regularly in the harbor.

Actual ambient sound levels for Apra Harbor are unavailable; however, they would likely be comparable to the ambient sound levels of 120-155 dB_{PEAK}, and 133 dB_{RMS} measured for a large marine bay, with heavy industrial use and boat traffic (CALTRANS 2015). These are given in decibels (dB) for the peak sound pressure level and root mean square (RMS) pressure, which is the square root of the average of the square of the pressure of the sound over a given duration. Ambient sound levels in the Commercial Port measured in 2009 ranged from 50.4 to 60.6 Leq, and were estimated at 52 to 62 Ldn (EA 2012).

The project limits do not encompass any sensitive receptors, but are adjacent to Outhouse Beach, which is the nearest sensitive receptor. The project would install a stormwater outfall nearby and improve the driveways at both ends of Outhouse Beach, which is located approximately 0.202 miles east of Hotel Wharf. Family Beach is located about 0.095 miles (153 m) from the western extent of the project, where access road improvements would occur, and 0.188 miles (302 m) from Hotel Wharf (Table 3).

Table 3. Sensitive Receptors in the Vicinity of the Proposed Action

Land Use	Distance to Hotel Wharf (miles)	Distance to Hotel Wharf APE (miles)
Pedro Santos Park	2.616	1.998
Hoover Park	2.553	1.938
Family Beach	0.188	0.095
Outhouse Beach	0.202	0.003
Piti Village	2.685	2.072
Our Lady of Assumption Catholic Church, Piti	2.754	2.140
Jose Rios Elementary School, Piti	2.629	2.023

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects relative to noise and vibration.

Proposed Action Alternative. ***Construction Phase:*** The new sheet pile bulkhead retaining wall will require up to 151 steel H piles and 191 steel PZ-type sheet piles. The in-water pile driving is conservatively anticipated to be completed within 60 to 70 days. Steel H piles (16-inch wide) and steel PZ-type (18-inch wide) sheet piles would be used for the bulkhead wall and would be driven to -68 ft and -52 ft below mean sea level, respectively. An impact hammer would be used to drive the heavier king piles (H piles), and a vibratory hammer would be used to drive the lighter PZ-type sheet piles. The piles would be inserted into a steel template to ensure proper alignment and plumbness. The maximum pile rate is estimated at 3 king piles and infill sheets per 10-hour shift. The cycle would repeat again with the relocation of the template.

Pile driving activities and construction for the wharf would create noise for the duration of the work. The in-water pile driving is conservatively anticipated to be completed within 60 to 70 days if an impact hammer is used for H piles and a vibratory hammer is used for sheet piles. Steel H piles (16-inch wide) and steel PZ-type (18-inch wide) sheet piles would be used for the bulkhead wall, and would be driven to -68 ft and -52 ft below MSL, respectively. The overall length of the sheet pile bulkhead is approximately 717.5 ft, including the two return (east and west) bulkhead walls at 101.75 ft each.

Previous NMFS coordination for sheet pile driving estimated the ranges to effects from noise levels based on the in-water noise measurements compiled by CALTRANS (2007), using the following equation: RL = SL - 15LogR, where RL is the received noise level, SL is the source level (sound energy at 1 m from the source), and R is the range from the source in meters (NMFS 2010). The estimates are based on 24-inch steel sheet piles, which are the closest available example to the 18-inch PZ sheet piles proposed at Hotel Wharf. Using the same equation, similar estimates were made for the H piles. Since no 16-inch H pile noise information was available in the CALTRANS Compendium, the 15-inch

steel H pile noise data was used (CALTRANS 2007). Table 4 presents a summary of the estimated effects and ranges to in-water effects for the proposed pile driving activities.

Table 4. Estimated source levels and ranges to effects threshold isopleths for proposed pile driving types

Pile Type	Sound Level (SL)	Range to 180 dB	Range to 160 dB
24-inch Steel Sheet	178 dB (vibratory hammer)	< 1 m	16 m
15-inch Steel H Pile	195 dB (impact hammer)	10 m	215 m

Three marine species listed under the U.S. Endangered Species Act (ESA) have the potential to occur in the vicinity of the proposed action: green sea turtle, hawksbill sea turtle, and scalloped hammerhead shark (see Section 4.1.11). The exposure of marine life to high-intensity noise levels may result in adverse effects that vary with the frequency, intensity, and duration of the sound source, and the hearing characteristics of the exposed animal (NMFS 2010). Exposure to very high levels may result in soft tissue damage and direct fatality, while lower levels may cause permanent hearing damage (or permanent threshold shift, PTS); even lower levels may result in behavioral effects ranging from temporarily reduced sensitivity (temporary threshold shifts or TTS), to temporarily masked communications and/or acoustic environmental cues, and areal avoidance (NMFS 2010). For exposure to sounds in water, NMFS considers ≥180 dB as the threshold for PTS for cetaceans, and ≥ 160 dB as the threshold for TTS for all marine mammals for impulsive noises (NMFS 2010). These marine mammal thresholds are used for sea turtles, since no acoustic thresholds have been established for sea turtles, and are used with the assumption that they are likely conservative for sea turtles, who appear to rely more heavily on visual cues rather than auditory input (NMFS 2010).

For sea turtles, the sheet pile driving activities would generate potentially injurious sound levels at or above 180 dB (PTS threshold) radiating out less than 1 m, and sound levels at or above 160 dB (TTS threshold) radiating out approximately 16 m. The H pile driving activities would generate potentially injurious sound levels at or above 180 dB (PTS threshold) radiating out approximately 10 m, and sound levels at or above 160 dB (TTS threshold) radiating out approximately 215 m. The ranges to these PTS thresholds (<1 m and 10 m, respectively) fall within the mandatory shut-down range of 50 m for these activities during biological monitoring, which would ensure that no ESA-listed marine animals are exposed to sound levels at 180 dB. Pile driving activities may expose sea turtles to sound levels at or above 160 dB out to 16 m from sheet pile driving, and 215 m from H pile driving. These ranges would be limited to the harbor channel area, where most vessel movement and shipping activity occurs. Sea turtles are mostly solitary individuals that tend to avoid human activities. It is anticipated that with exposure of sea turtles to pile driving noise that exceeds their tolerance thresholds, they are expected to engage in avoidance behavior on a moderate to high energy level, and leave the area immediately with no injuries. Given the anticipated 60-day pile driving period, it is possible that some turtles, after initially moving away from the noise, may eventually become habituated to it and move toward the area and remain there. Although these

turtles may remain in the area and experience a degree of low level TTS, they are not expected to be injured, and there would be no measurable impacts on their ability to forage, shelter or avoid threats (such as vessels and predators).

The probability of an interaction with sea turtles will be reduced by monitoring the work area for sea turtles prior to starting any activities, and by ceasing work activities when turtles are present. Given the likely non-injurious outcome of interactions, and the measures that will be taken to reduce the possibility of interactions, the proposed activities are expected to result in a low likelihood of adverse effects on the well-being of green and hawksbill sea turtles.

Since there are no acoustic thresholds for the scalloped hammerhead shark, the *Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities* was used as a reference, where the agreed upon criteria for injury is a peak of 206 dB (for all size of fish), and a cumulative SEL of 187 dB for fish 2 grams or more, and 183 dB for fish less than 2 grams (Fisheries Hydroacoustic Working Group 2008). The criteria were developed for impact driving, and not vibratory pile driving, hence, the injury threshold for impact driving is likely to be much lower than for vibratory pile driving (CALTRANS 2015). Using the same formula as before, the estimated ranges to effects for the proposed impact pile driving of steel H piles are 3.5 m radiating out to 187 dB, and less than 1 m for sound levels at or above 206 dB. The injury threshold for vibratory pile driving is likely to be lower than impact pile driving; therefore, scalloped hammerhead sharks would be exposed to lower sound levels for sheet pile driving than for the H pile driving. The ranges to the peak and cumulative injury criteria thresholds (3.5 m and <1 m, respectively) fall within the mandatory shut-down range of 50 m for these activities during biological monitoring, which would ensure that no ESA-listed scalloped hammerhead sharks are exposed to sound levels at or above 187 dB.

According to several studies, there is no scientifically supported threshold for behavioral effects on fish from underwater sound, although a general guideline of 150 dB_{RMS} is used as a conservative threshold for ESA-listed salmon and bull trout by USFWS and NOAA Fisheries (CALTRANS, 2015). For the impact hammer pile driving for the steel H piles, the range to 150 dB_{RMS} would be 1,000 m; however, this is within the range of the ambient sound levels for a large marine bay, with heavy industrial use and boat traffic (CALTRANS, 2015), which is comparable to Apra Harbor. As cartilaginous fish, sharks lack a swim bladder and have different ear structures than bony fish, hence, they are considered to be less sensitive to sound than bony fish, such as salmon and trout, who sense sound through their inner ear and swim bladder (CALTRANS, 2015). Additionally, pile driving activities would occur during daylight hours, whereas sharks have been observed to forage more actively at night (Miller et al., 2014). Therefore, the sound levels from the proposed activities in Apra Harbor would not be expected to have adverse behavioral effects on scalloped hammerhead sharks.

During construction on land, the project would require the use of heavy equipment, such as dump trucks, cranes, bulldozers, excavators, backhoes, and pavers, aside from the pile drivers (vibratory and impact hammers) that would be used during pile-driving activities. The measured noise levels from these equipment range from 76 dBA for a dump truck to 101 dBA for an impact pile driver (Table 5). Based on their distance from the construction limits of about 2 miles or more, sensitive receptors (such as Hoover Park) located outside the Port would not receive noise levels during construction beyond the USEPA limits and the thresholds for these uses in Table 2. Family Beach and Outhouse Beach may receive noise levels that exceed these thresholds, particularly during pile-driving activities. Since Family Beach and Outhouse Beach are within Port property, the use of these locations can be temporarily restricted by PAG to minimize impacts to users of these areas. Noise from construction activities, therefore, would not be anticipated to result in a significant impact on sensitive receptors in the vicinity of the proposed action.

Table 5. Noise Levels of Selected Construction Equipment

Equipment Description	Impact Device?	Equipment Specification Limit Lmax (dBA, slow) at 50 ft	Actual Measured Lmax (dBA, slow) at 50 ft
Backhoe	No	80	78
Compactor (ground)	No	80	83
Compressor (air)	No	80	78
Concrete Mixer Truck	No	85	79
Concrete Pump Truck	No	82	81
Concrete Saw	No	90	90
Crane	No	85	81
Dozer	No	85	82
Drum Mixer	No	80	80
Dump Truck	No	84	76
Excavator	No	85	81
Flat Bed Truck	No	84	74
Front End Loader	No	80	79
Generator	No	82	81
Grader	No	85	N/A
Grapple (on backhoe)	No	85	87
Impact Pile Driver	Yes	95	101
Jackhammer	No	85	89
Pavement Scarifier	No	85	90
Paver	No	85	77
Pickup Truck	No	55	75
Scraper	No	85	84
Vibratory Pile Driver	No	95	101
Welder/Torch	No	73	74

Source: FWHA Highway Construction Noise Handbook, 2006. N/A = not available.

The *S.M.S. Cormoran* and *Tokai Maru* are submerged historic properties listed on the National Register of Historic Places. These shipwrecks are located approximately 2,000 feet (ft) away and outside the project area of potential effect. Sheet pile driving activities for the extension of the Hotel Wharf bulkhead will not generate any surface or sub-surface wave action, but do have the potential to create ground vibrations underwater. Given the nearly 0.4-mile distance away from the proposed activities, the potential ground vibrations would be sufficiently dampened such that they are not anticipated to have an adverse impact on these submerged National Register-listed properties.

Operation Phase: Upon its return to service, Hotel Wharf would support breakbulk cargo handling, roll-on/roll-off vehicle operations, and passenger vessel berthing, which would generate operational and traffic noise. Vessel and vehicle traffic at Hotel Wharf during the operation phase would be associated with a shift in overflow operations to relieve the Commercial Port area. As existing activities, the noise from vessel and vehicle traffic at the wharf is not anticipated to have a significant effect on sensitive receptors in the vicinity of the proposed action.

4.1.5 Public Services and Utilities

New underground piping for water and wastewater will be installed beneath the road and appropriately sized to serve the wharf. The wastewater generated on the Hotel Wharf will flow to a wastewater holding tank to be located approximately in the middle of the wharf, and sized appropriately to address sanitary loads. The holding tank will be periodically pumped out at a frequency to be determined by local agencies. A new 8-inch diameter fire water main loop system will be provided in lieu of the existing 8-inch and 4-inch diameter fire water mains. The new fire water mains would be connected to a new fire water storage tank and pumping system to be located on the northeastern corner of the Hotel Wharf site. The electrical power system would draw power from the 13.8 kilovolt (kV) Guam Power Authority (GPA) overhead distribution line located in the access road. A power drop will be routed underground to a substation located in the northeast corner of the site to feed site power to the perimeter lighting system, the future building locations at the northwest and northeast corners of the site, the fire pump station, and selected locations within the open terminal yard.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on public services and utilities.

Proposed Action Alternative. The proposed action will not have a significant impact upon public services and utilities. The project would use a holding tank for wastewater collection, which would reduce the burden on the municipal sewer collection system. The fire suppression system would use a holding tank to ensure adequate water pressure is maintained on the wharf. Filling of the holding tank would be coordinated to avoid adverse effects on the municipal potable water system.

4.1.6 Water Quality

4.1.6.1 Currents and Circulation Patterns

A coastal engineering assessment was completed for a separate Port project that proposed improvements at Hotel Wharf (U.S. Army Corps of Engineers and Wil Chee Planning, Inc. 2007). The study included a current measurement program that involved deployment of a current meter for one month at a water depth of 45 ft offshore of Hotel Wharf, and tracking of current drift drogues in the project vicinity for four days (Sea Engineering, Inc. 2005). The current measurement program indicated that the currents are primarily driven by winds, and are directed to the west to southwest during typical tradewinds. Surface current speeds averaged 10 cm/second, while mid-water column currents averaged 6 cm/second. The drogues indicated the currents in deeper water averaged 1.5 cm/second. In the harbor basin, a two-layer flow pattern is present, with surface currents directed downwind toward the harbor entrance, and bottom layer flow to the east. In shallower water near the shoreline, currents flowed to the west, parallel to shore (Sea Engineering, Inc. 2005). The average tide level ranges from 1.3 ft during neap tides and 2.1 ft during spring tides. Edward K. Noda and Associates, Inc. (1990) calculated storm tidal ranges for the west coast of Guam to be 23.6 ft high with period of 16 seconds (5-year significant wave) and 46.5 ft high with period of 22 seconds (100-year significant wave).

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on currents and circulation patterns.

Proposed Action Alternative. The proposed action would not have significant effects on currents and circulation patterns. There would be no dredging activities associated with the pile-driving for the installation of sheetpiles for the bulkhead extension. Nearshore currents around the bulkhead are anticipated to continue to move west as driven by the winds, parallel to the shore.

4.1.6.2 Water Column Characteristics

The existing water depths within the project area range from the shoreline to approximately -34 ft below MLLW. The southern wharf face extends to a depth of approximately 9 m (30 ft) at the mudline, while the eastern and western flanks extend southward, and perpendicular to, the riprapped shoreline, across the shallow (1.5 m) reef flat to a maximum depth of approximately 8 to 9 m (Burdick 2019).

Water quality near the proposed outfalls is potentially impacted from freshwater input and minor silt introduction by roadway runoff during precipitation events. Existing conditions in the vicinity of the proposed outfalls varies from coarse grained coral beach

to rocky intertidal areas perched on fossilized fringe reef, and surface waters adjacent to the wharf face.

Guam Environmental Protection Agency (GEPA) designates the water quality in the project area as M-2 and M-3 under the Guam Water Quality Standards (GEPA, 2001). Category M-3 (Fair) waters are designated for general, commercial, and industrial use, while allowing for protection of marine life, aesthetic enjoyment, and limited body contact. Category M-2 (Good) waters must be of sufficient quality to allow for propagation and survival of marine organisms, aesthetic enjoyment, and whole-body contact and recreation. M-3 waters are located offshore from the south face of Hotel Wharf and extend east to the Commercial Port area. The waters adjacent to the west face of Hotel Wharf are designated as M-2 waters, and extend west to the harbor mouth, and south into the central basin of Outer Apra Harbor.

According to the USEPA, Apra Harbor is assigned four beneficial uses, one of which is listed as impaired on the CWA Section 303(d) list. The designated beneficial uses and status assigned to Apra Harbor include: Aesthetic Enjoyment (Aesthetic Value) – not assessed; Aquatic Life (Fish, Shellfish, And Wildlife Protection and Propagation) – "Good"; Consumption (Aquatic Life Harvesting) – "Impaired"; and Whole Body Contact Recreation (Recreation) – "Good". The cause of impairment of the consumption beneficial use for reporting years 2008 and 2010 was based on an advisory of Polychlorinated Biphenyls (PCBs) in fish tissue. Sponges, soft corals, sea cucumbers and fish from Apra Harbor were enriched with PCBs, according to studies of marine sediments and food chains in the harbor (Porter 2005). A Total Maximum Daily Load (TMDL) has not currently been developed for this water body, and is listed as low priority.

Through the National Pollutant Discharge Elimination System (NPDES) permit system, USEPA authorizes the discharge of industrial stormwater and tank water into Apra Harbor and the Piti Channel that leads to the harbor. These discharges, from fuel storage, oil and bilge, and power generating facilities, are other potential human-induced impacts on water quality in the harbor.

Sampling of water quality parameters at six stations in Outer Apra Harbor for a previous Port project showed little variability in temperature and salinity, with survey ranges of 28 to 30 ^{o}C, and 34 to 34.36 parts per thousand (ppt) (U.S. Army Corps of Engineers and Wil Chee Planning, Inc. 2007). The stations included three nearshore areas along the Glass Breakwater, two in the central portion of Outer Apra Harbor, and one in the Cabras Island Channel.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on water quality.

Proposed Action Alternative. *Construction Phase: Turbidity Curtain Installation*. The supplemental marine survey report identified and surveyed an aggregate reef and mixed sand/hardbottom area, with higher coral density than the surrounding sandy areas, and located approximately 20 to 40 m from the south face of the existing wharf (Burdick, 2019) (Appendix B). The 20 m distance from the wharf is considered the Indirect Impacts Zone (Figure 3). The turbidity curtain to confine sediments during pile driving would have an enclosure area of approximately 43,367.8 sq. ft (4,029 sq. m) within this 20 m Indirect Impacts Zone. The curtain will be installed with a 3 m (10 ft) buffer from the aggregate reef to ensure the curtain and ballast (chain weight) do not impact the reefs during its deployment and operation (Figure 3). The turbidity curtain would be installed to allow a clearance of one (1) foot between the channel seafloor and the bottom of the curtain. The clearance would prevent the bottom of the curtain from dragging on the seafloor, thus avoiding the generation of additional turbidity and minimizing potential abrasion of sessile organisms. The bottom clearance would also avoid entrapment of marine organisms by allowing them an escape route below the curtain. Turbidity generated by the pile driving will be trapped within the limits of the turbidity curtain and have the potential to adversely affect any resident corals within this area. The turbidity curtain will remain in place for the duration of the project, which is anticipated to last approximately two months. ***Debris Removal*.** Prior to pile driving, the contractor will remove debris between the existing bulkhead and the proposed bulkhead to accommodate sheet pile driving only to the extent necessary to drive the sheet pile. All activities will be contained within the turbidity curtain. Debris will be lifted and will not be dragged along the soft bottom to minimize disturbance to sediment. In-water construction activities will begin with installation of the turbidity curtain, debris removal, driving of sheet piles, backfill, then capping. This sequence of construction activities will minimize ecological disturbance by preventing the level of disturbance and cleanup that would be associated with removing existing piles first.

The proposed action would not have a significant effect on water quality. BMPs, such as sand bags, silt fencing, and a turbidity curtain would be implemented during construction to prevent the movement of soils and sediment beyond the work zone. Water quality monitoring would be performed in accordance with an approved monitoring plan. Appropriate measures, such as slowing the pace of construction, would be implemented if monitoring indicates the Guam Water Quality Standards are exceeded.

Operation Phase: Upon completion of construction, stormwater infrastructure would actively collect, pre-treat and discharge runoff from the project into Apra Harbor via new stormwater outfalls. This discharge would require regular surveillance under an NPDES permit to ensure compliance with Guam Water Quality Standards. Since there is no existing stormwater infrastructure, the pre-treatment of runoff prior to discharge is anticipated to improve and have a beneficial impact to the water quality of the Apra Harbor receiving waters. The PAG proposes to install seven stormwater outfalls along the existing access road and wharf as part of the proposed action. Since there are currently no stormwater infrastructure facilities serving this area, stormwater runoff sheetflows

unmanaged and untreated into Apra Harbor. The wharf would receive two outfalls, which will have oil-water separators. The area known as Diver's Beach or Outhouse Beach is located to the east of Hotel Wharf, and the west end is the proposed location for outfall S-105. The beach is a popular site for PAG's commercial tenants to bring their customers who are enrolled in scuba diving certification classes. The outfall has the potential to generate minor turbidity; however, the site is subject to high human activity that also generates turbidity. The effect of turbidity from the outfall is not anticipated to be significant. The new stormwater collection and discharge system will result in improvements to water quality within these M-3 (Fair) designated waters.

4.1.7 Surface and Ground Waters

The project site is in the Apra watershed, which encompasses portions of Yona, Santa Rita, and Piti municipalities, and drains west into Apra Harbor and the Philippine Sea (Kottermair, 2012). There are no freshwater streams in the vicinity of the project area. The nearest river is the Sasa River, which empties into Sasa Bay approximately 3.5 km southeast of Hotel Wharf. Stormwater runoff is currently not collected along the wharf access road; hence, runoff sheetflows in various directions before it enters the marine waters of Apra Harbor.

The Hotel Wharf project site not located within the recharge area or stream source area of the Northern Guam Sole Source Aquifer (USEPA, 2012). USEPA defines a sole or principal source aquifer as an aquifer that supplies at least 50% of the drinking water consumed in the area overlying the aquifer. The wharf and adjacent road do not contain any groundwater production or monitoring wells.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on surface or ground water.

Proposed Action Alternative. The proposed action would not have a significant effect on surface waters, since there are no streams or rivers within the project area. Similarly, the proposed action would not have a significant effect on ground water since the project site is not located over the aquifer, nor does it encompass any ground water production or monitoring wells.

4.1.8 Wetlands and Waters of the U.S.

There are no mangrove stands or wetlands located on or adjacent to the project site. According to a Delineation of Jurisdictional Waters conducted by AMEC Environment & Infrastructure, Inc. (AMEC) in December 2011, the nearest wetland is over 1,000 ft from the western terminus of the proposed project.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on wetlands or waters of the U.S.

Proposed Action Alternative. The proposed action would not affect wetlands, and stormwater discharges would avoid these special aquatic sites. The proposed action would extend the existing bulkhead approximately 4,577 sq. ft (425 sq. m) into navigable waters of the U.S. The water column and seafloor within this area would be replaced with a sheetpile bulkhead containing approximately 4,396 cubic yards of fill. Fill material placed between the existing bulkhead and the new sheet pile wall will be contained, and will not be in contact with open water, thereby minimizing impacts; however, this action would result in the permanent loss of waters of the U.S. Mitigation to offset this loss is proposed in Section 6.0.

4.1.9 Floodplains

Executive Order 11988 (Floodplain Management) requires all federal agencies to evaluate the likely effects of their actions located in floodplains. The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) indicates that the Hotel Wharf and shoreward portions of the access road are within Flood Hazard Area Zone A (FEMA, 2007). Areas located within this zone are subject to inundation by the 1% annual chance flood (100-year flood); however, no base flood elevation has yet been determined (FEMA, 2007). The remaining areas of the project site are mapped within Zone X, which FEMA designates as areas located outside the 100-year flood zone.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects floodplains.

Proposed Action Alternative. The proposed action would not result in any increase in flood levels to the Zone A sectors during the base flood discharge (100-year storm) in compliance with E.O. 11988. The project would install a new stormwater system that would collect, pre-treat, and dispose of the runoff. This would avoid the potential for adverse effects to flood levels, including backwater effects, from the proposed action.

4.1.10 Fish and Wildlife

4.1.10.1 Terrestrial Resources

The entire project footprint is designated in the PAG Master Plan Update Report as "Marine Industrial" (August 2013) and is currently developed with commercial and industrial uses, an above ground pipeline, a roadway lined with boulder riprap, and beaches. Thus, the project site is largely devoid of vegetation. In areas bordering the roadway and other developments, the overall vegetation community includes primarily

upland species within *Leucaena leucocephala* (tangantangan) and *Casuarina equisetifolia* (ironwood) forests. The common coastal strand species in the area include: banalo (*Thespesia populnea*), Indian camphorweed (*Pluchea indica*), nanaso (*Scaevola taccada*), gasoso (*Colubrina asiatica*), and lodugao (*Clerodendrum inerme*). The vegetation along the south side of the roadway is interrupted by rock riprap, which divides the roadway from the sandy beach and nearshore environment.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on terrestrial resources.

Proposed Action Alternative. The proposed action would not have a significant effect on terrestrial resources. No species in the project area are special-status plant species nor are there mangrove stands or wetlands vegetation.

4.1.10.2 Marine Resources and Essential Fish Habitat

Essential Fish Habitat. The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), requires Federal agencies to consult with National Marine Fisheries Service (NMFS) on activities that may adversely affect Essential Fish Habitat (EFH). On Guam, EFH is defined as the marine water column from the surface to a depth of 1,000 m from shoreline to the outer boundary of the Economic Exclusion Zone (EEZ) (5,150 km/200 nautical miles/230 miles), and the seafloor from the shoreline out to a depth of 700 m around the island. This EFH designation includes the water column and seafloor of Apra Harbor where the Hotel Wharf project is proposed, and its surrounding waters and submerged lands that support various life stages for the Management Unit Species (MUS) identified under the Western Pacific Regional Fishery Management Council's (WPRFMC) Pelagic and Mariana Archipelago Fishery Ecosystem Plans (FEP) (2009a and 2009b). These MUS include bottomfish (BMUS); crustaceans (CMUS); coral reef ecosystem species (CRE-MUS) (including currently harvested coral reef taxa (CHCRT) complex and potentially harvested coral reef taxa (PHCRT) complex); and pelagic species (PMUS). In addition to EFH, the WPRFMC identified Habitat Areas of Particular Concern (HAPC) within EFH for all Fishery Management Plans (2009 a, 2009b). HAPCs are specific areas within EFH that are essential to the life cycle of important coral reef species.

The following habitats are available in the project action area to provide EFH for MUS in the Mariana Archipelago. The action area is not within any designated HAPC for MUS; the nearest HACP is Jade Shoals in Apra Harbor (Figure 1A).

Water Column: bottomfish eggs and larvae; adult/juvenile bottomfish; spiny and slipper lobster complex and Kona crab complex eggs and larvae; CHCRT complex and PHCRT complex of CRE-MUS; temperate and tropical species complex PMUS eggs and larvae and

juveniles/adults; shark eggs and larvae and juveniles/adults; and squid eggs and larvae and juveniles/adults.

Softbottom Substrate: adult/juvenile bottomfish; spiny and slipper lobster complex and Kona crab complex juvenile and adults; CHCRT complex and PHCRT complex of CRE-MUS.

Coral Reef/Hardbottom Substrate: adult/juvenile bottomfish; spiny and slipper lobster complex and Kona crab complex juvenile/adults; CHCRT complex and PHCRT complex of CRE-MUS.

Marine Resources. The existing substrate surrounding Hotel Wharf can be categorized by four distinct zones: Reef Flat, Sand Flat, Aggregate Reef, and Mixed Sand/Hardbottom. A significant amount of debris currently occupies portions of the seafloor, with concentrations being higher closer to the wharf, as described in the marine survey by Burdick (2019) (Appendix B). The survey describes the types and distributions of corals and other marine life within the project area.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on marine resources, or lead to the introduction of invasive species.

Proposed Action Alternative. The proposed action would impact a benthic footprint calculated at approximately 4,577 sq. ft (425 sq. m or 0.105 acre). The existing wharf face would be covered and backfilled, resulting in an impact to approximately 15,015.6 sq. ft (1,395 sq. m.) of vertical area. These would result in direct impacts and mortality to marine resources (such as, algae, corals, sessile macroinvertebrates) and loss of habitat for fish and other associated coral reef species. Mitigation to offset these adverse impacts is proposed in Section 6.0.

The project would not cause or promote the spread or introduction of invasive species, in compliance with Executive Order 13112. The proposed action would implement BMPs (Section 6.0) to minimize the movement of the snowflake coral (if confirmed) to other areas of Apra Harbor or Guam. Support vessels used during the in-water work would be inspected prior entering the project area.

4.1.11 Threatened and Endangered Species, and Critical Habitat

The ESA-listed species (including distinct population segments (DPS)) under NMFS' jurisdiction that are known to occur, or could reasonably be expected to occur, in the action area, and may be affected by the proposed activities are listed in Table 6. The only ESA-listed species under U.S. Fish and Wildlife Service (USFWS) jurisdiction that may occur in the action area is the green sea turtle (*Chelonia mydas*). A turtle nesting beach is

located approximately 900 m east of Hotel Wharf, and will not be disturbed by the proposed action.

Table 6. ESA-Listed Species that are known to occur or may occur in the action area

Common Name	Scientific Name	ESA Status
Green Sea Turtle Central North Pacific DPS	*Chelonia mydas*	Threatened
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered
Indo-West Pacific Scalloped hammerhead shark DPS	*Sphyrna lewini*	Threatened

Effective November 13, 2014, 15 Indo-Pacific coral species were listed as threatened under the ESA (79 FR 53851), including three corals that occur within Guam's waters: *Acropora globiceps*, *Acropora retusa*, and *Seriatopora aculeata*. None of these ESA-listed species (i.e., corals, turtles or shark), or any other listed species, were observed in the Direct or Indirect Impacts Zones during supplemental marine biological surveys in January and February 2019 (Burdick, 2019). The proposed action is not within the critical habitat designated at the northern end of Guam for three ESA-listed species: Mariana fruit bat, Mariana crow, and Guam Micronesian kingfisher (69 FR 62943). There is no critical habitat designation for ESA-listed marine species in the Mariana archipelago.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on threatened and endangered species, or their critical habitat.

Proposed Action Alternative. Based on an analysis of the proposed action and minimization of impacts provided by the proposed implementation of BMPs, the proposed action is not likely to adversely affect the ESA-listed species under NMFS jurisdiction (Table 5). On March 12, 2019, NMFS concurred with this determination of effect and concluded informal consultation for the proposed action under Section 7 of the U.S. Endangered Species Act. Similarly, the proposed action may affect but is not likely to adversely affect ESA-listed species under USFWS jurisdiction. On April 12, 2019, USFWS concurred with this determination of effect and concluded informal consultation for the proposed action under Section 7 of ESA.

4.1.12 Cultural, Historic and Section 4(f) Resources

Section 106 of the National Historic Preservation Act (NHPA) requires federal agencies to take into account the effects of their undertakings on historic properties. A federal undertaking is a project, activity, or program either funded, permitted, licensed, or approved by a federal agency. Historic properties are any prehistoric or historic districts, sites, buildings, structures, or objects that are listed or eligible for listing on the National Register of Historic Places (NRHP). Section 4(f) refers to the original section within the U.S. Department of Transportation Act of 1966 which provided for consideration of park and recreation lands, wildlife and waterfowl refuges, and historic sites during

transportation project development. The law, now codified in 49 U.S.C. §303 and 23 U.S.C. §138, applies only to the U.S. Department of Transportation (U.S. DOT).

Moore and Hunter-Anderson (2005) prepared the *Archaeological Investigations for the Proposed Harbor Wharf Project Apra Harbor, Guam* for PAG's previously proposed harbor wharf improvements and land reclamation at Apra Harbor, which included a deep-draft wharf to the east of Hotel Wharf. Information from this report was used to identify historic properties in the vicinity of the current proposed undertaking for Hotel Wharf and its adjacent access road.

The only structure currently located atop the Hotel Wharf is a concrete building that used to be owned and operated by a tenant of PAG. The structure is a restroom and shower building that is less than 50 years old; thus, it is not generally considered eligible for listing on the NRHP. An archaeological survey of the eastern portion of Cabras Island east of Commercial Port was completed in 1977 and produced only one historic site (GHRD Site 66-03-1116), which consisted of the concrete remains of a quarantine station constructed around 1914 on the south side of Cabras Island (Price, 1977). The ruins were documented over 1.5 miles (2.4 km) to the east of the project's area of potential effect (APE); therefore, the project would not affect this site.

Three sites are known within a half-mile (0.8 km) radius of Hotel Wharf (Personal communication, John Mark Joseph, Territorial Archaeologist, Guam Historic Resources Division (GHRD)) (Table 7). The two submerged NRHP-listed properties, *S.M.S. Cormoran* and *Tokai Maru*, are located in Apra Harbor approximately 2,000 ft from the project site. The *S.M.S. Cormoran* is a German ship that was scuttled in 1917; the *Tokai Maru* is a Japanese passenger-cargo ship that was sunk in 1943 and has settled near the *S.M.S. Cormoran* in 120 ft of water (Moore and Hunter-Anderson, 2005). These properties are located outside the project APE.

Table 7. Sites within the Vicinity of the Hotel Wharf Project Site

Name	GHRD Inventory Number	Significance
Tokai Maru	66-03-1089	Listed in Guam and National Registers
S.M.S. Cormoran	66-03-1037	Listed in Guam and National Registers
Glass Breakwater	66-03-2950	Eligible for listing in National Register

Construction of the Glass Breakwater was completed in 1947, and it is now over 71 years old. According to Lauter-Reinman (1998), the Glass Breakwater retains its integrity of location, design, setting, materials and workmanship, and was assessed as eligible for listing to the NRHP. Quays A, B and C were constructed in the 1940s and, by their location, correlate to existing facilities in Apra Harbor. Moore and Hunter-Anderson (2005) determined that the Sea Plane Ramp (quay C), the early portion of G Wharf (quay B) and Outhouse Beach (quay A) may qualify for listing in the NRHP under Criterion (a)

because of their possible association with World War II (WWII). According to Moore and Hunter-Anderson (2005), the Glass Breakwater and its features (quays A, B and C) could be considered significant under Criterion (c) for their unique workmanship using WWII "Magic Boxes" in pontoon pier construction.

Hotel (or "H") Wharf is over 60 years old, and according to Moore and Hunter-Anderson (2005), may qualify for National Register listing under Criterion (a) because of its association with the Vietnam Conflict. Hotel Wharf was the location of the Navy's ammunition wharf at the time of the Conflict. Moore and Hunter-Anderson (2005) noted, however, that at Hotel Wharf, "there is little on its surface to remind us of its role in the transportation of ammunition from military ships at anchor in the harbor to the appropriate magazines on Guam's military bases during the Vietnam Conflict." Moore and Hunter-Anderson (2005) did not perform any underwater investigations, but recommended that an underwater survey should be conducted to ensure that all cultural resources in the underwater portion of the project area have been located and evaluated for historical significance.

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects cultural resources.

Proposed Action Alternative. The proposed undertaking would have not have an adverse effect on the breakwater, since the roadway and shoulder areas will be improved in the same location, and the excavation for the stormwater outfalls and other utilities would not be deep. The proposed project would not affect the three older quays (A, B, and C) built on the Glass Breakwater that correspond to Sea Plane Ramp (quay C), the early portion of G Wharf (quay B) and Outhouse Beach (quay A), since these lie outside the project APE. Based on Moore and Hunter-Anderson's (2005) assessment, the Hotel Wharf is not eligible for listing on the NRHP, and the documentation and references contained in the Moore and Hunter-Anderson (2005) report is sufficient mitigation for the potential loss of features from the archaeological record at Hotel Wharf resulting from the proposed Hotel Wharf improvements.

The SHPO issued a letter on September 13, 2018 concurring with a determination of No Adverse Effect, provided that PAG perform archaeological monitoring of the access road during construction, and contract a qualified underwater archaeologist to conduct a survey of Hotel Wharf's "Area of Potential Effect" (APE). The SHPO requested that the survey include the identification of submerged historic properties and determine their significance and eligibility to the National Register of Historic Places. Dr. William Jeffery, Maritime Archaeologist and Assistant Professor, Anthropology, University of Guam, was contracted to perform an underwater archaeology survey of Hotel Wharf's APE, and to report on its findings. Based on the findings during underwater surveys conducted from March 15 to 17, 2019, Dr. Jeffery concluded that the APE off Hotel Wharf contains no Historic Properties eligible for inclusion on the National Register of Historic Places. The

SHPO also requested that additional archival research be performed for the Glass Breakwater and Hotel Wharf. On February 26, 2019, the PAG requested deferral of this archival research until the PAG has further undertakings at these locations; the SHPO concurred with this request on March 12, 2019.

The Glass Breakwater is a Section 4(f) property since it is considered eligible for listing in the National Register. The proposed undertaking would have no adverse effect on this site and is not subject to additional Section 4(f) determinations.

4.1.13 Environmental Justice

Executive Order 12898 (Environmental Justice) established the responsibility for each federal agency to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low income populations in the United States and its territories and possessions...", with the goal of achieving environmental protection for all communities.

Demographic Profile. The U.S. Census Bureau reported a total islandwide population of 159,358 for the 2010 Census of Population and Housing on Guam. The closest populated place to the Hotel Wharf project site is the municipality of Piti, which had a population of 1,454 people reported in the 2010 Census. Piti's population density of 192.8 persons per square mile is the 4th lowest on Guam. The 7.54-square mile municipality encompasses the PAG facilities in Apra Harbor; however, the main village center is located approximately two miles to the east of the project site along Route 1 (Marine Corps Drive).

The village center contains mostly single-family residences amid supporting uses, including Our Lady of the Assumption Church, the Piti Mayor's office, and Jose L.G. Rios Middle School. Piti also hosts industrial uses, such as the Piti and Cabras Power Plants and Department of Defense Sasa Valley Fuel Farm, and low-level commercial uses, such as mom-and-pop convenience stores and a gas station. Guam Veterans Cemetery, Tepungan Beach Park, Pedro Santos Memorial Park, and the Piti Underwater Observatory are major village landmarks along Route 1.

According to the 2010 Census, for persons reporting as one ethinic origin or race, over 57 percent were Pacific Islander (Table 8), and of this group, 729 were of Chamorro ancestry. This was similar to the proportion in the overall island population, with nearly 50 percent reported as Pacific Islanders of a single ethnicity, and 59,381 of this group reported as Chamorro. The Chamorros are the indigenous people of Guam and the Northern Mariana Islands. The next largest single ethnic group in Piti was White (16 percent), which was higher than the islandwide proportion of about 7 percent. Although Asians comprised nearly a third of the island's single ethnic group population, this demographic accounted for just 11 percent of the Piti population in the 2010 Census. A slightly higher proportion

(nearly 12 percent) of Piti residents were reported to have two or more ethnic origins or race when compared with the whole island (nearly 10 percent).

Table 8. Ethnic Origin or Race Census Data

Ethnic Origin or Race	Piti		Guam	
	Total	% of Total	Total	% of Total
Total Population	1,454		159,358	
One Ethnic Origin or Race	*1,280*	*88.03*	*144,429*	*90.63*
Native Hawaiian and Other Pacific Islander	835	57.43	78,582	49.31
Asian	165	11.35	51,381	32.24
Black or African American	32	2.20	1,540	0.97
Hispanic or Latino	12	0.83	1,201	0.75
White	234	16.09	11,321	7.10
Other	2	0.14	404	0.25
Two or More Ethnic Origins or Race	*174*	*11.97*	*14,929*	*9.37*
Native Hawaiian and Other Pacific Islander	136	9.35	11,656	7.31
Asian and Other Groups	102	7.02	8,574	5.38

Source: U.S. Census Bureau

The 2010 Census showed that the municipality of Piti had a smaller average household size and family size than the overall islandwide average (Table 9). Piti exceeded the islandwide total for educational attainment, with higher percentages obtaining their high school and bachelor's degrees. Unemployment was lower in Piti (6.2%) compared with the whole island (8.2%), and the mean household income in this municipality exceeded the islandwide mean by $22,511 dollars. Fewer than 1 percent of the families on Guam with incomes below the poverty level lived in Piti during the 2010 Census. A higher proportion of Piti residents lived in their own home, and fewer lived in rented housing units, compared with the entire island. Based on the demographic data from the 2010 Census, Piti municipality would not be considered a low-income population when compared with the islandwide population.

Table 9. Summary of Selected Demographic Data

Demographic Feature	Piti	Guam
Median Age	31.6	29.5
Average Household Size	3.23	3.67
Average Family Size	3.86	4.07
Percent High School Graduate or Higher	87.5	79.4
Percent Bachelor's Degree or Higher	28.2	20.4
Percent of Unemployed Civilian Labor Force 16 years and over	6.2	8.2
Median Household Income in 2009 Dollars	61,094	48,274
Mean Household Income in 2009 Dollars	83,182	60,671
Families with Income in 2009 Below Poverty Level	41	6,514
Families with Income in 2009 Below Poverty Level with Related Children under 18 Years	39	5,491

Demographic Feature	Piti	Guam
Population with Income in 2009 Below Poverty Level	241	35,848
Total Population in Occupied Housing Units	1,439	154,060
Owner-Occupied Housing Units	844	80,966
Renter-Occupied Housing Units	595	73,094

Source: U.S. Census Bureau

Economic Activity. Federal spending by the Department of Defense (DoD), and tourism, are the major drivers of the island's economy. The military build-up, which would relocate U.S. Marines Corps troops from Okinawa to a new base on Guam, has been in progress for several years, although the first wave of Marines are not set to begin arriving until 2025 (Bureau of Statistics and Plans (BSP) 2018). DoD appropriations for military construction increased from $248 million in 2017 to $354 million in 2018 (BSP 2018). The tourism industry on Guam accounts for up to 60 percent of the Government of Guam's annual revenues (GVB 2014), and continues to grow, with over 1.5 million visitors in 2016. Visitor spending reached $1.75 billion, and supported nearly 21,100 jobs (34 percent of the total employment on Guam), with an associated tourism labor income of $617 million (GVB 2018). The annual visitor arrivals to the island in 2017 surpassed previous records, with 1,540,723 visitors (BSP 2018).

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on minority or low-income populations.

Proposed Action Alternative. The proposed project would be in compliance with E.O. 12898 and would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations. The proposed project would be constructed within the Port's property, and will not require any right-of-way or private property acquisition to repair the existing access road and wharf. There are no existing residential populations within the PAG project area that would be displaced by the proposed action. Based on the 2010 Census data, the residents of Piti municipality would not be considered a low-income population. The residents of Piti and the entire island of Guam are predominantly Pacific Islanders, which would ordinarily constitute a minority population when compared with the overall U.S. population. However, the proposed action is only being considered on Guam, hence, it would primarily affect the population of Guam. Within the context of environmental justice, disproportionate effects would be relevant to the siting of the project on Guam. Since the project would involve maintenance and repair of the existing wharf and access road, there would be no disproportionate effects on low-income or minority populations resulting from site selection. The proposed project improvements would benefit all sectors of the island community through PAG's ability to efficiently sustain overflow and emergency break bulk and bulk cargo handling operations, container operations on self-sustaining vessels, potential military mobilization, and cruise vessel mooring and passenger screening operations.

4.1.14 Traffic and Safety

Access to Hotel Wharf is via an existing two-lane, partially paved, unnamed roadway that extends west from the terminus of Route 11. Route 11 is 2.9-mile long two-lane, asphalt-paved road that is the main access to the Port via a signalized intersection with Route 1. Route 1 is a multi-lane arterial highway connecting the western sectors of Guam. Vehicle traffic volume along the unnamed access road is very low and the currently posted speed limit is 25 miles per hour (mph); therefore, acceleration and deceleration lanes are not proposed for ingress and egress to Hotel Wharf (PB 2014). Along the wharf, the traffic pattern for vehicles involved in loading and unloading operations is non-standard. The high-volume movement of vehicles within the Port's terminal yards is more predictable and controllable with appropriate signage and pavement markings (PB 2014).

The Route 11 traffic capacity is considered sufficient well into the future, and no short-term or long-term capacity expansion is recommended (PB 2013). The Port Modernization Program proposed improvements within the Port's property east of Hotel Wharf that included construction of a new Break Bulk Terminal area in the western portion of the Terminal Yard (west of Berths F-4 to F-6); expansion of the Cargo Terminal; and construction of new entrance and exit gates and truck routing to increase efficiency and reduce queuing times on Route 11 (EA Engineering, Science, and Technology, Inc. (EA) 2012). The Port Modernization EA estimated traffic volumes from the expansion of the Cargo Terminal Yard, while considering the increases in population described in the 2010 Guam Military Relocation Program Final Environmental Impact Statement (FEIS), which proposed the relocation of approximately 8,600 Marines and their 9,000 dependents from Okinawa to Guam. The assumptions for traffic congestion on Routes 1 and 11 were projected to be 14,000 vehicles per day (VPD) in 2014, which was the projected peak of military construction activity. A Level of Service (LOS) Standard and Volume/Capacity ratio were used for the analysis. LOS describes the quality of traffic operations conditions from A (0 to 10 second delay) to F (greater than 80 seconds delay) rated by the length of delay experienced per vehicle at a given intersection (EA 2012). The v/c ratio is a metric for traffic congestion generated by dividing the volume of cars on a section of road by the number of vehicles the road was designed to carry (capacity); a v/c ratio of greater than 1 indicates the road volume exceeds the road capacity, resulting in congestion (EA 2012). The most recent traffic counts for Route 11 showed approximately 9,100 vehicles per day (VPD) and a v/c ratio of 0.00-0.80 in both directions during peak a.m. and p.m. hours in 2008.

The completion of the Port modernization improvements, coupled with the Guam Military Relocation Program during the buildup period (2012-2016) were not anticipated to exceed the Guam Transportation Plan's Level of Service (LOS) E Standard (55.1-80 second delay per vehicle) at the Route 1/11 intersection, or exceed the Guam Transportation Plan's v/c ratio of 1 on Routes 1 or 11 (EA 2012). Since then, the U.S. Marine Corps 2012 Roadmap Adjustments for the Department of Defense (DoD) realignment (military buildup) reduced the scope to approximately 5,000 Marines with

approximately 1,300 dependents. The Traffic Operations Report for the 2012 Roadmap Adjustments provided an in-depth traffic analysis, with forecasts for the year of peak construction activity (2021) and for conditions after full build-out (2030) (PB 2013). The 2013 report indicated the existing LOS B (10-20 second delay per vehicle) at the Route 1/11 intersection was projected to remain at LOS B in 2021 (PB 2013). The peak military construction period has since been revised to 2022/2023 (PB 2018).

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on traffic and safety.

Proposed Action Alternative. ***Construction Phase:*** The traffic generated by construction activities is not anticipated to exceed the LOS or v/c ratio for Route 11 or Route 1. Construction activities would involve the movement of equipment and materials to the project site. Some material would be sourced locally, including 4,396 cubic yards of new fill for the bulkhead. Based on a capacity of 10 to 14 cubic yards per dump truck, an estimated 314 to 440 vehicle trips would be generated to transport the fill material to the wharf site. Other items, such as piles, would be brought in by surface freight through the Port and staged at the wharf. Construction debris would be hauled off-site to an approved hardfill. A traffic management plan would be implemented by the contractor to coordinate the movement of construction materials and equipment to and from the site, and minimize local congestion with Port operations and any other on-going construction projects. Route 11 was resurfaced and strengthened in 2012 under the Department of Defense Access roads (DAR) program. The wharf access road would be resurfaced as part of the access road improvements under the proposed action. Construction is anticipated to be completed in 2021, prior to the peak military construction period in 2022/2023 (PB 2018). Therefore, the construction phase would not have a significant impact upon Route 11 or the wharf access road. ***Operation Phase:*** The wharf access road is classified as an industrial/commercial very low-volume road (PB 2014). The proposed project does not include expansion of capacity on this access road. While there will be an increase in vehicle traffic on this road, much of it would be local traffic driven by the shifting of overflow operations from the Commercial Port to Hotel Wharf. The traffic on the wharf and access road would include bulk/break-bulk transport vehicles, such as commercial and private trucks; very minimal cargo handling equipment would be needed, since container operations would remain confined to the Cargo Terminal. Cruise passenger buses, taxis and rental vehicles would be used during the occasional port calls from cruise ships and research vessels. Upon completion of the road repairs, the existing 25 mph speed limit would be maintained, and traffic and markings signs would be installed to regulate the flow of traffic and provide for the safe movement of vehicles and pedestrians. Therefore, the proposed action is not anticipated to have a significant effect on traffic volumes or safety on Routes 11 and 1.

4.1.15 Land Use and Visual Impacts

The entire project footprint is designated in the PAG Master Plan Update Report as "Marine Industrial" (PB 2013) and is currently developed with commercial and industrial uses, an above-ground pipeline, a roadway lined with boulder riprap, and beaches. Bulk storage fuel tanks are located to the east of the project site in the Marine Industrial Terminal (Figure 1B).

Environmental Consequences

No Action Alternative. The No Action Alternative would not involve new construction; hence, it would have no new effects on land use and or cause visual impacts.

Proposed Action Alternative. The proposed action would not have a significant effect on land use, or have significant visual impacts. The proposed improvements are consistent with the existing land use designation for the project site in the Port's Master Plan (PB 2013). The road improvements would not significantly alter the horizontal or vertical alignments of the existing access road. The proposed stormwater outfalls along the road would terminate behind the existing riprap along the shoreline, and would not be conspicuous. The wharf improvements would involve mainly horizontal extension of the bulkhead, and installation of utilities and mooring bollards; no conspicuous vertical structures would be constructed.

5. INDIRECT AND CUMULATIVE IMPACTS

5.1 Indirect Impacts

Indirect impacts from the proposed action would affect the marine resources and receiving waters within the Indirect Impacts Zone. This zone, located beyond the Direct Impacts Zone, would encompass the low-density hard coral (3.4 +/- 4.2% cover) and sand flat within 20 m of the wharf face where sediment would be confined by a turbidity curtain during pile-driving activities. The impacts would mainly arise from sediment and turbidity generated by pile-driving, and by anchoring of the barge and support vessels used in construction. Minor turbidity would also be generated during the installation and removal of the turbidity curtain. The effects are anticipated to be short-term, lasting for the duration of the in-water construction period. Following construction, there would be minor turbidity impacts from vessel movement and anchoring once the wharf is placed back in service and becomes fully functional and operational.

5.2 Cumulative Impacts

Cumulative effects are impacts on the environment that result from the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes such actions (Council on Environmental Quality 1997). The scope for assessing cumulative impacts encompasses reasonably foreseeable actions that have been completed recently, or are likely to happen concurrently with the proposed action, or shortly afterward.

Reasonably Foreseeable Actions. The PAG has proposed the following projects under its Port Improvement Program (PIP) that would be executed over a five-year period (2018-2022) using various funding sources to support the Port's long-term sustainability (PB 2018). The completion of certain projects is dependent upon securing financing, hence, some projects may be delayed until funding is secured; however, they are still reasonably foreseeable actions and are included here for analysis.

Group A - PIP Projects located within the Commercial Port vicinity:

- New Administration Building (CIP)
- Waterline Replacement and Relocation (CIP)
- EQMR Building Repairs and Upgrades (CIP)
- F-1 Fuel Pier Upgrades (CIP)*
- Warehouse 1 Repairs and Upgrades (CIP)
- Gate Operating System (CIP)
- Golf Pier Repairs and Improvements (CIP)*
- Pre-Disaster Mitigation Hardening of Port Facilities
- Terminal Operating System
- Load Center Refurbishment and Hardening
- Harbor of Refuge Renovations*

- Data Warehousing Systems
- Maintenance and Sustainment of Prime Power Generators
- Port Police Security Upgrade

Group B - PIP Projects located outside the Commercial Port vicinity:

- Hagatna Marina Phase III (CIP)*
- Agat Marina Loading Dock Structural Repair*
- Agat Marina Dock B Repairs*
- Guam Police Department/Agat Marina Wi-Fi Digital Connectivity

Capital Improvement Plan (CIP) projects are focused on new construction and significant repairs, renovations, and upgrades to the PAG facilities and major equipment, to maintain operations. An asterisk (*) denotes projects with an in-water component.

Cumulative Impacts of Reasonably Foreseeable Actions and the Proposed Action. The potential effects of the proposed action were assessed against potential short-term and long-term effects of the reasonably foreseeable actions listed above.

a. Soils, Geology and Seismicity. The cumulative effects of the proposed action and PAG PIP projects on soils, geology and seismicity are not anticipated to be significant. These projects would have minor effects on soils during construction activities; however, these would be short-term, and minimized within regulatory thresholds through BMPs. The project designs would be required to comply with the seismic code for Guam. Operational effects are anticipated to be minimal; exposed soils would be restored upon completion of construction.
b. Air Quality. There is a potential for cumulative impacts to air quality given the likelihood for temporal overlap between the proposed action and PIP projects. These are most likely during construction, when fugitive dust (such as dust from 4,396 cubic yards of clean fill) and exhaust from heavy equipment vehicles may cumulatively affect air quality if projects are in close proximity. These effects would be short-term, and would be minimized by the use of BMPs. The projects are not anticipated to generate stationary source emissions during the operations phase, while mobile emissions from vehicles and vessels are expected to be similar to existing conditions, since most of the CIP projects are related to repairs and upgrades. Therefore, these projects are not anticipated to result in significant cumulative effects upon air quality.
c. Hazardous Materials and Waste Management. No cumulative effects from hazardous materials and waste management are anticipated from the proposed action and PIP projects. The PIP projects are largely repairs and upgrades, with some new construction; however, these are not anticipated to generate significant amounts of hazardous materials or waste during construction or operation. Debris removal from the seafloor along Hotel Wharf prior to construction would be conducted with the appropriate UXO surveillance, and disposal of the debris would be in accordance with solid waste regulations. The removal of this debris would have a positive cumulative effect on EFH.

d. Noise and Vibration. The proposed action is anticipated to have short-term effects on noise and vibrations. Cumulative effects may occur during construction from noise from heavy equipment vehicles and construction equipment, and during the in-water pile-driving activities, particularly if other in-water PIP projects are under construction during the same two-month period as Hotel Wharf. While Hagatna Marina and Agat Marina are over 5 miles away from the proposed action, the upgrades to F-1 Fuel Pier and Golf Pier would occur in the project vicinity. If there is temporal overlap, then noise attenuation measures will be implemented as necessary during pile-driving. The PAG may consider phasing their PIP projects to minimize overlap. Therefore, cumulative impacts from noise and vibration are not anticipated to be significant from these projects.
e. Public Services and Utilities. Cumulative effects on public services and utilities are not anticipated to be significant from the proposed action and PIP projects, either during construction or operation of the facilities. The PAG would coordinate the filling of the Hotel Wharf fire suppression holding tanks to avoid adverse effects on the municipal water system.
f. Water Quality. The proposed action would involve pile-driving, which would have short-term effects during construction. Cumulative effects may occur if other in-water PIP projects are under construction during the same two-month period as Hotel Wharf. Some projects are distant (e.g., Hagatna Marina and Agat Marina upgrades) from the proposed action; however, the upgrades to F-1 Fuel Pier and Golf Pier would occur in the project vicinity. If there is temporal overlap, then additional BMPs will be implemented as necessary during pile-driving. The PAG may consider phasing their PIP projects to minimize overlap. Therefore, cumulative impacts on water quality are not anticipated to be significant.
g. Surface and Ground Waters. The proposed action and Group A PIP projects are not located over any ground water sources of potable water, nor do they encompass any rivers or streams. The Group B projects are spatially separated by over 5 miles from the proposed action vicinity. Therefore, the proposed action and PIP projects are not anticipated to have cumulative effects on surface or ground waters.
h. Wetlands and Waters of the U.S. The nearest wetlands are located 1,000 ft from the project's western terminus. No stormwater outfalls from the proposed action are proposed to discharge into this wetland. Therefore, the proposed action would not have cumulative effects on wetlands. The proposed action would result in the loss of 425 sq. m of waters of the U.S.; this loss would be offset with mitigation (see Section 6.0). There is a potential for cumulative effects on waters of the U.S. if other in-water PIP projects also result in a similar loss. The cumulative effects would be reduced through avoidance or mitigation of impacts during the design and construction of these PIP projects, such that there is no net loss. Therefore, the cumulative impacts on waters of the U.S. are not anticipated to be significant.
i. Floodplains. The proposed action is located within the 100-year flood zone; however, stormwater infrastructure would be installed to collect, treat and

discharge stormwater runoff. Therefore, the proposed action would not contribute cumulative effects when considered with the PIP projects.

j. Fish and Wildlife. The proposed action, when considered with the PIP projects, would not have significant cumulative effects on terrestrial plants and animals, since no special-status species have been documented in the action area. Mitigation for marine resources would offset impacts from the proposed action; therefore, cumulative impacts with PIP projects would not be significant.

k. Threatened and Endangered Species. The proposed action is not likely to adversely affect or result in a take of any of the three ESA-listed species that have the potential to occur in the vicinity of the action area. These species may potentially occur in the areas of effect for the in-water PIP projects. Cumulative effects on these species may occur should there be a temporal overlap between the proposed action and Group A PIP projects during in-water construction activities; the Group B projects are spatially separated from the proposed action. The cumulative effects with Group A are not anticipated to be significant given the short-term duration of the in-water work at Hotel Wharf. The PAG may also consider phasing the PIP projects to avoid overlap with the proposed action, and further reduce the likelihood of cumulative effects.

l. Cultural, Historic and Section 4(f) Resources. The proposed action would have no adverse effect on cultural, historic or section 4(f) resources. Therefore, it would not contribute towards cumulative effects on these resources when considered with the PIP projects.

m. Environmental Justice. Since the proposed action would not involve the acquisition of right-of-way or lands, it would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations. Therefore, the proposed action would not contribute towards cumulative effects with regard to environmental justice, when considered with the PIP projects.

n. Traffic and Safety. Vehicle traffic would increase along Route 11 and Route 1, and the wharf access road during construction of the proposed action. There is a potential for cumulative effects on traffic if Group A PIP projects are scheduled during the same construction period. A traffic management plan would be implemented by the contractor to coordinate the movement of construction materials and equipment to and from the site, and minimize local congestion with Port operations, and with any on-going PIP projects. The PAG would also consider phasing the PIP projects to minimize the overlap with the proposed action. Therefore, cumulative effects on traffic from the proposed action and PIP projects would be less than significant.

o. Land Use and Visual Impacts. The proposed action and PIP projects would follow the PAG Master Plan land use designations, ensuring compatible land use. The proposed action would not construct conspicuous vertical structures. Therefore, the proposed action would not contribute to significant cumulative effects on visual resources or land use when considered with the PIP projects in Group A.

6. MITIGATION MEASURES

6.1 Best Management Practices

The following avoidance and minimization measures, and best management practices (BMPs) (which include conservation measures recommended by USFWS and NOAA) will be implemented to reduce potential environmental impacts from the proposed project to less than significant:

A. Erosion and Sediment Control Measures

1. The PAG will follow standard conditions and implement BMPs listed in the U.S. Environmental Protection Agency's (USEPA) NPDES Multi-Sector General Permit (MSGP) for stormwater discharges associated with industrial activity. Prior to construction of the outfalls, an electronic Notice of Intent will be filed online.
2. Implement erosion and sediment control measures, such as silt fencing.
3. Temporarily impacted areas where vegetation is removed will be revegetated with native seed to pre-construction conditions.
4. Excavation to install new tie-rods and utilities and to make roadway drainage improvements is not currently expected to result in the disposal of unsuitable materials. However, in the event unsuitable materials are detected once construction begins, proper disposal and replacement with clean materials and structural fill will be required.
5. Turbidity curtain
    a. A turbidity curtain will be installed approximately 60 ft (18 m) from the south face of the existing bulkhead to protect the existing aggregate coral patch reef community, and minimize abrading and anchoring impacts from the barge that will operate within the curtain during the pile driving activities.
    b. The curtain and its anchors will be installed with a minimum of 10 ft (3 m) separation distance to the aggregate reef (Figure 3). There will be a minimum 10 ft (3 m) separation between the aggregate reef and any vessel anchors.
    c. The curtain will have one (1) foot of bottom clearance to avoid generation of additional turbidity, abrasion of sessile organisms, and to avoid entrapment of marine organisms by providing an escape route below the curtain.
    d. The curtain will remain in place for the duration of the in-water activities, and will be periodically checked and maintained to ensure proper functioning.
6. Marine debris
    a. Debris in the area will be removed to accommodate sheet pile driving only to the extent necessary to drive the sheet piles.
    b. All debris removed to accommodate new sheet piles will be lifted, and not dragged on the seafloor, to prevent disturbance of sediments.
    c. Prior to the start of the in-water pile driving construction activities, the water will be scanned for debris or other obstruction.

   d. Any debris encountered during the in-water pile driving activities will be completely removed from the work area and disposed of in an appropriate upland site.
   e. All debris will be transported to, and disposed of, at an appropriate upland site.
7. Fill material placed between the existing bulkhead and the new sheet pile wall will be contained, and will not be in contact with open water, thereby minimizing impacts.
8. No rip rap will be installed within waters of the United States.
9. The Port and its contractor will cease activities that result in sediment/pollutant discharges during the primary hard and soft coral spawning events each year. The Port will coordinate with the NOAA Fisheries Guam Field Office to determine the avoidance dates.
10. The Port and its contractor will cease activities that result in sediment/pollutant discharges during coral bleaching events. The Port will coordinate with the NOAA Fisheries Guam Field Office to determine when these events are anticipated to occur.
11. The Port and its contractor will establish protocols for confining the work area and ceasing construction activities due to inclement weather, and will establish a contingency plan for removing/securing equipment and the work site during storms.

B. Dust Control Measures

The following BMPs will be implemented to minimize impacts to air quality from construction activities:

1. Use watering trucks to minimize dust; watering should be sufficient to confine dust plumes to the project work areas.
2. Suspend grading and earth moving when wind gusts exceed 25 mph unless the soil is wet enough to prevent dust plumes.
3. Cover all trucks hauling dirt when traveling at speeds greater than 15 mph.
4. Stabilize the surface of dirt piles if not removed within 2 days.
5. Limit vehicular paths on unpaved surfaces and stabilize any temporary roads.
6. Minimize unnecessary vehicular and machinery activities.
7. Sweep paved streets at least once per day where there is evidence of dirt that has been carried onto the roadway.
8. Revegetate disturbed land, including vehicular paths created during construction.
9. Use newer diesel-burning construction equipment (newer than 1996).
10. Properly maintain construction equipment according to manufacturers' specifications.

C. ESA-Listed and Sensitive Species Avoidance Measures

The following measures and BMPs will be implemented to avoid and impacts to sea turtles, sharks and marine mammals:

1. Sea Turtle Nesting
   a. No construction is proposed on any turtle nesting beach, including the known sea turtle nesting beach located approximately 900 ft east of Hotel Wharf and south of the access road improvements, as identified by Guam Department of Agriculture's DAWR. Stormwater outfall S-108 has been eliminated and work is no longer

proposed on the turtle nesting beach at this location (eastern extent of project limits, east of Sea Plane Ramp).

b. To avoid direct impacts to nesting sea turtles, construction activities on the access road north of the potential nesting areas shall occur during non-nesting periods. Work will be avoided during the concentrated green sea turtle nesting season for Guam, which is April through August.
c. A qualified biologist will conduct a thorough survey for the presence of nesting activity within 300 ft of the project site. If there is evidence of an active nest in the vicinity of the project site, a 100-ft buffer would be maintained, and no work activities would be allowed within the buffer. Guam Department of Agriculture biologists would be informed.
d. Reasonable setbacks shall be established between the ocean and any permanent buildings to protect both the nesting beach and coastal infrastructure. Contractors shall be informed of the importance of these setbacks, and of preserving native vegetation within a buffer zone.
e. To avoid crushing sea turtle nests or increased erosion, driving and machinery use are restricted to existing roads. Motorized vehicles shall be prohibited from driving on sandy beaches.
f. Minimize removal of beachfront vegetation and revegetate impacted areas with native plant species.

2. Lighting
   a. Nighttime work would be avoided during the nesting season.
   b. Minimize the use of lighting and the effects of lighting during construction and post-construction at the repaired Hotel Wharf.
   c. If lighting is used, light shields would be used that are completely opaque, sufficiently large, and positioned so that the bulb is only visible from below and that light from the shielded source cannot be seen from the beach. Areas behind nesting beaches should be sufficiently dark, to allow for the transit of turtle hatchlings as they orient away from dark silhouettes behind the nesting beach and towards the brighter open horizon. All light visible from nesting beach areas should be shielded, directed only where light is needed, placed as low as practicable, and use long wavelength lamps (e.g., red/amber LEDs, low pressure sodium) and black baffles.
   d. Exterior lighting shall avoid bright white light, such as metal halide, halogen, fluorescent, mercury vapor, and incandescent lamps – and never use where such light could be visible from the beach.
3. In-Water Work
   a. A qualified biologist would conduct a visual survey of the project site just prior to commencement or resumption of construction activities to ensure that no green sea turtles are present within 50 m (164 ft). There would be a mandatory shut-down of construction activities if turtles are observed within this range.
   b. If sea turtles are found within the project area, or approach the project area while construction is occurring, all potentially disruptive activities (including human activity, mechanical or construction disturbance) will be stopped until the animal(s) voluntarily leave the area.

c. Actions that damage seagrass or coral shall be prohibited.
d. Minimize the exposure of sea turtles to vessel collisions by using a trained wildlife observer who will look for sea turtles during vessel transit. Reduce vessel speeds in known sea turtle locations. Avoid areas where marine mammals and sea turtles are sighted.
e. All marine vessels shall be moored or docked.
f. Anchoring shall be restricted to non-sensitive marine areas.
g. During construction, all anchor lines, mooring lines, and lines attached to objects should be kept to the minimum length required. Mooring lines shall consist of a single line with no additional lines or material capable of entangling marine life. All lines and turbidity curtains should be temporary and only in the water for the length of time necessary to complete construction. The turbidity curtain should be checked daily and maintained. Construction-related debris will be removed that may pose an entanglement threat to sea turtles from the project site if not actively being used and at the conclusion of the project.
h. Minimize the discharge of sedimentation and pollution.

4. Cease work during adverse weather conditions and tidal/flow conditions and stabilize all work areas at the end of each work day.
5. Develop a contingency plan to control and clean spilled petroleum products and other toxic materials (on barge and land) and retain absorbent booms and other appropriate materials on site to contain and clean potential spills.
6. Containment will be performed of food waste and other attractants to rats and other potential predators upon sea turtle nests, and waste will be disposed appropriately on a daily basis.
7. The construction contractor will implement a construction education program to ensure that contractors and all construction personnel are informed of the biological constraints associated with the construction site. The education program shall focus on (a) the purpose of resource protection, (b) contractor identification of sensitive resource areas in the field such as areas delineated on maps and by flags or fencing, (c) sensitive construction practices, (d) protocol to resolve conflicts that may arise at any time during the construction process, and (e) ramifications of non-compliance.

D. Invasive Species Avoidance Measures

The following measures will be implemented in order to avoid introducing any invasive non-native marine species into Guam's waters:

1. The Port and its contractors will fully comply 33 CFR 151, Subpart D, Ballast Water Management for Control of Indigenous Species in Waters of the United States. No ballast water discharge is permitted 12 nautical miles of Guam, unless an approved ballast water management system is in place.
2. All local vessels (e.g., barges and tugs) will be visually inspected for marine invasive and non-native species prior to entering the Hotel Wharf project area. Vessels navigating to the project area will be inspected at their place of departure to confirm compliance. All bivalves, crustaceans, or algae, not only those known to be invasive and non-native, will

be removed from local support vessels prior to the vessels entering the Hotel Wharf project area.

3. All construction equipment that may have any contact with the water will be cleaned prior to use to prevent introduction of alien and invasive species.
4. Dense octocoral growth along the southern wharf face will be sampled for confirmation if it is the non-native and potentially invasive octocoral, *Carijoa riisei* (snowflake coral). If positively identified, these colonies will be quarantined to this area and buried during wharf construction to avoid their spread to other areas of Apra Harbor and to the coral transplant recipient site. Samples will be collected in ethanol, and submitted to Guam Department of Agriculture DAWR.
5. The contractor would prepare and implement a Hazard Analysis and Critical Control Point (HACCP) Plan for the movement of equipment and materials, such as fill material, during construction.

6.2 Coral Relocation

The Direct Impacts Zone encompasses the footprint for in-water construction, calculated at 4,577 sq. ft (0.105 acre). Additionally, the entire wharf face will be covered and backfilled, resulting in an impact to approximately 15,015.6 sq. ft (1,395 sq. m.) of vertical area. In order to minimize adverse impacts from the loss of EFH (substrate and water column) for MUS, PAG proposes to relocate corals within the Direct Impacts Zone that meet specific criteria, such as size (i.e., greater than 10 cm diameter), and morphology. Those taxa with encrusting forms, such as *Leptastrea*, will not be relocated, nor will those taxa that appear to be unhealthy (e.g., exhibit paling) and would not successfully survive the relocation. Based on size class information collected during the marine surveys, a conservative estimate of 194 colonies within the wharf base (sea floor) and approximately 636 colonies on the wharf face fall within the size range for relocation (i.e., 10 to 1000 cm) within the Direct Impacts Zone.

While this relocation action would minimize impacts to certain corals within the Direct Impacts Zone, there would be a loss of the remaining corals, filter-feeders, macrophytes and other sessile CRE-MUS that are not relocated. CRE-MUS within the 20 m Indirect Impacts Zone would be exposed to turbidity within the turbidity curtain that will be installed to enclose the work zone during in-water construction activities. Therefore, additional offsets are proposed below to address impacts to EHF and the associated MUS in these zones.

6.3 Debris Removal

The seafloor surrounding the base of the wharf contains an accumulation of various types of marine debris which have been introduced (intentionally or unintentionally) over the years by the users of the wharf since its construction in the 1940's.

The Port proposes to remove selected debris within the Direct Impacts Zone and a portion of the Indirect Impacts Zone prior to construction. The Direct Impacts Zone encompasses approximately 4,577 sq. ft (425.22 sq. m). Benthic surveys estimate the percent cover of marine debris within this area as 58.2 ± 28.8% along the south face, 1.7 ± 0.0% along the east face, and 3.0 ± 0.0% along the west face (Burdick, 2019). Based on this cover estimate, marine debris within the Direct Impacts Zone occupies 1,829.81 ± 905.47 sq. ft along the south face, 12.63 ± 0.0 sq. ft along the east face, and 20.7 ± 0.0 sq. ft along the west face. Debris that does not pose an obstacle to the pile driving activities will be left in place, enclosed behind the new sheet pile bulkhead, and buried by fill material. Certain non-rigid objects (such as tires) are not suitable for burial and will be removed. Other debris that poses a potential environmental hazard (such as marine batteries), or presents an obstacle to pile driving, will be removed.

The PAG proposes to remove a portion of the marine debris within the 20 m Indirect Impacts Zone from the new bulkhead out to approximately 3 ft (0.9 m) seaward along the east and west faces, and 5.5 ft (1.67 m) from the south face. This area encompasses approximately 3,192.90 sq. ft (296.63 sq. m). Benthic survey estimates of the percent cover of marine debris within this zone were used to estimate the area covered by marine debris. Based on these cover estimates, the projected area covered by marine debris is 1,594.35 sq. ft (148.12 sq. m) within this zone.

This activity is a coral reef compensatory mitigation and restoration option identified by the U. S. Coral Reef Task Force (USCRTF) in the *Handbook of Coral Reef Impacts* (USCRTF 2016). As a specific function or service, the removal of marine debris would protect sessile biological components of coral reef habitat from damage by moving debris that could migrate with storm and wave action into unimpacted areas, reduce stress on the existing coral community, and restore substrate for MUS (USCRTF 2016).

6.4 Public Education and Outreach

There is currently no public education and outreach program within PAG's commercial permit system to engage the many users of the Port's recreational resources at Outhouse Beach. According to the Port, one vendor alone brings an estimated 80 patrons per day to this beach for scuba diving instruction (Personal Communication, Carl Quinata, PAG Commercial Division). PAG proposes to establish an education and outreach program to offset impacts to EFH affected by physical damage, irradiance, and sedimentation. The program would educate dive instructors and guides leading their patrons on recreational water activities. These instructors and guides would, in turn, be responsible for informing their patrons of the best management practices while using the marine resources at the Port. Penalties for non-compliance by vendors may include revoking their commercial permit. The PAG would enforce this program with periodic visits and monitoring of the resources against an initial baseline level. PAG may consider measures, such as limiting the volume of patrons per day or per week, if warranted, based on the results of monitoring.

7. AGENCY COORDINATION AND PUBLIC INVOLVEMENT

7.1 Agency Coordination

Bureau of Statistics and Plans (BSP), Government of Guam

- June 4, 2018 - The PAG issued a determination of consistency under the Coastal Zone Management Act (CZMA) to BSP for the proposed Hotel Wharf project.
- August 24, 2018 - BSP concurred with PAG's consistency determination.
- January 4, 2019 - MARAD and the PAG amended the project description, updating the project footprint due to incorrect calculations from AMEC (2014) that were used in the initial determination of consistency.
- April 25, 2019 - BSP responded that the concurrence issued on August 24, 2018 remained applicable to the amended project description.

Department of Agriculture, Division of Aquatic and Wildlife Resources (DAWR)

Guam Endangered Species Act

- November 1, 2013 - The PAG sent a request to DAWR for information regarding permitting requirements for the proposed Hotel Wharf project.
- November 14, 2013 - DAWR participated in an agency coordination meeting to discuss environmental opportunities and constraints of the proposed project.
- January 2018 - A site visit was conducted with DAWR to discuss agency's concerns with potential discharge of stormwater at outfall S-108 outfall the sea turtle nesting beach.
- April 4, 2018 - A follow-up site visit was conducted with DAWR regarding a proposed alternative of discharging to outfall S-107 to avoid the sea turtle nesting beach.
- April 19, 2018 - DAWR concurred with the proposed alternative for stormwater discharge at outfall S-107, which completely avoids the sea turtle nesting beach.

Coral Translocation Permit, 5 Guam Code Annotated (GCA), Section 63601

- February 28, April 25, and May 9, 2019 - The PAG and DAWR met and discussed the proposed translocation of corals that requires authorization by DAWR.

Fish and Wildlife Coordination Act (FWCA), Ms. Chelsa Muna-Brecht

- April 22, 2019 - The PAG sent a letter to DAWR requesting consultation under FWCA.
- May 14, 2019 - DAWR responded to the PAG with recommendations.

Guam Environmental Protection Agency (GEPA)

- November 1, 2013 - The PAG sent a request to GEPA for information regarding permitting requirements for the proposed Hotel Wharf project.
- November 14, 2013 - GEPA participated in an agency coordination meeting to discuss environmental opportunities and constraints of the proposed project.
- June 4, 2018 - The PAG submitted an application for certification of compliance with the Guam Water Quality Standards, under Section 401 of the Clean Water Act.

State Historic Preservation Officer (SHPO), Department of Parks and Recreation

- August 13, 2013 - The PAG sent a request to the Guam SHPO for concurrence under Section 106 of the National Historic Preservation Act (NHPA) with a determination of no adverse effect to historic properties for the proposed Hotel Wharf and maintenance road undertaking.
- September 13, 2018 - The SHPO issued a letter to the PAG that concurred with the PAG's determination of effect, provided that PAG contract a qualified underwater archaeologist to conduct a survey of the Hotel Wharf area of potential effect (APE).
- January 4, 2019 - MARAD and PAG amended the project description, updating the project footprint due to incorrect calculations from AMEC (2014) that were used in the initial determination of effect.
- February 4, 2019 - The SHPO responded to the PAG's amendment and confirmed that the change in the project description would not creation any potential to significantly affect the original Section 106 determination of "no adverse effect".

National Marine Fisheries Service (NMFS)

Section 7, U.S. Endangered Species Act (ESA), Ms. Ann Garrett

- September 13, 2018 - MARAD and the PAG initiated informal Section 7 consultation with NMFS for compliance with ESA.
- February 20, 2019 - NMFS concurred with the determination that the project is not likely to adversely affect (NLAA) the following endangered or threatened species under NMFS jurisdiction: endangered hawksbill sea turtles, endangered Central West Pacific Distinct Population Segment (DPS) green sea turtles, and threatened Indo-West Pacific DPS scalloped hammerhead sharks.
- January 4, 2019 - MARAD and the PAG amended the project description, updating the project footprint due to incorrect calculations in the AMEC (2014) report used in the initial consultation request.
- March 12, 2019 - USFWS responded, concurring with the determination that the project may affect but is not likely to adversely affect the green and hawksbill sea turtles.

Magnuson-Stevens Act (MSA), Mr. Gerald Davis

- September 13, 2018 - The PAG initiated consultation with NMFS for compliance with the MSA for effects to EFH.
- October 24, 2018 - NMFS requested the PAG to initiate expanded consultation on the basis that additional information was required for NMFS to provide highly specific conservation recommendations.
- April 10, 2019 - The PAG submitted the additional information requested by NMFS, along with a request for expanded consultation.
- April 15, 2019 - NMFS confirmed the consultation package was complete, and initiated expanded consultation.
- May 23, 2019 - NMFS responded to the PAG with conservation recommendations.

Fish and Wildlife Coordination Act (FWCA), Mr. Gerald Davis

- April 22, 2019 - PAG transmitted a letter to NMFS requesting consultation under FWCA.

U.S. Fish & Wildlife Service (USFWS)

Section 7, U.S. Endangered Species Act (ESA), Ms. Jacqueline Flores

- September 13, 2018 - MARAD and the PAG initiated informal Section 7 consultation with the USFWS for compliance with ESA.
- November 5, 2018 - USFWS sent a response concurring with the determination that the project may affect but is not likely to adversely affect listed species.
- January 4, 2019 - MARAD and the PAG amended the project description, updating the project footprint due to incorrect calculations from AMEC (2014) that were used in the initial consultation request.
- April 4, 2019 - USFWS sent a response to the PAG concurring with the determination that the project may affect but is not likely to adversely affect the green sea turtle (*Chelonia mydas*) and the hawksbill sea turtle (*Eretmochelys imbricata*).

Fish and Wildlife Coordination Act (FWCA), Ms. Katherine Mullett

- April 22, 2019 - The PAG transmitted a letter to USFWS requesting consultation under FWCA. Similar letters were transmitted on the same date to DAWR and NMFS.
- April 24, 2019 - USFWS confirmed receipt of the letter and initiated consultation.
- May 13, 2019 - USFWS responded to the PAG with recommendations.

7.2 Public Involvement

The following agencies have provided an opportunity for public comment on the proposed action through the review process for their respective permits.

Bureau of Statistics and Plans, Government of Guam

- 21-day comment period in August 2018 for Federal Consistency Certification under Coastal Zone Management Act (CZMA).

U.S. Army Corps of Engineers

- 30-day comment period from July 17 to August 16, 2018 for Individual Department of the Army Permit.

8. CONCLUSIONS

The proposed action is concluded to have a less than significant effect on the following resource areas:

- Soil, Geology and Seismicity
- Air Quality
- Hazardous Materials and Waste Management
- Noise and Vibration
- Public Services and Utilities
- Water Quality
- Surface and Ground Waters
- Wetlands
- Floodplains
- Terrestrial Resources
- Threatened and Endangered Species, and Critical Habitat
- Cultural Resources
- Environmental Justice
- Land Use and Visual Resources

The proposed action is concluded to have a less than significant, but adverse impact on the following resource areas:

- Waters of the U.S.
- Marine Resources

Section 6.0 describes proposed mitigation to offset these adverse impacts.

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10. LIST OF PREPARERS AND REGULATIONS

10.1 List of Preparers

A. This Environmental Assessment was prepared by the following entities:

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B. The document was reviewed and edited by the following entities:

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Dora Cruz Perez, Planner IV, Strategic Planning Division
Jared Perez, Planner II, Strategic Planning Division

WSP USA, Inc.
Linda R. Cruz, Environmental Lead
Robert Johansen, Engineer

10.2 List of Regulations

This Environmental Assessment was prepared in compliance with and in consideration of the following laws and regulations.

A. National Environmental Policy Act (NEPA)
B. Clean Air Act
C. Clean Water Act
D. National Historic Preservation Act
E. U.S. Endangered Species Act
F. Magnusson-Stevens Act
G. Fish and Wildlife Coordination Act
H. Executive Order 11988 (Floodplain Management)
I. Executive Order 13112 (Invasive Species)
J. Executive Order 12898 (Environmental Justice)

APPENDIX A. Maps and Figures

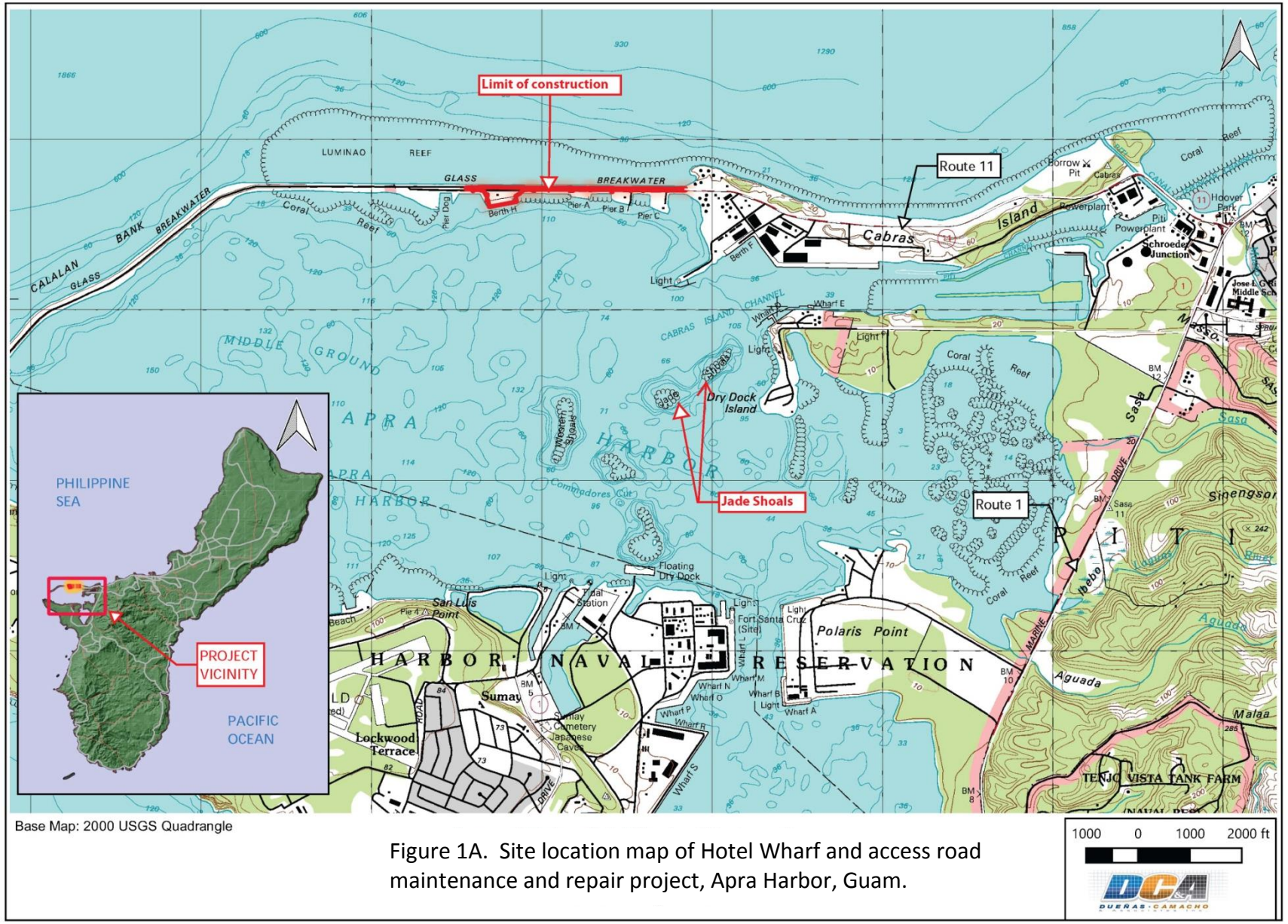


Figure 1A. Site location map of Hotel Wharf and access road maintenance and repair project, Apra Harbor, Guam.

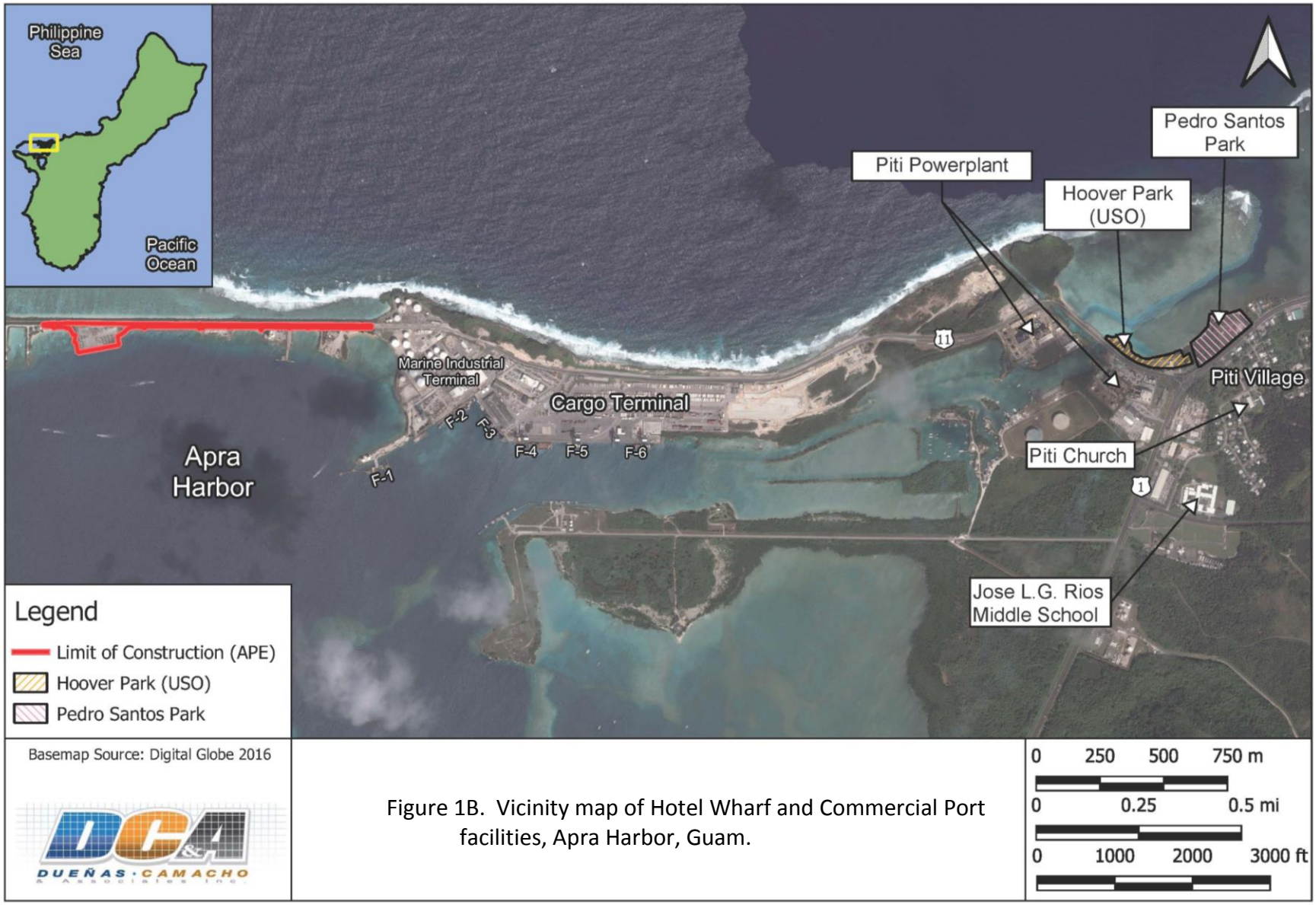


Figure 1B. Vicinity map of Hotel Wharf and Commercial Port facilities, Apra Harbor, Guam.

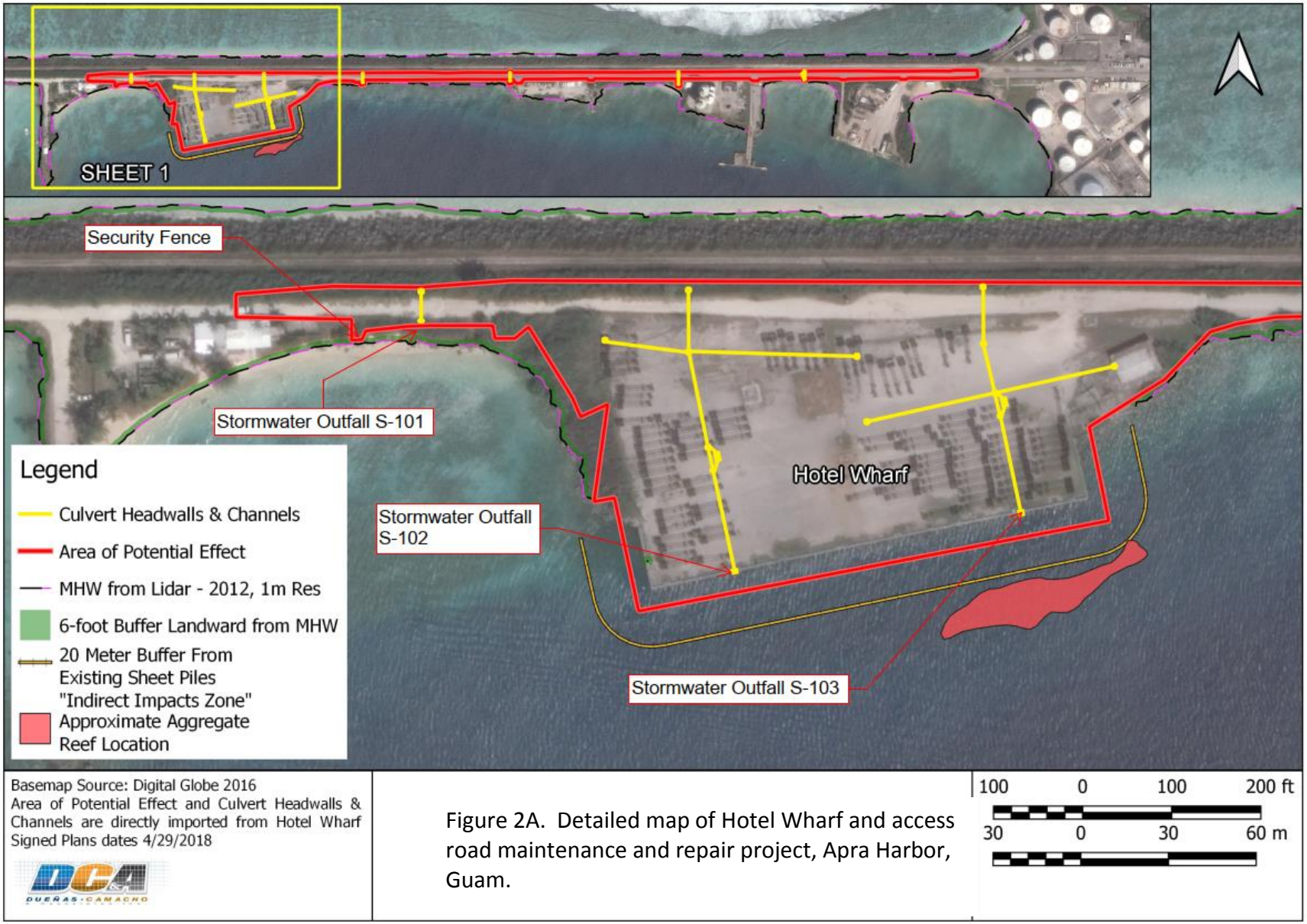


Figure 2A. Detailed map of Hotel Wharf and access road maintenance and repair project, Apra Harbor, Guam.

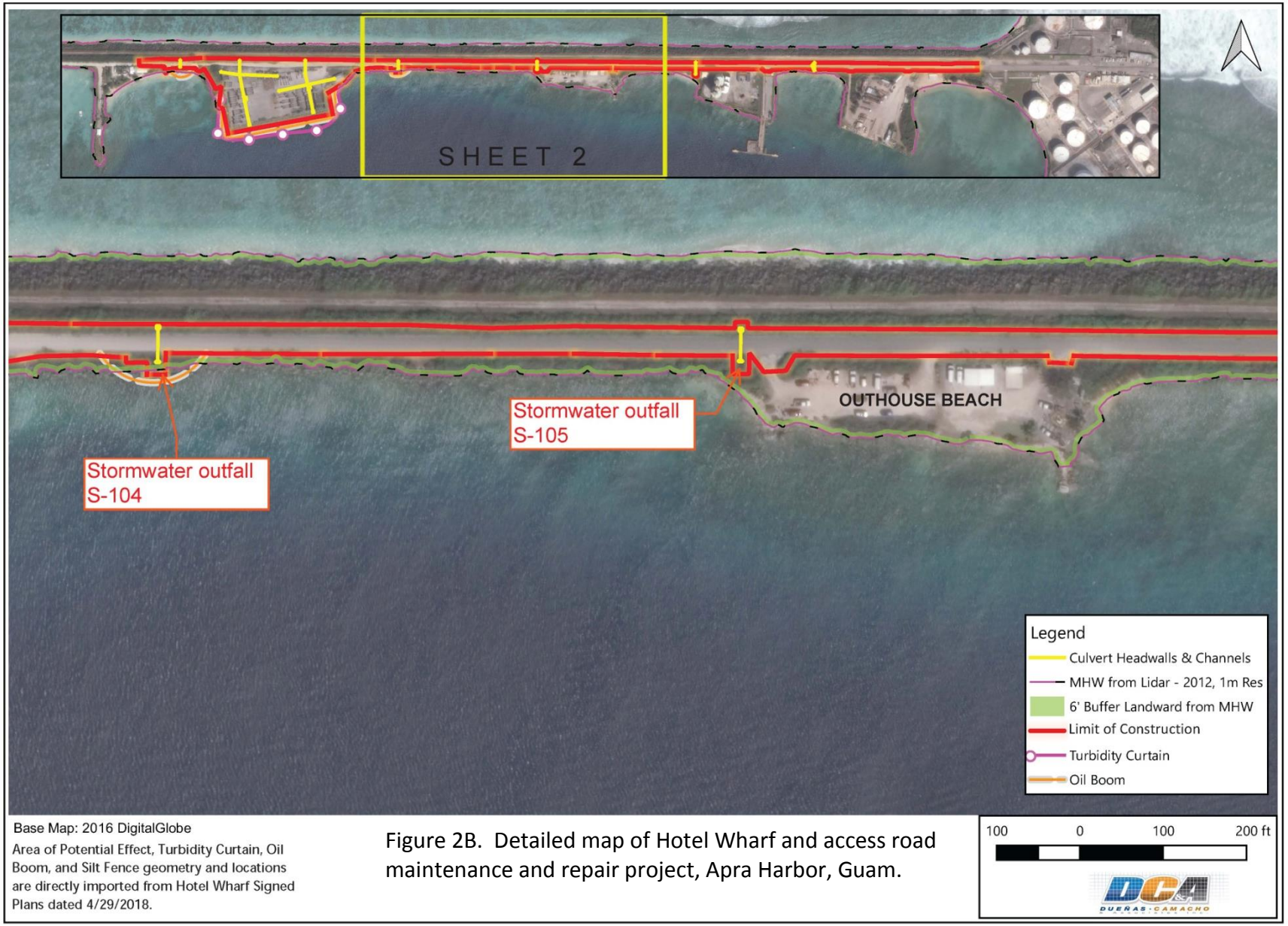


Figure 2B. Detailed map of Hotel Wharf and access road maintenance and repair project, Apra Harbor, Guam.

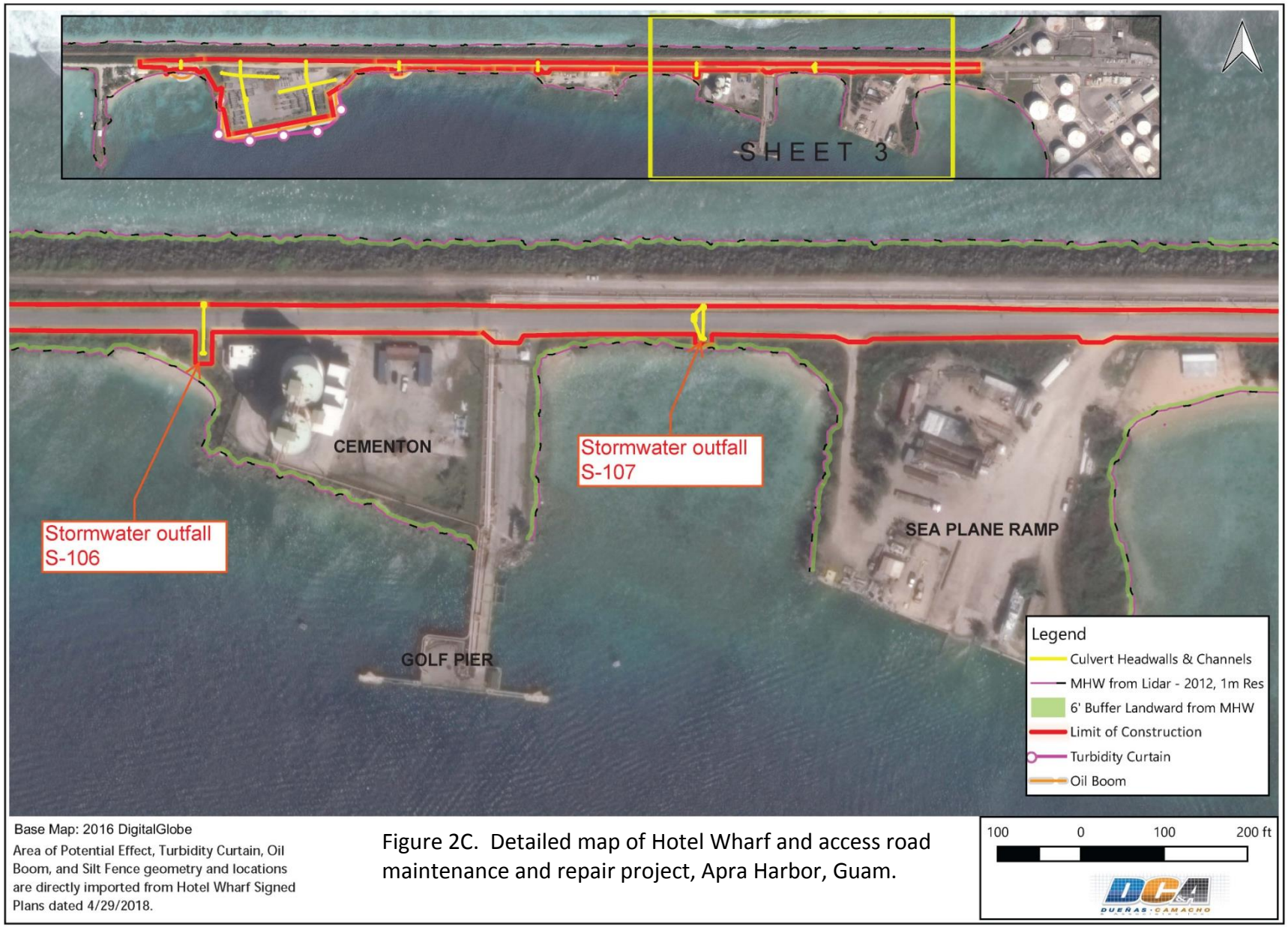


Figure 2C. Detailed map of Hotel Wharf and access road maintenance and repair project, Apra Harbor, Guam.

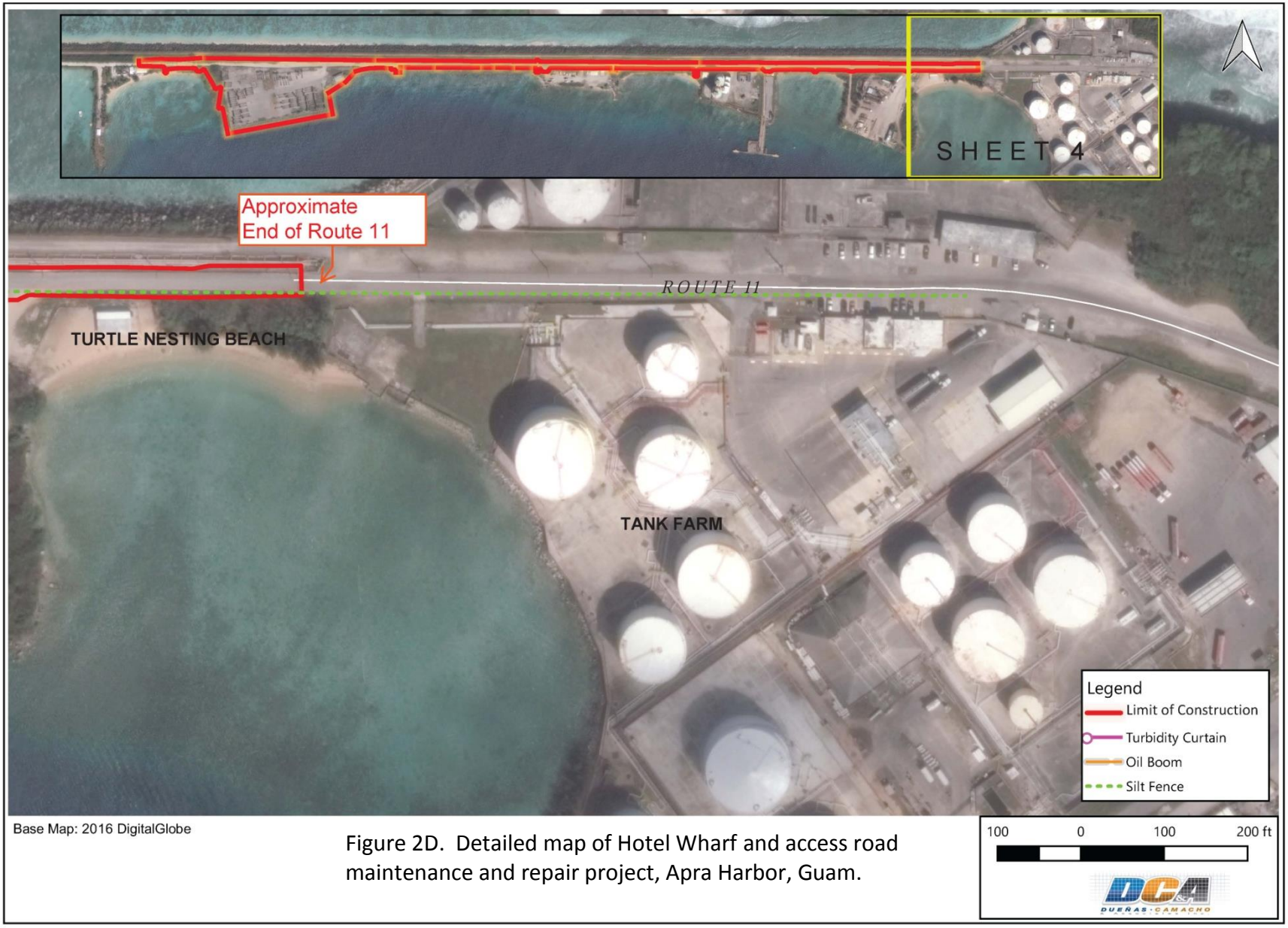


Figure 2D. Detailed map of Hotel Wharf and access road maintenance and repair project, Apra Harbor, Guam.

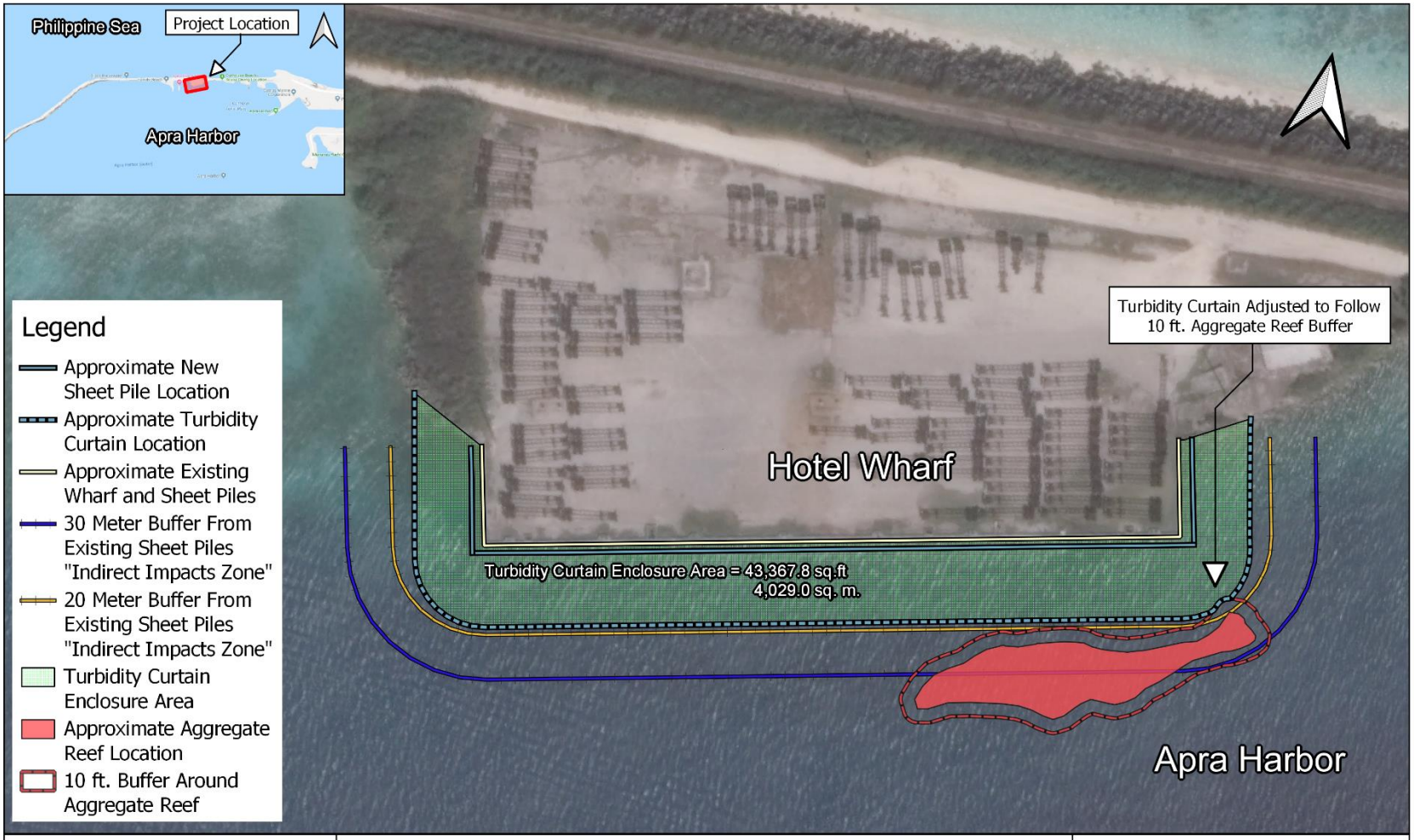


Figure 3. Satellite imagery of Hotel Wharf project site, Apra Harbor, Guam.

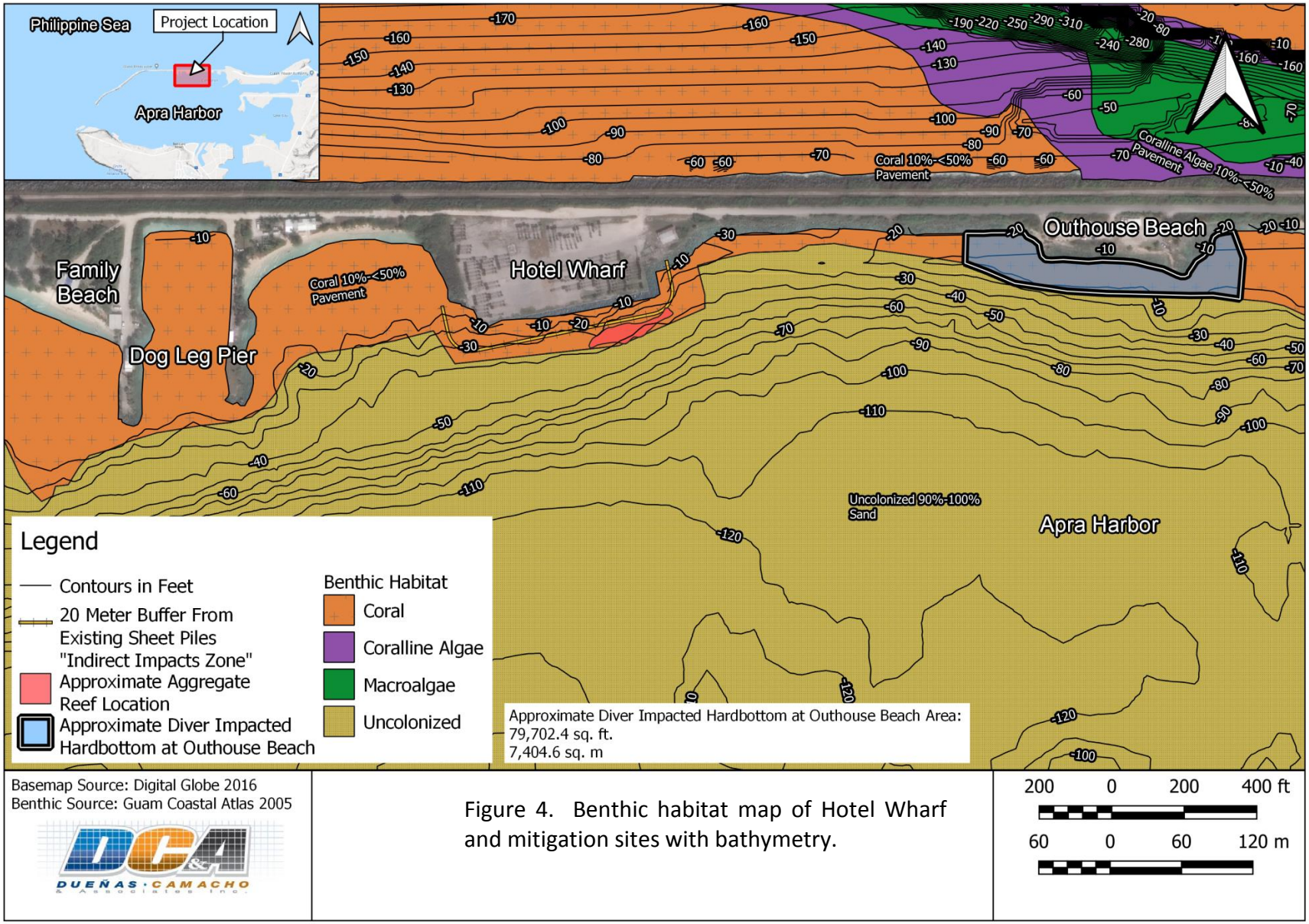


Figure 4. Benthic habitat map of Hotel Wharf and mitigation sites with bathymetry.

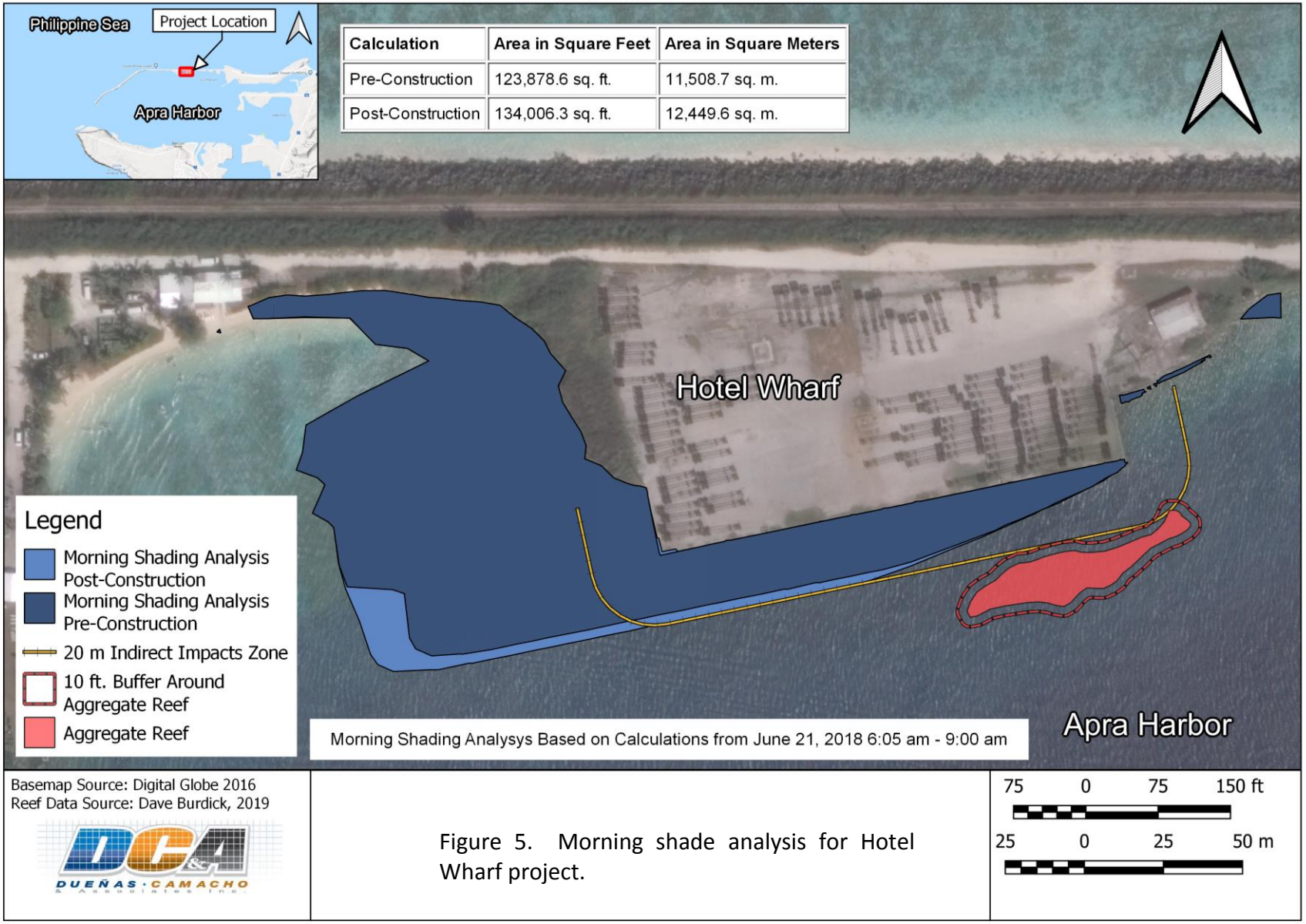


Figure 5. Morning shade analysis for Hotel Wharf project.

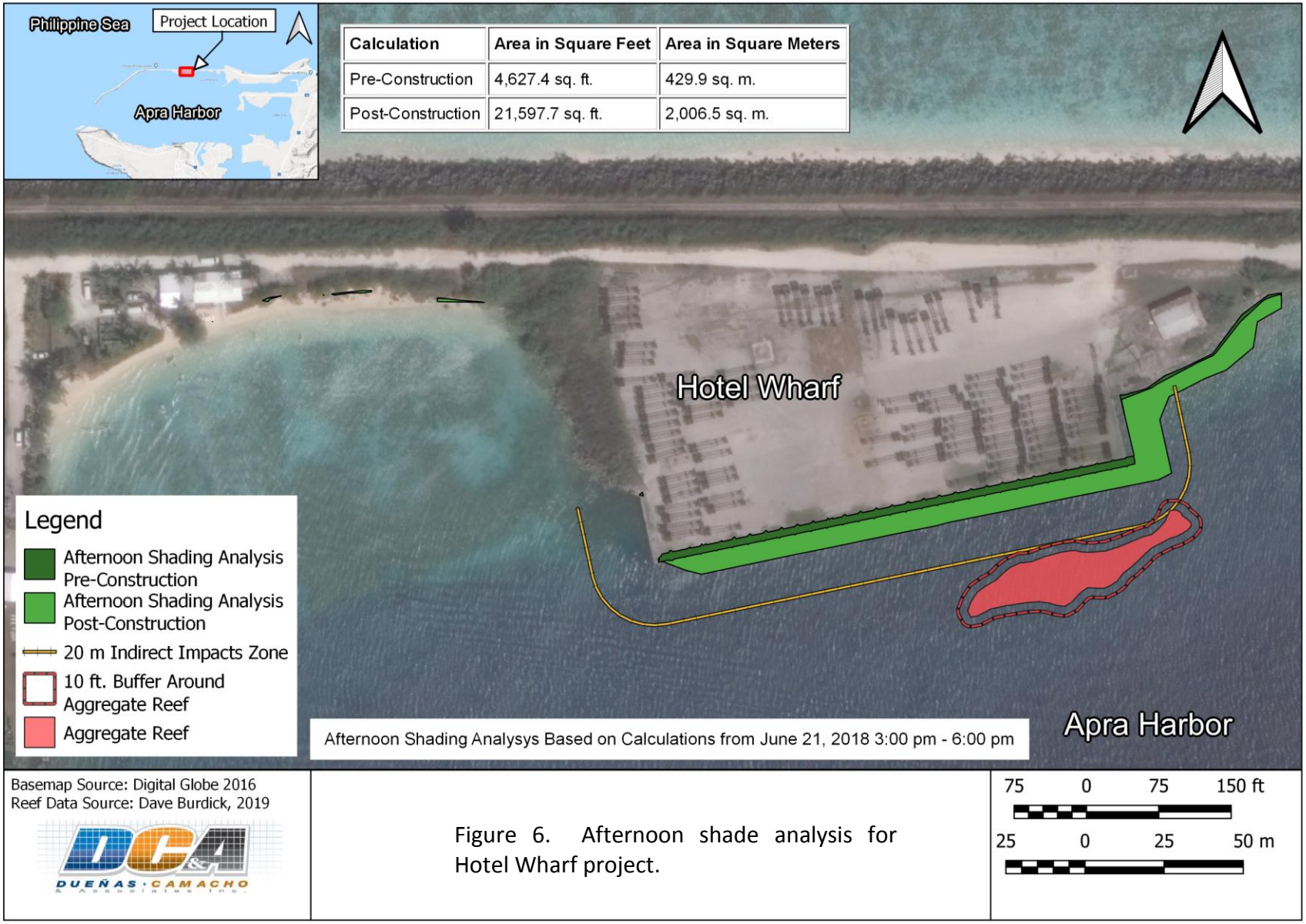


Figure 6. Afternoon shade analysis for Hotel Wharf project.

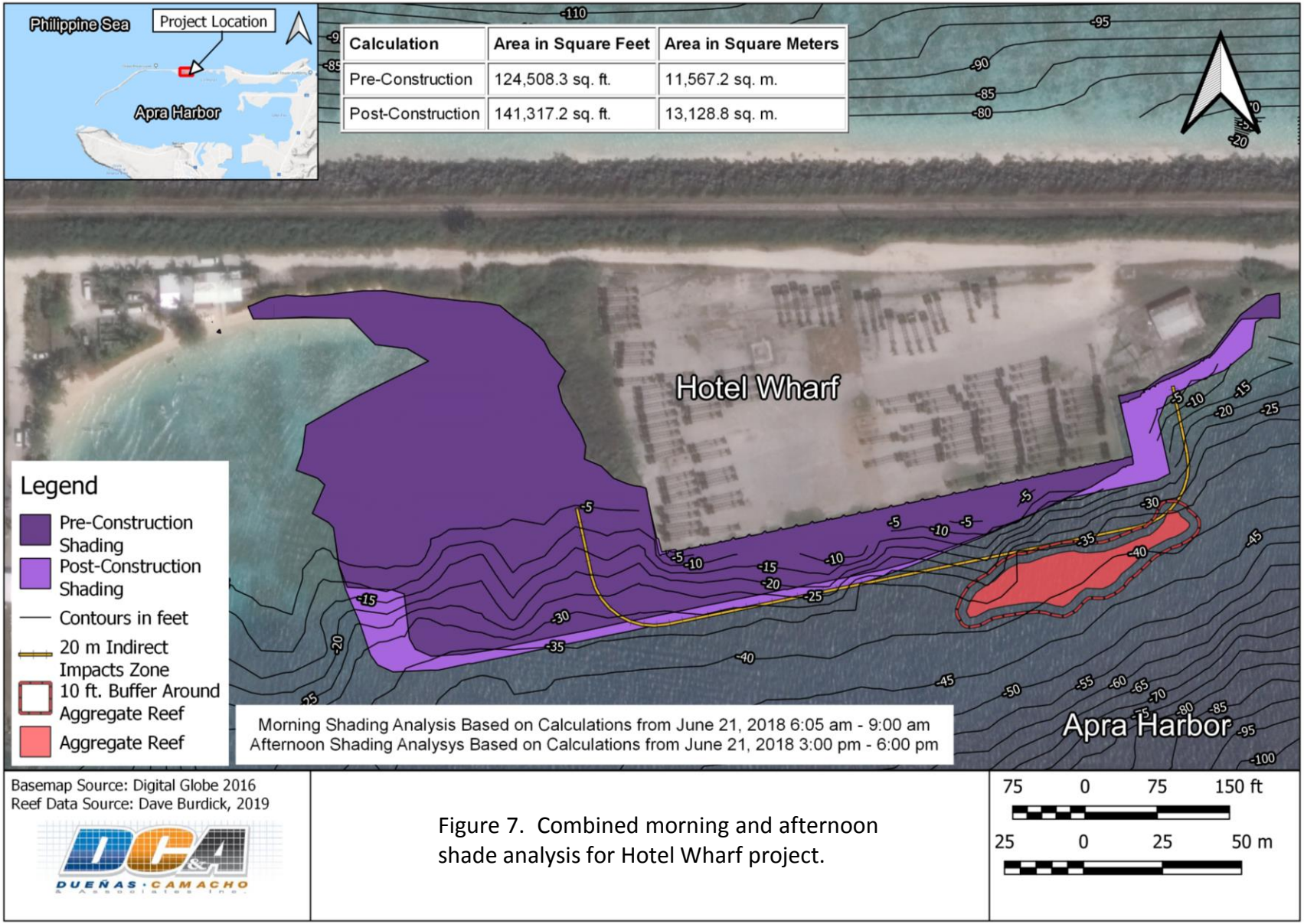
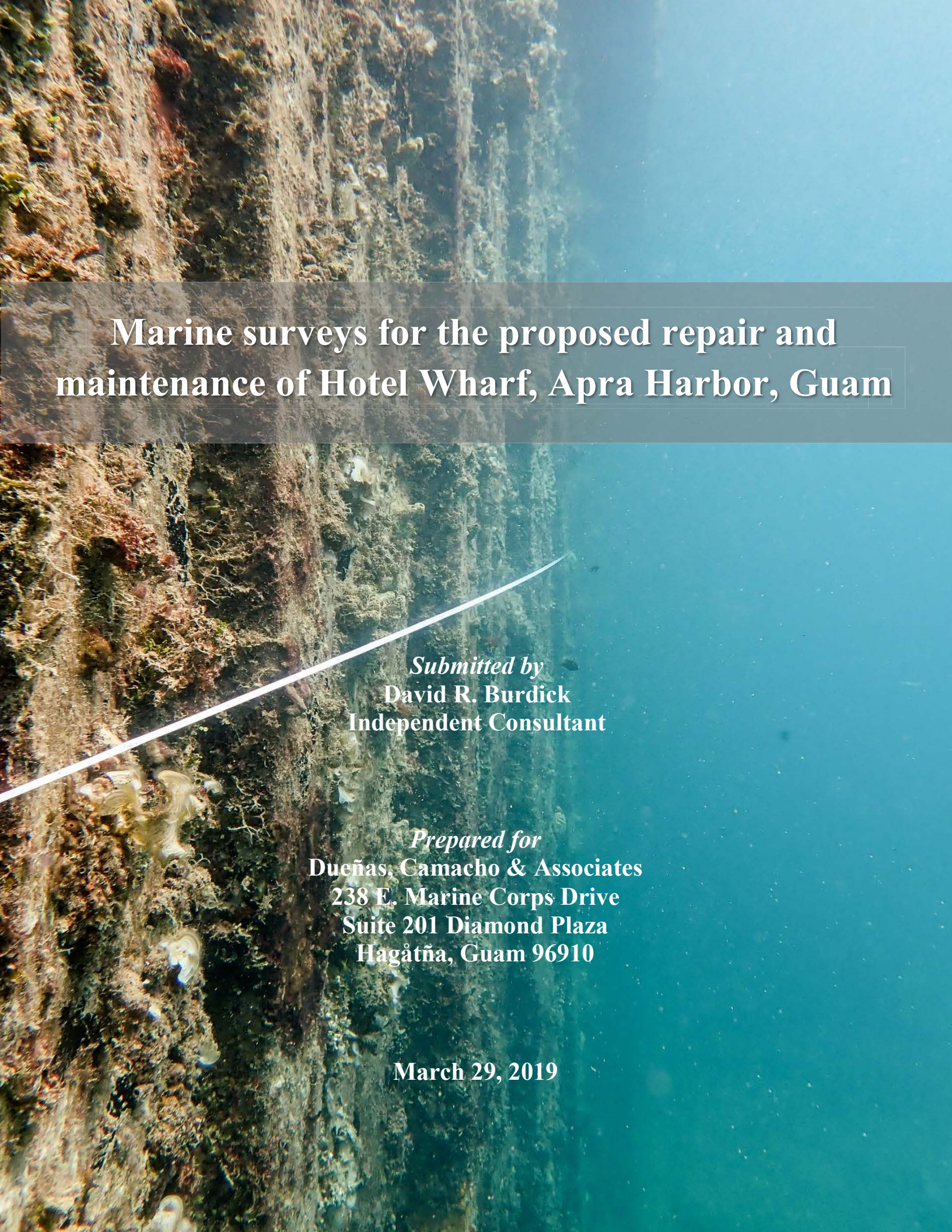


Figure 7. Combined morning and afternoon shade analysis for Hotel Wharf project.

APPENDIX B. Marine Surveys for the Proposed Repair and Maintenance of Hotel Wharf, Apra Harbor, Guam (Burdick 2019)



Marine surveys for the proposed repair and maintenance of Hotel Wharf, Apra Harbor, Guam

Submitted by
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March 29, 2019

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1. INTRODUCTION

1.1. Project Background

The Port Authority of Guam (PAG) is proposing to carry out repair and maintenance activities at Hotel Wharf and approximately 1.6 km (1 mi) of adjacent access road within the Jose D. Leon Guerrero Commercial Port, Apra Harbor. The wharf repair will involve the removal and replacement of the existing cap, the installation of new tie rods and anchoring, the driving of new sheet pile outside of the existing structure, backfilling the new sheet pile, and capping. In order to adequately assess the potential impacts to corals and other reef benthos within the areas expected to be impacted by the repair and maintenance of Hotel Wharf, and to obtain information required to avoid and minimize these impacts, Duenas, Camacho & Associates, Inc. (DCA) contracted the author to conduct a survey of corals, benthic cover, macroinvertebrates, and Endangered Species Act (ESA)-listed or candidate species that occur within the project area. This report provides the results of the surveys and includes recommendations to assist with the permitting requirements for the proposed project. A more detailed description of the project is presented in a report submitted previously by AMEC Environmental & Infrastructure, Inc. (AMEC) (2014).

1.2. Scope of work

The relevant resource agencies are requiring marine surveys for the submerged south, west, and east sides of Hotel Wharf, as well as the seafloor occurring in the vicinity of the wharf. The area of seafloor targeted for surveys extends 30 m from the base and sides of the wharf; this area includes the area of seafloor where the new wharf face will occur, as well as the area of seafloor that would be contained within a silt curtain during construction. Additionally, discrete patch reefs that occur within the 30 m impact area, but which are not intersected by the transects, as well as those patch reefs and other natural hardbottom communities that occur within 50 m from the wharf will also be surveyed, as these communities may be indirectly impacted by degraded water quality during construction. The resource agencies are requiring the following information be obtained for the wharf sides and the seafloor in the vicinity of the wharf:

- Hard coral colony density and size class data
- Benthic cover estimates
- Large mobile macroinvertebrate density data
- Detailed location information for any listed and candidate threatened or endangered species occurring within the vicinity of the project

2. METHODS

2.1. Site description

Hotel Wharf is part of the Jose D. Leon Guerrero Commercial Port, which is located on the north side of Apra Harbor (Figure 1). The harbor hosts Guam's only deep (>40 m) lagoon environment, bounded to the south by Orote Peninsula and to the north by Cabras Island and the Glass Breakwater. Following World War II, the breakwater was built across the Luminao barrier reef and the Calalan Bank, a submerged bank that extends westward of the reef. The depth of the harbor and its relatively calm water conditions facilitate significant commercial, military, and recreational activities, but also support an environment unique among the islands of the Mariana Archipelago. This important marine environment is comprised of several biophysical zones, each supporting distinct marine communities, and hosts a large number of species not found anywhere else in Guam's waters (Paulay et al. 1997).

Hotel Wharf occurs within the Zone II designated by Paulay et al. (1997), which corresponds to the original backreef of Luminao Reef. The wharf interrupts a shallow (~1.5 m) reef flat that extends from the western side of Cabras Island in the east to the western edge of the Luminao barrier reef in the west. The area of reef flat immediately to the west of Hotel Wharf extends approximately 80 m from the shore, which is comprised a mix of riprap and naturally-accumulated sand, to the southern edge of the flat. The reef flat to the east of the wharf extends approximately 15 m from riprap to the southern edge of the flat. The reef flat adjacent to both sides of the wharf both abruptly drop 2–3 m to a sandy slope. The sandy slope extends southward, dropping more steeply from the edge of the reef flat to an area approximately in line with the southern wharf face, then sloping gradually across a distance of about 70 m before sloping more steeply to the lagoon bottom.

The southward-oriented wharf face is 153 m (~500 ft) across, and both the eastern and western sides extend approximately 22 m (~59 ft) from the adjacent riprap on shore, for a total wharf length of 192 m (~629 feet) below the mean high-water mark. The wharf face extends to a depth of approximately 9 m (~-30 ft) at the mudline, while the eastern and western wharf sides extend southward, and perpendicular to, the riprapped shoreline, across the shallow (1.5 m) reef flat to a maximum depth of approximately 8–9 m. Based on figures provided by DCA, the surface area of the existing submerged vertical sheet pile is approximately 1395 m^2. This area estimate does not account for the ribbed topography of the sheet pile, but was considered suitable for calculating area coral colony count estimates, as coral colonies almost entirely absent from the shaded, recessed sides of the sheet pile.

The primary area of seafloor targeted for surveys extends 30 m from the base of the sheet pile wall on the west, south, and east sides of the wharf; this area includes the area of seafloor where the new wharf face will occur, as well as the area of seafloor that would be contained within a silt curtain during construction. The 30 m wide indirect impacts area was initially proposed by a previous contractor, AMEC, and approved by the relevant agencies. However, information provided to the author after the scope of the current study was approved and field work had begun indicated that the silt curtain could be placed as close as 12 m from the existing wharf face. Additionally, discrete patch reefs and other areas of hardbottom that occur within the 50 m impact area were also surveyed, as these communities may be indirectly impacted by degraded water quality or anchor damage during construction.

2.2. General survey approach

All surveys were carried out by a team of three biologists, including the author, a subcontracted coral biologist (Roxanna Miller), and a biologist (Devin Keogh) employed with DCA across five days between January 19 and February 2, 2019. The coral colony, benthic cover, and macroinvertebrate surveys occurred along transects placed on the three wharf sides, the seafloor at the base of the wharf, and the area of seafloor extending 30 m from the wharf sides. Additional transects were placed along a relatively large area of aggregate reef and mixed sand/hardbottom that runs roughly parallel to, and approximately 25 m from, the south wharf face. Transects were not used for the small (< 5 m in longest dimension) patch reefs occurring within the survey area; instead, all corals and large mobile macroinvertebrates were censused, and benthic cover was measured, for the whole patch reef.

A total of nine 50-meter-long transects were surveyed on the southern wharf face, including three sets of transects placed nearly end-to-end at depths of 1 m, 5 m, and 9 m (Figure 2). The transects placed along the 1 m depth contour targeted a concrete beam that extends 30 cm from the wharf just below the sea surface (Figure 23). Review of video footage taken in November 2013 by AMEC revealed the presence of hard corals along this beam, but fewer reef-building corals in the shaded underside of the beam. It should be noted, however, that numerous non-reef-building dendrophylliid corals (a.k.a. “tube corals” or “sun corals”) were known to occur on the underside of the beam. An additional set of two transects each were surveyed on the east and west sides at depths of 1 m and 5 m (Figure 2).

A set of three 50 m transects were placed nearly end-to-end along the base of the south wharf face, at a distance of approximately 1.5 m from the wharf, in order to assess the area of seafloor that will be directly impacted by the placement of the new wharf face and sides (Figure 4). Similar seafloor transects (22 m and

25 m long, respectively) were placed along the east and west wharf sides at the same offset distance from the base of the wharf.

A set of sixteen 30 meter-long transects were placed at regular intervals (every 15 m), and extending perpendicularly from, the bottom of the wharf sides in order to assess marine communities that may occur within the area encompassed by the silt curtain (Figure 5). Benthic photo transect surveys were carried out along two additional seafloor transects (transects A and B, Figure 5) on March 9 to increase the sample size for the reef flat areas adjacent to the wharf. Two 30 m transects were placed on the area of mixed sand and hardbottom occurring parallel to the wharf face, and one 50 m and one 35 m transect were placed on the area of aggregate reef also occurring parallel to the wharf face (Figure 5). Portions of these areas of hardbottom extended several meters beyond the 30 m distance from the wharf face, but all data collected on these areas were included in the analysis. All patch reefs occurring within an area extending 50 m from the wharf were mapped, their area estimated, and marine communities assessed (Figure 6). While many of the patch reefs occurred at a distance greater than 30 m from the wharf face, data collected at all surveyed patch reefs were included in the analysis. A Global Positioning System (GPS) receiver placed on a float was used in combination with a camera calibrated with the GPS to generate location information for the patch reefs, Endangered Species Act (ESA) listed or candidate species, and other notable features. The images were georeferenced using the RoboGEO software application and maps were generated using QGIS, an open-source Geographic Information System (GIS) application.

2.3. Coral colony survey

All coral colonies occurring within a one-meter-wide belt centered on the transect tape were identified and sized (longest dimension to nearest cm) along all wharf sides and all seafloor transects except the two additional transects later surveyed on the reef flat adjacent to the wharf. All coral colonies occurring on small (< 5 m in longest dimension) patch reefs located within 50 m of the wharf face were censused. Colony density estimates for the shallow (1 m) wharf face transects were calculated using area values that accounted for the additional survey area added to the width of the shallow transects on the wharf face and sides by the concrete beam that extended 30 cm from the wharf.

2.4. Benthic cover survey

Benthic photo transect surveys were carried out across the length of all sides of the wharf face as well as the seafloor transects. Images were obtained every meter along the left side of the transect using a compact point-and-shoot camera placed atop a PVC pipe monopod. A single planar-view image was obtained for

each patch reef. Images were imported from the Secure Digital (SD) card into Adobe Lightroom software and a batch white balance adjustment was applied to groups of images with similar white balance characteristics. Images were then exported and renamed.

Benthic cover estimates were generated through an analysis of the photo transect images using the Coral Point Count with Excel Extension (CPCe) application. A total of 16 points were overlaid on each image using a random-stratified approach, whereby a single point was randomly placed within each cell of a four by four grid placed over the image. The benthic feature falling under each point was identified. Hard corals were identified to species when possible, although some taxa, such as massive *Porites*, *Montipora*, and others, often could not be identified to species level using the photo transect images. Other biological cover types identified in the point count analysis include soft corals and sponges. All other points were classified as occurring on hardbottom, unconsolidated sediment, or debris. Due to the small size of the patch reefs and the limited number of visible coral colonies, it was determined that more accurate estimates of percent coral cover would be obtained by utilizing the area measurement function of CPCe to delineate the area of each patch reef and all visible coral colonies. The cover of sponges was not assessed for patch reefs; no soft corals were observed on the patch reefs.

2.5. Macroinvertebrate survey

All mobile macroinvertebrates were identified and counted within two-meter-wide belt transects centered on the transect tape for all transects. Patch reefs were also censused for mobile macroinvertebrates. As with the coral belt transect surveys, the macroinvertebrate belt transect area—and thus the macroinvertebrate density calculations—accounted for the additional area added to the width added to shallow wharf face transects by the concrete beam.

2.6. ESA-listed or candidate species survey

All listed or candidate ESA species observed on the wharf sides or within an area extending 50 m from the wharf were noted and their location recorded using geo-referenced images. Any listed or candidate ESA species incidentally observed beyond the 50 m area were also recorded. A comprehensive list of all listed or candidate ESA species known or expected to occur in the waters around Guam is provided in Appendix A.

3. RESULTS AND DISCUSSION

3.1. Overview

The results of the multiple surveys are presented separately for the areas expected to be directly (Direct Impacts Zone) and indirectly (Indirect Impacts Zone) impacted by activities associated with the proposed repair and maintenance of Hotel Wharf. In consideration of the possibility that the silt curtain may be placed closer to the wharf than the original 30 m estimate, the Indirect Impacts Zone is further divided into the 30 m Indirect Impacts Zone and the 20 m Indirect Impacts Zone. Areas expected to be directly impacted by the proposed project activities include the wharf sides and the area of seafloor extending 2.4 m, 1.9 m, and 3 m from the base of the west, south, and east wharf sides, respectively. It is anticipated that all of the corals and other benthic organisms occurring in the Direct Impacts Zone will experience total mortality. Areas expected to be indirectly impacted by the proposed project activities include the area of seafloor and water column located between the expected location of the newly constructed wharf face and the inner side of the silt curtain; the silt curtain is expected to be placed at either 30 m or 20 m from the planned location of the newly constructed wharf face.

3.2. Direct Impacts Zone

As described above, the Direct Impacts Zone includes the wharf face and the area of seafloor extending 2.4 m, 1.9 m, and 3 m from the base of the west, south, and east wharf sides, respectively. The construction of the new wharf face and sides will result in the mortality of all benthic organisms within the direct impact area, and potentially of small mobile, site-attached, organisms associated with benthos within the direct impact area.

3.2.1. Qualitative observations

All sides of the wharf face hosted similar benthic communities, although some differences in the abundance and diversity of macrophytes and turf algae—likely related to light exposure— were observed. Common conspicuous algae taxa on the wharf face included the erect macrophytes *Padina* sp., *Dichotomaria marginata, Tricleocarpa fragilis, Halimeda* spp., and *Dictyota* spp., as well as several unidentified adherent fleshy and crustose coralline species. Solitary and colonial ascidians and encrusting sponges were also common on the wharf face, and an unidentified oyster species was abundant in the area of the wharf face above a depth of about 1 m. The abundance, biomass, and diversity of benthic organisms generally decreased with depth along the wharf face, likely in response to the reduction in light and greater accumulation of sediment (Figures 24–25). The benthic community occurring on the shaded underside of

the concrete beam was distinct from other areas of the wharf face, being primarily comprised of encrusting sponges, crustose coralline algae, and *Halimeda* spp., with few other macrophytes. This area also hosted numerous dendrophylliid corals, also known as tube or sun corals (Figure 26), and at the southeast corner numerous colonies of an octocoral—possibly the non-native species, *Carijoa riisei* (snowflake coral)—were observed (Figure 27).

Benthic communities occurring on the seafloor at the base of the wharf face can be broadly divided into those occurring on the hardbottom of the reef flats to the east and west of wharf and those occurring on the sandy slope and flat at the base of the south wharf face and the deeper portions of the east and west sides. The benthic communities on the reef flat were dominated by fleshy erect macrophytes such as *Padina* sp., *Halimeda* spp., *Dichotomaria marginata*, and *Dictyota* spp. (Figure 28). The sandy slope and flat at the base of the south wharf face and the deeper portions of the eastern and western sides hosted a mix of uncolonized sand/silt and debris primarily colonized with sediment-laden turf algae, but also hosting the occasional sponge or hard coral colony (Figure 29).

3.2.2. Coral diversity, colony density and colony size

A total of 2739 coral colonies, at a mean density of 3.4 ± 2.6 col/m^2, were recorded along transects surveyed within the Direct Impacts Zone, with 2529 (92%) observed on the wharf sides at a mean density of 4.4 ± 2.5 colonies/m^2 and 210 (8%) observed on the transects surveyed at the seafloor along the base of the wharf at a mean density of 1.1 ± 0.3 colonies/m^2 (Table 1, Figure 7). Colony density values for all taxa are provided for all transects surveyed on the wharf sides in Appendix B, and for the transects surveyed at the base of the wharf in Appendix C.

Based on relative abundance values derived from the belt transect survey colony counts, the coral community across the wharf face and sides was comprised primarily of *Leptastrea purpurea* (39% of all colonies), dendrophylliid sp. (26%), *Pocillopora damicornis* (12%), and massive *Porites* spp. (6%). However, different assemblages were observed in association with distinct, depth-influenced habitat types that spanned the wharf sides. The coral community occurring on and immediately above the beam was comprised primarily by *Leptastrea purpurea* (53%), *Pocillopora damicornis* (18%), dendrophylliid sp. (16%), and unidentified *Leptastrea* species (7%), while the community observed at the mid-depth (5 m) and deep (9 m) transects on the wharf face and sides was comprised primarily of dendrophylliid sp. (43%), *Leptastrea purpurea* (16%), massive *Porites* spp. (14%), and *Stylocoeniella armata* (6%) colonies. The relatively low-density coral community occurring on the seafloor at the base of the wharf was also distinct,

primarily comprised of massive *Porites* spp., *Stylocoeniella armata, Pocillopora damicornis*, and *Lobophyllia hemprichii*.

A total of 43 coral taxa were observed within the Direct Impacts Zone, including 35 coral taxa observed on the wharf sides and 29 observed at the wharf base. Note that species counts are likely underestimates, as multiple species may be identified as the single taxon (e.g., "*Porites* sp. -massive") because of the difficulty in identifying these species in the field.

Mean colony diameter for all colonies observed on transects surveyed within the Direct Impacts Zone was small, at 4.8 ± 6.2 cm (Table 1, Figure 9). Mean colony diameter of colonies observed on transects surveyed on the wharf sides was similarly small (4.3 ± 5.5 cm), influenced by the large number of small *Leptastrea purpurea* colonies, while mean colony diameter for the seafloor at the base of the wharf, which hosted fewer small *Leptastrea* colonies, was larger, at 10.8 ± 9.3 cm.

Based on the colony density values derived from the count values obtained for the belt transect surveys and the area of substrate, it is estimated that 6528 coral colonies occur within the Direct Impact Zone, including 6071 on the wharf face and 428 on the seafloor at the base of the wharf (Appendix I).

3.2.3. Benthic cover

Benthic cover estimates for areas within the Direct Impacts Zone were derived from a total of 703 benthic photo transect images, including 56 images obtained from the total of four transects placed along the east and west wharf sides, 450 images from nine transects placed along the south wharf side, and 197 images from the five transects placed along the base of the wharf. Mean percent cover of hard corals, soft corals, sponges, other hardbottom, unconsolidated sediment, and debris are presented for each survey area within the Direct Impacts Zone (Tables 2–3) and can be visualized in Figures 11–12. Percent cover values for each transect within the Direct Impacts Zone are provided in Appendix K (south wharf side), Appendix L (east and west wharf sides), and Appendix M (wharf base), and can be visualized in Figures 15–16.

Mean percent coral cover across all depths for the east, west, and south wharf sides was 0.5 ± 0.7%, 2.3 ± 1.0%, and 0.6 ± 0.4%, respectively. Coral cover, averaged across all transects on the wharf was 0.9 ± 0.8%. Mean coral cover on the seafloor at the base of the entirety of the wharf was 0.6 ± 0.3%, and was 0.3%, 1%, and 0.5 ± 0.2% for the east, west, and south sides, respectively. A mixed algal assemblage comprised of erect and adherent macrophytes described in Section 3.2.1 was by far the most dominant cover type on

the wharf sides ("Other hardbottom", ~97%). Soft coral and sponge percent cover were relatively low on the wharf sides (0.1% ± 0.3%, and 2.1 ± 2.3%, respectively), although the difficulty of discerning encrusting sponges from other benthic cover types may have resulted in an underestimation of total sponge cover. The seafloor at the base of the wharf, which included both reef flat hardbottom and sand/debris habitat, was covered by a mixed algal assemblage on hardbottom areas, sand, and debris, with each cover type comprising approximately a third of the total cover for the area. Sponge cover was very low (0.2 ± 0.3) and soft corals were not detected for the seafloor at the base of the wharf.

3.2.4. Macroinvertebrate diversity and density

A total of 130 mobile macroinvertebrates representing 14 species were observed in belt transects surveys within the Direct Impact Zone, for a total density of 0.09 ± 0.1 ind/m^2, including 97 individuals (0.07 ± 0.09 ind/m^2) representing 12 species on the wharf sides and 33 individuals (0.12 ± 0.13ind/m^2) representing 7 species along the base of the wharf (Table 6, Figure 21). The most commonly observed macroinvertebrate taxa in the Direct Impacts Zone were *Diadema* sp., *Actinopyga echinites*, *Echinometra mathaei*, and *Culcita novaeguineae*, with *Diadema* sp., *A. echinites* and *C. novaeguineae* dominant on the wharf sides and *E. mathaei*, *A. echinites*, and *C. novaeguineae* dominant on the seafloor at the base of the wharf. The most abundant taxa in the Direct Impacts zone, the long-spined sea urchin (*Diadema* sp.), was almost exclusively observed in recesses in the underside of the shallow beam across the wharf sides. Density values for all macroinvertebrate taxa observed within each of the belt transects placed on the wharf are provided in Appendix Q, while values for transects placed along the base of the wharf are provided in Appendix R.

3.2.5. *ESA-listed or candidate species*

No ESA-listed or candidate species were observed in the vicinity of the project site.

3.3. Indirect Impacts Zone

As described above, the Indirect Impacts Zone includes the area of seafloor located between the wharf face and the inner side of the silt curtain; the silt curtain was originally expected to be placed approximately 30 m from the wharf face, but more recent information indicates that it may be placed closer and that the area of indirect impacts may extend 20 m from the wharf face. In consideration of this new information, data are presented for both the 30 m and 20 m Indirect Impacts Zones when appropriate. The difference between the impacts associated with a 30 m or 20 m indirect impacts buffer distance is significant, and is not proportional to the difference in the area of these two buffer zones, as an area of aggregate reef and mixed sand and hardbottom with much higher coral cover than the surrounding sandy areas occurring parallel to

the wharf face would partially fall within the 30 m buffer. If the silt curtain is placed 20 m from the wharf the aggregate reef and mixed sand/hardbottom areas would fall outside of the silt curtain and there would be a 3 m or more separation from the silt curtain anchors. Unless highly turbid water escapes the silt curtain or anchors are improperly placed, impacts to the benthic communities associated with these areas are likely to be minimal or avoided entirely if the 20 m Indirect Impacts Zone is implemented.

3.3.1. Qualitative observations

The seafloor within the Indirect Impacts Zone includes distinct bottom types, each supporting different benthic assemblages. The benthic communities on the shallow reef flat areas occurring adjacent to the eastern and western wharf sides were similar, being dominated by the erect macrophytes *Padina* sp., *Halimeda* spp., and *Galaxaura rugosa*, and supporting some coral taxa, such as *Pavona decussata* and *Porites cylindrica*, that were not observed elsewhere in the project site (Figure 28). The slope and flat occurring at the base of the southern wharf face and the deeper portion of the wharf sides is primarily covered by uncolonized sand, but debris and hardbottom, including the surveyed patch reefs and smaller patches of hardbottom colonized by turf algae and *Halimeda* spp. are scattered across the area (Figures 30 and 33). The area of hardbottom occurring at the seaward edge of the 30 m Indirect Impacts Zone, and extending up to 40 m from the wharf face, can be broadly divided into an area of mixed sand and hardbottom (Figure 31) and an aggregate reef area that is primarily hardbottom and hosts more coral growth (Figure 33). The hardbottom within the mixed sand/hardbottom and aggregate reef areas hosts a benthic community similar to that of other hardbottom occurring elsewhere in the Indirect Impacts Zone, primarily dominated by turf algae and *Halimeda* spp., with *Porites rus* and, to a lesser degree, other coral taxa, also comprising a notable proportion of the benthic community in the aggregate reef area.

3.3.2. Coral diversity, colony density and colony size

A total of 1283 coral colonies, at a mean density of 2.1 ± 1.6 col/m^2, were recorded along transects surveyed within the Indirect Impacts Zone, with 531 observed on the seafloor transects perpendicular to the wharf face at a mean density of 1.1 ± 0.8 col/m^2, 510 on the transects surveyed on the area of hardbottom occurring parallel to the south wharf face at a mean density of 3.5 ± 2.2 col/m^2, and 242 on the 26 surveyed patch reefs at a mean density of 2.5 ± 1.6 col/m^2 (Table 1, Figure 8). Colony density values for all taxa are provided for all of the seafloor transects placed perpendicular to the wharf face in Appendix D, for the transects in the mixed sand/hardbottom and aggregate reef areas in Appendix E, and for individual patch reefs in Appendix F (patch reefs 1–13) and Appendix G (patch reefs 14–26).

Based on relative abundance values for colonies observed across the entirety of the Indirect Impacts Zone, the coral community across this area was comprised primarily of *Porites rus* (31% of all colonies), massive Porites spp. (18%), unidentified *Astreopora spp.* (9%), and *Astreopora gracilis* (8%). However, as with the Direct Impacts Zone, different coral assemblages were observed in association with distinct habitat types within the Indirect Impact Zone. The coral community occurring on the reef flat transects placed perpendicular to the wharf face and sides was comprised primarily of massive *Porites* spp. (39%), *Pocillopora damicornis* (27%), *Pavona decussata* (10%), and *Porites rus* (10%), while the community observed on the transects placed across the sand flat was comprised primarily of *Porites rus* (23%), *Astreopora gracilis* (16%), massive *Porites* spp. (15%), a massive *Porites* species tentatively identified as *P. stephensoni* (12%), and unidentified *Astreopora* spp. (10%). The area of mixed sand/hardbottom hosted a coral community comprised primarily of *Porites rus* (34%), unidentified *Astreopora* spp. (29%), and massive *Porites* spp. (12%), while the adjacent aggregate reef area with a greater proportion of hardbottom and higher coral cover hosted a coral community dominated by *Porites rus* (68%), with some massive *Porites* spp. (9%) and *P. horizontalata* (7%). When considered in aggregate, the coral community of the surveyed patch reefs was primarily comprised of massive *Porites* spp. (20%), *Astreopora gracilis* (17%), and *A myriophthalma*.

A total of 39 coral taxa were observed across the entirety of the Indirect Impact Zone, with 13 observed on the reef flat transects, 20 on the sand flat transects, 19 on the hardbottom transects, and 23 across all surveyed patch reefs.

Mean colony diameter across the Indirect Impacts Zone (17 ± 21 cm) was significantly larger than that observed in the Direct Impacts Zone, likely a result of the relatively few *Leptastrea* colonies, the absence of dendrophylliid sp. colonies, and the relatively large *Porites rus* colonies in the Indirect Impacts Zone (Table 1, Figure 10). Mean colony diameter within the Indirect Impacts Zone was largest (19 ± 25 cm) in the aggregate reef hardbottom area occurring at the seaward extend of the zone, and smallest (13 ± 15 cm) on the reef flat adjacent to the east and west wharf sides.

Based on the colony density values derived from the count values obtained for the belt transect surveys and the area of suitable substrate, it is estimated that 7794 coral colonies occur within the 30 m Indirect Impacts Zone, including 2241 on the reef flat and 5055 on the sand flat. It is estimated that 4639 coral colonies occur within the 20 m Indirect Impacts Zone, including 1417 on the reef flat and 2978 on the sand flat. The colony count estimate for the Indirect Impacts Zone was determined using only the data from the transects

placed perpendicular to the wharf face, as these transects were placed in a systematic, unbiased manner within the zone, and the ends of some of which traversed portions of the mixed sand/hardbottom and aggregate reef areas. It is important to note that the colony estimates for the 20 m Indirect Impacts Zone are likely an overestimate, as the colony density values used to arrive at these estimates were from 30 m-long belt transects that extended into the aggregate reef and mixed sand/hardbottom areas that fall outside the 20 m buffer area but within the 30 m buffer area. The coral belt transects survey data could not be extracted for a 20 m length post-hoc, as it was not known at the time of the surveys that a 20 m buffer area is likely to be implemented.

3.3.3. Benthic cover

Benthic cover estimates for areas within the 30 m Indirect Impacts Zone were derived from a total of 685 benthic photo transect images, including 540 images obtained from the total of 18 transects (16 original + 2 additional) placed on the seafloor perpendicular to the wharf and 145 images from four transects placed along the area of mixed sand/hardbottom and aggregate reef oriented parallel to the south wharf face. Mean percent cover of hard corals, soft corals, sponges, other hardbottom, unconsolidated sediment, and debris are presented for each area within the 30 m Indirect Impacts Zone in Table 4 and Figures 13, and for the 20 m Indirect Impacts Zone in Table 5 and Figure 14. Percent cover values for each transect within the 30 m Indirect Impacts Zone are provided in Appendix N (perpendicular seafloor transects) and Appendix O (seafloor hardbottom areas), and can be visualized in Figures 17–18. Percent cover values for the seafloor transects within the 20 m Indirect Impacts Zone are provided in Appendix P and Figure 18, while percent cover values for the surveyed patch reefs are provided in Figures 19–20.

Mean percent coral cover for the reef flat transects and sand flat transects in the 30 m Indirect Impacts Zone was 2.8 ± 2.6% and 1.2 ± 1.8%, respectively, while it was 3.4 ± 4.2% and 0% for the 20 m Indirect Impacts Zone. Coral cover was 2.6 ± 1.3% and 14.8 ± 2.5% for the mixed sand/hardbottom and aggregate reef areas, respectively. A mixed algal assemblage comprised of erect and adherent macrophytes described in Section 3.3.1 was the most dominant cover type on the reef flat (“Other hardbottom”, 85% in 30 m zone and 91% in 20 m zone), while uncolonized sand was the dominant cover type on the sand flat transects (71% in 30 m zone and 73% in 20 m zone). The cover of debris, which was colonized primarily by sediment-laden turf algae and encrusting sponges, was a notable 13% on the sand flat transects within the 30 m Indirect Impacts Zone and X% within the 20 m Indirect Impacts Zone. Soft coral cover on the reef flat and sand flat transects in both the 30 m and 20 m zones was below the level of detection, and sponge cover was very low (<0.3%) on the sand flat transects and absent on the reef flat transects. A mixed algal assemblage comprised

primarily of *Halimeda* spp. and turf algae ("Other hardbottom," 45%) contributed the greatest percentage of cover for the aggregate reef area, followed by uncolonized sand (39%) and hard coral (15%), while uncolonized sand (62%) was the dominant cover type for the mixed sand/hardbottom area, followed by a mixed algal assemblage of *Halimeda* spp. and turf algae ("Other hardbottom," 32%). Sponge cover was low (<1%) for both the aggregate reef and mixed sand/hardbottom areas; soft coral cover was below the level of detection for both areas.

3.3.4. Macroinvertebrate diversity and density

A total of 55 mobile macroinvertebrates representing 10 species were observed in belt transects surveys within the 30 m Indirect Impact Zone, for a total density of 0.02 ± 0.07 ind/m^2, including 50 individuals (0.05 ± 0.11 ind/m^2) representing nine species on the seafloor transects perpendicular to the wharf face, four individuals (0.02 ± 0.01 ind/m^2) representing two species along the transects on the mixed sand/hardbottom and aggregate reef areas, and one *Parasalenia gratiosa* (0.01 ± 0.03) on the surveyed patch reefs (Table 6, Figure 21). The most commonly observed macroinvertebrate taxa in the 30 m Indirect Impacts Zone were *Actinopyga echinites*, *Echinometra mathaei,* and *Culcita novaeguineae*. *Actinopyga echinites*, *E. mathaei,* and *Bohadschia argus* were the most common macroinvertebrate taxa on the perpendicular seafloor transects, while three *C. novaeguineae* and one *Thelenota anax* were the only macroinvertebrates observed on the transects placed on the mixed sand/hardbottom and aggregate reef areas. The macroinvertebrate counts for the 20 m Indirect Impacts Zone could not be extracted post-hoc, but the density calculations should be relatively similar for both the 30 m and 20 m zones. Density values for all macroinvertebrate taxa observed within each of the belt transects surveyed on the reef flat and sand flat within the 30 m Indirect Impacts Zone are provided in Appendix S, while values for transects placed along the hardbottom areas within the Indirect Impacts Zone are provided in Appendix T.

3.3.5. *ESA-listed or candidate species*

No ESA-listed or candidate species were observed in the vicinity of the project site.

4. CONCLUSIONS AND RECOMMENDATIONS

This marine assessment aimed to document the corals and other benthic organisms, mobile macroinvertebrates, and ESA-listed or candidate species within the vicinity of the proposed Hotel Wharf repair and maintenance project site. The project site was divided into a Direct Impacts Zone, which includes the submerged portions of the wharf face as well as the seafloor at the base of the wharf face, and two Indirect Impacts Zones, which includes the area of reef flat, sand slope, and sand flat extending 20 m and 30 m from the wharf face. Patch reefs extending up to 50 m from the wharf face were also surveyed. The 30 m Indirect Impacts Zone included an area of mixed sand and hardbottom as well as an area of aggregate reef that occur parallel to the southern wharf face and which straddle the seaward boundary of the zone. These hardbottom areas occur entirely outside the 20 m Indirect Impacts Area. It is expected that all benthic organisms and site-attached mobile species occurring within the Direct Impacts Zone will be destroyed during construction of the new wharf face and face and sides, while a portion of those present within the Indirect Impacts Zones may experience partial or full mortality as a result of impaired water quality or from physical damage associated with improper anchor placement, debris removal, or other activities.

It is estimated that a total of 6528 coral colonies occur within the Direct Impacts Zone, while 7794 colonies and 4639 colonies are estimated to occur in the 30 m and 20 m Indirect Impacts Zones, respectively. As mentioned above, it is important to note that the colony count estimates for the 20 m Indirect Impacts Zone are likely overestimates, as the colony density values used to arrive at these estimates were from 30 m-long belt transects that extended into the aggregate reef and mixed sand/hardbottom areas that fall outside the 20 m buffer area. In addition to providing estimates of the number of colonies that would be impacted by the construction of the new wharf face, the colony count estimates for individual taxa can also be used to estimate the number of colonies that could be removed from the project site and transplanted to suitable habitat. The number of colonies that are candidates for transplants is likely much lower than the total number colonies estimated to occur in the project area, as the abundant taxa, *Leptastrea* spp. and dendrophylliid sp., which in combination represent 4374 of the 6528 colonies estimated to occur within the Direct Impacts Zone, are not likely to be transplanted from the site. The colony size data collected during this survey effort could also be used to further refine the estimates of the number of colonies that are suitable for transplantation.

While impaired water quality and physical damage is likely to affect corals and other benthic organisms occurring within the silt curtain, the lack of dredging activity associated with this project will likely mean

that impacts to water quality will be relatively limited, and excessive physical damage can be minimized by placing anchors or other objects on sandy areas and avoiding contact with hardbottom by the anchor, chain, or line. It is strongly recommended that no anchors or other objects be placed near the aggregate reef area, as this area has relatively high coral cover and hosts large *Porites rus* (a.k.a. "plate-and-pillar corals") colonies that are easily damaged by physical contact. It is also recommended that individuals traversing the shallow reef flat adjacent to the wharf take care to avoid contact with corals occurring on the reef flat, which include fragile species such *as Pavona decussata* and *Pocillopora damicornis*.

REFERENCES

AMEC Environmental & Infrastructure, Inc. 2014. Marine survey and Essential Fish Habitat Assessment report, Hotel Wharf and Access Road Maintenance and Repair Project, Cabras Island, Guam.

Paulay, G., L. Kirkendale, G. Lambert, and J. Starmer. 1997. The marine invertebrate biodiversity of Apra Harbor: significant areas and introduced species, with focus on sponges, echinoderms, and ascidians. Report prepared for Naval Activities Guam.

TABLES

Table 1. Number of surveyed transects, total survey area (m^2), total number of colonies, mean colony density (col/m^2 ± SD), and mean colony diameter (cm ± SD) for survey areas within the Direct and 30 m Indirect Impacts Zones of the Hotel Wharf repair and maintenance project site.

	No. of trans.	Total survey area	Total no. of colonies	Mean colony density	Mean colony diameter
Direct Impact Zone	**18**	**762**	**2739**	**3.4 ± 2.6**	**4.8 ± 6.2**
Wharf sides	**13**	**561**	**2529**	**4.4 ± 2.5**	**4.3 ± 5.5**
East side	2	30	195	5.8 ± 1.7	4.2 ± 4.8
South side	9	495	2125	4.1 ± 2.5	4.3 ± 5.6
West side	2	36	209	4.0 ± 4.4	4.7 ± 5.2
Wharf base	**5**	**201**	**210**	**1.1 ± 0.3**	**10.8 ± 9.3**
East side	1	25	28	1.1 ± -	11.1 ± 6.7
South side	3	150	152	1.0 ± 0.5	10.0 ± 9.7
West side	1	26	30	1.2 ± -	14.6 ± 8.6
30 m Indirect Impact Zone	**20**	**725**	**1283**	**2.1 ± 1.6**	**17.1 ± 20.7**
Seafloor transects	**16**	**480**	**531**	**1.1 ± 0.8**	**14.4 ± 16.8**
Reef flat	3	120	224	2.3 ± 0.8	12.5 ± 14.8
Sand	13	360	307	0.8 ± 0.5	15.7 ± 18.0
Seafloor hardbottom	**4**	**145**	**510**	**3.5 ± 2.2**	**19.4 ± 25.2**
Aggregate reef	2	85	372	4.7 ± 2.8	21.3 ± 27.9
Mixed sand/HB	2	60	138	2.3 ± 1.1	14.2 ± 14.9
Patch reefs (n = 26)	**-**	**100**	**242**	**2.5 ± 1.6**	**18.0 ± 16.6**

Table 2. Percent cover (± SD) of major benthic classes for the wharf sides (Direct Impacts Zone).

	South	East	West	Entire wharf
Cover type				
Hard coral	**0.6 ± 0.4**	**0.5 ± 0.7**	**2.3 ± 1.0**	**0.9 ± 0.8**
Soft coral	0.1 ± 0.1	0.4 ± 0.6	0.0 ± 0.0	0.1 ± 0.3
Sponge	2.6 ± 2.3	2.2 ± 3.2	0.0 ± 0.0	2.1 ± 2.3
Dead coral	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Other hardbottom	96.5 ± 2.1	96.8 ± 3.1	97.7 ± 1.0	96.7 ± 2.0
Sand	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Debris	0.2 ± 0.7	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.6

Table 3. Percent cover (± SD) of major benthic classes for the area of seafloor at the base of the wharf (Direct Impacts Zone).

	South	**East**	**West**	**Entire base**
Cover type				
Hard coral	**0.5 ± 0.2**	**0.3 ± -**	**1.0 ± -**	**0.6 ± 0.3**
Soft coral	0.0 ± 0.0	0.0 ± -	0.0 ± -	0.0 ± 0.0
Sponge	0.3 ± 0.3	0.0 ± -	0.0 ± -	0.2 ± 0.3
Dead coral	0.0 ± 0.0	0.0 ± -	0.0 ± -	0.0 ± 0.0
Other hardbottom	1.7 ± 1.6	72.4 ± -	65.5 ± -	28.6 ± 37.0
Sand	39.4 ± 27.2	25.6 ± -	30.5 ± -	34.8 ± 20.3
Debris	58.2 ± 28.8	1.7 ± -	3.0 ± -	35.8 ± 36.7

Table 4. Percent cover (± SD) of major benthic classes for seafloor transects surveyed within the 30 m Indirect Impacts Zone.

	Seafloor transects						**Hardbottom area**					
	Reef flat			**Sand flat**			**Agg. reef**			**Mixed sand/HB**		
Cover type												
Hard coral	**2.8**	**±**	**2.6**	**1.2**	**±**	**1.8**	**14.8**	**±**	**2.5**	**2.6**	**±**	**1.3**
Sponge	0.1	±	0.1	0.3	±	0.3	0.8	±	0.8	0.9	±	0.7
Other hardbottom	85.4	±	12.2	15.4	±	13.2	44.8	±	11.8	31.5	±	5.6
Sand	11.3	±	13.6	70.6	±	13.9	38.8	±	9.5	62.0	±	3.7
Debris	0.4	±	0.6	12.5	±	10.4	0.9	±	0.7	3.0	±	4.0

Table 5. Percent cover (± SD) of major benthic classes for seafloor transects surveyed within the 20 m Indirect Impacts Zone.

	Seafloor transects	
	Reef flat	**Sand flat**
Cover type		
Hard coral	**3.4 ± 4.2**	**0.0 ± 0.0**
Soft coral	0.0 ± 0.0	0.0 ± 0.0
Sponge	0.1 ± 0.2	0.2 ± 0.3
Other hardbottom	90.5 ± 6.0	9.1 ± 9.7
Sand	5.3 ± 6.9	72.7 ± 12.3
Debris	0.6 ± 0.9	18.1 ± 12.3

Table 6. Mean density (ind/m^2 ± SD) of major macroinvertebrate groups observed during surveys of the Direct Impacts Zone and 30 m Indirect Impacts Zone.

	Seastars	Urchins	Sea cucumbers	Edible mollusks	All macroinverts
Direct impacts zone	**0.01 ± 0.01**	**0.04 ± 0.07**	**0.04 ± 0.08**	**0.00 ± 0.01**	**0.09 ± 0.1**
Wharf sides	**0.01 ± 0.01**	**0.03 ± 0.06**	**0.03 ± 0.06**	**0.00 ± 0.01**	**0.07 ± 0.09**
East side	0.00 ± 0.00	0.00 ± 0.00	0.11 ± 0.16	0.01 ± 0.02	0.13 ± 0.18
South side	0.01 ± 0.01	0.04 ± 0.07	0.02 ± 0.03	0.00 ± 0.00	0.07 ± 0.08
West side	0.03 ± 0.04	0.01 ± 0.01	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.05
Wharf base	**0.01 ± 0.02**	**0.05 ± 0.09**	**0.06 ± 0.12**	**0.00 ± 0.00**	**0.12 ± 0.13**
East side	0.00 ± 0.00	0.02 ± 0.00	0.28 ± 0.00	0.00 ± 0.00	0.3 ± -
South side	0.02 ± 0.02	0.00 ± 0.00	0.00 ± 0.01	0.00 ± 0.00	0.03 ± 0.02
West side	0.00 ± 0.00	0.22 ± 0.00	0.02 ± 0.00	0.00 ± 0.00	0.24 ± -
30 m Indirect impacts zone	**0.00 ± 0.01**	**0.01 ± 0.03**	**0.01 ± 0.06**	**0.00 ± 0.00**	**0.02 ± 0.07**
Seafloor hardbottom	**0.01 ± 0.01**	**0.00 ± 0.00**	**0.00 ± 0.01**	**0.00 ± 0.00**	**0.02 ± 0.01**
Aggregate reef	0.01 ± 0.01	0.00 ± 0.00	0.01 ± 0.01	0.00 ± 0.00	0.01 ± 0.02
Mixed sand/HB	0.02 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.00
Seafloor perp trans	**0.00 ± 0.01**	**0.01 ± 0.03**	**0.04 ± 0.09**	**0.00 ± 0.00**	**0.05 ± 0.11**
Reef flat	0.01 ± 0.02	0.06 ± 0.05	0.14 ± 0.20	0.00 ± 0.00	0.21 ± 0.18
Sand flat	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.04	0.00 ± 0.00	0.02 ± 0.04
Patch reef (n=26)	**0.00 ± 0.00**	**0.01 ± 0.03**	**0.00 ± 0.00**	**0.00 ± 0.00**	**0.01 ± 0.03**

FIGURES I.

Maps and Graphs

Figure 1. Map of Guam depicting the location of the Jose D. Leon Guerrero Commercial Port and Hotel Wharf, Apra Harbor.

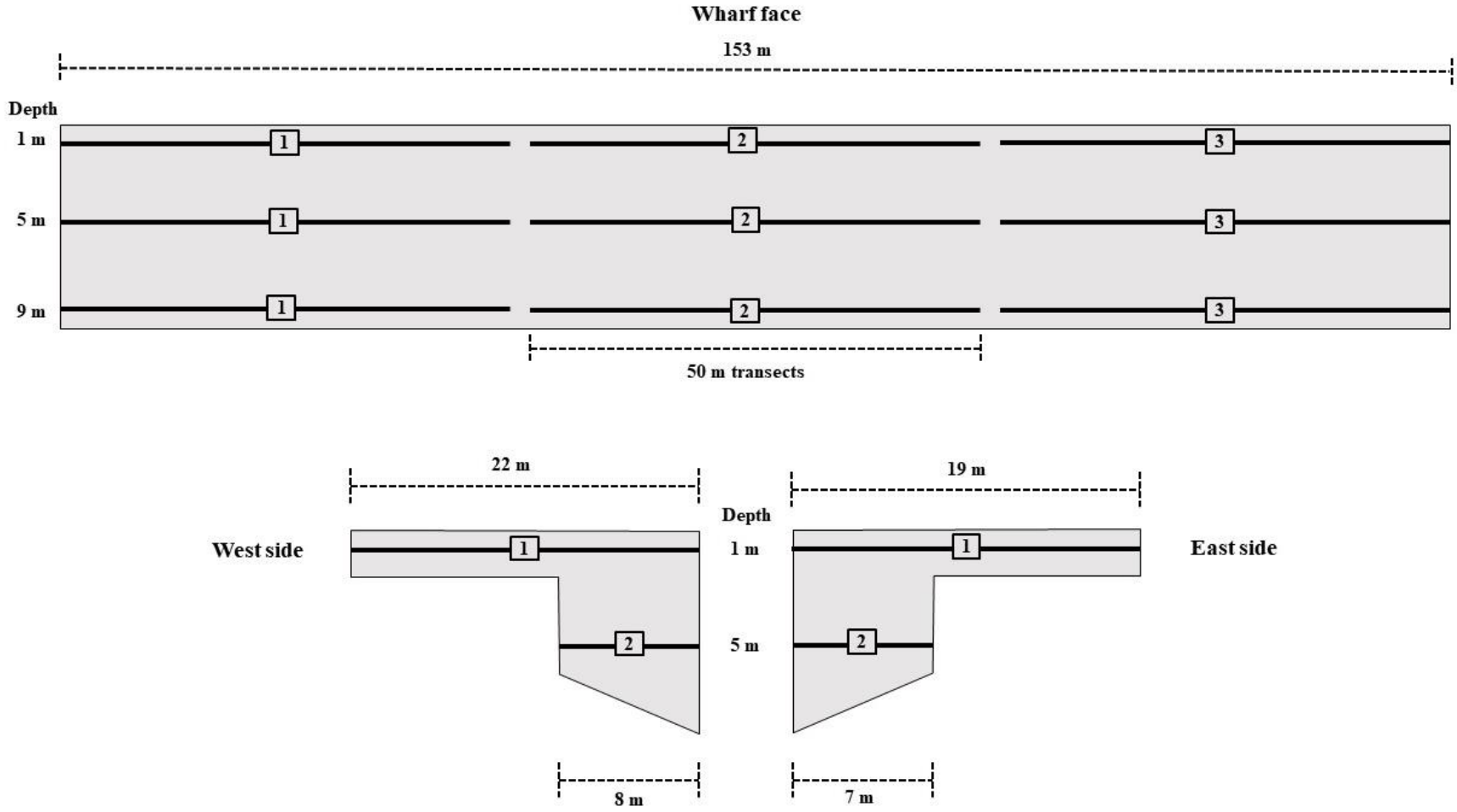

Figure 2. Diagram depicting the locations of survey transects on the wharf sides. Not to scale.

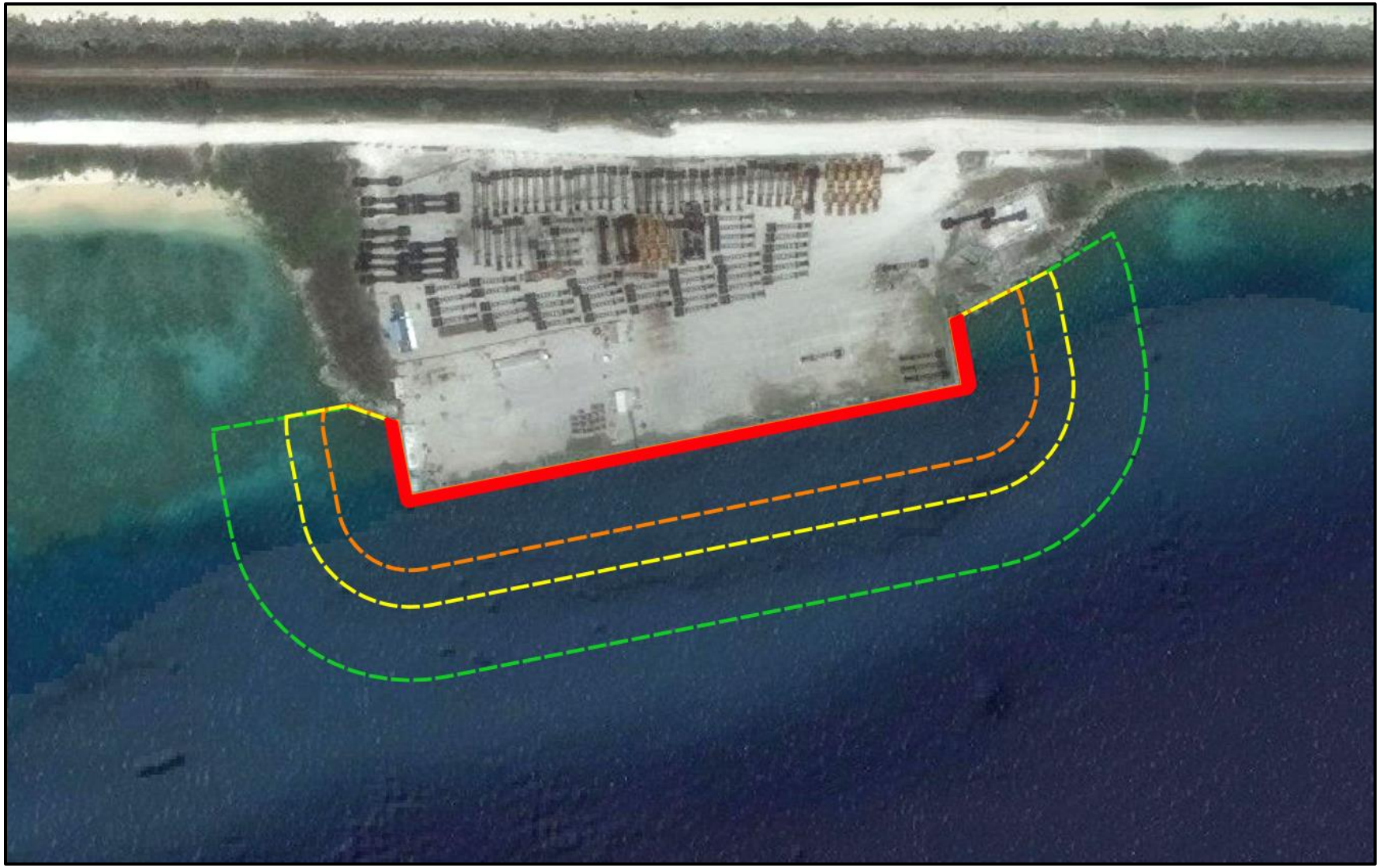

Figure 3. Map depicting the Direct Impacts Zone (red) and the 20 m (orange), 30 m (yellow), and 50 m (green) Indirect Impacts Zones. Note that this map depicts only the general location of the Direct Impacts Zone and not the exact placement of the new wharf face.

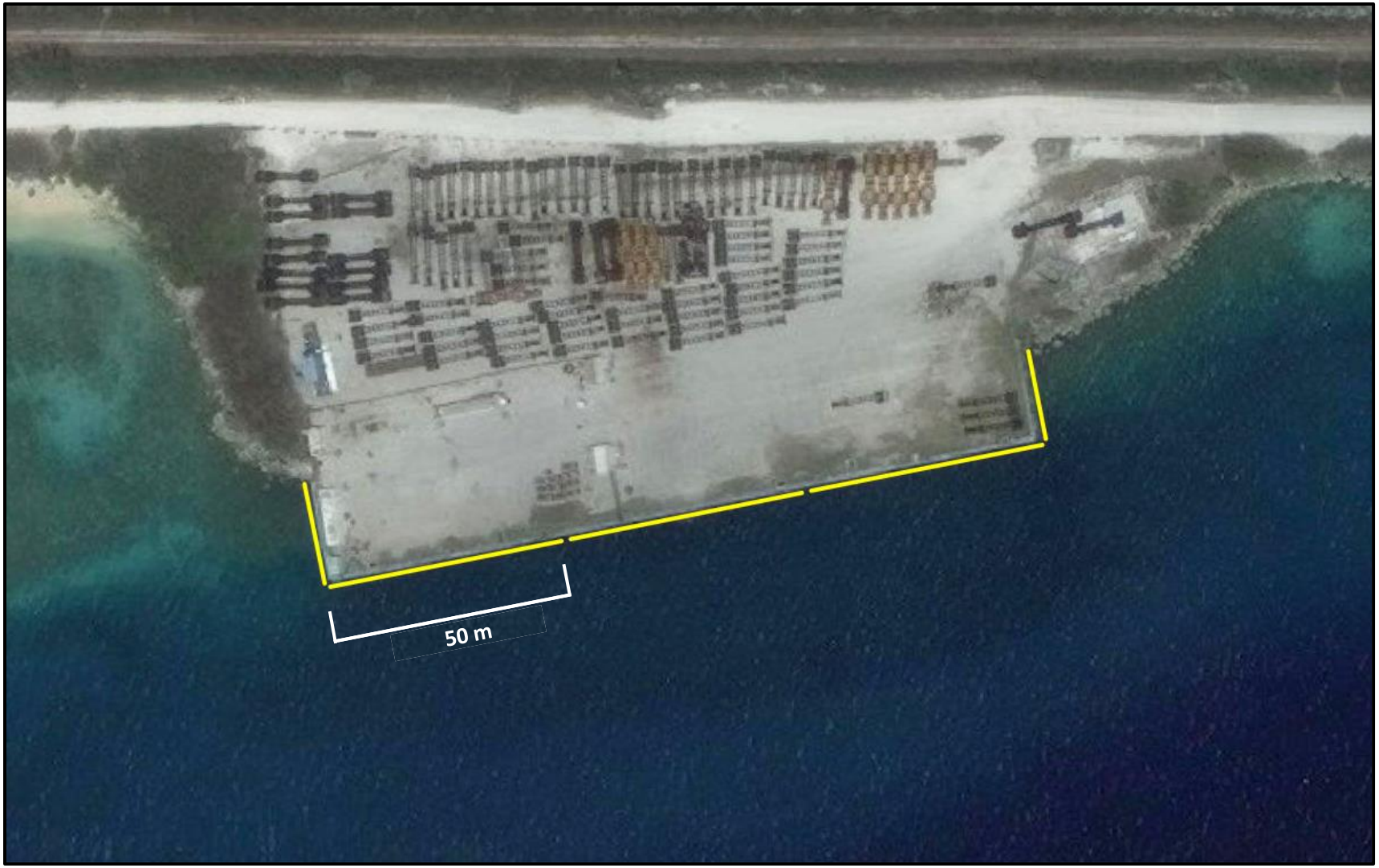

Figure 4. Map depicting the location of the transects placed at the base of the wharf (Direct Impacts Zone).

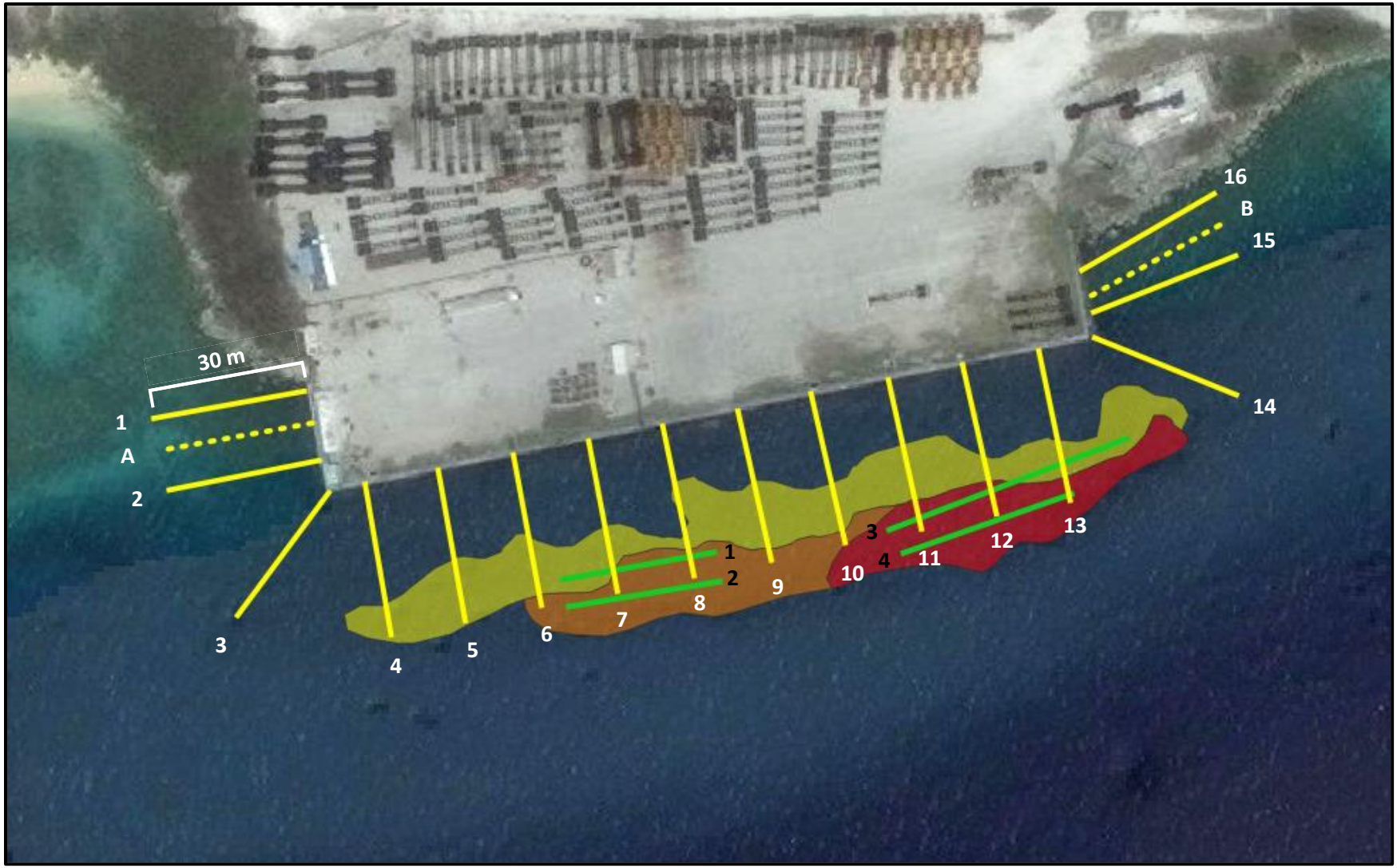

Figure 5. Map depicting the location of the seafloor transects Indirect Impacts Zone, including the 30-meter-long transects placed perpendicular to the wharf (yellow) and transects (mixed lengths) placed across an area of hardbottom oriented parallel to the south wharf face (green). The red, orange, and yellow polygons represent areas with aggregate reef and high coral cover (red), mixed sand and hardbottom with low coral cover (orange), and sand with widely scattered hardbottom and few coral colonies (yellow).

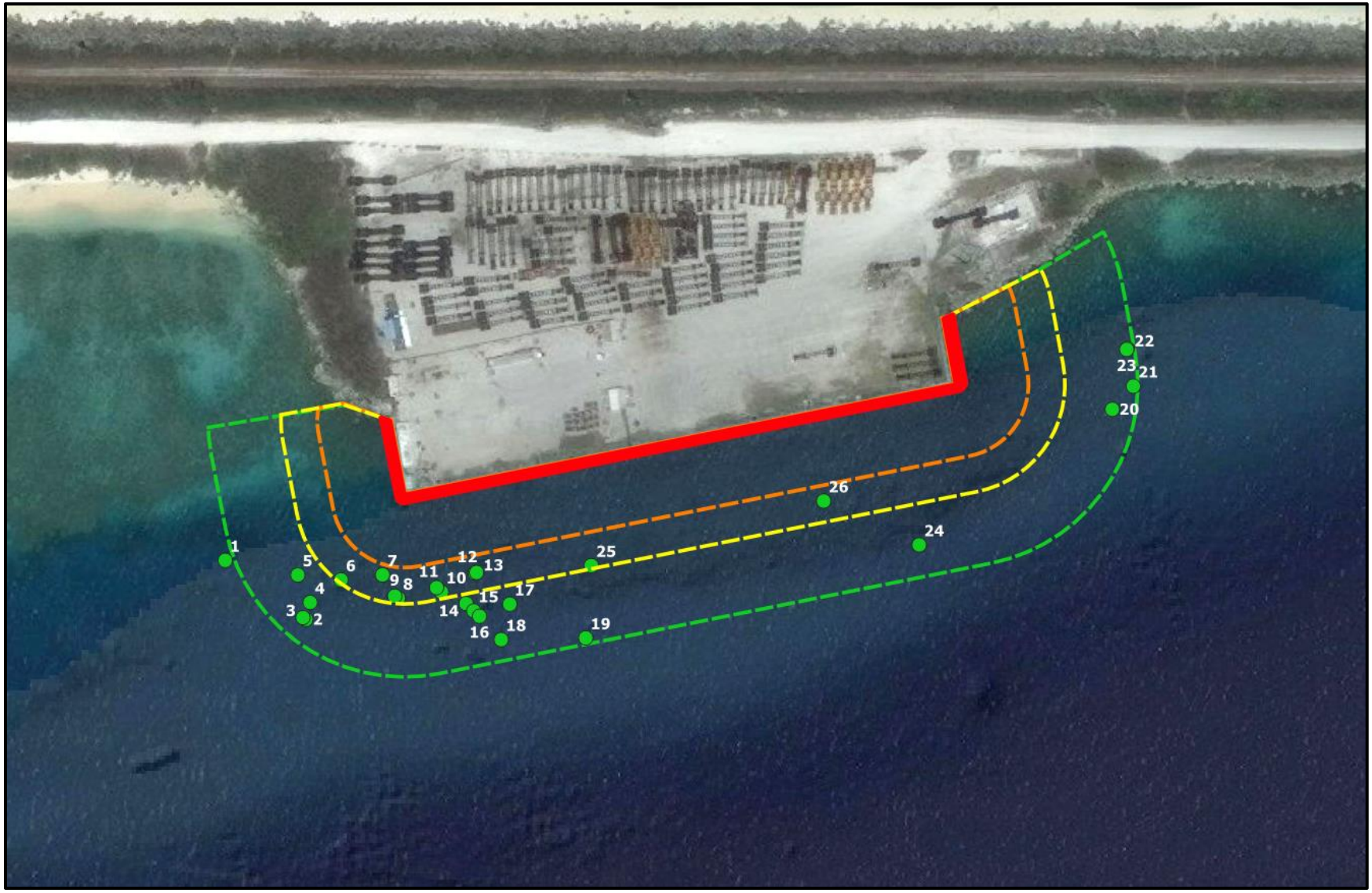

Figure 6. Map depicting the location of the surveyed patch reefs in relation to the Direct Impacts Zone (red) and the 20 m (orange), 30 m (yellow), and 50 m (green) Indirect Impacts Zones. Note that this map depicts only the general location of the Direct Impacts Zone and not the exact placement of the new wharf face.

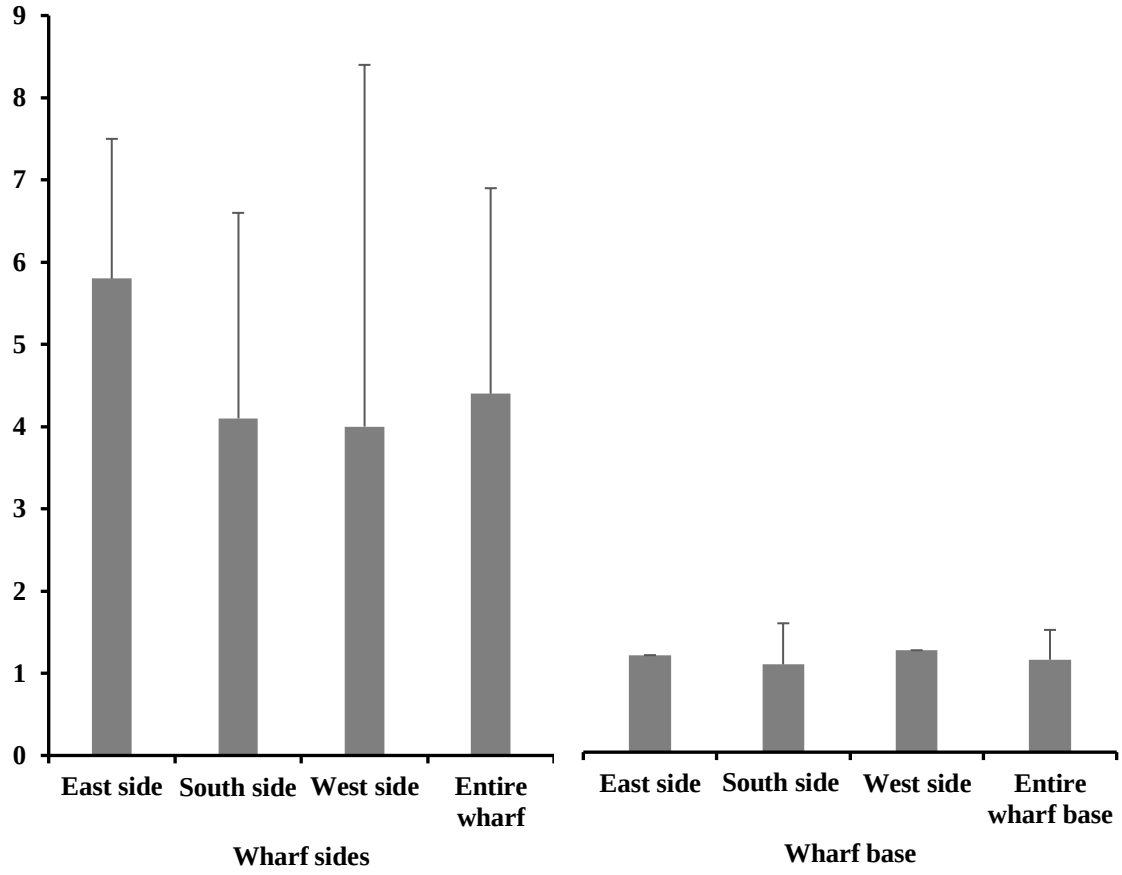

Figure 7. Mean coral colony density (col/m^2 ± SD) for transects surveyed on the wharf and the seafloor at the base of the wharf (Direct Impacts Zone).

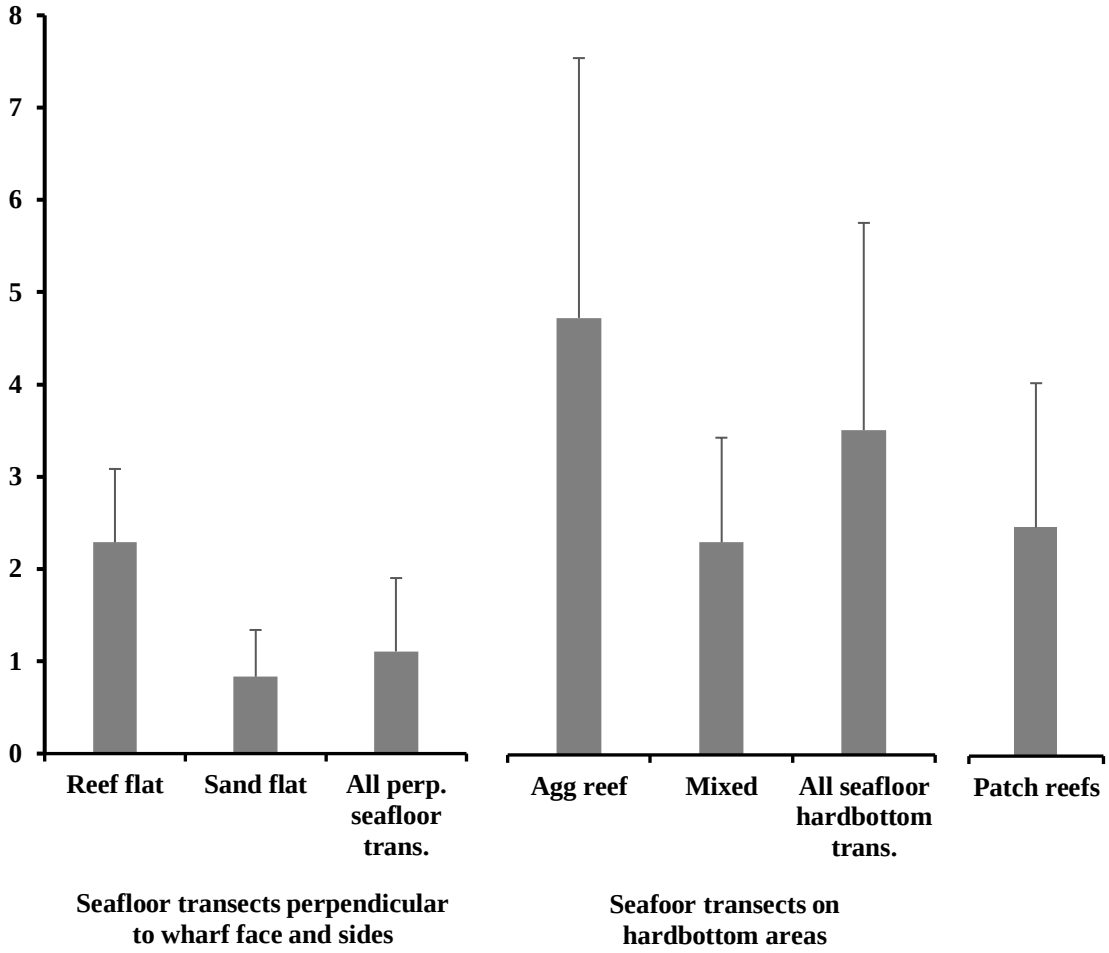

Figure 8. Mean coral colony density (col/m^2 ± SD) on seafloor transects and patch reefs surveyed within the 30 m Indirect Impacts Zone.

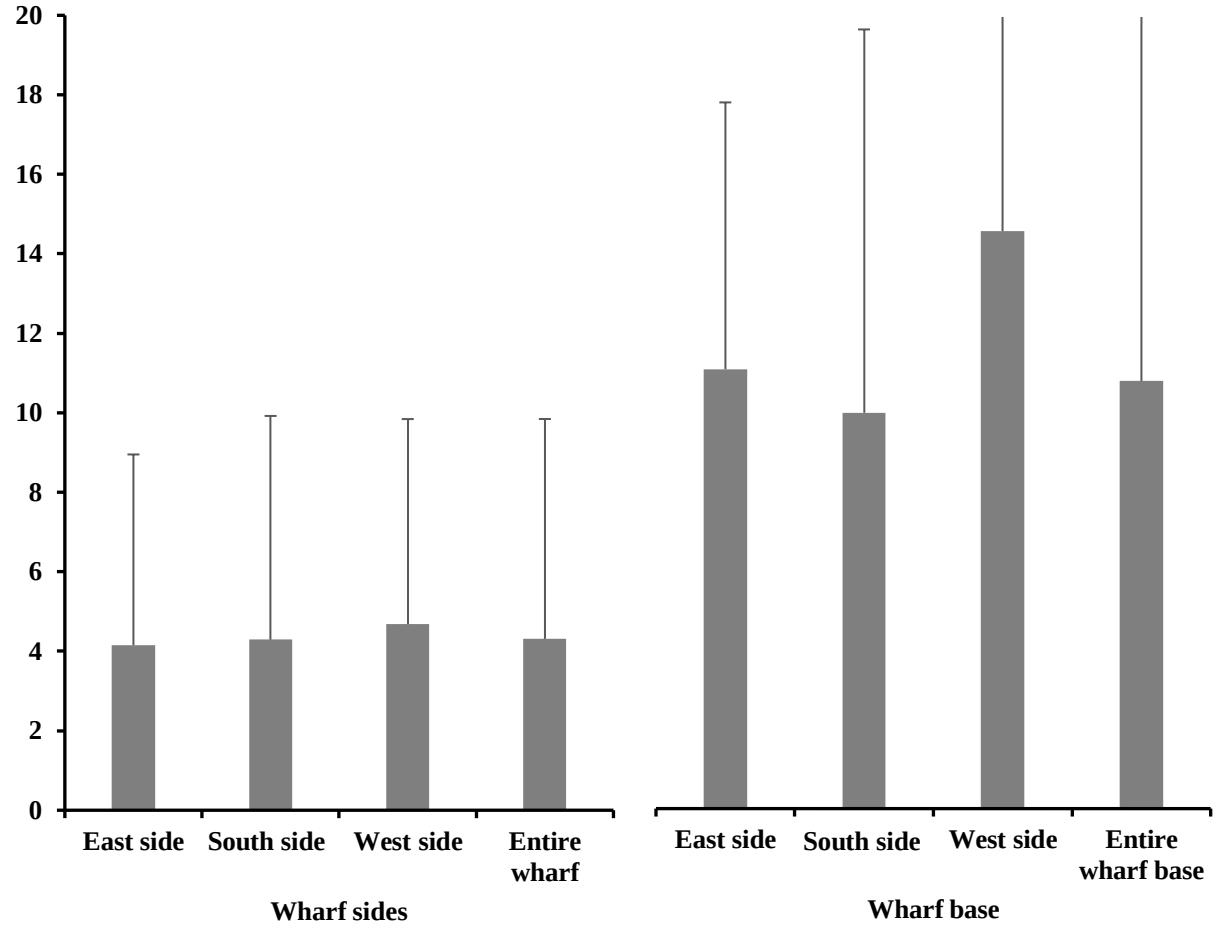

Figure 9. Mean coral colony diameter (cm ± SD) for transects surveyed on the wharf and the seafloor at the base of the wharf (Direct Impacts Zone).

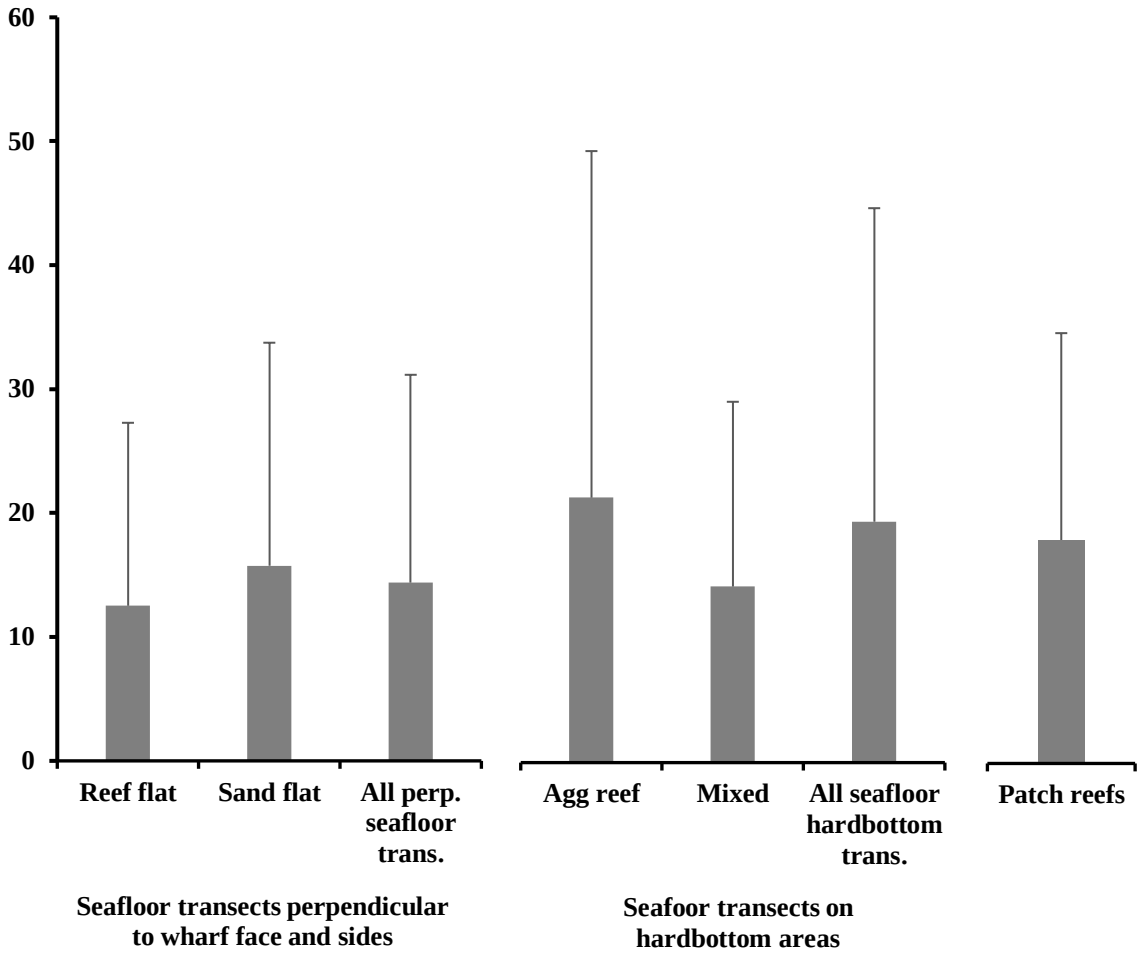

Figure 10. Mean coral colony diameter (cm ± SD) for seafloor transects and patch reefs surveyed within the 30 m Indirect Impacts Zone.

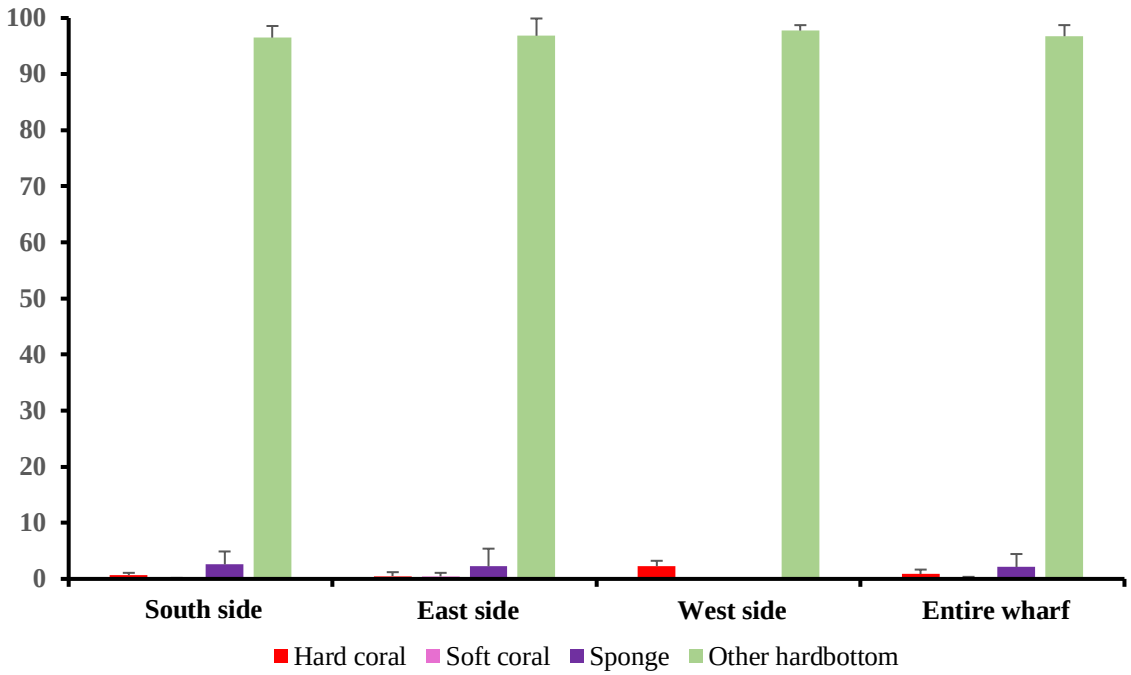

Figure 11. Percent cover (± SD) of major benthic classes for the wharf sides and the entire wharf within the Direct Impacts Zone.

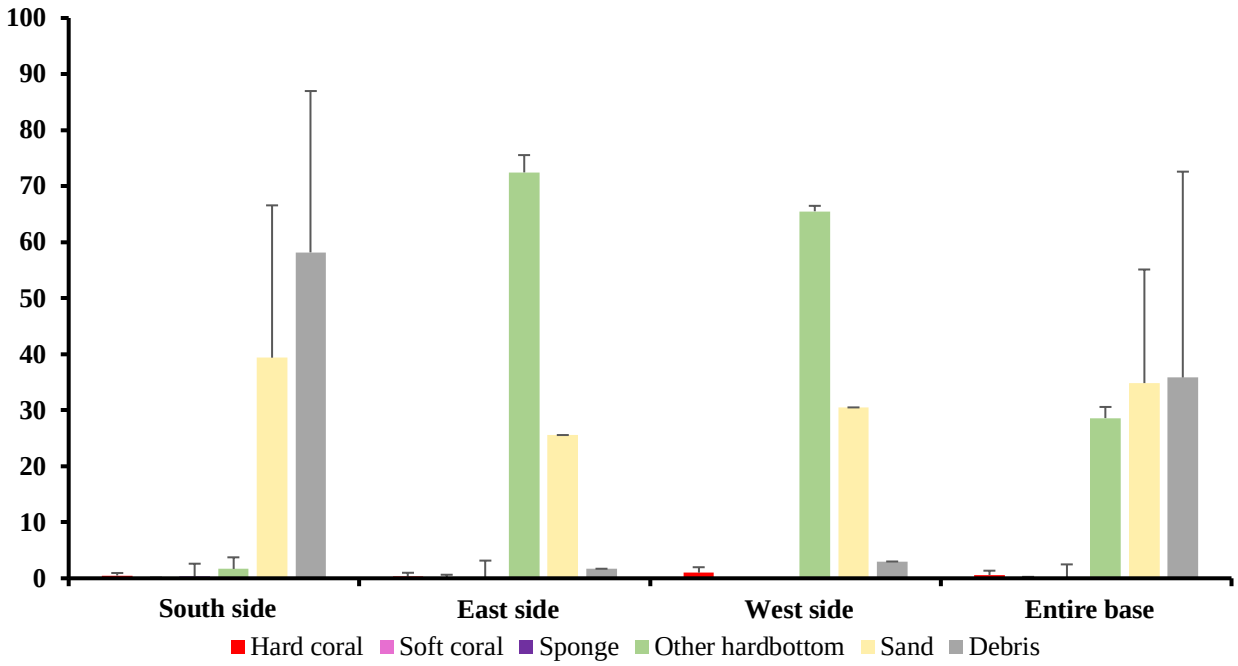

Figure 12. Percent cover (± SD) of major benthic classes for the area of seafloor at the base of the wharf within the Direct Impacts Zone.

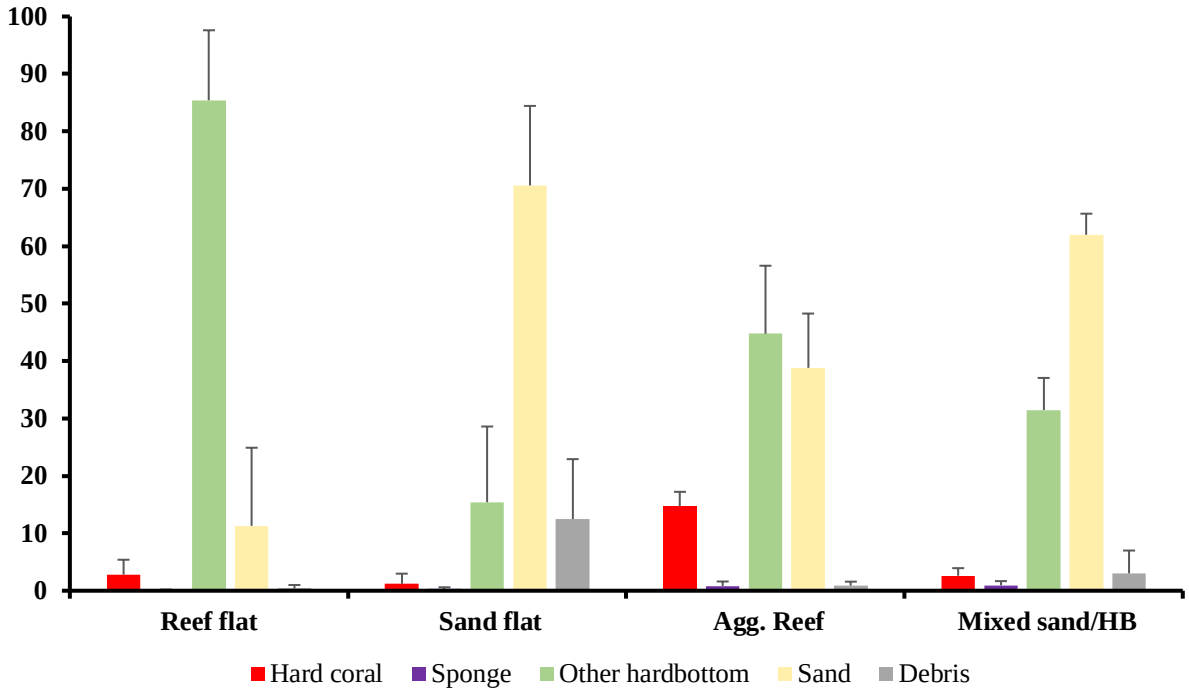

Figure 13. Percent cover (± SD) of major benthic classes for seafloor transects surveyed within the 30 m Indirect Impacts Zone.

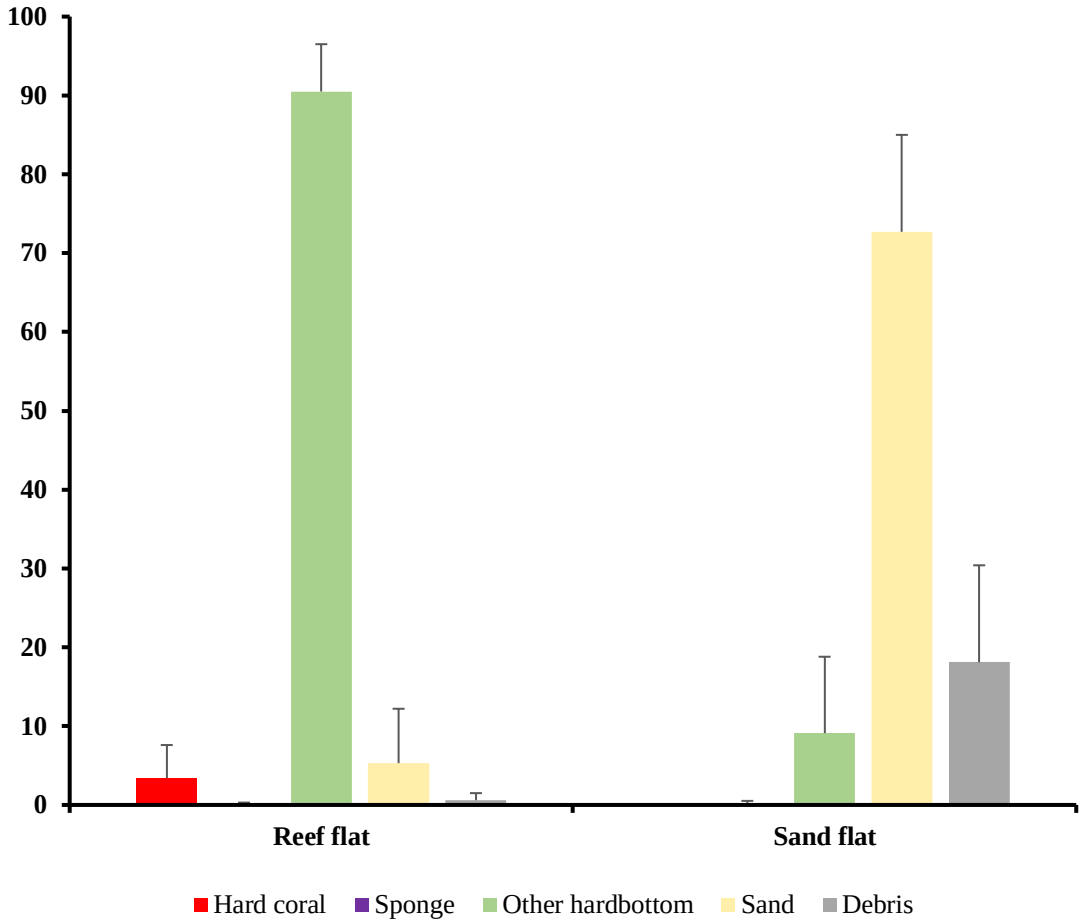

Figure 14. Percent cover (± SD) of major benthic classes for seafloor transects surveyed within the 20 m Indirect Impacts Zone.

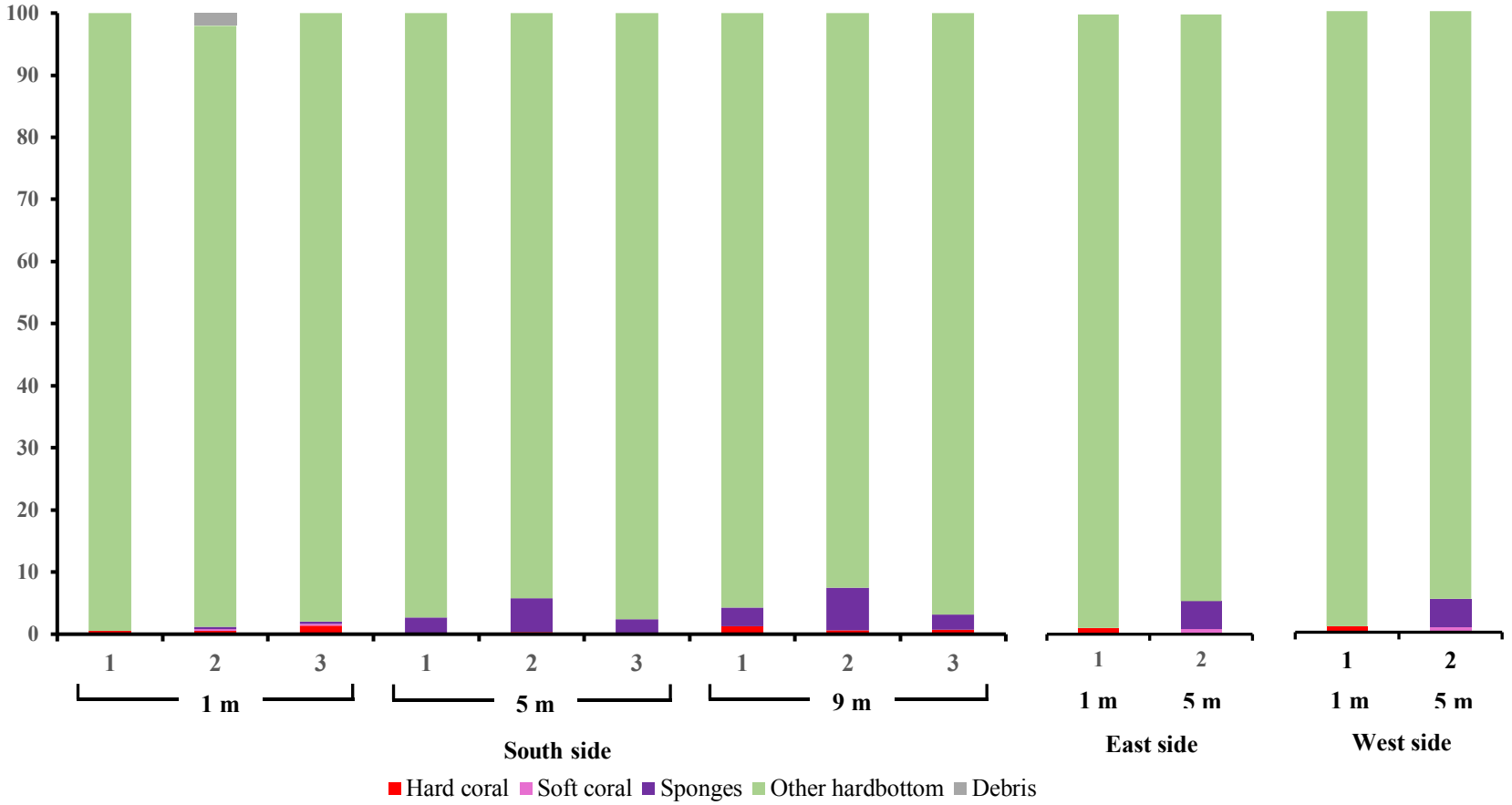

Figure 15. Percent cover of major benthic classes for the wharf transects surveyed within the Direct Impact Zone.

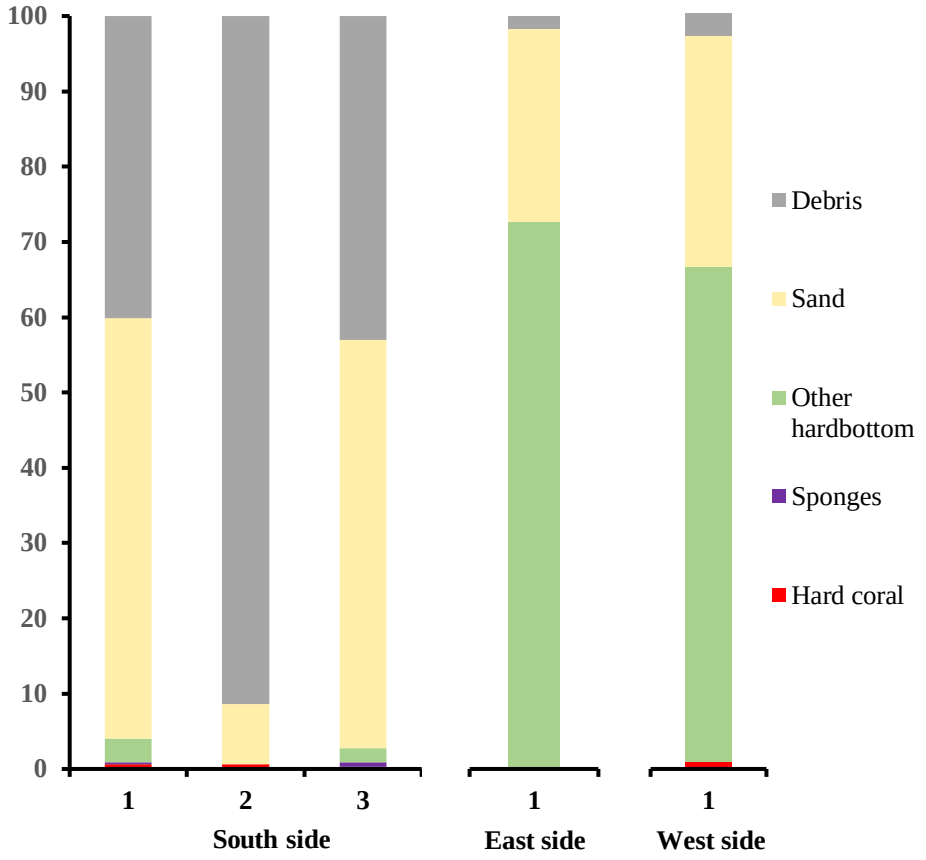

Figure 16. Percent cover of major benthic classes for seafloor transects at the base of the wharf (Direct Impacts Zone).

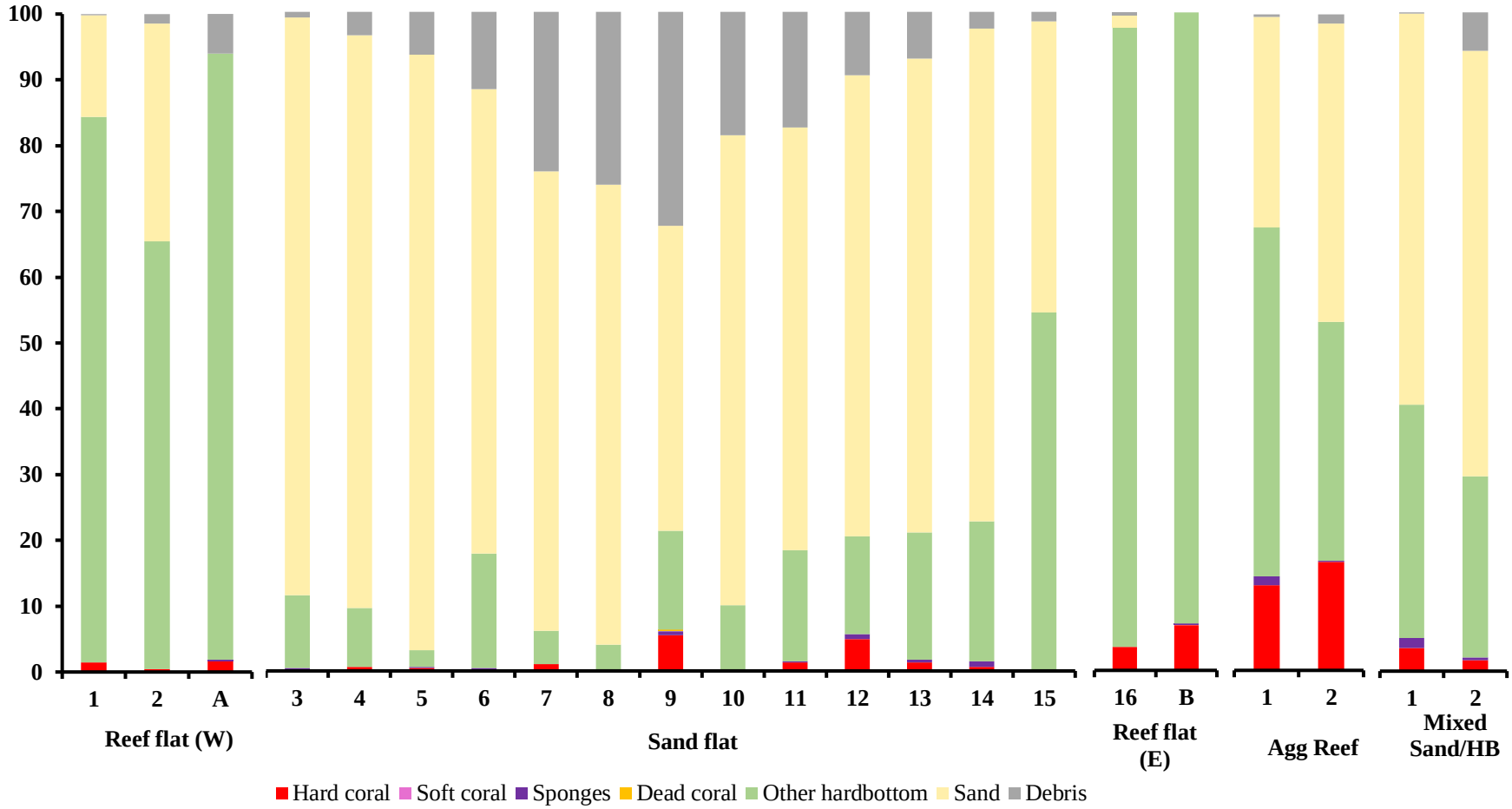

Figure 17. Percent cover of major benthic classes for seafloor transects within the 30 m Indirect Impacts Zone.

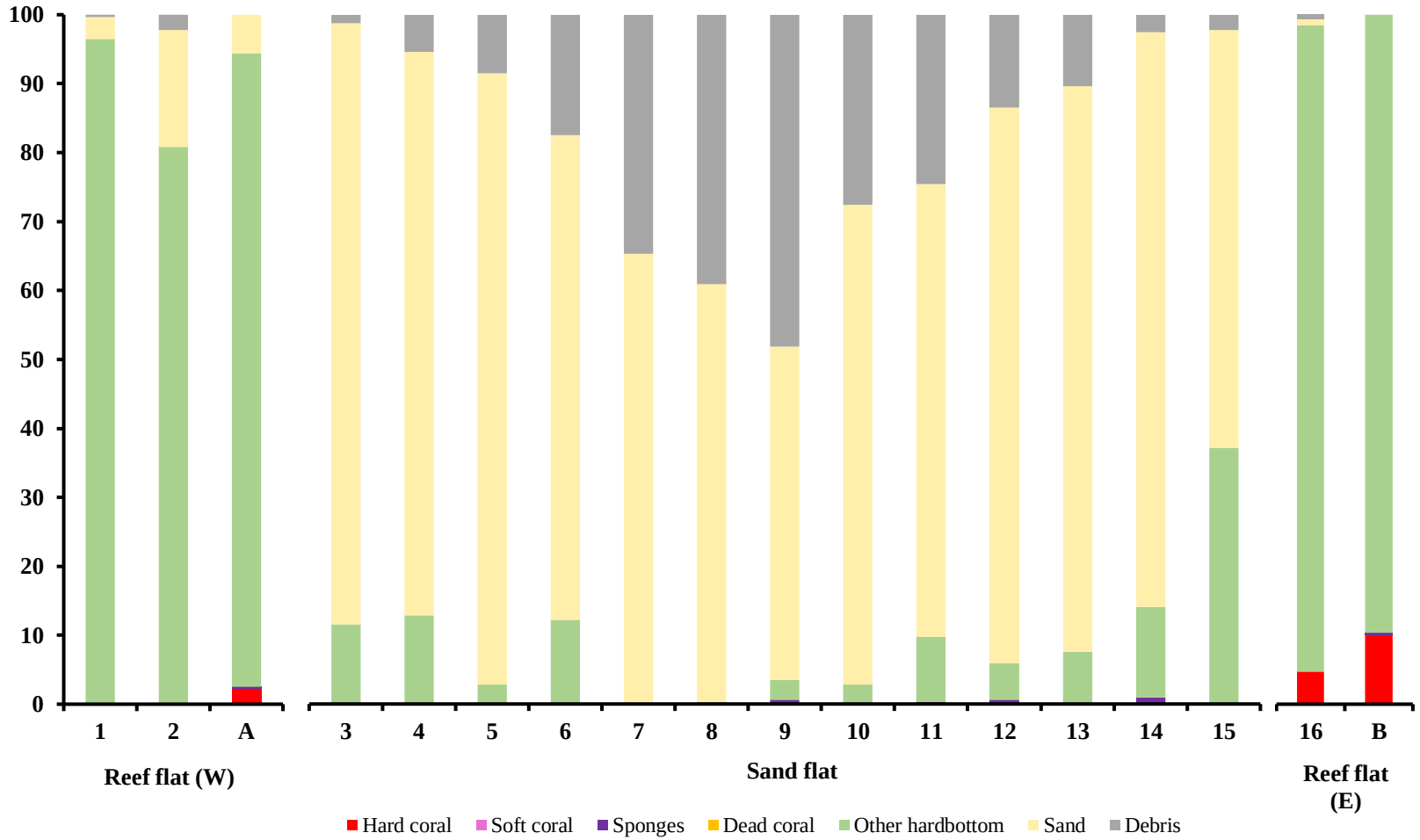

Figure 18. Percent cover of major benthic classes for seafloor transects within the 30 m Indirect Impacts Zone.

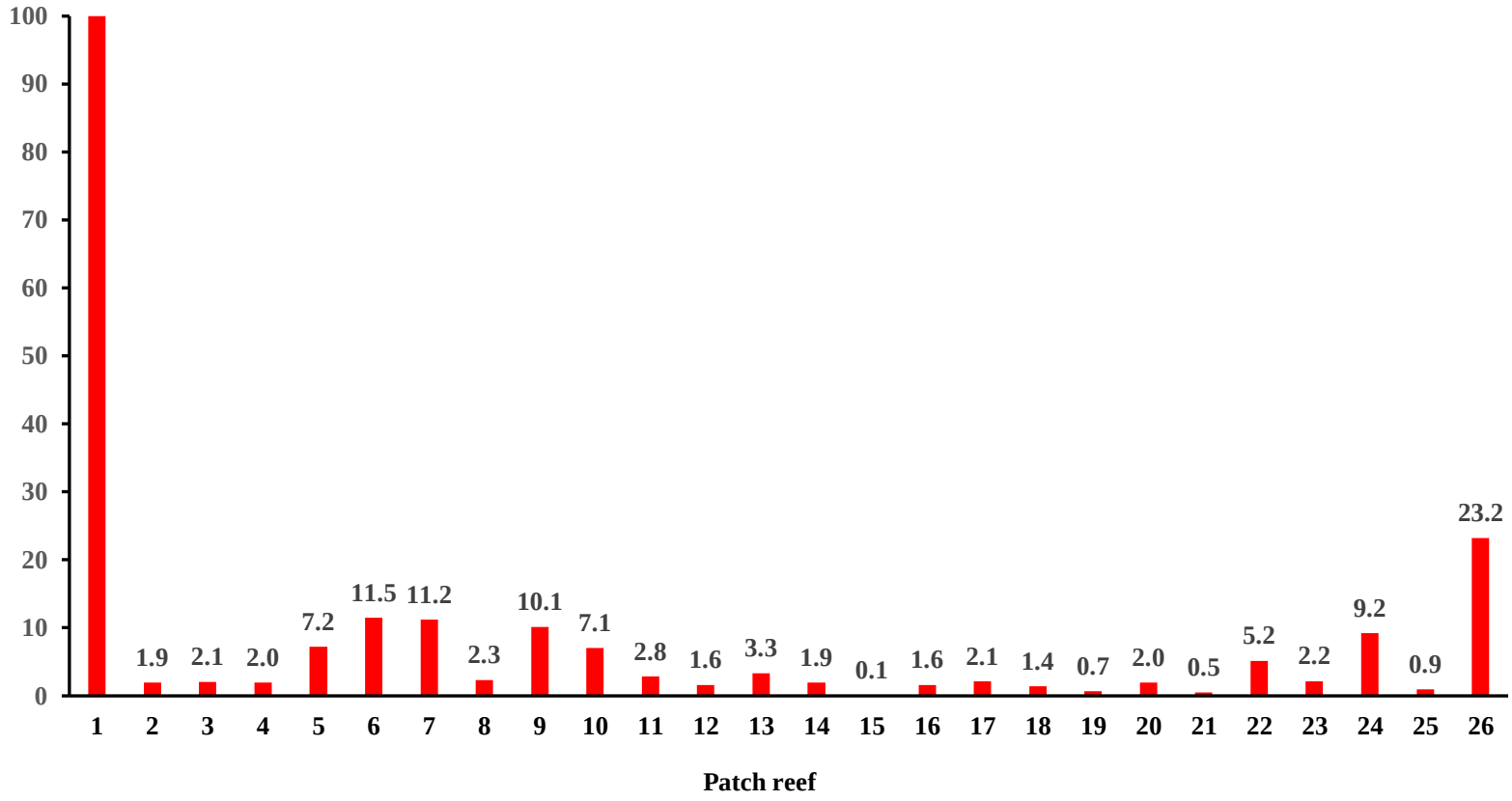

Figure 19. Percent coral cover for patch reefs surveyed within the Indirect Impacts Zone. While some patch reefs (including Patch reef 1, which was a single, large *Porites rus* colony) occurred beyond the 30 m zone (but within 50 m of the wharf), data for all patch reefs were included in the analysis for the Indirect Impacts Zone.

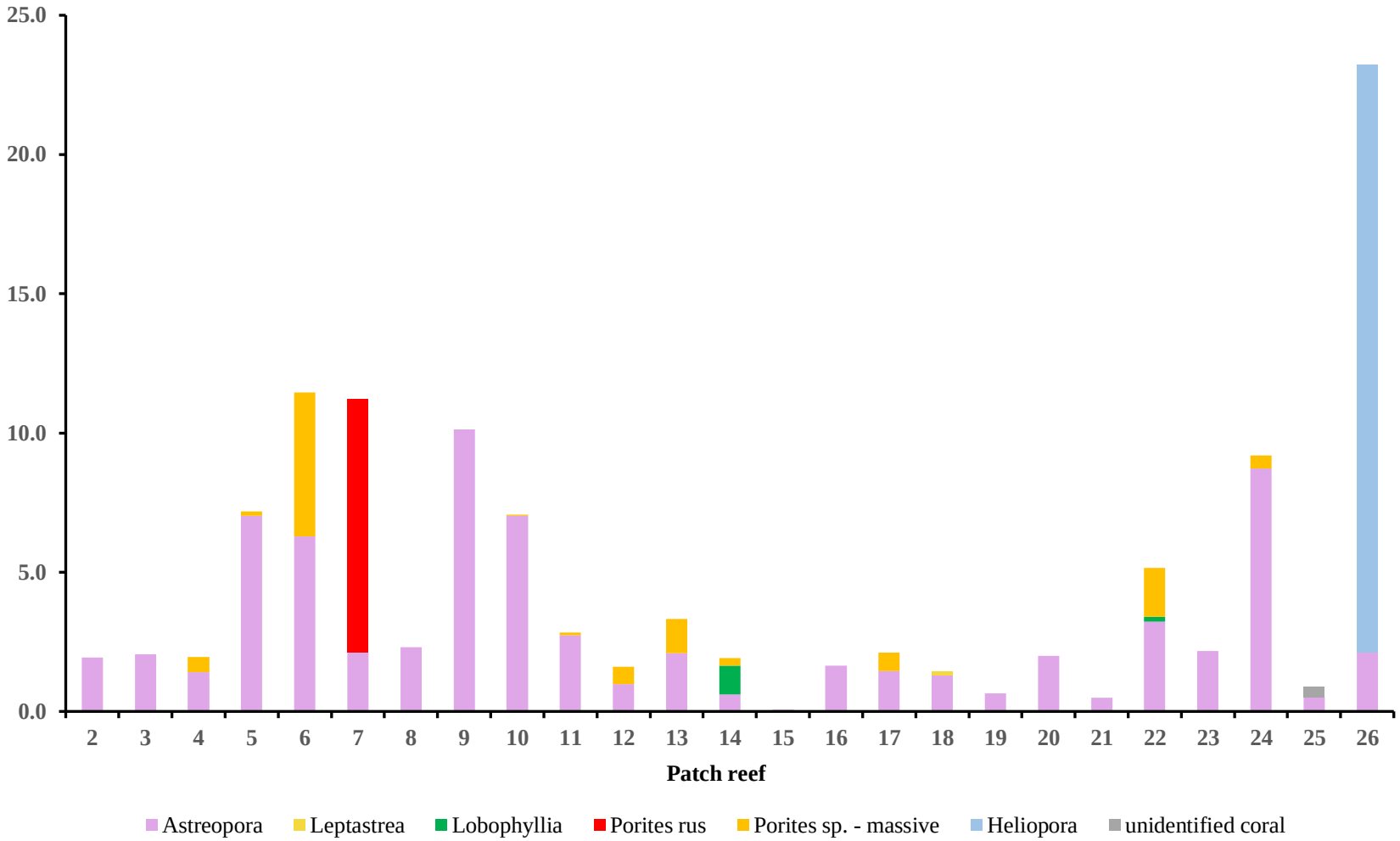

Figure 20. Percent cover of coral taxa for patch reefs surveyed within the Indirect Impacts Zone. Patch reef 1, which was comprised of a single, large *Porites rus* colony (100% coral cover), was excluded from this figure.

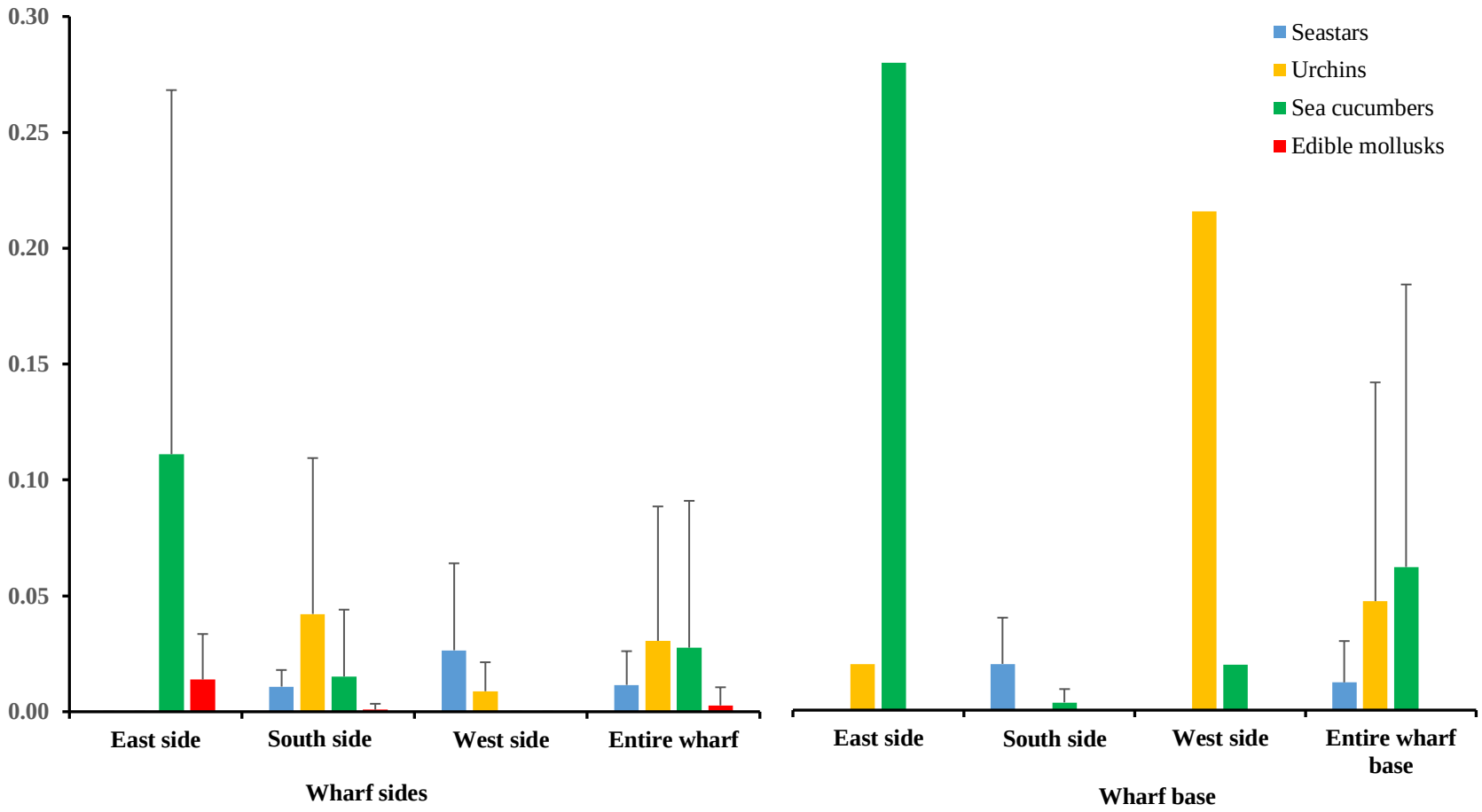

Figure 21. Density (ind/m^2) of macroinvertebrate taxa observed within belt transects placed on the wharf sides and at the base of the wharf (Direct Impacts Zone).

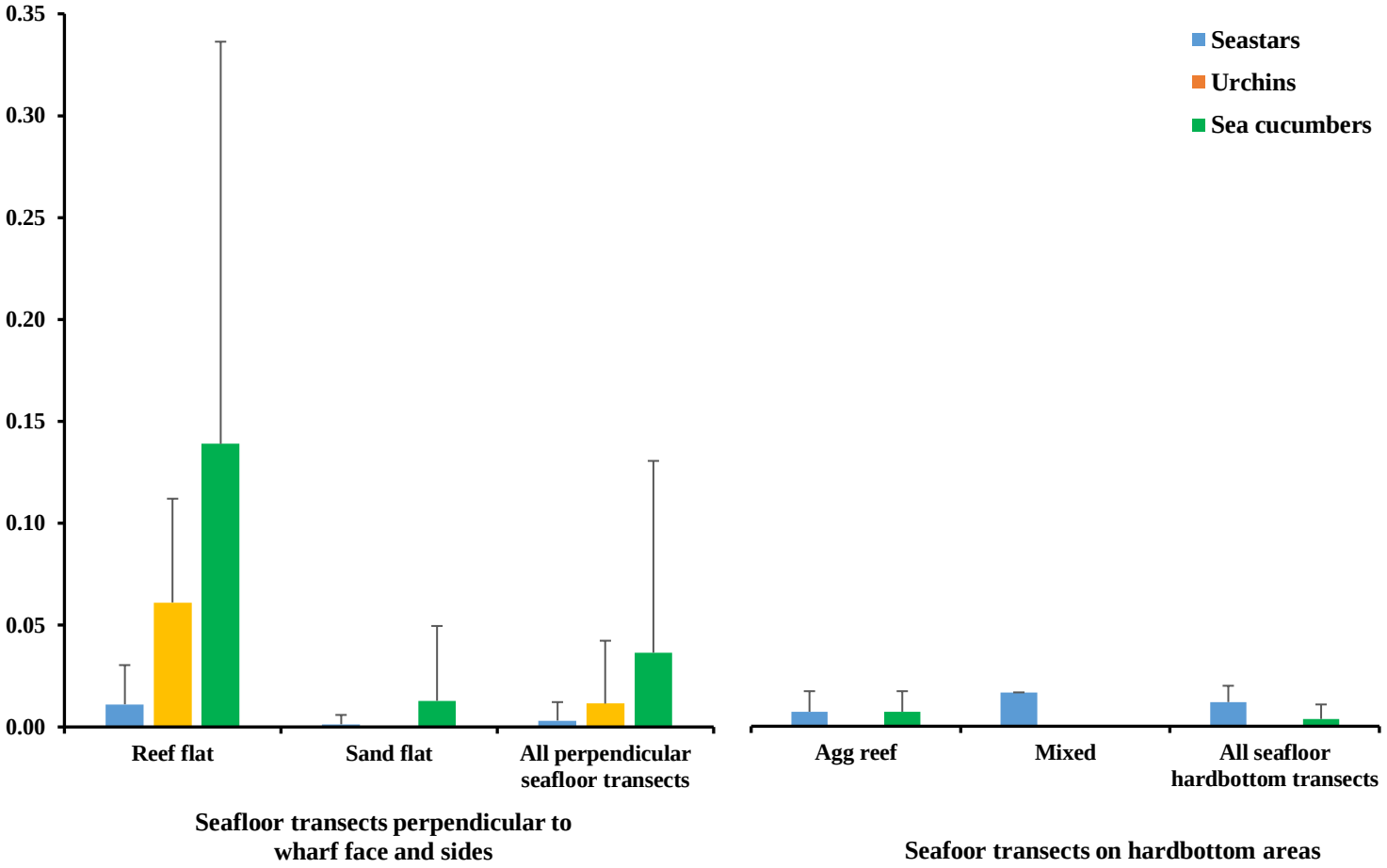

Figure 22. Density (ind/m^2) of macroinvertebrate taxa observed in belt transects placed on the seafloor perpendicular to the wharf, and transects placed on an area of hardbottom that occurs parallel to the wharf face (30 m Indirect Impacts Zone).

FIGURES II.

Site photos

Figure 23. One of the shallow (~1.5 m) transects placed on a concrete beam that runs the length of the wharf sides.

Figure 24. A shallow (~1.5 m) benthic community on the west side of the wharf dominated by erect macrophytic algae.

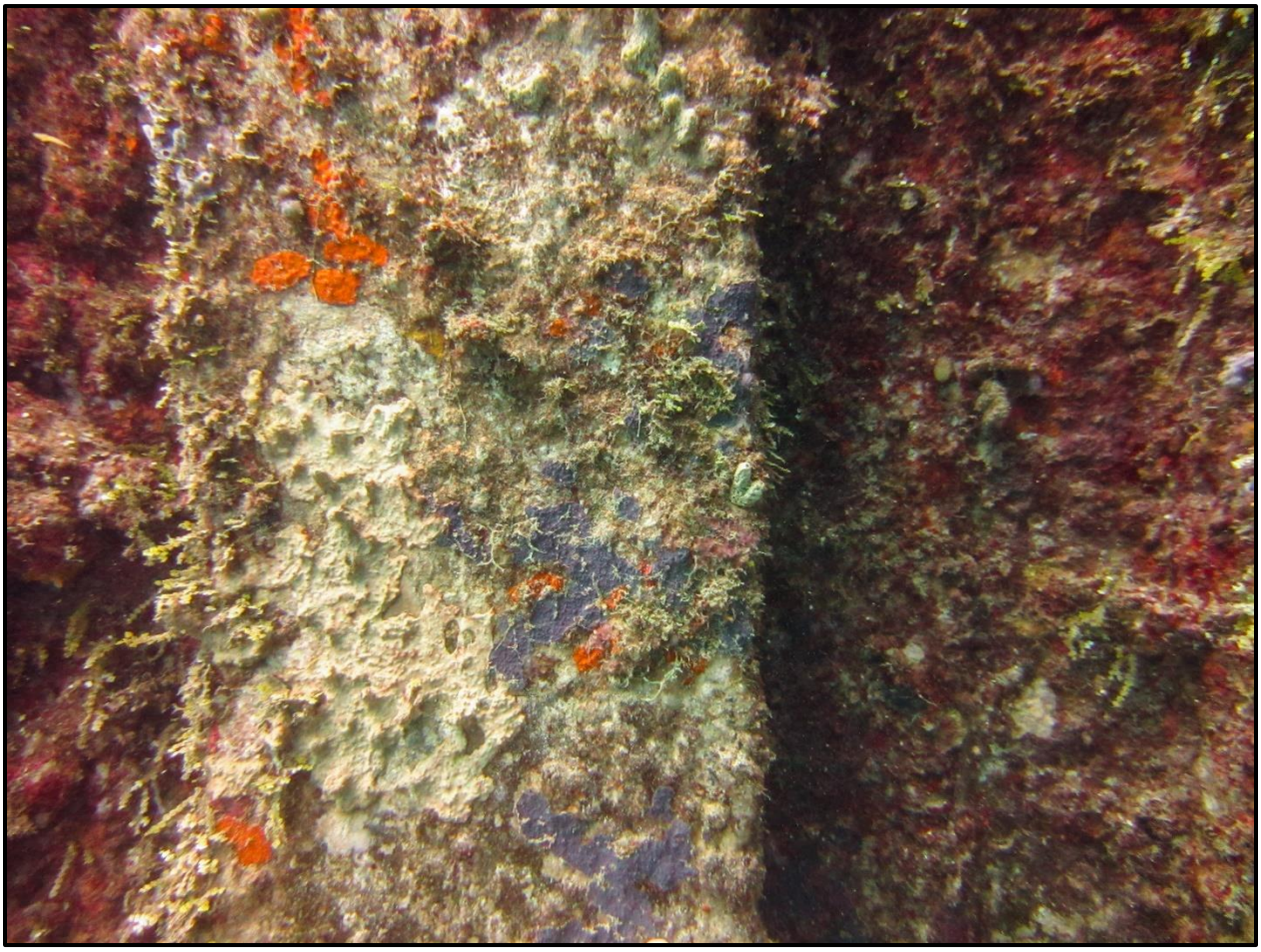

Figure 25. A benthic community at a depth of about 9 m dominated by encrusting sponges and turf algae, typical of the extent of the wharf sides occurring below the shallow beam.

Figure 26. A benthic community dominated by encrusting sponges and turf algae, and numerous dendrophylliid corals, typical of the underside of the concrete beam that extends across the length of the wharf sides at a depth of approximately 1.5 m.

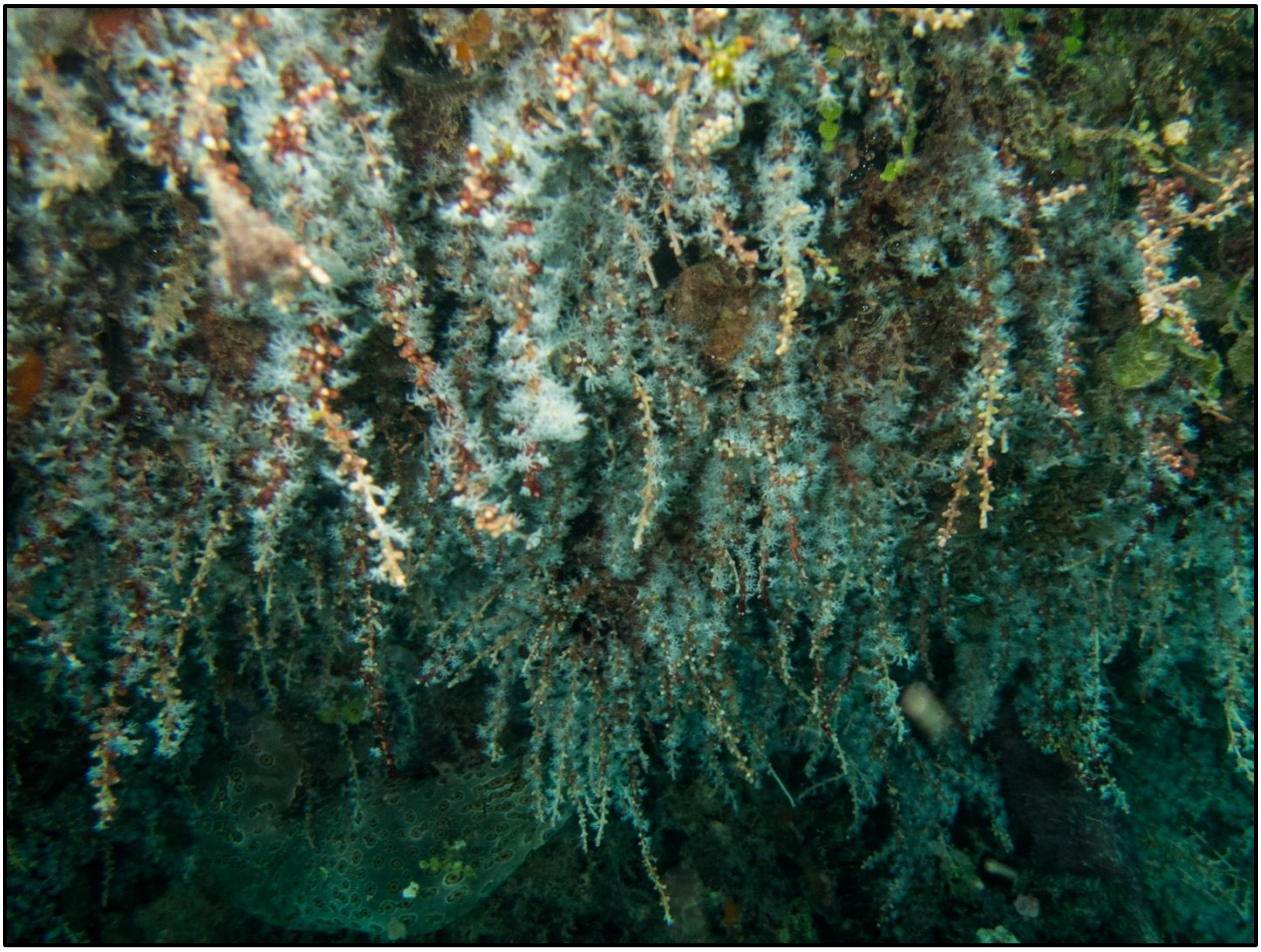

Figure 27. Dense octocoral growth below the concrete beam near the southeast corner of the wharf. While a specimen must be collected to confirm the identification, this species appears similar to the non-native octocoral, *Carijoa riisei*.

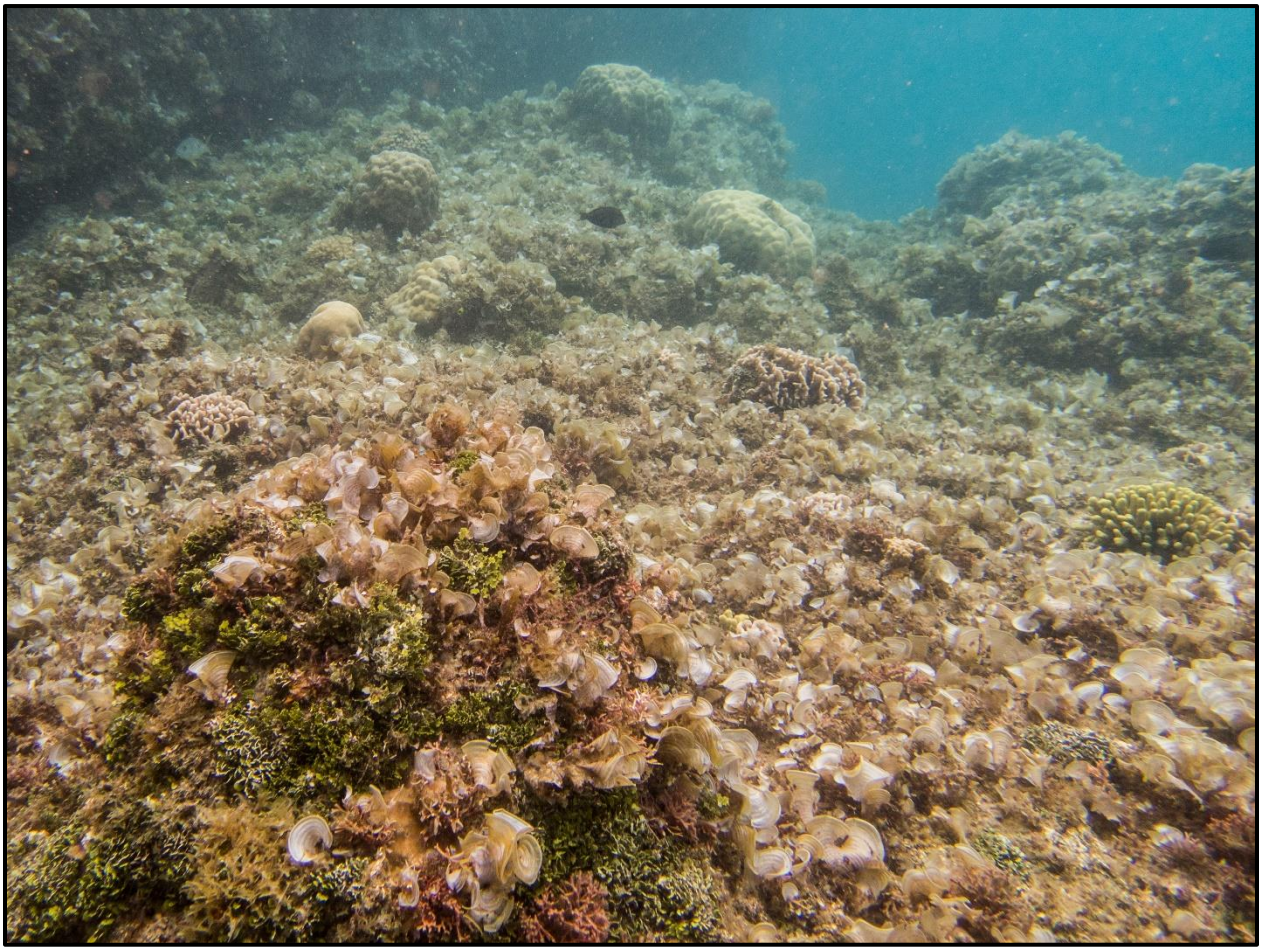

Figure 28. A benthic community on the reef flat adjacent to the west side of the wharf dominated by erect macrophytes, primarily *Padina* sp. and *Halimeda* spp. Coral cover is generally low across the reef flat, but notable colonies, such as the *Pavona decussata*, massive *Porites* spp., and *Porites cylindrica* colonies visible in this image, were observed in close proximity to the wharf.

Figure 29. A portion of the debris field occurring at the base of the south wharf face at a depth of approximately 9 m. The debris are strewn across a seafloor dominated by uncolonized, unconsolidated sediment, but some coral colonies were observed growing on the debris.

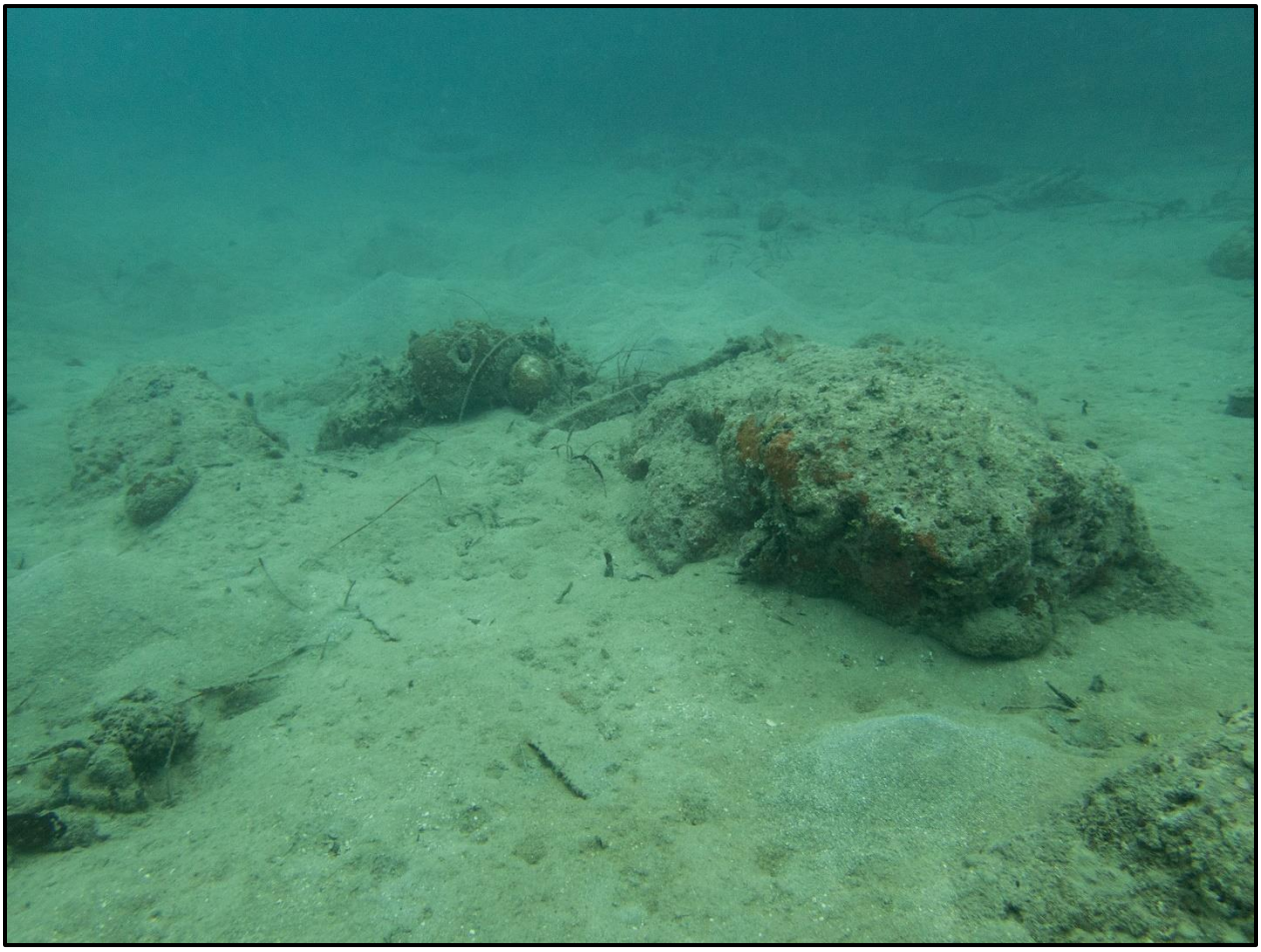

Figure 30. A view of the sand flat in the Indirect Impacts Zone, which is predominantly covered by uncolonized sand, with small patches of hardbottom.

Figure 31. A view of the area of mixed sand/hardbottom that runs parallel to, and approximately 20–35 m from, the south wharf face. This area straddles the 30 m Indirect Impacts Zone but occurs beyond the 20 m Indirect Impacts Zone.

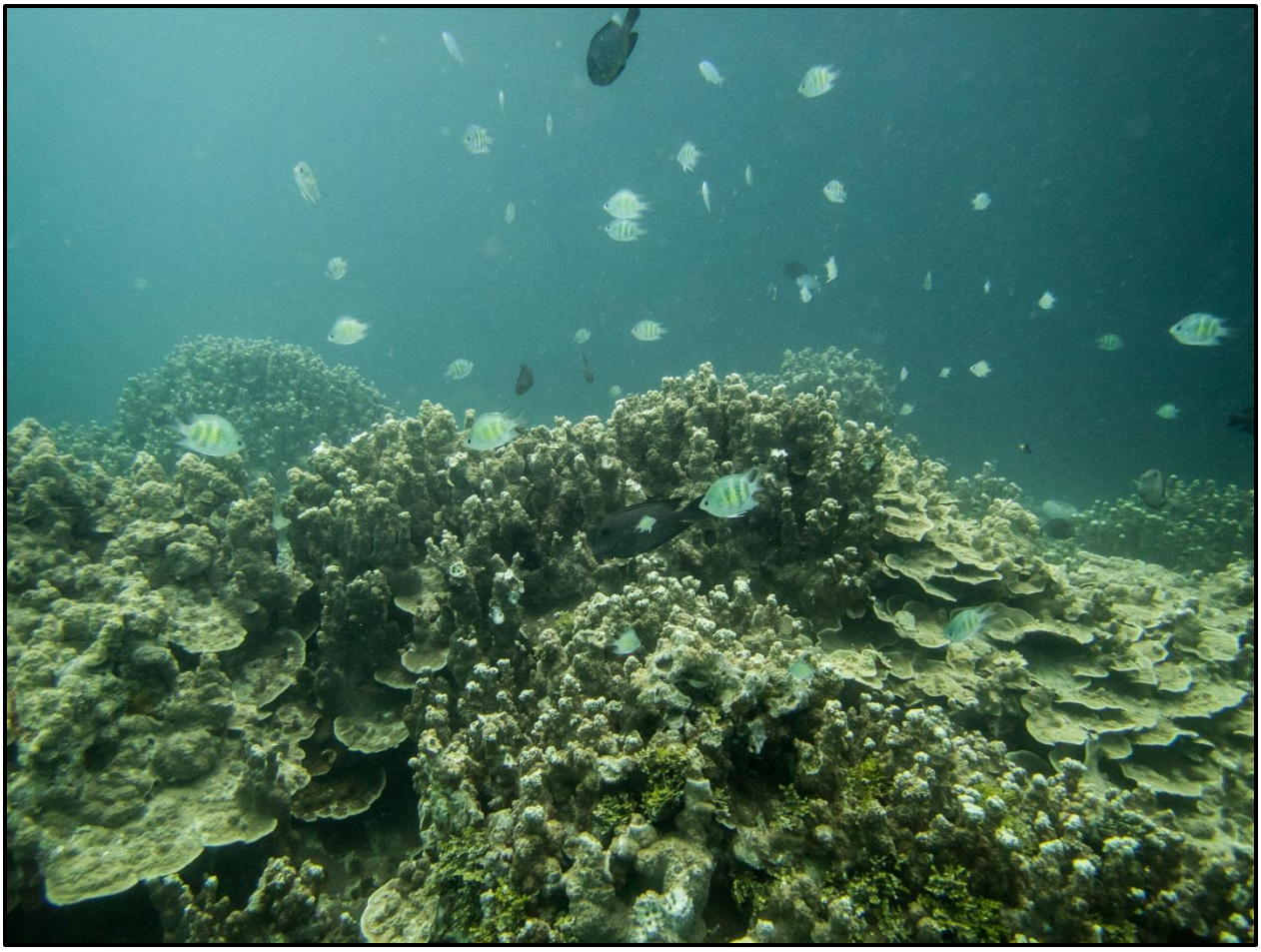

Figure 32. Dense growth of the plate-and-pillar coral, *Porites rus*, and associated reef fishes, in the area of aggregate reef running parallel to, and approximately 25–40 m from, the south wharf face. This area partially occurs within the 30 m Indirect Impacts Zone, but falls outside the 20 m Indirect Impacts Zone.

Figure 33. A typical patch reef on the sand flat within the Indirect Impacts Zone.

APPENDIX A

Marine species reported from the waters of the Mariana Islands that are currently protected, or under consideration for protection, under the U. S. Endangered Species Act. Source: NOAA Fisheries.

Appendix A.

	Common Name	Scientific Name	ESA Listing
Marine mammals	Blue Whale	*Balaenoptera musculus*	Endangered
	Fin Whale	*Balaenoptera physalus*	Endangered
	Humpback Whale	*Megaptera novaeangliae*	Endangered
	Sei Whale	*Balaenoptera borealis*	Endangered
	Sperm Whale	*Physeter macrocephalus*	Endangered
	Dugong	*Dugong dugon*	Endangered
Sea turtle	Green Turtle, Central West	*Chelonia mydas*	Endangered
	Hawksbill Turtle	*Eretmochelys imbricata*	Endangered
	Leatherback Turtle	*Dermochelys coriacea*	Endangered
	Loggerhead Turtle, North	*Caretta caretta*	Endangered
	Olive Ridley Turtle	*Lepidochelys olivacea*	Threatened
Fishes	Scalloped Hammerhead Shark,	*Sphyrna lewini*	Threatened
	Giant Manta Ray	*Manta birostris*	Threatened
	Oceanic Whitetip Shark	*Carcharhinus*	Threatened
Corals	Needle coral	*Seriatopora aculeata*	Threatened
		Acropora globiceps	Threatened
		Acropora retusa	Threatened
	Cauliflower coral	*Pocillopora meandrina*	Candidate
Non-coral invertebrates	Giant clam	*Hippopus hippopus*	Candidate
	Giant clam	*Tridacna derasa*	Candidate
	Giant clam	*Tridacna gigas*	Candidate
	Giant clam	*Tridacna squamosa*	Candidate

APPENDIX B

Density (col/m^2) of coral colonies for transects surveyed on the wharf (Direct Impacts Zone).

Appendix B.

	East side		South side									West side	
	1 m	5 m	1 m			5 m			9 m			1 m	5 m
	1	2	1	2	3	1	2	3	1	2	3	1	2
Astreopora	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.10**	**0.14**	**0.02**	**0.08**	**0.04**	**0.18**	**0.00**	**0.08**
Astreopora gracilis	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.02	0.00	0.02	0.04	0.00	0.00
Astreopora randalli	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Astreopora sp.	0.00	0.00	0.00	0.00	0.00	0.02	0.14	0.00	0.08	0.02	0.14	0.00	0.00
***Cyphastrea* sp.**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**
dendrophylliid sp.	**0.26**	**2.24**	**0.62**	**2.65**	**0.51**	**1.28**	**3.62**	**2.42**	**0.14**	**0.02**	**0.00**	**0.21**	**0.00**
Favia	**0.00**	**0.19**	**0.02**	**0.00**	**0.00**	**0.00**	**0.04**	**0.02**	**0.02**	**0.00**	**0.02**	**0.00**	**0.00**
Favia favus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Favia sp.	0.00	0.19	0.02	0.00	0.00	0.00	0.04	0.00	0.02	0.00	0.02	0.00	0.00
***Fungia* sp.**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
***Homophyllia* sp.**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Leptastrea	**5.00**	**0.28**	**2.55**	**1.37**	**6.72**	**1.26**	**0.24**	**1.12**	**0.12**	**0.18**	**0.16**	**5.55**	**0.24**
Leptastrea purpurea	0.00	0.00	2.55	1.37	6.72	1.26	0.10	1.12	0.12	0.18	0.10	5.55	0.24
Leptastrea sp.	5.00	0.28	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.06	0.00	0.00
Leptoseris	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.06**	**0.02**	**0.06**	**0.12**	**0.00**	**0.00**	**0.00**	**0.00**
Leptoseris incrustans	0.00	0.00	0.00	0.00	0.02	0.06	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Leptoseris mycetoseroides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Leptoseris sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.10	0.00	0.00	0.00	0.00
Lobophyllia	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.10**	**0.04**	**0.14**	**0.16**	**0.26**	**0.00**	**0.00**
Lobophyllia corymbosa	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.04	0.00	0.02	0.04	0.00	0.00
Lobophyllia hemprichii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00
Lobophyllia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.14	0.00	0.22	0.00	0.00

Appendix B. Continued.

	East side		South side									West side	
	1 m	5 m	1 m			5 m			9 m			1 m	5 m
	1	2	1	2	3	1	2	3	1	2	3	1	2
Montastraea magnistellata	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Pavona	**0.00**	**0.00**	**0.03**	**0.00**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Pavona danai	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pavona minuta	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pavona varians	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pocillopora	**1.71**	**0.00**	**1.94**	**0.25**	**1.89**	**0.14**	**0.04**	**0.16**	**0.08**	**0.02**	**0.00**	**1.31**	**0.08**
Pocillopora acuta	0.00	0.00	0.09	0.00	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Pocillopora damicornis	0.00	0.00	1.85	0.25	1.78	0.10	0.04	0.16	0.08	0.02	0.00	1.31	0.00
Pocillopora sp.	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Porites	**0.09**	**0.09**	**0.05**	**0.00**	**0.25**	**0.68**	**0.52**	**0.32**	**1.06**	**0.26**	**0.90**	**0.07**	**0.16**
Porites cylindrica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Porites horizontalata	0.00	0.00	0.00	0.00	0.00	0.02	0.12	0.00	0.00	0.06	0.24	0.00	0.00
Porites rus	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.50	0.00	0.10	0.00	0.08
Porites sp. -massive	0.09	0.09	0.05	0.00	0.23	0.64	0.38	0.32	0.50	0.20	0.50	0.07	0.08
Porites sp. - other	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.06	0.00	0.00
Porites sp. - submassive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
Psammocora	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.02	0.02	0.00	0.14	0.00	0.00
Psammocora haimeana	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Psammocora profundacella	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Psammocora superficialis	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Psammocora sp.	0.00	0.00	0.00	0.00	0.00	0.04	0.10	0.00	0.02	0.00	0.14	0.00	0.00
Stylocoeniella armata	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.06**	**0.44**	**0.18**	**0.38**	**0.00**	**0.00**
All coral colonies	**7.05**	**2.80**	**5.20**	**4.26**	**9.43**	**3.68**	**4.84**	**4.26**	**2.24**	**0.86**	**2.06**	**7.14**	**0.57**

APPENDIX C

Density (col/m^2) of coral colonies observed along transects placed on the seafloor at the base of the wharf (Direct Impacts Zone).

Appendix C.

	East	South			West
	1	1	2	3	1
Astreopora	**0.00**	**0.16**	**0.10**	**0.08**	**0.00**
Astreopora gracilis	0.00	0.02	0.00	0.00	0.00
Astreopora listeri	0.00	0.00	0.00	0.00	0.00
Astreopora myriophthalma	0.00	0.00	0.02	0.00	0.00
Astreopora ocellata	0.00	0.00	0.00	0.00	0.00
Astreopora randalli	0.00	0.08	0.00	0.00	0.00
Astreopora scabra	0.00	0.02	0.00	0.00	0.00
Astreopora sp.	0.00	0.04	0.08	0.08	0.00
Cycloseris sp.	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**
Cyphastrea	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Cyphastrea serailia	0.00	0.00	0.00	0.00	0.00
Cyphastrea sp.	0.00	0.00	0.00	0.00	0.00
dendrophylliid sp.	**0.00**	**0.04**	**0.00**	**0.00**	**0.00**
Favia	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**
Favia favus	0.00	0.00	0.00	0.00	0.00
Favia sp.	0.00	0.00	0.00	0.02	0.00
Fungia	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**
Fungia concinna	0.00	0.00	0.02	0.00	0.00
Fungia sp.	0.00	0.00	0.00	0.00	0.00
Goniastrea retiformis	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Heliopora coerulea	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Homophyllia sp.	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Leptastrea	**0.12**	**0.06**	**0.00**	**0.00**	**0.04**
Leptastrea purpurea	0.12	0.06	0.00	0.00	0.04
Leptastrea transversa	0.00	0.00	0.00	0.00	0.00
Leptastrea sp.	0.00	0.00	0.00	0.00	0.00
Leptoseris	**0.00**	**0.02**	**0.00**	**0.00**	**0.00**
Leptoseris incrustans	0.00	0.02	0.00	0.00	0.00
Leptoseris mycetoseroides	0.00	0.00	0.00	0.00	0.00
Leptoseris sp.	0.00	0.00	0.00	0.00	0.00

Appendix C. Continued.

	East	South			West
	1	1	2	3	1
Lobophyllia	**0.00**	**0.26**	**0.12**	**0.02**	**0.00**
Lobophyllia corymbosa	0.00	0.06	0.00	0.00	0.00
Lobophyllia hataii	0.00	0.02	0.00	0.00	0.00
Lobophyllia hemprichii	0.00	0.18	0.12	0.00	0.00
Lobophyllia robusta	0.00	0.00	0.00	0.00	0.00
Lobophyllia sp.	0.00	0.00	0.00	0.02	0.00
Montastrea magnistellata	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Montipora	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Montipora informis	0.00	0.00	0.00	0.00	0.00
Montipora sp.	0.00	0.00	0.00	0.00	0.00
Pavona	**0.04**	**0.00**	**0.00**	**0.00**	**0.39**
Pavona danai	0.00	0.00	0.00	0.00	0.00
Pavona decussata	0.00	0.00	0.00	0.00	0.39
Pavona minuta	0.00	0.00	0.00	0.00	0.00
Pavona varians	0.04	0.00	0.00	0.00	0.00
Pocillopora	**0.52**	**0.06**	**0.00**	**0.02**	**0.31**
Pocillopora acuta	0.00	0.06	0.00	0.00	0.08
Pocillopora damicornis	0.52	0.00	0.00	0.00	0.24
Pocillopora sp.	0.00	0.00	0.00	0.02	0.00
Porites	**0.44**	**0.52**	**0.16**	**0.42**	**0.43**
Porites cylindrica	0.00	0.00	0.00	0.00	0.00
Porites deformis	0.00	0.00	0.00	0.00	0.00
Porites horizontalata	0.00	0.02	0.00	0.00	0.00
Porites murrayensis	0.00	0.00	0.00	0.00	0.00
Porites rus	0.00	0.00	0.00	0.16	0.00
Porites stephensoni	0.00	0.00	0.08	0.00	0.00
Porites vaughani	0.00	0.04	0.00	0.00	0.00
Porites sp. -massive	0.44	0.46	0.08	0.24	0.43
Porites sp. - other	0.00	0.00	0.00	0.02	0.00
Porites sp. - submassive	0.00	0.00	0.00	0.00	0.00
Psammocora	**0.00**	**0.10**	**0.00**	**0.06**	**0.00**
Psammocora contigua	0.00	0.00	0.00	0.00	0.00
Psammocora haimeana	0.00	0.00	0.00	0.06	0.00
Psammocora profundacella	0.00	0.00	0.00	0.00	0.00
Psammocora superficialis	0.00	0.00	0.00	0.00	0.00
Psammocora sp.	0.00	0.10	0.00	0.00	0.00
Stylocoeniella armata	**0.00**	**0.32**	**0.22**	**0.24**	**0.00**
All coral colonies	**1.12**	**1.54**	**0.62**	**0.88**	**1.18**

APPENDIX D

Density (col/m^2) of coral colonies on seafloor transects placed perpendicular to the wharf (30 m Indirect Impacts Zone).

Appendix D.

	Reef flat (W)		Sand flat													Reef flat (E)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Astreopora	**0.00**	**0.00**	**0.33**	**0.03**	**0.10**	**0.13**	**0.23**	**0.03**	**0.37**	**0.23**	**0.80**	**0.37**	**0.20**	**0.37**	**0.03**	**0.00**
Astreopora gracilis	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.20	0.60	0.27	0.13	0.27	0.03	0.00
Astreopora listeri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00
Astreopora myriophthalma	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.07	0.00	0.10	0.00	0.00
Astreopora ocellata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Astreopora randalli	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00
Astreopora scabra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Astreopora sp.	0.00	0.00	0.33	0.00	0.10	0.00	0.23	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
***Cycloseris* sp.**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Cyphastrea	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Cyphastrea serailia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyphastrea sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
dendrophylliid sp.	**0.00**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Favia	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Favia favus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Favia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fungia	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Fungia concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fungia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Goniastrea retiformis	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Heliopora coerulea	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Homophyllia* *sp.	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Leptastrea	**0.27**	**0.20**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.10**	**0.07**	**0.03**
Leptastrea purpurea	0.27	0.20	0.03	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.03	0.00	0.10	0.07	0.03
Leptastrea transversa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leptastrea sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix D. Continued.

	Reef flat (W)		Sand flat													Reef flat (E)
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Leptoseris	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Leptoseris incrustans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leptoseris mycetoseroides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leptoseris sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lobophyllia	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.03**	**0.00**	**0.00**	**0.00**
Lobophyllia corymbosa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lobophyllia hataii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lobophyllia hemprichii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00
Lobophyllia robusta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lobophyllia sp.	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Montastraea magnistellata	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Montipora	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.07**
Montipora informis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Montipora sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Pavona	**0.77**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.07**
Pavona danai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Pavona decussata	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pavona minuta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pavona varians	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pocillopora	**0.73**	**0.53**	**0.07**	**0.00**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.83**
Pocillopora acuta	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Pocillopora damicornis	0.73	0.50	0.07	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.77
Pocillopora sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix D. Continued .

	Reef flat (W)		Sand flat													Reef flat (E)
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Porites	**1.33**	**0.93**	**0.13**	**0.07**	**0.03**	**0.67**	**0.23**	**0.60**	**0.90**	**0.03**	**0.57**	**0.90**	**1.13**	**0.47**	**0.50**	**0.93**
Porites cylindrica	0.07	0.03	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00
Porites deformis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Porites horizontalata	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00
Porites murrayensis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.03	0.00	0.00
Porites rus	0.27	0.17	0.00	0.00	0.00	0.00	0.00	0.37	0.20	0.00	0.07	0.73	1.03	0.00	0.30	0.00
Porites stephensoni	0.00	0.03	0.00	0.03	0.00	0.53	0.00	0.07	0.00	0.03	0.10	0.10	0.10	0.27	0.00	0.00
Porites vaughani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Porites sp. -massive	1.07	0.73	0.00	0.03	0.03	0.03	0.23	0.17	0.57	0.00	0.30	0.03	0.00	0.17	0.20	0.93
Porites sp. - other	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Porites sp. - submassive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Psammocora	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.00**
Psammocora contigua	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Psammocora haimeana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Psammocora profundacella	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Psammocora superficialis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Psammocora sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stylocoeniella armata	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.03**	**0.03**	**0.00**	**0.07**	**0.10**	**0.23**	**0.17**	**0.00**	**0.03**	**0.00**	**0.00**
All coral colonies	**3.20**	**1.73**	**0.57**	**0.10**	**0.23**	**0.90**	**0.50**	**0.67**	**1.33**	**0.37**	**1.63**	**1.47**	**1.43**	**1.03**	**0.60**	**1.93**

APPENDIX E

Density (col/m^2) of coral colonies observed on transects placed on hardbottom habitat occurring parallel to the south wharf face (Indirect Impacts Zone).

Appendix E.

	Mixed sand/HB		Aggregate reef	
	1	2	3	4
Astreopora	**0.57**	**1.20**	**0.34**	**0.44**
Astreopora gracilis	0.27	0.00	0.00	0.14
Astreopora listeri	0.00	0.00	0.00	0.02
Astreopora myriophthalma	0.10	0.00	0.00	0.08
Astreopora ocellata	0.00	0.00	0.00	0.00
Astreopora randalli	0.00	0.00	0.00	0.04
Astreopora scabra	0.07	0.00	0.00	0.08
Astreopora sp.	0.13	1.20	0.34	0.08
***Cycloseris* sp.**	**0.00**	**0.00**	**0.00**	**0.00**
Cyphastrea	**0.03**	**0.00**	**0.03**	**0.00**
Cyphastrea serailia	0.03	0.00	0.00	0.00
Cyphastrea sp.	0.00	0.00	0.03	0.00
dendrophylliid sp.	**0.00**	**0.00**	**0.00**	**0.00**
Favia	**0.00**	**0.00**	**0.00**	**0.00**
Favia favus	0.00	0.00	0.00	0.00
Favia sp.	0.00	0.00	0.00	0.00
Fungia	**0.00**	**0.00**	**0.00**	**0.00**
Fungia concinna	0.00	0.00	0.00	0.00
Fungia sp.	0.00	0.00	0.00	0.00
Goniastrea retiformis	**0.00**	**0.00**	**0.00**	**0.00**
Heliopora coerulea	**0.00**	**0.00**	**0.00**	**0.00**
Homophyllia* *sp.	**0.00**	**0.00**	**0.00**	**0.00**
Leptastrea	**0.07**	**0.03**	**0.06**	**0.00**
Leptastrea purpurea	0.07	0.00	0.00	0.00
Leptastrea transversa	0.00	0.00	0.00	0.00
Leptastrea sp.	0.00	0.03	0.06	0.00
Leptoseris	**0.00**	**0.00**	**0.00**	**0.00**
Leptoseris incrustans	0.00	0.00	0.00	0.00
Leptoseris mycetoseroides	0.00	0.00	0.00	0.00
Leptoseris sp.	0.00	0.00	0.00	0.00
Lobophyllia	**0.07**	**0.00**	**0.03**	**0.02**
Lobophyllia corymbosa	0.00	0.00	0.03	0.00
Lobophyllia hataii	0.00	0.00	0.00	0.00
Lobophyllia hemprichii	0.07	0.00	0.00	0.02
Lobophyllia robusta	0.00	0.00	0.00	0.00
Lobophyllia sp.	0.00	0.00	0.00	0.00
Montastraea magnistellata	**0.00**	**0.00**	**0.00**	**0.00**

Appendix E. Continued

	Mixed sand/HB		Aggregate reef	
	1	**2**	**3**	**4**
Montipora	**0.07**	**0.00**	**0.00**	**0.00**
Montipora informis	0.07	0.00	0.00	0.00
Montipora sp.	0.00	0.00	0.00	0.00
Pavona	**0.00**	**0.00**	**0.00**	**0.00**
Pavona danai	0.00	0.00	0.00	0.00
Pavona decussata	0.00	0.00	0.00	0.00
Pavona minuta	0.00	0.00	0.00	0.00
Pavona varians	0.00	0.00	0.00	0.00
Pocillopora	**0.00**	**0.00**	**0.00**	**0.00**
Pocillopora acuta	0.00	0.00	0.00	0.00
Pocillopora damicornis	0.00	0.00	0.00	0.00
Pocillopora sp.	0.00	0.00	0.00	0.00
Porites	**0.60**	**1.57**	**5.94**	**2.28**
Porites cylindrica	0.00	0.00	0.00	0.00
Porites deformis	0.00	0.00	0.00	0.00
Porites horizontalata	0.00	0.00	0.46	0.18
Porites murrayensis	0.00	0.00	0.00	0.00
Porites rus	0.53	1.03	4.74	1.76
Porites stephensoni	0.07	0.00	0.00	0.04
Porites vaughani	0.00	0.00	0.00	0.00
Porites sp. -massive	0.00	0.53	0.51	0.30
Porites sp. - other	0.00	0.00	0.23	0.00
Porites sp. - submassive	0.00	0.00	0.00	0.00
Psammocora	**0.00**	**0.00**	**0.00**	**0.00**
Psammocora contigua	0.00	0.00	0.00	0.00
Psammocora haimeana	0.00	0.00	0.00	0.00
Psammocora profundacella	0.00	0.00	0.00	0.00
Psammocora superficialis	0.00	0.00	0.00	0.00
Psammocora sp.	0.00	0.00	0.00	0.00
Stylocoeniella armata	**0.10**	**0.30**	**0.31**	**0.00**
All coral colonies	**1.50**	**3.10**	**6.71**	**2.74**

APPENDIX F

Density (col/m^2) of coral taxa for patch reefs 1−13 surveyed within the Indirect Impacts Zone.

Appendix F.

	1	2	3	4	5	6	7	8	9	10	12	13
Astreopora	**0.0**	**0.7**	**0.6**	**0.7**	**1.8**	**1.4**	**0.2**	**1.3**	**1.8**	**2.8**	**0.1**	**1.1**
Astreopora gracilis	0.0	0.0	0.3	0.2	1.5	0.3	0.1	0.0	0.5	1.6	0.0	0.4
Astreopora listeri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Astreopora myriophthalma	0.0	0.3	0.0	0.2	0.0	0.6	0.1	0.3	1.3	0.9	0.1	0.2
Astreopora ocellata	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Astreopora randalli	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Astreopora scabra	0.0	0.3	0.0	0.2	0.2	0.4	0.0	1.0	0.0	0.3	0.0	0.4
Astreopora sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
***Cycloseris* sp.**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Cyphastrea	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Cyphastrea serailia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyphastrea sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dendrophylliid sp.	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Favia	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Favia favus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Favia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fungia	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Fungia concinna	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fungia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Goniastrea retiformis	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Heliopora coerulea	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
***Homophyllia* sp.**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Leptastrea	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.3**	**0.0**	**0.0**
Leptastrea purpurea	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.0
Leptastrea transversa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptastrea sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptoseris	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Leptoseris incrustans	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Leptoseris mycetoseroides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptoseris sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lobophyllia	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**
Lobophyllia corymbosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lobophyllia hataii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Lobophyllia hemprichii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lobophyllia robusta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lobophyllia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montastraea magnistellata	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Montipora	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Montipora informis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montipora sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0

Appendix F. Continued.

	1	2	3	4	5	6	7	8	9	10	12	13
Pavona	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Pavona danai	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pavona decussata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pavona minuta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pavona varians	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pocillopora	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Pocillopora acuta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pocillopora damicornis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pocillopora sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites	**0.4**	**1.5**	**0.0**	**0.5**	**1.0**	**1.8**	**0.4**	**0.0**	**0.0**	**1.1**	**0.5**	**2.4**
Porites cylindrica	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites deformis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites horizontalata	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.2
Porites murrayensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4
Porites rus	0.4	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Porites stephensoni	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.0	0.6
Porites vaughani	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites sp. -massive	0.0	1.5	0.0	0.5	1.0	1.7	0.0	0.0	0.0	0.8	0.1	1.1
Porites sp. - other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Porites sp. - submassive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Psammocora	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**0.0**
Psammocora contigua	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Psammocora haimeana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Psammocora profundacella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0
Psammocora superficialis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Psammocora sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stylocoeniella armata	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
All coral colonies	**0.4**	**2.3**	**0.6**	**1.2**	**2.8**	**3.3**	**1.0**	**1.6**	**1.8**	**4.3**	**2.5**	**3.6**

APPENDIX G

Density (col/m^2) of coral taxa for patch reefs 14–26 within the Indirect Impacts Zone.

Appendix G.

	14	15	16	17	18	19	20	21	22	25	26
Astreopora	**0.9**	**0.4**	**0.5**	**0.8**	**1.8**	**3.0**	**1.1**	**0.1**	**1.6**	**2.1**	**5.1**
Astreopora gracilis	0.0	0.4	0.2	0.5	0.6	1.0	0.7	0.1	0.3	0.0	0.0
Astreopora listeri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Astreopora myriophthalma	0.0	0.0	0.0	0.2	0.6	0.5	0.3	0.0	0.3	0.0	2.5
Astreopora ocellata	0.4	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Astreopora randalli	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Astreopora scabra	0.4	0.0	0.2	0.0	0.3	0.5	0.0	0.0	0.3	0.0	0.0
Astreopora sp.	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.5	2.1	2.5
***Cycloseris* sp.**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Cyphastrea	**0.0**	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Cyphastrea serailia	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyphastrea sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
dendrophylliid sp.	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Favia	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**
Favia favus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Favia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Fungia	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Fungia concinna	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fungia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Goniastrea retiformis	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Heliopora coerulea	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.6**
***Homophyllia* sp.**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Leptastrea	**0.0**	**0.0**	**0.2**	**0.0**	**0.9**	**0.0**	**0.0**	**0.3**	**0.0**	**0.0**	**0.0**
Leptastrea purpurea	0.0	0.0	0.2	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Leptastrea transversa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Leptastrea sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptoseris	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Leptoseris incrustans	0.0	0.0	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
Leptoseris mycetoseroides	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Leptoseris sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lobophyllia	**0.4**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.0**	**1.2**
Lobophyllia corymbosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lobophyllia hataii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lobophyllia hemprichii	0.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	1.2
Lobophyllia robusta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Lobophyllia sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montastrea magnistellata	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Montipora	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Montipora informis	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montipora sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix G. Continued.

	14	15	16	17	18	19	20	21	22	25	26
Pavona	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**
Pavona danai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Pavona decussata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Pavona minuta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Pavona varians	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Pocillopora	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**
Pocillopora acuta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Pocillopora damicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Pocillopora sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Porites	**0.46**	**0.20**	**0.00**	**1.30**	**0.31**	**1.03**	**0.74**	**0.00**	**1.30**	**0.86**	**0.0**
Porites cylindrica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Porites deformis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Porites horizontalata	0.00	0.00	0.00	0.87	0.00	1.03	0.00	0.00	0.00	0.00	0.0
Porites murrayensis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.00	0.0
Porites rus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Porites stephensoni	0.46	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.0
Porites vaughani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Porites sp. -massive	0.00	0.20	0.00	0.43	0.00	0.00	0.74	0.00	0.19	0.86	0.0
Porites sp. - other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Porites sp. - submassive	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Psammocora	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.0**
Psammocora contigua	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Psammocora haimeana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Psammocora profundacella	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Psammocora superficialis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Psammocora sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Stylocoeniella armata	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.18**	**0.00**	**0.43**	**0.0**
All coral colonies	**1.85**	**0.60**	**1.11**	**2.74**	**3.09**	**4.62**	**2.22**	**0.88**	**3.15**	**3.43**	**7.0**

APPENDIX H

Mean density of coral colonies (col/m^2) for all coral taxa within the Direct Impacts Zone

Appendix H.

	Wharf base				Wharf Face				Direct Impacts
	East	South	West	Entire base	East	South	West	Entire face	Zone
All coral colonies	**1.120**	**1.013**	**1.176**	**1.067**	**5.833**	**4.092**	**4.039**	**4.352**	**3.440**
Astreopora	**0.000**	**0.113**	**0.000**	**0.068**	**0.000**	**0.062**	**0.067**	**0.053**	**0.057**
Astreopora gracilis	0.000	0.007	0.000	0.004	0.000	0.013	0.000	0.009	0.008
Astreopora listeri	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Astreopora myriophthalma	0.000	0.007	0.000	0.004	0.000	0.000	0.000	0.000	0.001
Astreopora ocellata	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Astreopora randalli	0.000	0.027	0.000	0.016	0.000	0.004	0.067	0.013	0.014
Astreopora scabra	0.000	0.007	0.000	0.004	0.000	0.000	0.000	0.000	0.001
Astreopora sp.	0.000	0.067	0.000	0.040	0.000	0.044	0.000	0.031	0.033
***Cycloseris* sp.**	**0.000**	**0.007**	**0.000**	**0.004**	**0.000**	**0.000**	**0.000**	**0.000**	**0.001**
Cyphastrea	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**	**0.000**	**0.002**	**0.001**
Cyphastrea serailia	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cyphastrea sp.	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.001
dendrophylliid sp.	**0.000**	**0.013**	**0.000**	**0.008**	**1.974**	**1.250**	**0.106**	**1.185**	**0.858**
Favia	**0.000**	**0.007**	**0.000**	**0.004**	**0.154**	**0.013**	**0.000**	**0.033**	**0.025**
Favia favus	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.001
Favia sp.	0.000	0.007	0.000	0.004	0.154	0.011	0.000	0.031	0.024
Fungia	**0.000**	**0.007**	**0.000**	**0.004**	**0.000**	**0.002**	**0.000**	**0.002**	**0.002**
Fungia concinna	0.000	0.007	0.000	0.004	0.000	0.000	0.000	0.000	0.001
Fungia sp.	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.001
Goniastrea retiformis	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Heliopora coerulea	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
***Homophyllia* sp.**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**	**0.000**	**0.002**	**0.001**
Leptastrea	**0.120**	**0.020**	**0.039**	**0.044**	**2.731**	**1.525**	**2.976**	**1.934**	**1.409**
Leptastrea purpurea	0.120	0.020	0.039	0.044	0.000	1.503	2.976	1.498	1.094
Leptastrea transversa	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Leptastrea sp.	0.000	0.000	0.000	0.000	2.731	0.022	0.000	0.436	0.315

Appendix H. Continued.

	Wharf base				Wharf Face				Direct
	East	South	West	Entire base	East	South	West	Entire face	Impacts Zone
Leptoseris	**0.000**	**0.007**	**0.000**	**0.004**	**0.000**	**0.031**	**0.000**	**0.021**	**0.016**
Leptoseris incrustans	0.000	0.007	0.000	0.004	0.000	0.015	0.000	0.010	0.009
Leptoseris mycetoseroides	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.001
Leptoseris sp.	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.009	0.007
Lobophyllia	**0.000**	**0.133**	**0.000**	**0.080**	**0.000**	**0.080**	**0.000**	**0.055**	**0.062**
Lobophyllia corymbosa	0.000	0.020	0.000	0.012	0.000	0.016	0.000	0.011	0.011
Lobophyllia hataii	0.000	0.007	0.000	0.004	0.000	0.000	0.000	0.000	0.001
Lobophyllia hemprichii	0.000	0.100	0.000	0.060	0.000	0.016	0.000	0.011	0.024
Lobophyllia robusta	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lobophyllia sp.	0.000	0.007	0.000	0.004	0.000	0.049	0.000	0.034	0.026
Montastrea magnistellata	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**	**0.000**	**0.001**	**0.001**
Montipora	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Montipora informis	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Montipora sp.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pavona	**0.040**	**0.000**	**0.392**	**0.086**	**0.000**	**0.007**	**0.000**	**0.005**	**0.027**
Pavona danai	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.001
Pavona decussata	0.000	0.000	0.392	0.078	0.000	0.000	0.000	0.000	0.022
Pavona minuta	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.002	0.002
Pavona varians	0.040	0.000	0.000	0.008	0.000	0.002	0.000	0.001	0.003
Pocillopora	**0.520**	**0.027**	**0.314**	**0.183**	**0.855**	**0.502**	**0.721**	**0.590**	**0.477**
Pocillopora acuta	0.000	0.020	0.078	0.028	0.000	0.027	0.067	0.029	0.028
Pocillopora damicornis	0.520	0.000	0.235	0.151	0.000	0.475	0.654	0.430	0.352
Pocillopora sp.	0.000	0.007	0.000	0.004	0.855	0.000	0.000	0.131	0.096

Appendix H. Continued.

	Wharf base				Wharf Face				
	East	South	West	Entire base	East	South	West	Entire face	Direct Impacts Zone
Porites	**0.440**	**0.367**	**0.431**	**0.394**	**0.120**	**0.450**	**0.169**	**0.356**	**0.367**
Porites cylindrica	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.001
Porites deformis	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Porites horizontalata	0.000	0.007	0.000	0.004	0.000	0.049	0.000	0.034	0.026
Porites murrayensis	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Porites rus	0.000	0.053	0.000	0.032	0.000	0.071	0.067	0.059	0.052
Porites stephensoni	0.000	0.027	0.000	0.016	0.000	0.000	0.000	0.000	0.004
Porites vaughani	0.000	0.013	0.000	0.008	0.000	0.000	0.000	0.000	0.002
Porites sp.	0.000	0.007	0.000	0.004	0.000	0.009	0.000	0.006	0.006
Porites sp. - submassive	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.005	0.003
Porites sp. -massive	0.440	0.260	0.431	0.330	0.120	0.313	0.102	0.251	0.273
Psammocora	**0.000**	**0.053**	**0.000**	**0.032**	**0.000**	**0.047**	**0.000**	**0.032**	**0.032**
Psammocora contigua	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Psammocora haimeana	0.000	0.020	0.000	0.012	0.000	0.002	0.000	0.002	0.004
Psammocora profundacella	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.006	0.004
Psammocora sp.	0.000	0.033	0.000	0.020	0.000	0.033	0.000	0.023	0.022
Psammocora superficialis	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.001
Stylocoeniella armata	**0.000**	**0.260**	**0.000**	**0.156**	**0.000**	**0.118**	**0.000**	**0.082**	**0.102**

APPENDIX I

Colony count estimates for all coral taxa within the Direct Impacts Zone

Appendix I.

	Wharf base				Wharf Face			
	East	South	West	Entire base	East	South	West	Entire face
Surface area	**74**	**291**	**62**	**428**	**226**	**958**	**210**	**1395**
				Colony estimates				
All coral colonies	**83**	**295**	**73**	**457**	**1321**	**3922**	**849**	**6071**
Astreopora	**0**	**33**	**0**	**29**	**0**	**60**	**14**	**74**
Astreopora gracilis	0	2	0	2	0	13	0	13
Astreopora listeri	0	0	0	0	0	0	0	0
Astreopora myriophthalma	0	2	0	2	0	0	0	0
Astreopora ocellata	0	0	0	0	0	0	0	0
Astreopora randalli	0	8	0	7	0	4	14	19
Astreopora scabra	0	2	0	2	0	0	0	0
Astreopora sp.	0	19	0	17	0	43	0	43
***Cycloseris* sp.**	**0**	**2**	**0**	**2**	**0**	**0**	**0**	**0**
Cyphastrea	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**2**
Cyphastrea serailia	0	0	0	0	0	0	0	0
Cyphastrea sp.	0	0	0	0	0	2	0	2
dendrophylliid sp.	**0**	**4**	**0**	**3**	**447**	**1198**	**22**	**1654**
Favia	**0**	**2**	**0**	**2**	**35**	**12**	**0**	**45**
Favia favus	0	0	0	0	0	2	0	2
Favia sp.	0	2	0	2	35	10	0	43
Fungia	**0**	**2**	**0**	**2**	**0**	**2**	**0**	**2**
Fungia concinna	0	2	0	2	0	0	0	0
Fungia sp.	0	0	0	0	0	2	0	2
Goniastrea retiformis	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Heliopora coerulea	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
***Homophyllia* sp.**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**2**

Appendix I.

	Wharf base				Wharf Face			
	East	**South**	**West**	**Entire base**	**East**	**South**	**West**	**Entire face**
Leptastrea	**9**	**6**	**2**	**19**	**618**	**1462**	**626**	**2698**
Leptastrea purpurea	9	6	2	19	0	1440	626	2090
Leptastrea transversa	0	0	0	0	0	0	0	0
Leptastrea sp.	0	0	0	0	618	21	0	608
Leptoseris	**0**	**2**	**0**	**2**	**0**	**29**	**0**	**30**
Leptoseris incrustans	0	2	0	2	0	14	0	15
Leptoseris mycetoseroides	0	0	0	0	0	2	0	2
Leptoseris sp.	0	0	0	0	0	13	0	13
Lobophyllia	**0**	**39**	**0**	**34**	**0**	**77**	**0**	**77**
Lobophyllia corymbosa	0	6	0	5	0	15	0	15
Lobophyllia hataii	0	2	0	2	0	0	0	0
Lobophyllia hemprichii	0	29	0	26	0	15	0	15
Lobophyllia robusta	0	0	0	0	0	0	0	0
Lobophyllia sp.	0	2	0	2	0	47	0	47
Montastrea magnistellata	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**2**
Montipora	0	0	0	0	0	0	0	0
Montipora informis	0	0	0	0	0	0	0	0
Montipora sp.	0	0	0	0	0	0	0	0
Pavona	**3**	**0**	**24**	**37**	**0**	**7**	**0**	**7**
Pavona danai	0	0	0	0	0	2	0	2
Pavona decussata	0	0	24	34	0	0	0	0
Pavona minuta	0	0	0	0	0	3	0	3
Pavona varians	3	0	0	3	0	2	0	2
Pocillopora	**39**	**8**	**20**	**78**	**194**	**481**	**152**	**823**
Pocillopora acuta	0	6	5	12	0	26	14	40
Pocillopora damicornis	39	0	15	65	0	455	138	599
Pocillopora sp.	0	2	0	2	194	0	0	183

Appendix I.

	Wharf base				Wharf Face			
	East	**South**	**West**	**Entire base**	**East**	**South**	**West**	**Entire face**
Porites	**33**	**107**	**27**	**169**	**27**	**431**	**35**	**497**
Porites cylindrica	0	0	0	0	0	2	0	2
Porites deformis	0	0	0	0	0	0	0	0
Porites horizontalata	0	2	0	2	0	47	0	47
Porites murrayensis	0	0	0	0	0	0	0	0
Porites rus	0	16	0	14	0	68	14	82
Porites stephensoni	0	8	0	7	0	0	0	0
Porites vaughani	0	4	0	3	0	0	0	0
Porites sp.	0	2	0	2	0	9	0	9
Porites sp. - submassive	0	0	0	0	0	6	0	6
Porites sp. -massive	33	76	27	141	27	300	21	350
Psammocora	**0**	**16**	**0**	**14**	**0**	**45**	**0**	**45**
Psammocora contigua	0	0	0	0	0	0	0	0
Psammocora haimeana	0	6	0	5	0	2	0	2
Psammocora profundacella	0	0	0	0	0	9	0	9
Psammocora sp.	0	10	0	9	0	32	0	32
Psammocora superficialis	0	0	0	0	0	2	0	2
Stylocoeniella armata	**0**	**76**	**0**	**67**	**0**	**113**	**0**	**114**

APPENDIX J

Mean density of coral colonies (col/m^2) and colony estimates for all coral taxa within the 30 m and 20 m Indirect Impacts Zones

Appendix J.

	Reef flat	Sand	Indirect Impacts Zone	Reef flat	Sand	30 m Indirect Impacts Zone	Reef flat	Sand	20 m Indirect Impacts Zone
Substrate area (m^2)				**979**	**6066**	**7045**	**619**	**3574**	**4193**
	Colony density			**Colony estimates**					
All coral colonies	**2.289**	**0.833**	**1.106**	**2241**	**5055**	**7794**	**1417**	**2978**	**4639**
Astreopora	**0.000**	**0.249**	**0.202**	**0**	**1509**	**1424**	**0**	**889**	**847**
Astreopora gracilis	0.000	0.126	0.102	0	762	719	0	449	428
Astreopora listeri	0.000	0.005	0.004	0	31	29	0	18	17
Astreopora myriophthalma	0.000	0.028	0.023	0	171	161	0	101	96
Astreopora ocellata	0.000	0.000	0.000	0	0	0	0	0	0
Astreopora randalli	0.000	0.008	0.006	0	47	44	0	27	26
Astreopora scabra	0.000	0.003	0.002	0	16	15	0	9	9
Astreopora sp.	0.000	0.079	0.065	0	482	455	0	284	271
***Cycloseris* sp.**	**0.000**	**0.000**	**0.000**	**0**	**0**	**0**	**0**	**0**	**0**
Cyphastrea	**0.000**	**0.000**	**0.000**	**0**	**0**	**0**	**0**	**0**	**0**
Cyphastrea serailia	0.000	0.000	0.000	0	0	0	0	0	0
Cyphastrea sp.	0.000	0.000	0.000	0	0	0	0	0	0
dendrophylliid sp.	**0.011**	**0.000**	**0.002**	**11**	**0**	**15**	**7**	**0**	**9**
Favia	**0.000**	**0.000**	**0.000**	0	0	0	0	0	0
Favia favus	0.000	0.000	0.000	0	0	0	0	0	0
Favia sp.	0.000	0.000	0.000	0	0	0	0	0	0
Fungia	**0.000**	**0.000**	**0.000**	**0**	**0**	**0**	**0**	**0**	**0**
Fungia concinna	0.000	0.000	0.000	0	0	0	0	0	0
Fungia sp.	0.000	0.000	0.000	0	0	0	0	0	0
Goniastrea retiformis	**0.011**	**0.000**	**0.002**	**11**	**0**	**15**	**7**	**0**	**9**

Appendix J. Continued.

	Reef flat	Sand	Indirect Impacts Zone	Reef flat	Sand	30 m Indirect Impacts Zone	Reef flat	Sand	20 m Indirect Impacts Zone
Heliopora coerulea	**0.000**	**0.000**	**0.000**	**0**	**0**	**0**	**0**	**0**	**0**
***Homophyllia* sp.**	**0.000**	**0.000**	**0.000**	**0**	**0**	**0**	**0**	**0**	**0**
Leptastrea	**0.167**	**0.021**	**0.048**	**163**	**124**	**338**	**103**	**73**	**201**
Leptastrea purpurea	0.167	0.021	0.048	163	124	338	103	73	201
Leptastrea transversa	0.000	0.000	0.000	0	0	0	0	0	0
Leptastrea sp.	0.000	0.000	0.000	0	0	0	0	0	0
Leptoseris	**0.000**	**0.000**	**0.000**	**0**	**0**	**0**	**0**	**0**	**0**
Leptoseris incrustans	0.000	0.000	0.000	0	0	0	0	0	0
Leptoseris mycetoseroides	0.000	0.000	0.000	0	0	0	0	0	0
Leptoseris sp.	0.000	0.000	0.000	0	0	0	0	0	0
Lobophyllia	**0.000**	**0.008**	**0.006**	**0**	**47**	**44**	**0**	**27**	**26**
Lobophyllia corymbosa	0.000	0.000	0.000	0	0	0	0	0	0
Lobophyllia hataii	0.000	0.000	0.000	0	0	0	0	0	0
Lobophyllia hemprichii	0.000	0.005	0.004	0	31	29	0	18	17
Lobophyllia robusta	0.000	0.000	0.000	0	0	0	0	0	0
Lobophyllia sp.	0.000	0.003	0.002	0	16	15	0	9	9
Montastrea magnistellata	**0.000**	**0.000**	**0.000**	**0**	**0**	**0**	**0**	**0**	**0**
Montipora	**0.022**	**0.000**	**0.004**	**22**	**0**	**29**	**14**	**0**	**17**
Montipora informis	0.000	0.000	0.000	0	0	0	0	0	0
Montipora sp.	0.022	0.000	0.004	22	0	29	14	0	17
Pavona	**0.278**	**0.000**	**0.052**	**272**	**0**	**367**	**172**	**0**	**218**
Pavona danai	0.022	0.000	0.004	22	0	29	14	0	17
Pavona decussata	0.256	0.000	0.048	250	0	338	158	0	201
Pavona minuta	0.000	0.000	0.000	0	0	0	0	0	0
Pavona varians	0.000	0.000	0.000	0	0	0	0	0	0

Appendix J. Continued.

	Reef flat	Sand	Indirect Impacts Zone	Reef flat	Sand	30 m Indirect Impacts Zone	Reef flat	Sand	20 m Indirect Impacts Zone
Pocillopora	**0.700**	**0.010**	**0.140**	**685**	**62**	**983**	**433**	**37**	**585**
Pocillopora acuta	0.033	0.000	0.006	33	0	44	21	0	26
Pocillopora damicornis	0.667	0.010	0.133	653	62	939	413	37	559
Pocillopora sp.	0.000	0.000	0.000	0	0	0	0	0	0
Porites	**1.100**	**0.490**	**0.604**	**1077**	**2971**	**4256**	**681**	**1750**	**2533**
Porites cylindrica	0.033	0.010	0.015	33	62	103	21	37	61
Porites deformis	0.000	0.003	0.002	0	16	15	0	9	9
Porites horizontalata	0.000	0.013	0.010	0	78	73	0	46	44
Porites murrayensis	0.000	0.008	0.006	0	47	44	0	27	26
Porites rus	0.144	0.208	0.196	141	1260	1380	89	742	821
Porites stephensoni	0.011	0.095	0.079	11	575	558	7	339	332
Porites vaughani	0.000	0.000	0.000	0	0	0	0	0	0
Porites sp.	0.000	0.018	0.015	0	109	103	0	64	61
Porites sp. - submassive	0.000	0.000	0.000	0	0	0	0	0	0
Porites sp. -massive	0.911	0.136	0.281	892	824	1981	564	486	1179
Psammocora	**0.000**	**0.003**	**0.002**	**0**	**16**	**15**	**0**	**9**	**9**
Psammocora contigua	0.000	0.003	0.002	0	16	15	0	9	9
Psammocora haimeana	0.000	0.000	0.000	0	0	0	0	0	0
Psammocora profundacella	0.000	0.000	0.000	0	0	0	0	0	0
Psammocora sp.	0.000	0.000	0.000	0	0	0	0	0	0
Psammocora superficialis	0.000	0.000	0.000	0	0	0	0	0	0
Stylocoeniella armata	**0.000**	**0.054**	**0.044**	**0**	**327**	**308**	**0**	**192**	**183**

APPENDIX K

Percent cover of major benthic classes for the south wharf face transects (Direct Impacts Zone).

Appendix K.

	1 m			5 m			9 m		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Cover type									
Hard coral	**0.5**	**0.5**	**1.4**	**0.0**	**0.4**	**0.3**	**1.3**	**0.6**	**0.8**
Soft coral	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Sponges	0.0	0.4	0.4	2.7	5.4	2.1	3.0	6.9	2.4
Dead coral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other hardbottom	99.5	96.7	97.9	97.3	94.3	97.6	95.7	92.5	96.9
Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Debris	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX L

Percent cover of major benthic classes for the east and west wharf side transects (Direct Impacts Zone).

Appendix L.

	East		West	
	1 m	5 m	1 m	5 m
	1	2	1	2
Cover type				
Hard coral	**1.0**	**0.0**	**2.9**	**1.6**
Soft coral	0.0	0.9	0.0	0.0
Sponges	0.0	4.5	0.0	0.0
Dead coral	0.0	0.0	0.0	0.0
Other hardbottom	99.0	94.6	97.1	98.4
Sand	0.0	0.0	0.0	0.0
Debris	0.0	0.0	0.0	0.0

APPENDIX M

Percent cover of major benthic classes for the transects at the base of the wharf (Direct Impacts Zone).

Appendix M.

	South side			East side	West side
	1	**2**	**3**	**1**	**1**
Cover type					
Hard coral	**0.6**	**0.6**	**0.3**	**0.3**	**1.0**
Soft coral	0.0	0.0	0.0	0.0	0.0
Sponges	0.3	0.0	0.6	0.0	0.0
Dead coral	0.0	0.0	0.0	0.0	0.0
Other hardbottom	3.1	0.0	1.9	72.4	65.5
Sand	55.9	8.0	54.3	25.6	30.5
Debris	40.1	91.4	43.0	1.7	3.0

APPENDIX N

Percent cover of major benthic classes for seafloor transects within the 30 m Indirect Impacts Zone.

Appendix N.

	Reef flat (W)		Sand flat													Reef flat (E)
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Cover type																
Hard coral	**1.5**	**0.4**	**0.0**	**0.6**	**0.4**	**0.2**	**1.0**	**0.2**	**5.4**	**0.2**	**1.3**	**4.8**	**1.3**	**0.6**	**0.0**	**3.5**
Soft coral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sponges	0.0	0.0	0.4	0.0	0.2	0.2	0.0	0.0	0.6	0.0	0.2	0.8	0.4	0.8	0.0	0.0
Dead coral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other hardbottom	82.9	65.0	11.1	9.0	2.5	17.3	5.0	3.8	15.0	9.8	16.9	14.8	19.4	21.3	54.4	94.2
Sand	15.4	33.1	87.7	86.9	90.4	70.5	69.7	69.8	46.3	71.3	64.2	70.0	71.9	74.8	44.2	1.9
Debris	0.2	1.5	0.8	3.5	6.5	11.7	24.2	26.3	32.5	18.8	17.5	9.6	7.1	2.5	1.5	0.4

APPENDIX O

Percent cover of major benthic classes for seafloor transects that targeted hardbottom habitat within the 30 m Indirect Impacts Zone.

Appendix O.

	Aggregate reef		Mixed sand/HB	
	1	**2**	**1**	**2**
Cover type				
Hard coral	**13.0**	**16.5**	**3.5**	**1.7**
Soft coral	0.0	0.0	0.0	0.0
Sponges	1.4	0.3	1.5	0.4
Dead coral	0.0	0.0	0.0	0.0
Other hardbottom	53.1	36.4	35.4	27.5
Sand	32.1	45.5	59.4	64.6
Debris	0.4	1.4	0.2	5.8

APPENDIX P

Percent cover of major benthic classes for seafloor transects that targeted hardbottom habitat within the 20 m Indirect Impacts Zone.

Appendix P.

	Reef flat (W)			Sand flat												Reef flat (E)	
	1	**2**	**A**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**B**
Cover type																		
Hard coral	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	10.0
Soft coral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sponges	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.3	0.6	0.0	0.9	0.0	0.0	0.3
Dead coral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other hardbottom	96.5	80.8	91.9	11.6	12.9	2.8	12.2	0.0	0.3	2.8	2.8	9.4	5.3	7.5	13.1	37.2	93.8	89.7
Sand	3.2	17.0	5.6	87.2	81.8	88.8	70.3	65.3	60.6	48.4	69.6	65.7	80.6	82.1	83.4	60.6	0.9	0.0
Debris	0.3	2.2	0.0	1.3	5.3	8.4	17.5	34.7	39.1	48.1	27.6	24.5	13.4	10.3	2.5	2.2	0.6	0.0

APPENDIX Q

Density (ind/m^2) of macroinvertebrate taxa observed within belt transects placed on the wharf (Direct Impacts Zone).

Appendix Q.

	East side		South side									West side	
	1	**2**	**1**	**2**	**3**	**5**	**6**	**7**	**9**	**10**	**11**	**1**	**2**
Seastars	0.00	0.00	0.02	0.00	0.02	0.00	0.01	0.02	0.02	0.01	0.01	0.05	0.00
Culcita novaeguineae	0.00	0.00	0.02	0.00	0.01	0.00	0.01	0.01	0.02	0.01	0.01	0.00	0.00
Linckia multifora	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.05	0.00
Urchins	0.00	0.00	0.15	0.00	0.00	0.16	0.00	0.00	0.05	0.02	0.00	0.02	0.00
Diadema sp.	0.00	0.00	0.09	0.00	0.00	0.09	0.00	0.00	0.02	0.02	0.00	0.00	0.00
Echinometra mathaei	0.00	0.00	0.01	0.00	0.00	0.04	0.00	0.00	0.02	0.00	0.00	0.02	0.00
Echinometra sp. A	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Echinostrephus aciculatus	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Echinothrix diadema	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parasalenia gratiosa	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sea cucumbers	0.22	0.00	0.04	0.00	0.00	0.01	0.00	0.00	0.08	0.01	0.00	0.00	0.00
Actinopyga echinites	0.19	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Actinopyga varians	0.03	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.05	0.00	0.00	0.00	0.00
Bohadschia argus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Holothuria atra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Holothuria leucospilota	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thelanota anax	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Edible mollusks	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Octopus cyanea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tectus niloticus	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All macroinvertebrates	0.25	0.00	0.22	0.00	0.02	0.17	0.01	0.02	0.15	0.04	0.01	0.07	0.00

APPENDIX R

Density (ind/m^2) of macroinvertebrate taxa observed within belt transects placed on the seafloor at the base of the wharf (Direct Impacts Zone).

Appendix R.

	East	South			West
	4	4	8	12	4
Seastars	0.00	0.04	0.00	0.02	0.00
Culcita novaeguineae	0.00	0.04	0.00	0.02	0.00
Linckia multifora	0.00	0.00	0.00	0.00	0.00
Urchins	0.02	0.00	0.00	0.00	0.22
Diadema sp.	0.00	0.00	0.00	0.00	0.00
Echinometra mathaei	0.02	0.00	0.00	0.00	0.22
Echinometra sp. A	0.00	0.00	0.00	0.00	0.00
Echinostrephus aciculatus	0.00	0.00	0.00	0.00	0.00
Echinothrix diadema	0.00	0.00	0.00	0.00	0.00
Parasalenia gratiosa	0.00	0.00	0.00	0.00	0.00
Sea cucumbers	0.28	0.00	0.00	0.01	0.02
Actinopyga echinites	0.20	0.00	0.00	0.00	0.00
Actinopyga varians	0.02	0.00	0.00	0.00	0.02
Bohadschia argus	0.02	0.00	0.00	0.01	0.00
Holothuria atra	0.02	0.00	0.00	0.00	0.00
Holothuria leucospilota	0.02	0.00	0.00	0.00	0.00
Thelanota anax	0.00	0.00	0.00	0.00	0.00
Edible mollusks	0.00	0.00	0.00	0.00	0.00
Octopus cyanea	0.00	0.00	0.00	0.00	0.00
Tectus niloticus	0.00	0.00	0.00	0.00	0.00
All macroinvertebrates	0.30	0.04	0.00	0.04	0.24

APPENDIX S

Density (ind/m^2) of macroinvertebrate taxa observed within belt transect surveyed on the reef flat and sand flat within the 30 m Indirect Impacts Zone

Appendix S.

	Reef flat (W)		Sand flat													Reef flat (E)
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Seastars	0.00	0.03	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Culcita novaeguineae	0.00	0.03	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Linckia multifora	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urchins	0.12	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Diadema sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Echinometra mathaei	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Echinometra sp. A	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Echinostrephus aciculatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Echinothrix diadema	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paraselenia gratiosa	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sea cucumbers	0.03	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.37
Actinopyga echinites	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.33
Actinopyga varians	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Bohadschia argus	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Holothuria atra	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
Holothuria leucospilota	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thelanota anax	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Edible mollusks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Octopus cyanea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tectus niloticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All macroinvertebrates	0.15	0.07	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.42

APPENDIX T

Density (ind/m^2) of macroinvertebrate taxa observed during surveys of transects placed on hardbottom habitat within the 30 m Indirect Impacts Zone.

Appendix T.

	Mixed sand/HB		Aggregate reef	
	1	**2**	**3**	**4**
Seastars	0.02	0.02	0.01	0.00
Culcita novaeguineae	0.02	0.02	0.01	0.00
Linckia multifora	0.00	0.00	0.00	0.00
Urchins	0.00	0.00	0.00	0.00
Diadema sp.	0.00	0.00	0.00	0.00
Echinometra mathaei	0.00	0.00	0.00	0.00
Echinometra sp. A	0.00	0.00	0.00	0.00
Echinostrephus aciculatus	0.00	0.00	0.00	0.00
Echinothrix diadema	0.00	0.00	0.00	0.00
Parasalenia gratiosa	0.00	0.00	0.00	0.00
Sea cucumbers	0.00	0.00	0.01	0.00
Actinopyga echinites	0.00	0.00	0.00	0.00
Actinopyga varians	0.00	0.00	0.00	0.00
Bohadschia argus	0.00	0.00	0.00	0.00
Holothuria atra	0.00	0.00	0.00	0.00
Holothuria leucospilota	0.00	0.00	0.00	0.00
Thelanota anax	0.00	0.00	0.01	0.00
Edible mollusks	0.00	0.00	0.00	0.00
Octopus cyanea	0.00	0.00	0.00	0.00
Tectus niloticus	0.00	0.00	0.00	0.00
All macroinvertebrates	0.02	0.02	0.03	0.00